NASA SP-3072

ASRDI OXYGEN TECHNOLOGY SURVEY

Volume II: Cleaning Requirements, Procedures, and Verification Techniques

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Scientific and Technical Information Office 1972
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C.

PREFACE

This document is one of a series of publications developed by the Aerospace Safety Research and Data Institute for use as oxygen system design and operation guidelines. The material presented herein is a survey of oxygen technology dealing with cleaning requirements, procedures, and verification techniques. It documents the different levels of hardware cleanliness requirements as functions of the particular oxygen service application, the cleaning methods used to attain the required degree of cleanliness, and the verification techniques presently practiced to establish that the cleanliness level required has been attained. No attempt is made to select recommended cleaning procedures since a basis for such selection is not now available.

This report includes an appendix which presents abstracts of the cleaning methods reviewed for this survey. Furthermore, a microfiche supplement of references is attached inside the back cover to make pertinent pages of listed references readily available to the reader. Some references are included in their entirety, while only selected pages or sections of others are reproduced. The location of each reference in the supplement is noted in the list of references.

The following representative at the NASA centers participated in the critical review of the text: Haggai Cohen and Thomas Kerr of NASA Headquarters; Melvin G. Olsen of Kennedy Space Center; Leslie W. Ball and personnel of the Science and Engineering Directorate of Marshall Space Flight Center; Bernard I. Sather and Frank E. Belles of Lewis Research Center; G. Hennings and J. W. Gibb of Plum Brook Station; and specialists in the Quality Assurance Office and the Engineering and Development Directorate of Manned Space Center.

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INTRODUCTION

Cleanliness requirements for mechanical systems have been undergoing a continuous evolution. With the advent of the airplane hydraulic and pneumatic systems and their associated close tolerances, special requirements had to be instituted to prevent malfunction or excessive wear due to particulate matter or contaminants. When man prepared to venture into the hostile environment of space more stringent requirements were necessary. With the more recent widespread use of oxygen, both in industry and space, additional scope had to be added to the cleanliness requirements. Recognition of oxygen's inherent reactivity characteristic as well as the fact that relatively small quantities of contaminants could serve as ignition sources and thus cause the burning of otherwise satisfactory containment materials led to these necessary additional requirements.

During this evolution a proliferation of cleanliness requirements has been generated. In part, this has occurred because the applications vary in scope from industrial use, with the least stringent requirements, to manned space vehicles, with the most demanding requirements. It has also been caused by the fact that the actual degree of cleanliness required has a small scientific base. Thus, many groups in both industry and government have generated cleaning specifications by trial and have verified them by operating experience accumulated with particular applications.

This report displays the oxygen system cleaning specifications drawn from 23 industrial and government sources, cleaning processes employed for meeting these specifications, and recommended postcleaning inspection procedures for establishing the cleanliness achieved.

It is the purpose of this document to collate and examine areas of agreement and difference in the specifications, procedures, and inspection. Also, the lack of clarity or specificity will be discussed. This absence of clarity represents potential safety hazards due to misinterpretation. Also, it can result in exorbitant expenditures of time and money in satisfying unnecessary requirements.

CLEANLINESS REQUIREMENTS

The degree of required cleanliness depends on the intended application of the component or system and is usually expressed in terms of allowable limits of contaminants. A contaminant is defined as any material which by being present in a system or component may cause mechanical malfunction, fire, or explosion. The types of most common contaminants and their relative sizes are illustrated in figure 1 (ref. 1). Techniques



If this solid circle represents particle 10 microns in diameter, the larger circle represents the cross section of the average human hair (100 microns). The major problem in contamination control is the tendency of the small particles to group and form larger particles.

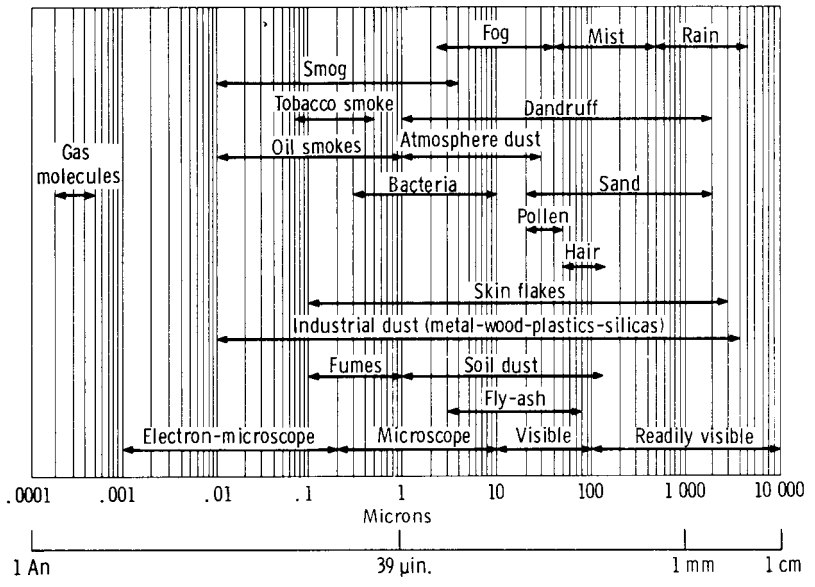


Figure 1. - Approximate sizes of common particles (ref. 1).

required to detect these contaminants as a function of their size are also indicated. Sources of contaminants which are probably the most difficult to predict are the fabrication and assembly operations such as grinding, cutting, welding, etc. Effective cleaning will

(1) Prevent functional interference with components by particles deposited on moving parts, valve seats, and system sensors and controls

(2) Reduce the likelihood of fire by rubbing friction which might occur if the clearance between moving system parts fills with contaminants

(3) Avoid accumulations of finely divided contaminants which are more easily ignited in oxygen than the bulk system materials

The cleanliness requirements can be placed in the following two general categories:

(1) Aerospace clean - applies to flight systems, components, ground service equipment for flight systems, environmental chambers, space cabins, and breathing apparatuses.

(2) Commercial clean - applies to industrial and process systems in which the threat, or consequences, of failure are low.

Wherever possible, the specifications, cleaning processes, and verification procedures are grouped in this report according to these cleanliness grades. Unfortunately, the originators of the cleaning requirements seldom classified them according to this scheme, but this pattern is discernible in the accumulated cleaning information.

Description of Contaminants

The following five contaminants are mentioned in the 33 cleanliness requirements (refs. 2 to 22) reviewed:

(1) Particulate matter - general term applied to finely divided solid matter of dimensions measured in microns (10^{-6} m or 3.9×10^{-5} in.). Its population in a system (or component) is determined by counting the particles in a unit volume of wash fluid (liquid or gas) that passed through the system at the end of the cleaning process. The cleanliness of the system (or components) is reported in terms of the number of particles of a given size range per unit area of the surface rinsed or washed. If the internal surfaces are accessible after cleaning, then the particle count can be made from a wipe of the surface and reported on the basis of the particle distribution per unit area of the internal system surface.

(2) Fiber - particle having a length of 100 microns or greater with a length to width ratio of 10:1 or greater. Fibers are classed according to length in microns and reported as a population number per square foot of internal surface area. (The internal surface which is exposed to the service media is often referred to in the literature as the "critical surface area.")

(3) Condensable hydrocarbons - usually refers to hydrocarbons capable of going from a gaseous to a liquid or solid state at system temperature and pressure. They are measured and reported as parts per million by weight of system fluid. In chemical use it usually refers to 1 microgram per gram.

(4) Solvent soluble organic residue - usually refers to hydrocarbons remaining on a surface after cleaning. It is measured in milligrams per milliliter of rinse solvent and reported in milligrams per square foot of critical surface area.

(5) Total solids - constitute the sum total of solid material obtained by filtering and evaporating a unit volume of the cleaning solvent. Total solids are reported in units of weight per unit area of the system or component.

Cleanliness Requirements for Particulate Matter Contaminants

In the reviewed cleanliness requirements particulate matter is given the greatest emphasis. The cleanliness requirements listed in table I (pp. 63 to 66) show considerable variation in the specification for particulate cleanliness. In some cases acceptable particle sizes and population are small and carefully defined; in other cases only the population of the largest acceptable sizes are specified. The differences are suspected to relate to the clearance dimensions of the moving parts of the system of concern when the specifications were first prepared. Permissible particle sizes are kept well below

these clearance dimensions. Also, it is desirable to point out that generally the smallest particles have the tendency to group and form larger particles. However, if they do not agglomerate and become suspended in the wash fluid, they are most easily washed from the system since the smallest particles are more readily maintained suspended in the wash fluid. Removal of the smallest particles from the surface becomes increasingly less effective as particle size decreases because of their ability to tenaciously adhere to the surface. This adherence is further enhanced by the wetting action of the wash fluid through the formation of residual film and corresponding surface tension. Any attempt to remove the particle must overcome this surface tension. By placing an upper limit on the permissible size and population of the larger particles, one is reasonably assured that the population of smaller particles will not be troublesome. The designer must judge the range of permissible particle sizes remaining in his system after cleaning on the basis of the sensitivity of the system components to interference by particles (ref. 23). It might be noted that past experience (described in the proposed Lewis Research Center design criteria monograph on liquid rocket valve assemblies) indicates that the particle size should be restricted to one-eighth of the clearances available. Furthermore, a John F. Kennedy Space Center (KSC) study of cleanliness specification (ref. 24, p. 26) states that for a given cleanliness level a standard particle distribution can be calculated per MIL-STD-1246A to obtain the total particle volume. This calculated volume used in conjunction with the available clearance can then be related to the allowable particulate contamination level and thus the degree of cleanliness required for the system. The pore size of the filters that can be used to protect these components and the ignition hazard posed by cavities in the system where particles may drop out of suspension in the process fluid and form dangerous accumulations must also be taken into consideration. The particulate specifications given in table I have served successfully for the systems indicated. The designer may use the one which comes closest to matching his system.

Overall cleanliness requirements for manned and unmanned space flight hardware systems (tanks, pipes, propulsion units, etc.) are presented in figure 2. The particle cleanliness requirements for manned space flight hardware are inconclusive for particles smaller than 175 microns. For unmanned ballistic flight systems these requirements are inconclusive for particles smaller than 300 microns. However, the limits of the largest allowable size of contaminants are very specific: 1000 microns for unmanned ballistic flight systems, and 2500 microns for systems used in manned space flight applications. According to KSC personnel, the largest allowable size of contaminant acceptable for manned space flight applications derived from actual "field tests" at the KSC complexes represents the maximum cleanliness results obtainable in the field during the 1960 to 1964 time period.

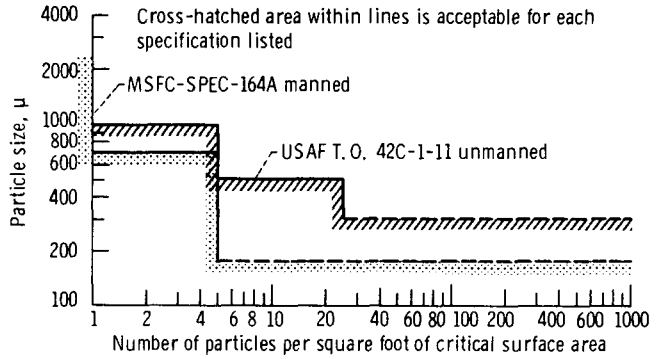


Figure 2. - Particulate matter - cleanliness requirements for space hardware.

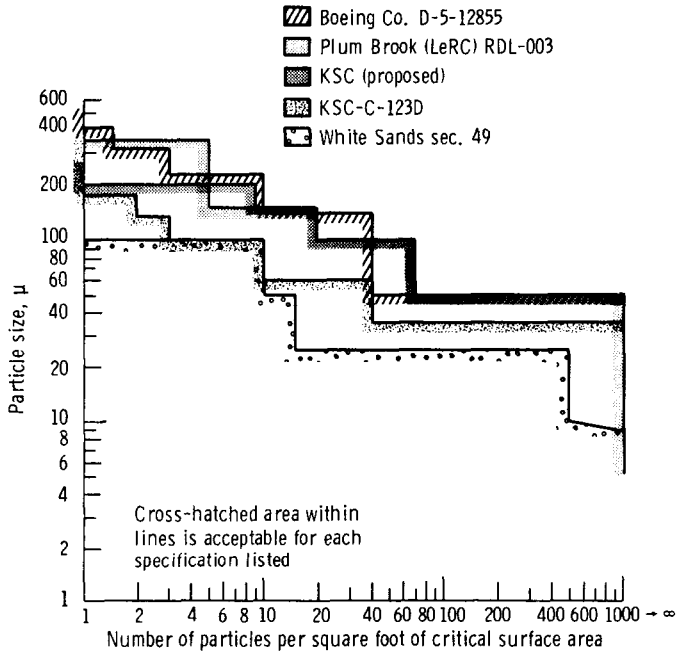


Figure 3. - Particulate matter - cleanliness requirements for ground based components and systems that may interface with flight systems.

Figure 3 shows the particulate cleanliness requirements for systems in the fabrication phase or test apparatus operations. Some of the systems in fabrication may be interfaced with space flight hardware or may be ground support equipment for space flight hardware. In the latter case the contaminant control is a very significant part of operations because of the extensive reuse of the equipment and the associated hazard of contaminant accumulation. In comparison to space flight systems cleanliness requirements, the requirements for ground service equipment illustrated in figure 3 allow fewer larger size particulate matter contaminants. Reasons for this are not readily obvious from the

available literature. A comparison of the KSC-C-123D (ref. 10) cleanliness requirements with the KSC proposed cleanliness requirements (ref. 11) indicates that the cleanliness requirements may be relaxed somewhat.

Figure 4 shows the particulate cleanliness requirements for environmental chambers, space cabins, and breathing oxygen components. The wide spread in allowable population of particulate matter is emphasized. However, this may be understandable because more contaminants must be accommodated by the design because man is a source of contamination in these cases. Rationale for abrupt changes in permitted size of population of particulate matter could not be established from the available literature.

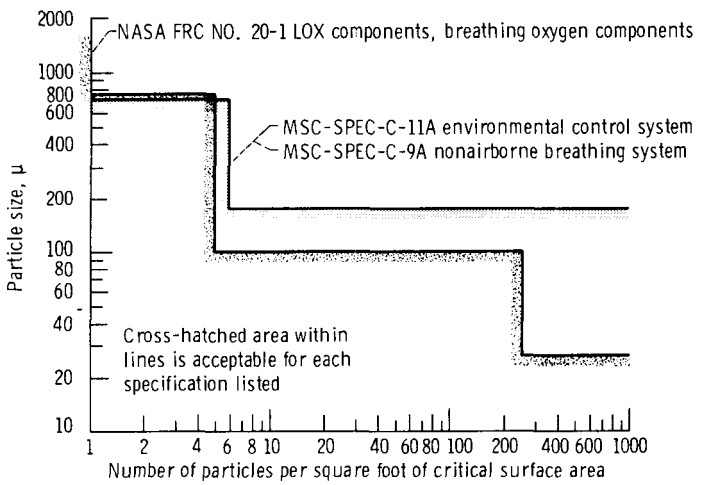


Figure 4. - Particulate matter - cleanliness requirements for space cabins, environmental chambers, breathing oxygen components.

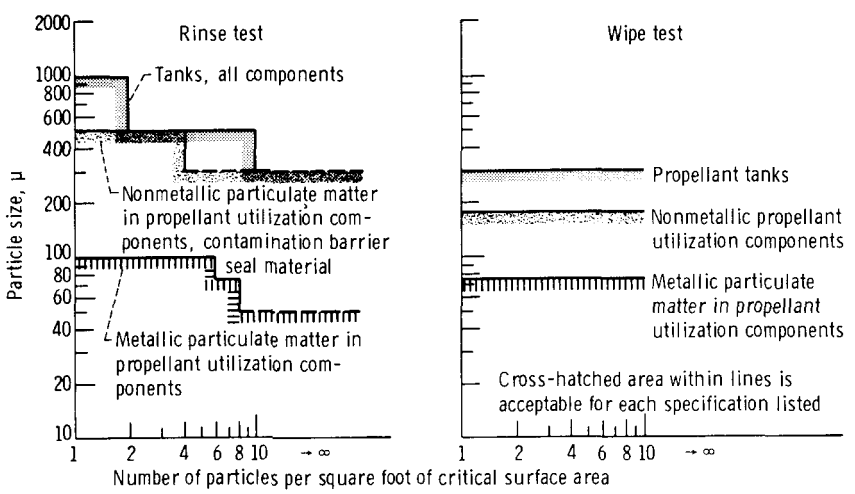


Figure 5. - Particulate matter - cleanliness requirements as function of material and inspection technique (spec. 075192B GDA-Convair, Dec. 13, 1967).

Figure 5 presents particulate cleanliness requirements specified by General Dynamics - Convair Division (ref. 19). The outstanding feature of these requirements is the classification of cleanliness requirements according to cleanliness verification techniques and the nature of the contaminant. The cleanliness requirements are more stringent for metallic particles than for nonmetallic regardless of verification techniques used.

Figure 6 is an example of the particulate cleanliness requirements established by commercial industry engaged in oxygen production. Three distinct classes of cleaning requirements are defined:

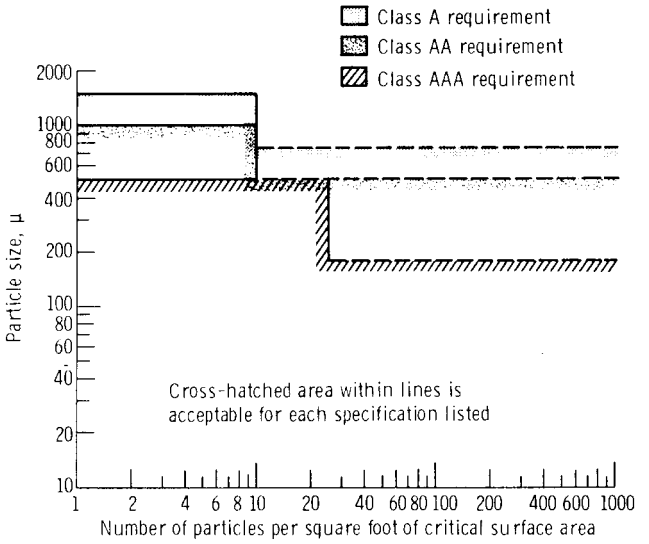


Figure 6. - Pariculate matter - air products and chemicals cleanliness requirements.

(1) Class AAA is the most demanding class of cleanliness requirements; it is applicable to equipment or apparatus with moving surfaces which contact liquid or gaseous oxygen. In relation to the government and aerospace industry cleanliness requirements, this class is within the general space flight hardware limits.

(2) Class AA is the more general cleanliness requirements; it is applicable to shop fabricated or purchased equipment where fixed surfaces contact liquid or gaseous pure oxygen.

(3) Class A is the least strigent class of cleanliness requirements; it is applicable to surfaces which through use will contact fluids other than pure oxygen, for example, liquid air or crude oxygen.

Cleanliness Requirements for Fiber Contaminants

The cleanliness requirements for fiber contaminants are not as extensive as for the particulate matter. The information listed in table I clearly indicates that stated requirements vary from disallowing presence of any fiber contaminants at all (White Sands Test Facility, sec. 49) (ref. 6) to the very explicit requirements exemplified by Plum Brook (Lewis Research Center, LeRC) RDL-003 (ref. 3). In this realm of variations the following are noteworthy:

(1) Nine sets of cleanliness requirements do not state allowable fiber contaminant limits.

(2) Eight sets of cleanliness requirements state one point limits above which fiber contaminants cannot be tolerated, namely, no fibers greater than 2000, 4000, or 6000 microns in length.

(3) The KSC (proposed, ref. 11) cleanliness requirements permit the fiber contaminants to be classed and counted as particulate matter contaminant.

(4) The GDA 0-75192B (ref. 19) cleanliness requirements, consistent with particulate matter contaminant treatment, explicitly differentiate between metallic and nonmetallic fiber allowable limits. These limits are also adjusted on the basis of verification techniques used. Metallic fiber contaminants are totally disallowed, while nonmetallic fiber contaminant limits vary from none greater than 2000 microns in length

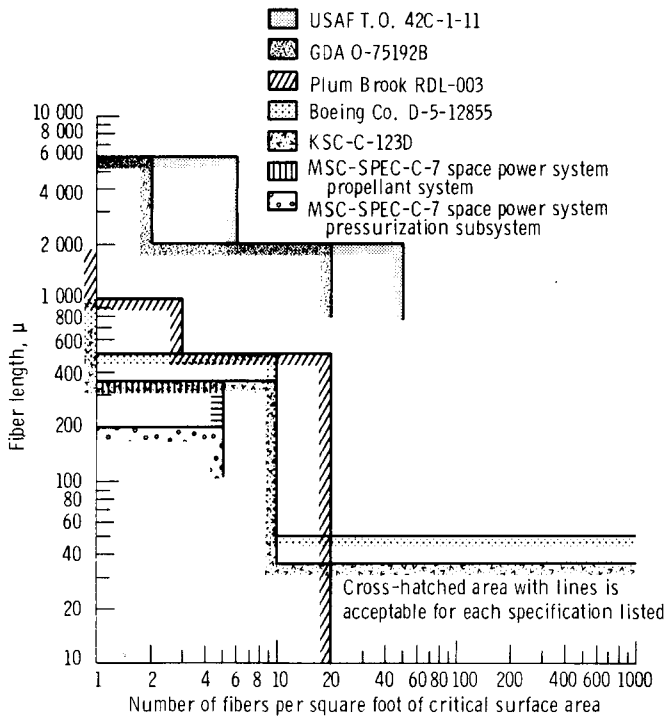


Figure 7. - Fiber-cleanliness requirements.

to none greater than 6000 microns in length depending on the systems involved.

The more explicit fiber contaminant requirements are illustrated in figure 7. The allowable fiber length limits are plotted as functions of the allowable population per square foot of critical surface area. Maximum allowable limits are indicated by the solid lines. Plum Brook (LeRC) cleanliness requirement limits for fiber type contaminants are the most explicit (ref. 3). These requirements limit fiber contaminant to 20 fibers of 0 to 500 microns in length, three fibers of 501 to 1000 microns in length, and one fiber to 1001 to 1875 microns in length. Thus, these specifications leave no doubt about the cleanliness level to be attained. Other requirements illustrated in the figure are less explicit.

Cleanliness Requirements for Condensable Hydrocarbons

Most of the cleanliness requirements do not indicate the condensable hydrocarbon type contaminant limits. In the few instances where the allowable contaminant limits are specified they vary from very explicit to extremely vague requirements. For example, from the data presented in table I the statements are as follows:

(1) Very explicit.

(a) 2.0 ppm by weight of test gas[1] (KSC-C-123D, ref. 10).

(b) 1.0 ppm by weight of test gas[1] (KSC proposed, ref. 11).

(c) 0 ppm by weight of test gas[1] (Plum Brook RDL-003, ref. 3).

(2) Explicit - no fluorescence on the cleaned surface using ultraviolet light (USAF T.O. 42C-1-11, (ref. 12); GDA 0-75192B (ref. 19); QCL 107F Air Products (ref. 4)).

(3) Vague.

(a) Low intensity fluorescence on the cleaned surface is acceptable (QCL 105F Air Products, ref. 4).

(b) No fluorescence (QCL 106F Air Products, ref. 4). (However, the specification allows isolated particles of lint on the cleaned surfaces.)

Cleanliness Requirements for the Remaining Types of Contaminants

Cleanliness requirements for solvent soluble organic residue, total solids, and other contaminants are either totally not stated or specified in the 1 to 5 milligram per square foot range of critical surface area. An exception is the Linde cleanliness requirement (ref. 8). It specifically limits nonvolatile residue to 500 milligrams per

[1]A sample of purge gas used to dry the system as part of the cleaning procedure.

square foot of critical surface area and solvent soluble organic residue to 10 milligrams per square foot of critical surface area. (The techniques used for measuring are discussed in the VERIFICATION OF CLEANLINESS section.)

For all the previously described contaminant limits the relation between the realistic cleanliness level and the specified cleanliness level is not defined in any of the requirements reviewed. There is no record in the documents reviewed of the basis for the selection of the cleanliness requirements generated by the separate groups within government and industry.

CLEANING PROCEDURES

Twenty-three cleaning procedures have been reviewed (refs. 2 to 22 and 25) to compare their approach to cleaning problems and highlight similarities or differences. A complete set of summaries of the procedures is given in the appendix and a complete set of detailed procedures is included in the attached microfiche supplement. Several general comments can be made regarding these cleaning procedures:

(1) All cleaning procedures except USAF T.O. 42C-1-11 (ref. 12) are written as guidelines and not as explicit specifications.

(2) Cleaning procedures vary according to the cleanliness requirements, the system components being cleaning, and the system materials.

(3) Cleaning procedures may be classified as aerospace clean or commercial clean.

(4) Cleaning procedures are most involved and costly for aerospace clean and least involved and costly for commercial clean.

A precautionary remark regarding cleaning agents and equipment used in these procedures is appropriate at this point. The toxicity of the cleaning solvents and the bodily harm associated with ultrasonically activated equipment or solutions present personnel health hazards which require protective measures.

There are five distinct steps that may be repeated several times in a given cleaning procedure. These steps are listed in table II (p. 66) with the associated information regarding cleaning agents, mechanical methods used with each step, and the purpose of each step. The particular sequence or number of these steps in a given procedure is a direct function of the cleanliness requirements and intended application or prior cleaning history of the item being cleaned.

The chemicals, cleaning agents, and mechanical aides used from table II vary as functions of materials of the components or systems being cleaned. In some instances cleaning procedures are specified according to the material used in the construction of the component, whereas in other instances the procedures are specified according to the components. The latter approach is most often used where two or more dissimilar ma-

terials (such as a metal and a nonmetal) or two different metals are used in fabricating the component. Not all cleaning agents can be used with such combinations of materials. For example, a highly acidic or alkaline cleaning agent may be suitable for one metal but not for the other, whereas some organic solvents may cause nonmetallic materials to swell and possibly degrade the physical or chemical properties due to solvent absorption or leaching action. Table III (ref. 26, pp. 68 to 71) illustrates some of the effects the common cleaning agents have on system materials. When all parts of a system cannot tolerate the same cleaning agent, they are cleaned separately before assembly. Subsequent assembly under clean conditions (clean room, etc.) avoids the need for further cleaning with strong agents.

An example of the cleaning procedures specified according to material as given in the appendix is presented in tables IV and V. Table IV (pp. 72 and 73) presents procedures for components made from various steel alloys, while table V (pp. 74 and 75) presents procedures for aluminum and its alloys. The procedures range from highly complex (i. e., numerous repetitions of basic steps) to very simple. The difference in metals to be cleaned affects the choice of cleaning agents, their concentrations, and metal exposure times and temperature ranges at which exposure to cleaning chemicals is made. This is evident, for example, by an examination of step 10 in table IV and step 8 in table V. For the steel alloys (step 10, table IV), cleaning agent formulation contains a quantity of phosphoric acid (exposure times range from 15 to 20 min) at temperatures between 80° and 175° F. For the aluminum and its alloys (step 8, table V), the cleaning formulation is mildly alkaline and exposure times are 30 to 120 minutes at 80° to 95° F or as short as 1 to 3 minutes at 140° to 180° F. Comparing the aforementioned individual cleaning steps for the given material, one becomes aware of the variations in cleaning agent concentrations, temperatures, and exposure times from one procedure to another. On the basis of the documents available at this time, technical justification for these differences cannot be established.

The information presented in tables IV and V must mirror the cleanliness requirements previously established. Thus, the cleaning procedures fall into the same general classes as the cleanliness requirements. The following are some examples:

(1) Aerospace clean. This category of cleaning procedures must meet the most demanding cleanliness requirements to ensure system reliability and safety. Cleaning procedures in this category can be further grouped into four distinct groups:

(a) Manned space flight. Preparation for such flights involves the greatest number of cleaning steps and related inspections to meet the most stringent cleanliness requirements for both space flight hardware and ground support equipment.

(b) Short duration space flight. For these flights the cleaning procedures are simplified somewhat by using fewer repetitive steps and inspections.

(c) Environmental chambers. These chambers could be environmental simulators on the ground or spacecraft cabins. A new factor, the human body, becomes an additional source of contamination. It is a living source of contamination which cannot be eliminated by cleaning. Therefore, the problems it presents must be accommodated by a very careful choice of materials, detailed design considerations, and corresponding operating procedures. The floors and walls, where feasible, are thoroughly scrubbed to remove visible soils (ref. 26). People are required to wear lintless protective clothing, booties, and head gear in the environmental chambers and the spacecraft prior to launch. This protective equipment is cleaned to oxygen service requirements.

(d) Research test apparatus. Relatively simple procedures are used if the apparatus is small and the consequences of fire or system failure are limited to tolerable levels.

(2) Commercial clean. This cleaning category generally involves the simplest cleaning procedures since the consequences of failure are designed to be small in ground-base commercial equipment built to large safety factors. Commercial oxygen processors do achieve aerospace clean conditions when required.

Cleaning is expensive. Cleaning requirements which are more exacting than the risk involved in system failure would justify are not cost effective.

VERFICATION OF CLEANLINESS

The verification methods for determining the cleanliness achieved are reviewed in references 2 to 22 and 25. A list of the more common verification tests are presented in table VI (pp. 76 to 78) along with a general description of the procedures used in each test, the results that should be expected, and the limitations of the test method. Verification of cleanliness usually involves a sequence of tests; these tests are presented separately in table VI. The types and sequence of verification methods to be used are usually specified along with the cleanliness requirements by the originating agency.

The tests described in the table are of two categories:

(1) Direct determination. The verification techniques are based on direct determination of the cleanliness condition of the critical surface:

(a) pH paper - to determine the acidity or alkalinity of the surface

(b) Wipe - to detect particulate matter

(c) Visual

(i) Ultraviolet light or black light - to detect hydrocarbons by means of fluorescence

(ii) Water break - to determine the presence of contaminant film by the water's inability to wet the surface

(iii) Flood light - to detect particulates

These are all qualitative in nature and are effective only in situations where the critical surface areas are easily accessible to sight or touch.

(2) Indirect determination. The verification techniques are based on the analysis of a sample of the final rinse fluid (gas or liquid) to indirectly determine the cleanliness condition of the critical surface. The test methods in this category are the following:

(a) Gas blowdown - to determine by filtering and counting the particulate contaminants collected on the filter paper

(b) Solvent flush - to determine by filtering and counting the particulate contaminants collected on the filter paper

(c) Solvent soluble organic residue - to detect and determine organic contaminants such as oils, hydrocarbons, protective film coatings, etc.

(d) Condensable hydrocarbons - to determine presence and quantity of hydrocarbons

(e) Nonvolatile residue - to determine the quantity of solid matter contaminants

Sampling and analysis of the final rinse fluid using the aforementioned tests constitute the entire basis for determining the cleanliness condition of the critical surface area. The fluid used in the final rinse operations has to be of exceptional purity to facilitate a reasonably accurate determination of the quantity of contaminants entrained by the fluid. Also, the sampling technique must be properly executed to obtain a highly representative sample of the rinse fluid. A properly executed sampling technique means the following:

(1) The quantity and number of samples taken must be commensurate with the sensitivity and precision of the cleanliness verification method used.

(2) The samples taken must be representative of the entire fluid used in flushing the critical surface area. Also, the sampling should be done at normal operating conditions of the system or component, and the sampling points must be properly located.

(3) The samples must be clear of extraneous contamination such as unclean sampling equipment.

Otherwise, the results achieved may be erroneous and an acceptably clean part may be rejected or unacceptably clean part may be accepted.

The gas blowdown and solvent flush tests are qualitative in nature, because the particle count is an estimate of an average count. The remaining three tests in this category are quantitative in nature because the infrared spectrophotometric or gravimetric determinations are used in establishing the quantity of the contaminants in the representative sample. The condensable hydrocarbon test, however, is probably the least accurate of the three. This is because of the intricate manipulations required to isolate

the condensable hydrocarbons and because an arbitrary factor called "compensating evaporation factor" must be used in the computation to determine the concentration of the contaminants. These combine to severely degrade the test results.

In general, the reproducibility and accuracy of all the test results described in table VI vary widely and are functions of sampling procedures, the test methodology itself, and the ability and attitude of the technician performing the test.

A limited amount of verification methodology evaluation was performed by Hayes International under contract from Marshall Space Flight Center (ref. 27). This evaluation showed that evaporation of the solvent for nonvolatile residue content was erratic because of the effects of partial vapor pressures of the organic constituents, whereas infrared differential absorption spectroscopy yielded reproducible and accurate data. The evaluation also showed that the basic theoretical parameters required to provide for accurate and reproducible verifications have not been adequately defined.

The summary of a paper by J. P. McDonald of Martin Marietta Corporation (ref. 28) very aptly describes the current state-of-the-art:

> ... It is not a well understood fact (outside of contamination control circles) that the sole quantitative content of all vehicle fluid system cleanliness criteria specifications for components lies in the content of the final rinse, the parameters for which have never been quantitatively defined. All effort expended on this activity in the vehicle aerospace field has relied on criteria that have not been dimensionally defined by determinative parameters, at least with regard to force of impingement, velocity (or "volume" of flow), orientation of surface being sampled, accessory sampling energy (e.g., insonation), or other characteristics that vitally affect the validity of results. The effort has depended almost totally on operator interpretation.

CONCLUDING REMARKS

The review of the cleanliness requirements, cleaning procedures, and verification techniques indicates the following:

1. Existing cleaning requirements generally allow the quantity of particulate contaminants to increase with a corresponding decrease in size of the particle whether metallic or nonmetallic.

2. Cleanliness requirements for manned space flight are the most stringent as regards allowable maximum particle size and quantity of particles, while general industrial requirements are the least demanding.

3. The quantitative justification for most of the requirements was not presented in the documents reviewed. Whether such justification exists or testing is required to es-

tablish the requirements cannot be stated from this review.

4. Large areas of uncertainty or areas subject to interpretation exist in some of the cleanliness requirements reviewed. For example, at a given particle size the permissible quantity is not specified in some cases.

5. The various cleaning procedures are all based on five steps: degrease, clean, rinse, inspect, and dry. The sequence and repetition of these steps in a given cleaning procedure depends on the stringency of the cleaning requirements.

6. The tests used to verify a required level of cleanliness are, in general, unsupported by adequate quantitative test data and are subject to the introduction of errors by the test technician.

7. Although very difficult to achieve, the proper balance between cleaning requirements, procedures, and verification techniques is quite necessary. Without it one may expend an unwarranted amount of time and effort unnecessarily recleaning an item or may damage the system by introducing an inadequately cleaned item.

8. Consideration should be given to establishing joint National Aeronautics and Space Administration - Department of Defense - American Medical Association - Environmental Protection Agency - industry effort to develop a series of uniform procedures. These should be based on actual test and experimental data and would establish the level of cleanliness required, methods of accomplishment, and verification as a function of the final application.

APPENDIX - CLEANING PROCEDURE SUMMARIES

Summaries of the cleaning procedures reviewed in this report (refs. 2 to 22 and 25) are contained in this appendix. These summaries are grouped according to the application of the cleaning procedures. The order of the grouping is as follows:

A. Components
   1. Breathing oxygen components - metallic
   2. Breathing oxygen components - nonmetallic
   3. Components with dissimilar elements
   4. Nonmetallic components containing nonmetallic parts
   5. Metal filter elements
   6. Transducers, pressure gages, dead-end cavity items

B. Materials
   1. Aluminum
   2. Brass, bronze, copper
   3. Carbon steel and carbon steel alloys

C. Tanks
   1. Aluminum and aluminum alloy tanks
   2. Cryogenic tanks

D. Tubing
   1. Aluminum alloy tubing
   2. Nonferrous pipe assemblies, tubing
   3. Steel pipe, pipe assemblies, tubing

A. Components

1. Breathing oxygen components - metallic
2. Breathing oxygen components - nonmetallic
3. Components with dissimilar elements
4. Nonmetallic parts and components containing nonmetallic parts
5. Metal filter elements
6. Transducers, pressure gages, dead-end cavity items

CLEANING METHODS AND PROCESSES, NASA FRC PROCESS SPECIFICATION 20-1, NOVEMBER 1, 1970 (REF. 22)

Specific Cleaning Processes for Breathing Oxygen Components - Metallic

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
1	Preclean				By hand wiping, brushing, and scraping.	6.3.1.1 (5.1.1)
2	Clean	Trichloroethylene	5		Ultrasonic or vapor degrease or flush with 5μ filtered solvent at circulation rate of 20 component volumes per minute. When flush procedure is used, heated solvent of 120^{o} - 140^{o} F is desired, but in no case shall temperature be less than 60^{o} F.	6.3.1.1 (5.1.2)
3	Rinse	Trichloroethylene			Solvent shall be fresh filtered (5μ nominal). Step omitted if flush procedure used in step 2.	6.3.1.1 (5.1.3)
4	Dry	Dry nitrogen and/or heating to		180 (max)	Nitrogen filtered to 5μ nominal.	6.3.1.1 (5.1.4)
5	Flush	Ethyl alcohol			Filtered 5μ nominal.	6.3.1.2
6	Rinse	Demineralized or distilled water				6.3.1.3
7	Dry	Dry nitrogen or by heating to		180 (max)		6.3.1.4
8	Check	Halogen detector			Sniff check or equivalent to ensure that all traces of trichloroethylene or other halogen vapors are removed.	6.3.1.5

CLEANING METHODS AND PROCESSES, NASA FRC PROCESS SPECIFICATION 20-1, NOVEMBER 1, 1970 (REF. 22)

Basic Cleaning Process for Metallic Articles

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
1	Preclean				By wiping, brushing, and scraping.	5. 1. 1
2	Clean	Trichloroethylene	5		Ultrasonic or vapor degrease or flush with 5μ filtered trichloroethylene at circulation rate of 20 component volumes per minute. When flush procedure is used heated trichloroethylene of 120^{o} - 140^{o} F is desired, but in no case shall temperature be less than 60^{o} F.	5. 1. 2
3	Rinse	Trichloroethylene			Solvent shall be fresh, filtered (5μ nominal). Step omitted if flush procedure used in step 2.	5. 1. 3
4	Dry	Dry nitrogen and/or heat to		180 (max)	Nitrogen filtered to 5μ nominal.	

CLEANING METHODS AND PROCESSES, NASA FRC PROCESS SPECIFICATION 20-1, NOVEMBER 1, 1970 (REF. 22)

Specific Cleaning Processes for Breathing Oxygen Components - Nonmetallic

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
1	Preclean	Paper			Hand wipe clean of any visible grease, oil, or contaminants.	6.3.2 (5.2.1)
2	Clean	1% nonionic detergent and water solution		140 (max)	Either scrub with nonmetallic brush, flush with detergent solution at flow rate of 20 component volumes per minute for 3 minutes, or ultrasonic clean in detergent solution.	6.3.2 (5.2.2)
3	Dry	Dry, oil-free nitrogen gas or air				6.3.2 (5.2.3)
4	Rinse	Demineralized or distilled water		140 (max)		6.3.2 (5.2.4)
5	Dry	(a) Dry, oil-free nitrogen gas			Filtered through 5μ filter.	6.3.2 (5.2.5)
		(b) Heat in oven		120 - 140	Nonmetallic gaskets or parts, such as O-rings, shall not be subjected to temperature above 140^{o} F.	
		(c) Vacuum				
6	Check	Halogen detector			Sniff check of equivalent to ensure that all traces of trichloroethylene or other halogen vapors are removed.	6.3.2

CLEANING METHODS AND PROCESSES, NASA FRC PROCESS SPECIFICATION 20-1, NOVEMBER 1, 1970 (REF. 22)

Basic Cleaning Process for Nonmetallic Articles

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
1	Preclean	Paper			Hand wipe clean of any visible grease, oil, or contaminants.	5.2.1
2	Clean	1% nonionic detergent and water solution		140 (max)	Either scrub with nonmetallic brush, flush with detergent solution at flow rate of 20 component volumes per minute for 3 minutes, or ultrasonic clean in detergent solution.	5.2.2
3	Dry	Dry, oil-free nitrogen gas or air				5.2.3
4	Rinse	Demineralized or distilled water		140 (max)		5.2.4
5	Dry	(a) Dry, oil-free nitrogen gas			Filtered through 5μ filter.	5.2.5
		(b) Heat in oven		120 - 140	Nonmetallic gaskets or parts, such as O-rings, shall not be subjected to temperatures above 140^{o} F.	

KSC (PROPOSED)
NONMETALLIC MATERIALS (REF. 11)

[Ref. par. 3.10.2.1.2 and others as noted. Removable nonmetallic parts may be cleaned as separate items. When nonmetallic parts cannot be removed it shall be cause to clean the item as a nonmetallic.]

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
1	Clean	0.5% solution of detergent per MIL; D-16791 and deionized water	5 - 15	110 - 130	Clean by flushing, soaking, spraying, or sonic energy.	3.9.3.3
2	Rinse	Water	5	90 - 110		
3	Rinse	Deionized water	5		If ultrasonic cleaning used, rinse for additional 10 minutes in ultrasonic cleaner.	
4	Inspect	Narrow range pH paper			pH must be between 6 and 8, otherwise repeat steps 1 - 3.	4.3
5	Dry	Gaseous nitrogen or vacuum drying oven		100 - 120	Type I, class 1, grade B of spec. BB-N-411.	3.10.2.4
6	Clean	Trichlorotrifluoroethane or isopropyl alcohol	1		Use only compatible solvent-material combinations.	
7	Inspect				Particle count of fluid from step 6, in accordance with 4.3.	
8	Dry	Gaseous nitrogen or vacuum oven		100 - 120	Remove all traces of solvent (see spec. BB-N-411).	

SYSTEMS AND EQUIPMENT CLEANING, CPIA PUBLICATION 194
ROCKET PROPELLANTS(B) OXYGEN (REF. 21)

Plastic Parts

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
1	Disassemble				To separate aluminum steel and plastic parts.	10. a. 1
2	Clean	4% detergent solution	30	120		10. b. 1
3	Rinse	Distilled water			Several times.	10. b. 2
4	Dry	Nitrogen gas				10. b. 3

CLEANING AND INSPECTION PROCEDURES FOR BALLISTIC MISSILE SYSTEMS T. O. 42C-1-11 CHANGE 2, NOVEMBER 15, 1967 (REF. 12)

Electroplated Parts and Components Containing Dissimilar Metals

Step	Process	Agent	Time, min	Temperature, °F	Remarks	Reference paragraph
1	Degrease	Trichloroethylene or trichlorotrifluoroethane	As required	Ambient		3-15 3-75
2	Vapor degrease	Trichloroethylene or trichlorotrifluoroethane		Boiling	Immerse parts in vapor until condensation ceases. Flush with freshly condensed degreaser solvent.	3-15 3-64
3	Alkaline clean	Alkaline cleaner: 5 - 10 oz/gal tap water	15 - 25	150 - 175	Parts shall be completely free of step 2 solution because of explosion hazard.	3-77
4	Rinse	Tap water	5 - 10	150		3-84
5	Rinse	Demineralized water	5 - 10	150		3-84
6	Dry	Oven, nitrogen gas, or vacuum		180 - 200 140		3-87
7	Rinse	Detergent solution: 1/2 - 1 oz/gal tap water, demineralized water, or trichloroethylene	15 - 25 As required	120 - 140	MIL-D-16791 type I.	3-86 3-85
8	Flush	Demineralized water	As required	150	Do not flush of solvent used in step 7.	
9	Inspect					
10	Dry	Oven, nitrogen gas, or vacuum		180 - 200 140		3-87

CLEANING AND INSPECTION PROCEDURES FOR BALLISTIC MISSILE SYSTEMS T. O. 42C-1-11 CHANGE 2, NOVEMBER 15, 1967 (REF. 12)

Nonmetallic Parts and Components Containing Nonmetallic Parts

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
1	Detergent clean	Detergent solution: 1/2 - 1 oz/gal of tap or demineralized water	5 - 10	120 - 140	MIL-D-16791 type I.	3-86
2	Rinse	Tap water	5 - 10	150		3-84
3	Rinse	Demineralized water	5 - 10	150		3-84
4	Dry	Oven, nitrogen gas, or vacuum		180 - 200 140		3-87
5	Detergent rinse	Detergent solution: 1/2 - 1 oz/gal of tap or demineralized water	15 - 20	120 - 140		3-86
6	Inspect					3-89
7	Dry	Oven, nitrogen gas, or vacuum		180 - 200 140		3-86

CLEANING AND INSPECTION PROCEDURES FOR BALLISTIC MISSILE SYSTEMS T. O. 42C-1-11 CHANGE 2, NOVEMBER 15, 1967 (REF. 12)

Metal Filter Elements

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
1	Vapor degrease	Trichloroethylene or trichlorotrifluoroethane	As required	Boiling	MIL-T-27602 (FSN 6850-681-5688).	3-64
2	Dry	Oven, nitrogen gas, or vacuum		180 - 200 140		3-87
3	Ultrasonic clean	Trichloroethylene or trichlorotrifluoroethane	3 - 5	10^{o} below boiling point		3-15 3-79
4	Rinse	Trichloroethylene	5 - 7	Ambient	Solvent filtered through 10μ filter.	3-85
5	Inspect					
6	Dry	Oven, nitrogen gas, or vacuum		180 - 200 140		3-87

CLEANING, TESTING, AND HANDLING OF OXYGEN, FUEL, AND PNEUMATIC COMPONENTS
D5-12855, BOEING CO., MAY 15, 1968 (REF. 9)

Dead-End Components (Pressure Gages, Transducers, etc.)

[Ref. par. 3.0 and others as noted. Components not to be immersed in cleaning media, and, also, components not to be exposed to acid (ref. par. 3.1).]

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
1	Inspection	Prior to precleaning			Inspect exterior and visible interior.	5.2
2	Precleaning	Trichloroethylene precision cleaning agent, Dowclene WR			Alternating vacuum solvent flush (28 in. of Hg min. vacuum). Fill and drain component a minimum of 20 times. Fresh solvent for each fill. Two other methods are also stated.	6.2.2
3	Final cleaning	Trichloroethylene precision cleaning agent, Dowclene WR, use minimum quantity of solvent per 7.3.1			Rinse significant surfaces using one of the methods in 3.2. Must be in controlled environment per 6.3.2.	3.3
4	Drying	Nitrogen gas per BB-N-411; air or other gas to be specifically approved by engineering		130 - 250	Temperature dependent on parts (see 6.2.6). Vacuum oven drying is preferred.	3.3 6.2.7

CLEANING AND INSPECTION PROCEDURES FOR BALLISTIC MISSILE SYSTEMS T. O. 42C-1-11 CHANGE 2, NOVEMBER 15, 1967 (REF. 12)

Transducers, Pressure Gages, and Other Dead-End Cavity Parts

Step	Process	Agent	Time, min	Temperature, °F	Remarks	Reference paragraph
1	Fill	Trichloroethylene			3/4 full and rotate component gently to circulate fluid. Repeat fill and rotate procedure two times.	3-15
2	Rinse	Petroleum ether				
3	Inspect					3-89
4	Dry	Oven, nitrogen gas, or vacuum		180 - 200 140		3-87

CLEANING OF OXYGEN PRESSURE GAGE COMPONENTS, NAVAL BOILER, AND TURBINE LABORATORY, MARCH 26, 1965 (REF. 18)

Step	Process	Agent	Time, min	Temperature, °F	Remarks	Reference paragraph
1	Disassemble				Disconnect from piping system, remove back of gage, elongate coil of capillary tubing, and open capillary tubing filing off tip.	1-6
2	Clean	Freon PCA			Forced by air pressure (5 psig) flow 150 ml of Freon PCA at approximately 50 ml/min. Repeat with two additional 124 ml portions and reverse flush with 100 ml of solvent.	7-10
3	Rinse	Freon PCA			Introduce 50 ml of solvent through connection end of gage, collect effluent in white porcelain dish, and evaporate to dryness.	11
4	Inspect	Ultraviolet light (3600 - 3900 Å)			White dish from step 3 checked for fluorescence. If fluorescence observed, continue flushing.	11-12
5	Assemble					13-15

CLEANING AND TESTING OF OXYGEN AND NITROGEN GAS PIPING SYSTEMS
MIL-STD-1330 (SHIPS), MAY 10, 1968 (REF. 20)

Bourdon C Tube Pressure Gages

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
1	Disassemble					4.5.1.1
2	Clean	Trichlorotrifluoroethane			MIL-C-81302 type I ultra-clean at flow rate of 50 mil/min.	4.5.1.8
3	Check	Ultraviolet light (3600 - 3900 Å)			Continue flushing if fluorescence is evident.	4.5.1.10
4	Dry	Dry, oil-free nitrogen				4.5.1.11

CLEANING METHODS AND PROCESSES, NASA FRC PROCESS
SPECIFICATION 20-1, NOVEMBER 1, 1970 (REF. 22)

Specific Cleaning Process for Pressure Transducers and Bourdon Tubes

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
1	Preclean	Trichloroethylene			Hot solvent.	6.5.1.1
2	Clean	Trichloroethylene	1	180±5	Soak in hot solvent.	6.5.1.2
			1	Ambient	Place in ambient solvent. Repeat cycle 10 times. Ambient solvent not to exceed 85^{o} F.	6.5.1.3
3	Dry	Oven	150	250±10	For Bourdon tubes.	6.5.1.4
			150	180±10	For pressure transducers.	

B. Material

1. Aluminum
2. Brass, bronze, copper
3. Carbon steel and carbon steel alloys

CLEANING AND INSPECTION PROCEDURES FOR BALLISTIC MISSILE SYSTEMS T. O. 42C-1-11 CHANGE 2, NOVEMBER 15, 1967 (REF. 12)

Aluminum

Step	Process	Agent	Time, min	Temperature, °F	Remarks	Reference paragraph
1	Mechanical descaling		As required			3-39
2	Degrease	Trichloroethylene	As required	Ambient	MIL-T-27602.	3-15 3-75
3	Vapor degrease	Trichloroethylene or trichlorotrifluoroethane			MIL-T-27602 (FSN 6850-681-5688).	
4	Alkaline clean	Sodium carbonate (3 oz/gal), trisodium phosphate (3 oz/gal), remainder tap water	1 - 3	140 - 180		
5	Rinse	Tap water		150		
6	Pickle	HNO_3 (12% by volume), HF (1% by volume), remainder tap water		Ambient		
7	Rinse	Demineralized water		150		
8	Dry	Oven heated nitrogen or vacuum		180 - 200 140	MIL-P-27401; filtered through 10μ filter.	
9	Rinse	Detergent solution: 1/2 - 1 oz of sol/gal tap or demineralized water or trichloroethylene	15 - 25	120 - 140	MIL-D-16791 type I. MIL-T-27602.	
10	Flush	Demineralized water	As required	150	Do not flush if solvent used in step 9.	
11	Inspect					
12	Dry	See step 8				

CLEANING PROCEDURES - METALS CLEANING SPI-49.111
LINDE COMPANY, DIV. OF UNION CARBIDE, DECEMBER 28, 1965 (REF. 8)

Aluminum

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
1	Preclean	Diversey 1319 (1) 3 oz/gal		Ambient	(1) Code 3008-2825: step 1, preclean with solution gun only if aluminum is contaminated with oil or other heavy soil.	.02.1
2	Rinse	Cold water (2) or hot water (2)			(2) Water shall be potable. (3) Code 3008-3000.	.02.2
3	Clean/etch	Aluminux: Diversey aluminum (6 oz/gal) Diversey 202(4) (2 oz/gal of water)	(5) 1 - 2	160	(4) Code 3008-2775. (5) For light gage material; heavy gage material not to be soaked longer than necessary.	.02.3
4	Rinse	Hot water				.02.4
5	Deoxidize or desmut	Diversey 596(6) (7 oz/gal water), H_2SO_4 (7% by volume), remainder water			(6) Code 3002-1300.	.02.5
6	Rinse	Hot water				.02.6
7	Dry	Air (7)			(7) Clean, dry, oil free.	

SYSTEMS AND EQUIPMENT CLEANING, CPIA PUBLICATION 194
ROCKET PROPELLANTS(B) OXYGEN (REF. 21)

Aluminum, Aluminum Alloys

Step	Process	Agent	Time, min	Temperature, °F	Remarks	Reference paragraph
1	Disassembly				To separate aluminum plastic and steel parts.	10. a. 1
2	Degrease	Perchloroethylene	30			10. a. 2
3	Rinse	Alcohol				10. a. 2
4	Rinse	Water				10. a. 2
5	Clean	4% solution of aluminum cleaner	30			10. a. 3
6	Rinse	Water				10. a. 3
7	Final clean	Steam				10. a. 5a
8	Dry	Nitrogen				10. a. 5b

ALUMINUM CLEANED BY SOLUTION SPRAYING
KSC (PROPOSED) (REF. 11)

[Ref. Par. 3.10.3.5 and others as noted.]

Step	Process	Agent	Time, min	Temperature, °F	Remarks	Reference paragraph
1	Precleaning	Trichloroethylene type II, trichlorotrifluoroethane, or 0.5% solution of a detergent in deionized water	5 - *15	110 - *130	Conform to MSFC-SPEC-217. Conform to MSFC-SPEC-237. *For detergent solution only.	3.10.3.5.1a (3.9.3 & 3.10.3.1)
2	Clean	Formula IV: % by wt — Material 9±0.4 — 2-butoxyethanol solvent 1.5±0.1 — Na_2HPO_4 0.5±0.05 — Surfactant (alkyl aryl polyethylene glycol ether) Remainder deionized water	60 - 120	80 - 95	Spray minimum flow of 6 gal/min/ft at item; maximum i.d. at a spray head delivery; P = 150 - 200 psig.	3.10.3.5.1b (3.10.3.3.3)
3	Rinse	Deionized water	30	Ambient	Delivery rate same as step 2. Continue rinse until evidence of surfactant disappears.	
4	Brighten	Formula V: % by vol — Material 23±0.5 — 61% HNO_3 Remainder deionized water	20 - 40	Ambient	Spray delivery rate same as step 2.	3.10.3.5.1c (3.10.3.3)
5	Rinse	Steps 1 and 3			Steps 4 and 5 to be accomplished if smut has developed on the part during steps 1 - 3.	3.10.5.1d

Continued. ALUMINUM CLEANED BY SOLUTION SPRAYING
KSC (PROPOSED) (REF. 11)

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
6	Final rinse	Deionized water			(1) For rotating head spray machine - (a) Lower spray head to lowest point of item cleaned. (b) Spray at rate 2.2 gal/min/ft. (c) Delivery P = 150 - 200 psig. (d) Rinse spray head vertically at rate of 1 ft/min. (e) Take test samples from lowest point. (f) 2500 ml sample to be obtained in 58 - 62 sec. (g) Steps (a) - (e) must be correlated so that 2500 ml test sample will represent 1 ft^2 of critical surface area. (h) Collect first 2500 mil sample at start of spray; second when spray head traversed 50% of vertical distance; collect third sample as spray head approaches highest point. (2) For rotating spray wand - same as step 6 except 2500 ml samples will be taken at first, third, and fifth minutes of spray.	3.10.3.5.1d

Concluded. ALUMINUM CLEANED BY SOLUTION SPRAYING
KSC (PROPOSED) (REF. 11)

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
7	pH test	Narrow range pH paper			All samples analyzed to to 4.3. pH sensitive to 0.1 pH unit. pH range, 6.0 - 8.0. If nonconformance flush 15 minutes and test, on second failure reclean steps 1 - 6.	3.10.3.5.1e (3.10.3.3i)
8	Dry	Gaseous nitrogen			To a dew point of -65^{o} F at all critical parts per 4.3. Final 5 minutes gaseous nitrogen at system operating pressure; if unattainable, purge velocity at farthest downstream exit port, shall be 35 SCFM.	(3.10.3.3j) (3.10.3.3k)
9	Repeat rinse	Trichloroethylene; trichlorotrifluoroethane	15		Flow rate of 6 gal/min/ft. Spray head pressure 80 - 100 psig.	
10	Drain					
11	Repeat rinse	Step 6 (1) or 6 (2)			Delivery pressure, 20 - 100 psig. Test solvent - if unacceptable, repeat steps 1 - 11.	
12	Test					
13	Dry	Same as step 8				

KSC (PROPOSED) (REF. 11)

Aluminum

[Ref. par. 3.10.2.3 and others as noted.]

Step	Process	Agent	Time, min	Temperature, °F	Remarks	Reference paragraph
1	Mechanical descale	Brushing, shot peening, etc.			As required.	3.9.2
2	Degrease	Trichloroethylene or trichlorotrifluoroethane			Solvent or vapor MSFC-SPEC-217 or MSFC-SPEC-237.	3.9.3.1
3	Dry	Gaseous nitrogen			Type I, class 1, grade B of spec. BB-N-411.	3.10.2.4
4	Remove corrosion	23±5% by volume of 61% nitric acid, remainder is deionized water	10 - 60	Ambient	Formula V.	3.10
5	Rinse	Water	5	90 - 110		
6	Rinse	Deionized water	3			
7	Dry	Gaseous nitrogen		120 - 140		
[a]8	Clean	By weight: 9% 2-Butoxyethanol solvent 1.5% Sodium phosphate, dibasic, anhydrous 0.5% Surfactant Remainder is deionized water	30 - 120	80 - 95	Flush, soak, brush, or sonic clean.	3.10
9	Rinse	Water	5	90 - 110		
10	Rinse	Deionized water	3		If ultrasonic cleaning used, rinse additional 10 minutes in ultrasonic cleaner.	
11	Brighten and passivate	Same as step 4	10 - 30	Ambient	Step 8, cleaning is usually adequate.	
12	Rinse	Water	5	90 - 110	Only if step 11 used.	

[a]All fluids used in steps 8 to 18 shall be prefiltered prior to use to meet the cleanliness level specified for the item when tested according to 4.5.2.

Concluded. KSC (PROPOSED) (REF. 11)

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
13	Rinse	Deionized water	5		Only if step 11 used.	
14	pH test	Narrow range pH paper			Repeat steps 2 - 13 if pH not between 6.0 and 8.0.	
15	Dry	Gaseous nitrogen		120 - 140	Vacuum drying oven also acceptable.	
16	Flush	Trichlorotrifluoroethane	1		MSFC-SPEC-237.	
17	Inspect				By analysis of fluid from 16.	
18	Dry	Gaseous nitrogen		120 - 140	Vacuum drying oven also acceptable.	

CLEANING, TESTING, AND HANDLING OF OXYGEN, FUEL, AND PNEUMATIC COMPONENTS
DS-12855, BOEING CO., MAY 15, 1968 (REF. 9)

Coated Aluminum

[Not to be subjected to temperatures exceeding 130° F.]

Step	Process	Agent	Time, min	Temperature, °F	Remarks	Reference paragraph
1	Rough cleaning				Clean per BAC5765.	7.5.2a
2	Solvent flush	Trichloroethylene, precision cleaning agent, or Dowclene WR				6.2.2
3	Ultrasonic detergent	Detergent-water solution (1)	5	130 (max) (2)	(1) Water distilled or deionized having minimum specific resistance of 50 000 Ω. Detergents conform to MIL-D-16791 type I. Detergent concentration, 0.1 - 0.6 oz/gal of water. (2) Solution may be heated to 130° F (max), provided it is followed by a heated (max, 130° F) water rinse.	6.2.4
4	Ultrasonic water rinse	Distilled or deionized water (3)	5		(3) Must have minimum specific resistance of 50 000 Ω and pH 6.0 - 8.0.	6.2.5
5	Dry	Nitrogen gas, air, or other gas specifically approved by engineering			(4) Gas shall meet requirements of 6.2.1.1: shall not contain considerable hydrocarbons in excess of 3 ppm by weight, shall not exceed 60% relative humidity at ambient temperature. (5) Drying gas may be heated providing parts do not exceed 130° F for MIL-C-5541 coated parts.	6.2.6 or 6.2.7

Concluded. CLEANING, TESTING, AND HANDLING OF OXYGEN, FUEL, PNEUMATIC COMPONENTS DS-12855, BOEING CO., MAY 15, 1968 (REF. 9)

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
6	Visual acceptance inspection					4.9
7	Final flush	Step 2	3			6.2.2
8	Dry	Step 5				6.2.6 or 6.2.7

CLEANING AND INSPECTION PROCEDURES FOR BALLISTIC MISSILE SYSTEMS T. O. 42C-1-11 CHANGE 2, NOVEMBER 15, 1967 (REF. 12)

Brass, Copper, and Bronze

Step	Process	Agent	Time, min	Temperature, °F	Remarks	Reference paragraph
1	Mechanical descaling		As required			3-39
2	Degrease	Trichloroethylene	As required	Ambient	MIL-T-27602.	3-15 3-75
3	Vapor degrease	Trichloroethylene or trichlorotrifluoroethane			MIL-T-27602 (FSN 6850-681-5688).	3-15 3-16 3-64
4	Alkaline clean	Alkaline cleaner: 5 - 10 oz/gal tap water		150 - 175	Fed. spec. P-C-436.	3-59
5	Rinse	Tap water	5 - 10	150		
6	Pickle	H_2SO_4, 8.6% by volume; HNO_3, 1.4% by volume; demineralized water, 90% by volume; or HF, 10 - 15% by volume; demineralized water for remainder		120 - 130	Solution temperature and immersion time to be determined from test coupons.	3.61
7	Rinse	Demineralized water	5 - 10	150		
8	Dry	Oven, nitrogen gas, or vacuum		180 - 200 140		3-87
9	Rinse	Detergent solution: 1/2 - 1 oz/gal of tap water, demineralized water, or trichloroethylene	15 - 25	120 - 140	MIL-D-16791 type I.	3-86 3-85
10	Flush	Demineralized water	As required	150	Do not flush if solvent used in step 9.	
11	Inspect					3-89
12	Dry	Same as step 8				3-87

KSC (PROPOSED) (REF. 11)

Copper and Copper Alloys (3. 10. 2. 4)

Step	Process	Agent	Time, min	Temperature, °F	Remarks	Reference paragraph
1	Mechanical descale	Brushing, shot peening, etc.			As required.	3. 9. 2
2	Degrease	Trichloroethylene or trichlorotrifluoroethane			MSFC-SPEC-217. MSFC-SPEC-237.	3. 9. 3. 1
3	Dry	Gaseous nitrogen			Type I, class 1, grade B of spec. BB-N-411.	3. 10. 2. 4
4	Corrosion removal	6. 5 - 93% Sulfuric acid 17 - 61% Nitric acid Remainder is deionized water	10 - 30	Ambient	For heavy corrosion.	3. 10. 1. 7
5	Rinse	Water	5	90 - 110		
6	Rinse	Deionized water	3		One if step 4 is used.	
7	Dry	Gaseous nitrogen		120 - 140		
8	Clean	30 - 85% Orthophosphoric acid 20 - 2% 2-Butoxyethanol solvent 1% Surfactant Remainder is deionized water	60 - 90	80 - 105	Will remove light corrosion and oxidation so that step 4 may not be required.	3. 10. 2. 4
9	Rinse	Water	5	90 - 110		
10	Rinse	Deionized water	3		If ultrasonic cleaner used, rinse additional 10 minutes in ultrasonic cleaner.	3. 10. 2. 4
11	Brighten	Same as 4	10 - 30	Ambient	For cupro-nickel alloys and silicon bronzes	3. 10. 2. 4
12	Rinse	Water	5	90 - 110	Only if step 11 is used.	3. 10. 2. 4
13	Rinse	Deionized water	5			
14	pH test	pH paper (narrow range)			Repeat steps 2 - 13 if pH not between 6. 0 and 8. 0.	3. 10. 2. 4

Concluded. KSC (PROPOSED) (REF. 11)

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
15	Dry	Gaseous nitrogen or vacuum drying oven		120 - 140		3.5.7.2
16	Flush	Trichlorofluoroethane	1		MSFC-SPEC-237.	3.10.2.4
17	Inspect				By analysis of fluid from 16 in accordance with 4.3.	
18	Dry	Gaseous nitrogen (same as step 15)				

CLEANING AND INSPECTION PROCEDURES FOR BALLISTIC MISSILE SYSTEMS T. O. 42C-1-11 CHANGE 2, NOVEMBER 15, 1967 (REF. 12)

Carbon Steel and Carbon Steel Alloys

Step	Process	Agent	Time, min	Temperature, °F	Remarks	Reference paragraph
1	Mechanical degrease		As required			3-39
2	Degrease	Trichloroethylene			MIL-T-27602.	3-15 3-75
3	Vapor degrease	Trichloroethylene or trichlorotrifluoroethane	As required	Degreaser operating temperature	MIL-T-27602 (FSN 6850-681-5688).	3-15
4	Alkaline clean	Alkaline cleaner 5 - 10 oz/gal of tap or demineralized water	15 - 20	150	Fed. spec. P-C-436. Parts shall be completely free of step 3 solvents because of possible explosion hazard.	3-77
5	Rinse	Tap water	5 - 10	150		3-84
6	Pickle	HF, 15 - 20% by volume; Rodine 50 or equivalent inhibitor, 0.25 - 0.50% by volume; tap water, balance.	15 - 30	Ambient		3-51
7	Rinse	Tap water	5 - 7	150	Omit if step 6 omitted.	3-84
8	Rinse	Demineralized water	3 - 5	150		3-84
9	Bake		180	375±25	Required only for steels harder than Rockwell C32 to prevent hydrogen embrittlement.	
10	Protective coat	Corrosion preventative	As required	Ambient		3-55
11	Dry	Oven, nitrogen gas, or vacuum	As required	180 - 200 140		3-87
12	Rinse	Detergent solution, 1/2 - 1 oz/gal tap water, demineralized water, or trichloroethylene	15 - 25	120 - 140	MIL-D-16791 type I.	3-86

Concluded. CLEANING AND INSPECTION PROCEDURES FOR BALLISTIC MISSILE SYSTEMS T. O. 42C-1-11 CHANGE 2, NOVEMBER 15, 1967 (REF. 12)

Step	Process	Agent	Time, min	Temperature, °F	Remarks	Reference paragraph
13	Flush	Demineralized water	As required	150	Do not flush if solvent used in step 12.	
14	Inspect					
15	Dry	Same as step 10.				3-87

PLUM BROOK RDL-003 (REF. 3)

Carbon/Steel

Step	Process	Agent	Time, min	Temperature, °F	Remarks	Reference paragraph
1	Degrease	Trichloroethylene (Fed. spec. O-T-634b)			As required.	3.1.1
		or detergent-water solution		140 - 160	As required.	
2	Rinse	Distilled or deionized water			Until detergent is no longer evident.	3.1.2
3	Clean	20% by volume of inhibited hydrochloric acid (Fed. spec. O-A-86)			Until area is clean and free of rust and scale.	3.1.3
4	Rinse	0.02% by weight of citric acid solution			Continue rinse until effluent pH = influent pH.	3.1.4
5	Flush	By weight a solution of 0.5% sodium hydroxide, 0.5% sodium nitrate, 0.25% monosodium phosphate with distilled or deionized water.	30			3.1.5
6	Inspect					4.0
7	Dry	Dry, hydrocarbon-free, gaseous nitrogen	2		As required.	3.1.6
8	Package					

C. Tanks

1. Aluminum and aluminum alloy tanks
2. Cryogenic tanks

SYSTEMS AND EQUIPMENT CLEANING, CPIA PUBLICATION 194
ROCKET PROPELLANTS(B) OXYGEN (REF. 21)

Aluminum and Aluminum Alloy Tanks

Step	Process	Agent	Time, min	Temperature, °F	Remarks	Reference paragraph
1	Preclean				Remove burns, grease, dirt, scale.	10.d.1
2	Degrease	Solvent	30			10.d.2
3	Rinse	Alcohol				10.d.3
4	Wash	Water				10.d.4
5	Clean	4% aluminum cleaning solution	20	Room		10.d.5
6	Wash	Water or steam clean				10.d.7
7	Dry	Dry nitrogen				10.d.7

CLEANING PROCEDURES - METALS CLEANING SPI-49.111
LINDE COMPANY, DIV. OF UNION CARBIDE, DECEMBER 28, 1965 (REF. 8)

Aluminum Shells

Step	Process	Agent	Time, min	Temperature, °F	Remarks	Reference paragraph
1	Etch	Diversey aluminux, (1) 6 oz/1 gal water; Diversey 202 (2) 2 oz/gal water		160	Swab with solution: (1) Code 3008-3000 (2) Code 3008-2775	.08.1
2	Rinse	Cold water (3)			(3) Water shall be potable.	.08.2
3	Deoxidize/ desmut	Diversey 596, 7 oz/gal water; H_2SO_4 7% by volume; remainder water		Ambient	Swab with solution inside and outside of the shell.	.08.3
4	Rinse	Cold water				.08.4

CLEANING OF CRYOGENIC TANKS FOR LO_2, LN_2, AND LH_2 SERVICE, AIR FORCE ROCKET PROPULSION LABORATORY TECHNICAL INSTRUCTION, AFRPL TI 5-4-3, NOVEMBER 1967 (REF. 25)

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
1	Clean	Solvent			Hot vapors of unspecified solvent until inlet and outlet temperatures are within 5^{o} F.	6. c. 1
2	Dry	Nitrogen gas			Purge with warm gas filtered through 10 μ filter until escaping gas smells sweet (no evidence of characteristic solvent fumes) and registers a dew point of -63^{o} F or less.	6. c. 2

CLEANING OF CRYOGENIC TANKS FOR LO_2, LN_2, and LH_2 SERVICE, AIR FORCE ROCKET PROPULSION LABORATORY TECHNICAL INSTRUCTION, AFRPL TI 5-4-3, NOVEMBER 1967 (REF. 25)

Detergent or Alkaline Solution Cleaning

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
1	Preclean	Vacuum			NO SWEEPING, dust cannot be removed from the vessel.	6.a.1
2	Clean[a]	Hot solution	30	175 - 180	Unspecified.	6.b.1
3	Rinse	Demineralized water		Ambient	Filtered through 10μ filter. (a) For alkaline solutions, use pH meter or transmitted light examination to determine when the alkalinity of outlet equals inlet. (b) For neutral solutions, flow a volume at least 6 times the capacity of the vessel.	6.b.5
4	Dry	Warm dry nitrogen gas			Purge until escaping gas registers a dew point of -63^{o} F or less.	6.b.6

[a]Do not clean aluminum alloy vessels with caustic or alkaline solutions unless specifically approved.

CLEANING OF CRYOGENIC TANKS FOR LO_2, LN_2, AND LH_2 SERVICE, AIR FORCE ROCKET PROPULSION LABORATORY TECHNICAL INSTRUCTION, AFRPL TI 5-4-3, NOVEMBER 1967 (REF. 25)

Manual Cleaning

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
1	Preclean	Vacuum			NO SWEEPING, dust cannot be removed from the vessel.	6. a. 1
2	Clean	Unspecified solvent			Solvent if not certified must pass through 10μ filter; in all cases surfaces shall be thoroughly wiped or scrubbed with rags or brushes.	6. a. 3
3	Rinse	Potable or demineralized water				6. a. 3
4	Pressure check	Dry nitrogen			Pressurize to operating pressure; hold 24 hours within 3 psig corrected for temperature. Closure shall not leak.	6. a. 7
5	Purge	Gaseous nitrogen			Repeatedly pressurize and dump until effluent gas smells sweet (no evidence of characteristic odors of cleaning solution used and dew point = -63^{o} F or less).	6. a. 8. a

D. Tubing

1. Aluminum alloy tubing
2. Nonferrous pipe assemblies, tubing
3. Steel pipe, pipe assemblies, tubing

MSFC SPEC-164A (REF. 5)

Aluminum Alloy Tubing

Step	Process	Agent	Time, min	Temperature, °F	Remarks	Reference paragraph
1	Cleaning		10	160±10	Circulation rate at least 20 tubing or hose volumes per min.	3.5.2.6 3.5.1.6
2	Flushing	Tap water	10	Room		
3	Cleaning	3.0 - 5.0% nitric acid	5 (min) 7 (max)	85 - 95	Spec. O-N-350: Phosphoric acid solution 0.5% by wt to remove heavy soils.	3.5.2.6
4	Flushing	Demineralized water	10	Room	No particle over 175 microns, etc.	3.2.10 3.5.1.6 3.5.2.6 4.4.3.1
5	Dry					

CLEANING PROCEDURES - METALS CLEANING SPI-49.111
LINDE COMPANY, DIV. OF UNION CARBIDE, DECEMBER 28, 1965 (REF. 8)

Nonferrous Pipe Assemblies and Parts

Step	Process	Agent	Time, min	Temperature, °F	Remarks	Reference paragraph
1	Preclean	Diversey 1319 (1) 3 oz/gal water		Ambient	(1) Code 3008-2825; step 1 optional.	.03
2	Rinse	Hot water (2)			Remove flux; (2) water shall be potable	.03.1
3	Pickle	$Na_2Cr_2O_7$, 9 oz/gal water; H_2SO_4, 16% by volume water		Ambient	Soak until uniformly pickled.	.03.2
4	Rinse	Cold or hot water				.03.3
5	Clean	Step 1				.03.4
6	Rinse	Step 4				.03.5
7	Dry					

CLEANING PROCEDURES - METALS CLEANING SPI-49.111
LINDE COMPANY, DIV. OF UNION CARBIDE, DECEMBER 28, 1965 (REF. 8)

Nonferrous Pipe and Tubing - Straight Lengths

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
1	Preclean	Diversey 1319: (1) 3 oz/gal water		Ambient	(1) Code 3008-2825.	.04.1
2	Rinse	Cold water (2)			(2) Water shall be potable.	.04.2
3	Pickle	$Na_2Cr_2O_2$, 9 oz/gal water; H_2SO_4, 16% by volume in water		Ambient	Soak until uniformly pickled.	.04.3
4	Rinse	Step 2				.04.4
5	Clean	Step 1				.04.5
6	Dry					.04.6

CLEANING AND TESTING OF OXYGEN AND NITROGEN GAS PIPING SYSTEMS
MIL-STD-1330 (SHIPS) MAY 10, 1968 (REF. 20)

Oxygen System Flush

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
1	Disassemble					5.2.3
2	Flush	Trichlorotrifluoroethane	30		MIL-C-81302 type I, ultraclean. Repeat flushing if more than 5 ppm total contamination is found.	5.2.4.1
3	Drain					5.3.1.4
4	Dry	Dry, oil-free nitrogen, air, or vacuum				5.3.1.4

MSFC-SPEC-164A (REF. 5)

Corrosion-Resistant Steel Tubing

Step	Process	Agent	Time, min	Temperature, °F	Remarks	Reference paragraph
1	Cleaning	Nonetch alkaline: e.g., Turco 4215 - concentration, 10±2 oz/gal	10	160±10	Circulation rate at least 20 tubing or hose volumes of liquid per min.	3.5.1.6
2	Flushing	Tap water	10	Room		3.5.1.6
3	Cleaning	Nitric acid solution, 10±2% by wt	5 (min) 10 (max)	170 - 190	See spec. D-N-250.	3.5.1.6
4	Flushing	Demineralized water	10	Room	No particle over 175 microns; no more than 5 particles from 100 - 175 micron size; specific resistance, 50 000 Ω; pH rating between 6 and 8.	3.2.10
5	Dry					

CLEANING OF PIPING AND EQUIPMENT - SECTION 49
WHITE SANDS (REF. 6)

Piping Steel

Step	Process	Agent	Time, min	Temperature, °F	Remarks	Reference paragraph
1	Mechanical	Grinding, brushing, sandblasting (Al_2O_3 sand), vacuum clean, flushing with clean water.				49-07a
2	Degreasing[a]	Trichloroethylene or mild commercial alkaline cleaner		140 - 160	MIL-T-27602: 5 - 7 oz/gal water solvent reused until contaminant concentration reaches 0.1% by wt.	49-07b
3	Rinsing	Clean water until cleaning solvent not evident			For alkaline cleaner only.	49-07c
4	First inspection	Visual			Presence of rust, scale etc. Proceed to step 5.	49-07d
5	Chemical descaling	Solution of fluorides and HNO_3			Steel surfaces - conditions to be determined by tests on representative specimens.	49-07e
		Method A: 20% NaOH in water		140 - 160	Remove varnish from surfaces. Flush until effluent pH stabilizes between 3.0 to 4.0.	49-074

[a]Valves and accessories are to be disassembled and cleaned in accordance with this specification (49-07i). Parts, such as gaskets and seals, that might be harmed by cleaning chemicals shall be cleaned by dipping in isopropyl alcohol.

Concluded. CLEANING OF PIPING EQUIPMENT - SECTION 49
WHITE SANDS (REF. 6)

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
6	Passivation	(1) 0.0.1% citric acid (2) 0.25 - 0.50% NaOH solution (3) Rinse with demineralized water			Rinse with alkaline.	
		(4) 0.25% monosodium phosphate, 0.25% disodium phosphate; 0.50% sodium nitrite; 99.0% demineralized water	60		Surface treat.	
		Method B: (1) 0.10% Na_2CrO_4 solution (2) Rinse with demineralized water (3) Dry	15 - 20		Surface treat.	49-07f
7	Final rinse	Demineralized water			Until pH effluent = pH influent.	49-07g
8	Dry	(1) Air or (2) Vacuum evacuation		140 - 250		49-07h
9	Final dry	Purge gas		140	Until a dew point of -60^{o} F is reached.	49-07h

CLEANING, TESTING, AND HANDLING OF OXYGEN, FUEL, AND PNEUMATIC COMPONENTS
D5-12855, THE BOEING CO., MAY 15, 1968 (REF. 9)

Small Tubing (1 in. i.d. max) Length to Inside Diameter Ratio Greater Than 10

[Tubing over 1 in. i.d. and with length i.d. ratio less than 10 will be processed as parts.]

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
1	Rough clean					5.2
2	Solvent flush	Trichloroethylene precision cleaning agent or Dowclene WR	5		Processing times given are minimum; flushing solution flow rates shall be 10 ft/sec minimum.	6.2.2
3	Alkaline flush	Turco 4215, 4215S, 4142, or 4142S or comparable nonsilicated alkaline cleaner, 1.0 - 2.0 oz/gal in water	10	150 - 170	Water distilled or deionized; minimum spec. resistance, 50 000 Ω.	6.2.3
4	Dry	Nitrogen, air, or other gas specifically approved by engineering			Shall meet 6.2.1.1; shall not contain condensable hydrocarbons in excess of 3 ppm by weight; shall not exceed 60% RH at ambient temperature.	6.2.6 or 6.2.7
5	Visual acceptance inspection					4.9
6	Final flush	Step 2	3			6.2.2
7	Dry	Step 4				6.2.6 or 6.2.7

CLEANING PROCEDURE - METALS CLEANING SPI-49.111
LINDE CO., DIV. OF UNION CARBIDE, DECEMBER 28, 1965 (REF. 8)

Steel Pipe and Steel Pipe Assemblies and Steel Parts

Step	Process	Agent	Time, min	Temperature, ^{o}F	Remarks	Reference paragraph
1	Strip paint	Diversey aluminum: (1) 12 oz/gal of water Diversey G-60: (2) 4 oz/gal of water		165	(1) Code 3008-3000. (2) Code 3008-2770. Soak until all paint is removed or loosened.	.06.1
2	Preclean	Diversey 1319: (3) 3 oz/gal water		Ambient	(3) Code 3008-2825.	.06.2
3	Rinse	Cold or hot water (4)			(4) Water shall be potable.	.06.3
4	Pickle	Diversey Everite: 20% by volume in water	120	Ambient	(5) If solution is at 140^{o} F soak for 60 minutes. Sheet steel parts should not be soaked any longer than is necessary to remove rust and scale.	.06.4
5	Rinse	Step 3				.06.5
6	Rust proof	Oakite 87, 6 oz/gal of water	5	170		.06.6
7	Rinse	Step 3				.06.7
8	Rust proof	H_2CrO_4, 0.1 oz/gal water	2		DO NOT RINSE	.06.8
9	Dry					.06.9

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TABLE I. - CLEANLINESS REQUIREMENTS

(a) Aerospace clean category

Specification	Service	Particulate limits		Fiber limits		Condensable hydrocarbons, ppm by weight of test gas	Nonvolatile residue, mg/ft^2	Total solids, mg/ft^2	Solvent soluble organic residue, mg/ft^2
		Size, μ	no./ft^2	Length, μ	Population, no./ft^2				
MSC-SPEC-C-7	LM propellant subsystem	0 - 50 50 - 100 100 - 250 >250	Unlimited 100 4 0	NS[a]	NS	NS	1	NS	NS
	LM ECS oxygen cabin pressure	0 - 50 50 - 75 75 - 100 >100	Unlimited 100 10 0	NS	NS	NS	1	NS	NS
	RCS-CM/SM propellant subsystem	0 - 50 50 - 75 75 - 100 >100	Unlimited 100 10 0	NS	NS	NS	1	NS	NS
	SPS pressurization subsystem	0 - 50 50 - 100 100 - 200 >200	Unlimited 200 32 0	100 - 200 >200	5 0	NS	1	NS	NS
	SPS propellant system	0 - 50 50 - 100 100 - 180 180 - 350 >350	Unlimited 100 20 5 0	100 - 350 >350	5 0	NS	1	NS	NS
KSC-C-123D	LOX and fuel parts, field parts, assemblies, and subsystems (*level III*)	0 - 35 36 - 60 61 - 95 96 - 135 136 - 170 171 - 350 >350	Unlimited 40 10 3 2 1 0	0 - 35 36 - 350 351 - 700 >700	Unlimited 10 1 0	2	1	NS	NS
KSC (proposed)	GSE LOX and fuel systems, parts, assemblies, subsystems, etc. (level C)	<50 50 - 100 101 - 150 151 - 200 201 - 250 >250	Unlimited 69 20 9 1 0	Fibers are counted as particles; fiber size is determined by the length		1	NS	NS	1
USAF T.O. 42C-1-11	LOX component subsystem (Thor, Atlas, and Titan I)	300 - 500 501 - 1000 >1000	25 5 0	750 - 2000 2001 - 6000 >6000	50 5 0	None using black light inspection	NS	5	NS
MSFC-SPEC-164A	LOX and GOX tubing, hoses, rigid tubing, flex hose assemblies, miscellaneous components and control assemblies (onboard and GSE; see Containers)	175 - 700 701 - 2500 >2500	5 1 0	NS	NS	----------	1	NS	NS

[a]Not specified.

TABLE I. - Continued. CLEANLINESS REQUIREMENTS

(a) Continued. Aerospace clean category

Specification	Service	Particulate limits		Fiber limits		Condensable hydrocarbons, ppm by weight of test gas	Nonvolatile residue, mg/ft^2	Total solids, mg/ft^2	Solvent soluble organic residue, mg/ft^2
		Size, μ	no. /ft^2	Length, μ	Population, no. /ft^2				
SDA 0-75192B	Propellant utilization system components; wipe test	[b]175 [c]175	[b]0 [c]0	>[b]2000 (c, d)	[b]0 (c, d)	No fluorescence	NS	NS	NS
Boeing Company D-5-12855	Cleaning, cleanliness testing and handling of oxygen, fuel, and pneumatic components (IOM 01671, level IV)	0 - 50 51 - 140 141 - 230 231 - 320 321 - 410 411 - 500 >500	Unlimited 40 10 3 2 1 0	0 - 50 51 - 500 501 - 1000 1001	Unlimited 10 1 0	NS	2	NS	NS
MSC-SPEC-C-7	EPS cryogenic distribution subsystem	0 - 50 50 - 100 100 - 175 >175	Unlimited 100 10 0	NS	NS	NS	1	NS	NS
	EPS cryogenic tanks	0 - 175 175 - 700 >700	Unlimited 6 0	700 - 1500 >1500	1 0	NS	1	NS	NS
GDA 0-75192B	Tanks, all components (rinse test)	300 - 500 500 - 1000 >1000	10 2 0	700 - 2000 2000 - 6000 >6000	20 2 0	No fluorescence	NS	2	NS
White Sands sec. 49	Piping and equipment	0 - 9 10 - 25 25 - 50 50 - 100 >100	Unlimited 500 15 10 0	(d)	(d)	----------	NS	4	NS
Air Products QCL 107F	Class AAA	175 - 500 >500	25 0	>2000	0	No fluorescence	NS	NS	NS
GDA 0-75192B	Propellant utilization system components (rinse test)	[b]300 - 5000 >[b]500 [c]50 - 75 [c]75 - 100 >[c]100	[b]4 [b]0 [c]8 [c]6 [c]0	[b]1000 - 2000 >[b]2000 (c, d)	[b]2 [b]0 (c, d)	No fluorescence	NS	2	NS
	Interchangeable standard parts (rinse test)	300 - 500 >500	4 0	1000 - 2000 >2000	2 0	No fluorescence	NS	2	NS
	Contamination barrier and seal material (rinse test)	[b]300 - 500 >[b]500 [c]50 - 75 [c]75 - 100 >[c]100	[b]4 [b]0 [c]8 [c]6 [c]0	[b]1000 - 2000 >[b]2000 (c, d)	[b]2 [b]0 (c, d)	No fluorescence	NS	2	NS
	Propellant tanks (wipe tests)	>300	0	>4000	0	(d)	NS	NS	NS
	All other components (wipe tests)	>175	0	>2000	0	(d)	NS	NS	NS

[b]Nonmetallic.
[c]Metallic.
[d]None allowed.

TABLE I. - Continued. CLEANLINESS REQUIREMENTS

(a) Concluded. Aerospace clean category

Specification	Service	Particulate limits		Fiber limits		Condensable hydrocarbons, ppm by weight of test gas	Nonvolatile residue, mg/ft^2	Total solids, mg/ft^2	Solvent soluble organic residue, mg/ft^2
		Size, μ	no./ft^2	Length, μ	Population, no./ft^2				
MSC-SPEC-C-11A	Pressurization systems, reaction control propellant systems	0 - 5 5 - 15 15 - 25 25 - 50 50 - 100 >100	Unlimited 170 100 40 20 0	NS	NS	NS	1	NS	NS
	Electrical power systems	0 - 10 10 - 25 25 - 50 50 - 100 100 - 175 >175	Unlimited 100 10 5 1 0	NS	NS	NS	1	NS	NS
	Small propulsion systems	0 - 5 5 - 15 15 - 25 25 - 50 50 - 100 100 - 250 >250	Unlimited Unlimited Unlimited 2100 100 4 0	NS	NS	NS	1	NS	NS
	Main propulsion systems	0 - 25 25 - 50 50 - 100 100 - 180 180 - 350 >350	Unlimited 1000 100 20 5 0	350 >350	5 0	NS	1	NS	NS
NASA FRC process spec. 20-1	LOX components, breathing oxygen components	10 - 26 26 - 100 100 - 750 750 - 1500 1500	[e]Unlimited (6000) [e]13 250 (250) [e]265 (5) [e]53 (1) [e]0 (0)	NS	NS	NS	NS	NS	NS
MSC-SPEC-C-9A	Nonairborne breathing systems	0 - 175 175 - 700 >700	Unlimited 6 0	700 - 1500 >1500	1 0	---	1	NS	NS
MSC-SPEC-C-11A	Environmental control systems	0 - 175 175 - 700 >700	Unlimited 6 0	700 - 1500 >1500	1 0	NS	1	NS	NS
LeRC RDL-003	LOX and GOX components (Plum Brook Station)	5 - 50 51 - 100 101 - 150 151 - 350 >350	Unlimited 40 18 5 0	0 - 500 501 - 1000 1001 - 1875 >1875 (up to 25 diam)	20 3 1 0	0	NS	2.5	NS
GDA 0-75192B	Transducers, surface area of 1 ft^2 or greater	300 - 500 >500	4 0	>2000	0	No fluorescence	NS	NS	NS
	Transducers, surface area of less than 1 ft^2	300 - 500 >500	2 0	>2000	0	No fluorescence	NS	NS	NS

[e]Extrapolated from 47 mm diam filter paper count; parentheticals are actual values.

TABLE I. - Concluded. CLEANLINESS REQUIREMENTS

(b) Commercial clean category

Specification	Service	Particulate limits		Fiber limits		Condensable hydrocarbons, ppm by weight of test gas	Nonvolatile residue, mg/ft^2	Total solids, mg/ft^2	Solvent soluble organic residue, mg/ft^2
		Size, μ	no./ft^2	Length, μ	Population, no./ft^2				
Linde Division's oxygen		NS (10 mg)		NS	NS	NS	500	NS	10
Air Products QCL 105F	Class A	750 - 1500 >1500	10 0	6000	0	Low intensity fluorescence acceptable	---	---	---
Air Products QCL 106F	Class AA	500 - 1000 >1000	10 0	2000	0	No fluorescence, isolated particle of lint acceptable	---	---	---

TABLE II. - GENERAL DESCRIPTION OF CLEANING PROCEDURES

Cleaning step	Cleaning agent	Method	Purpose
Preclean	Trichloroethylene, trichlorotrifluoroethane, mixtures of nitric and hydrofluoric acid, compressed air	Soak, brush, blow, spray, dip, shot peening, vapor degrease	Remove gross contamination such as scale, slag, rust, surface adhering soils, greases, oxides
Clean	Trichloroethylene, trichlorotrifluoroethane, mixtures of nitric and hydrofluoric acid, alkaline cleaning agents, phosphoric acid organic solvent mixtures, detergent solutions	Soak, brush, apply ultrasonic energy, dip, soak, spray, flush, vapor degrease, mechanical washers	Remove soils, greases, fibers, particulate matter in precision cleaning operations; remove fine contaminants
Rinse	Tap water, demineralized water, distilled water, alcohol, trichloroethylene, trichlorotrifluoroethane, methylene chloride	Soak, brush, apply ultrasonic energy, dip, soak, spray, flush, mechanical washers	Remove detergent or solvent solutions
Inspect		Visual, ultraviolet light, water break, flood light, pH paper, solvent brush, wipe test, gas blowdown, nonvolatile residue, solvent soluble organic residue, condensable hydrocarbon	Determine and/or verify the level of cleanliness attained during cleaning process
Dry	Dry, filtered air, nitrogen, heat, vacuum	Mechanical: Dry, filtered air or nitrogen blowoff Thermal: Ovens, vacuum ovens	Remove last remnants of rinse solvents

TABLE III. - EFFECTS OF COMMON

Cleaning solvent	Federal or MIL specification	Plastics			
		Polystyrene	Polyvinyl chloride	Polyethylene	Bakelite (phenolic)
					Chlorinated
Methylene chloride (dichloromethane, technical)	MIL-D-6998A-1 Grade A - 0.005% max acidity Grade B - 0.010% max acidity	Dissolves	Will damage	Will damage on prolonged contact	None
Trichloroethylene, technical	O-T-634a Type I - Regular Type II - Stabilized for vapor degreasing (Supersedes MIL-T-7003)	Dissolves	4 hr - swollen	4 hr - slight effect	None
1, 1, 1-trichloroethane (inhibited methyl chloroform, technical inhibited)	O-T-620a-2 (Supersedes Safety Solvent) MIL-S-18718(Aer)-1 which consistec of 70% mineral spirits, 25% methylene chloride, 5% perchloroethylene)	Dissolves	1 hr - none 4 hr - slight swell	1 hr - none 4 hr - slight swell	None
Carbontetrachloride (tetrachloromethane, technical grade)	O-C-141 (Cancelled)	Dissolves	5 min - none	5 min - slight swell	None
Blend of chlorinated solvents (composition proprietory)		Dissolves	10 min - none	1 hr - none 4 hr - slight swell	None
Perchloroethylene (tetrachloroethylene, technical grade)	O-T-236a (Supersedes O-P-191a)	Dissolves on long	4 hr - none	4 hr - slight effect	None
					Aromatic
Benzene (benzol, technical)	VV-B-231c Grade A - Industrial-grade benzene Grade B - Industrial-90 benzene	Dissolves			
Toluene (toluol, technical)	TT-T-548c	Dissolves			
Xylene (xylol)	TT-X-916b	Dissolves			
Naptha (distilled from petroleum, aromatic)	TT-N-97b Type I - Boiling range (190° - 264° F) Grade A - high solvent power Grade B - low solvent power Type II - Boiling range (265° - 376° F) Type III - Boiling range (340° - 425° F)				

[a]Effects data determined by Sandia Laboratory, Albuquerque, New Mexico.

CLEANING SOLVENTS ON MATERIALS

Effect on materials of construction[a]								
Elastomers			Wire coatings, insulating varnishes, and marking inks					
Teflon (TFE)	Neoprene rubber	Silicon rubber	Formvar polyvinyl formal	Bondar	Glyptal 1201 (air-dried)	Glyptal 1202 (air-dried)	GE 9740 (baked)	Ink
hydrocarbons								
None	Swells	Swells	Severe crazing	Slight effect	Lifted	Lifted	Lifted	Removed
None	Swells	Swells	Will soften	None	Lifted	Lifted	Lifted	Removed
None	3 min - none 5 min - slight swell	3 min - none 5 min - swell	5 min - none	5 min - none	5 min - none	5 min - lifted	5 min - lifted	Some removed (will not remove epoxy-based ink)
None	5 min - swell	Swells	Slight effect	None	Slight effect	Slight effect	Slight effect	Partially removed
None	5 min - slight swell	Swells	5 min - none	5 min - none	5 min - none	5 min - lifted	5 min - lifted	Partially removed
None	Swells on prolonged contact	Swells	None	None	None	Slight effect	Slight effect	Partially removed
petroleum								
	Dissolves							
	Dissolves		1 hr - softened					
			1 hr - solvent discolored indicating resin extraction					

TABLE III. - Concluded. EFFECTS OF COM

Cleaning solvent	Federal or MIL specification	Plastics			
		Polystyrene	Polyvinyl chloride	Polyethylene	Bakelite (phenolic)
					Fluorinated
Trichloromonofluoromethane (fluorocarbon 11) (solvent grade)		Dissolves on long exposure	Slight effect	Slight effect	None
Trichlorotrifluoroethane (fluorocarbon 113) (solvent grade)	MIL-C-81302 Wep (Covers Freon PCA and equivalent grade solvents; is being revised to also cover Freon TF and equivalent grade solvents)	4 hr at 75° F - none 4 hr boiling - cracked and brittle	4 hr - none	4 hr - none	None
					Aliphatic
Naptha, aliphatic (petroleum naptha)	TT-N-95a Type I - For organic coating Type II - For cleaning acrylic plastics				
Stoddard solvent (dry cleaning solvent)	P-D-680 (Supersedes P-S-661b) Type I - 100° F min flashpoint Type II - 140° F min flashpoint	5 min - none	None	None	
Mineral spirits Thinner; paint, volatile spirits (petroleum spirits)	TT-T-291c Grade 1 - Light thinner Grade 2 - Heavy thinner				
					Oxygenated
Isopropyl alcohol (anti-icing fluid and solvent)	TT-1-735o (Supersedes MIL-F-5566 and MIL-1-10428A) Grade A - 0.1% max water; for use in manufacturing Grade B - 0.4% max water; for use as antiicing fluid and solvent	5 min - none	5 min - extracts plasticizer	None	None
Methyl alcohol (methanol)	O-M-232d Grade A - 99.8% synthetic (solvent use) Grade AA - 99.8% synethetic ($H\text{-}CO_2$ generators) Grade B - 99% technical (solvent use) Grade C - wood alcohol (denaturing grade)	5 min - none	5 min - extracts plasticizer	None	None
Ethyl alcohol (ethanol)	O-E-760b (Supersedes O-A-396)	5 min - none	5 min - extracts plasticizer	None	None
Acetone, technical	O-A-51d	Dissolves	Dissolves	None	Dissolves

[a]Effects data determined by Sandia Laboratory, Albuquerque, New Mexico.

MON CLEANING SOLVENTS ON MATERIALS

Effect on materials of construction[a]								
Elastomers			Wire coatings, insulating varnishes, and marking inks					
Teflon (TFE)	Neoprene rubber	Silicon rubber	Formvar polyvinyl formula	Bondar	Glyptal 1201 (air-dried)	Glyptal 1202 (air-dried)	GE 9740 (baked)	Ink
hydrocarbons								
None	Slight swell	Slight swell						
None	1 hr - none	1/2 hr - 6% swell	100 hr - none	100 hr - none	Unknown	Unknown	Unknown	None
petroleum								
None	None	None	None	None	None	None	None	None
solvents[a]								
None	None	None	None	5 min - none	5 min - none	5 min - none	10 min - none	Varies with ink
None	None	None	None	5 min - none	5 min - none	5 min - none	10 min - none	Varies with ink
None	None	None	None	5 min - none	5 min - none	5 min - none	5 min - none	Varies with ink
None	Swells	Extracts plasti-cizer	None	5 min - none	Dissolves	Dissolves	Dissolves	Removes

TABLE IV. - CLEANING PROCEDURES

Step	Process	Aerospace clean category				
		KSC (proposed, ref. 11) CRES (pickling required)	KSC (proposed, ref. 11) CRES (pickling not required)	KSC (proposed, ref. 11) CRSE (cleaning in field)	T.O. 42C-1-11 (ref. 12) 400 Series stainless and free machining grade 300 series parts	T.O. 42C-1-11 (ref. 12) 300 Series stainless steel except free machining parts
1	Mechanical descale or preclean	Brushing, shot peening, etc.	Brushing, shot peening, etc.	12±0.5% of 61% HNO_3 by volume, 1.5±0.05% of 48% HF by volume; balance is deionized H_2O for 15 - 60 min at ambient	Mechanical descaling	Mechanical descaling
2	Solvent and/or vapor degrease	Trichloroethylene or trichlorotrifluoroethane	Trichloroethylene or trichlorotrifluoroethane		Solvent degrease-trichloroethylene and vapor degrease trichloroethylene or trichlorotrifluoroethane	Degrease trichloroethylene and vapor degrease trichloroethylene or trichlorofluoroethane
3	Dry	Gaseous N_2	Gaseous N_2			
4	Detergent grease	0.5% detergent solution MIL-D-16791 and deionized H_2O for 5 - 15 min at 110° - 130° F				
5	Rinse	H_2O for 5 min at 90° - 110° F				
6	Pickle	12±0.5% of 61% HNO_3 1.5±0.5% of 48% HF in deionized H_2O for 15 - 60 min at ambient				
7	Rinse	H_2O for 5 min at 90° - 120° F				
8	Rinse	Deionized H_2O for 3 min				
9	Dry	Gaseous N_2 at 120° - 140° F.				
10	Clean	5±0.5% of 85% H_3PO_4; 10±0.5% of 2-butoxy-ethanol solvent, 0.5±0.05% surfactant; balance is H_2O for 30 - 120 min at 80° - 105° F.	5±0.5% of 85% H_3PO_4; 10±0.5% of 2-butoxy-ethanol solvent; 0.5±0.05% surfactant; balance is H_2O for 30 - 120 min at 80° - 105° F	5±0.5% of 85% H_3PO_4, 10±0.5% of 2-butoxy-ethanol solvent; 0.5±0.05% surfactant; balance is H_2O for 60 - 120 min at 85° - 105° F	Alkaline cleaner (Fed. Spec. P-C-436): 5 - 10 oz/gal of tap H_2O for 15 - 25 min at 150° - 175° F	Alkaline cleaner (Fed. Spec. P-C-436): 5 - 10 oz/gal of tap H_2O for 15 - 25 min at 150° - 175° F
11	Rinse	H_2O for 5 min at 90° - 110° F	H_2O for 5 min at 90° - 110° F	Deionized H_2O for 30 min at ambient	Detergent solution (Fed. Spec. P-C-437): 1/2 - 1 oz/gal of tap H_2O or demineralized H_2O for 15 - 25 min at 120° - 140° F	Detergent solution (Fed. Spec. P-C-437): 1/2 - 1 oz/gal of tap H_2O for 15 - 25 min at 120° - 140° F
12	Rinse	Deionized H_2O for 3 min	Deionized H_2O for 3 min		Tap H_2O for 5 - 10 min at 150° F	Tap H_2O for 5 - 10 min at 150° F
13	Passivate pickle	15±0.5% of 61% HNO_3 by volume; balance is deionized H_2O for 15 - 60 min at ambient	15±0.5% of 61% HNO_3 by volume; remainder is deionized H_2O for 15 - 60 min at ambient		12% HNO_3 by volume; 1% HF by volume; balance is tap H_2O for 10 min at 60° - 100° F	20% HNO_3 by volume; 3% HF by volume; tap H_2O for 15 min at 60° - 100° F
14	Rinse	H_2O for 5 min at 90° - 110° F	H_2O for 5 min at 90° - 110° F		Tap H_2O for 5 - 7 min at 150° F	Tap H_2O for 5 - 7 min at 150° F
15	Rinse	Deionized H_2O for 5 min	Deionized H_2O for 5 min		Demineralized H_2O for 5 - 10 min at 150° F	Demineralized H_2O for 5 - 10 min at 150° F
16	pH test	Narrow range pH paper (pH - 6.0 - 8.0)	Narrow range pH paper (pH - 6.0 - 8.0)	pH paper sensitive to each 0.1 pH unit (pH - 6.0 - 8.0)		
17	Dry	Gaseous N_2 at 120° - 140° F	Gaseous N_2 at 120° - 140° F	Gaseous N_2 to dew point (-65° F)	Oven at 180° - 200° F; gaseous N_2 at 140° F vacuum	Oven at 160° - 200° F; gaseous N_2 at 140° F vacuum
18	Rinse			Trichloroethylene or trichlorotrifluoroethane (30 min)	Detergent solution (MIL-D-16791 type I): 1/2 - 1 oz/gal tap of or demineralized H_2O or trichloroethylene (150° F) for 15 - 25 min at 120° - 140° F	Detergent solution (MIL-D-16791 type I): 1/2 - 1 oz/gal H_2O for 15 - 25 min at 120° - 140° F or trichloroethylene
19	Flush final clean	Trichlorotrifluoroethane	Trichlorotrifluoroethane, 1 min		Demineralized H_2O at 150° F; omit if solvent used in step 18	Demineralized H_2O at 150° F; omit if solvent used in step 18
20	Inspect	Verify cleanliness	Verify cleanliness			
21	Dry	Gaseous N_2 at 120° - 140° F vacuum	Gaseous N_2 at 120° - 140° F vacuum	Gaseous N_2	Oven at 180° - 200° F; gaseous N_2 at 140° F vacuum	Oven at 160° - 200° F; gaseous N_2 at 140° F vacuum

FOR VARIOUS STEELS

			Commercial clean category		
CPIA publication 194 Stainless steel tanks (ref. 21)	CPIA publication 194 Stainless steel components (ref. 21)	Plum Brook RDL-003 Stainless steel (ref. 3)	Linde SPI-49. 111 Steel and stainless shells (ref. 8)	Linde SPI-49. 111 Stainless steel (ref. 3)	Linde SPI-49. 111 9% nickel and stainless steel heads (ref. 8)
Mechanical descaling or HNO_3 mixture					Diversey 1319 3 oz/gal H_2O at ambient
Solvent	Perchloroethylene	Trichloroethylene or detergent water solution			
				Cold H_2O	
				4% HF by volume; 14% HNO_3 + H_2O; 145° F	
Alcohol	Alcohol				
H_2O or steam	H_2O	Distilled or deionized H_2O		Cold, potable H_2O	Cold potable H_2
				Dry air or N_2	Dry air or N_2
4% detergent for 30 min at 150° F	4% detergent solution for 30 min at 120° F	3 - 5% by volume HF; 35 - 45% technical grade HNO_3 and deionized H_2O	Diversey 1319 3 oz/gal H_2O at ambient		
	H_2O				
	40 - 50% HNO_3 bath for 60 min				
		Deionized H_2O pH effluent = pH influent	Potable H_2O		
Particle free, deionized H_2O	Steam				
N_2	Gaseous N_2	Hydrocarbon free, gaseous N_2	Gaseous N_2 or air		

TABLE V. - CLEANING PROCEDURES FOR ALUMINUM

Step	Process	Aerospace clean category				Commercial clean category	
		KSC (proposed) aluminum	KSC (proposed) in field aluminum cleaning by solution spray (ref. 11)	Boeing Aircraft Co. DS-12855, May 15, 1968; aluminum (ref. 9)	CPIA Publication 194 October 20, 1970; aluminum and aluminum alloys (ref. 21)	T. O. 42C-1-11 (ref. 12)	Linde Co. SPI-49. 111 December 28, 1965; aluminum (ref. 8)
1	Rough cleaning	Brushing, shot peening, etc.		Clean per BAC 5765. Not to be subjected to temperatures exceeding 130° F		As required mechanical descaling	
2	Preclean or degrease	Trichloroethylene or trichlorotrifluoroethane	Trichloroethylene or trichlorotrifluoroethane (5 min, 110° F) or 0.5% detergent solution (15 min, 130° F)	Trichloroethylene, precision cleaning agent or Dowclene WR	Perchloroethylene for 30 min	Trichloroethylene	Diversey 1319, 3 oz/gal; H_2O at ambient
3	Dry	Gaseous N_2					
4	Remove corrosion	Formula V, 10 - 60 min at ambient				Vapor degrease with trichloroethylene or trichlorotrifluoroethane	
5	Rinse	H_2O for 5 min at 90° - 110° F			Alcohol		
6	Rinse	Deionized H_2O for 3 min			H_2O		Cold or hot potable H_2O
7	Dry	Gaseous N_2 at 120° - 140° F					
8	Clean	Formula V, 30 - 120 min at 80° - 95° F	Formula IV for 60 - 120 min at 80° - 95° F	Ultrasonic and detergent water solution for 5 min at 130° F max	4% solution of aluminum cleaner	Sodium carbonate, 3 oz/gal; trisodium phosphate, 3 oz/gal; balance is tap H_2O for 1 - 3 min at 140° - 180° F	Diversey aluminux, 6 oz/gal H_2O. Diversey, 2 oz/gal H_2O for 1 - 2 min at 160° F

9	Rinse	H_2O for 5 min at 90^o - 110^o F				Tap H_2O at 150^o F	
10	Rinse	Deionized H_2O for 3 min	Deionized H_2O for 30 min	Ultrasonic and distilled or deionized H_2O for 5 min			Hot H_2O
11	Brighten/ passivate	Formula V for 10 - 60 min at ambient	Formula V for 20 - 40 min at ambient			HNO_3, 12% by volume; HF, 1% by volume, balance tap H_2O at ambient	Diversey 596, 7 oz/gal; H_2SO_4, 7% by volume; rest, H_2O at ambient
12	Rinse	H_2O for 5 min at 90^o - 110^o F	Trichloroethylene or trichlorotrifluoroethane (5 min at 110^o F); or 0.5% detergent solution (15 min at 130^o F)			Demineralized H_2O at 150^o F	
13	Rinse	Dionized H_2O for 3 min	Dionized H_2O for 30 min at ambient		H_2O		Hot H_2O
14	Dry			Gaseous N_2		Oven, 180^o - 200^o F; or nitrogen, 140^o F; or vacuum	
15	Inspect	Narrow range (6.0 - 8.0) pH paper	Narrow range (6.0 - 8.0) pH paper	Visually			
16	Dry	Gaseous N_2	Gaseous N_2				Gaseous N_2
17	Final flush or final clean	Trichlorotrifluoroethane	Trichloroethylene or trichlorotrifluoroethane	Trichloroethylene, precision cleaning agent or, Dowclene WR	Steam	Detergent solution: 1/2 - 1 oz/gal tap or demineralized H_2O or trichloroethylene; if solution used rinse with demineralized H_2O at 150^o F	
18	Inspect	Analysis of solvent from step 17	Analysis of solvent from step 17				
19	Dry	Gaseous N_2	Gaseous N_2	Gaseous N_2, air, or other gas specifically approved	Gaseous N_2	Oven 180^o - 200^o F, or nitrogen gas at 140^o F, or vacuum	

TABLE VI. - CLEANLINESS VERIFICATION TECHNIQUES

Test	Test method	Results		Reference specifications
		Characteristic results	Test limitations	
Direct determination methods				
pH paper	All surfaces that have been cleaned shall be tested for acidity and alkalinity with narrow-range pH paper while surfaces are wet from final water rinse. Dry surfaces may be wet with few drops of distilled water to permit testing as required. Narrow range pH paper is sensitive to each 0.1 pH unit change.	pH range from 6.0 to 8.0. pH value outside specified range will cause rejection and subsequent recleans or rerinses.	1. Difficult to ascertain small color changes. 2. Very qualitative. 3. Not representative of the overall system.	KSC-C-123(D) KSC Proposed MSC-SPEC-164A
Wipe	Wipe test shall be made on interior surface of each component using new, clean filter paper (Whatman No. 42, S and S 602, or Whatman No. 44, or equal). This test shall consist of at least two movements of the filter paper across 1 ft^2 of surface.	Filter papers shall be examined under microscope for particulate contamination and under ultraviolet light for fluorescence. Failure to conform with cleanliness requirements will cause rejection, reclean, and reinspection.	1. Very qualitative. 2. Not truly representative of cleanliness where accessibility is limited. 3. Subject to operator errors. 4. Questionable reproducibility.	USAF T.O. 42C-1-11 AFRPL-TI-No. 5-1-5 RDL-003 Linde SPI-49.117 GDA 14170 Air Products
Visual: Ultraviolet or black light	Surfaces to be in contact with service medium shall be visually examined using flash light, mirrors, borescope, or ×10 magnifying glass for evidence of corrosion, moisture, scale, direct grease, oil, paints, preservatives, metal chips, weld scales, and other foreign matter.	Presence of visible contamination causes rejection. Surface discoloration due to welding or passivation permitted provided no scale or other objectionable film remains. Widely used.	1. Unaided by magnifying glass visual examination limited to 40 μ smallest particle detection. 2. Subjective test. 3. Most effective with particulate matter. 4. Least effective with invisible films. 5. Highly trained microscopist may increase validity of test results. 6. Highly qualitative.	USAF T.O. 42C-1-11 KSC-C-123D KSC Proposed AFRPL-TI-5-1-5 RDL-003 Linde SPI-49.117 GDA-14170 MSFC-SPEC-164A Air Products
	Visual inspection with aid of ultraviolet light source 2500 to 3700 A shall be accomplished on all accessible surfaces to determine presence of petroleum-type hydrocarbons. Ultraviolet source (3200-3800 Å) may also show some glow or fluorescence because of presence of fibers, grease, oil, and other foreign materials not visible in ordinary light.	Presence of fluorescence causes rejection.	1. Very qualitative. 2. Animal oils such as fish oil rust preservatives will not fluoresce. 3. Vegetable oils such as caster oil-based cutting emulsions will not glow. 4. Extent of contamination detectable: $\leq$50 ppm - not discernable. 50-100 ppm - barely discernable. $\geq$100 ppm - definitely discernable.	USAF T.O. 42C-1-11 MIL-STD-1330 (SHIPS) AFRPL-TI-No. 5-1-5 RDL-003 Linde SPI-49.117 GDA 14170 Air Products
Water break	Wet surface with clean water or observe receding water film as water drains off part.	Water film if unbroken for 5 seconds is indicative of cleanliness.	1. Qualitative test. 2. Contaminants in water lessen sensitivity. 3. Test limited to horizontal surfaces only. 4. Use of deionized water and a trained inspector may increase sensitivity to one molecular thickness of contaminant.	AFRPL-TI-No. 5-1-5 Linde SPI-49.117
Flood light	High-tensity light source (200 W or better) shining at oblique angle to determine particulate contamination. Dust or lint when viewed from outside bright light becomes visible.	For aerospace application, presence of lint or dust causes rejection. For commercial applications, small amounts of particulate contamination are acceptable.	1. Very qualitative. 2. Inspector dependent. 3. Of limited applicability.	AFRPL-TI-No. 5-1-5 Air Products
		Indirect determination methods		
Gas blowdown	Use a blowhorn or similar device to hold millipore filter disk (0.45±0.02 μ pores, 47 mm diameter, while 3.08 mm grid, capable of filtering 80 cc of distilled water per square centimeter per minute at 70 cm of mercury - 13.5 psia at ±25° C). Flow a minimum volume of 100 SCF of gas through test item at minimum flow rate of 35 SCFM, or at normal system operating flow rate is 3 SCRM or less, total volume of test gas used may be reduced to 35 SCF. Critical surface area shall be calculated to nearest 0.1 ft^2.	Stain on filter membrane, evidence of fluorescence of particles exceeding maximum size and count criteria, or exceeding criteria by actual count will cause reclean and reinspection of test item. Second failure of item to meet particulate requirements of applicable cleanliness level will cause rejection of item.	1. Very qualitative. 2. Indicative of lack of sufficient cleanliness, but not achieved cleanliness. 3. Contaminants may not volatalize sufficiently into gas stream to provide detectability.	KSC Proposed FRC P.S. 20-1

TABLE VI. - Continued. CLEANLINESS VERIFICATION TECHNIQUES

Test	Test method	Results		Reference specifications
		Characteristic results	Test limitations	
Solvent flush	100 - 500 ml of representative flushing fluid for each square foot of critical surface area is filtered through 45 μ, type HA white grid, 47 mm diameter membrane filter. Particles are counted or estimated using ×45 magnification for particles larger than 2.5 μ and ×90 magnification for particles 25 μ or smaller. Estimates of heavily soiled are made by (1) Counting number of particles on 20 randomly selected grid squares and multiplying number by 5. (Method applicable for a given particle size estimated to be between 50 and 1000.) (2) For estimated particle count between 1000 and 5000, count number of particles on 10 randomly chosen grid squares, multiplying number by 10 to obtain total statistical count. (3) For estimated particle count exceeding 5000 in a given particle size range, particles are counted on 10 or more randomly selected grid squares. Total statistical count is arrived at by the formula $P_t = N_t \frac{E}{nA_f}$ N_t total number of particles counted in n unit areas E 960 mm^2, total effective filter area n number of unit areas counted A_f 3.08 L, unit area, mm^2 L calibrated length of ocular micrometer, mm	If particle count in a given size range as listed in table I or figures 2 through 7 is exceeded, part, system or item is rejected and submitted to additional cleaning, rinsing and inspections.	1. Qualitative test. 2. Variable reproducibility. 3. Accuracy dependent upon technician doing the counting. 4. Extremely vulnerable to error. 5. Laboratory technicians must be trained until they are able reproducibly to count standard filters.	USAF T.O. 42C-1-11 KSC Proposed FRC P.S. 20-1 MIL-STD-1330 (SHIPS) AFRPL-TI-No. 5-1-5 RDL-003 GDA 14170 MSFC-SPEC-164A
Solvent soluble organic residue	Use a precision cleaned hypodermic syringe to transfer test fluid sample and reference standard to respective infrared sealed cells with sodium chloride windows. Nominal cell path length is 3 mm for single beam infrared spectrophotometer record absorption of reference standard at 3.42 μ (2924 cm^{-1}) as A and for test sample as B. For double beam IR spectrophotometer insert reference and test sample and record net absorption at 3.42 μ for test sample as C. Calculate absorbance $\log_{10} \frac{Io}{I}$ of A, B, and C. By standard infrared baseline method (ASTM E168-64T, sec. 6) refer to previously prepared reference standard curve to obtain milligrams of solvent soluble organic residue per milliliter of solvent. Calculate per methods in results column.	Calculated SSOR/ft^2 of critical area: 1. Single beam $mg/ft^2 = \frac{(F)(E-D)}{G}$ D mg SSOR/ml (ref. std.) (calculated from A) E mg SSOR/mp test sample (calculated from B) E - D net concentration of test solvent, mg SSOR/ml F total volume of test solvent, ml G total area of critical surface tested, ft^2 2. Double beam $mg/ft^2 = \frac{(F)(H)}{G}$ F total volume of test solvent used, ml H concentration of test solvent, mg SSOR/ml (calculated from C) Exceeding the allowable limits in table I shall cause the item to be recleaned.	1. Assumes any organic material remaining on critical surface will be soluble in solvent. 2. Quantitative measurement. 3. Commercial clean does not specify of IR spectrometer.	KSC Proposed USAF T.O. 42C-1-11 (reference test only) AFRPL-TI-No. 5-1-5 (referee test only) RDL-003 (referee test only) Linde SPI-49.117 GDA 14170 (referee test only)

TABLE VI. - Concluded. CLEANLINESS VERIFICATION TECHNIQUES

Test	Test method	Remarks		Reference specifications
		Characteristic results	Test limitations	
Condensable hydrocarbons	Spectrograde CCl_4 is distilled and IR spectrophotometrically examined for hydrocarbon impurity absorbance at 3.42 μ (2924 cm^{-1}). There will be no absorbance at above bandhead. Absorption will cause CCl_4 redistillation. Using this CCl_4 and standard hydrocarbon mixture (90% by wt U. S. P. heavy white mineral oil and 10% by wt reagent grade triolein (glycerol trioleate - $(C_{17}H_{33}COO)_3C_3H_5$) reference standard absorption curve will be prepared. Three gas washing bottles (250 ml capacity) properly cleaned shall be charged with 150 ml or redistilled CCl_4, sealed at top, and interconnected with appropriate tubing to allow passage of test gas. Gas flow is measured by wet test gas meter downstream of third gas washing bottle. Record barometric pressure, wet test gas meter temperature at beginning and end of test. Adjust gas flow rate to 5 - 6 liters per minute. Allow 600 liters of test gas to flow through bottles without blowing CCl_4 from one bottle to another or reduced in volume. Upon completion, quantitatively transfer CCl_4 to beaker and evaporate to 2 ml. Transfer to 5 ml volumetric flask and dilute it to volume. Determine IR absorbance and from reference standard curve obtain milligrams of condensable hydrocarbons.	1. Total condensable hydrocarbons: $A = \frac{(B)(C)(1.54)}{1000}$ A total condensable hydrocarbons B mg condensable hydrocarbon/ml CCl_4 C total volume CCl_4 1.54 compensating evaporation factor 2. Condensable hydrocarbons, ppm by wt $D = \frac{(E)(F)(273.1)}{(760)(273.1 + G)}$ D volume test gas, liters as STP E volume test gas, liters F barometric pressure, mm Hg G average wet test gas meter temperature, °C 3. $H = (D)(I)$ H wt of test gas, g I density of test gas, g/liter 4. $J = \frac{A \times 10^6}{H}$ J condensable hydrocarbons (in ppm by wt of test gas) A total condensable hydrocarbons in 1 above. Failure to meet requirements in table I results in rejection.	1. Use of "fudge" factor can cause erroneous results: Hydrocarbon evaporation coefficient is not characteristic property and varies with experimental conditions 2. Hydrocarbons may not be volatile enough to produce detectability. 3. Process routine is sufficiently difficult to result in aborted test. 4. Test is not representative of system cleanliness. 5. IR procedure is highly quantitative, but sampling and sample treatment is highly susceptible to errors. 6. To prevent CCl_4 from backing up or spilling while replenishing it during test requires manual dexterity; lack of which affects reproducibility and accuracy of the test.	KSC-C-123(D) KSC Proposed
Nonvolatile residue	Transfer 500 ml (some procedures specify 100 ml, other procedures specify 1000 ml) into a clean degreased beaker. Evaporate solvent to 10 - 20 ml volume in steam bath. Transfer solvent to constant weight (within 0.3 mg) tared 30 ml weighing bottle, weighed to nearest 0.1 mg. Continue evaporation to volume of 5±0.5 ml. Do not let solvent evaporate to dryness. Place weighing bottle in constant temperature oven at 221° - 230° F for 1.5 hours. Cool weighing bottle in desiccator and then weigh to nearest 0.1 mg. Return weighing bottle to constant temperature oven for 0.5 hour. Repeat weighing. If difference between successive weighings is ≤0.3 mg, repeat drying until difference is ≤0.3 mg or evaporate solvent to dryness being careful not to overheat or bake residue. Cool residue and weigh to constant weight.	Test results are compared to tared blank. Difference between weights shall not exceed specified limits of contamination; otherwise, test item will be recleaned and reinspected.	1. Semiquantitative. 2. Low sensitivity. 3. Low accuracy. 4. Hydrocarbon evaporation coefficient varies with experimental conditions and is not characteristic property. 5. Solvents contain stabilizers which contribute to erroneous results. 6. Tedious procedure requiring laboratory to be carried out. 7. Laboratory manipulations can result in loss of hydrocarbons.	USAF T. O. 42C-1-11 KSC-C-123(D) KSC Proposed AFRPL-TR-No. 5-1-5 Linde SPI-49.117 MSFC-SPEC-164A Air Products

Card #1

REFERENCE
1

MAY, KENNETH D.: ADVANCED VALVE TECHNOLOGY. NASA-SP-5019, 1965.

We Humane

NASA SP-5019

TECHNOLOGY SURVEY

Technology Utilization Division

ADVANCED VALVE TECHNOLOGY



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA SP-5019

TECHNOLOGY SURVEY

Technology Utilitization Division

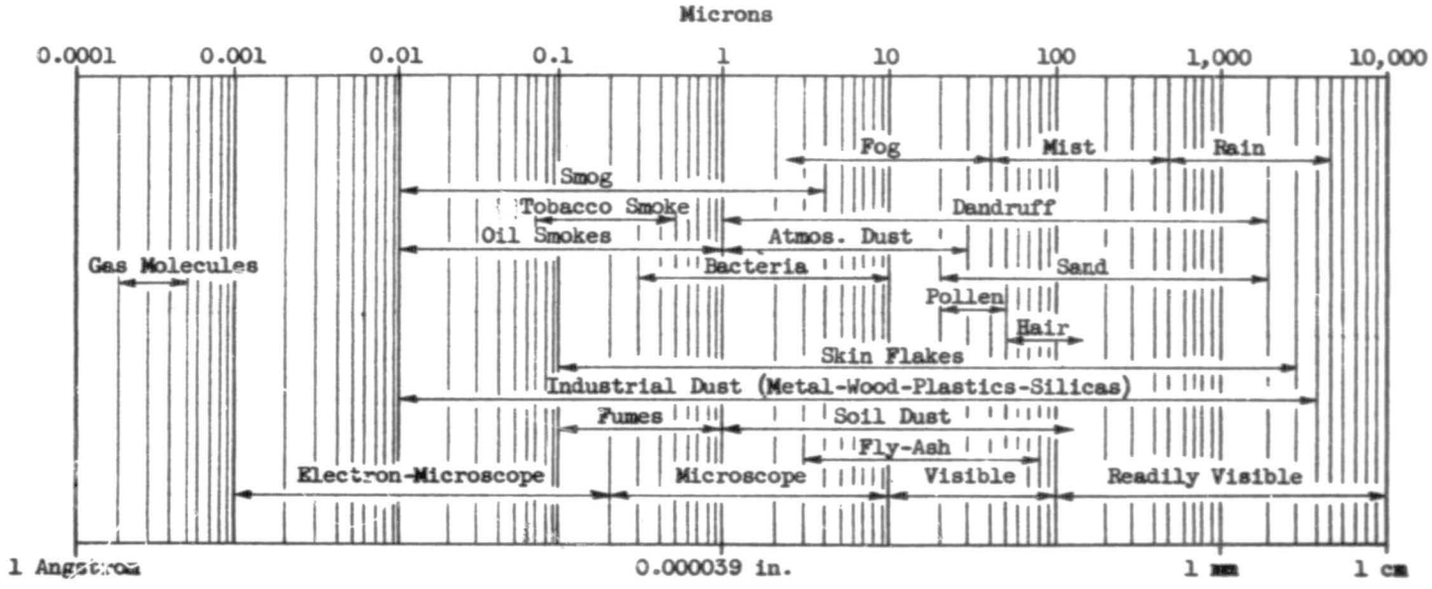
ADVANCED VALVE TECHNOLOGY

By KENNETH D. MAY

Prepared under contract for NASA
by Midwest Research Institute
Kansas City, Missouri

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Washington, D. C. *February 1965*





● With this figure representing a particle 10 microns in diameter, the larger figure represents the cross section of the average human hair (100 microns). The major problem in contamination control is the tendency of the small particles to group and form larger particles.

Chart 8. Approximate Sizes of Common Particles

TABLE XV. APPROXIMATE PARTICLE SIZE AND CONCENTRATIONS IN TYPICAL RURAL AND METROPOLITAN AREAS

Particle Size in Microns	Particles per Cubic Foot	
	City	Rural
0.7 - 1	1,000,000 - 1,500,000	40,000 - 50,000
1 - 3	100,000 - 125,000	10,000 - 15,000
3 - 6	35,000 - 40,000	4,500 - 5,000
6 - 12	3,000 - 4,000	1,000 - 1,200
12 - 25	400 - 500	5 - 10

TABLE XVI. TYPICAL SOURCES OF LARGER PARTICLES GENERATED IN LABORATORIES, MANUFACTURING SHOPS, AND STORAGE AREAS

Source	Size (Microns)
Crumpling paper	65
Writing with ballpoint pen on ordinary paper	20
Vinyl abraded by a wrench or other object	8
Rubbing or abrading an ordinary painted surface	90
Rubbing an epoxy painted surface	40
Handling passivated metals	10
Seating screws	30
Sliding metal surfaces (nonlubricated)	75
Belt drive	30
Abrading the skin	4
Soldering (60/40 solder)	3

END OF REFERENCE
I

REFERENCE
2

ANON.: CLEANING AND INSPECTION OF OXYGEN AND NITROGEN PIPING SYSTEMS. BUSHIPS INSTRUCTION 9230.12A, FEB. 8, 1961.

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS
WASHINGTON 25, D. C.

IN REPLY REFER TO
BUSHIPS 9230.12A
Ser 648F-186
8 February 1961

7.4-0-0

BUSHIPS INSTRUCTION 9230.12A

From: Chief, Bureau of Ships
To: Distribution List

Subj. Oxygen and nitrogen piping systems, cleaning and inspection of

Encl: (1) Cleaning Procedures - Oxygen and Nitrogen Systems

1. Purpose: The purpose of this instruction is to promulgate procedures for cleaning and inspecting shipboard oxygen and nitrogen piping systems. These procedures are not applicable to gas generating plants which shall be cleaned in accordance with manufacturers' cleaning procedures.

2. Cancellation: This instruction supersedes and cancels Bureau of Ships Instruction 9230.12 Ser 648F-2039 of 31 August 1960.

3. Action: Enclosure (1) should be adhered to in cleaning and inspecting all oxygen systems and any nitrogen systems which are specified to be used for the storage and distribution of oil-free nitrogen on all stations and all ships, including nuclear powered ships.

J. B. GUERRY
by Direction

Distribution List:

SNDL		
	21	CINC
	24A	NAVAIRFORCOM(30)
	24C	SUBFORCOM
	28K	SUBRON
	29G	CVS
	29H	CVA,CVA(N)
	29S	SUBMARINES
	32DD	AS
	J35	SUBTRAFAC
	J74	(Compressed Gas School)
	J88	SUBSCOL
	L1	NAVSHIPYDS
	L3	SUPSHIPS
	L19	SHIPREPFAC
	L30	SUBASE
	L40	REPFAC
	X7	BUSHIPS Special List

S327

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Aerospace Safety Research and Data Institute
MAR 29 1971
CLEVELAND, OHIO

Enclosure (1)

Cleaning Procedures - Oxygen and Nitrogen Systems

I. Introduction.

1. Oxygen systems must be cleaned following their assembly and prior to being placed in service. The word "clean" as used herein is defined as "being free of all loose scale, rust, grit, filings and other foreign substances; and free of oil, grease and other organic materials".

2. Oxygen equipment which is received from a manufacturer with a statement that it has been cleaned for oxygen service need not be recleaned provided the means for protecting the equipment is intact.

3. After the initial cleaning operation, the system need not be recleaned unless it has been opened to the atmosphere for modification or repair or when the pressure drops below the minimum permissible operating pressure of 25 psig.

4. Systems which are to handle dry, oil-free nitrogen such as missile nitrogen systems on submarines and tenders shall be treated in the same manner as an oxygen system.

II. Cleaning Procedures.

1. The following materials are to be used as indicated:

Application	Materials
Piping Systems	Trisodium phosphate (Na_3PO_4), anhydrous, technical grade, Fed. Spec. O-S-642, Type I, FSN G6810-664-7487 or Trisodium phosphate ($Na_3PO_4.12H_2O$), dodeca-hydrate, technical grade, Fed.Spec. O-S-642,Type II FSN G6810-?40-2115 and G6810-240-2116.

Application	Materials
Small or delicate Equipment	O_2 System Cleaner, Mil. Spec. MIL-C-8638, Stock Number RN6850-597-7166-G500.

2. Oxygen and nitrogen distribution systems.

a. Systems should be cleaned by exposure, scrubbing and/or flushing, as required, with cleaning solution followed by thorough rinsing with clean water and drying with dry, oil-free nitrogen.

b. Material required consists of:

(1) Supply of cleaning solvent.

(2) Supply of oil-free, filtered, fresh water for mixing cleaning solution and for rinsing.

(3) Steam or other source of heat for the cleaning solution and rinse water.

(4) Supply of oil-free nitrogen which is either compressed by a water-lubricated compressor or is produced from liquid nitrogen which contains no oil. Federal Specification BB-N-411, Type I, Class 1, Grade A or B, applies.

(5) Rubber gloves, safety goggles, rubber boots and aprons or other protective clothing to be worn while cleaning.

(6) Brush for scrubbing with solution or a paddle to stir solution if scrubbing is not practical, or a Kenick Hydro-Steam Cleaner, Type S-D, made by the Clayton Manufacturing Company, Del Monte, California, or equivalent.

(7) For large equipment use a portable cleaning machine consisting of two 55 gallon tanks connected to a Gould Company 1/2 H.P. bronze centrifugal pump (or equivalent) with a capacity of 15 gpm at 20 psi, mounted on an appropriate platform truck. Tanks should have steam heating coils capable of heating cleaning solution to boiling point.

(8) Vacuum pump capable of pulling at least a 25-inch Hg. vacuum for use in cleaning dead ended systems. Pump shall be provided with means, such as solenoid valve, to prevent the pump's lubricant from being introduced into the system being cleaned due to pump failure.

3. Cleaning Procedure.

a. Before installation, all parts including fittings, piping, etc. must be completely disassembled and cleaned as follows: Note - Valves must be procured for oxygen service, cleaned by the manufacturer for oxygen service and received in plastic bags which are intact.

(1) Prepare cleaning solvent by dissolving 2 pounds of technical grade anhydrous trisodium phosphate or 4.5 pounds of technical grade dodecahydrate trisodium phosphate to each 5 gallons of water. Heat to boiling point.

(2) Place small parts in cleaning bath and soak for at least ten minutes, agitating solution. Scrub with brush until all visible traces of dirt or grease disappear.

(3) Clean large equipment with portable washer by circulating or spraying solution for at least ten minutes after equipment has warmed to solution temperature.

(4) If the shape of the material to be cleaned precludes the use of a brush, use the hydrosteam cleaner. Solution shall be prepared by dissolving 10 oz. of technical grade anhydrous trisodium phosphate or 24 oz. of technical grade dodecahydrate trisodium phosphate per gallon of water.

(5) After cleaning operation, rinse thoroughly with running water at approximately 160°F. Do not re-use rinse water.

(6) Dry with dry, oil-free nitrogen.

(7) Protect equipment against contamination until installed.

b. After installation the assembled systems should be cleaned as follows:

(1) Open ended systems -

(a) Prepare cleaning solution as specified in sub-paragraph II.3.a.(1).

(b) Fill the system with hot cleaning solution using the portable cleaning machine and let stand for a period of at least 30 minutes. Exposures in excess of 30 minutes do not significantly improve oil removal.

(c) Drain the system. During system draining, obtain, in laboratory cleaned containers, the volume of cleaning solution required in Section III. for system inspection.

(d) If the analysis of the cleaning solution reveals that the system is not cleaned to allowable limits, repeat steps (b) and (c) above.

(e) If the analysis of the cleaning solution reveals that the system is within allowable limits, rinse the system thoroughly with running water at approximately 160°F immediately after cleaning. Do not re-use rinse water.

(2) Dead ended systems -

(a) Prepare cleaning solution as specified in sub-paragraph II.3.a.(1).

(b) Evacuate the system to at least 25 inches Hg. and fill the system with hot cleaning solution and let stand for a period of at least 30 minutes. Exposures in excess of 30 minutes do not significantly improve oil removal.

(c) Drain the system by using the vacuum pump and a vacuum tank system. During system draining, obtain, in laboratory cleaned containers, the volume of cleaning solution required in Section III. for system inspection. *

(d) If the analysis of the cleaning solution reveals that the system is not cleaned to allowable limits, repeat steps (b) and (c) above. *

(e) If the analysis of the cleaning solution reveals that the system is within allowable limits, rinse the system by filling and draining the system, in the same manner as with the cleaning solution, with water at approximately 160°F at least two times. Do not re-use rinse water. *

NOTE: If system requires testing, proceed with testing in accordance with specified test procedures. If the system does not require testing, dry the system by purging with dry, oil-free nitrogen and then evacuate to 0.2 inch of mercury absolute. *

c. Cleaning small or delicate equipment. *

(1) For indicating, recording and controlling* equipment or other small or delicate equipment to which cleaning with hot cleaning solvent is not applicable, oxygen system cleaner shall be used. This material shall be used at room temperature and at full strength and, following cleaning operation, equipment dried with oil-free nitrogen. * *

d. Caution.

(1) Trisodium phosphate solutions and O_2 system cleaner are harmful to eyes and skin. If contact occurs, flush area with copious quantities of water. * *

(2) After cleaning of systems, extreme care should be taken to prevent oil or any other contaminants from entering the system. * * *

III. Inspection Procedures.

All oxygen and nitrogen systems are to be inspected for the presence of undesirable contaminants, including oil and phosphate ester lubricants, following each cleaning operation, but prior to flushing. Samples of the cleaning solution drained in sub-paragraph II.b.(1)(c) or II.b.(2)(c) above are to be analyzed by one of the following methods. The first method which uses an infra-red spectrophotometer is preferred due to its higher accuracy and the relative ease with which the sample can be handled. It should be used wherever a dispersive type, 2 to 12 micron range spectrophotometer equipped with sodium chloride prisms and absorption cells of 0.5 mm minimum path length is available. The performance of all the following operations must be accompanied by scrupulous cleanliness and care.

1. Analysis by spectrophotometric means.

a. Take a sample from among the last few gallons of cleaning solution drained from the system in accordance with sub-paragraph II.b.(1)(c) or II.b.(2)(c) above. The sample size is dependent upon the sensitivity of the spectrophotometer used. It should be determined by establishing the weight of hydrocarbon oil which, when dissolved in 5 ml. of carbon tetrachloride (CCl_4)(Spectrophotometer Grade) will reduce the transmission at 3.42 microns by 5 percent. By referring this amount to the allowable limits of 0.2 PPM (by weight) of oil in the used cleaning solution, the sample size can be established.

b. Extract the sample with carbon tetrachloride (CCl_4). The extraction is to be performed in two steps, each utilizing an amount of carbon tectachloride equivalent to one tenth of the cleaning solution sample size, arrived at in a. above.

c. Filter the extract through medium grade filter paper to remove suspended cleaning agent.

d. Over a steam bath evaporate the extract to 5 ml.

e. Repeat steps b, c, and d. above with a sample of unused cleaning solution equivalent in size to the sample in step a.

f. Analyze the concentrated extracts from steps d. and e. in an infra-red spectrophotometer of the type previously specified. This is done by measuring the base line transmission of both extracts at a wave length of 3.42 microns. If the difference in transmission is less than 5%, the system is to be considered clean. If this value is exceeded the system shall be recleaned per sub-paragraph II.b.(1) or II.b.(2) above.

g. Evaporate the extract from step d., including the volume of extract used in the absorption cell during step f., to dryness and redissolve the residue in 5 ml. of carbon disulfide (CS_2)(Caution - Highly Inflammable) and analyze for phosphate ester lubricant. The base line transmission of the extract is to be measured at a wave length of 10.35 microns. No blank sample is needed. If the reduction in transmission from the base line is less than 5% the system contains less than 0.4 PPM of phosphate ester lubricant and is considered clean.

2. Analysis by gravimetric means. This method gives total oil and phosphate ester contamination.

a. Take a 5 liter sample from among the last few gallons of cleaning solution drained from the system in accordance with sub-paragraph II.b.(1)(c) or II.b.(2)(c) above.

b. Extract the sample with 1000 ml. of carbon tetrachloride (CCl_4), in two increments of 500 ml. each.

c. Filter the extract through medium grade filter paper to remove suspended cleaning agent.

d. Repeat steps b. and c. above with a 5 liter sample of unused cleaning solution.

e. Evaporate both extracts to dryness on a steam bath and weigh residues. If the weight of the residue from the used cleaning solution does not exceed the residue weight of the unused solution by more than 1 mg., the system is considered to be clean. If this value is exceeded, the system must be recleaned per sub-paragraph II.b.(1) or II.b.(2) above.

END OF REFERENCE
2

REFERENCE
3

ANON.: CLEANLINESS OF CRYOGENIC SYSTEMS, CLEANING FOR CRYOGENIC FLUIDS. NASA PLUM BROOK STATION RDL-003, MAY 10, 1968.

Title: Cleanliness of Cryogenic Systems, Cleaning for Cryogenic Fluids

1. Introduction:

This procedure is intended to define the required levels of cleanliness for cryogenic systems and fluid used at Plum Brook Station

1.1 Purpose

To establish a cleaning standard for incorporation into Rocket Systems cleaning program contracts. This procedure provides a standardized cleaning specification outlining the cleaning criteria and inspection procedures to assure the desired cleanliness level of components and systems handling liquid and gaseous nitrogen, oxygen, helium and hydrogen. This procedure sets forth cleanliness levels which can be achieved at reasonable cost.

1.2 Implementation

This cleaning standard should replace present contractual documents as rapidly as possible, consistent with the best interest of the Government.

1.3 Scope

This procedure covers: The inspection procedures and permissible contamination limits for individual components of liquid and gaseous oxygen, liquid nitrogen, helium and hydrogen utilized in the Rocket Systems Division at Plum Brook Station.

2. Applicable Publications and Definitions:

a. George C. Marshall Space Flight Center; National Aeronautics and Space Administration Specifications:

MSFC-SPEC-399A	Propellant, Oxygen, July 31, 1967
MSFC-SPEC-234A	Space Vehicle Grade, Nitrogen, July 27, 1967
MSFC-SPEC-364	Propellant, Helium, August 15, 1967
MSFC-SPEC-356A	Space Vehicle Grade, Hydrogen, Jan. 27, 1967

b. Bureau of Mines Standard for Helium:

Grade A 99.995% pure by volume

c. George C. Marshall Space Flight Center Standard for Nitrogen:

(1) Type I Gaseous 99.99% by volume
(2) Type II Liquid 99.99% by volume

Prepared by Alfred A Williams Date 5/10/68

Approved by Dean W. Shibley

d. George C. Marshall Space Flight Center Standard for Oxygen:

Type I & II, Grade A 99.995% by volume

e. George C. Marshall Space Flight Center Standard for Hydrogen:

Type I Gaseous 99.995% by volume

f. Filter Rating

Absolute filter rating specifies removal of all particles and fibers whose smallest diameter is larger than the specified pore size for the filter.

g. System

A collection of components assembled in such a manner as to allow them to interact with each other to perform some specification function.

h. Components

A component is an integral unit, portion of an assembly or system. Examples are tanks, valves, reservoirs and pipes.

i. Fiber

A fiber is defined as any material having a diameter of 40 microns or less and a length to diameter ratio of approximately 10:1 or minimum length of 400μ.

j. Solid Particles

A solid particle is defined as any solid material which cannot be classified as a fiber. The size of a particle shall be determined by its largest dimension.

3. Suggested Cleaning Procedures:

3.1 Procedure I, Cleaning and Passivation Procedure for Carbon Steel

3.1.1 Degrease by flushing with trichloroethylene which meets Federal Specification O-T-634b or with a detergent-water solution between 140° to 160°F.

3.1.2 Rinse with distilled or deionized water if the mild alkaline cleaner was used until the detergent is no longer evident.

3.1.3 Acid clean with technical grade, inhibited hydrochloric acid to meet Federal Specification O-A-86, 20% by volume, until surface area is clean and free of rust and scale.

3.1.4 Rinse with a citric acid solution of 0.02% by weight until the effluent pH is the same as the pH of the influent.

3.1.5 Flush for a minimum period of 30 minutes with a passivation solution composed of 0.5% sodium hydroxide, 0.5% sodium nitrate, 0.25% monosodium phosphate or 0.25% disodium phosphate. The passivation solution is based on percent by weight using distilled or deionized water.

3.1.6 The system shall be drained and immediately dried with dry, hydrocarbon-free nitrogen gas.

3.2 Procedure II, Cleaning and Passivation Procedure for Stainless Steel

3.2.1 Degrease by flushing with trichloroethylene which meets Federal Specification O-T-634b, or with a detergent-water solution between 140° and 160°F.

3.2.2 Rinse with distilled water or deionized water if a mild alkaline cleaner was used until the detergent is no longer evident.

3.2.3 Flush the system with 3 to 5% solution by volume of HF. Rinse with deionized water.

3.2.4 Flush with a solution of 35% to 45% technical grade nitric acid by weight with deionized water for approx. 30 minutes.

3.2.5 Rinse with deionized water until the pH of the effluent is equal to the pH of the influent water.

3.2.6 The system shall be drained and immediately dried with clean, dry hydrocarbon-free nitrogen. The filters between the transporting trailer and the storage tanks shall be capable of removing all particles greater than the limits set forth herein.

If the above procedures aren't adequate to clean to the indicated levels, the contractor shall present an alternate cleaning procedure for approval. The contractor procedures shall guarantee the levels of contamination set forth herein without damage to NASA's equipment.

4. Components Inspection:

Cleanliness of components shall be verified by the procedures of Inspection Number 1, 2, 3, and 4 as specified below. Inspection Number 1 (utilizing the solvent rinse method) shall be used for detecting particle size and quantity. Inspection Number 4 shall be resorted to as a means of inspection only in those instances where Inspection Number 1 and Number 3 are impossible or impractical. All piping and tubing shall be Millipore tested for cleanliness. If a component fails to pass inspection, the component shall be recleaned at the expense of the contractor. Total hydrocarbon contamination shall be specified in Inspection Number 5 (Reference 3).

a. Inspection No. 1 - Particles Inspection:

Inspection of cleaned components shall be performed by solvent rinse method where possible. This will generally be accomplished during the final cleaning stages and just prior to drying operation. The effluent shall be examined for particles by the Millipore method (Reference 4).

If any sample fails to meet the requirements specified herein, a second sample, twice the size of the first, shall be selected and tested. If any item from the second sample fails to meet the requirements specified herein, the entire lot represented by the sample shall be rejected.

Permissible contamination limits for all components shall be as follows, with cleanliness ascertained by flush or solvent rinse test:

Oxygen

Solid Particles	Number of Particles per 100 cc Sample Millipore Test
5-50μ	unlimited
51-100μ	40
101-150μ	18
151-350μ	5
> 350μ	none

Fiber Particles

up to 25μ diameter

0-500μ	20
501-1000μ	3
1001-1875μ	1
> 1875μ	none

Hydrocarbons

none

Total Solids and Fibers

2.5 mg per sq ft

Nitrogen

Solid Particles	Number of Particles per 100 cc Sample Millipore Test
0-50μ	unlimited
51-100μ	115
101-200μ	10
201-350μ	5
> 350μ	0

Fiber Particles

up to 25μ diameter

0-500μ	10
501-1000μ	2
1001-2000μ	1
> 2000μ	0

26 to 40 microns diameter

0-500μ	4
501-800μ	2
801-1000μ	1
> 1000μ	0

Hydrocarbons

none

Total Solids and Fibers

2.5 mg per sq ft

Helium

Solid Particles	Number of Particles per 100cc Sample Millipore Test
0-50μ	unlimited
51-100μ	145
101-250μ	6
251-400μ	3
> 400μ	1

Fiber Particles

up to 25μ diameter

0-500μ	10
501-1000μ	5
1001-2000μ	1
> 2000μ	0

26 to 40 microns diameter

0-500μ	8
501-1000μ	3
1001-1500μ	1
> 1500μ	0

Hydrocarbons

none

Total Solids

2.5 mg per sq ft

Hydrogen

Solid Particles	Number of Particles per 100cc Sample Millipore Test
0-50μ	unlimited
51-150μ	210
151-300μ	45
301-400μ	8
> 400μ	1

Fiber Particles

up to 25μ diameter

0-500μ	12
501-1000μ	7
1001-2500μ	4
2501-3500μ	1
> 3500μ	0

26 to 40 microns diameter

0-500μ	8
501-1000μ	2
1001-2500μ	1
> 2500μ	0

Hydrocarbons

none

Total Solids and Fibers

3.0 mg per sq ft

b. Inspection No. 2 - Visual:

All equipment pipes and components shall be examined for evidence of corrosion products, metal chips, scales, weld scales, oil, grease, paints, preservatives, or other contamination of foreign matter (Reference 4).

c. Inspection No. 3 - Ultraviolet ("black light"):

Visual inspection with the aid of an ultraviolet light source 2500 to 3700 o/A units shall be accomplished on all accessible surfaces to determine the presence of petroleum-type hydrocarbon (Reference 4).

d. Inspection No. 4 - Wipe Test:

The wipe test shall be made on the interior surface of each component using a new, clean filter paper (Whatman No. 42, S and S 602, or equal. This test shall consist of at least two movements of the filter paper across one square foot of surface. No fluorescence shall be observed with the filter paper wipe sample subject to the previously described ultraviolet inspection (Reference 4).

f. Inspection No. 5 (referee tests):

Infrared and/or Gravimetric Quantitative Measurements for Non-Volatile Hydrocarbons in LOX System Components:

(1) This test is applicable only to cleaned components and is not to be utilized to determine system cleanliness. The permissible non-volatile hydrocarbon contamination in any component tested in conformance with this procedure shall not exceed 2.5 milligrams per square foot of component internal surface area. In case the exact surface area cannot be computed, the internal surface area shall be estimated. Reference for determination of hydrocarbon is Chemistry Procedure #3-17A (Reference 7).

(2) Each component or component package which has been processed in accordance with this specification shall have attached evidence showing it meets cleanliness requirements. Evidence shall consist of tags, label or stamp incorporating the appropriate part cleanliness identification, reference, the date of acceptance and the name or stamp of the responsible inspection (Reference 4).

5. References:

1. George C. Marshall Space Flight Center Specification "Cleanliness of Components for Use in Oxygen, Fuel and Fluid Systems" (MSFC 164).

2. Applied Cryogenic Engineering Series, Edited by R.W. Vance and W.M. Duke.

3. Aerojet-General - Sacramento Plant (A.E.T. Specification Number 7900-0006; August 1964).

4. Permissible Contamination Limits and Inspection Criteria for Liquid Oxygen, Nitrogen, RP-1 Fuel, Gaseous Oxygen, Nitrogen Instrument Air and Helium Components and Handling Systems; prepared by HQ Air Force Ballistic Systems Division, March 5, 1962.

5. John F. Kennedy Space Center: National Aeronautics and Space Administration Specification Title: Cleanliness Levels, Cleaning, Protection and Inspection Procedures for Parts, Filled Parts, Assemblies, Subsystems and Systems for Fluids Used in Support Equipment, KSC-C-123(D), amendment 3, July 12, 1965.

6. Memorandum to Chief, Rocket Systems Division, from Alfred Williams, Radiochemistry Section, dated October 23, 1967 (LAF-1394): "A Reasonable and Workable Specification for a LN_2 System Consisting of Tanks, Valves, and Pipelines".

7. Chemistry-Radiochemistry Procedures Manual for NASA, Reactor Division, Plum Brook Station, March 1, 1967.

8. Chemical Process Specifications and Procedures, Rocketdyne (North American Aviation, Inc.) FL11-5-1096, April 1965 (revision).

END OF REFERENCE
3

REFERENCE
4

ANON.: CLEANING PROCEDURES 05.04 AND QCL'S. AIR PRODUCTS, JULY 1, 1971.

Air Products and Chemicals

QUALITY CONTROL LAYOUT

III B

I-B-C CLEANING

Number: QCL 101F
Effective: 7/1/71
Page: 1 of 2
Supersedes: 4/14/69

CLEANING REQUIREMENTS FOR AIR PLANT EQUIPMENT

I. PURPOSE AND SCOPE

This QCL lists the cleaning classifications which will apply to components and/or circuits of air plants to provide adequate cleanliness.

Where special requirements apply to an item and/or assembly, they shall take precedence over this QCL.

II. GENERAL

There are four classifications used by Air Products and Chemicals, Inc. to indicate specific degrees of cleanliness. These classifications - listed in decreasing order of magnitude - are identifed as Class AAA, Class AA, Class A and Class B. They are defined as follows:

A. Class AAA cleaning. Class AAA is the most stringent standard cleaning classification. It is normally appled to reciprocating compressors, pumps, valves, etc., which will, thru use, contact liquid or gaseous oxygen. Acceptance criteria for Class AAA cleaning are listed in QCL 107F and QCL 116F.

B. Class AA cleaning. Class AA is the more generally applied standard cleaning classification. It is applied to most shop fabricated or purchased equipment where fixed surfaces will, thru use, contact liquid or gaseous oxygen. Acceptance criteria for Class AA cleaning are listed in QCL 106F and QCL 116F.

C. Class A cleaning. Class A is the most relaxed standard cleaning classification applied to equipment which will, thru use, contact an oxygen rich atmosphere or a product fluid. Acceptance criteria for Class A cleaning are listed in QCL 105F and QCL 115F.

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APCI DOCUMENT NO. 99-000772

(NOTE: Equipment intended for a pure product fluid service rather than oxygen [such as nitrogen] that may, thru use, be converted to liquid or gaseous oxygen service shall be cleaned to the proper classification of oxygen cleaning.)

D. Class B cleaning. Class B is the standard cleaning classification which is normally applied to equipment which will not contact liquid air, oxygen enriched atmosphere or product fluids. Acceptance criteria for Class B cleaning are listed in QCL 104F and QCL 114F.

III. APPLICATION

A. Proper application of cleaning classifications will be determined from the following:

1. QCL's 104F, 105F, 106F and 107F are normally applied to materials cleaned by Air Products and Chemicals, Inc.
2. QCL's 114F, 115F, 116F and 117F will apply when the material is cleaned by the supplier.

B. Specified cleaning classifications for various circuits and/or components are listed in the attachment to this QCL.

ATTACHMENT TO QCL 101F

	REQUIRED CLEANING			
Vendor Cleaned	117F	116F	115F	114F
APCI Cleaned	107F	106F	105F	104F
	AAA	AA	A	B
1. Air Circuit				
1.1 Air Drier				B
1.2 Carbon Dioxide Adsorbers				B
1.3 Caustic Purifiers				B
1.4 Compressors				
1.4.1 Coolers				B
1.4.2 Separators				B
1.4.3 Surge Tanks				B
1.4.4 Condensate Traps				B
1.5 Condensate Traps				B
1.6 Exchangers				
1.6.1 Air Precoolers				B
1.6.2 Freon-Air Exchangers				B
1.6.3 Main Air Exchangers				B
1.7 Expanders				
1.7.1 Expander Oil Adsorbers				B
1.8 Filters				
1.8.1 Air Drier Filters				B
1.8.2 Expander Oil Adsorber Filters				B
1.9 Piping Upstream of A-1				B
1.10 Regenerators				B
1.11 Separators				B
1.12 Valves up to the A-1 Valve				B

	REQUIRED CLEANING			
Vendor Cleaned	117F	116F	115F	114F
APCI Cleaned	107F	106F	105F	104F
	AAA	AA	A	B
2. Liquid Air Circuits				
2.1 Piping downstream of A-1 Valve up to the high pressure column			A	
2.2 Receivers			A	
2.3 Valves including A-1 valve and up to the high pressure column	AAA			
3. Crude Oxygen or Oxygen Enriched Circuits				
3.1 CO2 Filters and Adsorbers (Crude Oxygen Circuit)			A	
3.2 High Pressure Column Components and Assembly			A	
3.3 Hydrocarbon Adsorbers			A	
3.4 Subcoolers, Crude O2 Side			A	
3.5 Phase Separators			A	
3.6 Piping up to the Hydrocarbon Adsorber Inlet			A	
3.7 Valves up to the Hydrocarbon Adsorbers	AAA			
3.8 Piping downstream of the Hydrocarbon Adsorbers			A	
3.9 Valves downstream of the Hydrocarbon Adsorbers	AAA			
3.10 Expanders processing Oxygen Enriched Air		AA		
4. Liquid and Gaseous Oxygen Circuits				
4.1 Column Components and Column Assembly		AA		
4.2 Charging Manifolds		AA		
4.3 Compressors				
4.3.1 Reciprocating	AAA			
4.3.2 Centrifugal		AA		

	REQUIRED CLEANING			
Vendor Cleaned	117F	116F	115F	114F
APCI Cleaned	107F	106F	105F	104F
	AAA	AA	A	B
4.4 Expanders		AA		
4.5 Instrumentation				
4.5.1 Flowmeters (Turbine or Displacement)	AAA			
4.5.2 Rotameters	AAA			
4.5.3 Others		AA		
4.6 Phase Separators		AA		
4.7 Pumps	AAA			
4.8 Piping		AA		
4.9 Reboiler Condensers				
4.9.1 Pot Type		AA		
4.9.2 Thermo Siphon		AA		
4.10 Storage Tanks (Inner Surface)		AA		
4.10.1 Double Jacketed Tanks (Outer Surface of Inner Tank and Inner Surface of Outer Tank -Particle Size Requirements are Waived)			A	
4.11 Storage Tubes		AA		
4.12 Subcoolers		AA		
4.13 Valves (Check, Control, Hand and Safety)	AAA			
4.14 Vaporizers		AA		
4.15 Vents			A	
5. Nitrogen Circuits				
5.1 Reactivation Circuits				

	REQUIRED CLEANING			
Vendor Cleaned	117F	116F	115F	114F
APCI Cleaned	107F	106F	105F	104F
•	AAA	AA	A	B
5.1.1 Drier and Oil Adsorber Reactivation Heater and Piping				B
5.1.2 CO2 and Hydrocarbon Adsorber Reactivation Heater and Piping			A	
5.2 Nitrogen Side of Reboiler Condensers			A	
5.3 Nitrogen Phase Separators and piping supplying Reflex to the Column			A	
5.4 Subcoolers, Reflux Nitrogen			A	
5.5 Other Piping				B
6. Defrost Circuits				
6.1 Heater			A	
6.2 Piping (Circuits should be cleaned to the cleanliness required by the circuit to be defrosted.)				
6.3 Vent Stacks				
7. By-Products Circuits (Argon and Others)				
7.1 Columns			A	
7.2 Condensers			A	
7.3 Piping			A	
7.4 Separators			A	
7.5 Valves	AAA			
8. Pure Product Circuits (Other than Oxygen)				
8.1 Instrumentation		AA		
8.2 Charging Manifolds			A	
8.3 Piping			A	

		REQUIRED CLEANING			
	Vendor Cleaned	117F	116F	115F	114F
	APCI Cleaned	107F	106F	105F	104F
		AAA	AA	A	B
8.4	Storage Tanks			A	
8.5	Storage Tubes			A	
8.6	Pumps		AA		
8.7	Vaporizers			A	
8.8	Valves	AAA			
9.	Service Circuits				
9.1	Refrigeration				B
9.2	Steam				B
9.3	Water				B

CLEANING REQUIREMENTS FOR BOURDON TUBE TYPE GAGES USED FOR OXYGEN SERVICE

I. PURPOSE AND SCOPE

This standard lists the cleaning requirements for bourdon tube type gages used in liquid or gaseous oxygen circuits. It applies whenever a specification or order requires that this type gage be cleaned for oxygen service.

II. CLEANING SOLVENTS

A. Technical grade methylene chloride or neutral, stabilized trichlorethylene shall be used to clean.

B. Use of other solvents will require written approval from Quality Control or the Safety Department prior to cleaning.

III. PROCEDURE

A. Use any method which will insure complete tube fill, total solvent removal, and which will allow analysis of the effluent. Suggested procedure to accomplish manual cleaning is as follows:

1. Place the gage so that the presssure inlet is facing up.
2. Use a hypodermic needle with graduated syringe to accomplish fill. Gently tap the gage during the operating to encourage fill.
3. Empty the solvent into a clean graduated container. Compare the amount of solvent removed with the quantity introduced (2 above) to determine complete removal.
4. Examine the effluent for contamination. Continue the cleaning process until acceptance (per par. IV) is possible.

APCI DOCUMENT NO. 9-6000-78

CLEANING REQUIREMENTS
FOR BOURDON TUBE TYPE GAGES USED FOR OXYGEN SERVICE

IV. QUALITY REQUIREMENTS

A. In a darkended area, use ultrviolet light (3200 to 4000 a.u. wavelength) to examine the effluent. Compare the result with an ultraviolet examination of a sample of unused solvent. A noticeable increase in fluorescence of the used solvent will require that additional cleaning be performed.

B. After the effluent is determined hydrocarbon free (per A above), pass the used solvent thru a filter to detect the amount and size of solid matter in the solvent. Use Whatman #44, or equal, filter paper.

C. After the solvent has completely evaporated from the filter paper, examine the residue. Solid matter is limited to:

1. No particle larger 1000 microns (.040") in size. A particle is defined as any solid matter other than a fiber. The size is determined by the longest single dimension.
2. Not more than five particles between 500 and 1000 microns.
3. No fiber in excess of 2000 microns in length, and no accumulation of fibers. A fiber is defined as a nonmetallic, flexible, thread-like structure with a length to diameter ratio of at least 10.

D. When the effluent is found acceptable, purge the bourdon tube with dry, oil free air or nitrogen. Sniff the inlet after purge to determine solvent removal.

CLEANING REQUIREMENTS
FOR BOURDON TUBE TYPE GAGES USED FOR OXYGEN SERVICE

V. SEAL AND IDENTIFICATION

Gages cleaned in accordance with this standard shall be labeled to indicate oxygen service cleanliness, and require suitable seal to prevent contamination.

1. Seal shall consist of a nondeteriorating, inert, greaseless barrier material.
2. The cleanliness label shall not interfere with usability of the gage.

Air Products and Chemicals

QUALITY CONTROL LAYOUT

Number: QCL 104F
Effective: 7/1/71
Page: 1 of 1
Supersedes: 4/14/69

CLASS B CLEANLINESS REQUIREMENTS

I. PURPOSE

To list acceptance criteria for product cleaned to Class B by Air Products and Chemicals, Inc.

II. SCOPE

The requirements of the standard apply to surfaces which thru use do not contact liquid air, oxygen enriched atmosphere or product fluids. Materials, components and/or assemblies of process equipment with specified Class B cleaning, or with no cleaning requirement listed, will be determined acceptable by this standard.

III. QUALITY REQUIREMENTS

The Plant Inspection Supervisor will insure adequate cleanliness. Visual inspection of the direct surface under bright white light shall indicate:

A. No evidence of moisture.

B. No accumulation of loose rust, scale or other foreign matter.

C. Free of easily visible films or accumulations of organic materials, such as oil, grease, paint and similar materials.

IV. RELATED PROCEDURES

QCL 101F lists correct application of this standard for air plant components.

FORM 6020

APCI DOCUMENT NO. 920000 72

CLASS A CLEANLINESS REQUIREMENTS

I. PURPOSE

To list criteria to be used for acceptance of product cleaned to Class A by Air Products and Chemicals, Inc.

II. SCOPE

The requirements of this standard apply to surfaces which thru use contact fluid other than pure oxygen. Examples are: argon, liquid air, crude oxygen, hydrogen, nitrogen, etc.

III. RESPONSIBILITY

A. The Manager of the Engineering Department specifying product design is responsible to list on drawing and/or specification, the need for Class A cleaning as appropriate.

B. The Manager of Quality Control is responsible to assure conformance of application.

IV. PROCEDURE

The Plant Inspection Supervisor will use the following approved methods, as necessary, to determine adequate cleanliness. Other methods which experience shows more efficient or economical may be used with prior approval from Quality Control.

1. Accessible Surfaces

a. Examine the surface under bright white light for visible contamination.

b. Examine the surface under ultraviolet light (3660 a.u. wavelength) for organic contamination.

FORM 6540

APCI DOCUMENT NO. 2200820

c. Wipe the surface with clean filter paper or lint-free cloth and examine for contamination.

2. Inaccessible Surfaces

Flush the surface, filter the effluent, and examine the residue.

V. QUALITY REQUIREMENTS

A. Visual examination of the direct surface under strong white light shall indicate:

1. No evidence of moisture.
2. Free of loose (or potentially loose) rust, scale or other foreign matter.
3. Free of slag and weld spatter.
4. Essentially free of organic material, such as oil, grease, crayon, paint, etc.

B. Ultraviolet (3660 a.u. wavelength) examination shall show the surface:

1. Essentially free of fluorescence. Isolated particles of lint and small area of low intensity fluorescence are acceptable.

C. Wipe test (using Whatman #44, or equal, filter paper or lint free cloth) examination by rubbing lightly over the surface shall indicate:

1. No appreciable discoloration of the wiping media except that which is due to oxidation of the parent metal.
2. No evidence of oily residue.

CLASS A CLEANLINESS REQUIREMENTS

D. Particle population per square foot of surface tested must conform to the limits listed below. (A 100 ml. - approximately 3.5 oz. - sample of flush solution may be considered as representing the rinse of one square foot of enclosed surface.) Contamination per square foot is limited to:

1. No particle larger than 1500 microns (approx. 1/16 inch). A particle is defined as any solid matter other than a fiber. The size is determined by the longest single dimension.
2. Not more than ten particles between 750 and 1500 microns.
3. No fiber in excess of 6000 microns (approx. 1/4 inch), and no accumulation of fibers. A fiber is defined as a nonmetallic, flexible, threadlike structure with a length to diameter ratio of at least 10.

VI. RELATED FORMS

A. Record of an inspection will be listed on Form 1086, or the product may be indicated as acceptable for cleanliness on a related check sheet, if prepared, for the assembly.

B. Form 6561 will be used as label to indicate the degree of cleanliness established when such information is necessary in the field.

VII. RELATED PROCEDURES

QCL 101F lists the correct cleaning level to be applied to cryogenic components.

CLASS AA CLEANLINESS REQUIREMENTS

I. PURPOSE

To list criterial to be used for acceptance of product cleaned to Class AA by Air Products and Chemicals, Inc.

II. SCOPE

The requirements of this standard apply to fixed surfaces which thru use contact pure oxygen.

III. RESPONSIBILITY

A. The Manager of the Engineering Department specifying product design is responsible to list on drawing and/or specification the need for Class AA cleaning as appropriate.

B. The Manager of Quality Control is responsible to assure conformance of application.

IV. PROCEDURE

The Plant Inspection Supervisor will use the following approved methods as necessary to determine adequate cleanliness. Other methods which experience shows to be more efficient or economical may be used with prior approval from Quality Control.

1. Accessible Surfaces

a. Examine the surface under bright white light for visible contamination.

b. Examine surface under ultrviolet light (3660 a.u. wavelength) for organic contamination.

c. Wipe surface with clean filter paper or lint free cloth and examine for contamination.

APCI DOCUMENT NO. 99000 81

d. Rinse surface with clean solvent and examine the effluent for contamination.

2. Inaccessible Surface

a. Flush the surface, filter the effluent, and examine the residue.

V. QUALITY REQUIREMENTS

A. Visual examination of the direct surface under strong white light shall indicate:

1. No evidence of moisture.

2. Essentially free of corrosion products.

3. Free of scale, slag, weld spatter and other foreign matter.

4. Free of organic material such as oil, grease, crayon, paint, etc.

B. Ultraviolet (3660 a.u. wavelength) inspection shall indicate:

1. No hydrocarbon fluorescence.

2. Isolated particles of lint are acceptable.

C. Wipe test (using Whatman #44, or equal, filter paper or lint free cloth) examination by rubbing lightly over the surface shall indicate:

1. No appreciable discoloration of the wiping media, except that due to oxidation of the parent metal.

2. No evidence of oily residue (not detectable by A or B above).

D. Particle population per square foot of surface tested must conform to the limits listed below. (A 100 ml. - approximately 3.5 oz. - sample of flush solution may be considered as representing the rise of one square foot of enclosed surface). Contamination per square foot is limited to:

CLASS AA CLEANLINESS REQUIREMENTS

1. No particle larger than 1000 microns. A particle is defined as any solid matter other than a fiber. The size is determined by the longest single dimension.
2. Not more than ten particles between 500 and 1000 microns.
3. No fiber in excess of 2000 microns in length, and no accumulation of fibers. A fiber is defined as a nonmetallic, flexible, thread-like structure with a length to diameter ratio of at least 10.

VI. RELATED FORMS

A. Record of an inspection will be listed on Form 1086; or the product may be indicated as acceptable for cleanliness on a related check sheet, if prepared, for the assembly.

B. Form 6561 will be used as label to indicate the degree of cleanliness established when such information is necessary in the field.

VII. RELATED PROCEDURES

QCL 101F lists the correct cleaning level to be applied to cryogenic components.

Air Products and Chemicals

QUALITY CONTROL LAYOUT

Number: QCL 107F
Effective: 7/1/71

Supersedes: 4/14/69

CLASS AAA CLEANLINESS REQUIREMENTS

I. PURPOSE

To list criteria to be used for acceptance of product cleaned to Class AAA by Air Products and Chemicals, Inc.

II. SCOPE

The requirements of this standard apply to components with movable parts which thru use contact liquid or gaeous oxygen. Valves in pure product circuits other than oxygen; and in by-product (argon and others) circuits are included.

III. RESPONSIBILITY

A. The Manager of the Engineering Department specifying product design is responsible to list on drawing and/or specification, the need for Class AAA cleaning as appropriate.

B. The Manager of Quality Control is responsible to assure conformance of application.

IV. PROCEDURE

The Plant Inspection Supervisor will use the following approved methods as necessary to determine adequate cleanliness. Other methods which experience shows to be more efficient or economical may be used with prior approval from Quality Control.

1. Accessible Surfaces

a. Examine the surface under bright white light for visible contamination.

b. Examine surface under ultraviolet light (3660 a.u. wavelength) for organic contamination.

FORM 6520

APCI DOCUMENT NO. 9000082

c. Wipe surface with clean filter paper or lint free cloth and examine for contamination.

d. Rinse surface with clean solvent and examine the effluent for contamination.

2. Inaccessible Surface

a. Flush the surface, filter the effluent, and examine the residue.

V. QUALITY REQUIREMENTS

A. Visual examination of the direct surface under strong white light shall indicate:

1. No evidence of moisture.

2. Free of corrosion, scale, slag, weld spatter, and other foreign matter.

3. Free of organic materials, such as oil, grease, crayon, paint ink, etc.

B. Ultraviolet (3660 a.u. wavelength) inspections shall indicate:

1. No hydrocarbon fluorescence.

2. Complete removal of lint. If present, use nitrogen or dry oil-free air for removal.

C. Wipe test (using Whatman #44, or equal, filter paper or lint free cloth) examination by rubbing lightly over the surface shall indicate:

1. No appreciable discoloration of the wiping media.

2. No evidence of oily residue (not detectable by A or B above).

CLASS AAA CLEANLINESS REQUIREMENTS

D. Filter (millipore) test must indicate:

1. Only mild discoloration of the filter.

2. Particulate contamination within the limits specified in E below.

E. Particle population per square foot of surface tested must conform to the limits listed below. (A 100 ml. - approximately 3.5 oz. - sample of flush solution may be considered as representing the rinse of one square foot of enclosed surface). Contamination per square foot is limited to:

1. No particle greater than 500 microns. A particle is defined as any solid matter other than a fiber. The size is determined by the longest single dimension.

2. Not more than 25 particles between 175 and 500 microns.

3. No fiber in excess of 2000 microns in length, and no accumulation of fibers. A fiber is defined as a nonmetallic, flexible, threadlike structure with a length to diameter ratio of at least 10.

VI. RELATED FORMS

A. Record of an inspection will be listed on Form 1086, or the product may be indicated as acceptable for cleanliness on a related check sheet, if prepared, for the assembly.

B. Form 6561 will be used as label to indicate the degree of cleanliness established when such information is necessary in the field.

VII. RELATED PROCEDURES

QCL 101F lists the correct cleaning level to be applied to components of cryogenic equipment.

Air Products and Chemicals

QUALITY CONTROL LAYOUT

Number: QCL 114F
Effective: 7/1/71
Page: 1 of 2
Supersedes: 4/14/69

REQUIREMENTS FOR VENDOR CLASS B CLEANING

I. PURPOSE

This standard lists the acceptance criteria for product cleaned by a vendor to Class B.

II. SCOPE

These requirements normally apply to surfaces which thru use will not contact liquid air, oxygen enriched atmosphere or product fluids. Examples are: surfaces in air, refrigeration or similar circuits.

III. GENERAL

A. Solvents used for cleaning shall be of commercially approved grade and/or type. Cleaning may be accomplished by any method, or combination of methods, which will provide acceptable result.

B. Cleaned systems shall be drained and thoroughly purged of cleaning media.

C. Flux residue shall be removed from brazed and soldered connections of assemblies.

D. Pressure test of assemblies, if performed after cleaning, may be accomplished with tap water (fit for drinking) or shop air. Systems tested hydrostatically shall be throughly dried.

IV. QUALITY REQUIREMENTS

Visual inspection of the direct surface under bright white light shall indicate:

1. No evidence of moisture.

2. No accumulation of rust, scale or other foreign matter.

FORM 6520

APCI DOCUMENT NO. 9900083

REQUIREMENTS FOR VENDOR CLASS B CLEANING

3. Free of easily visible films or concentrations of organic materials such as oil, grease, paint or similar materials.

V. SEALING

Cleaned surfaces shall have sufficient protection to maintain established cleanliness.

Air Products and Chemicals

QUALITY CONTROL LAYOUT

Number: QCL 115F
Effective: 7/1/71
Page: 1 of 2
Supersedes: 4/14/69

REQUIREMENTS FOR VENDOR CLASS A CLEANING

I. PURPOSE

This standard lists the acceptance criteria for product cleaned by a vendor to Class A.

II. SCOPE

These requirements apply to surfaces which thru use contact fluid other than pure oxygen. Examples are: argon, liquid air, crude oxygen, hydrogen, nitrogen, etc.

III. GENERAL

A. Solvents used for cleaning shall be of commercially approved grade and/or type. Cleaning may be accomplished by any method, or combination of methods, which will provide acceptable result.

B. Cleaned systems shall be drained and thoroughly purged of cleaning media.

C. Flux residue shall be removed from brazed and soldered connections of assemblies.

D. Pressure test of assemblies, if performed after cleaning, will be accomplish with water (fit for drinking), or dry, oil-free air or nitrogen. Systems tested hydrostatically shall be thoroughly dried.

IV. QUALITY REQUIREMENTS

A. Visual examination of the direct surface under strong white light shall indicate:

1. No evidence of moisture.
2. Free of loose (or potentially loose) rust, scale or other foreign matter.
3. Free of slag and weld spatter.
4. Essentially free of organic material, such as oil, grease, crayon, paint, etc.

AIR PRODUCTS DOCUMENT NO. 990008

REQUIREMENTS FOR VENDOR CLASS A CLEANING

B. Ultraviolet (3660 a.u. wavelength) examination shall show the surface:

1. Essentially free of fluorescence. Isolated particles of lint and small are? of low intensity fluorescence are acceptable. ✓

C. Wipe test (using Whatman #44, or equal, filter paper or lint free cloth) examination by rubbing lightly over the surface shall indicate:

1. No appreciable discoloration of the wiping media except that which is due to oxidation of the parent metal.
2. No evidence of oily residue.

D. Particle population per square foot of surface tested is limited to:

1. No particle larger than 1500 microns (approx. 1/16 inch). A particle is defined as any solid matter other than a fiber. The size is determined by the longest single dimension.
2. Not more than ten particles between 750 and 1500 microns.
3. No fiber in excess of 6000 microns (approx. 1/4 inch), and no accumulation of fibers. A fiber is defined as a non-metallic, flexible, threadlike structure with a length to diameter ratio of at least 10.

V. SEALING

The cleaned surface of components shall be protected against contamination by use of inert, vapor free, greaseless barrier materials.

VI. MARKING

Material cleaned to this standard shall be labeled 'Cleanded to Class A.'

REQUIREMENTS FOR VENDOR CLASS AA CLEANING

I. PURPOSE

This standard lists the acceptance criteria for product cleaned by a vendor to Class AA.

II. SCOPE

These requirements apply to fixed surfaces which thru use come in contact pure oxygen.

III. GENERAL

A. Solvents used for cleaning shall be of commercially approved garde and/or type. Cleaning may be accomplished by any method, or combination of methods, which will provide acceptable result.

B. Cleaned systems shall be drained and thoroughly purged of cleaning media.

C. Flux residue shall be removed from brazed, soldered and welded joints of assemblies.

D. Pressure test of assemblies, if performed after cleaning, will be accomplished with filtered (as necessary to maintain required cleanliness) water, nitrogen, or dry, oil-free air. Systems tested hydrostatically shall be thoroughly dried.

IV. QUALITY REQUIREMENTS

A. Visual examination of the direct surface under strong white light shall indicate:

1. No evidence of moisture.
2. Essentially free of corrosion products.
3. Free of scale, weld spatter and other foreigh matter.
4. Free of organic material such as oil, grease, crayon, paint, etc.

B. Ultraviolet (3660 a.u. wavelength) inspection shall indicate:

FORM 6520

AIR PRODUCTS AND CHEMICALS, INC. NO. 616330

REQUIREMENTS FOR VENDOR CLASS AA CLEANING

1. No hydrocarbon fluorescence.

2. Isolated particles of lint are acceptable.

C. Wipe test (using Whatman #44, or equal, filter paper or lint free cloth) examination by rubbing lightly over the surface shall indicate:

1. No appreciable discoloration of the wiping media.

2. No evidence of oily residue (not detectable by A or B above).

D. Particle population per square foot of surface tested is limited to:

1. No particle larger than 1000 microns. A particle is defined as any solid matter other than a fiber. The size is determined by the longest single demension.

2. Not more than ten particles between 500 and 1000 microns.

3. No fiber in excess of 2000 microns in length, and no accumulation of fibers. A fiber is defined as a nonmetallic, flexible, thread-like structure with a length to diameter ratio of at least 10.

V. SEALING

The cleaned surface of components shall be protected against moisture or contamination with suitable inert, vapor-free, greaseless barrier material.

VI. MARKING

Material cleaned to this standard shall be labeled 'Cleaned to Class AA'.

Air Products and Chemicals

QUALITY CONTROL LAYOUT

Number: QCL 117F
Effective: 7/1/71
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REQUIREMENTS FOR VENDOR CLASS AAA CLEANING

I. PURPOSE

This standard lists the acceptance criteria for product cleaned by a vendor to Class AAA.

II. SCOPE

These requirements apply to components with movable parts which thru use contact liquid or gaseous oxygen. Valves in pure product circuits other than oxygen, and in by-product (argon and others) circuits are included.

III. GENERAL

A. Solvents used for cleaning shall be of commercially approved grade and/or type. Cleaning may be accomplished by any method, or combination of methods, which will provide acceptable result.

B. Cleaned systems shall be drained and thoroughly purged of cleaning media.

C. Flux residue shall be removed from brazed, soldered and welded joints of assemblies.

D. Pressure test of assemblies, if performed after cleaning, will be accomplished with filtered (as necessary to maintain required cleanliness) water, nitrogen, or dry, oil-free air. Systems tested hydrostatically shall be thoroughly dried.

IV. QUALITY REQUIREMENTS

A. Visual examination of the direct surface under strong white light shall indicate:

1. No evidence of moisture.

2. Free of corrosion, scale, slag, weld spatter and other foreign matter.

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REQUIREMENTS FOR VENDOR CLASS AAA CLEANING

3. Free of organic materials, such as oil, grease, crayon, paint, ink, etc.

B. Ultraviolet (3660 a.u. wavelength) inspection shall indicate:

1. No hydrocarbon fluorescence.

2. Complete removal of lint. If present, use nitrogen or dry, oil-free air for removal.

C. Wipe test (using Whatman #44, or equal, filter paper or lint free cloth) examination by rubbing lightly over the surface shall indicate:

1. No appreciable discoloration of the wiping media.

2. No evidence of oily residue (not detectable by A or B above).

D. Filter (millipore) test must indicate:

1. Only mild discoloration of the filter membrane.

2. Particulate contamination within the limits specified in E below.

E. Particle population per square foot of surface tested is limited to:

1. No particle greater than 500 microns. A particle is defined as any solid matter other than a fiber. The size is determined by the longest single dimension.

2. Not more than twenty-five particles between 175 and 500 microns.

3. No fiber in excess of 2000 microns in length, and no accumulation of fibers. A fiber is defined as an nonmetallic, flexible, thread-like structure with a length to diameter ratio of at least 10.

REQUIREMENTS FOR VENDOR CLASS AAA CLEANING

V. SEALING

The cleaned surface of components shall be protected against moisture or contamination with nondeteriorating, inert, vapor-free, greaseless barrier material. Wood and paper barriers are not acceptable.

VI. MARKING

Material cleaned to this standard shall be labeled 'Cleaned to Class AAA'.

Air Products and Chemicals

QUALITY CONTROL LAYOUT

Number: QCL 119F
Effective: 7/1/71
Page: 1 of 2
Supersedes: 4/14/69

BRAZED ALUMINUM HEAT EXCHANGER CLEANING REQUIREMENTS

I. PURPOSE

This standard lists the controls and defines the acceptance criteria for insuring cleanliness of brazed aluminum heat exchangers as specified in APCI purchase order.

II. QUALITY CHECK POINTS

A. Cleanliness of raw materials.

B. In-process braze of assembly.

C. Periodic cleaning of braze bath.

D. Wash and rinse of assembly.

E. Test for cleanliness of streams.

F. Quality tests of assembly.

III. PROCEDURE

A. Core construction materials will be cleaned of hydrocarbon contamination before core stacking.

B. Braze operations will be controlled to minimize dragout of the braze bath materials.

C. Periodic cleanout of the braze bath will be performed to control the buildup of sludge.

D. Wash and rinse solutions, and their length of application, will be controlled by standard vendor procedure to assure conformance to limits of halide count and surface neutrality.

E. Each stream of a core shall be determined acceptable by testing a water flush sample.

1. Halide count (after correction for blank) must not exceed 5 ppm.

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APCI DOCUMENT NO. 9000027

2. pH value must be between 6.0 and 8.0.

3. A millipore filtered sample shall contain not more than 2 mg of solid residue per 100 ml of water sample. Filtration is required only when a visual examination of a sample indicates questionable quantity of solid residue.

F. The port faces of oxygen streams will be cleaned of aluminum oxide and other braze residue. Core attachment surfaces, which thru use will contact product fluid, will be cleaned of hydrocarbon contamination. Examination of accessible surface with ultraviolet (3200 to 4000 angstrom unit long-wave filter) shall indicate:

1. No evidence of fluorescence due to petroleum type hydrocarbons.

2. Mild reflection due to insignificant amount of aluminum oxide residue, or fluorescence due to isolated particles of lint, is acceptable.

G. Cleaned surfaces of assemblies will, during additional fabrication, be maintained at a cleanliness level equal to the in-process checks.

H. Hydrostatic tests will be made with clean, potable water.

I. Drying will be accomplished in such a manner that will maintain cleanliness.

J. Pneumatic tests will be performed with dry, oil-free air or nitrogen.

K. Bubble type leak detection fluids, if used, will be thoroughly rinsed from surfaces of the assembly.

L. All openings of assemblies will be sealed for shipment to prevent entry of water or contamination. Seal requires:

1. A vapor-free, inert, nondeteriorating, greaseless barrier material.

2. Wood and paper barriers are not acceptable.

END OF REFERENCE
4

REFERENCE
5

ANON.: CLEANING FOR OXYGEN, FUEL AND PNEUMATIC SYSTEMS.
MSFC-SPEC-164A, NASA, OCT. 1, 1970.

MSFC-SPEC-164A
October 1, 1970
SUPERSEDING
MSFC-SPEC-164
April 16, 1962

GEORGE C. MARSHALL SPACE FLIGHT CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUNTSVILLE, ALABAMA

CLEANLINESS OF COMPONENTS FOR USE IN OXYGEN, FUEL, AND PNEUMATIC SYSTEMS, SPECIFICATION FOR

1. SCOPE

1.1 Scope. - This specification covers the cleanliness levels of components used in oxygen, pneumatic, and fuel systems of space vehicles and associated ground support equipment.

1.2 Classification. - The cleanliness level and inspection procedures as specified shall be applicable to the types and classes, classified according to configuration and materials, as follows:

Type I - Tubing, rigid[1]

Class 1 - Corrosion resistant, 300 series, steel

Class 2 - Aluminum alloy

Type II - Flexible hose assemblies[2]

Class 1 - Teflon lined

Class 2 - All metal

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[1]Tubing, as defined for the purpose of this classification, shall include rigid tubing in sizes up through 2-inch outside diameter. Tubing having a diameter greater than 2 inches shall be considered as miscellaneous components (type III).

[2]Flexible hose assemblies, as defined for the purpose of this classification, shall include braided hoses in sizes up through 2-inch inside diameter. Flexible hoses with a diameter greater than 2 inches shall be considered as miscellaneous components (type III).

Type III - Miscellaneous components

Class 1 - Metallic and teflon

Class 2 - Nonmetallic

Type IV - Control assemblies[3]

Type V - Containers, metallic

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids, form a part of this specification to the extent specified herein.

SPECIFICATIONS

Federal

O-H-765	Acid, Hydrochloric (Muriatic), Technical Grade.
O-H-795	Hydrofluoric Acid, Technical.
O-M-232	Methyl Alcohol, Methanol.
O-N-350	Nitric Acid, Technical.
O-O-670	Orthophosphoric Acid.
O-S-642	Sodium Phosphate, Tribasic, Technical, Anhydrous, Dodecahydrate, and Monohydrate.
BB-N-411	Nitrogen.
UU-T-81	Tags, Shipping and Stock.
PPP-T-60	Tape, Pressure-Sensitive Adhesive, Waterproof for Packaging and Sealing.

[3]Control assemblies shall include such items as valves, regulators, pressure switches, and temperature control switches.

Military

MIL-D-16791	Detergents, Nonionic.
MIL-P-27401	Propellant Pressurizing Agent, Nitrogen.
MIL-T-27602	Trichloroethylene, Oxygen Propellant Compatible, (By Flushing Methods).
MIL-C-81302	Cleaning Compound, Solvent, Trichlorotrifluoroethylene.
MIL-T-81533	1, 1, 1 - Trichloroethane (Methyl Chloroform) Inhibited, Vapor Degreasing.

George C. Marshall Space Flight Center

MSFC-SPEC-106	Testing Compatibility of Materials for Liquid Oxygen Systems.
MSFC-SPEC-217	Trichloroethylene, Technical.
MSFC-SPEC-234	Nitrogen, Space Vehicle Grade.
MSFC-SPEC-237	Solvent, Precision Cleaning Agent.
MSFC-SPEC-456	Film, Transparent, Plastic, LOX Compatible, Gas and Contamination Barrier.
MSFC-SPEC-471	Solvent, 1, 1, 1 - Trichloroethane, High Purity, Inhibited.

STANDARDS

George C. Marshall Space Flight Center

MSFC-STD-246	Design and Operational Criteria of Controlled Environment Areas.
MSFC-STD-343	Preservation, Packaging, Packing, Marking, Handling, and Shipping of Space Vehicle Components, Parts, and Associated Equipment, General Standard for.

PROCEDURE

George C. Marshall Space Flight Center

MSFC-PROC-404 Gases, Drying and Preservation, Cleanliness Level and Inspection Methods.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 Production cleaning and preservation process approval. - The cleaning and preservation process and the type equipment to be used shall be left to the discretion of the manufacturer; however, approval of the process and the type of equipment to be used shall be obtained from the procuring activity prior to cleaning and handling. The utilization of a recommended procedure will not guarantee acceptance of the end product. The contractor shall be required to submit to the contracting officer a statement in writing containing the following information:

(a) Processing materials to be used. This shall include, as applicable, trade names, specifications, chemical and physical properties.

(b) Processing equipment and cleaning procedures to be used.

(c) Quality assurance provisions to be utilized. This shall include in process control procedures to prevent built-in contamination or latent corrosion.

(d) Preservation methods and preservation materials to be used.

(Preservation methods proposed shall reflect the requirements presented in Standard MSFC-STD-343.)

(e) Controlled environment levels to be maintained for cleaning, assembly, handling, and test.

3.2 Materials. - Processing and protection materials used shall be as specified herein, on the drawing, or of a quality approved by the procuring activity (see 3.1).

3.2.1 Test and cleaning solvents. - Normally the selection of cleaning solvents is left to the discretion of the cleaning activity (see 3.1). However, selected solvents shall be compatible with the item being cleaned (e.g., methyl alcohol, O-M-232, is compatible with and shall be used to clean or test Kel-F materials; but, chlorinated solvent, such as

trichloroethylene and trichloroethane, are not compatible with titanium alloys and shall not be used unless specifically approved by the procuring activity). Test and cleaning solvents are subject to rapid chemical decomposition when exposed to even small quantities of water or dissimilar solvents which result in adverse effects on both metallic and nonmetallic materials. Every effort shall be made to prevent contamination of solvents with water or dissimiliar solvents.

NOTE

Due to degradation caused by mixtures of some solvent-water or dissimiliar solvents, parts or components subjected to the solvents specified herein during cleaning or testing operations shall be thoroughly dried with drying gas (see 3.2.2) prior to and subsequent to a water or dissimiliar solvent flush.

3.2.1.1 Test solvent. - Test solvents shall conform to Specification, type I of MIL-C-81302, type I of MIL-T-27602, type I or type II of MSFC-SPEC-217, MSFC-SPEC-237, or MSFC-SPEC-471 and shall meet the following requirements.

(a) The nonvolatile residue shall be not greater than 0.010 gram (g) per 500 milliliters (ml) at 221 ± 9 degrees Fahrenheit (^{o}F) when tested in accordance with 4.4.3.2.

(b) There shall be no particle over 175 microns in any dimension and no more than 5 particles from 100 to 175 microns in size when tested in accordance with 4.4.3.1.

3.2.1.2 Cleaning solvent.

3.2.1.2.1 Vapor degreasing. - Unless otherwise approved in accordance with 3.1, solvents used for vapor degreasing cleaning processes shall conform to: type I of MIL-T-27602, MIL-C-81302, MIL-T-81533, type I or type II of MSFC-SPEC-217, or MSFC-SPEC-237.

NOTE

The 1, 1, 1 trichloroethane (inhibited) covered by Specification MIL-T-81533 is intended for vapor degreasing where air pollution regulations preclude the use of other materials.

3.2.1.2.2 Immersion cleaning solvents. - Unless otherwise approved in accordance with 3.1, solvents used for immersion cleaning process shall conform to: type I of MIL-T-27602, type I of MIL-C-81302, type I or type II of MSFC-SPEC-217, MSFC-SPEC-237, or MSFC-SPEC-471 and shall meet the nonvolatile residue content as specified for test solvents (see 3.2.1.1).

3.2.1.3 Fluids. - Fluids other than fluids in controlled environment areas (see 3.2.13) that contact cleaned surfaces after final cleaning or testing for cleanliness shall, as a minimum, meet the requirements for test solvents (see 3.2.1.1) for liquids and drying gas (see 3.2.2) for gases.

3.2.2 Drying, testing or preservation gas. - Gases used in drying, testing, or preservation processes shall conform to the cleanliness and quality assurance requirements for gases as specified in Procedure MSFC-PROC-404.

3.2.2.1 Nitrogen. - Nitrogen gas used in the drying or preservation processes shall conform to type I, class 1, grade B of BB-N-411; to type I of MIL-P-27401; or to type I of MSFC-SPEC-234, and shall meet the requirements of 3.2.2.

3.2.2.2 Air. - Air used in the drying or preservation processes shall conform to the requirements specified in 3.2.2.

3.2.3 Filter paper. - Filter paper shall be either approved membrane (10 micron pore size, or less) or fiber type (e.g., Whatman No. 42, 45 MM) and shall be compatible with the fluids being tested.

3.2.4 Trisodium phosphate. - Trisodium phosphate used in the cleaning process shall conform to Specification O-S-642.

3.2.5 Nitric acid. - Nitric acid used in the cleaning process shall conform to Specification O-N-350.

3.2.6 Phosphoric acid. - Phosphoric acid used in the cleaning process shall conform to Specification O-O-670.

3.2.7 Hydrochloric acid. - Hydrochloric acid if used in the cleaning process shall conform to Specification O-H-765.

3.2.8 Hydrofluoric acid. - Hydrofluoric acid if used in the cleaning process shall conform to Specification O-H-795.

3.2.9 Detergent cleaning agent. - Detergent cleaning agents used in the cleaning process shall conform to Specification MIL-D-16791.

3.2.10 Demineralized water. - Demineralized water, if specified for rinsing or testing operations, shall contain no particle over 175 microns in any dimension and no more than 5 particles from 100 to 175 microns in size when tested in accordance with 4.4.3.1. The minimum specific resistance of the water shall be 50,000 ohms with a pH rating between 6.0 and 8.0.

3.2.11 Tape. - Tape used to secure and reinforce protective covers shall conform to Specification PPP-T-60.

3.2.12 Protective materials and devices. - Protective materials and devices that serve as contamination barriers in contact with or exposed to significant surfaces shall be compatible with the applicable service media (e.g. oxygen systems per MSFC-SPEC-106). Prior to use, the materials or devices shall be cleaned and dried to a level compatible with the component cleanliness requirement. Under normal usage, the materials or devices shall be lint free, and shall not delaminate, peel, disintegrate, slough or otherwise deteriorate in a manner that will contaminate the cleaned item. (See MSFC-SPEC-456).

3.2.13 Controlled areas. - Final cleaning, testing, assembly, packaging, and analysis of components cleaned in accordance with this specification shall be performed in an environmentally controlled area compatible with the component cleanliness requirements (see 3.1.e). Standard MSFC-STD-246 will be used by the procuring activity to evaluate the applicable environmentally controlled area.

3.3 Precleaning.

3.3.1 Precleaning. - Dust and grit, scale, corrosion, grease, oil, and other major soils shall be removed and a pressure test performed as applicable prior to final cleaning.

3.3.2 Precleaning and surface treatment. - Metallic items shall be treated (cleaning, passivating, and coating processes) to prevent latent corrosion and contamination. Items that do not lend themselves to this type of treatment, as an assembled item, shall be treated prior to assembly. Surface treated areas imparied during fabrication and assembly shall be reprocessed, as required, to restore the original protective finish.

3.4 Tubing and hoses.

3.4.1 Particle size limitations. - Tubing and hoses used in onboard and ground support equipment oxygen[4], fuel, or pneumatic systems shall be

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[4]Oxygen, as defined for the purpose of this specification, shall include both gaseous and liquid forms.

cleaned to comply with the limits specified herein. Particles of contamination per square foot of component surface area (see 6.3) shall not exceed the following limits:

(a) No particle[5] greater than 2500 microns in any dimension.

(b) One particle between 700 and 2500 microns.

(c) Five particles between 175 and 700 microns.

3.4.2 Nonvolatile-residue content.

3.4.2.1 Oxygen systems. - The nonvolatile-residue contamination on the significant surfaces[6] of the tubing and hoses used in oxygen systems shall be not greater than 0.001 g per square foot of surface area as determined by analysis of the reliability test solution tested in accordance with 4.4.2.2.

3.4.2.2 Fuel systems. - No nonvolatile residue requirement.

3.4.2.3 Pneumatic systems.

3.4.2.3.1 Onboard systems. - The cleaning procedure shall completely remove all traces of oil, wax and gum, and other organic soils as determined by visual examination or any other test method determined acceptable by the procuring activity.

3.4.2.3.2 Ground support equipment systems. - The nonvolatile-residue contamination on the significant surfaces of tubing and hoses used in ground support equipment pneumatic systems shall be not greater than 0.001 g per square foot of surface area as determined by analysis of the reliability test solution tested in accordance with 4.4.2.2.

3.4.3 Rinsing. - Cleaned tubes and hoses shall be rinsed, as applicable, to remove cleaning and preparation chemicals. The cleaned and rinsed tube and hose surfaces shall register a pH within a range from 6.0 to 8.0.

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[5]Particles, as defined for the purpose of this specification, shall include all foreign material whether it is metallic or non-metallic.

[6]Significant surfaces, as defined for the purpose of this specification, shall include all component surfaces that may come in contact with the respective service medium.

3.4.4 Drying. - Tubes and hoses shall be thoroughly dried by flowing prefiltered drying gas (see 3.2.2) through the tubes and hoses. The effluent gas shall not exhibit moisture pickup or measurable concentrations of residual organic solvents when tested in accordance with 4.4.2.3. Miscellaneous items, control assemblies, and large containers that do not lend themselves to this type of drying or testing procedures shall be dried and tested in accordance with procedures approved by the procuring activity (see 3.1).

3.4.5 Protection. - Tubes and hoses shall be protected by sealing openings with approved coverings (see 3.2.12) and secured with tape (see 3.2.11). Tubes and hoses to be shipped or stored after cleaning shall be placed in visually clean bags. The interior of the bags and parts shall be purged with an inert drying gas (see 3.2.2) to assure an inert storage package. The bags shall be completely sealed. The sealed bags shall be overpacked as necessary to prevent damage to the bags, tubes, hoses, or integral parts. Desiccants, when required for additional corrosion protection shall not be placed in such a manner as to recontaminate the cleaned surfaces of components. Provisions shall be made for monitoring desiccants. Other packaging materials compatible with the applicable service media may be used; however, the gas purging and overpackaging requirements shall be as listed above. If alternate methods are used, prior approval of the materials and procedures shall be obtained from the procuring activity.

3.5 Tubing, rigid.

3.5.1 Corrosion-resistant steel.

3.5.1.1 Particle size limitations. - Corrosion-resistant steel tubing used in onboard and ground support equipment oxygen, fuel, or pneumatic systems shall be cleaned to meet the requirements specified in 3.4.1.

3.5.1.2 Nonvolatile-residue content.

3.5.1.2.1 Oxygen systems. - The nonvolatile-residue contamination shall be no greater than as specified in 3.4.2.1.

3.5.1.2.2 Fuel systems. - No nonvolatile-residue requirements.

3.5.1.2.3 Pneumatic system.

3.5.1.2.3.1 Onboard systems. - The cleaning procedure shall be as specified in 3.4.2.3.1.

3.5.1.2.3.2 Ground support equipment systems. - The nonvolatile-residue contamination shall be not greater than that specified in 3.4.2.3.2.

3.5.1.3 Rinsing. - Tubing shall be rinsed as specified in 3.4.3.

3.5.1.4 Drying. - Tubing shall be dried as specified in 3.4.4.

3.5.1.5 Protection. - Tubing shall be protected as specified in 3.4.5.

3.5.1.6 Recommended procedure. - A cleaning, rinsing, and drying procedure that has been found acceptable to the procuring activity for cleaning corrosion-resistant steel tubing to the levels specified herein is as follows:

(a) Circulate an approved inhibited nonetch alkaline cleaning solution (e.g. Turco 4215 - Concentration 10 plus or minus 2 oz per gallon, or equal) at 160 plus or minus 10 degrees F, through the tubing or hoses for a minimum of 10 minutes. The circulation rate shall be not less than 20 tubing or hose volumes of liquid per minute.

(b) Flush tubing thoroughly with large quantities of tap water for a minimum of 10 minutes at room temperature.

(c) Circulate a solution of 10 plus or minus 2.0 percent by weight a nitric acid, conforming to Specification O-N-350, at 170 to 190 degrees F, through the tubing for a minimum of 5 minutes and maximum of 10 minutes.

(d) Flush thoroughly with large quantities of demineralized water (see 3.2.10) in the manner described in step (b).

(e) Dry tubing thoroughly with a drying gas (see 3.2.2) in accordance with procedure specified in 3.4.4 or by a vacuum drying process.

3.5.2 Aluminum alloy.

3.5.2.1 Particle size limitations. - Aluminum alloy tubing used in onboard and ground support equipment oxygen, fuel, or pneumatic systems shall be cleaned to meet requirements specified in 3.4.1.

3.5.2.2 Nonvolatile-residue content.

3.5.2.2.1 Oxygen systems. - The nonvolatile-residue contamination shall be not greater than that specified in 3.4.2.1.

3.5.2.2.2 Fuel systems. - No nonvolatile residue requirements.

3.5.2.2.3 Pneumatic systems.

3.5.2.2.3.1 Onboard systems. - The cleaning procedure shall be as specified in 3.4.2.3.1.

3.5.2.2.3.2 Ground support equipment systems. - The nonvolatile residue contamination shall be not greater than that specified in 3.4.2.3.2.

3.5.2.3 Rinsing. - Tubing shall be rinsed as specified in 3.4.3.

3.5.2.4 Drying. - Tubing shall be dried as specified in 3.4.4.

3.5.2.5 Protection. - Tubing shall be protected as specified in 3.4.5.

3.5.2.6 Recommended procedure. - A cleaning, rinsing, and drying procedure that has been found acceptable to the procuring activity for cleaning aluminum alloy tubing to the levels specified herein is as follows:

(a) Circulate a solution as described in step (a) for corrosion-resistant steel tubing (see 3.5.1.6).

(b) Flush tubing thoroughly with large quantities of tap water in the same manner as described in step (b) for corrosion-resistant steel (see 3.5.1.6).

(c) Circulate a solution of 3.0 to 5.0 percent nitric acid, conforming to Specification O-N-350, through the tubing at 85 to 95 degrees F for a minimum of 5 minutes and a maximum of 7 minutes. A solution of 5 plus or minus 0.5 percent by weight of phosphoric acid conforming to Specification O-O-670 at 160 to 180 degrees F may be used for removing heavy soils that cannot be removed with the nitric acid solution. In such cases circulate the solution through the tubing for a minimum of 5 minutes and a maximum of 7 minutes.

(d) Flush tubing thoroughly with large quantities of demineralized water (see 3.2.10) in the same manner as described in step (d) for corrosion-resistant steel tubing (see 3.5.1.6).

(e) Dry the tubing thoroughly as described in step (e) for corrosion-resistant steel tubing in 3.5.1.6.

3.6 Flexible hose assemblies.

3.6.1 Teflon lined.

3.6.1.1 Particle size limitations. - Teflon-lined flexible hoses used in onboard and ground support equipment oxygen, fuel, and pneumatic systems shall be cleaned to meet requirements specified in 3.4.1.

3.6.1.2 Nonvolatile-residue content.

3.6.1.2.1 Oxygen systems. - The nonvolatile-residue contamination shall be not greater than that specified in 3.4.2.1.

3.6.1.2.2 Fuel systems. - No nonvolatile-residue requirement.

3.6.1.2.3 Pneumatic systems.

3.6.1.2.3.1 Onboard systems. - The cleaning procedure shall be as specified in 3.4.2.3.1.

3.6.1.2.3.2 Ground support equipment systems. - The nonvolatile-residue contamination shall be not greater than that specified in 3.4.2.3.2.

3.6.1.3 Rinsing. - Hoses shall be rinsed as specified in 3.4.3.

3.6.1.4 Drying. - Hoses shall be dried as specified in 3.4.4.

3.6.1.5 Protection. - Hoses shall be protected as specified in 3.4.5.

3.6.1.5.1 Recommended procedure. - A cleaning, rinsing, and drying procedure that has been found acceptable to the procuring activity to meet the levels specified herein for teflon-lined flexible-hose assemblies is as follows:

(a) Brush interior of components thoroughly for 10 to 15 minutes with a nylon brush and 0.5 percent detergent and water solution at a temperature of 122 (plus or minus 9) degrees F.

(b) Flush interior of hoses for 2 to 5 minutes with demineralized water (see 3.2.10) at room temperature.

(c) Vacuum dry or purge with prefiltered drying gas (see 3.2.2).

(d) Flush with solvent conforming to requirements specified in 3.2.1.2.2.

(e) Purge with prefiltered drying gas conforming to the requirements of 3.2.2.

(f) Vacuum dry internal and external surfaces.

3.6.2 All metal hose.

3.6.2.1 Particle size limitations. - All metal flexible-hose assemblies used in onboard and ground support equipment oxygen, fuel, and pneumatic systems shall be cleaned to meet requirements specified in 3.4.1.

3.6.2.2 Nonvolatile-residue content.

3.6.2.2.1 Oxygen systems. - The nonvolatile-residue contamination shall be not greater than that specified in 3.4.2.1.

3.6.2.2.2 Fuel systems. - No nonvolatile-residue requirement.

3.6.2.2.3 Pneumatic systems.

3.6.2.2.3.1 Onboard systems. - The cleaning procedure shall be as specified in 3.4.2.3.1.

3.6.2.2.3.2 Ground support equipment systems. - The nonvolatile-residue contamination shall be not greater than that specified in 3.4.2.3.2.

3.6.2.3 Rinsing. - All metal flexible-hose assemblies shall be rinsed as specified in 3.4.3.

3.6.2.4 Drying. - All metal flexible-hose assemblies shall be dried as specified in 3.4.4.

3.6.2.5 Protection. - All metal flexible-hose assemblies shall be protected from recontamination by sealing all openings with approved secured closures, placing the assemblies in polyethylene bags, purging bags with a dry oil-free gas to assure an inert package during storage, heat-sealing both ends of bags, and overpacking as necessary to prevent recontamination or damage during handling and storage.

3.6.2.6 Recommended procedure. - Cleaning, rinsing, and drying procedures that have been found acceptable to the procuring activity to meet the levels specified herein for all metal flexible-hose assemblies are as follows:

(a) Ultrasonic cleaning.

*1. Clean hose assemblies in an ultrasonic cleaning tank equipped with a recirculating system utilizing a 10 micron filter. The solution shall be a detergent cleaning agent (see 3.2.9) and demineralized water (see 3.2.10).

*2. Rinse by flushing with demineralized water.

3. Vacuum dry or purge with prefiltered dry, oil-free gas.

4. Flush with solvent conforming to the requirements specified in 3.2.1.2.2.

*5. Purge with prefiltered drying gas conforming to the requirements of 3.2.2.

*6. Vacuum dry internal and external surfaces.

(b) Detergent cleaning.

*1. Brush interior of flexible hose assemblies thoroughly for 10 to 15 minutes with a nylon brush and 0.5 percent detergent and water solution at a temperature of 122 plus or minus 9 degrees F.

*2. Flush for 2 to 5 minutes with demineralized water (see 3.2.10) at room temperature.

3. Vacuum dry or purge with prefiltered drying gas (see 3.2.2).

4. Flush with solvent conforming to the requirements specified in 3.2.1.2.2.

*5. Purge with prefiltered drying gas conforming to the requirements of 3.2.2.

*6. Vacuum dry internal and external surfaces.

NOTE

Steps preceded by * are only steps recommended for fuel systems. All steps are applicable to recommended procedure for oxygen and pneumatic systems.

3.7 Miscellaneous components.

3.7.1 Metallic and Teflon.

3.7.1.1 Particle size limitations. - Miscellaneous metallic and teflon components used in onboard and ground support equipment oxygen, fuel, and pneumatic systems shall be cleaned to meet requirements specified in 3.4.1.

3.7.1.2 Nonvolatile-residue content.

3.7.1.2.1 Oxygen systems. - The nonvolatile-residue contamination shall be not greater than that specified in 3.4.2.1.

3.7.1.2.2 Fuel systems. - No nonvolatile-residue requirements.

3.7.1.2.3 Pneumatic systems.

3.7.1.2.3.1 Onboard systems. - The cleaning procedure shall be as specified in 3.4.2.3.1.

3.7.1.2.3.2 Ground support equipment systems. - The nonvolatile-residue contamination shall be not greater than that specified in 3.4.2.3.2.

3.7.1.3 Rinsing. - Miscellaneous metallic and teflon components shall be rinsed as specified in 3.4.3.

3.7.1.4 Drying. - Miscellaneous metallic and teflon components shall be dried as specified in 3.4.4.

3.7.1.5 Protection. - All significant surfaces or openings to surfaces that will contact the applicable service medium of miscellaneous metallic and teflon components shall be protected from recontamination by sealing the surfaces or openings with approved coverings (see 3.2.12) and secured with tape (see 3.2.11) or other approved methods. The protected components shall be placed in visually clean bags (bags purged with drying gas - see 3.2.2), completely sealed to assure an inert package during storage, and overpacked as necessary to prevent damage during storage and handling. If alternate methods are used, prior approval of the materials (other than materials conforming to Specification MSFC-SPEC-456) and procedures shall be obtained from the procuring activity (see 3.1). See 3.4.5 for use of desiccants.

3.7.1.6 Recommended procedure. - Due to various types and complexities of components covered under this classification, no recommended procedure is included. Contractors shall submit respective procedure for approval in accordance with 3.1.

3.7.2 Nonmetallic components.

3.7.2.1 Particle size limitations. - Nonmetallic miscellaneous components shall be cleaned in such a manner that all visible foreign contamination will be removed.

3.7.2.2 Freedom from oils and greases. - The cleaning procedure shall be as specified in 3.4.2.3.1.

3.7.2.3 Rinsing. - Nonmetallic components shall be rinsed as specified in 3.4.3.

3.7.2.4 Drying. - Nonmetallic components shall be dried as specified in 3.4.4.

3.7.2.5 Protection. - Nonmetallic components shall be protected as specified in 3.7.1.5.

3.7.2.6 Recommended procedure. - Due to various types and complexities of components covered under this classification, no recommended procedure is included. Contractors shall submit procedure for approval in accordance with 3.1.

3.8 Control assemblies.

3.8.1 Metallic control assemblies or assembly components.

3.8.1.1 Particle size limitations. - Requirements for metallic control components and assemblies used in onboard and ground support equipment oxygen, fuel, or pneumatic systems shall be as specified in 3.4.1.

3.8.1.2 Nonvolatile residue content.

3.8.1.2.1 Oxygen systems. - The nonvolatile-residue contamination shall be no greater than as specified in 3.4.2.1.

3.8.1.2.2 Fuel systems. - No nonvolatile-residue requirement.

3.8.1.2.3 Pneumatic systems.

3.8.1.2.3.1 Onboard systems. - The cleaning procedure shall be as specified in 3.4.2.3.1.

3.8.1.2.3.2 Ground support equipment systems. - The nonvolatile-residue contamination shall be no greater than specified in 3.4.2.3.2.

3.8.1.3 Rinsing. - Metallic control components and assemblies shall be rinsed as specified in 3.4.3.

3.8.1.4 Drying. - Metallic control components and assemblies shall be dried as specified in 3.4.4.

3.8.1.5 Protection. - Metallic control components and assemblies shall be protected as specified in 3.7.1.5.

3.8.1.6 Recommended procedure. - Due to various types and complexities of components covered under this classification, no recommended procedure is included. Contractors shall submit respective procedure for approval in accordance with 3.1.

NOTE

Many control assemblies are cleaned and inspected as metallic and nonmetallic parts, then assembled. Cleaning and testing of control assemblies, by flushing with liquids or purging with gases are not generally recommended. However, if applicable, the contractor shall include, as a part of the cleaning and preservation processes (see 3.1), procedures for cleaning, handling, assembling, protecting, and testing of assembled components.

3.8.2 Nonmetallic control assembly components.

3.8.2.1 Particle size limitations. - Nonmetallic control assembly components shall be cleaned as specified in 3.7.2.1.

3.8.2.2 Freedom from oils and greases. - The cleaning procedure shall be as specified in 3.4.2.3.1.

3.8.2.3 Rinsing. - Nonmetallic control assembly components shall be rinsed as specified in 3.4.3.

3.8.2.4 Drying. - Nonmetallic control assembly components shall be dried as specified in 3.4.4.

3.8.2.5 Protection. - Nonmetallic control assembly components shall be protected as specified in 3.7.1.5.

3.8.2.6 Recommended procedure. - Due to various types and complexities of components covered under this classification, no recommended procedure is included. Contractors shall submit respective procedure for approval in accordance with 3.1. (See NOTE 3.8.1.6)

3.9 Containers (metallic).

3.9.1 Liquid and pneumatic.

3.9.1.1 Particle size limitation. - Liquid and pneumatic containers shall be cleaned to meet the cleanliness limits specified herein based on the specified sampling plan (see 4.4.1.4.1). Particles of contamination per square foot of surface area (area exposed to the service medium (see 6.3)) shall not exceed the following limits:

(a) No particle greater than 2500 microns in any direction.

(b) One particle between 700 and 2500 microns.

(c) Five particles between 175 and 700 microns.

3.9.1.2 Nonvolatile-residue content.

3.9.1.2.1 Oxygen containers. - The nonvolatile-residue contamination on the significant surfaces of oxygen containers (according to component surface area) shall be not greater than 0.005 g per square foot as determined by analysis of the test solution of 4.4.1.4.2 in accordance with 4.4.2.2.

3.9.1.2.2 Fuel containers. - No nonvolatile-residue requirement.

3.9.1.2.3 Pneumatic containers.

3.9.1.2.3.1 Onboard systems. - The cleaning procedure shall completely remove all traces of oil, wax, gum, and other organic soils as determined by visual examination or any other test method determined acceptable by the procuring activity.

3.9.1.2.3.2 Ground support equipment systems. - The nonvolatile-residue contamination on the significant surfaces of ground support equipment pneumatic system containers (according to component surface area) shall be not greater than 0.001 g per square foot as determined by analysi of the test solution of 4.4.1.3 in accordance with 4.4.2.2.

3.9.1.3 Rinsing. - Liquid and pneumatic containers shall be adequately rinsed to remove cleaning and preparation chemicals.

3.9.1.4 Drying. - Inner surfaces of liquid and pneumatic containers shall be thoroughly dried as evidenced by no moisture pickup in prefiltered gas (see 3.2.2) passing through the container.

3.9.1.5 Protection. - Immediately after drying, liquid and pneumatic container openings shall be covered with approved precleaned dry covers secured in a manner to prevent detachment or damage during handling, storage, or shipment. Covers shall be designed to facilitate tank-venting and to prevent recontamination of the tank interior.

3.9.1.6 Recommended procedure. - Due to size of containers and the complexity of construction, no recommended procedure is submitted. The contractor shall submit procedures for approval in accordance with 3.1. However, the procedure and materials used shall be such that harmful residue cannot be entrapped within the container.

3.10 Marking. - Unless otherwise specified by the procuring activity, cleaned components shall be marked with tags conforming to type C, Specification UU-T-81, and shall contain the following information:

(a) Part or identification number.

(b) Contractor identification.

(c) Contractor cleaning and packaging procedure identification (number, title, etc.)

(d) Date of cleaning.

(e) Title, date, and number of this specification.

(f) Service medium or intended use of component.

(g) Manufacturer's serial number.

4. QUALITY ASSURANCE PROVISIONS

4.1 The supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own or any other inspection facilities and services acceptable to the Government. Inspection records of the examination and tests shall be kept complete and available to the Government as specified in the contract or order. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Sampling, acceptance inspection.

4.2.1 Visual inspection. - The sample for the inspection of 4.3.1 and 4.3.2, as applicable, shall consist of all cleaned components.

4.2.2 Reliability sample. - Unless otherwise specified, a quantitative analysis reliability sample for the test of 4.4 consisting of a minimum of 5-percent of the items cleaned, but not less than one sample for each group of 20 or less (except as noted in 4.2.2.2 and 4.2.2.3) of the items cleaned, shall be selected at random by Government inspection from production items that have been cleaned, examined in accordance with 4.3, and found acceptable. The sample shall be selected in a manner that will provide maximum representation of the affected lot. The reliability sample and the segment of production that it represents shall be clearly identified as specified by the procuring activity.

4.2.2.1 Small components. - The reliability sample for small components (components having a significant surface area less than 1.0 square foot) shall consist of a sufficient number of components to make up 1 square foot (minimum) of surface area. When the total quantity of items

procured have a combined surface area less than 1.0 square foot, a quantity (sufficient to make up 1.0 square foot of surface area) of clean stock items shall be used in preparation of the reliability sample or upon written request by the contractor to the procuring activity, a special test procedure will be furnished.

4.2.2.2 Containers. - All containers submitted for acceptance shall be inspected for size of particles of contamination. All oxygen and pneumatic containers shall be inspected for nonvolatile residue contamination.

4.2.2.3 Rigid tubing. - The reliability of the cleaning procedure for rigid tubing shall be determined and the cleaning process qualified as specified herein. After qualification of the procedure and equipment, reliability sampling shall be left to the discretion of the procuring activity. Samples for the applicable tests of 4.4 to determine conformance to 3.5.1.1, 3.5.1.2, 3.5.2.1, and 3.5.2.2, as applicable, and qualification of the cleaning process and cleaning equipment to be used in production cleaning shall be selected as follows:

(a) Select a minimum of 5 cleaned tubes a minimum of 3 feet long and having a minimum combined significant surface area of 1.0 square foot from each size (diameter) and type (corrosion resistant steel or aluminum alloy) tube to be cleaned. Select test samples from tubes cleaned in accordance with the exact procedures and utilizing the equipment approved in accordance with 3.1.

(b) Upon satisfactory qualification (conformance of samples from step (a) to meet the requirements of 3.5.1.1, 3.5.1.2, 3.5.2.1, and 3.5.2.2 when tested in accordance with 4.4) of the cleaning procedure and equipment, periodic spot checks in addition to the inspection of 4.3 will be made to insure that the cleaning procedures continue to be effective.

4.3 Acceptance inspection. - Except as specified herein, acceptance inspection shall be performed on applicable components used for the space vehicle and associated ground support equipment.

4.3.1 Examination. - Surfaces of all cleaned components that will contact the respective service medium shall be visually inspected for the presence of contaminants such as moisture, corrosion, scale, dirt, oil, grease, and similar foreign material. A flashlight or borescope may be required to examine internal surfaces. Components, such as small diameter tubing (1/2-inch diameter or less), having limited accessibility to visual examination shall be accepted or rejected on the basis of the reliability inspections. The presence of contamination shall require a reliability test (see 4.4) to determine acceptance or rejection, however, components

that do not lend themselves to a solvent-rinse test method shall be accepted or rejected on the basis of visual examination of other methods approved by the procuring activity (see 3.1). Scale-free discoloration due to welding and passivation is permitted. All components shall also be examined to determine conformance to paragraph 3.10.

4.3.2 Acidity or alkalinity. - External and internal surfaces of cleaned and rinsed components shall be tested with pH-indicating paper while the component is still wet from the last rinse or after wetting the test surface with a few drops of distilled water to determine that the surface acidity or alkalinity registers a pH between 6.0 and 8.0. The pH-indicating paper shall be sensitive to the requirement specified above.

4.4 Reliability tests. - Cleaned components selected by the Government inspector for reliability tests shall be subjected to all examinations and tests specified herein. The visual examinations of 4.3.1 and 4.3.2, as applicable, shall precede the reliability tests.

4.4.1 Preparation of test solution. - Preparation of test solution (see 3.2.1.1) for oxygen, fuel, and pneumatic system components, that lend themselves to solvent cleaning, shall be as specified herein.

4.4.1.1 Small components. - A 500 ml, (minimum) test solution to determine particle population (particles greater than 175 microns in size) and the nonvolatile residue on the significant surfaces of small components (less than 1.0 square foot in surface area) selected for reliability tests shall be prepared as follows:

(a) Divide the 500 ml, test solution (see 3.2.1) into quantities in proportion to the surface area of the individual components used to make up 1.0 square foot of surface area (see 4.2.2.1).

(b) Flush each component with proportionate share of test solution.

(c) Collect the flushing solvent for the analysis of 4.4.2.1 and 4.4.2.2 as applicable.

(d) Thoroughly dry components after completion of flushing operation.

4.4.1.2 Components 1.0 square foot to 5.0 square feet in surface area. - A 500 ml, (nominal) test solution to determine the particle population (particles greater than 175 microns in size) and the nonvolatile residue on the significant surfaces of the reliability samples selected from components having significant surface areas from 1.0 square foot through 5.0 square feet shall be prepared by flushing the

test solvent (see 3.2.1.1) over the significant surfaces and collecting the solvent for the analysis of 4.4.2.1 and 4.4.2.2 as applicable. The component shall be thoroughly dried after completion of flushing operation.

4.4.1.3 Components with surface areas greater than 5.0 square feet. - The test solution to determine the particle population (particles greater than 175 microns in size) and nonvolatile residue on the significant surfaces of the reliability sample (see 4.2.2 and 4.2.2.2) from components, except for containers specified in 4.4.1.4, having significant surface areas greater than 5.0 square feet shall be prepared as follows:

(a) Flush the significant surfaces with 100 ml, (maximum) of test solvent per square foot of surface area.

(b) Collect the flushing solvent.

(c) If more than 500 ml, of test solvent is used, the flushings shall be thoroughly agitated and a 500 ml, sample shall be taken from the total quantity of flushing solution for the quantitative analysis of 3.4.2.1 and 4.4.2.2, as applicable.

(d) The component shall be thoroughly dried after the flushing operation (step (a)).

4.4.1.4 Containers, oxygen and fuel. - The samples for determining the presence of excessive large particles and nonvolatile-residue on significant surfaces of oxygen and fuel containers, as applicable, shall be determined as specified herein.

4.4.1.4.1 Particle size. - The particle size determination, based on a cleaning procedure utilizing a high-pressure liquid spray, with a rotating nozzle traversing the length of the container-interior, shall be obtained as follows:

(a) With container in vertical position, traverse the interior of the container with a spray utilizing demineralized water (see 3.2.10) or an acceptable substitute at a minimum flow rate of 40 gallons per minute (gpm) and a pump pressure of 250 (plus or minus 50) pounds per square inch. The pressure drop between the pump discharge and the spray nozzle shall be not greater than 20 pounds per square inch gage (psig).

(b) From a continuous flow of test medium through the sampling line (a funnel-shaped flange located at the bottom of the container), take a minimum of five 500 ml samples. The samples shall be taken at equally spaced intervals (vertical positions of the spray nozzle) during the rinsing operation.

(c) A 500 ml sample of the rinsing medium, to determine conformance to 3.2.10 or specified purity of acceptable substitute, shall be taken at the beginning and at the end of the rinsing period. The samples shall be taken from a sampling line for the rinsing medium located as near the spray nozzle as practical.

4.4.1.4.2 Nonvolatile-residue (oxygen containers only). - The nonvolatile-residue contamination sample for oxygen containers shall be prepared by one of the following methods:

(a) Vertical position (spray operation).

(1) With container in vertical position, traverse the interior of the container with a spray utilizing trichloroethylene (see 3.2.1.1) or an acceptable substitute at a minimum flow rate of 5 gpm and a pump pressure of 60 plus or minus 10 psig.

(2) From a continuous flow of test medium through the sampling line (a funnel-shaped flange located at the bottom of the container), take a minimum of five 1000 ml samples. The samples shall be taken at equally spaced intervals (vertical positions of the spray nozzle) during the rinsing operation.

(3) A 500 ml sample of the rinsing medium, to determine conformance to 3.2.1.1 or specified purity of acceptable substitute, shall be taker at the beginning and at the end of the rinsing period. The samples shall be taken from a sampling line for the rinsing medium located as near the spray nozzle as practical.

(b) Horizontal position (barrel-roll operation).

(1) Place the container in a horizontal position and fill with sufficient amount of test solvent

to completely cover all projecting surfaces. The total weight of solvent used in any one complete rotating cycle shall be determined prior to introduction into the container.

(2) Sample the rinsing solvent before and during approved intervals in the rotation cycle.

(3) Conduct tests in accordance with 4.4.2.2 to determine the total nonvolatile-residue pickup.

(4) Continue rotation of the container until the increase in the nonvolatile-residue during an approved interval of rotation, is 2 milligrams (mg) or less per liter of solution.

(5) If the total compound nonvolatile-residue per square foot of significant surface area is greater than 0.005 g per square foot of surface area, the container shall be recleaned.

(6) The test solvent shall be drained from the container and the interior thoroughly dried prior to application of protection.

NOTE

Alternate test methods and sampling procedures may be used with prior approval by the procuring activity.

4.4.2 Tests.

4.4.2.1 Particle size analysis. - Each sample reliability test solution from 4.4.1.1, 4.4.1.2, 4.4.1.3, and 4.4.1.4.1 shall be filtered through filter paper (see 3.2.3) and the residue examined for particulate under 10 to 45 power microscope. The larger particles (175 microns in any dimension and greater) shall be measured with a filter micrometer and the contamination per square foot of surface area calculated to determine the reliability of the visual examination of 4.3.1 and conformance to 3.5.1.1, 3.5.2.1, 3.6.1.1, 3.6.2.1, 3.7.1.1, 3.8.1.1, and 3.9.1.1, as applicable. Alternate methods of determining reliability may be used by the contractor with prior approval by the procuring activity (see 3.1).

4.4.2.2 Nonvolatile-residue. - The filtered sample (500 ml nominal volume) of 4.4.2.1 from oxygen and applicable pneumatic components or a

500 ml sample from 4.4.1.4.2 shall be analyzed for nonvolatile residue content to determine reliability of the examinations of 4.3.1 and conformance to 3.5.1.2.1, 3.5.1.2.3.2, 3.5.2.2.1, 3.5.2.2.3.2, 3.6.1.2.1, 3.6.1.2.3.2, 3.6.2.2.1, 3.6.2.2.3.2, 3.7.1.2.1, 3.7.1.2.3.2, 3.8.1.2.1, 3.8.1.2.3.2, 3.9.1.2.1, and 3.9.1.2.3.2 as follows:

(a) Transfer 500 ml of the solvent into a clean degreased 800 ml beaker.

(b) Evaporate the solvent to 10 to 20 ml volume in a steam bath.

(c) Transfer the solvent to a constant-weight (within 0.3 mg) tared 30 ml weighing bottle, weighed to the nearest 0.1 mg.

(d) Continue evaporation to a volume of 5 plus or minus 0.5 ml. Do not let the solvent evaporate to dryness.

(e) Place the weighing bottle in a constant temperature oven at 221 to 230 degrees F for 1.5 hours.

(f) Cool weighing bottle in a desiccator and then weigh to the nearest 0.1 mg.

(g) Return the weighing bottle to the constant temperature oven for one-half hour.

(h) Repeat (f). If the difference between the weights is greater than 0.3 mg, repeat step (g) until the difference between successive weighing is 0.3 mg or less.

(i) Compare the results obtained from used solvent with the results obtained from unused solvent. The difference between the weights shall be not greater than the increase specified for the affected item (based on surface area and total amount of solvent used for testing).

4.4.2.3 Drying. - Unless otherwise approved by the procuring activity, the reliability of the drying procedure for items subjected to liquids during cleaning or drying procedures shall be determined by testing the sample of 4.2.2 before and after the tests of 4.4.2.1 and 4.4.2.2. The presence of surface moisture and residual organic solvents on the cleaned, tested, and dried items shall be tested as follows:

(a) Flow prefiltered drying gas through or over the affected surfaces of the item being tested.

(b) Monitor the dew point of the drying gas entering and leaving the affected item to determine presence of moisture on cleaned and dried surfaces. Any moisture pickup in the drying gas that has flowed through or over the affected surfaces shall necessitate additional drying prior to packaging or application of protective coverings.

(c) Monitor the effluent drying gas with a halogen detector to determine if affected surfaces are free from residual organic solvents. If no measurable concentrations are indicated by the halogen detector, the affected surfaces shall be considered free from excessive residual organic solvents. Any measurable concentrations in the drying gas that has flowed through or over the affected surfaces shall necessitate additional drying prior to packaging or application of protective coverings.

NOTE

Additional verification may be required to ascertain the dryness of components having deep recesses and entrapment areas. Certification shall be made by a quality assurance representative that approved drying procedures (proven by adequate tests) for the affected component has been followed.

4.4.3 Solvent control checks.

4.4.3.1 Particle size. - At least once daily while being used, particle size control tests shall be conducted on solvent to determine conformance to 3.2.1.1. Filter 500 ml of solvent through filter paper (see 3.2.3) and examine for particulate in accordance with 4.4.2.1. Alternate methods of determining particle count may be used with prior approval of the procuring activity.

4.4.3.2 Nonvolatile-residue. - At least once daily while being used, nonvolatile-residue content tests shall be conducted on solvent to determine conformance to 3.2.1.1. Test procedure specified in 4.4.2.2 for a 500 ml sample shall be used.

4.5 Rejection and resubmittal.

4.5.1 Individual rejection. - Components that fail the visual inspection of 4.3.1 or the test of 4.3.2, as applicable, shall be rejected and reprocessed.

4.5.2 Lot rejection. - If any reliability sample fails to meet the requirements specified herein, a second sample, twice the size of the first, shall be selected and tested. If any item from the second sample fails to meet the requirements specified herein, the entire lot represented by the sample shall be rejected.

4.5.3 Resubmittal. - Before resubmittal of rejected lots, full particulars concerning previous rejection and corrective measures taken to prevent recurrence of the failure shall be made available to the procuring activity.

5. PREPARATION FOR DELIVERY

Not applicable.

6. NOTES

6.1 Intended use. - The procedures, cleaning levels, and preservation methods covered by this specification are intended for use in cleaning, inspecting, and protecting of components used in oxygen, pneumatic, and fuel systems of space vehicles and associated ground support equipment.

6.2 Ordering data. - Procurement documents should specify the following:

(a) Title, number, and date of this specification.

(b) Whether preproduction approval is required (see 3.1).

(c) Cleanliness level required.

6.3 Surface area. - The standard unit (area) used for determination of contamination levels is 1.0 square foot of significant surface area (area that will contact the service medium). Exact calculations of surface areas are not mandatory. Approximate surface area calculations acceptable to the Government inspector may be used.

Notice. - When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be

regardad by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may be in any way related thereto.

Custodian:	Preparing activity:
NASA - George C. Marshall Space Flight Center	George C. Marshall Space Flight Center

END OF REFERENCE
5

CONTINUED ON CARD 2

Card #2

REFERENCE
6

ANON.: SPECIFICATION FOR LEM TEST FACILITY. VOL. IV, SEC 49. WHITE SANDS TEST FACILITY.

SECTION 49

CLEANING OF PIPING AND EQUIPMENT

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SECTION 49

CLEANING OF PIPING AND EQUIPMENT

49-01 SCOPE: This section covers cleaning requirements for the liquid oxygen storage vessels, fuel and oxidizer dump tanks, high pressure nitrogen gas vessels, nitrogen gas system, vehicle propellant system and vacuum piping and equipment, complete.

49-02 APPLICABLE PUBLICATIONS: The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto:

a. Military Specifications:

MIL-P-27401A	Propellant, Nitrogen Pressurizing.
MIL-T-27602	Trichloroethylene, Oxygen Compatible (by Flushing Methods).
AFM-32-3	Accident Prevention Handbook.
AEP-160-6-4	Health Hazards and Their Control in Metal Degreasing.

b. Society of Automotive Engineers:

ARP-598-1960	Procedure for the Determination of Particulate Contamination of Hydraulic Fluids by the Particle Count Method.

c. American Society of Testing and Materials Standard:

E-11-61	Sieves for Testing Purposes.

49-03 GENERAL: After completion of welding, threading, machining, hydrostatic testing, and any other potentially contaminating operation, the Contractor shall clean all propellant systems, gas piping system and vacuum piping system, components and subassemblies except piping and components falling in piping classification "B" as indicated in the section entitled

WATER AND COMPRESSED AIR PIPING SYSTEMS. All cleaned portions and items shall be inspected and sealed to prevent contamination until connected into the systems. Cleanliness requirements shall be enforced throughout any operations which involve assembly or removal and replacement of clean components. Assembly of clean components shall not require welding or machining, except final welding for field installation of piping. Cleaning procedures shall incorporate safety principles contained in AEP-160-6-4 and AFM-32-3.

a. Requirements: The cleaning procedures specified herein are the minimum requirements. The Contractor shall employ whatever additional cleaning procedures he finds necessary to comply with the permissible contamination limits. Inspection and tests shall be witnessed by the Contracting Officer. The Contractor shall be required to furnish the services of a qualified laboratory to perform the inspection and tests specified for cleaning of piping and equipment.

(1) Internal Cleaning: The internal surfaces of each vessel and tank including the liquid oxygen inner container vessel and all nozzles, piping and components serving the inner container including pumps, piping and components between the storage vessels and run tank shall be cleaned until the permissible contamination limits are complied with, dried and protected by sealing; all in accordance with the procedures and requirements herein set forth.

b. Methods: The Contractor shall provide a cleaning facility of a design that will properly accomplish the cleaning requirements specified herein. The facility shall contain dust-free, air-locked rooms for cleaning, inspection, testing, assembling and sealing of components and subassemblies. The rooms shall be maintained at a pressure slightly above that of the outside atmosphere. Personnel working within the clean rooms must wear nylon smocks, caps, and shoe covers. Clean, nonshedding plastic gloves shall be worn when handling cleaned components. Cleaning methods are divided roughly into the following groups:

(1) Precleaning: This group includes methods for removing all contaminants resulting from fabrication procedures, all factory-applied paints, varnish and preservatives, and all markings made with crayon, ink, dye, tape or decals. This requirement applies chiefly to piping subassemblies and shall be accomplished by mechanical and chemical methods. Factory-procured items such as valves and instruments will not normally require precleaning.

(2) Specific Cleaning: This group includes methods for degreasing, flushing and drying to remove contaminants, foreign materials and moisture. All components shall be cleaned by the appropriate processes specified herein to accomplish the required results, either subsequent to precleaning or to fulfill total cleaning requirements where precleaning is not needed.

49-04 PERMISSIBLE CONTAMINATION LIMITS: Permissible contamination limits for the vessels, piping and components shall not exceed the following:

a. Gross Contaminants: No corrosion products, metal chips, scale, weld slag, organic solvents, oil, grease, paints, ink preservatives, solvents, decals, or other debris, or foreign matter which constitutes a reactive or functional hazard to the equipment shall be present on a significant surface when visually inspected by the method of inspection Nos. 2, 3 and 5 hereinafter described.

b. Oily Residues: None as evidenced by inspections Nos. 2, 3 and 4.

c. Total Filterable Solids: A maximum of 4.0 mg/sq. foot of significant surface area is permitted in the effluent test media, as determined by the method of inspection Nos. 1 and 5 and the following particulate distribution limits shall apply:

(1) Cryogenic System

Particles

Size (Microns)	No./ft^2
0-9	No Limit
10-25	500
25-50	15
50-100	10
Over-100	0

Fibers: None

(2) Alcohol System, Vehicle Propellant and Gas System, Vacuum System Piping and Equipment

Particulate Matter

Size (Microns)	No./ft^2
0-25	No Limit by Count
25-50	4960
50-100	1260
100-175	590
175-350	25
350 and larger	0

Fibers: None in excess of 500 microns in length.

d. Moisture Removal: Moisture removal will be considered adequate when the dew point of the effluent gas is minus 60 degrees F., or lower.

49-05 CLEANING SEQUENCE: The following cleaning sequence outlines the minimum steps that shall be followed in cleaning the vessels and manifolds and preparing them for shipment. The Contractor shall provide whatever additional steps are necessary to comply with the permissible contamination limits. These cleaning steps shall also apply to all piping and components forming a part of the system unless otherwise herein specified.

a. Mechanical cleaning

b. Degreasing

c. Rinsing

d. Inspection

e. Chemical Descaling (if required)

f. Passivation (if required)

g. Rinsing

h. Particulate inspection

i. Drying

j. Final inspection

k. Sealing

l. Pressurizing of vessels and piping

49-06 DEFINITIONS:

a. Nominal Rated Filters: The nominal rating of a filter describes the efficiency of a filter and specified the removal of 98 percent by weight of all particles whose two smallest dimensions are greater than the pore size or openings in the filter media. Filters made by powder metallurgy processes shall not be used.

b. Demineralized Water: Demineralized water shall be water with total filterable solids content no higher than 20 p.p.m. by weight or a conductivity of not more than 40 micro ohms.

c. Clean Water: Clean water is defined for use in these specifications as color-free water containing no visible suspended particles or hydrocarbons.

d. Dry Gas: Dry gas is defined for use in these specifications as oil-free gas which has been processed through a dehydrator so that its dew point is minus 63.5 degrees F. at one atmosphere, or a maximum of 26.3 p.p.m. water vapor by volume.

e. Purge Gas Requirements: Nitrogen used to purge, or dry components and subsystems after the final rinse shall conform to Military Specification MIL-P-27401. A nominally rated 10 micron stainless steel filter (dutch twill weave or equivalent) shall be used between the purge gas source and the component or subsystem.

f. One Micron: One-millionth of an international meter, or 0.00003937 inch.

g. Fiber: A nonmetallic, flexible, threadlike structure with a length to diameter ratio of at least 20.

h. Particle: Any foreign solid matter in a fluid or on a surface, other than fibers. Particle size is the longest single dimension.

i. Particulate Matter: Particles and fibers, less than 10,000 microns in size, (i.e. less than a centimeter).

j. Mesh: The number of openings per linear inch of sieve. A 50 mesh has 50 openings per linear inch.

k. System: A system is an assembly of parts which may be identified as a composite whole within a given classification and which may be tested for contamination as a distinct unit.

l. System Component: A component is an integral unit portion of an assembly or system.

m. Significant Surface: Significant surface refers to that surface of a component which directly contacts the service media. Contact may take place by the service media flowing over, being contained in, or impinging on the effective surface; or the significant surface may be immersed in the service media.

n. Total Filterable Solids: The solids which will be retained on an HA or AA millipore filter disc or equivalent.

o. Rinse Test: A rinse test is a test to determine cleanliness by entrainment, or by solution of soluble materials, with a suitable rinsing fluid. The effluent is examined for particulate contamination by the millipore, or equivalent, method. The filtrate is examined for soluble contaminants by spectrochemical and/or gravimetric techniques.

49-07 MATERIALS AND CLEANING PROCEDURES: The general procedures and materials used are described below. Degreasing and chemical descaling may be augmented by scrubbing with nonmetallic brushes. The solutions shall be applied by immersing, spraying, wiping, circulating, or applied in a manner that all surfaces to be cleaned shall be completely wetted with the solutions. Any sections of the item to be cleaned that can trap or retain any liquid shall be drained or emptied between the applications of each different solution of chemical mixture. Rinse water shall not be reused. After solutions have been introduced into a system, equipment, or subassembly, the surface to be cleaned shall not be allowed to become dry between steps of the procedure until the drying step has started Only demineralized water shall be used for final rinsing and making solutions.

a. Mechanical Cleaning: All weld surfaces shall be cleaned and weld spatter shall be removed by grinding, brushing with stainless steel wire brushes and sandblasting using aluminum oxide sand. Brushes shall not have been used on carbon steel. Inner surfaces of nozzles, piping and fittings shall be cleaned with a "go-devil" type of device. All debris,

loose dirt, abrasive or loose scale shall be completely removed by vacuum cleaning, blowing, brushing or flushing with clean water or other methods.

b. Degreasing: Degreasing shall be accomplished with trichloroethylene conforming to Military Specification MIL-T-27602 or with mild commercial alkaline cleaner in the proportions of 5 to 7 ounces per gallon of water at 140 to 160 degrees F. Sonic vibration may be used in conjunction with degreasing. Solvent may be reused until contaminant content reaches 0.1 percent by weight, after which reuse will not be allowed.

c. Rinsing: If alkaline cleaner is used, surfaces shall be rinsed with clean water until the cleaning solution is no longer evident. The vessel shall then be drained and dried before inspection. Piping, valves, fittings and other system components shall be similarly rinsed.

d. First Inspection: Surfaces shall be inspected visually and by wipe test as specified for inspections Nos. 2 and 3 hereinafter. Presence of rust, scale, weld spatter and other foreign material will require chemical descaling of the surfaces. If inspection shows no further descaling necessary, final rinse shall be initiated.

e. Chemical Descaling: Descaling and rinse solutions shall be sprayed, circulated, or applied in such manner that all surfaces to be cleaned will be completely wetted with the solution and will remain wetted until the drying step is started. All portions of the item that can trap liquid shall be drained between the application of each different solution. During or after the final rinse and prior to the drying step, each flange connection shall be loosened or opened to assure removal of all contamination between flange faces. Water for solutions shall be demineralized water.

(1) Acid Pickling: A solution of fluorides and nitric acid with inhibitor shall be used for deoxidizing and descaling the steel surfaces.

(2) Test Specimens: Conditions for pickling solutions and methods shall be determined by test on representative specimens of the same metal as that being descaled. Each specimen shall contain a weld with typical oxides and scale unremoved prior to this test. Concentration of solution, temperature, required agitation, and time of exposure shall be such that all scale and other contaminants will be removed to

bare metal. The conditions will be considered satisfactory when contaminants are removed and etching of metal does not exceed 0.001 inch on either side.

(3) Quality Control: Solution concentration and composition shall be sampled and analyzed every 48 hours and shall be maintained at the quality previously established.

(4) Procedures: The procedures used for descaling the significant surfaces shall be the same as established by test specimens, including solution concentration, temperature, method and exposure time. After completion of descaling, all solution shall be drained and rinsing initiated before surfaces become dry.

(5) Preservative and Varnish Removal: Where preservatives or varnish have been applied to inside surfaces of carbon steel pipe, or fittings, complete removal is required. Varnish shall be removed using 20 percent sodium hydroxide in solution with water at 140 to 160 degrees F. The solution shall be flushed or sprayed through the pipe under pressure. Carbon steel pipe and fittings thus processed will not require degreasing but shall be thoroughly flushed with water and inspected for complete removal of all residues prior to passivation.

f. Passivation: Carbon steel surfaces, whether acid pickled or not, shall be passivated to prevent rust. Where water rinsing has been used the rustproofing shall be initiated within five minutes after completion of flushing. One of the following rustproofing methods shall be used.

METHOD A

(1) Flush with 0.01 percent citric acid solution until the effluent pH stabilizes between 3.0 and 4.0.

(2) Rinse with sodium hydroxide solution, 1/4 to 1/2 percent, until slightly alkaline.

(3) Rinse with demineralized water.

(4) Surface treat for one hour in a filtered (10 micron nominal rated filter) solution of the following percentages:

Monosodium phosphate - 1/4
Disodium phosphate - 1/4

Sodium nitrite - 1/2
Demineralized water - 99.0

(5) Dry.

METHOD B

(1) Surface treat for 15 to 20 minutes in a 0.10 percent sodium chromate solution.

(2) Rinse with demineralized water.

(3) Dry.

g. Final Rinse: Final rinse shall be accomplished using demineralized water filtered through a 10-micron nominal rated filter. The rinse shall be continued until the pH of the effluent is equal to the pH of the influent. Rinse water shall not be reused. Pipe assemblies and large components shall be rinsed using a pressure spray nozzle. Small components may be rinsed by immersion. Provision shall be made for collection of effluent samples required for inspection No. 1.

h. Drying: Rinse water shall be drained and the vessel, tank or piping and subassemblies shall be thoroughly dried. Drying may be accomplished by heating and circulating air at 140 to 250 degrees F., or by vacuum evacuation where vessels or tanks can withstand vacuum condition. Final drying shall be accomplished by purging with dry purge gas at 140 degrees F. and of the quality specified hereinbefore until a dewpoint of minus 60 degrees F. is reached. Clean filter elements shall be used for each individual drying operation. All connection hoses, valves, and regulators shall be precleaned to the degree required for vessel cleanliness.

i. Cleaning of Valves and Accessories: All valves and components to be installed in piping manifolds connected to or into the inner container shall be cleaned in accordance with this specification. Valves and safety head assemblies shall be disassembled for cleaning and shall be reassembled after drying. Parts such as gaskets and seals that may be harmed by cleaning chemicals shall be cleaned by dipping in isopropyl alcohol. All items cleaned previous to assembly into the manifolds shall be protected in sealed, double layer polyethylene bags until time for installation. Cleaned components shall be handled and assembled in a controlled, dust free atmosphere by personnel wearing clean, lint free clothing and clean polyethylene gloves. Piping valves, fittings and other

system components shall be similarly cleaned.

49-08 INSPECTIONS: The following inspections shall be employed as specified and as required to assure cleanliness of all significant surfaces. Inspection No. 4 shall not be applied to the piping and equipment for the Vehicle Gas and Propellant System. Inspection No. 5 shall not be applied to the Cryogenic System and the Alcohol System. Numbering of the inspection does not necessarily indicate the sequence of inspection Care shall be taken not to recontaminate the cleaned surfaces during inspection. In the case of small components, selection shall be made to provide maximum representation and to fulfill area requirements for inspection of significant surfaces.

a. Inspection No. 1 - Particulate Inspection: After the pH of the final demineralized water rinse has been established as specified and prior to the drying operation, the effluent shall be passed through a 100 mesh sieve (ASTM Designation E11, Fine Series #100). For this purpose an additional rinse shall be performed using a minimum amount of fresh demineralized water equivalent to 100 milliliters per square foot of internal surface area, using a pressure spray nozzle. The sieve shall be inspected with a 5 to 10 power magnifying glass. If no particles remain on the sieve, the cleanliness will be judged to have met this inspection requirement. Any particulate matter retained on the sieve will be cause for rejection and recleaning of the component or components. Final inspection shall be by means of a particulate count by the membrane filter method in accordance with the Society of Automotive Engineers Method ARP-598. Three separate samples of 100 millileters each shall be used for this test. A minimum of 5 percent of all significant surfaces cleaned shall be represented in this inspection.

b. Inspection No. 2 - Visual Inspection: All parts of each vessel and components shall be examined for evidence of corrosion products, metal chips, scale, weld scale, oil, grease, paints, preservatives, decals, or other contamination or foreign matter. The presence of any such products shall be cause for chemical recleaning. The use of special devices to visually examine normally inaccessible areas of components is required. Any evidence of contamination in excess of the permissible contamination limits shall be cause for recleaning and reinspection.

c. Inspection No. 3 - Wipe Test: All nozzle openings and ports shall be examined for foreign materials by wipe

test. A clean, lint-free wiper shall be rubbed lightly over the significant surface and observed under mangification for the presence of oils, rust or other debris. Significant surfaces of pipe interiors shall be wipe tested using a probe. The wiper shall be firmly attached to the probe to prevent loss within the pipe. Evidence of contamination as described above shall be cause for recleaning and reinspection.

d. Inspection No. 4 - Detection of Oil or Grease: The following procedures shall be used to support inspections Nos. 2 and 3 for detection of oil and grease.

(1) Ultraviolet Light Inspection: A minimum of 5 percent of significant surfaces shall be inspected by ultraviolet lamp (wavelength 2,500 to 3,700 Angstroms) for fluorescence. Preferably, the surface shall be examined under a direct beam from the lamp. Where surfaces are inaccessible, a wipe test shall be made as specified for inspection No. 3, and the wiper examined under a direct beam from the lamp. Any evidence of grease or oil will require recleaning by degreasing methods specified herein.

(2) Water Break Test: To detect oily residues that may not be visible to the eye or detectable by ultraviolet light inspection, examine as follows, using an atomizer and demineralized water. With surface to be tested in vertical (preferred) position, spray with sufficient water to cover the surface without drenching. Formation of droplets will be considered as evidence of oily surface contaminants and recleaning by degreasing will be required.

(3) Surfaces External to Inner Container: Outer surfaces of the liquid oxygen inner container and both surfaces of the outer vessel shall be thoroughly cleaned to eliminate all oil, grease, rust, scale, slag, weld spatter, paint, crayon markings, decals or other foreign matter.

e. Inspection No. 5 - Blowdown: In addition to the above inspections the vessels and tanks shall be subjected to a blowdown inspection. A test strainer, consisting of an 18-inch long section of 3-inch stainless steel, shall be connected to the inspection nozzle. A pair of flanges on the opposite end of the test strainer shall accommodate a filter consisting of stainless steel backup screen and a pad of 10 to 15 layers of cheesecloth to retain all particles over 150 microns in size. Filtered purge gas shall be piped to the inlet flange at 100 psig and shall be flowed through the vessel and the test pad in an unrestricted manner for three

minutes. The filter pad shall then be examined under clean room conditions for particles both visually and microscopically. Particle count shall be in accordance with Society of Automotive Engineers' Procedure ARP-743. Any evidence of contamination in excess of the permissible contamination limits shall be cause for recleaning and reinspection.

49-09 SEALING:

a. General: The vessels, manifolds and piping shall be sealed immediately after it has been determined that they are clean in accordance with the cleaning inspections. Seals shall be tight enough to prevent contamination and shall be protected so that they will not be broken or warped during shipment. Seals shall remain in place until final assembly. Tape for sealing procedures shall not leave any residue on connections, when removed.

b. Flanged Openings: Flanged openings shall be sealed with a suitable full face blank gasket 1/8 inch thick composed of Teflon or other nonflammable, noncontaminating material and a bolted blank flange of aluminum or stainless steel at least 1/4 inch thick. All items shall be clean and dry when installed. Stainless steel bolts shall be used in contact with stainless steel blank flanges. Bolts for use with aluminum blank flanges shall be cadmium plated. There shall be a bolt in each bolt hole correctly torqued to correspond to particular flange and gasket design. Gaskets and flanges shall be cleaned as required by this specification.

c. Threaded Openings: Threaded openings shall be appropriately cleaned, dried and sealed with caps or plugs made of corrosion-resisting steel.

d. Nonthreaded Openings: Nonthreaded openings in subassemblies shall be sealed by use of a nonthreaded cap or plug, sealed in place by pressure-sensitive tape. No lubricant shall be used when sealing nonthreaded openings.

e. Use of Lubricants: Lubricants shall not be used on gaskets. For threaded openings Teflon tape (RBO-140-002) shall be used by applying to male threads only but not beyond the first thread of the fitting where it might be sheared off and get into the pipe or component. The tape shall be wrapped around the male threads with a small overlap and stretched slightly so that the tape conforms to the shape of the threads.

49-10 CERTIFICATION: Each item which has been processed in accordance with this specification shall have attached a certificate of inspection showing that the item meets the requirements of this specification. The certificate shall show the date of inspection and the signature of the Contractor's inspector. Piping that has been cleaned in place and inspected by the Contracting Officer shall have [redacted] attached bearing his stamp, signature or other indicati[redacted]t such inspection has been made and the piping approved as clean.

a. Certification of Sealed Components: Each component or subassembly which has been processed in accordance with this section shall have a decal of approximately the following configuration attached to a surface which will not be in contact with the operating fluid. Decal shall not be attached to sealing or working surfaces.

N_2O_4 Clean		LOX Clean	
Date	Insp.	Date	Insp.

(1) Packaged items shall have this decal attached in such a manner that the decal will be torn in two when the package is opened.

b. Decal: Decal shall be marked with inspector's stamp and date of inspection.

c. Packaged Items: Packaged items with torn decals or evidence of puncture shall be recleaned in accordance with the requirements of this section.

49-11 CONTINUOUS POSITIVE PRESSURE PROTECTION:

a. Vessels: The vessels shall be pressurized to 15 psig with nitrogen immediately following the cleaning inspections and sealing of the vessels. The vessels shall be maintained at positive pressure adequate to assure positive pressure during storage at the plant and shipment to the site and until final system acceptance. All vessels shall be equipped with a shut-off valve and a gage for pressuring. The gage shall be a compound type with scale range 30" Vac. to 20 psi with 2-1/2% accuracy over range 0-5 psi and shall be furnished with maximum and minimum dead pointers. A protective metal cover shall be provided around the gage and valving. Complete loss of pressure shall be cause for reinspection and recleaning

as necessary to meet the permissible contamination limits by and at the expense of the Contractor.

b. Piping: Continuous positive pressure protection shall be provided. Care shall be taken to prevent contamination of cleaned subassemblies and components before, during and after installation. A nitrogen gas purge or positive pressure of 2 psig shall be maintained in piping during installation of pipe and components and shall be continued until final system acceptance. The nitrogen gas shall conform to Military Specification MIL-P-27401 and shall be filtered through a 40-micron nominal rated filter prior to introduction into the piping. The nitrogen purge shall be discontinued only when welding with argon back purge is required. In this case, special attention shall be given to ensure complete evacuation of nitrogen atmosphere prior to start of welding. After completion of the welds, positive pressure of 2 psi nitrogen gas shall be reinstated.

49-12 INSPECTION RESPONSIBILITY: The Government will provide the services of a qualified laboratory for cleanliness inspection. Certifications shall be made solely by that laboratory.

END OF REFERENCE
6

REFERENCE
7

ANON.: PRECISION CLEANING. MSC-SPEC-C-11A, NASA, JUNE 9, 1967.

MSC-SPEC-C-11A
June 9, 1967
Supersedes
MSC-SPEC-C-11
Dated September 1966

MANNED SPACECRAFT CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HOUSTON, TEXAS

PRECISION CLEANING,

SPECIFICATION FOR,

This specification has been approved by the Manned Spacecraft Center (MSC) for use by MSC contractors, MSC, and other Centers, as appropriate.

1. SCOPE

This specification describes general methods of cleaning spacecraft systems and components. The constraints implied by cleaning and techniques of cleaning are covered. This specification is not an operating procedure or job instruction which details every specific step required to perform a cleaning operation. These operating procedures/job instructions are the responsibility of the operating element and are not within the scope of this document.

2. APPLICABLE DOCUMENTS

The following documents form a part of this specification to the extent indicated herein.

STANDARDS

Manned Spacecraft Center

MSC-STD-C-1	Definitions for Contamination Programs
MSC-STD-C-4	Clean Rooms and Work Stations

En Closure 7

Federal

FED-STD-209 Clean Room and Work Station Requirements, Controlled Environment

SPECIFICATIONS

Manned Spacecraft Center

MSC-SPEC-C-12A Precision Clean Packaging

3. DEFINITIONS

3.1 MSC-STD-C-1 lists definitions used in the MSC contamination program. In case of conflict, the MSC-STD-C-1 will govern, unless specified otherwise. The following definitions are included to clarify this specification:

3.1.1 Visibly Clean

The freedom of the surface from particulate matter approximately 50 microns and larger in size and from all films other than known innocuous films.

3.1.2 Critical Surface

That surface of a component which directly contacts the service media.

3.1.3 Nonvolatile Residue (NVR)

Soluble (or suspended) material and insoluble particulate matter remaining after controlled evaporation of a filtered volatile liquid, usually measured in grams. Filtration is normally through a 0.45 micron or 0.8 micron membrane filter.

4. REQUIREMENTS

4.1 GENERAL

All systems or components requiring cleaning shall be cleaned and inspected in conformance with this specification. Systems may require disassembly to permit cleaning. (It is almost

impossible to clean a system without disassembly.) Any part or a component which might be damaged during the cleaning procedures shall be removed before cleaning, and cleaned as a separate item. Cleaning or disassembly operations on precision components which might affect tolerances or impair calibration shall be performed only under the supervision of personnel qualified in the handling, calibration, and/or assembly of the components. Each system or component to be cleaned in conformance with this specification shall be cleaned in accordance with a detailed procedure which shall be within the confines of this specification. The cleaning procedure established for each system or component shall be compatible with design configuration.

Selection of the cleaning solution(s) and/or method(s) shall be consistent with the contaminants to be removed, the materials of construction of the system or component to be cleaned, and the level of cleanliness desired. Acceptance requirements for cleanliness must be adequate for meeting the design requirements of the system or component as regards its intended usage and the level requirements. Cleaning methods must be nondetrimental to the materials of construction and/or the mechanical design requirement of the system or component. Application of each cleaning solution must be restricted to usages where problems subsequent to cleaning will not occur as a result of the application, e.g., corrosion from entrapped cleaning fluids, corrosive cleaning fluid residues, etc.

Contaminated items which cannot be cleaned because of special tooling or calibration requirements shall be returned to the manufacturer or other disposition taken as required.

All steps in any procedure must progress in an uninterrupted series of operations through the final rinse and drying operation. Precautions must be taken to protect systems or parts after final rinsing and drying until inspection, assembly, and/or packaging.

4.2 MECHANICAL DESCALING

This method removes contaminants by abrasive action. This cleaning method shall be used only when contaminants so generated can be removed or when physical damage to the item being cleaned will not occur.

Mechanical descaling may be accomplished by brushing, shot peening, grit blasting, vapor honing, tumbling, or grinding. Surfaces which contain scale and/or oxides and all steel or stainless steel welds which will be exposed to gas or liquid and are accessible, shall be thoroughly cleaned with a stainless steel wire brush, or grinder, or abrasive material. Carbon steel surfaces may be shot blasted. The use of the same stainless steel wire brush for carbon steel and stainless steel shall be forbidden. Material to be used for abrasive cleaning stainless steel surfaces shall contain no ferrous or ferric materials. Internal surfaces of pipe may be cleaned by a "go-devil" type of device with a grinder of 150 grit abrasive or finer. All loose dirt, abrasive or scale shall be completely removed from components by vacuum cleaning, blowing, brushing, or flushing with clean water. Components whose welds are not accessible for mechanical descaling shall be descaled by pickling. All piping will be further descaled by acid pickling.

4.3 VAPOR DEGREASING

Soluble organic contaminant (e.g., oils, greases, hydrocarbon fuels, etc.) are removed by vapor degreasing.

Parts to be vapor degreased shall be processed in a standard commercial degreaser, or degreasing vapors shall be blown into the component parts so that the vapor will condense on and properly degrease all surfaces. The operation of the commercial vapor degreaser shall be in accordance with the manufacturer's recommendations.

4.4 SOLVENT DEGREASING

Soluble organic contaminants are removed by organic solvent cleaners. These solvents are also used for final system flushing. Not only are soluble hydrocarbons removed but also particulate contaminants are removed through entrainment.

If both oils and preservatives are present on a component, solvent degreasing is required followed by detergent degreasing. Components may be steam cleaned prior to solvent degreasing. Components to be solvent degreased shall be immersed in or partially filled with trichloroethylene, perchloroethylene, chlorothene, or other chlorofluorocarbons. Components shall be rolled or rocked to be sure that the solvent washes all surfaces requiring degreasing.

4.5 DETERGENT DEGREASING

Alkaline cleaners and detergents are used for removal of organic and inorganic contamination which can be removed by solution or emulsification (e.g., oils, fat, shop soils, grease, etc.).

Components shall be degreased in a solution of detergent and water. Surfaces of the component should be swept with a soft nylon brush. Detergent degreasing can also be accomplished in a sonic cleaner. Rinsing shall be done under tap water followed by demineralized water and then the components shall be oven dried.

4.6 ALKALINE DEGREASING

Components may be degreased with commercial alkaline cleaners. The components shall be filled, immersed, sprayed, or scrubbed with the particular alkaline cleaner in accordance with manufacturer's recommendations.

4.7 ACID PICKLING

Acid cleaners are to be used to remove contamination not soluble in other solutions (e.g., weld scale, corrosion products, oxide film, etc.).

Components which contain rust, scale, weld splatter, or other foreign material after degreasing, shall be pickled. All pipe and tubing and weldments shall be acid pickled. Mechanical cleaning shall not be performed after pickling.

4.7.1 Stainless Steel

Acid pickling effectively loosens corrosion from stainless steel. All parts such as those found in valves and filter elements that contain materials which may be damaged during pickling shall be removed to prevent their damage. Prior to pickling, the component shall be thoroughly flushed with clean water. The particular pickling agent shall be used in accordance with manufacturer's recommendations.

4.7.2 Carbon Steel

Carbon steel shall be pickled in a bath of either inhibited hydrochloric acid or phosphoric acid, or descaling may be accomplished by using alkaline solutions. The pickling or alkaline procedures shall be followed immediately by flushing with demineralized water. Within five minutes after removal from the pickling acids, an acceptable rust-inhibiting procedure shall be initiated. If alkaline solutions are used for descaling, this step is not required.

4.7.3 Aluminum and Aluminum Alloys

Aluminum and aluminum alloys shall be pickled as required with an acceptable procedure. After alkaline cleaning, rinsing shall be done immediately with warm water to prevent dry-on. The final rinse shall be made with deionized water.

4.7.4 Copper and Copper Alloys

Copper and copper alloys shall be pickled with an acceptable solution. Provision shall be made to assure that acid cleaning solutions shall be free of iron. Ammoniacal solutions shall not be used for cleaning brass. The final rinse for copper and copper alloys shall be made with deionized water.

4.8 PASSIVATION

All components shall be passivated by an acceptable method. Passivating solutions are supplementary treatments to acid, alkaline, and mechanical cleaning to prevent corrosion.

Care shall be taken to prevent damage to passivated surfaces from scratching, nicking, abrasion, etc.

Passivation should not be confused with conversion films or other protective film processes.

4.9 DRYING

Drying shall take place immediately after the final rinse using nitrogen gas, oven drying, air drying, or vacuum drying.

4.10 FINAL PACKAGING

Packaging shall be accomplished per MSC-SPEC-C-12A.

4.11 INSPECTION METHODS

4.11.1 Ultraviolet Light (Black Light)

Components shall be inspected with an ultraviolet light source of 3200 to 3800 angstroms for contaminants. Any evidence of fluorescent materials shall be cause for recleaning.

Ultraviolet light inspection will not detect common hydrocarbon fuels, some silicone greases, MIL-O-5606 hydraulic oil, thread sealants, and fluorocarbon greases commonly found as contaminants. Ultraviolet light will cause the following commonly used materials to fluoresce: most water soluble machining and cutting oils, some lints, molybdenum disulfide, MIL-O-6086 lubricating oil, MIL-G-4343 grease (DC-55), silicates from cleaning solutions, and some metallic compounds.

4.11.2 Visual Observation

Visual observation is the most common inspection method. It is used to detect the presence of substances such as oils, greases, preservatives, corrosion products, weld slag and scale, shop or other dirt and other materials foreign to the item.

All equipment, pipes, and components shall be examined for evidence of corrosion products, metal chips, casting, molding and/or forging scale, weld scale, oil, grease, paints, preservatives, decals, and other contamination or foreign matter which constitutes a reactive or functional hazard to the system. Any visual contamination shall be cause for recleaning. Observations must be made with the unaided eye and light of sufficient intensity to illuminate the area being inspected. No magnification lenses are to be used except to further identify a contaminant. Visual observation is limited to use where the surfaces to be inspected are accessible. (This does not preclude the use of borescopes or other similar devices.)

4.11.3 Wipe Tests

Wipe tests may be used to detect oily residues that may not be visible because of configuration, color, or other characteristics of the item being inspected.

The desired surface to be inspected is lightly rubbed with a lint-free medium. The medium must be visually observed for the presence of oils and debris. Care should be taken so as not to rub too hard on most surfaces. Aluminum, for instance, will abrade and soil the wiping medium which can be confused with contamination. When the wiping medium is to be extracted with solvent to determine hydrocarbon contamination, the area being wiped must be calculated and the amount of extraction solvent measured. A hydrocarbon determination must be made as a blank on the medium, and the blank should be subtracted from the sample hydrocarbon determination.

4.11.4 Water Break Test

The water break test is used to detect oily residues that may not be visible because of configuration, color, or other characteristics of the item being inspected.

An atomizer with distilled water is used to perform this test. The surface to be checked will be made accessible preferably in the horizontal face-upward position. The area to be tested is sprayed sufficiently to completely cover the surface with droplets or a thin layer of water. The presence of predominant droplets on the surface is the indication of the possible presence of oily hydrocarbons. There are monohydrocarbon materials that will cause water to form droplets on a surface. Also, there are materials which are hydrocarbons that will not cause water to form droplets.

4.12 DECONTAMINATION

Parts used in fuel or oxidizer systems, or otherwise exposed to fuel or oxidizer must be decontaminated to obtain a surface condition that is safe for subsequent handling or cleaning and free of corrosive residue. Water immersible parts shall be soaked in clean water followed by thorough rinsing. Nitrogen shall be used for drying. Before nonwater immersible parts (gauges, transducers and all electromechanical devices) are decontaminated, the component must be encased and sealed with tape in such a manner that only the system media entry or exit ports of the component are exposed. The interior of ports and sensing chambers or compartments shall be flushed with deionized water. Warm dry nitrogen shall be used for drying.

4.13 FINAL (PRECISION) CLEANING

All systems and components shall be subjected to a clean room environment following general cleaning as heretofore described. Clean rooms are described in FED-STD-209 and MSC-STD-C-4. Those items scheduled for cleaning in a clean room environment shall be flushed or wiped with a suitable cleaning solution or solvent and/or vacuum cleaned or blown off with clean, dry air to prevent entry of gross contaminants into clean rooms. Solvent cleaning or blowing an item with clean air may be omitted when these procedures are detrimental.

Final cleaning shall be accomplished using solvents or other cleaning solutions (such as detergents) previously filtered to remove particulate and other contaminants and suitably low in NVR and particulate consistent with the cleanliness levels to be achieved.

4.14 RINSE - TEST

Unless otherwise specified, following final cleaning, each cleaned item shall be rinsed using a minimum of 100 ml. of unused filtered solvent as in final cleaning for each square foot of critical surface tested. A 500 ml. sample shall be the minimum used in any case. Rinsing shall be accomplished by agitation, sloshing, or by spraying the test solvent over the critical surface in such manner as necessary to obtain a reliable rinse test solution. The test solvent shall be drained immediately to prevent particle redeposition on the test surface. Clean components should be placed in the inner packaging wrap (not sealed) during the particulate/nonvolatile residue determination to preclude contaminating the component.

4.15 CLEANLINESS REQUIREMENTS

In the absence of specific requirements, one of the following levels shall be selected for surface cleanliness on the basis of end item application, subject to the review and approval of the cognizant operating element. These are system levels. Generally, assemblies below the system configuration have to be cleaned at least one level cleaner than that required for the system.

	Particulate Distribution Per Sq. Ft. of Critical Surface[1]		Nonvolatile Residue[2] Per Sq. Ft. of Critical Surface (max)	
	Size Range	Quantity (max)		Suggested Use
Level 1	0-5 microns	Unlimited[3]	1 mg	Pressurization Systems Reaction Control Propellant Systems
	5-15 microns	170		
	15-25 microns	100		
	25-50 microns	40		
	50-100 microns	20		
	>100 microns	0		
Level 2	0-10 microns	Unlimited[3]	1 mg	Electrical Power Systems
	10-25 microns	100		
	25-50 microns	10		
	50-100 microns	5		
	100-175 microns	1		
	>175 microns	0		
Level 3	0-5 microns	Unlimited[3]	1 mg	Small Propulsion Systems
	5-15 microns	Unlimited[3]		
	15-25 microns	Unlimited[3]		
	25-50 microns	2100		
	50-100 microns	100		
	100-250 microns	4		
	>250 microns	0		
Level 4	0-25 microns	Unlimited[3]	1 mg	Main Propulsion Systems
	25-50 microns	1000		
	50-100 microns	100		
	100-180 microns	20		
	180-350 microns	5		
	>350 microns	0		
	Fibers:			
	350 microns	5		
	>350 microns	0		
Level 5	0-175 microns	Unlimited[3]	1 mg	Environmental Control Systems
	175-700 microns	6		
	>700 microns	0		
	Fibers:			
	700-1500 microns	1		
	>1500 microns	0		

NOTE 1 - A 100 ml sample of rinse fluid is used for each sq. ft. of critical surface (minimum sample to be 500 ml).
NOTE 2 - This requirement may be made optional in some systems.
NOTE 3 - Unlimited means that particles in this range are not counted; however, any obscuring of the filter grid lines shall be cause for rejection.

5. QUALITY ASSURANCE PROVISIONS

The cognizant Quality Assurance organization will determine compliance with the following requirements:

5.1 PRECLEANING (DESCALING, DEGREASING, PICKLING, ETC.)

5.2 PRECISION CLEANING

5.3 INSPECTION METHODS

5.4 CLEANLINESS REQUIREMENTS

5.5 FINAL PACKAGING AND CERTIFICATION OF CLEANLINESS

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Custodian:

NASA Manned Spacecraft Center

Prepared by:

MSC Flight Safety Office, AR
and Apollo RQ&T Division, PR

NASA — MSC — Coml., Houston, Texas

END OF REFERENCE
7

REFERENCE
8

ANON.: CLEANING PROCEDURES. UNION CARBIDE CORP., LINDE DIV.

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Linde

STUDY OF HANDLING STANDARDS AND SAFETY CRITERIA FOR LIQUID AND GASEOUS OXYGEN SYSTEMS

by

UNION CARBIDE CORPORATION
LINDE DIVISION

For

NASA Lewis Research Center
Cleveland, Ohio

CONTRACT NAS3-15082

SECTION 2.0 - CLEANING PROCEDURES

JULY, 1971

UNION CARBIDE

UNION CARBIDE CORPORATION
LINDE DIVISION

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UNION CARBIDE CORPORATION

LINDE DIVISION

TONAWANDA FACTORY

STANDARD PRACTICE INSTRUCTIONS

CLEANING AND PACKAGING

TONAWANDA FACTORY

LINDE COMPANY
DIVISION OF UNION CARBIDE CORPORATION
STANDARD PRACTICE INSTRUCTIONS

ENGINEERING DEPT.

SPI-25.001

DATE	SHEET NO.	OF
8-27-63	1	7

SUBJECT: PROCESSING AND PACKAGING OF GASKETS FOR OXYGEN SERVICE

BY LPC CH'D C.E.C. APP'D

CHANGES FROM PREVIOUS ISSUE

FORM LB-478

.01 GENERAL

Gaskets are available for use in liquid and gaseous oxygen service or gaseous oxygen service. The processing and packaging of gaskets for each class of service is given in this SPI.

.02 CLASS I - LIQUID AND GASEOUS OXYGEN SERVICE

.02.1 Cleaning

The gaskets must be cleaned for Oxygen Service as per SPI-25.153.

.02.2 Testing

Forward (quantity - see chart) gaskets from each lot of (quantity - see chart) or less to Meter Instrument Department for combustibility test in accordance with SPI-50.012.

.03 CLASS II - GASEOUS OXYGEN SERVICE ONLY

.03.1 Cleaning

The gaskets must be cleaned for Oxygen Service as per SPI-25.153.

.03.2 Testing

Forward (quantity - see chart) gaskets from each lot of (quantity - see chart) or less to Meter Instrument Department for combustibility test in accordance with SPI-50.012.

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BY G.P.C. CHK'D C.E.C. APP'D N.J.J.

CHANGES FROM PREVIOUS ISSUE

FORM LB-478

.04 PACKAGING AND LABELING

Package as specified in the charts and label as illustrated.

(Quantity - See Chart) Gaskets

LINDE COMPANY

Part or Code No. (See Chart)

CLEANED FOR OXYGEN SERVICE

NOTE: (1) Seal boxes with masking tape, or heat-seal bags.

(2) The gaskets must not be released for use or stock under any circumstances until the above operations have been completed. The gaskets should then be stocked under the original purchase part or code numbers.

.05 ADDITIONS TO CHART

Additions will be made under the service classification for which the new gasket is suitable.

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FORM LB-478 | CHANGES FROM PREVIOUS ISSUE | BY G.P.C. CH'KD C.E.C. APP'VD N.J.J.

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LINDE COMPANY
DIVISION OF UNION CARBIDE CORPORATION

ENGINEERING DEPT.

STANDARD PRACTICE INSTRUCTIONS

SPI-25.001

DATE 8-27-63 | SHEET NO. 3 | OF 7

SUBJECT PROCESSING AND PACKAGING OF GASKETS FOR OXYGEN SERVICE
CLASS I - LIQUID AND GASEOUS SERVICE

Code Number or Part Number	Name of Gasket	TEST SAMPLES		PACKAGING		
		Number to be Tested From Each Lot	Quantity in Each Lot	Quantity In Each Pkg.	Covering	Code Number or Part Number
D-35726	Akron Metallic	10	5,000	100	Box	3304-6800
D-92579	Akron Metallic	10	5,000	100	Box	3304-6900
4914-0650	McKim Copper Asbestos	1	10	1	Heat Sealable Bag	3304-1625
4914-1685	Victor Copper Asbestos	2	150	25	Box	266757
4914-2015	McKim Copper Asbestos	5	500	50	Box	3304-6600
4914-2165	McKim Copper Asbestos	5	500	50	Box	3304-7409
4914-8490	McKim Copper Asbestos	10	5,000	100	Box	3304-6800

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STANDARD PRACTICE INSTRUCTIONS

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SPI-25.001

DATE 8-27-63 | SHEET NO. 4 | OF 7

SUBJECT PROCESSING AND PACKAGING OF GASKETS FOR OXYGEN SERVICE
CLASS II - GASEOUS SERVICE

Code Number	Name of Gasket	PACKAGING		
		Quantity in Each Pkg.	Covering	Code or Part Number
4914-0150	McKim Copper Asbestos	100	Box	142481
4914-0420	Victor Copper Asbestos	10	Heat Sealable Bag	3304-1625
4914-0425	McKim or Victor Copper Asbestos	10	Heat Sealable Bag	3304-1625
4914-0430	McKim or Victor Copper Asbestos	25	Box	142481
4914-0475	McKim or Victor Copper Asbestos	10	Heat Sealable Bag	3304-1625
4914-0500	McKim or Victor Copper Asbestos	25	Box	142481
4914-0600	McKim or Victor Copper Asbestos	100	Box	3304-6900
4914-0865	McKim or Victor Copper Asbestos	25	Box	142481
4914-0960	McKim or Victor Copper Asbestos	5	Heat Sealable Bag	3304-1625
4914-1050	McKim or Victor Copper Asbestos	50	Box	266757
4914-1100	McKim or Victor Copper Asbestos	25	Box	142482
4914-1150	McKim or Victor Copper Asbestos	25	Box	3304-6670
4914-1200	McKim Copper Asbestos	1	Heat Sealable Bag	3304-1625
4914-1250	McKim or Victor Copper Asbestos	50	Box	3304-6900
4914-1350	McKim or Victor Copper Asbestos	25	Box	266757
4914-1450	Victor Copper Asbestos	1	Heat Sealable Bag	3304-1625
4914-1500	McKim or Victor Copper Asbestos	50	Box	3304-6900
4914-1510	McKim or Victor Copper Asbestos	10	Heat Sealable Bag	3304-1625
4914-1575	McKim Copper Asbestos	25	Box	266757
4914-1600	McKim or Victor Copper Asbestos	25	Box	266757
4914-1750	Victor Copper Asbestos	5	Heat Sealable Bag	3304-1625

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BY G.P.C. CHK'D C.E.C. APP'D N.J.J.

CHANGES FROM PREVIOUS ISSUE

FORM LB-478

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LINDE COMPANY
DIVISION OF UNION CARBIDE CORPORATION

ENGINEERING DEPT.

STANDARD PRACTICE INSTRUCTIONS

SPI-25.001		
DATE 8-27-63	SHEET NO. 5	OF 7

SUBJECT: PROCESSING AND PACKAGING OF GASKETS FOR OXYGEN SERVICE
CLASS II - GASEOUS SERVICE

BY G.P.C. CH'KD C.E.C. APP'VD N.J.J.

CHANGES FROM PREVIOUS ISSUE

Code Number	Name of Gasket	PACKAGING		
		Quantity in Each Package	Covering	Code or Part Number
4914-1800	McKim or Victor Copper Asbestos	50	Box	3304-6900
4914-1815	McKim or Victor Copper Asbestos	5	Heat Sealable Bag	3304-1625
4914-1900	Victor Copper Asbestos	10	Heat Sealable Bag	3304-1650
4914-1985	McKim Copper Asbestos	10	Heat Sealable Bag	3304-1650
4914-2055	McKim Copper Asbestos	10	Heat Sealable Bag	3304-1650
4914-2065	McKim Copper Asbestos	25	Box	3304-7250
4914-2100	McKim or Victor Copper Asbestos	10	Heat Sealable Bag	3304-1650
4914-2195	McKim or Victor Copper Asbestos	10	Heat Sealable Bag	3304-1280
4914-2200	McKim Copper Asbestos	10	Heat Sealable Bag	3304-1280
4914-2245*	McKim Copper Asbestos - 6-13/16" O.D. (2nd Stage Seat Gasket - Worthington 95% Oxygen Compressor)	24	Heat Sealable Bag	3304-1260
4914-2330	McKim Copper Asbestos	10	Heat Sealable Bag	3304-1280
4914-2332	McKim Copper Asbestos	10	Heat Sealable Bag	3304-1280
4914-2333*	McKim Copper Asbestos - 7-13/16" O.D. (2nd Stage Cover Gasket - Worthington 95% Oxygen Compressor)	24	Heat Sealable Bag	3304-1280
4914-2335*	McKim Copper Asbestos - 7-15/16" O.D. (1st Stage Seat Gasket - Worthington 95% Oxygen Compressor)	38	Heat Sealable Bag	3304-1280
4914-2340	McKim or Victor Copper Asbestos	1	Heat Sealable Bag	3304-1075
4914-2360*	McKim Copper Asbestos - 8-9/16" O.D. (1st Stage Cover Gasket - Worthington 95% Oxygen Compressor)	38	Heat Sealable Bag	3304-1075

*NOTE: Test Samples:
No. to be tested from each lot - 1
Quantity in each lot - 100

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FORM LB-478

SUBJECT PROCESSING AND PACKAGING OF GASKETS FOR OXYGEN SERVICE
CLASS II - GASEOUS SERVICE

BY G.P.C. CHKD C.E.C. APP'D N.J.J.

CHANGES FROM PREVIOUS ISSUE

Code Number	Name of Gasket	PACKAGING		
		Quantity in Each Pkg.	Covering	Code or Part Number
4914-2400	McKim Copper Asbestos	10	Heat Sealable Bag	9904-1075
4914-2950	Crane Corrugated Copper	1	Heat Sealable Bag	3304-1650
4914-3000	Corrugated Copper	5	Heat Sealable Bag	3304-1650
4914-3075	Crane Corrugated Copper	50	Box	3304-7409
4914-3100	Corrugated Copper	10	Heat Sealable Bag	3304-1650
4914-3200	Crane Corrugated Copper	1	Heat Sealable Bag	3304-1650
4914-3250	Corrugated Copper	10	Heat Sealable Bag	3304-1280
4914-3500	Hoyt Lead	1	Heat Sealable Bag	3304-1650
4914-3700	Hoyt Lead	5	Heat Sealable Bag	3304-1280
4914-3750	Hoyt Lead	10	Heat Sealable Bag	9904-1075
4914-3800	Hoyt Lead	1	Heat Sealable Bag	9904-1075
4914-3950	Hoyt Lead	10	Heat Sealable Bag	9904-1085
4914-4050	Hoyt Lead	10	Heat Sealable Bag	9904-1130
4914-4150	Hoyt Lead	1	Heat Sealable Bag	9904-1130
4914-6530	Lead/Copper	25	Box	142481
4914-8250	Kerotest Bushing	5	Heat Sealable Bag	3304-1625

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LINDE COMPANY
DIVISION OF UNION CARBIDE CORPORATION
STANDARD PRACTICE INSTRUCTIONS

ENGINEERING DEPT.

SPI-25.001

DATE 8-27-63 | SHEET NO. 7 | OF 7

SUBJECT: PROCESSING AND PACKAGING OF GASKETS FOR OXYGEN SERVICE
CLASS II - GASEOUS SERVICE

BY G.P.C. CHK'D C.E.C. APP'VD N.J.J.

CHANGES FROM PREVIOUS ISSUE

Code Number	Name of Gasket	PACKAGING		
		Quantity in Each Pkg.	Covering	Code or Part Number
4914-8260	Kerotest Diaphragm	5	Heat Sealable Bag	3304-1625
4914-8300	Kerotest Bushing - Copper	10	Heat Sealable Bag	3304-1625
4914-8325	Kerotest Diaphragm	5	Heat Sealable Bag	3304-1625
4914-8825	Bonnet	10	Heat Sealable Bag	3304-1650
4914-9430	Lead	5	Heat Sealable Bag	3304-1625
4914-9440	Lead	5	Heat Sealable Bag	3304-1625
4914-9460	Lead	100	Box	3304-6900
4914-9525	Bonnet	10	Heat Sealable Bag	3304-1650
4914-9700	Worthington	Do not	require packaging	
4914-9701	Worthington	Do not	require packaging	
4914-9710	Worthington	Do not	require packaging	
4914-9720	Worthington	Do not	require packaging	
4914-9721	Worthington	Do not	require packaging	
4914-9730	Worthington	Do not	require packaging	
4914-9731	Worthington	Do not	require packaging	
4914-9750	Worthington	Do not	require packaging	
4914-9760	Worthington	Do not	require packaging	

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STANDARD PRACTICE INSTRUCTIONS

ENGINEERING DEPT.

SPI-25.104

DATE	SHEET NO.	OF
1-1--67	1	1

SUBJECT CLEANING AND HANDLING COILS OF COPPER TUBING

CHKD. APPVD. BY

CHANGES FROM PREVIOUS ISSUE

FORM LB-478

Purpose

To establish the Stores Department procedures for cleaning and handling coils of copper tubing.

Cleaning

(1) Refrigeration tubing purchased per ASTM B 280 in 50 ft. sealed coils, Code Nos. 0587-3620 through 0587-3948, conforms to Linde Engineering Standard GS-38 and GS-39 for Class 2 Cleaning as received from the vendor. Therefore, this class of tubing should not be recleaned upon receipt by Linde.

(2) All other coils of copper tubing must be sent to Section 35, upon receipt, to be "Cleaned for Oxygen Service" on an "Intersectional Work Order", sealed, returned to the Stores Department and placed in stock.

(3) Any pieces of coils or full coils which are not sealed must be recleaned and sealed before being issued.

(4) Charge the cost of cleaning to the Material Code No. which applys.

Handling

(1) Coils of copper tubing must be kept sealed at all times.

(2) After a piece of tubing is cut from a coil, the piece being issued must be sealed on both ends and the remainder of the coil must be resealed.

(3) Cutting and deburring tools must be kept clean.

(4) The tubing may be sealed with either 2" wide Plastic Coated Green Cloth Tape, Code No. 9940-1030 on the proper size polethylene cap.

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LINDE COMPANY
DIVISION OF UNION CARBIDE CORPORATION
STANDARD PRACTICE INSTRUCTIONS

ENGINEERING DEPT.

SPI-25.153

DATE	SHEET NO.	OF
6-7-61	1	2

SUBJECT: CLEANING MISCELLANEOUS PARTS IN CHLOROTHENE

BY L.C.K. CH'KD C.H.K. APP'D E.K.S.

Substituted Chlorothene for trichlorethylene

CHANGES FROM PREVIOUS ISSUE

FORM LB-478

GENERAL PROCEDURE:

Parts to be cleaned are to be immersed in Chlorothene either outside the building or under an exhaust hood and agitated by hand until all visible traces of contamination on the part have disappeared. If contamination is extremely tenacious let part soak from 20 to 30 minutes and agitate again. When part is clean remove from solution and place it on a piece of clean Kraft paper to dry. An alternate method is to suspend part in air until dry. Do not "blow off" part with an air hose. Drying parts which have been cleaned in Chlorothene must be done outside the building or under an exhaust hood.

CLEANING GASKETS OF ALL TYPES:

(1) Immerse in Chlorothene until bubbling stops or a minimum of 20 minutes.

(2) Remove gaskets from solution and lay on a table covered with clean Kraft paper. (Operator must wear rubber gloves.)

(3) Move gaskets around until all of them are dry.

(4) Replace paper or Chlorothene whenever either one appears dirty.

(Visual examination for contamination is satisfactory.)

NOTE: Use above method on fibre discs (Code #9908-3373)

CLEANING SAFETY HEAD DIAPHRAGMS:

Use the same procedure as stated above. Handle diaphragms carefully to avoid denting. Wrap in clean tissue paper and pack as specified on the drawing to avoid denting.

CLEANING MISCELLANEOUS VALVE PARTS:

(1) Immerse in Chlorothene and agitate until clean.

(2) Remove from solution and place on a table covered with clean Kraft paper until part is dry. An alternate method is to suspend part in air until dry.

(3) CHANGE CHLOROTHENE WHEN DIRTY. REPEAT THIS AS OFTEN AS NECESSARY.

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LINDE COMPANY
DIVISION OF UNION CARBIDE CORPORATION
STANDARD PRACTICE INSTRUCTIONS

ENGINEERING DEPT.

SPI-25.153

DATE	SHEET NO.	OF
6-7-61	2	2

SUBJECT: CLEANING MISCELLANEOUS PARTS IN CHLOROTHENE

BY [illegible] CH'K'D [illegible] APP'D [illegible]

Substituted Chlorothene for trichlorethylene

CHANGES FROM PREVIOUS ISSUE

FORM LS-478

CLEANING STEM TYPE DIAL THERMOMETERS:

(1) Immerse stem and connection nut in clean Chlorothene and agitate until clean. Care should be taken that none of the solvent comes in contact with the thermometer case.

(2) Remove from solution and place on clean Kraft paper until dry.

(3) CHANGE CHLOROTHENE WHEN DIRTY. REPEAT THIS AS OFTEN AS NECESSARY.

SAFETY PRECAUTIONS:

Be sure that all the precautions are observed as outlined in SPI-53.001 which covers "Use of Chlorinated Solvents."

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STANDARD PRACTICE INSTRUCTIONS

ENGINEERING DEPT.

SPI-49.104

DATE	SHEET NO.	OF
10-10-52	1	4

Confidential Do Not Release to Outside Vendor

SUBJECT: GENERAL INSTRUCTIONS FOR TYPE 300 SERIES STAINLESS STEEL FOR CORROSION RESISTANCE.

BY MD CH'D RWS GPC APP'D GHB

RETYPED 5-31-63

Formerly SPI-9. CHANGES FROM PREVIOUS ISSUE

.01 SCOPE

The instructions in this article are intended for Type 300 series stainless steel only. These instructions are NOT to be followed for any other stainless steel or metal unless drawings or SPI's specifically call for "Stainless Steel Pickle" or "Stainless Steel Passivating Soltuion".

.02 ENGINEERING DATA

This subdivision is a guide for design engineers and is not intended as a shop instruction.

Unannealed welded types #304, 308, 309 and 316 stainless steels are not corrosion resistant unless water (or air for thin sections) quenched immediately upon welding. This can be done satisfactorily on lap but not on butt welds. These types of stainless steels when annealed and quenched after welding are corrosion resistant. Welded articles even for non-corrosive service which are fabricated from these stainless steels should not be "pickled" as welded unless first annealed as the pickling attacks areas adjacent to welds. Unannealed welded types #347 and #321 stainless steels are corrosion resistant in the as-welded condition.

.03 PREPARATION FOR WELDING STAINLESS STEEL

It has been well said that 90% of the task of insuring satisfactory weld deposits consists in preparing the work for the actual welding. In this connection, cleanliness of the metal to be welded and of the surroundings including jigs, etc., is most important. When cleaning with wire brushes or metal wool,, it is desirable to make sure they are of stainless steel. Use stainless Steel wedges for separating sheets or plates during welding. If steel must be used for an anvil surface for hammering or straightening stainless, the more polished the steel surface the less the imbedding of steel into the staindess. Rough machined steel surfaces will cause the most trouble. If stainless steel backing plates are used, a rough machined surface will not imbed any steel. Roll stainless sheets with paper on rolls.

The above precautions are especially necessary when it is stated that the stainless steel must pass the "free iron test".

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.04 WELDING STAINLESS STEEL

Each type of stainless steel requires a different welding procedure so each one is covered by a separate "Welding SPI".

.05 REMOVAL OF WELDING SCALE, FLUX, ETC.

When this SPI is referred to on drawings, the stainless steel is intended primarily for corrosion resistance in which case it is essential that any scale, flux or weld spatter formed during the welding operation be removed in order to avoid localized corrosion around these surface contaminations.

72M LB-478

Fluxes, after welding is completed, form hard vitreous coatings which are resistant to most acids. The best method of removing these fluxes is by hammering, chipping, brushing, grinding, soaking in hot water, passivating, or a combination of these.

Steel in forcible contact with stainless steels leaves a contamination that acid washing will not remove, therefore use only:

(1) Stainless Steel wire brushes for removing scale, flux, etc.
(2) Stainless Steel chisels when chipping excess from welds.
(3) Grinding wheels as near as possible iron free.
(4) Wear rubbers on shoes wherever worker has to stand on stainless.

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.06 DEGREASING (for corrosion or non-corrosion service)

Punch press, spinning and machining compounds usually consist of an oil base WHICH MUST BE REMOVED before annealing, passivating or pickling. If such oily or greasy solutions are left on the surfaces during the annealing process, they are burned into the surface and may cause carburization so that subsequent pickling becomes difficult, leaving a pitted surface.

.07 ANNEALING (for corrosion or non-corrosion service)

It is essential that all grease and oil be removed before annealing per paragraph .06 for corrosion or non-corrosion work.

It is essential that all welding fluxes be removed before annealing in the G.E. electric furnace for corrosion or non-corrosion work because the chemical gases given off will attack the heating elements in the furnace.

.08 ALL CARBIDE AND CARBON CHEMICALS CO. STAINLESS STEEL SPECIFICATIONS (for corrosion service)

Carbide and Carbon Chemicals Co. specifications require that all stainless steel be passivated. Passivating must be the last operation after all machining, rolling, handling, etc. These specifications do permit Stainless Steel Pickling for annealed parts in order to remove scale but require this be followed by passivating. The drawing must definitely state if Stainless Steel Pickle may be used.

.09 PASSIVATING

Use "Stainless Steel Passivating Solution" made up per SPI-49.100

This solution can be used at room temperature to remove most of the metallic surface contaminations and foreign matter adhering to the surface as a result of contact with tools. However, "passivation" cannot be accomplished unless the solution is hot, therefore, whenever this SPI is referred to, the solution

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must be in the temperature range of 120° to 145°F. Allow the article to remain in the solution, with occasional agitation for 10 to 20 minutes. Follow immediately by thorough scrubbing and rinsing in clear water followed by steam.

Safety precautions which must be followed are given in SPI-53.002.

.10 STAINLESS STEEL PICKLING

Use "Stainless Steel Pickling Solution" made up per SPI-49.100.

The improper use of this pickle must lead to serious and costly troubles. THEREFORE, THE SHOP MUST NOT USE THIS STAINLESS STEEL PICKLING SOLUTION ON ANY STAINLESS PARTS unless the drawing so specifies or unless authorized by G. H. Bohn, F. S. Kovacsev, or D. W. Morgan, in writing, for the shop, and Mr. C. M. Heath for the Laboratory. This solution must be in the temperature range of 120° to 145°F. Allow the article to remain in the solution with occasional agitation for ten to twenty minutes. Follow immediately by thorough scrubbing and rinsing in clear water followed by steam. A copious quantity of steam is necessary to remove all traces of this pickling solution. The hotter the solution, the higher the hydro fluoric content and the longer the time in the solution, the more severe is the pickling action. Never leave the metal in this solution longer than necessary to remove scale. It is better to pickle for a short time and then scrub with a stainless wire brush to further loosen the scale, then repickle; rather than to try to remove all of a tenacious scale in one pickle.

Safety precautions which must be followed are given in SPI-53.002.

.11 TESTING FOR FREE IRON REQUIRED ON ALL CARBIDE AND CARBON CHEMICALS CO. WORK

After passivating, the stainless steel surface in contact with fluids in service must be dried and then tested for the presence of free iron with an aceto-acetanilide solution. This solution is made up of four parts of solution "A" to one part of solution "B", and will be supplied by the Inspection Dept. The test for free iron is to be performed by the Inspection Dept. personnel. This solution must be applied to the suspected area by means of an all-rubber atomizer with glass bowl. The presence of free iron is indicated by the solution turning from a pink to a blood-red color. A period of from one to five minutes is required for the test. If the presence of free iron is indicated, the passivating or the acid washing and testing must be repeated until a neutral indication results. This is indicated by a white, grey, or a very light pink color. All of the aceto-acetanilide solution must be promptly removed after testing by washing off with clear, warm water. The presence of nitric acid is indicated by a purple color. Keep the solution away from open flames or hot metal.

NOTE: THE STAINLESS STEEL PICKLING SOLUTION AND THE STAINLESS STEEL PASSIVATING SOLUTION are not to be confused with Pickling Solutions for non-ferrous metals and are NEVER to be used for pickling non-ferrous metals.

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.12 COLD WORKED STAINLESS

Where stainless is being used for corrosion resistance, it is necessary that it be in the annealed condition. Carbide and Carbon Chemicals specifications require this for all Carbide and Carbon Chemicals Co. work. Where it is definitely known that there is severe cold working and the vessel is to be built per Carbide and Carbon Chemicals Co. specifications, the drawing will specify that stainless part to be annealed. However, there are cases where cold working such as rounding of shells is not foreseen by the designer. Therefore, in any such cases it is advisable to contact the Design Engineer, or his assistant, to see if annealing is necessary. Otherwise no hammering is permitted on stainless steel which is not going to be annealed afterwards.

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APP'D CH'KD BY CHANGES FROM PREVIOUS ISSUE FORM LB-479

TONAWANDA FACTORY

LINDE COMPANY
DIVISION OF UNION CARBIDE CORPORATION
STANDARD PRACTICE INSTRUCTIONS

ENGINEERING DEPT.

SPI-49.106

DATE	SHEET NO.	OF
1-21-57	1	2

SUBJECT: HANDLING AND CLEANING STAINLESS STEEL FOR OXYGEN, NITROGEN AND NON-CORROSIVE SERVICE

APP'VD GHB

CH'KD

BY GPC

Copied 4-25-62 leb

CHANGES FROM PREVIOUS ISSUE

GENERAL

The following instructions apply to stainless steel fabrication for non-corrosive service such as Linde Liquid Oxygen and Nitrogen vessels. The inside of the vessel or piping must be free from rust and iron deposits, also free from grease, oil, and other foreign materials. Following is the procedure to follow:

HANDLING OF STAINLESS

(1) Stainless steel material must not be stepped on or walked on while in stock or during fabrication because the material might be contaminated with iron or rust picked up from the floor on employee's shoes. Also, nails on shoes will contaminate the material. The cost of removing this type of contamination is high.

(2) Stainless steel sheets or plates must not be placed in direct contact with steel while in stock or during fabrication because it will rapidly become contaminated. This is especially true if the material is exposed to the weather.

(3) Bending rolls should be covered with paper, whenever practical, to reduce steel contamination during the rolling operation. If one side of a plate is rustier than the other, the rustiest side should be rolled to the outside. Repeat heat numbers on the outside of the shell if the original numbers have been rolled inside.

(4) Steel in forcible contact with stainless steel results in contamination which is difficult to remove, therefore all tools used in fabricating stainless steel, such as forming tools, hammers, anvils and wire brushes, should be stainless steel. If stainless tools are not available and steel has to be used for forming tools or for an anvil or a hammer for hammering stainless, the steel surfaces that come in contact with the stainless steel should be highly polished and free of burrs to keep the contamination of the stainless steel with steel at a minimum.

(5) Do not severly hammer, with metal hammers, abutting edges of stainless sheet, plate or pipe prior to welding since this hardens the edges and invites cracking during welding. If it is necessary to severly hammer small stainless parts, such as cones, during fabrication, the parts should be annealed and pickled prior to welding to avoid cracking.

CLEANING OF STAINLESS

(1) Rust and iron contamination ON THE INSIDE SURFACES OF THE EQUIPMENT ONLY, shall be removed by the most economical method such as wirebrushing with a stainless steel wire brush, disc grinding, or "Passivating" in accordance with SPI 49.104, paragraph .09. It is not necessary or required to check for free iron after passivating the equipment. NOTE; The "Stainless Steel Pickling Solution" should never be used unless authorized by the Design and Metallurigical Engineer.

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FORM LB-478

(2) **Cleaning for Oxygen Service**
The equipment shall be "Cleaned for Oxygen Service" in accordance with the instructions given in SPI's 49.001, 49.002, and 49.005.

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SPI-49.111

DATE	SHEET NO.	OF
12-28-65	1	6

SUBJECT: CLEANING PROCEDURES - METALS CLEANING DEPARTMENT, BUILDING #70

APP'VD

CH'KD

BY

CHANGES FROM PREVIOUS ISSUE

FORM LB-478

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.01 SCOPE

This specification describes the various cleaning procedures used in Building #70. All of the procedures which specify "Clean for O_2 Service" meet the requirements for Class 2 and 3 cleaning specified in SPI-49.117 and SPI-49.118, respectively.

.02 ALUMINUM

Operation Description: "Clean for Welding" or "Clean for O_2 Service".

1) Aluminum which is contaminated with oil, or other heavy soil, must be precleaned with the cleaning solution gun.
2) Rinse completely with cold water hose or dip in Tank No. 2.
3) Etch by soaking in Aluminux, Tank No. 1. Do not leave material in this tank any longer than necessary.

CAUTION: Light gage material; such as, column trays or threaded parts such as column studs must not be left in this tank longer than 1 to 2 minutes.

4) Immediately after the material is removed from Tank No. 1, submerge in Hot Water Rinse, Tank No. 2. Make sure material is completely rinsed and drained.
5) Deoxidize and/or de-smut material by soaking in No. 596, Tank No. 3. The material should be removed from the tank as soon as the discoloration is removed.
6) Rinse material completely in Hot Water Rinse, Tank No. 4. Blow dry. Inspect for "Clean for O_2 Service" if required.

.03 NON-FERROUS PIPE ASSEMBLIES AND PARTS

Operation Description: "Clean for O_2 Service".

NOTE. Preclean with cleaning solution gun, if necessary.

1) Soak in Hot Water Rinse, Tank No. 2, to remove flux.
2) Soak in Non-Ferrous Pickle, Tank No. 7, until material is uniformly pickled.
3) Rinse completely with cold water hose or in Hot Water Rinse, Tank No. 4.
4) Clean with solution gun.
5) Rinse completely with cold water hose or in Hot Water Rinse, Tank No. 4. Blow dry. Inspect for "Clean for O_2 Service".

APP'D CHKD BY

.04 NON-FERROUS PIPE AND TUBING - STRAIGHT LENGTHS

Operation Description: "Clean for O_2 Service".

1) Preclean with cleaning solution gun.
2) Rinse completely with cold water hose.
3) Soak in Non-Ferrous Pickle, Tank No. 12, until material is uniformly pickled.
4) Rinse completely with cold water hose.
5) Clean with solution gun.
6) Rinse completely with cold water hose, then blow dry. Inspect for "Clean for O_2 Service".

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.05 STAINLESS STEEL, 300 SERIES

Operation Description: "Degrease".

1) Material which is to be heat-treated:

a) Preclean with cleaning solution gun.
b) Rinse completely with cold water hose, blow dry. Inspect.

Operation Description: "Pickle to Remove Heat-Treat Scale".

2) Material which has been heat-treated:

a) Soak in Stainless Pickle, Tank No. 8, until discoloration has been removed. Scrub material with clean rags or brush if necessary to remove discoloration. Resoak in Tank No. 8 if necessary. Do not soak any longer than necessary to remove the discoloration.
b) Rinse completely with cold water hose, then blow dry. Inspect for "Clean for O_2 Service".

.06 STEEL PIPE AND STEEL PIPE ASSEMBLIES AND STEEL PARTS (INCLUDING SHEET STEEL) WHICH MUST BE CLEANED AND RUST-PROOFED OR PREPARED FOR PAINTING

Operation Description: "Clean for O_2 Service and Rustproof" or "Clean and Prepare for Painting".

1) If the parts have paint on any surface, soak in Paint Stripper, Tank No. 6, until all paint is removed or loosened.

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Changed Par 06

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2) Preclean with cleaning solution gun.
3) Rinse completely with cold water hose or in Hot Water Rinse, Tank No. 4.
4) Soak in Carbon Steel Pickle, Tank No. 9, until all rust and scale has been removed. Soak parts at least one hour when tank is at 140°F. If tank is at ambient temperature, soak parts at least two hours. NOTE: Do not soak sheet steel parts any longer than necessary to remove rust and scale.
5) Rinse completely with cold water hose, or in Hot Water Rinse, Tank No. 4.
6) Soak in first Carbon Steel Rustproof, Tank No. 10, for at least five minutes.
7) Rinse completely with cold water hose, or in Hot Water Rinse, Tank No. 4.
8) Soak in second Carbon Steel Rustproof, Tank No. 11, for at least two minutes. Lift material out of solution and drain completely. Do not rinse.
9) Blow dry. Inspect for "Clean for O_2 Service" or "Clean and Prepare for Painting".

.07 STEEL AND STAINLESS STEEL SHELLS

Operation Description: "Degrease" or "Clean for O_2 Service"

This procedure covers shells which will not fit into tanks.

1) Clean with solution gun.
2) Rinse completely with cold water hose.
3) Blow dry. Inspect for "Clean for O_2 Service", if required.

.08 ALUMINUM SHELLS

Operation Description: "Clean for Welding" or "Clean for O_2 Service".

This procedure covers shells which will not fit into tanks.

1) Etch inside and outside of shell by swabbing with solution from Tank No. 1.

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CHANGES FROM PREVIOUS ISSUE: Changed Par. .06(2) and (9)

FORM LB-478

.08 ALUMINUM SHELLS (CONT.)

2) Rinse completely with cold water hose.

3) Deoxidize and/or de-smut inside and outside of shell by swabbing with solution from Tank No. 3.

4) Rinse completely with cold water hose.

5) Blow dry. Inspect for "Clean for O_2 Service" if required.

.09 9% NICKEL AND STAINLESS STEEL HEADS - AFTER MACHINING

Operation Description: "Degrease"

1) Preclean with solution gun.

2) Rinse completely with cold water hose or in Tank No. 2.

3) Soak in Aluminux , Tank No. 1.

4) Rinse in Hot Water Rinse, Tank No. 2.

5) Blow dry. Inspect. This procedure is not "Clean for O_2 Service."

.10 9% NICKEL AND STAINLESS STEEL HEADS-FABRICATED-BEFORE ASSEMBLY ON SHELL

Operation Description: "Clean for O_2 Service"

1) Preclean with solution gun.

2) Rinse completely with cold water hose.

3) Blow dry. Inspect for "Clean for O_2 Service."

.11 PAINT STRIPPING

Operation Description: "Strip Paint"

1) Soak parts in Paint Stripper, Tank No. 6 until all paint is removed or loosened.

2) Clean with solution gun to remove loose paint.

3) Rinse completely with cold water hose.

4) Rust-proof in Chromic Acid Tank No. 11 for at least two minutes.

5) Drain and blow dry. Do not rinse. Inspect. This procedure is not "Clean for O_2 Service."

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.11 PAINT STRIPPING (CONT.)

NOTE: Do not use Tank No. 6 for stripping paint from Aluminum or Galvanized Steel.

.12 PIPE AND TUBING BENT ON BENDING MACHINES

Operation Description: "Degrease" or "Clean for O_2 Service"

1) Clean with solution gun to remove all bending machine oil.

2) Rinse completely with cold water hose.

3) Blow dry. Inspect for "Clean for O_2 Service" if required.

NOTE: a) "Degrease" will be specified under the "Operation Description" if precleaning is required (any type of metal) prior to fabrication or storage.

b) "Clean for O_2 Service" will be specified under "Operation Description" if this class of cleaning is required (all types of metal except Aluminum.)

c) If the pipe or tubing is Aluminum and "Clean for O_2 Service" is specified under the "Operation Description", use procedure given in par. .02.

.13 STEAM GUN CLEANING

Operation Description: "Clean for O_2 Service with Steam Gun" or "Degrease with Steam Gun"

When parts are too large to be brought into Building 70, such as assembled shells or CM Machines returned for rehabilitation, use the following procedure:

1) Clean with steam gun using detergent solution.

2) Rinse with hot water from steam gun and/or cold water hose.

3) Blow dry. Inspect for "Clean for O_2 Service" if required.

.14 GENERAL

1) If material has been "Cleaned for O_2 Service" and has openings, close openings per SPI-69.010 and/or SPI-69.011 after inspection.

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CLEANING PROCEDURES - METALS CLEANING DEPARTMENT, BUILDING #70

.14 GENERAL (CONT.)

2) Tag parts with Stainless Steel discs for processing if necessary for identification.

3) If no further work is going to be done inside a shell and first head assembly after cleaning, cover end of shell with Visqueen.

4) If material has marking ink on it which cannot be removed with cleaning solutions, use Chlorothene.

5) Remove tape and adhesive from material before cleaning.

6) All threaded ends must be protected with caps, all machined surfaces must be protected and all flange faces must be protected with fiber discs.

.15 TANK DESCRIPTIONS

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TANK NO.	SOLUTION USED	DIMENSIONS LONG	WIDE	DEEP
1.	Etch and/or clean Aluminum and other metals	14' - 0"	7' - 6'	12' - 9"
2.	Hot Water Rinse	14' - 0"	7' - 6"	12' - 9"
3.	Deoxidize and/or De-smut Aluminum	12' - 6"	6' - 0"	12' - 0"
4.	Hot Water Rinse	12' - 6"	6' - 0"	12' - 0"
6.	Strip Paint	12' - 0"	4' - 6"	4' 6"
7.	Pickle Non-Ferrous Materials (Except Aluminum)	12' - 0"	4' - 3"	4' - 6"
8.	Pickle Stainless Steel	8' - 6"	2' - 0"	3' - 6"
9.	Pickle Carbon Steel	15' - 0"	2' - 0"	3' - 6"
10.	Rust-Proof Carbon Steel (1st Step)	15' - 0"	2' - 0"	3' - 6"
11.	Rust-Proof Carbon Steel (2nd Step)	15' - 0"	2' - 0"	3' - 6"
12.	Pickle Non-Ferrous Material (Except Aluminum)	25' - 0"	2' - 0"	3' - 6"

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STANDARD PRACTICE INSTRUCTIONS

ENGINEERING DEPT.

SPI-49.112

DATE	SHEET NO.	OF
3/21/66	1	6

SUBJECT: COMPOSITION AND CONTROL OF SOLUTIONS - METALS CLEANING DEPARTMENT - BUILDING #70

APP'D

BY

DATE

CHANGES FROM PREVIOUS ISSUE: Added: (12) Diversey G-60, Par. .01

FORM LB-678

.01 MATERIALS

The following chemicals are stocked for making up and maintaining the solutions used in the Metals Cleaning Department:

1) Diversey Aluminux (in 450 lb. drums), Code No. 3008-3000.

2) Diversey No. 202 (in 400 lb. drums), Code No. 3008-2775.

3) Diversey No. 596 (in 175 lb. drums), Code No. 3002-1300.

4) Oakite No. 87 (in 375 lb. drums), Code No. 3030-8600.

5) Diversey Everite (in 13 gal. carboys), Code No. 6006-4220.

6) Sodium Dichromate Crystals (in 100 lb. drums), Code No. 3038-6900.

7) Chromic Acid (in 100 lb. cans), Code No. 3002-1500.

8) 66° Baume Technical Sulfuric Acid (in 13 gal. carboys), Code No. 3002-3000.

9) 42° Baume Technical Nitric Acid (in 13 gal. drums), Code No. 3002-2800.

10) 70% Technical Hydrofluoric Acid (in 30 gal. drums), Code No. 3002-2500.

11) Diversey No. 1319 (in 400 lb. drums), Code No. 3008-2825.

12) Diversey Diverstrip G-60 (in 425 lb. drums), Code No. 3008-2770.

.02 CAPACITITES, OPERATING TEMPERATURES AND COMPOSITION OF SOLUTIONS IN TANKS

1) Tank No. 1 - Aluminux (Aluminum, 9% Nickel and Stainless)

Capacity - 9450 gallons

Operating Temperature - 160°F.

Diversey Aluminux, 6 oz./gal. or 3545 lbs./batch

Diversey No. 202, 2 oz./gal. or 1180 lbs./batch

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NOTE: When making up new batch of solution, fill tank one-third full of water, circulate water and bring up to temperature. Add one drum of powder, then wait until dissolved. Add a second drum, etc. until all of the powder has been added. Continue adding fresh water, while adding powder, until tank is full. When bringing tank up to strength, drop temperature to 100° to 120°F. to avoid foaming when adding materials.

2) Tank No. 3 - No. 596 (Aluminum only)

Capacity - 6330 gallons

Operating Temperature - Ambient

Diversey No. 596, 7 oz./gal. or 2770 lbs./batch

Sulfuric Acid, 7% by volume or 443 gal./batch

NOTE: When making up a new batch of solution, fill tank one-half full, then add the No. 596 while continuing to add fresh water. After all of the powder has been added and dissolved, add the sulfuric acid. Continue to add fresh water until tank is full.

3) Tank No. 5 - Preclean (All Metals)

Capacity - 2085 gallons

Operating Temperature - 160°F.

Diversey No. 1319, 1.5 oz./gal. or 200 lbs./batch

NOTE: When making up a new batch of solution, fill tank one-half full. Circulate water and bring up to temperature. Slowly add Diversey while continuing to add fresh water until tank is full.

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Added: Diversey 0-66, Par. .02(4)
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4) Tank No. 6 - Paint Stripper

Capacity - 1515 gallons

Operating Temperature - 160°F.

Diversey Aluminux, 12 oz./gal. or 1135 lbs./batch

Diversey G-60, 4 oz./gal. or 380 lbs./batch

NOTE: When making up a new batch of solution, fill tank half full of water. Circulate water and bring up to temperature. Slowly add materials while continuing to add fresh water until tank is full. When bringing tank up to strength, drop temperature to 100° to 120°F. to avoid foaming when adding material.

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5) Tank No. 7 - First Non-Ferrous Pickle

Capacity - 1515 gallons

Operating Temperature - Ambient

Sodium Dichromate Crystals, 9 oz./gal. or 850 lbs./batch

Sulfuric Acid, 16% by volume or 242 gals./batch

NOTE: Fill tank half full of water. Slowly add Sodium Dichromate Crystals. As soon as crystals are dissolved, add sulfuric acid slowly. Continue to add fresh water until tank is full.

6) Tank No. 8 - Stainless Pickle

Capacity - 355 gallons

Operating Temperature - 145°F.

Hydrofluoric Acid, 4% by volume or 14 gals./batch

Nitric Acid, 14% by volume or 50 gals./batch

NOTE: Fill tank half full of water. Slowly add the hydrofluoric acid, then the nitric acid, while continuing to add fresh water, until tank is full.

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7) Tank No. 9 - Carbon Steel Pickle

Capacity - 625 gallons

Operating Temperature - Ambient

Diversey Everite - 20% by volume or 125 gals./batch

NOTE: Fill tank half full of water. Slowly add the Everite, while continuing to add fresh water, until tank is full.

8) Tank No. 10 - First Carbon Steel Rustproof

Capacity - 625 gallons

Operating Temperature - 170°F.

Oakite No. 87 - 6 oz./gal. or 235 lbs./batch

NOTE: Fill tank half full of water. Circulate water and bring up to temperature. Add Oakite No. 87. Add fresh water until tank is full.

9) Tank No. 11 - Second Carbon Steel Rustproof

Capacity - 625 gallons

Operating Temperature - 170°F.

Chromic Acid - 0.1 oz./gal. or 4 lbs./batch

NOTE: Fill tank full of water. Circulate water and bring up to temperature. Add the Chromic Acid.

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10) Tank No. 12 - Clean and Pickle Non-Ferrous Tubing

Capacity - 1030 gallons

Operating Temperature - Ambient

Sodium Dichromate Crystals, 9 oz./gal. or 580 lbs./batch

Sulfuric acid, 16% by volume or 165 gal./batch

NOTE: Fill tank one-half full of water. Slowly add sodium chromate crystals. As soon as crystals are dissolved, add sulfuric acid slowly. Continue to add fresh water until tank is full.

11) Drum for Steam Gun Solution

Capacity - 55 gallons

Operating Temperature - Ambient

Diversey No. 1319, 3 oz./gal. or 10 lbs./batch

NOTE: Fill drum with water. Add Diversey and stir until dissolved.

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GENERAL NOTE:

A full tank is within nine inches of the top of the tank (not top of bumper boards).

.03 CONTROL OF SOLUTIONS

1) All tanks must be kept full, by daily additions of water, except Tank No. 5 - Preclean (All Metals), which supplies solution for the solution guns.

2) The Chemist from the Molecular Sieve Department should sample the tanks in accordance with the Testing Schedule dated June 22, 1964. He should report the strength of the solutions in each tank and specify the amount of chemicals required to bring the solutions up to full strength.

APP'D CHK'D BY CHANGES FROM PREVIOUS ISSUE FORM LB-478

3) Copies of the Chemist's Test Report should be sent to the following:

Division Foreman - Building #70
Section No. 35 Foreman - Building #70
Process Development Department

4) The strength of the solutions should never be allowed to go below 75% of full strength.

5) The Section Foreman should consult with the Project Engineer in the Process Development Department before dumping and recharging a tank.

6) The Section Foreman is responsible for having additions of Chemicals made to the tanks immediately after receiving the Chemist's Test Report and recording on the Test Report the date the additions were made.

7) The Section Foreman is responsible for having the solutions kept free of oil and other foreign materials.

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CHANGES FROM PREVIOUS ISSUE
FORM LB-478

TONAWANDA FACTORY

LINDE COMPANY
DIVISION OF UNION CARBIDE CORPORATION
STANDARD PRACTICE INSTRUCTIONS

ENGINEERING DEPT.

SPI-49.116

DATE	SHEET NO.	OF
2-28-66	1	3

SUBJECT

WIPE CLEANING AND DEGREASING

APP'D A.E.F.

BY G.P.C. CHK'D

CHANGES FROM PREVIOUS ISSUE

Revised Par. .03(b), (c)
Added Par. .03(e), (f)

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.01 SCOPE

This specification describes the "wipe cleaning" procedure which is used in various sections throughout the Fabrication Department on large components. This procedure meets the requirements for Class 2 and 3 cleaning specified in SPI-49.117 and SPI-49.118, respectively.

.02 WIPE CLEANING (EXCEPT SECTION 31)

Operation Description: Wipe Clean per SPI-49.116.

(a) This procedure is to be used to clean columns, containers and other large components during the final assembly operations when it would not be economical to clean by any other method.

(b) Make up a solution of one part of Wyandotte Aerowash, Code No. 3008-2950 and five parts of clean water in the 55-gallon stainless steel drum provided for this purpose in the Main Fabrication Department, or in a clean pail depending on the amount of "wipe cleaning" to be done. This solution is used at room temperature.

(c) Apply the solution to all critical surfaces with a clean rag or brush. Scrub the surfaces thoroughly until clean.

(d) Rinse the solution off the surfaces with a clean rag wet with clean water or flush with a cold water hose if practical.

(e) Blow the rinse water out of all pockets or crevices with clean, oil-free air. Dry all surfaces with clean rags or air.

.03 WIPE CLEANING - SECTION 31

Operation Description: Wipe Clean per SPI-49.116.

(a) This procedure is to be used to clean the inside of containers after the first head is installed and before the closing head is installed.

(b) Make up a solution in a 55-gallon stainless steel drum with cover, which has an electric immersion heater with a thermostatic control to maintain the solution at 160°F as follows:

Fill drum to within six inches of the top with clean water. Turn heater on. Add three ounces of Diversey 1319

APP'D A.E.F.

BY G.P.C. CH'D

CHANGES FROM PREVIOUS ISSUE

.03 WIPE CLEANING - SECTION 31 (CONT.)

Code No. 3008-2825, per gallon of water (five quarts of powder for a full batch). Stir powder until dissolved and bring up to temperature before using.

(c) Apply the hot solution to the inside surfaces of the shell and first head and the closing head with a brush. Scrub the surfaces thoroughly until clean.

(d) Rinse the solution off the surfaces with a cold water hose.

(e) Make up a solution in a clean 55-gallon drum with cover as follows:

Fill drum to within six inches of the top with clean water. Add 1/2% by weight of Sodium Nitrite, Code No. 3038-7700, per gallon of water (one quart of powder for a full batch). Stir powder until dissolved. Use solution at room temperature.

(f) Apply the Sodium Nitrite solution to the inside surfaces of the shell and first head and the closing head with a brush until all of the inside surfaces are thoroughly wetted. Drain excess solution from shell and first head and the closing head. Blow solution from behind the back-up rings and blow excess solution out of the parts.

NOTE: Both the Diversey 1319 and Sodium Nitrite solutions may be transferred to the shell and heads in a galvanized pail for brushing down the surfaces.

CAUTION: Although the Wyandotte, Diversey and Sodium Nitrite solutions are very mild, rubber gloves should be worn when applying the solutions.

.04 DEGREASING PARTS BEFORE ASSEMBLY - SECTION 43

Operation Description: Degrease per SPI-49.116.

(a) This procedure is to be used to clean threaded pipe, fittings, and other parts before assembly.

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SUBJECT: WIPE CLEANING AND DEGREASING

.04 DEGREASING PARTS BEFORE ASSEMBLY - SECTION 43 (CONT.)

(b) Make up a solution in the long tank in the rear. Fill tank to within one inch of the overflow with clean water. Turn steam on heating coil and allow water to come up to the thermostatically controlled temperature of 160°F. Add six ounces of Turco No. 4781, Code No. 3008-2925, per gallon of water (thirty quarts of powder for a full batch). Stir powder until dissolved.

(c) Soak parts in hot solution until clean. Brush pipe threads with solution if necessary to remove cutting oil.

(d) Rinse parts in hot water rinse tank which is heated to at least 160°F with live steam.

(e) Blow parts dry with clean, oil-free air.

CAUTION: DO NOT clean aluminum in the Turco solution.

The Turco solution is to be used for degreasing ONLY. This solution DOES NOT meet the requirements for Class 2 and 3 cleaning specified in SPI-49.117 and SPI-49.118.

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BY G.P.C. CHKD
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STANDARD PRACTICE INSTRUCTIONS

ENGINEERING DEPT.

SPI-49.117

DATE	SHEET NO.	OF
12-7-64	1	13

SUBJECT: CLEANING FOR OXYGEN SERVICE - GENERAL (CLASS 2 CLEANING)

APP'D DCF

CH'K'D

BY JPC

CHANGES FROM PREVIOUS ISSUE

FORM LB-478

1. SCOPE

This specification outlines the general requirements for cleaning the equipment fabricated by the Tonawanda Factory for the production, storage or transportation of LIQUID OR GASEOUS OXYGEN, and in some cases, Nitrogen, Argon, Neon, Krypton, and other industrial gases. It also covers the requirements for inspection, protection, identification and other functions related to cleaning procedures.

2. DEFINITION OF TERMS

2.1 Clean

Containing no more contamination than that permitted by the class of service for which it is intended.

2.2 Oxygen Service

In contact with oxygen in the liquid or gaseous state, warm or cold, at any absolute pressure (unless pressure is stipulated).

2.3 Contaminant

Any substance foreign to the equipment, process or product.

2.4 Combustible

Possessing the potential to react rapidly or violently with oxygen, usually, but not always, requiring external stimulus. Example: ordinary lubricating oil.

2.5 Equipment

Any item which may come in contact with the product or by-products during manufacture, transportation, or storage operations.

2.6 Factory

Refers to the Tonawanda Factory.

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3. REQUIREMENTS FOR CLASS 2 CLEANING

This class of service requires essentially complete removal of contaminants; such as, hydrocarbon greases, oils, thread lubricants, shop dirt, water, filings, scale, weld spatter, chips, fluxes, paints, varnishes, marking materials, rust, powdered metal oxides, excelsior, packing materials, labels or any other foreign material. Many of these materials, especially hydrocarbon greases and oils, can react violently in the presence of oxygen, causing fires or explosions. Others, such as metal chips, can be propelled by a fluid stream with sufficient velocity to trigger an explosion on impact. Still others, by plugging small ports or seizing moving parts, can cause dangerous malfunctions of equipment. All of these materials are considered contaminants and must be removed. It is especially important to avoid trapping contaminants in locations difficult or impossible to clean after assembly. Therefore, cleaning and assembly procedures must be integrated to avoid this condition. Furthermore, once the equipment is cleaned, it must be kept clean until it is used.

4. METHOD OF COMPLIANCE

Cleaning for Class 2 Service shall be done in general conformance with this specification.

Detailed procedures are given in the following SPI's:

Stores Department

25.001	Processing and Packaging of Gaskets for O_2 Service
25.016	Packaging Instructions for Safety Head Diaphragms
25.050	Treatment of Asbestos Packing for O_2 Service
25.152	Washing Filter Stones
25.153	Cleaning Miscellaneous Parts in Chlorothene
25.257	Processing of Material for Oxygen Service

Quality Control and Inspection Department

30.007	Procedure for Checking Material Cleaned for Oxygen Service for Contamination

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4. METHOD OF COMPLIANCE (CONT.)

Manufacturing Department

48.002	Operating Instructions for Degreasing Machine
48.009	Control of and Operating Instructions for "Clean Room"
49.004	Cleaning and Testing of Repaired Model 12 and 60 Gallon Servicing Containers
49.111	Cleaning Procedures - Metals Cleaning Department, Building 70
49.112	Composition and Control of Solutions - Metals Cleaning Department, Building 70
49.116	Wipe Cleaning and Degreasing
49.253	Packaging of Ferrous Parts for Storage
49.256	Application of Protective PWO Wax Coating to Finished Surfaces Cleaned for Oxygen Service
50.016	Procedure for Checking Vacuum Pumps for Oxygen Service
50.021	Testing, Cleaning, Drying and Inspecting Roll-Bond Heat Transfer Elements
69.009	Manufacturing Linde Frangible Type Bursting Disc on the Manually Operated Lathe
69.012	Handling, Storing, Fabricating and Cleaning Brazed Aluminum Heat Exchangers

Vendors

49.108	Cleaning, Testing, Inspecting and Packaging Pop Safety and Relief Valves by Vendors
49.109	Cleaning, Testing and Packaging Solenoid Valves for Oxygen Service by Vendors
49.110	Cleaning, Testing and Packaging Pressure Gauges for Oxygen Service by Vendors
49.113	Cleaning, Testing, Inspecting and Packaging of Valves and other Similar Apparatus for Oxygen Service by Vendors
49.114	Manufacturing and Packaging of Spiral Wound Gaskets by Vendors

Safety Procedures

53.001	Use of Chlorinated Solvents
53.002	Pickling Chemicals - Safety

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5. GENERAL CONSIDERATIONS

In order to meet the stringent requirements of Class 2 Cleaning, there are many factors in addition to the actual cleaning operation which must be taken into consideration. These may be loosely defined as the "proper approach to good cleaning", and require that the Factory conform in fact or in principle to the requirements outlined below.

5.1 Personnel

Personnel should be thoroughly trained in the proper cleaning techniques and made aware of the serious consequences that could result from inadequate cleaning. They should be required to wear apparel which is free of oil and grease and to work with clean hands or clean gloves.

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5.2 Facilities

Cleaning and assembly shall be done in an environment reasonably free of dust, and completely free of oil, mist or vapors. The area itself should be clean and neat and arranged to prevent the accidental mixing of cleaned and uncleaned parts.

5.3 Utilities

Utilities directly involved in cleaning operations shall be compatible with Class 2 Service.

5.3.1 Gases

Air used for purging, drying or testing shall be clean, dry, and oil-free. Close inspection and control of filtering equipment is mandatory.

5.3.2 Water

Water used for making up solutions or for flushing, rinsing, or testing shall be potable.

5.3.3 Steam

Any steam used for direct-contact heating or cleaning shall be free from oil and scale.

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5. GENERAL CONSIDERATIONS (CONT.)

5.4 Tools and Equipment

Tools used in connection with Class 2 Cleaning operations shall either be kept separate from other tools or shall be thoroughly cleaned before each such use. This also applies to slings, cradles and other handling equipment, if they will contaminate surfaces that have been cleaned for Class 2 Service.

Work surfaces should be covered with clean Kraft paper or polyethylene sheeting, if there is a possibility that contaminated work surfaces might recontaminate equipment that has been cleaned.

Overhead cranes or monorails in the cleaning or assembly area should be dripless or provided with drip pans to prevent recontamination of cleaned equipment due to dripping grease or oil.

5.5 Sequence of Operations

The two most important factors in securing a clean end product are:

1) Choosing the right method based on the type and extent of contamination.

2) Carrying it out at the right time in relation to other operations.

The first factor is covered more completely in SPI's referred to in Section 4. The second factor requires integrating the cleaning operation with other phases of construction and assembly to insure complete removal of contaminants initially, and to prevent recontamination. In order to achieve this, Factory procedure should conform, whenever possible, to the following schedule:

5.5.1 Components shall be cleaned prior to final assembly to prevent trapping contaminants in inaccessible areas.

5.5.2 Insofar as possible, all testing shall be done prior to final cleaning. Where this is not feasible, all jigs, fixtures, and other test equipment shall be cleaned just prior to use, if such equipment will contaminate previously cleaned surfaces. For detecting air leaks, a water solution of Sulfatate "B" must be used.

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5. GENERAL CONSIDERATIONS (CONT.)

5.6 Removal of Cleaning Agent

All traces of the cleaning agent shall be removed by purging or rinsing and drying as required.

5.7 Handling and Storage

Parts which have been cleaned shall be tagged with "Cleaned for Class 2 Service", Tag 815-643, and protected from recontamination by packaging or covering them during storage and transit. The alternative method is to clean all parts just prior to final assembly.

6. CLEANING MATERIALS

Many cleaning agents available today do an excellent cleaning job. Several of these, however, because they are incompatible with oxygen, leave an undesirable residue, are corrosive or have some other disadvantage, are unacceptable for Class 2 Cleaning.

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6.1 Solvents

For removing organic contaminants such as oils, greases, paints and thread lubricants, chlorinated hydrocarbon solvents as listed below are to be used.

NOTE

Whenever a solvent is used, the equipment must be subsequently purged with clean, dry, oil-free air until all traces of solvent odor are gone.

6.1.1 Chlorothene

Dow Chemical Company's Chlorothene NU (1, 1, 1 trichlorothane, plus corrosion inhibitor) is to be used outside of buildings or under an exhaust hood for cold solvent cleaning.

6.1.2 Trichloroethylene

M.D. Grade stabilized trichloroethylene marketed by Hooker Chemical Corporation is to be used for vapor degreasing.

6. CLEANING MATERIALS (CONT.)

6.1.3 Contamination Tests

Solvent used for cold solvent cleaning shall be replaced when the concentration of contaminants in them exceeds 100 ppm. The contaminated solvent shall be redistilled and reused. One of the following methods may be used to determine this.

6.1.3.1 Color Test

Compare a one-gallon glass jug filled with used solvent with a similar jug filled with new solvent. If there is a noticeable difference in light transmission between the two, when they are both held up to the light and viewed simultaneously through the side, the contamination exceeds 100 ppm (taken as lubricating oil).

6.1.3.2 Black Light (Ultra-Violet) Test

With a clean eye dropper, measure 10 drops of used solvent on to a sheet of clean filter paper, (Whatman No. 42), and allow it to evaporate. The following table is a rough guide to the extent of contamination detectable when the paper is viewed under black light in darkness or subdued light.

Less than 50 ppm	-	not discernible
50 to 100 ppm	-	barely discernible
More than 100 ppm	-	definitely discernible

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6. CLEANING MATERIALS (CONT.)

6.1.3.3 Gravimetric Solvent Extraction

Evaporate a one-liter sample of solvent almost to dryness, transfer to a tared beaker and continue to evaporate to dryness. Cool the beaker and reweigh it. The weight difference due to the residue shall not exceed 100 mg. (approximately 100 ppm).

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6.1.4 Corrosion

Do not use a solvent to clean equipment unless the equipment is dry. Do not allow chlorinated solvents to become contaminated with water. Solvent plus water may form corrosion products harmful to bare metal.

6.2 Water Solutions

Composition of cleaning and pickling solutions and location of tanks are shown in SPI-49.112 and SPI-49.116.

6.3 Water

Water used for making up solutions, flushing, rinsing or testing should be potable.

7. METHODS

One or more of the following methods may be used, singly or in combination, to clean most types of equipment for this class of service.

7.1 Mechanical Cleaning

This method consists of brushing, sweeping, blowing, scraping, metal blasting, or otherwise physically removing contaminants from equipment. It is generally used as a precleaning technique, or in combination with other methods. The exception is metal blasting, which is normally used alone, and as a complete cleaning method.

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7. METHODS (CONT.)

7.2 Flushing

In this method, the equipment being cleaned is flushed with the Solution Gun in Section 35 in accordance with SPI-49.111. Thorough rinsing with cold water hose or in Tank No. 2 (Hotwater Rinse Tank)and subsequent drying with clean, oil-free dry air is also required.

7.2.1 Solvent

If a solvent is used, the vessel must be thoroughly purged with clean, oil-free dry air. Chlorothene is explosive in an oxygen atmosphere under certain circumstances.

7.3 Immersion

In this method the equipment to be cleaned is submersed in solvent or detergent solution. Normally this is used in conjunction with some form of mechanical cleaning for small parts.

NOTE

Non-metallic parts should not be immersed in solvent. Limit to immersion in detergent solution, or wipe with a clean rag moistened with trichloroethylene at a vapor degreaser adjacent to the exhaust system.

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7.4 Wiping or Mopping

Large parts having readily accessible surfaces may be cleaned by this method using detergent solution only. Typical examples would be large parts or vessels that can be entered.

7.5 Vapor Degreasing

In this method cleaning is effected by the flushing action of boiling solvent, clean solvent formed by the condensation of vapors from the heated solvent and condensation of vapors from the heated solvent, on the cool surface of the part being cleaned. Normally restricted to small parts because of the special equipment required, it has the advantage of continually distilling the solvent, so that only pure, clean solvent touches the parts in the final step.

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8. SELECTION OF A CLEANING METHOD

The selection of a cleaning method for a particular application depends on many factors, including the nature and amount of contamination, the type and size of equipment, etc. In every case, however, the end result should be the same - a piece of equipment which is free of essentially all traces of contaminants and which, therefore, from this standpoint, can be safely used in Class 2 Service.

It is beyond the scope of this specification to prescribe exact procedures for cleaning all types of equipment. Reference should be made to the SPI's listed in Paragraph 4.

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9. INSPECTION

Wherever possible, equipment built for Class 2 Service shall be inspected using black light (Paragraph 9.3), and whichever of the other methods given below apply to a particular situation. This covers both pre-cleaning and post-cleaning inspections. If any of the following tests reveal contaminants, the item must be recleaned.

9.1 Direct Visual Inspection

Look at, or in, the equipment to determine the type and extent of contamination, if any. This method is suitable to detect excessive grease and oil films, and filings, chips, or other particles.

9.2 Wipe Test

Wipe the surface with a clean, white cloth. Powdery residues and films will discolor the cloth. This is sometimes usable where direct visual examination is impossible.

9.3 Ultra-Violet or "Black Light" Inspection

Examine the surface in darkness or subdued light using a 3200-3800 AU black light. Most common hydrocarbon oils or greases fluoresce, so that they become visible under black light even though they are invisible in normal light. However, not all organic oils fluoresce, so this inspection should be backed up by a review of the manufacturing procedures involved, to make sure that no animal oils such as fish oil rust preventatives or vegetable oils such as castor oil-based

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9. INSPECTION (CONT.)

9.3 Ultra-Violet or "Black Light" Inspection (Cont.)

cutting emulsions, were used in its manufacture. On the other hand, certain other materials such as lint from laundry-washed rags may fluoresce, but are not considered harmful contaminants, except in excess. To summarize, if any fluorescence shows up as a blotch, blot, smear, smudge or film, reclean the item.

9.4 Ultra-Violet Wipe Test

Wipe the surface with laboratory type filter paper and examine it for fluorescence under black light. Do not use cloth for this test because the cloth itself may fluoresce.

9.5 Solvent Purity Test

This method can be used as an indirect criterion of cleanliness. Check the concentration of contaminants in successive solvent washes, by one or more of the methods given in Paragraph 6.1.3. When the concentration of impurities decreases below 100 ppm, the item can be presumed to be clean, as long as there are no pockets or recesses not readily accessible to the solvent.

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9.6 Water Break Test

Wet the surface with clean water. The water film formed must remain unbroken for at least five seconds for the part to be considered clean. This test is limited to horizontal surfaces.

10. PROTECTION OF CLEANED EQUIPMENT

After an item has been cleaned, adequate precautions shall be taken to insure that it remains clean until installed. One or more of the following methods should be used to protect the equipment.

10.1 Small Items

Small parts, valves, gaskets, etc., shall be sealed in 4-mil or heavier polyethylene bags. The inspection tag may be enclosed in the bag.

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FORM LB-47B

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10. PROTECTION OF CLEANED EQUIPMENT (CONT.)

10.2 Larger Items

Where bagging is impractical, larger items may be wrapped in 4-mil or heavier polyethylene sheet after all openings are sealed with fiberboard discs, metal or polyethylene protectors. Refer to SPI-69.010 and/or 69.011.

10.3 Heavy Equipment

Large equipment need not be completely enclosed in polyethylene sheeting, but all manholes, inspection ports, nozzles, and other openings must be sealed. Refer to SPI-69.010 and/or 69.011.

10.4 Ferrous Materials

Ferrous (except stainless) materials should be protected against rusting by one of the following methods, when specified on the drawing.

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10.4.1 VPI Paper

Wrap or stuff the equipment with Vapor Phase Inhibitor Paper, Code No. 9932-2085. This paper slowly gives off a chemical which reacts with the metal surface to prevent corrosion. Use about three square feet of paper for each cubic foot free volume or each six square feet of surface to be protected.

10.4.2 PWO Wax

Coat the interior surfaces with special protective wax in strict accordance with SPI-49.256.

10.4.3 Rust Prevention for Finished Parts

Use process specified in SPI-49.255.

10.4.4 Rustproof Steel Pipe, Assemblies and Parts

Use process specified in Paragraph .05, SPI-49.111.

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BY

CHANGES FROM PREVIOUS ISSUE

FORM LB-478

11. IDENTIFICATION

After equipment has been cleaned for this class of service, it shall be identified as such to avoid subsequent recontamination or recleaning. The method of marking will depend on the item cleaned, but it should at least conform to the following requirements.

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11.1 Legend

Marking should clearly state the following:

CAUTION
CLEANED FOR CLASS 2 SERVICE IN
ACCORDANCE WITH SPI-49.117 (NOTE #1)

INSPECTED BY _____ DATE _____

11.2 Packing Warning

If VPI paper or PWO wax is used, a tag should be attached to the equipment stating the following:

CAUTION
CONTAINS VPI PAPER - REMOVE BEFORE INSTALLING
(NOTE #2)

INSPECTED BY _____ DATE _____

OR

CAUTION
THIS EQUIPMENT HAS BEEN SPRAYED WITH PWO WAX
(NOTE #3)

INSPECTED BY _____ DATE _____

NOTES

#1 Use Form No. 815-643, Code No. 7812-6863
#2 Use Form No. 815-645, Code No. 7812-6865
#3 Use Form No. 815-646, Code No. 7812-6866

REFERENCE: GS-38, "Class 2 Cleaning by Seller", Engineering Department, Linde Division, Union Carbide Corporation, Tonawanda, New York

TONAWANDA FACTORY

LINDE COMPANY
DIVISION OF UNION CARBIDE CORPORATION
STANDARD PRACTICE INSTRUCTIONS

ENGINEERING DEPT.

SPI-49.253

DATE	SHEET NO.	OF
10-4-65	1	1

SUBJECT

PACKAGING OF FERROUS PARTS FOR STORAGE

APP'D Q.E.F. BY [illegible] CH'K'D

REVISED PROCEDURE FOR OVERWRAPPING

CHANGES FROM PREVIOUS ISSUE

FORM LB-478

PURPOSE

To provide information concerning the method of packaging that must be specified for all finished ferrous parts which are of such a size and shape that it is practical to wrap.

PROCEDURE

Parts are to be wrapped in VPI Paper (Code 9932-2085) allowing no surface to be exposed to the atmosphere. IMPORTANT: Make sure that white side of VPI Paper is in contact with surface to be protected. Overwrap in a polyethylene bag and heat seal or in polyethylene sheet and seal with plastic coated green cloth tape.

The above method has been approved for wrapping parts which have been "Cleaned for O_2 Service."

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CLEANLINESS INSPECTION PROCEDURE

1.0 SCOPE

To compile and summarize in one document the various cleaning specifications and test methods employed by the Manufacturing Quality Control Department.

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2.0 REFERENCE DOCUMENTS

GS-3 General Cleaning Information
GS-38 Requirements for Class 2 Cleaning
GS-39 Class 2 Cleaning in the Field
GS-40 Requirements for Class 3 Cleaning
GS-42 Requirements for Class 4 Cleaning
GS-50 Class 2 Cleaning of 9% Nickel Steel Storage Vessels
GS-51 Blast Cleaning of 9% Nickel Steel Storage Vessel Containers

3.0 RESPONSIBILITIES

3.1 It is the responsibility of the Design Engineering Department to determine the level of cleanliness required of a particular item and to so note the associated drawings, material purchase specifications, and code or part number descriptions for these items, as required in Specification GS-3.

3.2 It is the responsibility of the Industrial Engineering Department to schedule and designate the operations required to obtain the level of cleanliness required by the specifications, per GS-3.

3.3 It is the responsibility of the Manufacturing Quality Control Department to supply a level of inspection that will adequately assure conformance to the correct cleaning specification for all items purchased or manufactured. In addition, the Quality Control Department shall make recommendations for adjustments in the level of cleaning required and/or cleaning methods employed,to the responsible department.

3.4 The Cryogenic Testing and Metering Section of the Quality Control Department shall be responsible for the performance of all specialized cleanliness tests such as particle counts, non-volatile residue tests, combustion tests of foreign materials, etc. in addition to solvent purity tests and a periodic monitoring of the strnegth of the Acid Deck cleaning baths. This department shall also conduct all required combustion acceptance tests on material purchased for oxygen service.

4.0 PROCEDURES

4.1 Receiving Inspection. The purchase order description, material purchase specifications and drawings for all received materials shall be checked for cleanliness requirement specifications. Large quantities of low

value items that are packaged and certified or tagged as cleaned to a certain level shall be spot checked only for cleanliness if the vendor and his procedure have been approved by the Cleaning and Materials Suitability Assurance Engineer. Material that is received from a vendor that has not been approved or material that is not suitably packaged, certified or tagged shall be thoroughly inspected to the criteria of the applicable standard. (Ref. IP-3001, "Receiving Inspection Procedure," Table I attached, and documents listed under 2.0.) Large, high value items shall be individually and thoroughly inspected to the requirements of the applicable specification. Questions on vendor qualifications should be referred to the Cleaning and Materials Suitability Assurance Engineer. Material not meeting the cleaning criteria of the appropriate specification shall be rejected in accordance with IP-1007, "Preparation and Handling of Rejection Notices".

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4.2 Machine Shop Inspection. During in-process inspections and at final inspection, the inspectors shall check the material drawings and process sheets for cleanliness requirement specification stamps, notes and cleaning methods specified. The in-process control should consist of a check that the materials, upon completion, are routed to the correct section to be cleaned by the method specified on the Process Sheet. At final inspection, the inspectors shall check that the material has been cleaned to the applicable specification by the correct method. By the use of mirrors, borescopes and swabs, special attention shall be given to areas of the items that are not readily visible. After final inspection, the inspector shall suitably protect the material for delivery to the packaging section. Material that does not meet the criteria of the applicable specification shall be rejected in accordance with IP-1002, "Preparation and Handling of Rejected Material Tags". (Ref. IP-4007, "Machine Shop Quality Control Procedure," Table I attached and documents listed under 2.0.)

4.3 Fabrication Inspection. As material is processed through the various sections of the Factory, the section inspectors shall check the material drawings and process sheets for cleanliness requirement specification stamps, notes and cleaning methods specified. The inspectors shall signify that a component has been cleaned to the criteria of the correct specification,by the method noted on the Process Sheet, by placing his personal stamp adjacent to the applicable operation on the Process Sheet in accordance with IP-4004, "Recording of Inspection Progress on the Shop Copy of the Process Sheet," and/or stamping and noting the equipment check sheet. In addition, the fabrication inspectors shall monitor material and equipment that has been cleaned to assure that it is suitably protected to prevent re-contamination while awaiting final assembly. They shall also make cleanliness checks before final assembly and assure that completed equipment is suitably sealed and protected. The fabrication inspectors shall be especially watchful at final assembly not only for organic contaminants but for spatter, flux, chips and other loose material generated by the fabrication processes. If contaminants detected cannot be immediately removed satisfactorily, the inspector shall reject the item in question in accordance with IP-1002, "Preparation and Handling of Rejected Material Tags." They shall also check that water used for flushing or testing is properly inhibited and that the equipment is thoroughly dried, purged and tested with oil free air or nitrogen to maintain the level of cleanliness attained. (Ref. IP-4004, IP-4006, "In-Process Test and Final Inspection - Fab. Shop", Table I attached and documents

documents listed under 2.0.)

5.0 INSPECTION METHODS. Listed below are methods that may be employed in conjunction with Table I attached and the applicable cleaning specification.

Visual Inspection - Lighting the item as well as possible, observe the amount of grease and oil films, paint, varnish, chips. filings,rust, scale, loose weld spatter, flux, etc. that is present and compare with the requirements of the applicable specification.

Ultra-Violet Light Inspection - In as dark a surrounding as possible, observe the surface to be inspected using a 3200-3800 AU Ultra-Violet light. Most oils and greases and some fibers and other foreign materials will fluoresce or glow even though they are not visible in ordinary light. Observe the amount and type of fluorescence and compare with the requirements of the applicable standard. Note that not all contaminants will fluoresce and that this should not be considered to be an ultimate test.

Wipe Test - Wipe the critical surfaces of the item with a clean white cloth and examine under normal and Ultra-Violet light for discoloration, fluorescence, and particle adherence. Compare with the requirements of the applicable specification.

Solvent Color Test - To check inaccessible surfaces, rinse the item with new solvent and compare a one-pint jar of the rinse with a similar jar of unused solvent. Note the difference in color and the number of particles to estimate the cleanliness of the item.

Water Break Test - Wet the surface with clean water. If the item is clean, the water film formed must remain unbroken for five seconds.

Non-Volatile Residue Test (NVR) - This test will be performed by the Cryogenic Testing and Metering Department. Solvent rinsings are used and the parts per million residual contamination can be determined.

Combustion Tests - Carefully remove a one-gram sample of unknown or suspect material and place in a clean glass jar or vial, and deliver to the Cryogenic Testing and Metering Department. After an oxygen bomb and impact test are performed, a determination can be made, with the assistance of the Cleaning and Materials Suitability Assurance Engineer, of the compatibility of the foreign material with the level of cleanliness required.

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TABLE I

(For comparison and quick reference only - see appropriate specification for details)

Cleaning Level	Linde Spec.	Type of Service	General Requirements
Class I	None	Aerospace	1. "White Room" cleaning. Existing Government specifications will be used or special instructions will be written as required.
Class 2	GS-38	In contact with liquid or gaseous oxygen or enriched air. Nitrogen or Argon service that may be switched to oxygen service	1. Must be <u>free</u> (as demonstrated by thorough visual inspection in normal and ultraviolet light, wipe or swab testing, solvent color test, water break test or non-volatile residue test as required) of all traces of greases, oils, thread lubricants, water, paint, varnish, marking materials, penetrant dyes, ultrasonic lubricants, and all solid foreign materials such as dust, scale, flux (loose or adhering), chips, filings, loose or easily removable spatter, and excessive rust (a light film of tightly adhering rust is acceptable) (GS-38, 4.0). 2. Air or nitrogen used for drying, purging or testing must be oil free (GS-38, 6.4). 3. Water used for rinsing, flushing or testing after final inspection must contain an approved inhibitor, if required by the individual application (GS-38, 6.4). 4. Lubricants, thread sealants, etc. must be of the types approved for oxygen service and may not be substituted without approval. Excess material must be removed (See GS-38, 7.2 and 7.3 and QA-8). 5. All parts cleaned for Class 2 service must be adequately protected to prevent contamination prior to final assembly or packaging (GS-38, 10.0). 6. Final assemblies that are packaged or sealed must be inspected to assure that the cleaned surfaces are adequately protected to maintain Class 2 cleanliness by the method specified and that the items are properly marked as cleaned for Class 2 service (GS-38, 10.0 and 11.0).
Class 3	GS-40	Cryogenic or functional - <u>not for oxygen service</u>	1. <u>Excessive</u> amounts of contaminants (as verified by visual examination in normal light and wipe testing) listed above opposite Class 2 cleaning must be removed. Excessive amounts is defined as that quantity which could migrate to other points in the system, interfere with the operation of moving parts, damage critical surfaces or lower product purity below acceptable limits (GS-40, 4.0). Note that <u>all</u> hydrocarbon films need not be removed (6.0) and that a <u>moderate</u> film of rust is acceptable.

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Table I

Cleaning Level	Linde Spec.	Type of Service	General Requirements
Class 3 Cont'd			2. Lubricants and thread sealants, etc. need not be of any special type (7.0) but should have excesses removed. 3. Water used for rinsing, flushing, or testing should contain the proper inhibitor if required by the individual application (7.4). 4. All parts cleaned for Class 3 service should be adequately protected to prevent contamination beyond the limits noted prior to final assembly or packaging (GS-40, 10.0). 5. Items that are packaged or sealed should be inspected to assure that the cleaned surfaces are adequately protected by the method specified and the items are properly marked as Cleaned for Class 3 service (GS-40, 10.0 and 11.0).
Class 4	GS-42	Commercial Not for oxygen service	1. Excessive amounts (as verified by visual examination in normal light) as defined above opposite Class 3 Cleaning, of loose dirt, scale, chips, filings, oil and grease must be removed. The major consideration with this class of cleaning is that loose matter or amounts of fluids able to contaminate downstream equipment be removed. Rust, paint or other tightly adhering matter is acceptable. 2. Reasonable protection should be used in process and at final assembly and packaging to prevent excessive contamination.

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END OF REFERENCE
8

REFERENCE
9

ANON.: CLEANING, TESTING AND HANDLING OF OXYGEN, FUEL AND PNEUMATIC COMPONENTS. REP. D5-12855, REV. G, BOEING CO., MAY 15, 1968.

THE BOEING COMPANY
AERO-SPACE DIVISION
SATURN BOOSTER BRANCH

M-462 Repro

DOCUMENT NO. D5-12855

VOLUME ____ OF ____

TITLE Cleaning, Testing and Handling of Oxygen, Fuel and Pneumatic Components

MODEL NO. ____ CONTRACT NO. ____

ISSUE NO. ____ ISSUED TO W. M. Corners

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REV. SYM. G May 15, 1968

S-606-10-3 REV. 1/64

SECTION I

CLEANING, CLEANLINESS TESTING AND HANDLING OF OXYGEN, FUEL AND PNEUMATIC COMPONENTS MICHOUD PLANT SUB-SYSTEMS TEST AREA

4.0 DEFINITIONS (Continued)

4.10 RELIABILITY TEST

The Reliability Test is a Quantitative Analysis of particulate and non volatile residue (NVR) contamination of visually accepted parts. The purpose of the reliability test is to verify the visual examination and the adequacy of the cleaning process.

4.11 NON VOLATILE RESIDUE (NVR)

NVR consists of that material which is soluble in the reliability test solvent and which does not volatilize at the specified test drying temperature (221° - 230°F) e.g. oil and grease.

5.0. MANUFACTURING CONTROL

5.1 GENERAL NOTES

5.1.1 The cleaning, testing, assembly and packaging shall be conducted in environmentally controlled areas as specified in 6.3.

5.1.2 When the part being cleaned is set up as a closed system (such that external environment is prevented from contaminating the significant surfaces of the part) it shall be considered that the cleaning is being accomplished in an environment as clean as the media being used. The temperature and humidity requirements of 6.3 do not apply to closed system cleaning.

5.1.3 Only authorized personnel shall be allowed to enter environmentally controlled areas.

a. Personnel - Each person working directly in an environmentally controlled area, or working with open, clean components or systems shall be required to have satisfactorily completed a prescribed physical examination and a training course designed to familiarize him with techniques and philosophy of clean rooms and contamination control. A current listing of such authorized personnel shall be maintained at the clean room complex (for personnel authorized to work in clean room) and for other operations, at such points as may be required by Quality.

b. Observers - Observers shall be controlled so that they will not contribute to contamination of clean facilities, parts, components, etc.

5.1.4 Lubricated Components - Lubricated parts or assemblies shall not be subjected to cleaning which may remove the lubricant to the extent that function or reliability of the item is adversely affected. Detail parts of the component shall be cleaned by the

5.0 MANUFACTURING CONTROL (Continued)

5.1.4 Lubricated Components (Continued)

applicable method herein and tested for cleanliness prior to the application of "grease" or "oil" type lubricants.

Oil or grease lubricants used in assembly or testing of clean components shall comply with the following requirements:

(a) Lubricants which may contact LOX or GOX shall be LOX-compatible per MSFC-SPEC-106 (This requirement shall also apply to lubricant used in such location or manner that it could be transferred to "oxygen clean" surfaces or components).

(b) The amount of lubricant used shall be held to an absolute minimum. When applied on threads, lubricant shall be applied so that any excess will be runout to the outside non-significant surfaces, e.g., apply lubricant on male threads only and in addition avoid lubricant on the first two male threads.

(c) When used on multiple use items the lubricated area shall be examined after each disassembly for any evidence of the formation of "beads" of lubricant. Any such beads or visible lubricant on service media "wetted" surfaces, such that lubricant may have been carried into a clean component, shall require re-cleaning as necessary to comply with the applicable cleanliness requirements of this document.

(d) Visible "beads" of grease type lubricant and excessive grease or oil type lubricants which have (or should be expected to) migrated to clean significant surfaces outside the immediate, necessary, lubricated area shall be considered to be visible contamination (see 4.3).

(e) Lubricant supply shall contain not more than 1 particle per ml (or per gram) exceeding 175 microns in size.

5.1.5 Aluminum parts with a MIL-C-5541 conversion coating shall not be subject to temperatures in excess of 130 degrees F.

5.1.6 RECLEANING OF MECHANICAL FUNCTIONAL COMPONENTS

Except as otherwise specifically authorized by engineering, mechanical functional components shall be disassembled prior to recleaning. Disassembly shall be such that (1) all significant surfaces are readily accessible to cleaning, testing and drying media; (2) necessary relubrication can be accomplished; and (3) there are no entrapment areas where cleaning media or cleaning media residues may be retained. When any of the above requirements cannot be satisfied, engineering shall furnish specific procedures for the particular component involved. The general

5.0 MANUFACTURING CONTROL (Continued)

5.1.7 (Continued)

sequence for disassembly, recleaning and reassembly shall be as follows (see Section IV for detailed requirements for steps (a) and (d) thru (f).

(a) Disassemble per vendor and/or engineering approved procedure and the above requirements.

(b) Inspect parts for adherent contamination and damage (obtain replacement parts as necessary) and process as necessary to comply with 5.2.

(c) Process parts per 5.3.

(d) Reassemble, including specified lubrication, per vendor and/or engineering approved procedure.

(e) Functional test as specified, visually inspect for cleanliness following functional test.

(f) Package per 5.4.

5.2 ROUGH CLEANING

Prior to the initiation of the preclean operations:

(a) Parts shall be rough cleaned as necessary to remove all gross contamination including machining lubricants, scale, oxide films, rust, etc. Such cleaning, unless otherwise stated herein or on the engineering drawing, shall be in accordance with the applicable cleaning specification for the material involved, e.g. for ferrous alloys, clean per BAC 5751; for aluminum alloys clean per BAC 5765, for nickel and cobalt alloys clean per BAC 5758.

(b) Corrosion resistant steel parts shall be passivated. Parts shall be passivated, or repassivated, after completion of operations which remove or disrupt the passivating film e.g. etch type processing or metal removal or forming operations. Passivate per BAC 5751 using solution #14 (nitric acid).

NOTE: Castings with as-cast surfaces are difficult to passivate. In case of reoccurring rust on castings, contact M&P for instructions.

(c) Parts shall be inspected for and shall be free of any adherent contamination such as scale, rust, etc., i.e., the preclean and final clean operations are not intended to remove adherent contamination.

5.0 MANUFACTURING CONTROL (Continued)

5.2 (Continued)

(d) Parts shall be visually inspected and shall be free of unacceptable physical damage such as nicks, dents, etc., i.e., damage which makes the part unacceptable for its intended usage.

Parts failing to comply with (a), (b), (c), or (d) above shall not be accepted for precleaning or final cleaning.

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5.3 PRECLEAN AND FINAL CLEAN OF COMPONENTS

	I METALLIC PARTS	II [1] MIL-C-5541 CONVERSION COATED ALUMINUM	III SMALL TUBING (1 INCH I.D. MAX) LENGTH TO I.D. RATIO GREATER THAN 10 [4] [3]	IV NON-METALLIC PARTS [5] [6]	V FILTER ELEMENTS
A. INSPECT PER 5.2	X	X	X	X	X
B. VAPOR DEGREASE SOLVENT CLEAN PER 6.2.2 C-5MIN. & DRY PER 6.2.6 OR 6.2.7	X	SOLVENT FLUSH	FLUSH TUBE INTERIOR X	X [2]	X [2]
C. ULTRASONIC SOLVENT CLEAN PER 6.2.2 - 30 MINUTES MIN.					X
D. ULTRASONIC ALKALINE PER 6.2.3-5MIN	X				
E. ULTRASONIC WATER RINSE PER 6.2.5-5 MIN	X				
F. DRY AS REQUIRED PER 6.2.6 OR 6.2.7	X				X
G. ALKALINE FLUSH PER 6.2.3-10MIN			TUBE INTERIOR X		
H. WATER FLUSH PER 6.2.5-10MIN			TUBE INTERIOR X		
I. DRY AS REQUIRED PER 6.2.6 OR 6.2.7			X		

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5.3 PRECLEAN AND FINAL CLEAN OF COMPONENTS (Continued)

	I METALLIC PARTS	II [1] MIL-C-5541 CONVERSION COATED ALUMINUM	III SMALL TUBING (1 INCH I.D. MAX) LENGTH TO I.D. RATIO GREATER THAN 10 [4] [3]	IV NON-METALLIC PARTS [5] [6]	V FILTER ELEMENTS
J. ULTRASONIC DETERGENT PER 6.2.4- 5 MIN.		X		X [6]	X (30 MINUTES MINIMUM)
K. ULTRASONIC WATER RINSE PER 6.2.5- 5 MIN		X		X [6]	X (30 MINUTES MINIMUM)
L. DRY AS REQUIRED PER 6.2.6 OR 6.2.7		X		X	X
M. VISUAL ACCEPTANCE INSPECTION PER 4.9	X	X	X	X	X
N. FINAL FLUSH WITH SOLVENT PER 6.2.2-3 MIN & RELIABILITY TEST PER 7.0	X	X	X	X [2]	X
O. DRY PER 6.2.6 OR 6.2.7	X	X	X	X	X
P. PACKAGE PER 5.4	X	X	X	X	X

[1] DO NOT SUBJECT TO TEMPERATURES EXCEEDING 130 DEGREES FAHRENHEIT

[2] IF MATERIALS ARE INCOMPATIBLE WITH SOLVENTS PER 6.2.2 CONTACT THE MATERIALS AND PROCESSES UNIT. FOR PLASTICIZED ELASTOMERS, & WHEN ELASTOMER COMPOSITION IS UNKNOWN, OMIT STEPS "B", "N", AND "O".

[3] STEPS B THRU L ARE OPTIONAL FOR PARTS ROUGH CLEANED PER 5.2 AND ROUTED DIRECTLY TO THE PRECLEAN AREA.

5.3 PRECLEAN AND FINAL CLEAN OF COMPONENTS (continued)

4 LARGE TUBING (OVER 1 INCH I.D) AND TUBING WITH A LENGTH-TO-INSIDE DIAMETER RATIO LESS THAN 10 WILL BE PROCESSED AS A PART (SEE COLUMNS 1 AND II)
PROCESSING TIMES GIVEN ARE MINIMUM
TUBE FLUSHING SOLUTION FLOW RATES SHALL BE 10 FT/SEC MINIMUM

5 IF ULTRASONIC AGITATION IS NOT AVAILABLE, A NYLON BRISTLE BRUSH SHALL BE USED TO ASSIST IN CLEANING WHEN PERFORMING STEPS J AND K

6 DO NOT EXPOSE TEFLON COATED METALLIC PARTS TO ULTRASONIC ENERGY

5.4 PACKAGING

5.4.1 GENERAL

5.4.1.1 ENVIRONMENT

Initial packaging shall be completed within 8 hours after completion of the final drying process. Initial packaging (Sealing off of all significant surfaces from the exterior environment) shall be performed in the same environment as the final cleaning. Initial packaged items may be moved to a non-controlled area or a less stringently controlled area for installation of the outer enclosure.

5.4.1.2 MATERIALS

a. All "packaging" materials in contact with final cleaned significant surfaces of components shall be compatible with the service media applicable for that component and shall be clean prior to use to the same level of cleanliness as the item being packaged. Compatible materials are as listed below:

1. Oxygen Systems:
Teflon, Aclar, Aluminum Foil

2. Fuel and Pneumatic Systems:
Nylon, Mylar, Polyethylene, Saran, Teflon, Aclar, Aluminum Foil.

b. All other packaging materials shall be visually clean prior to use.

c. Minimum film thickness for packaging will be:

Polyethylene - 0.006 in. thick

Teflon or Aclar (inner package) - 0.002 in. thick

Nylon or Mylar - 0.004 in. thick

5.4.1.3 CLEANLINESS

a. Parts should be packaged as soon as possible after drying with a minimum amount of handling. Parts handling should be with clean tongs as is practical. Parts not packaged within two hours shall be covered with a material meeting the requirements of 5.4.1.2.a and c.

b. Packaging and parts must be purged with preservation gas per 6.2.6, during the packaging process prior to sealing to preserve cleanliness levels.

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CLEANLINESS (Continued)

c. Openings into cleaned parts which are sealed to preclude contamination shall be so constructed, applied, or "safe tied" so as to readily show any unauthorized breaking of the seal. Any part which shows unauthorized breakage of such a seal shall be assumed to have been contaminated and shall be tested and recleaned as required to verify compliance with the specified cleanliness level for the part. Similar parts sealed with a bag or equivalent, shall not require "tamper proof" seals; however, any unauthorized opening of, or damage to, the inner sealed bag shall require that the part be retested and recleaned as required to verify compliance with the specified cleanliness level.

5.4.2 SPECIFIC

5.4.2.1 Inner Wrap - Preserve significant surfaces cleanliness with a packaging material meeting requirements of 5.4.1.2.a and c. Packaging must be secured by sealing or taping, to avoid contamination; Small parts may be completely enclosed provided all surfaces are clean.

Tape shall not be allowed to come in contact with any significant surface.

5.4.2.2 Outer Wrap - The inner wrap shall be encased in an outer wrap using a material meeting requirements of 5.4.1.2.b and c. The function of the outer wrap is to preserve the inner wrap. Packaging must be secured to avoid contamination by sealing or taping.

5.4.2.3 Post Packaging Cleanliness Levels

Parts unpacked for assembly or for reinspection shall be visually clean except that on parts where all significant surfaces are visible and accessible, loose particles may be removed by vacuuming, wiping with a clean cloth or by a gas blow down using gas meeting the requirements of 6.2.6.
NOTE: Any final cleaned part which is contamination suspect or which is found to be discrepant for any other reason shall be protected such that the degree of cleanliness of the part at discovery will not be further degraded.

5.4.3 Identification

Parts which have been cleaned and accepted as meeting the requirements of this specification shall be labeled with the following information:

1. Part Number
2. Serial Number
3. Supplier

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REFERENCE 9 CONTINUED ON CARD 3

Card #3

5.4 PACKAGING (Continued)

5.4.3 Identification (Continued)

4. Cleaning Specification

5. (Service Medium)

6. Contamination Level after cleaning (as determined by the final cleanliness test)

7. Date cleaned

6.0 MAINTENANCE CONTROL

6.1 EQUIPMENT REQUIREMENTS

Processing equipment shall be capable of satisfying the requirements of this specification.

6.2 PROCESSING MEDIA

6.2.1 General Requirements for Processing Media

The media covered in this paragraph (6.2) shall conform to the applicable following requirements in addition to those requirements listed in the individual paragraphs applicable to each media.

6.2.1.1 Particle Size

Media used in processing of parts or components shall be free of particles to the extent specified below. For media used in tank operations, (immersion), the requirement shall apply to fresh solution added to the tank and where a recirculating filter is involved, the requirement shall apply just down stream from the filter. For media used in spray or flushing operations, the requirement shall apply to the fluid at the nearest practical sampling point to the delivery end of the fluid line.

a. Liquid media used for the final preclean rinse and for final cleaning, cleanliness testing or other operations performed on clean oxygen, fuel or pneumatic parts or components shall contain no particles exceeding 175 microns and a maximum of 5 particles in the range of 100 to 175 microns as determined on a 500 plus or minus 20 ml sample. In addition, solvents shall have a non-volatile residue content not greater than 0.010 grams per 500 ml.

b. Gas used for drying operations performed subsequent to the final preclean rinse and all preservation or testing gas

6.0 MAINTENANCE CONTROL (Continued)

6.2.1.1 Particle Size (Continued)

b. (Continued)

shall contain no particles (per cubic foot) exceeding 100 microns.

6.2.2 Cleaning and Testing Media

a. Solvent used for final cleaning or testing per this specification shall comply with the following requirements and in addition shall comply with the particle and non-volatile residue requirements of 6.2.1.1.

1. Trichloroethylene

Tichloroethylene shall conform to the requirements of BMS 11-6, Type II, MIL-T-27602 or O-T-634.

2. Precision Cleaning Agent

Precision cleaning agent shall comply with the requirements of MSFC-SPEC-237.

3. Dowclene WR, Dow Chemical Company

b. Solvent supply for preclean operations shall comply with BMS 11-6;O-T-634, Type II; MIL-T-27602, MSFC-SPEC-237, or Dowclene WR. Solvent immersion tanks shall be equipped with a recirculating filter and during the work shift, solvent shall be filtered at a minimum rate of at least four tank volumes per hour. Tank solvents shall be changed when non-volatile content, as determined per D5-12567, exceeds 0.006% by wt., or when pH exceeds the limits of 7.0 - 10.0.

c. Control and operation of the vapor degreaser shall be in accordance with BAC 5408.

d. Liquid nitrogen used for testing shall comply with MIL-P-27401 or BB-N-411 and in addition shall comply with 6.2.1.1 and shall not contain condensable hydrocarbons in excess of 3 PPM by wt. Condensable hydrocarbons may be determined by boiling off a sample of LN_2, conducting a solvent extraction on the residue and an NVR test on the extracted hydrocarbon.

6.2.3 Alkaline Cleaner

Alkaline cleaner used for cleaning in accordance with this specification shall be Turco 4215, 4215S, 4142 or 4142S or comparable non-silicated alkaline cleaner and shall be controlled as follows:

6.0 MAINTENANCE CONTROL (Continued)

6.2.3 Alkaline Cleaner (Continued)

Concentration	1.0 - 2.0 oz/gal in water
Temperature	150 degrees - 170 degrees F.
Solution Life	Solution shall be changed whenever any of the following occur:

1. Solution life exceeds 60 days.
2. Additions of make up chemicals exceed 100% of maximum initial charge.
3. The solution becomes obviously contaminated with grease, oil or particulate material.

Water used in making the alkaline cleaning solution shall be distilled or deionized and shall have a minimum specific resistance of 50,000 ohms.

6.2.4 Detergent-Water Solution

Water used in making up the water-detergent solution shall be distilled or de-ionized water having a minimum specific resistance of 50,000 ohms. Detergents shall conform to the requirements of MIL-D-16791, Type I. Water and detergent shall be thoroughly mixed prior to use to make a solution with concentration of 0.1 - 0.6 oz/gal of water.

a. The solution may be heated to a maximum temperature of 130 degrees Fahrenheit, provided it is followed by a heated water rinse (water shall not exceed 130 degrees Fahrenheit).

b. The solution shall have a maximum working life of two weeks and shall be discarded sooner if it becomes obviously contaminated with oil, grease, or particulate matter.

6.2.5 Rinse Water

Spray or flush rinse water and water as supplied to precleaning or final cleaning immersion rinse tanks shall be distilled or deionized; shall have a minimum specific resistance of 50,000 ohms; and shall meet the requirements of 6.2.1.1. Water containing visible oil, grease, or other contamination shall not be used. The pH shall be within the range of 6.0 - 8.0.

6.2.6 Drying, Testing or Preservation Gas

a. General Requirements

1. Gas shall be nitrogen meeting the requirements of BB-N-411, or MIL-P-27401, air or other gas specifically approved by engineering.

2. Gas shall meet the requirements of 6.2.1.1

3. Gas shall not contain condensable hydrocarbons in excess of 3 PPM by weight when tested per D5-12567.

4. Drying Gas may be heated providing parts do not exceed -

   1. 130 degrees F. for MIL-C-5541 coated parts
   2. 160 degrees F. for non-metals parts, and
   3. 250 degrees F. for metal parts.

5. Drying gas shall not exceed 60 per cent relative humidity at ambient temperature.

6. Preservation gas, as contrasted to drying gas used to remove liquid water or solvent, shall not contain moisture in excess of 24 PPM by volume (-65 degrees F. dew point at standard atmospheric pressure).

6.2.7 Oven Drying

Maximum allowable temperature limits shall be per 6.2.6 a(4). Vacuum oven drying is preferred.

6.3 ENVIRONMENTAL REQUIREMENTS

6.3.1 Preclean Area

The preclean operations (B through M in 5.3) may be accomplished in a factory environment.

6.3.2 Final Clean Area

Operations N through P in 5.3 must be accomplished in the Final Clean Area except for the outer wrap as specified in 5.4.

Temperature	75 plus or minus 5 degrees F.
Humidity	40 ± 20% R.H.

6.3.2 Final Clean Area (continued)

Particles (per cu. ft.)	30 particles, maximum, 25-100 micron 1 particle, maximum exceeding 100 microns 1 fiber* maximum, exceeding 100 microns
Airborne, Liquid or Solid Hydrocarbons	3 PPM by wt, maximum
Positive Pressure	0.10 inch water minimum, as compared to factory environment. In addition, rooms shall be maintained at not less than 0.02 inch of water above that of any connecting, less stringently controlled area and the final clean and the laboratory rooms shall be maintained at not less than 0.01 inch of water above test room pressures.

The area shall be inspected at least daily (when in operation) and shall be visually free of dust, particles, grease and oil. Tools and equipment shall be maintained visually clean.

Paper products shall not be exposed to clean room environments. Drawings, specifications or other paper products shall be enclosed in plastic, polyethylene or aclar bags prior to entry into clean room.

* Fiber is defined as a particle having a length to width ratio of 10 or greater.

6.3.3 Tube Cleaning Console

Laminar Flow Bench

Particles (per cu.ft.)	30 particles, maximum, 25-100 microns 1 particle, maximum exceeding 100 microns 1 fiber maximum exceeding 100 microns
Air Flow Velocity	70 feet per minute minimum.

7.0 QUALITY ASSURANCE

7.1 GENERAL

Quality Assurance may, at their option, perform reliability tests on 100 percent of parts, or where cleaning procedures are standardized such that adequate confidence is obtained by testing representative parts, a lower percentage, down to a minimum of 5 percent of each lot of parts may be tested (at least 1 each lot).

7.1 GENERAL (continued)

Reliability tests for initial acceptance shall occur only after visual acceptance and prior to packaging.

NOTE: For the purposes of this paragraph, a lot may be considered to include all of those small (less than 1 square foot per item) parts which are of comparable configuration and materials (for example, corrosion resistant alloy items with all surfaces open and readily accessible) and which are processed through preclean and final clean by same procedure within one work shift.

Quality Assurance shall enforce all requirements of this specification. The reliability test sample and the segment of production that it represents shall be clearly identified.

7.2 CLEANLINESS LIMITS

Unless otherwise specified on the engineering drawing, significant surfaces of parts or components shall conform to the following requirements when tested in accordance with 7.3. Parts failing to meet these requirements shall be rejected.

NOTE

COMPONENTS OR ASSEMBLIES CONTAINING MATERIALS WHICH ARE NOT LOX COMPATIBLE PER MSFC-SPEC-106 CAN NOT BE CLEANED FOR LOX SERVICE. CONTACT MATERIALS AND PROCESSES ENGINEERING FOR LOX COMPATIBILITY INFORMATION REGARDING SPECIFIC MATERIALS.

7.2.1 PARTICLE CONTAMINATION AND NONVOLATILE RESIDUE – MAX ALLOWABLE LIMITS (PER SQ. FT. OF SIGNIFICANT SURFACE AREA)

DESIGN REQUIREMENTS	PARTICLE POPULATION (IN MICRON RANGES)								NONVOLATILE RESIDUE
	0 to 175		176 to 700		701 to 2500		2500		
MSFC-SPEC-164									
OXYGEN	No Limit		5		1		0		0.001 GMS.
FUEL	No Limit		5		1		0		No Requirement
PNEUMATIC	No Limit		5		1		0		0.001 GMS.
10M01671 LEVEL IV	0-50	51-140	141-230	231-320	321-410	411-500	500		
POPULATION LIMIT FOR PARTICLES	No Limit	40	10	3	2	1	0		0.002 GMS.
10M01671 LEVEL IV	0-50		51-500		501-1000		1001		
FIBERS-- LENGTH & POPULATION LIMITS	No Limit		10		1		0		

* FIBER IS DEFINED AS A PARTICLE HAVING A LENGTH TO WIDTH RATION OF 10 OR GREATER

7.2.2 Acidity or Alkalinity

Representative critical surfaces of parts shall show a pH within the range of 6.0 - 8.0 when tested with a suitable pH indicating paper. Test shall be accomplished after the final preclean water rinse, either while surfaces are still wet or after wetting the surface with a drop of water per 6.2.5. Parts showing a pH outside the 6.0 - 8.0 range shall be rejected.

7.3 RELIABILITY METHODS

The following methods shall be used to determine conformance of parts or components to the particle and non-volatile limits as stated in 7.2. Components, or lots of components with less than one-fourth sq. ft. of test surface area, which are tested as a single unit or lot, may be considered to have one-fourth sq. ft. of test surface area.

7.3.1 Particle Contamination Sampling

Oxygen, fuel and pneumatic components shall be tested for particle contamination as follows:

a. On small parts with less than 5.0 sq. ft of critical surface area, flush all critical surface of the part with solvent per 6.2.2. Volume of solvent used shall be the minimum volume necessary to achieve rigorous rinsing of all critical surfaces except use a minimum of 500 ml for test areas 1 sq. ft. and larger. For test areas smaller than 1 sq. ft. use 500 ml per sq. ft. except where test area is less than 1/4 sq. ft. use a minimum of 100 ml. After rinsing, collect the solvent for analysis per 7.4.

b. On components exceeding 5.0 sq. ft. of critical surface, spray, flush or otherwise vigorously rinse all critical surfaces of the part with solvent 6.2.2. Volume of solvent used should not exceed 100 ml per sq. ft. of critical surface and shall be the minimum volume necessary to obtain effective rinsing. After rinsing, collect the solvent for analysis per 7.4. Failure of any sample shall require additional cleaning and/or retesting.

7.3.2 Non-Volatile Residue Sampling

Oxygen and pneumatic components shall be tested as follows to determine non-volatile residue contamination:

Oxygen and pneumatic components described by 7.3.1.a and 7.3.1.b shall be tested for non-volatile residue by using the filtered solvent sample from the 7.3.1.a or by 7.3.1.b test. Test for non-volatile residue per 7.4.

7.4 QUALITY ASSURANCE ANALYSIS

Verification and analysis of cleaning media, environmental controls and part cleanliness to the requirements of this document shall be performed per the methods of D5-12567.

Calculation of particle and NVR results shall be as follows:

Reported particles (or NVR) per sq. ft. = Observed particle count (Or NVR) (minus blank) X Total vol. of test fl. used / Vol. of test fluid analyzed x sq. ft. of test surface area.

7.5 INTERCHANGEABILITY OF CLEANLINESS LEVELS

Component Cleanliness Level (Spec-164)	ACCEPTABLE FOR USE IN		
	Oxygen Service	Pneumatic Service	Fuel Service
Oxygen	Yes	Yes	Yes
Pneumatic	No	Yes	Yes
Fuel	No	No	Yes

7.6 CLEAN ROOM GARMENTS

All personnel shall wear clean room type coveralls, booties and hoods when inside the clean room. Personnel shall be clean shaven or shall wear a clean face cover. Materials of construction must be continuous filament. The garments must be changed when visually contaminated. Stained garments shall not be worn in the laboratory or final clean areas. Clean garments shall be sealed in at least one plastic bag until used. Significant surfaces of clean parts shall not be touched with the bare hands. Gloves which are utilized shall not shed fibers.

APPENDIX A

SPECIAL CLEANING PROCEDURES FOR DETAILED PARTS

1.0 ELECTRICAL CABLE TYING BRAID

1.1 SCOPE

This procedure applies for braided tie material which is cleaned as an individual item, i.e., prior to making ties.

1.2 Ultrasonic clean in solvent per 6.2.6.a for 2-3 minutes (for braid to be used in oxygen service, solvent shall meet NVR limits of 0.010 grams max. NVR/500 ml.).

1.3 On removal from the ultrasonic cleaning, thoroughly spray rinse or immersion rinse the braid with solvent per 6.2.2.a.

1.4 Dry to remove solvent.

1.5 Lightly vacuum or blow with gas per 6.2.6 to remove loose particles.

1.6 Visually inspect for obvious foreign materials and fraying. Material shall be free of obvious foreign material and attached fibers exceeding approximately 1/4 inch in length.

1.7 Package acceptable material per 5.4

NOTE: Steps 1.3 through 1.7 above shall be accomplished in the controlled environment per 6.3.2.

2.0 ELECTRICAL CABLE ASSEMBLIES

2.1 SCOPE

This procedure applies for cleaning and inspection of electrical cable assemblies to be used in the LOX or fuel tanks or comparable clean systems.

2.2 Cables shall be cleaned, tested, etc. per this section of D5-12855 except as modified or expanded herein.

2.3 Cables may be cleaned in the assembled condition. Non accessible areas shall be accepted or rejected on the basis of the reliability sample.

2.4 Cable assemblies shall be considered visually clean when they are free of obvious foreign materials and dislodged particles of the cable assembly materials.

NOTE: Attached fibers of the cable assembly material not exceeding 1/4 inch in length shall not be cause for rejection.

2.5 In case of disagreement on the visual inspection, the cleanliness of the cable assembly shall be accepted or rejected based on the reliability test.

3.0 DEAD END COMPONENTS (PRESSURE GAGES, TRANSDUCERS, ETC.)

Dead end components shall be cleaned as follows:

3.1 Prior to precleaning, inspect exterior and visible interior surfaces per 5.2. Exterior surfaces shall be free of objectionable damage and gross contamination or shall be cleaned as necessary. Visible interior surfaces shall be free of gross or adherent contamination.

CAUTION: (a) Do not immerse components in cleaning media

(b) Do not expose components to acid - use solvent wipe or comparable method for removal of gross non-adherent contamination. Remove objectionable adherent contamination by local abrasive methods if this can be accomplished without adverse affect.

3.2 PRECLEANING

Precleaning may be accomplished in the preclean area or in the final clean area. Solvent supply shall conform to 6.2.2. One of the following precleaning methods shall be used.

(a) Using an alternating vacuum - solvent flush (28 inches of mercury minimum vacuum). Fill and drain component a minimum of 20 times. Use fresh solvent for each fill.

(b) Using a bell jar pull maximum vacuum to incipient boiling of solvent. Position component so that on release of vacuum solvent will be forced into component. Continue cycling to obtain 20 minimum fill and drain cycles. Use fresh solvent for each component and change solvent during the cycling if solvent becomes visibly contaminated.

(c) When a "syringe" can be inserted into the dead-end cavity so as to provide rinsing of all interior significant surfaces, insert syringe and solvent flush all interior significant surfaces for a minimum of five (5) minutes.

CAUTION: Use a stop or similiar precautions as required to insure that syringe does not damage diaphram or other fragile parts.

3.2 PRECLEANING (Continued)

(d) When a bleed tube is installed, connect pressurized solvent supply to bleed tube and flush for a minimum of five (5) minutes.

Following completion of the precleaning:

(a) The final cleaning, per .3.3, shall be initiated within a maximum of two hours, or

(b) dry per 6.2.7 using gas per 6.2.6 (Components with Bleed tubes or where a syringe precleaning is used may be purge dried).

3.3 FINAL CLEANING

Final cleaning shall be accomplished in an environment controlled per 6.3.2. Use solvent per 6.2.2.

(a) Rinse significant surfaces of the component with solvent using one of the methods per 3.2 above.

(b) Rinse significant surfaces of the component (and collect the effluent rinse) per 7.3.1 using solvent per 6.2.2. Use rinse methods per 3.2, Components failing to meet the requirements of 7.2 shall be recycled starting at .3.2 or 3.3 .a, as required.

NOTE: Where a flexible syringe is used and must be withdrawn around a bend, the syringe shall be withdrawn prior to drying the component and a solvent flush shall be used during the withdrawal.

(c) Dry components per 6.2.7 using gas per 6.2.6 (Components with a bleed tube, or where a "syringe" can be used, may be purge dried).

(d) Package components per 5.4.

4.0 CLEANING OF PRESSURE-VOLUME COMPENSATING, LOX SUCTION AND FUEL SUCTION DUCTS

The following procedure shall be used when it is determined that LOX suction ducts, fuel suction ducts or pressure-volume compensator (PVC) ducts require cleaning at Michoud prior to installation into the vehicle.

4.1 CLEANING OF PVC DUCTS AND FUEL SUCTION DUCTS

Cleaning shall be accomplished in an uncontrolled environment with contamination control precautions as required herein. Solvent as delivered by the spray wand shall comply with 6.2.2.

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4.1 CLEANING OF PVC DUCTS AND FUEL SUCTION DUCTS (Continued)

The cleaning procedure shall be as follows:

(a) Install handling fixtures which immobilize the duct to avoid handling damage. Remove duct end closures and inspect for damage, corrosion, etc. per 5.2. Minor, accessible adherent contamination may be removed abrasively provided surface finish requirements are maintained.

NOTE: Consult Engineering if rough cleaning, other than as allowed above, appears necessary.

(b) Position the duct in the preclean degreaser tank so as to provide good drainage and thoroughly rinse all accessible interior and exterior surfaces.

NOTE: Solvent in the ultrasonic tank shall be maintained free of obvious particulate matter.

(c) Completely immerse the duct in the ultrasonically agitated solvent for a minimum of three minutes.

(d) Hoist the duct out of the solvent and position to provide maximum drainage of convolutes.

(e) Spray flush the interior of the duct if obvious particulate contamination is visible on significant surfaces.

(f) Repeat steps c, d, and e. to obtain a minimum of 10 immersion-drain cycles.

(g) Using the spray wand, flush all accessible significant surfaces. Calculate total volume of rinse solvent used (100 to 500 ML per square foot of significant surface area) and collect a representative sample(s) of the effluent rinse for particulate and NVR tests per 7.3 and 7.4. Results shall comply with 7.2. Components which fail to meet the limits of 7.2 shall be recleaned as follows:

(1) If particle count is not more than five (5) times 7.2 limits the component may be spray rinsed until 7.2 limits are met or

(2) Components shall be recycled starting with step c. above.

(h) As soon as possible (10 minutes maximum) following completion of the final rinse, cover the openings into the duct and initiate gas purge drying. Covers need

4.1 CLEANING OF PVC DUCTS AND FUEL SUCTION DUCTS (Continued)

(h) not be sealed provided they preclude entrance of airborne contamination. Covers shall be visually clean.

(i) Continue purge and/or vacuum oven dry as necessary to insure complete removal of solvent. Temperatures up to 250°F maximum may be used to facilitate drying.

CAUTION: Do not subject ducts to negative internal pressure.

(j) Following drying, package the duct per 5.4 except that packaging shall be accomplished in an uncontrolled environment and clean ducts shall be open to the uncontrolled environment only for the minimum time, necessary to install, remove or change covers.

4.2 CLEANING OF LOX SUCTION DUCTS

Cleaning shall be accomplished in an uncontrolled environment with contamination control precautions as provided herein. Solvent supply (as sampled from the overflow weir reservoir) shall comply with 6.2.2.a. Drying and presservation gas shall comply with 6.2.6. The cleaning procedure shall be as follows:

(a) Install the duct in the "falling film" cleaning facility.

(b) Flow solvent from the overflow weir down the duct at a rate of 30 to 70 gallons per minute for a minimum of one hour.

NOTE: Solvent may be heated to facilitate subsequent drying of the duct.

(c) With solvent still flowing through the duct, collect two 500 ± 25 ML samples of effluent solvent from the duct with a minimum five (5) minute period between samples. The sampling port shall be designed to provide a sample representative of particulate matter in the effluent solvent from the duct.

(d) Filter and count the samples per 7.4. Particle count for each sample shall not exceed the per square foot limits per 7.2. Failure of either sample to comply with particle limits shall require continued rinsing and retesting until particle limits are met.

(e) A 500 ± 25 ML sample of effluent rinse solvent shall be collected per the instruction in step (c) above (or the filtrate from one of the particle samples may be used) for NVR analysis. When tested per 7.4 the 500 ML sample

4.2 CLEANING OF LOX SUCTION DUCTS (Continued)

(e) shall have an NVR pick up of not more than 0.001 gram. Failure to meet this limit shall require continued rinsing and retesting until the limit is met.

(f) Upon completion of the rinse cycle, purge the duct with drying gas as necessary to remove all solvent as indicated by one of the following methods:

(1) No increase in dew point of effluent gas as compared to influent gas.

(2) No indication of halogens in effluent gas when tested with a halogen detector.

(3) No solvent odor in effluent gas.

(g) Disassemble the rinse fixture as necessary to permit visual inspection from the lower end of the duct. Visible interior surfaces shall be dry and shall comply with 4.3. Minor amounts of particulate contamination concentrated at the lower end of the duct may be removed by vacuum. Non-accessible contamination, exceeding 4.3 limits, shall require recycling starting with step (a) above. Any evidence of liquids shall require continued drying as necessary to insure that the duct is dry.

(h) Immediately on opening of the upper end of the duct, install a temporary or permanent visually clean cover to preclude contamination of the duct. The lower end of the duct shall be similiarly protected except during actual operations which require that the duct be open.

(i) Package ducts per 5.4 except that packaging shall be accomplished in an uncontrolled environment and ducts shall be opened for only the minimum time required to install end closures.

NOTE: Following sealing, pressurize (2 - 4 psig) the duct with preservation gas or otherwise insure that ducts will not be subjected to negative internal pressure.

SECTION II

FINAL CLEANING AND PACKAGING OF S-IC LOX AND FUEL TANKS PER MSFC-SPEC-164

1.0 SCOPE

This section of the document defines the cleaning facilities, sequences, processes and controls to be used by The Boeing Company at the Michoud Plant (Vertical Assembly Building, Hydrostatic Test Area) for final cleaning and packaging of S-IC LOX and fuel tanks per MSFC-SPEC-164. Processing in accordance with this document will comply with the requirements of MSFC-SPEC-164.

The provisions of this section do not apply for operations covered by other sections of the document, e.g., cleaning of parts per section I or vehicle assembly per section III.

2.0 APPLICABILITY

When cleaning and packaging of S-IC LOX and fuel tanks is required by drawings, such processing accomplished by The Boeing Company at Michoud (Vertical Assembly Building, Hydrostatic Test Area) shall be in accordance with this document.

3.0 REFERENCES

3.1	MSFC-SPEC-164	Cleanliness Of Components For Use In Oxygen, Fuel and Pneumatic Systems
3.2	D5-12567	Quality Evaluation Laboratories Chemical Methods
3.3	BAC 5750	Manual Solvent Cleaning
3.4	MSFC-SPEC-237A	Solvent, Precision Cleaning Agent

4.0 MATERIALS CONTROL

When specified herein, materials shall conform to the following specifications or designations. Except when an issue date is shown, all references to these specifications may be considered to designate the latest issue of the specification.

a.	BB-N-411	Nitrogen
b.	MIL-P-27401	Propellant Pressurizing Agent, Nitrogen
c.	MIL-D-16791	Detergents, Non-ionic
d.	MIL-T-27602	Trichloroethylene, Oxygen Propellant Compatible (by flushing methods)

4.0 MATERIALS CONTROL (Continued)

e.	BMS 11-6	Trichloroethylene
f.	MSFC-SPEC-237 A	Solvent, Precision Cleaning Agent
g.	O-T-634-A	Trichloroethylene, technical

5.0 MANUFACTURING CONTROL

5.1 General Notes

5.1.1 The final cleaning and drying of the S-IC LOX and fuel tank shall be conducted in the Vertical Assembly Building, Hydrostatic Test Area. This section of the Michoud Plant is considered an uncontrolled environmental area. Local environmental type control shall be used only to the extent specified in this section of the document.

5.1.2 Only authorized personnel shall be allowed to enter the S-IC LOX or fuel tank during this final cleaning operation.

a. Personnel ---- Each person assigned to work in the tank shall be required to have satisfactorily completed a prescribed physical examination and a training program designed to familiarize him with techniques and philosophy of contamination control.

b. Observers ---- Observers that enter the S-IC LOX or fuel tank shall be controlled so that they will not contribute to contamination of clean parts.

5.1.3 All LOX and fuel tank surfaces shall have received the following minimum precleaning prior to initiation of the hydrostatic test operation.

a. Prior to assembly of detail parts, subassemblies or components that will form faying surfaces, any necessary pre-assembly fit-up which generates contamination (drilling, reaming, machining and grinding) shall be completed, and the parts shall then be disassembled and individually cleaned per BAC 5750 or equivalent method unless some other cleaning method has been specified by Engineering drawing callout. At the time of actual assembly, the faying surfaces shall be visually clean per BAC 5750.

NOTE: Parts, subassemblies and/or components which have been cleaned and packaged per MSFC-SPEC-164 shall be considered to comply with this precleaning requirement.

5.0 MANUFACTURING CONTROL (continued)

5.1.3 (continued)

b. All accessible tank interior surfaces, shall have been cleaned or kept clean such that all surfaces will pass the visual cleanliness requirements of BAC 5750.

NOTE: Cleaning materials and equipment used for this precleaning operation shall be selected to:

(1) Effectively accomplish necessary cleaning.

(2) Avoid damage to tank surfaces.

(3) Minimize particle generation. For the LOX tank, it is important to minimize use of LOX sensitive cleaning aids, e.g., plastic abrasive pads, which will add LOX sensitive contamination.

5.1.4 The following minimum requirements shall apply during the final cleaning of tanks:

5.1.4.1 A continuous air purge of the tank shall be maintained. Influent air shall comply with 6.2.5.1. In addition, the tanks shall be maintained at a minimum positive differential pressure of 0.5 inches of water during all spray cleaning or spray rinsing operations.

5.1.4.2 An inflatable particle barrier type enclosure with an interconnecting inflatable or flexible tunnel shall be attached to the tank opening. The interior surfaces of the particle barrier enclosure and interconnecting tunnel shall be hand wiped and vacuum cleaned after initial set up to remove all visible particles in excess of 1/10 inch. The effluent tank purge air shall flow from the tank through the interconnecting tunnel and finally exiting inside the particle barrier enclosure.

NOTE: The particle barrier enclosure is not required for tank entry prior to the cleanliness reliability test rinse.

5.1.4.3 All personnel shall wear clean room type coveralls, booties, hoods and gloves when inside the tank or the inflatable particle barrier enclosure or interconnecting tunnel. Personnel shall be clean shaven or shall wear a clean face cover. These garments must be visually clean.

NOTE: When the particle barrier enclosure is being used, clean room type clothing shall be put on immediately after entering the enclosure.

5.1.4.4 All tools, equipment, and safety items required for final cleaning operation shall be visually clean per BAC 5750 prior to entry into the inflatable particle barrier enclosure or tank. Remove protective bags before entry into the tank.

5.0 MANUFACTURING CONTROL (Continued)

5.1.4.4 (Continued)

NOTE: For difficult-to-clean items, compliance with this requirement may be accomplished by bagging, or comparable methods, which insures that the item will not contribute objectionable contamination to the tank.

5.1.4.5 An inventory, or equivalent system, shall be used to verify that all tools and equipment are removed from the tank after the operation is completed.

5.1.5 The S-IC LOX and fuel tanks retain a significant amount of liquid and particles in low spots of the lower bulkhead. Hence, all such liquid and particles retained in these areas shall be removed by hand wiping and/or vacuuming following the completion of the paragraphs 5.2.b, 5.3.b and 5.3.d (as applicable) rinse cycles.

5.2 S-IC Fuel Tank Final Cleaning

The fuel tank shall be final cleaned by the following procedure:

a. Spray clean interior of the tank with water-detergent solution per paragraph 6.2.3 for a minimum of two hours at 125 GPM minimum flow rate and 125 PSI minimum pressure.

b. Spray rinse interior of tank with demineralized water per paragraph 6.2.4 for a minimum of two hours at 125 GPM minimum flow rate and 125 PSI minimum pressure. Rinsing shall continue until effluent rinse water shows no foaming and is within the pH range at 6.0 to 8.0, and complies with the particle limits of paragraph 7.1.1. Tanks which fail to meet the particle limits may be recycled; starting with sequence (a) above, in lieu of continuing the rinse per sequence (b).

c. Dry interior of tank with gas per paragraph 6.2.5.1 to remove all moisture as indicated by effluent gas dew point determination. Tank shall be considered dry when dew point determination shows no measurable increase, as compared to influent gas and no evidence of moisture is indicated on the lower tank bulkhead.

d. Visually scan the tank for the presence of foreign materials and then inspect for visual cleanliness per paragraph 7.2.3. Particulate contamination exceeding paragraphs 7.2.3 limits by not more than five times may be removed by the procedure in paragraph 5.1.5. Tanks containing particulate contamination greater than five times paragraph 7.2.3 limits shall require recleaning starting with sequence (a) above.

e. After the sequences (a, b, c and d) have been successfully completed Quality Control will certify that the fuel tank has passed the Engineering drawing requirement for final

5.0 MANUFACTURING CONTROL (Continued)

5.2 S-IC Fuel Tank Final Cleaning (Continued)

e. (Continued)

cleaning per MSFC-SPEC-164 for fuel service.

5.3 S-IC LOX Tank Final Cleaning

The LOX tank shall be final cleaned by the following procedure:

a. Spray clean interior of the tank with water detergent solution per paragraph 6.2.3 for a minimum of two hours at 125 GPM minimum flow rate and 125 PSI minimum pressure.

b. Spray rinse interior of tank with demineralized water per paragraph 6.2.4 for a minimum of two hours at 125 GPM minimum flow rate and 125 PSI minimum pressure. Rinsing shall continue until effluent rinse water shows no foaming and is within the pH range of 6.0 to 8.0.

c. Dry interior of tank with gas per paragraph 6.2.5.1 to remove all moisture as indicated by effluent gas dew point determination. Tanks shall be considered dry when dew point determination shows no measurable increase as compared to influent gas and no evidence of moisture is indicated on the lower tank bulkhead.

d. Spray rinse the interior of the LOX tank with solvent per paragraph 6.2.2 at 125 GPM minimum flow rate and 125 PSI minimum pressure. Rinsing shall be continued as required until the particle and non volatile residue requirements per paragraph 7.1.1 and 7.1.2 are met.

e. Dry interior of tank with gas per paragraph 6.2.5.1 to remove all residual solvent. Tanks shall be considered dry when no measurable halogen concentration is indicated in effluent gas by a halogen detector and no evidence of solvent is indicated on the lower tank bulkhead.

f. Visually scan the tank for the presence of foreign materials and then inspect for visual cleanliness per paragraph 7.2.3. Particulate contamination exceeding paragraph 7.2.3.1limits by not more than five times may be removed by the procedure in paragraph 5.1.5. Tanks containing particulate contamination greater than five times paragraph 7.2.3 limits shall require recleaning starting with sequence (a) above.

g. After sequences (a, b, c, d, e and f) have been successfully completed, Quality Control will certify that the LOX tank has passed the engineering drawing requirement for final cleaning per MSFC-SPEC-164 for oxygen service.

5.0 MANUFACTURING CONTROL (Continued)

5.4 Packaging

After the fuel or LOX tank has been final cleaned per paragraph 5.2 or 5.3, as applicable, the tank shall be packaged. This packaging unless otherwise specified on the engineering drawing shall be accomplished in the following manner.

5.4.1 Blind flanges or other equivalent devices shall be used to seal off all tank interior surfaces from the uncontrolled environment. All sealing devices or blind flanges shall be cleaned and packaged per MSFC-SPEC-164 prior to installation. Tank flange sealing surface shall be solvent cleaned with Freon per BAC 5750 before sealing devices are installed.

5.4.2 Upon completion of sealing operation, the tank will be pressurized and maintained to 3 ± 2 PSIG. Gas used for pressurizing and maintaining pressure shall comply with the requirements per paragraph 6.2.5.2.

NOTE: The tank shall be maintained at 60% R. H. or less.

5.4.3 A "safe tie" or, tamperproof seal, or equivalent method shall be placed on all sealing flanges to prevent unauthorized opening of packaged tank. Opening of the tank shall be considered authorized only when accomplished by the methods per section III of D5-12855.

5.4.4 All tanks that have been certified cleaned per paragraph 5.2 or 5.3 as applicable and packaged per paragraph 5.4 shall be considered to have passed the engineering drawing requirement for final cleaning and packaging per MSFC-SPEC-164 for the applicable service. Tanks that have been accepted as having been cleaned and packaged per MSFC-SPEC-164 shall be labeled with the following information:

1. Part Number _____
2. Serial Number
3. Supplier - The Boeing Company, Michoud Plant
4. Cleaning Specification - MSFC-SPEC-164
5. (Service Medium) - Oxygen or fuel as applicable
6. Contamination level after cleaning (as determined by the final cleanliness reliability test)
7. Date final cleaned - _____
8. Date final packaged -

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6.0 MAINTENANCE CONTROL

6.1 Equipment requirement shall be capable of satisfying the requirements of this section of the document.

6.1.1 Filters

One or more depth or surface filtration stages may be used to meet filtering requirements of cleaning solutions, rinse, water, and drying gas. The final filtering stage shall have an absolute rating equal to, or finer than, the degree of filtration of the system. The filters shall be monitored by periodic pressure drop and down stream contamination checks, or equivalent methods and shall be changed or cleaned as required to function effectively and provide fluids meeting the requirements herein.

6.2 Processing Media

6.2.1 General requirements for processing media. The media covered in this paragraph (6.2) shall conform to the applicable following requirements.

6.2.1.1 Particle Size

Media used in processing of the tanks shall be free of particles to the extent specified below. The requirement shall apply to the fluid or gas at the nearest practical sampling point to the delivery end of the line.

(a) Liquid media used for cleaning, rinsing, and testing shall contain no particles exceeding 175 microns and a maximum of five particles in the range of 100 to 175 microns as determined on a 500 ± 25 ml sample.

(b) Gas used for drying and pressurization operations shall contain no particles (per cubic foot) exceeding 100 microns.

6.2.2 Trichloroethylene

Trichloroethylene used for final cleaning or testing per this section of the document shall comply with the following requirements and in addition shall comply with the particle requirements of paragraph 6.2.1.1.

(a) Trichloroethylene shall conform to the requirements of BMS 11-6, Type II, Mil-T-27602 or O-T-634A and non volatile residue requirements of MSFC-SPEC-164, paragraph 3.2.1.1.

(b) Trichloroethylene shall be changed when pH exceeds the limits of 7.0 - 10.0.

6.0 MAINTENANCE CONTROL (Continued)

6.2.3 Detergent Water Solution

Water used in making up the water detergent solution shall be distilled or demineralized water having a minimum specific resistance of 50,000 OHMS. Detergents shall conform to the requirements of MIL-D-16791, Type I. Water and detergent shall be thoroughly mixed prior to use to make a solution with a concentration of 0.1 - 0.5% by volume of detergent. Detergent water solution shall meet the particle requirements of paragraph 6.2.1.1.

NOTE: The solution may be heated to a maximum temperature of 130°F, provided it is followed by a heated water rinse (water shall not exceed 130°F).

6.2.4 Rinse Water

Spray rinse water shall have a minimum specific resistance of 50,000 OHMS, have a pH between 6.0 - 8.0, and shall meet the requirements of paragraph 6.2.1.1.

6.2.5 Drying and Pressurization Gas

6.2.5.1 Drying Gas

a. General Requirements

1. Gas shall be nitrogen meeting the requirements of BB-N-411 or MIL-P-27401, air or other gas specifically approved by Engineering.

2. Gas shall meet the requirements of 6.2.1.1.

3. Gas shall contain no condensable hydrocarbons in excess of 3 PPM by weight when tested per D5-12567.

4. Gas may be heated providing tank parts do not exceed 130°F.

5. Gas shall not exceed 60 percent relative humidity at ambient temperature.

6.2.5.2 Pressurization Gas

a. General Requirements

1. Gas shall be nitrogen meeting the requirements of BB-N-411 or MIL-P-27401, air or other gas specifically approved by Engineering.

6.0 MAINTENANCE CONTROL (Continued)

6.2.5.2 Pressurization Gas (Continued)

a. General Requirements (Continued)

2. Gas shall meet the requirements of 6.2.1.1

3. Gas shall contain no condensable hydrocarbon in excess of 3 PPM by weight when tested per D5-12567.

4. Gas shall contain no moisture in excess of 24 PPM by volume (-65°F dew point at standard atmospheric pressure).

7.0 QUALITY CONTROL

General

Quality Control shall enforce all requirements of this section of the document. Quality Control shall perform the reliability tests on 100 percent of tanks cleaned by this section of the document.

7.1 Cleanliness Limits

Unless otherwise specified on the engineering drawing, tank interior surfaces shall conform to the following requirements when tested in accordance with paragraph 7.2. Tanks shall be accepted or rejected on the basis of these requirements.

7.1.1 All particle sizes mentioned herein refer to the longest dimension of the particle, i.e., length, width or thickness.

a. All LOX and fuel tank interior surfaces shall meet the following requirements.

Size Range, Microns	Maximum Allowable Particles Per Square foot
0-175	No Limit
176-700	5
701-2500	1
2500 +	0

7.1.2 Non Volatile Residue

a. LOX tank interior surfaces shall contain no more than .005 grams of non-volatile residue per square foot of significant surface area.

b. Fuel tank interior surface - no requirement.

7.0 QUALITY CONTROL (Continued)

7.2 Test Methods

The following methods shall be used for determining conformance of all tank interior surfaces to the particle and non volatile residue limits as stated in paragraph 7.1.

7.2.1 Cleanliness Reliability Sampling of Fuel Tank

Traverse the interior of tank with a spray utilizing water per paragraph 6.2.4. Spray nozzle pressure shall be not less than 125 psig, flow rate (125 gpm minimum), nozzle positioning and nozzle configuration shall be suitable to vigorously rinse the interior tank surfaces. From a continuous flow of effluent rinse water, collect at least five 500 ml samples at five (or more) equally spaced intervals during one bottom-to-top cycle of the spray nozzles. Retain the samples for particle analysis per paragraph 7.3. Each sample shall be tested individually. Failure of any sample shall require additional cleaning and/or retesting.

7.2.2 Cleanliness Reliability Sampling of LOX Tank

Traverse the interior of tank with a spray utilizing trichloroethylene per paragraph 6.2.2. Spray nozzle pressure shall be not less than 125 psig. Flow rate (125 gpm minimum), nozzle positioning and nozzle configuration shall be suitable to vigorously rinse the tank interior surfaces. From a continuous flow of rinse solvent, collect at least five 1000 ml (minimum) samples at five or more equally spaced intervals during one bottom-to-top cycle of the spray nozzle. Retain the samples for particle and NVR analysis per 7.3. Each sample shall be tested individually for particle analysis but only a composite sample shall be used for non volatile residue analysis. Failure of any sample shall require additional cleaning and/or retesting.

7.2.3 Visual Cleanliness

Visually inspect at least 1% of the tank interior surface, selected from accessible, representative areas on a random basis for visual cleanliness. Visual cleanliness shall be considered to mean a surface that is free from oil, grease, paint, waxes, corrosion and scale when examined under white light (50-150 foot candles) and from a distance of one to two feet. Non-flaking surface indications such as controlled metals oxides (e.g. passivation films, anodizing, etc.), water marks and colorations, and surface imperfections, such as nicks, scratches and roughness are acceptable in-so-far as visual cleanliness is concerned. Surface indications of particles are acceptable provided the total particulate contamination observed divided by the number of square feet of area inspected, (i.e., average contamination per sq. ft.) does not exceed the limits per paragraph 7.1.1.

7.0 QUALITY CONTROL (Continued)

7.3 Quality Assurance Analysis

Verification and analysis of processing media, and tank cleanliness to the requirements of this document shall be performed per the methods of D5-12567, "Quality Evaluation Laboratories Chemical Process Control Methods".

Calculation of reported particles and NVR to determine compliance with 7.1 shall utilize the following formula.

$$\text{Reported particles (or NVR) per Sq. Ft.} = \frac{A \times B}{C \times D}$$

Where

A = Observed particle count or (NVR minus blank)

B = Total volume sprayed into tank during the bottom-to-top spray cycle, calculated from flow rate x time.

C = Volume of test fluid analyzed

D = Total interior surface area of LOX or fuel tank. Total interior surfaces of these tanks are:

Fuel Tank: 14,500 square feet

LOX Tank : 19,000 square feet

END OF REFERENCE
9

REFERENCE
10

ANON.: CLEANLINESS LEVELS, CLEANING, PROTECTION AND INSPECTION PROCEDURES FOR PARTS, FIELD PARTS, ASSEMBLIES, SUBSYSTEMS, AND SYSTEMS FOR FLUID USE IN SUPPORT EQUIPMENT. KSC-C-123(D), NASA, MAR. 14, 1968.

KSC-C-123(D)
AMENDMENT 3
SUPPLEMENT 1
March 14, 1968
SUPERSEDING
KSC-C-123(D)
AMENDMENT 3
July 12, 1965

JOHN F. KENNEDY SPACE CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPECIFICATION

CLEANLINESS LEVELS, CLEANING, PROTECTION, AND INSPECTION PROCEDURES FOR PARTS, FIELD PARTS, ASSEMBLIES, SUBSYSTEMS, AND SYSTEMS FOR FLUID USE IN SUPPORT EQUIPMENT

This supplement forms a part of John F. Kennedy Space Center Specification KSC-C-123(D), Amendment 3, July 12, 1965, and is mandatory for use by KSC and associated contractors.

Page 11, paragraph 3.3: Delete and substitute: "3.3 Cleanliness requirements, - All items of support equipment fluid systems that are cleaned shall comply with 3.3.1, 3.3.2, and 3.3.3 except that components, subsystems, and systems utilizing hydraulic fluid per MIL-H-5606 shall not be required to meet the criteria of 3.3.2 and 3.3.3 unless specified by the procuring activity."

KSC-C-123 (D)
AMENDMENT 3
July 12, 1965
SUPERSEDING
AMENDMENT 2
May 24, 1965

JOHN F. KENNEDY SPACE CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPECIFICATION

CLEANLINESS LEVELS, CLEANING, PROTECTION, AND INSPECTION PROCEDURES FOR PARTS, FIELD PARTS, ASSEMBLIES, SUBSYSTEMS, AND SYSTEMS FOR PNEUMATIC USE IN SUPPORT EQUIPMENT

This amendment forms a part of Kennedy Space Center Specification KSC-C-123 (D), December 14, 1965

(1) Page 1, Title: Delete word "Pneumatic", replace with word "Fluid".

(2) Page 1, paragraph 1.1: Delete the word "pneumatic" in the first sentence. Replace with the word "fluid".

(3) Page 2, paragraph 1.2.1: Delete procedures 2, 3, 4, and 5, and replace with the following:

"Procedure 2 - Parts, assemblies, subsystems, and systems cleaned with a detergent-water solution and flushed by trichloroethylene or trichlorotrifluoroethane (metallic and polytetrafluoroethylene items).

Procedure 3 - Parts, assemblies, subsystems, and systems cleaned with a solution of trisodium phosphate and flushed by a 8.0 to 12.0 percent solution of nitric acid, with a final flush of trichloroethylene or trichlorotrifluoroethane.

Procedure 4 - Parts, assemblies, subsystems, and systems cleaned with a solution of trisodium phosphate and flushed by trichloroethylene or trichlorotrifluoroethane (aluminum alloy tubing).

Procedure 5 - Parts, assemblies, subsystems, and systems cleaned in an ultrasonic cleaning tank by a recirculating detergent water solution and flushed by trichloroethylene or trichlorotrifluoroethane (flexible hose, all metal hose)."

(4) Page 3, figure 1: Delete the "Trichloroethylene Tank" and replace with "Solvent Tank".

(5) Page 4, paragraph 2.1: Delete Federal Specification "O-A-86" and replace with:

"O-H-765 Acid, Hydrochloric (Muriatic), Technical Grade."

Delete Federal Specification "O-A-88" and replace with:

"O-N-350 Acid, Nitric, Technical Grade."

Add the following Federal specification:

"L-P-378 Plastic Films, Polyethylene, Type II."

Add the following Marshall Space Flight Center Document:

"MSFC-SPEC-237 Solvent, Precision Cleaning Agent, Trichlorotrifluorothane."

(6) Page 6, paragraph 3.2.1: Delete the title "Trichloroethylene", replace with "Solvent".

(7) Page 6, paragraph 3.2.1.1: Delete the entire paragraph and replace with the following:

"3.2.1.1 Vapor degreasing solvent. - Type II, Trichloroethylene, conforming to Specification MSFC-SPEC-217 or Trichlorotrifluoroethane, conforming to Specification MSFC-SPEC-237, shall be used in vapor degreasing processes."

(8) Page 6, paragraph 3.2.1.2: Delete the entire paragraph and caution note and replace with the following:

"3.2.1.2 Cleaning, flushing, and testing solvent. - Type 1, Trichloroethylene, conforming to MSFC-SPEC-217 or Trichlorotrifluoroethane, conforming to MSFC-SPEC-237, shall be used as an immersion cleaning agent, flushing agent, or a testing solvent for surfaces of metallic and polytetrafluoroethylene parts, field parts, assemblies, subsystems, or systems, when applicable. Prior to its use, the solvent shall be filtered to the extent necessary to remove particles that are larger than the limits specified for the part, assembly, subsystem or system being cleaned, flushed, or tested.

CAUTION

Trichloroethylene or trichlorotrifluoroethane shall not be used in the solvent flush test of items containing nonmetallic (except Teflon) materials or lubricants. Permission to remove all nonmetallic (except Teflon) materials to permit testing with Trichloroethylene or Trichlorotrifluoroethane may be granted at the discretion of the procuring activity."

(9) Page 7, paragraph 3.2.3: Delete in entirety and replace with the following:

"3.2.3 Drying or preservation gas. - Gases used in drying or preservation processes shall be prefiltered to the extent that the contamination level shall meet the particulate limit and condensable hydrocarbon content specified for the item being dried or preserved. Dew point of drying gas shall be -65°F minimum."

(10) Page 7, paragraph 3.2.4: Delete the paragraph and replace the following:

"3.2.4 Test or purge gas. - The nitrogen gas used to perform the tests of purges specified herein shall conform to type I, class 1, grade A of Specification BB-N-411, except, the contamination level shall meet the particulate limit and the condensable hydrocarbon content specified for the item being tested. Dew point of the test or purge gas shall be -65°F minimum."

(11) Page 7, paragraph 3.2.5.1: Delete the paragraph in entirety.

(12) Page 8, paragraph 3.2.12: Delete and replace with the following:

"3.2.12 Demineralized water. - Demineralized water, if specified for flushing or testing operations, shall be prefiltered to remove all particles larger than the limits specified for the parts, field parts,

assemblies, subsystems, or systems being flushed or tested. The minimum specific resistance of the demineralized water supply shall be maintained at 50,000 ohms, and shall be checked and certified daily."

(13) Page 10, paragraph 3.2.17.4: Delete part (d) and replace with the following:

"(d) One wash bottle."

(14) Page 11, paragraph 3.3.1: Delete the word "pneumatic" in the first sentence and add the word "fluid".

(15) Page 12, paragraph 3.4.1: Delete the word "gas" and add the word "fluid".

(16) Page 14, paragraph 3.4.4.1.1: Delete and replace step (a) of the paragraph and add new step (f) as follows:

"(a) Brush surfaces thoroughly with a nylon bristle brush and a 0.5 percent solution of detergent and water. Water used for this purpose shall be either prefiltered tap water or demineralized water as approved by the procuring activity. Brush, spray, and soak, as necessary for a period of 10 to 15 minutes. Maintain the detergent-water solution at a temperature of 122 (plus or minus 9) degrees F.

(f) The times specified in items (a), (b), and (c) are to be used only as guides."

(17) Page 14, paragraph 3.4.4.2.1: Delete item (b) and replace with the following:

"(b) Brush surfaces thoroughly with a nylon bristle brush and a 0.5 percent solution of detergent and water. Water used for this purpose shall be either prefiltered tap water or demineralized water as approved by the procuring activity. Brush, spray, and soak, as necessary for a period of 10 to 15 minutes. Maintain the detergent-water solution at a temperature of 122 (plus or minus 9) degrees F."

(18) Page 15, paragraph 3.4.4.2.1: Delete item (e) and replace with the following:

"(e) Flush surfaces with trichloroethylene or trichlorotrifluroethane for a period of 15 to 30 minutes (See tables III, IV, and V for flushing data)."

(19) Page 15, paragraph 3.4.4.2.1: Add new step (i):

"(i) The times specified in items (b) and (c) are to be used only as guides."

(20) Page 16, Table IV. Informational tubing data: Add the following information to Table IV.

Ref. tube size (inches)	Wt. of trichloroethylene 100 ft. column (lbs.)	Wt. of trichlorotrifluoroethane 100 ft. column (lbs.)	Static pressure 100 ft. column same for all pipe sizes (psi)
1/4	1.62	1.71	
5/16	2.93	3.09	
3/8	4.65	4.89	
1/2	9.3	9.77	Water 43.3
5/8	15.5	16.4	trichloroethylene
3/4	21.4	22.3	63.2
7/8	30.2	31.8	trichlorotri-
1	40.8	43.0	fluoroethane
1 1/4	66.5	70.0	67.2
1 1/2	95.0	99.6	
1 3/4	131.0	138.5	
2	176.0	185.0	
3	414.0	436.0	
4	730.0	769.0	
5	1160.0	1220.0	
6	1665.0	1761.0	

(21) Page 17, paragraph 3.4.4.3.1: Delete 3.4.4.3.1 in entirety and replace with the following:

"3.4.4.3.1 Corrosion-resistant steel tubing or pipe

(a) Circulate a solution of 15 (±2) percent, by volume, Oakite 33 and water through the tubing or pipe for a minimum of 15 minutes. Water used for this purpose shall be either prefiltered tap water or demineralized water as approved by the procuring activity (see tables III, IV, and V for circulation data). Maintain the solution at a temperature within the range of 130° ±10°F.

CAUTION

Do not heat the Oakite 33 solution over 150°F as part of the solvent may be lost.

(b) Upon prior approval of procuring activity, a thorough 15 minute flush of the tubing or pipe with prefiltered tap water at room temperature may be substituted in place of the first 15 minutes of the flush with demineralized water as required in the following step (c) (see tables III, IV, and V for flushing data).

(c). Flush the tubing or pipe thoroughly with demineralized water at room temperature for a minimum of 25 minutes (or 10 minutes provided step (b) above was used) (see tables III, IV, and V for flushing data).

(d) Dry the tubing thoroughly with gas. A vacuum drying process, approved by the procuring activity, is an acceptable substitute.

(e) Flush tubing or pipe thoroughly with trichloroethylene or trichlorotrifluoroethane for a minimum of 15 minutes (see tables III, IV, and V for flushing data).

(f) Test cleaned and flushed surfaces for acidity and alkalinity with pH paper while the surfaces are wet. If surfaces are dry, wet with a few drops of distilled water and perform test. Test results shall be within a range of 6.0 to 8.0 pH. If conformance is not obtained, repeat steps (a) through (e) as necessary and retest.

(g) Dry tubing or pipes thoroughly with gas. A vacuum drying process, approved by the procuring activity, is an acceptable substitute."

(22) Page 18, paragraph 3.4.4.4.1: Delete 3.4.4.4.1 in entirety and replace with the following:

3.4.4.4.1 Aluminum alloy tubing or pipe.

"(a) Circulate a solution of 20 ± 2.0 percent by volume of Oakite No. 33 and water through the tubing or pipe for a minimum of 5 minutes. Water used for this purpose shall be either prefiltered tap water or demineralized water as approved by the procuring activity, (see tables III, IV, and V for circulation data). Maintain the solution at a temperature within the range of 130 ± 10 degrees F.

CAUTION

Do not heat the Oakite 33 solution over 150°F as part of the solvent may be lost.

"(b) Flush surfaces thoroughly with water at room temperature for a minimum of 10 minutes. Water used for this purpose shall be either prefiltered tap water or demineralized water as approved by the procuring activity. (see tables III, IV, and V for flushing data)

(c) Circulate a solution of 12 ounces of Oakite 34, per gal. of water, through the tubing or pipe for a minimum of 10 minutes. Water used for this purpose shall be either prefiltered tap water or demineralized water as approved by the procuring activity. Maintain the solution at a temperature within the range of 70 to 90 degrees F."

"(d) Flush the tubing or pipe thoroughly with demineralized water at room temperature for a minimum period of 10 minutes.

(e) Dry tubing or pipe thoroughly with gas. A vacuum drying process is an acceptable substitute.

(f) Flush tubing or pipe thoroughly with trichloroethylene or trichlorotrifluoroethane for a minimum of 15 minutes.

(g) Test cleaned and flushed surfaces for acidity and alkalinity with pH indicating paper while the surfaces are wet. If surfaces are dry, wet with a few drops of distilled water and perform test. Test results shall be within a range of 6.0 to 8.0 pH. If conformance is not obtained repeat steps (a) through (f) as necessary and repeat test.

(h) Dry tubing or pipe thoroughly with gas. A vacuum drying process is an acceptable substitute method."

(23) Page 19, paragraph 3.4.4.5.1: Delete item (d) and replace with the following:

"(d) Flush the hose with trichloroethylene or trichlorotrifluoroethane for a minimum of 15 minutes (See tables III, IV, and V for flushing data)."

(24) Page 20, paragraph 3.4.4.5.1: Delete item (f) and replace with the following:

"(f) Purge the hose with filtered gas."

(25) Page 20, paragraph 3.4.4.5.1: Delete item (g) and add:

"(g) Vacuum dry internal surfaces. Where possible, external surfaces shall be dried by a vacuum furnace or other approved procedure."

(26) Page 20, paragraph 3.4.4.6.1: Delete in entirety and replace with the following:

"3.4.4.6.1 Field parts only. - Clean field parts by a recirculating system utilizing cleaning procedures 1 through 5, as applicable, except as noted in 3.4.4.6.2. Welds performed in the field shall be cleaned by the applicable cleaning procedure 1 through 5."

(27) Page 20, paragraph 3.5.1.1: Delete the paragraph and replace with the following:

"3.5.1.1 Systems and components not requiring LOX compatibility.

3.5.1.1.1 Small components.

(a) All critical surfaces or openings to these surfaces will be protected by two layers of cleaned Saran Wrap or 2 mil nylon C thermal impulse seal where applicable; otherwise, secure with tape.

(b) Place the cleaned and protected item in a single or double polyethylene bag - 6 or 8 MIL thickness, sealed where applicable; otherwise, secure with tape."

(28) Page 21, paragraph 3.5.1.1.2: Delete and replace with the following:

"3.5.1.1.2 Large components, tubes, hoses, pipes, and miscellaneous non-packageable items.

(a) All critical surfaces, or openings to these surfaces will be protected by two layers of 2 MIL Nylon C or Saran Wrap. Thermal impulse seal where applicable; otherwise, secure with tape.

(b) Caps of a compatible material may be used to support and protect the initial wrappings. Secure with tape.

(c) Place the cleaned and protected item in a single or double polyethylene bag - 6 or 8 MIL thickness, sealed where applicable; otherwise, secure with tape."

(29) Page 21, paragraph 3.5.1.2.1 and 3.5.1.2.2: Delete the paragraphs and replace with the following:

"3.5.1.2.1 Systems and components requiring LOX compatibility.

CAUTION

Aclar films produce a highly reactive and toxic gas when allowed to decompose by excessive heat (above 390°F). Do not allow to contact flame directly.

CAUTION

Do not use any chloronated solvents with Aclar. Use reagent grade Acetone and or Butyl Alcohol on Aclar 33C for cleaning purposes.

"3.5.1.2.2 Small components.

(a) All critical surfaces or openings to these surfaces shall be protected by one or two layers of 2 MIL Aclar 33C. Thermal impulse seal where applicable; otherwise, secure with tape.

(b) Place the cleaned and protected item in a single or double polyethylene bag - 6 or 8 MIL thickness, sealed where applicable; otherwise, secure with tape."

(30) Page 22, paragraph 3.5.1.2.3: Delete the paragraphs and replace with the following:

"3.5.1.2.3 Large components, tubes, hoses, pipes, and miscellaneous non-packagable items.

(a) All critical surfaces or openings to these surfaces will be protected by one or two layers of cleaned 5 MIL Aclar 33C. Thermal impulse seal where applicable; otherwise, secure with tape.

(b) Caps of a compatible material may be used to support and protect the initial wrappings. Secure with tape.

(c) Place the cleaned and protected item in a single or double polyethylene bag - 6 or 8 MIL thickness, sealed where applicable; otherwise, secure with tape."

(31) Page 28, paragraph 4.4.3.6.3: Delete the word "Freon" and replace with "trichlorotrifluoroethane."

(32) Page 31, paragraph 4.4.4.4.1: Delete item (c) and replace with:

"(c) Thoroughly wash the millipore filter holder and the millipore filter membrane with solvent (prefiltered trichloroethylene or trichlorotrifluoroethane)."

(33) 4.4.4.4.1 Add the following item:

"(l) The presence of a stain on the membrane shall be cause for rejection."

(34) Page 34, paragraph 4.4.4.6.2: Delete in entirety and replace with:

"4.4.4.6.2 Lot rejection. - If any acceptance sample fails to meet the requirements specified herein, a second sample shall be selected and tested. If any item from the second sample fails to meet the requirements specified herein, the entire lot represented by the sample shall be rejected."

(35) Page 34, paragraph 6.1: Delete the word "Pneumatic" and replace with the word "Fluid".

(36) Page 36, paragraph 6.3: Add new paragraph 6.3.12:

"6.3.12 Fluid. - For the purpose of this specification, fluid is defined as a gas or liquid."

Custodian:

NASA - John F. Kennedy Space Center

Preparing Activity:

John F. Kennedy Space Center
Launch Support Equipment
Engineering Division

KSC-C-123 (D)
December 14, 1964

JOHN F. KENNEDY SPACE CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPECIFICATION

CLEANLINESS LEVELS, CLEANING, PROTECTION, AND INSPECTION PROCEDURES FOR PARTS, FIELD PARTS, ASSEMBLIES, SUBSYSTEMS, AND SYSTEMS FOR PNEUMATIC USE IN SUPPORT EQUIPMENT

1. SCOPE

1.1 Scope. - This specification covers the cleanliness levels, cleaning, protection, and inspection procedures for pneumatic system parts, field parts, assemblies, subsystems, and systems, used in support equipment.

1.2 Classification. - The cleaning procedures, cleanliness levels, and testing methods applicable to parts, field parts, assemblies, subsystems, and systems of support equipment, (as applicable see 6.2), are classified as specified herein.

1.2.1 Cleaning procedures.

Procedure 1 - Parts, assemblies, subsystems, and systems cleaned with a detergent-water solution and flushed by ethyl alcohol, (nonmetallic items except polytetrafluoroethylene).

Procedure 2 - Parts, assemblies, subsystems, and systems cleaned with trichloroethylene and a detergent-water solution and flushed by trichloroethylene, (metallic and polytetrafluoroethylene items).

Procedure 3 - Parts, assemblies, subsystems, and systems cleaned with a solution of trisodium phosphate and flushed by an 8.0 to 12.0 percent solution of nitric acid, (corrosion resistant steel tubing).

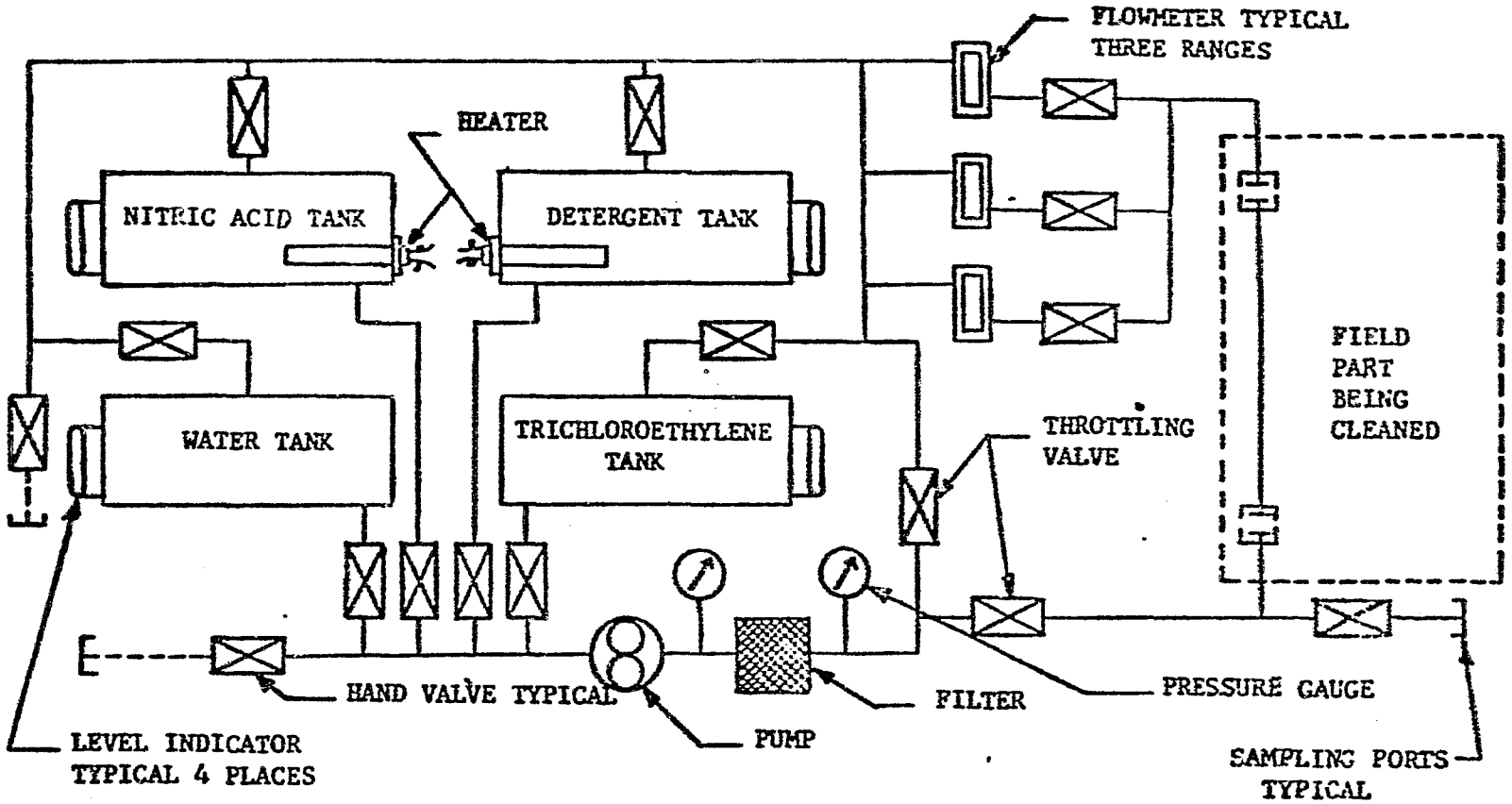
Procedure 4 - Parts, assemblies, subsystems, and systems cleaned with a solution of "Oakite" detergent and flushed by a 3.0 to 5.0 percent solution of nitric acid, (aluminum alloy tubing).

Procedure 5 - Parts, assemblies, subsystems, and systems cleaned in an ultrasonic cleaning tank by a recirculating detergent-water solution and flushed by trichloroethylene, (flexible hose, all metal hose).

Procedure 6 - Field parts shall be cleaned by a recirculating system utilizing Procedures 1 through 5, as applicable. (See figure 1, Typical Field Parts Cleaning System Diagram.)

1.2.2 Cleanliness levels.

Level I - Maximum particle size permitted, 100 microns (μ); maximum fiber length permitted, 100 μ when tested as specified in 4.4.3 or 4.4.4.



NOTES

1. PROVISIONS SHALL BE MADE TO PERMIT SAMPLING DOWNSTREAM AND UPSTREAM OF THE LINE BEING CLEANED AND DOWNSTREAM OF THE FILTER AND PUMP.

2. THE CLEANING EQUIPMENT SHALL BE SO ARRANGED THAT THERE WILL BE NO POCKET OF STAGNANT FLUID THAT DOES NOT DRAIN FOLLOWING EACH SEQUENCE OF THE CLEANING CYCLE.

Figure 1. Typical cleaning system diagram.

Level II - Maximum particle size permitted, 150 μ; maximum fiber length permitted, 300 μ when tested as specified in 4.4.3 or 4.4.4.

Level III - Maximum particle size permitted, 350 μ; maximum fiber length permitted, 700 μ when tested as specified in 4.4.3 or 4.4.4.

Level IV - Maximum particle size permitted, 500 μ; maximum fiber length permitted, 1000 μ when tested as specified in 4.4.3 or 4.4.4.

Level V - Maximum particle size permitted, 1000 μ; maximum fiber length permitted, 2000 μ when tested as specified in 4.4.3 or 4.4.4.

Level VI - Maximum particle size permitted, 2000 μ; maximum fiber length permitted, 4000 μ when tested as specified in 4.4.3 or 4.4.4.

1.2.3 Test Methods.

Method A - Solvent-flush test for particle population and nonvolatile residue, when applicable.

Method B - Gas flow test for particle population and condensable hydrocarbon content, when applicable.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids, form a part of this specification to the extent specified herein.

SPECIFICATIONS

Federal

~~O-A-86~~ O-H-765 Acid, Hydrochloric (Muriatic), Technical Grade.

~~O-A-88~~ O-N-350 Acid, Nitric, Technical Grade.

O-E-760 Ethyl Alcohol (Ethanol); Denatured Alcohol; and Proprietary Solvent.

O-H-795	Hydrofluoric Acid, Technical.
O-O-670	Orthophosphoric (Phosphoric) Acid, Technical.
O-S-642	Sodium Phosphate, Tribasic, Technical, Anhydrous, Dodecahydrate, and Nonohydrate.
BB-N-411	Nitrogen.
UU-T-81	Tags, Shipping and Stock.
PPP-T-60	Tape, Pressure Sensitive Adhesive, Water-Proof, for Packaging and Sealing.
L-P-378	Plastic Films, Polyethylene, Type II

Military

MIL-D-16791	Detergents, Nonionic.

Marshall Space Flight Center

MSFC-SPEC-217	Trichloroethylene, Technical

PUBLICATIONS

National Aeronautics and Space Administration

NPC 200-2	Quality Program Provisions for Space System Contractors.
NPC 200-3	Inspection System Provisions for Suppliers of Space Materials, Parts, Components, and Services.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity, or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 Production cleaning and preservation process approval. - The cleaning, handling, and preservation processes to be used shall be as specified herein; however, the contractor may use other materials and processes provided written approval of the process and the material to be used is obtained from the procuring activity prior to cleaning, handling, or protection. The utilization of the procedures specified herein will not guarantee acceptance of the end product. The contractor shall be required to submit to the procuring activity a statement in writing containing the following information:

(a) Processing materials to be used. This shall include, as applicable; trade names, specifications, chemical, and physical properties.

(b) Processing equipment and cleaning procedures to be used.

(c) Quality assurance provisions to be utilized. This shall include in-process control procedures to control built-in contamination or latent corrosion.

(d) Preservation and protection methods and materials to be used.

3.2 Materials - Processing and protecting materials used shall be as specified herein, or on the drawings, or shall be of a quality approved by the procuring activity (see 3.1).

3.2.1 Trichloroethylene.

3.2.1.1 Vapor degreasing solvent. - Type II, trichloroethylene, conforming to MSFC-SPEC-217, shall be used in vapor degreasing processes.

3.2.1.2 Cleaning, flushing, and testing solvent. - Type I trichloroethylene, conforming to MSFC-SPEC-217, shall be used as an immersion cleaning agent, flushing agent, or a testing solvent for surfaces of metallic and polytetrafluoroethylene parts, field parts, assemblies, subsystems, or systems, when applicable. Prior to its use, the solvent shall be filtered to the extent necessary to remove particles that are larger than the limits specified for the part, assembly, subsystem, or system being cleaned, flushed, or tested.

CAUTION

Trichloroethylene shall not be used in the solvent-flush test of items containing nonmetallic (except Teflon) materials. Permission to remove all nonmetallic (except Teflon) materials to permit testing with trichloroethylene may be granted at the discretion of the procuring activity.

3.2.2 Ethyl alcohol.

3.2.2.1 Testing and flushing agent - Ethyl alcohol, used as a flushing and testing agent on nonmetallic (except polytetrafluoroethylene) parts, field parts, assemblies, subsystems, or systems, when applicable, shall conform to grade I, class B; grade II, class B; or grade III ethyl alcohol of Specification O-E-760. Prior to use, the ethyl alcohol shall be filtered to the extent necessary to remove particles larger than the limits specified for the part, assembly, subsystem, or system being flushed or tested.

3.2.3 Drying or preservation gas. - Gases used in drying or preservation processes shall be prefiltered to the extent that the contamination level shall meet the particulate limit and condensable hydrocarbon content specified for the item being dried or preserved.

3.2.3.1 Nitrogen gas. - Nitrogen gas used in the drying or preservation processes shall conform to type I, class 1, grade B of Specification BB-N-411, except requirements of 3.2.3 shall be met.

3.2.3.2 Compressed air. - Compressed air used in the drying or preservation processes shall conform to the requirements of 3.2.3.

3.2.4 Test or purge gas. - The nitrogen gas used to perform the tests or purge specified herein shall conform to type I, class 1, grade A of Specification BB-N-411, except the contamination level shall meet the particulate limit and the condensable hydrocarbon content specified for the item being tested.

3.2.5 Filtration medium.

3.2.5.1 Filter paper. - The filter paper used for particle removal shall be sensitive to the requirements specified herein.

3.2.5.2 Filter membrane. - The filter membrane used for particle removal in the gas analysis shall be a Millipore filter or an approved equal, capable of particle removal as required by the cleanliness level applicable to the item being tested.

3.2.6 Trisodium phosphate. - Trisodium phosphate, if used in the cleaning process, shall conform to Specification O-S-642.

3.2.7 Nitric acid - Nitric acid, if used in the cleaning process, shall conform to Specification O-A-88.

CAUTION

Stainless steel joints that have been silver-brazed, or components that have been silver plated, shall not be flushed with nitric acid solution. Ethyl alcohol shall be substituted for this requirement.

3.2.8 Phosphoric acid. - Phosphoric acid, if used in the cleaning process, shall conform to Specification O-O-670.

3.2.9 Hydrochloric acid. - Hydrochloric acid, if used in the cleaning process, shall conform to Specification O-A-86.

3.2.10 Hydrofluoric acid. - Hydrofluoric acid, if used in the cleaning process, shall conform to Specification O-H-795.

3.2.11 Detergent cleaning agent. - Detergent cleaning agent, if used in the cleaning process, shall be Dowell F-33 (see 6.5), or an approved equal, conforming to Specification MIL-D-16791. Oakite 33, 34, or approved equal, shall be used for cleaning aluminum.

3.2.12 Demineralized water. - Demineralized water, if specified for flushing or testing operations, shall be prefiltered to remove all particles larger than the limits specified for the parts, field parts, assemblies, subsystems, or systems being flushed or tested. The minimum specific resistance of the water shall be maintained at 50,000 ohms, and shall be checked and certified daily.

3.2.13 Protective covers.

3.2.13.1 Nylon C. - Nylon C (Ref 6.6), used to protect cleaned surfaces, shall be cleaned to remove all particles that are larger than the limits specified for the part, assembly, subsystem, or system being protected.

3.2.13.2 Aclar 33C. - Aclar 33C (Ref. 6.7), used to protect cleaned surfaces, shall be cleaned to remove all particles that are larger than the limits specified for the part, assembly, subsystem, or system being protected.

3.2.13.3 Saran wrap - Saran wrap (Ref. 6.4), used to protect cleaned surfaces, shall be cleaned to remove all particles that are larger than the limits specified for the part, assembly, subsystem, or system being protected.

3.2.14 Tape. - Tape used to secure and reinforce protective covers shall conform to Specification PPP-T-60.

3.2.15 pH indicating paper. - pH indicating paper used to test surfaces of parts, field parts, assemblies, subsystems, and systems shall be sensitive to the requirements specified herein.

3.2.16 Test equipment. - The following equipment shall be provided for the sampling and examination of drying, preservation, and test gases:

(a) Filter holder.

(b) Gas flowmeter.

(c) Microscope.

(d) Measuring eyepiece.

(e) Stage micrometer.

(f) Microscope lamp.

(g) Forceps (unserrated tips).

3.2.17 Analysis material and equipment. - The material and equipment specified herein shall be provided for the sampling and testing of drying, preservation, and test gases for condensable hydrocarbons.

3.2.17.1 Acetone. - Acetone, spectro-grade, shall be used as a flushing agent in the cleaning of gas washing bottles and beakers.

3.2.17.2 Carbon tetrachloride. - Carbon tetrachloride, spectro-grade, (redistilled), shall be used as a flushing and cleaning agent in the gas washing procedure.

3.2.17.3 Carbon tetrachloride distillation equipment. - The following test equipment for carbon tetrachloride distillation equipment shall be provided:

(a) One 2 to 5 liter boiling flask.

(b) One 30 centimeter (cm) fractionating column (filled with Raschig rings).

(c) One condenser, Leibig or Allihn (jacket length 400 millimeter (mm), with standard taper joints 24/40).

3.2.17.4 Analytical equipment. - The following analytical equipment shall be provided:

(a) One calibrated wet test meter.

(b) Three gas washing bottles, 300 ml capacity with coarse or medium fritts.

(c) One 800 ml beaker.

(d) One wash bottle, polyethylene (unplasticized).

(e) New rubber tubing, white gum.

(f) One 5 ml volumetric flask.

(g) One infrared spectrophotometer.

(h) One 3 mm sodium chloride sealed cell.

(i) One 5 ml hypodermic syringe, Luer-Lok.

3.2.18 Field parts cleaning equipment. - The following equipment shall be provided for cleaning of field parts (see figure 1):

(a) Containers having sufficient capacity to fill the system being cleaned, prevent pump cavitation, and cover the heater units.

(b) Heating equipment having sufficient capacity to control and maintain the temperatures required at the specified flow rates.

(c) Filters shall be installed and be capable of maintaining the cleanliness levels specified in tables I and II.

(d) Circulating pump capable of sustaining the flow rates specified against the pressure losses of the system in compliance with table III.

(e) Flowmeters, if used, having sufficient capacity to measure the flows specified in table III.

(f) Pressure gauges capable of being interpreted in the middle two-thirds of the gauge scale and accurate to one-half percent of full scale.

(g) Hand valves and other components of sufficient size and capacity to minimize pressure drop and obtain flow rates in compliance with table III.

3.3 Cleanliness requirements.

3.3.1 Particulate limitations. - All items of support equipment pneumatic systems that are cleaned, as specified in 3.4.4.1, 3.4.4.2, 3.4.4.3, 3.4.4.4, 3.4.4.5, or 3.4.4.6, shall comply with the limits specified herein. Particles of contamination and fiber content on each square foot of surface area (see 6.3.1 and see 4.3.2.1 when applicable) shall not exceed the limits specified in tables I and II as applicable.

Suggested application:

Level I	-	For critical systems, for example; gas bearing and slosh measuring systems.
Level II	-	For parts, field parts, and assemblies for critical vehicle applied systems (pneumatic).
Level III	-	For liquid oxygen and fuel systems, parts, field parts, assemblies, and subsystems.
Level IV	-	For parts, field parts, and assemblies (flow through), and for vehicle applied systems (pneumatic).
Level V	-	For parts, field parts, and assemblies (dead end services), for example; gauges, pressure switches, and relief valves.
Level VI	-	For facility type systems, not affiliated or oriented with the vehicle, and for vent systems downstream of relief valves and check valves toward atmosphere.

3.3.2 Nonvolatile residue content. - When testing surface areas (see 6.3.1 and 4.3.2.1 when applicable) of less than one square foot, as specified herein (see 4.4.3), the difference between the used and the unused testing solvent shall indicate an increase for each 100 ml in the nonvolatile residue content of the used solvent over that of the unused solvent (see table I). When testing surface areas greater than one foot, the increase shall be not greater than the limits specified in table I.

3.3.3 Condensable hydrocarbon content. - When tested, as specified herein (see 4.4.4), the amount of condensable hydrocarbons (parts per million (ppm)) in the test gas that has been used in testing shall be determined as specified in 4.4.4.5.2. The condensable hydrocarbon content shall not exceed the limits specified for the applicable cleanliness level in table I.

3.4 Cleaning procedures.

3.4.1 Critical surfaces. - All surfaces of items that may contact the gas supply medium shall be considered as critical surfaces, and shall be subject to the cleaning procedures and cleanliness requirements for critical surfaces specified herein.

3.4.2 Visible contamination. - All surfaces of parts, field parts, assemblies, subsystems, and systems shall be visually free of corrosion, scale, dirt, grease, oil, and other foreign contamination.

3.4.3 Preparation for cleaning.

3.4.3.1 Disassembly.- When necessary, assemblies, subsystems, or field parts, shall be disassembled as required in preparation for the cleaning of individual parts.

3.4.3.2 Precleaning. - Dust, grit, scale, corrosion, grease, oil, and other major soils shall be removed, and a pressure test shall be performed when applicable.

3.4.3.3 Precleaning treatment of corrosion-resistant steel. - Corrosion-resistant steel items shall be treated (pickling and passivating processes) to prevent latent corrosion or contamination. Assemblies that do not lend themselves to this type treatment as an assembly shall be treated as subassemblies or parts prior to assembly.

Table I. Cleanliness Requirements

Maximum particle population	Cleanliness Levels					
	I	II	III	IV	V	VI
	Particle size					
No limit	0-20 μ	0-20 μ	0-35 μ	0-50 μ	0-100 μ	0-175 μ
40	21-40 μ	21-45 μ	36-60 μ	51-140 μ	101-280 μ	176-540 μ
10		46-70 μ	61-95 μ	141-230 μ	281-460 μ	541-950 μ
3	41-80 μ	71-95 μ	96-135 μ	231-320 μ	461-640 μ	951-1270 μ
2		96-125 μ	136-170 μ	321-410 μ	641-820 μ	1271-1635 μ
1	81-100 μ	126-150 μ	171-350 μ	411-500 μ	821-1000 μ	1636-2000 μ
0	101 μ +	151 μ +	351 μ +	501 μ +	1001 μ +	2001 μ +
Condensable hydrocarbon ppm/weight	0.2	1.0	2.0	3.0	3.0	5.0
Nonvolatile residue in grams						
Surface Area one square foot and over	0.001 per sq. ft.	0.001 per sq. ft.	0.001 per sq. ft.	0.002 per sq. ft.	0.002 per sq. ft.	0.003 per sq. ft.

Table II. Fiber* length and population limits

Maximum Population	Fiber length limits by cleanliness level					
	I	II	III	IV	V	VI
No limit	0-20 μ	0-20 μ	0-35 μ	0-50 μ	0-100 μ	0-175 μ
10	21-40 μ	21-150 μ	36-350 μ	51-500 μ	101-1000 μ	176-2000 μ
1	41-100 μ	151-300 μ	351-700 μ	501-1000 μ	1001-2000 μ	2001-4000 μ
0	101 μ +	301 μ +	701 μ +	1001 μ +	2001 μ +	4001 μ +

* Fiber is defined as a particle having a length to width ratio of 10 to 1 or greater.

3.4.4 Cleaning processes. - Unless otherwise approved by the procuring activity, the cleaning processes described herein shall apply to the cleaning of all surfaces that may be defined as critical surfaces (see 3.4.1). Material or combinations of materials, and alternate methods not within the scope of this specification shall be used only after written approval of the cognizant activity of the National Aeronautics and Space Administration (NASA).

3.4.4.1 Cleaning procedure 1.

3.4.4.1.1 Nonmetallic items (except polytetrafluoroethylene)

(a) Brush the surfaces of the item thoroughly with a nylon bristle brush and 0.5 percent solution of detergent and water. Brush for a period of 10 to 15 minutes, and maintain the detergent-water solution at a temperature of 122 (plus or minus 9) degrees F.

(b) Flush surfaces thoroughly with demineralized water for a period of 5 to 10 minutes (see tables III, IV, and V for flushing data).

(c) Flush surfaces with ethyl alcohol for a period of 15 to 30 minutes (see tables III, IV, and V for flushing data).

(d) Test cleaned and flushed surfaces for acidity and alkalinity with pH indicating paper while the surfaces are wet. If surfaces are dry, wet with a few drops of distilled water and perform test. Test results shall be within a range of 6.0 to 8.0 pH. If conformance is not obtained repeat steps (a), (b), and (c), as necessary, and retest.

(e) Gas dry the cleaned and tested item for 30 minutes.

3.4.4.2 Cleaning procedure 2.

3.4.4.2.1 Metallic and polytetrafluoroethylene items.

(a) Clean surfaces by vapor degreasing.

(b) Brush surfaces thoroughly with a nylon bristle brush and a 0.5 percent solution of detergent and water. Brush for a period of 10 to 15 minutes, and maintain the detergent-water solution at a temperature of 122 (plus or minus 9) degrees F.

(c) Flush surfaces thoroughly with demineralized water for a period of 5 to 10 minutes (see tables III, IV, and V for flushing data).

(d) Dry tubing thoroughly with gas. A vacuum drying process is an acceptable substitute.

(e) Flush surfaces with trichloroethylene for a period of 15 to 30 minutes (see tables III, IV, and V for flushing data).

(f) Test cleaned and flushed surfaces for acidity and alkalinity with pH indicating paper while the surfaces are wet. If surfaces are dry, wet with a few drops of distilled water and perform test. Test results shall be within a range of 6.0 to 8.0 pH. If conformance is not obtained, repeat steps (a), (b), (c), (d), and (e), as necessary, and retest.

(g) Dry the cleaned and tested items in a vacuum oven normalized at 20 inches of mercury at a temperature of 250 degrees F for a minimum of one hour.

(h) Remove items from the oven, and completely dry with gas.

Table III. Information on flow rates for flushing and circulation operations

Tube size (inches)	Tube I. D. (inches)	Velocity (ft/sec)	Flow (gpm)	Pressure drop/100 ft. (psi)
1/4	0.180	4	0.317	27.3
5/16	0.2425	4	0.58	18.1
3/8	0.305	4	1.0	14.0
1/2	0.430	4	2.0	8.8
5/8	0.555	4	3.4	6.4
3/4	0.652	4	4.0	5.4
7/8	0.777	4	6.4	4.3
1	0.902	4	8.8	3.6
1 1/4	1.152	4	14.0	2.57
1 1/2	1.370	4	20.0	2.07
1 3/4	1.620	4	30.0	1.715
2	1.870	4	35.0	1.385
3	2.870	4	84.0	0.86
4	3.810	4	156.0	0.61
5	4.813	4	200.0	0.46
6	5.761	4	300.0	0.36

NOTE: It is recommended that tubing and pipe larger than 2 inches be cleaned prior to assembly and installed as a clean part.

Table IV. Informational tubing data

Tube size (inches)	Tube I.D. (inches)	Volume/100 ft. (gal.)	Volume/100 ft. ($in.^3$)	Volume/100 ft. ($ft.^3$)	Wt. of trichloroethylene in 100 ft. column (lbs.)	Static pressure 168 ft. column (psi)
1/4	.180	.180	30.4	.0176	1.62	107.5
5/16	.2425	.24	55.2	.0319	2.93	107.5
3/8	.305	.38	87.0	.0505	4.65	107.5
1/2	.430	.76	174.0	.101	9.3	107.5
5/8	555	1.27	292.0	.169	15.5	107.5
3/4	.652	1.75	402.0	.233	21.4	107.5
7/8	.777	2.47	568.0	.329	30.2	107.5
1	.902	3.35	768.0	.445	40.8	107.5
1 1/4	1.152	5.45	1250.0	.725	66.5	107.5
1 1/2	1.370	7.8	1775.0	1.03	95.0	107.5
1 3/4	1.620	10.8	2470.0	1.43	131.0	107.5
2	1.870	14.4	3300.0	1.91	176.0	107.5
3	2.870	33.9	7770.0	4.5	414.0	107.5
4	3.810	60.0	13700.0	7.95	730.0	107.5
5	4.813	95.0	21800.0	12.6	1160.0	107.5
6	5.761	136.0	31500.0	18.1	1665.0	107.5

Table V. Rigid tubing inside surface area chart (sq. ft.)

O.D.	Wall thk.	Surface area for lengths specified					
		1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.
.125	.020	.0222	.0445	.0667	.0890	.1112	.1335
.250	.020	.0549	.1099	.1649	.2199	.2748	.3298
.250	.035	.0471	.0942	.1413	.1884	.2355	.2826
.250	.049	.0398	.0796	.1194	.1592	.1989	.2388
.375	.028	.0835	.1670	.2505	.3341	.4176	.5011
.375	.035	.0798	.1597	.2395	.3194	.3992	.4791
.375	.049	.0725	.1450	.2175	.2900	.3626	.4351
.500	.035	.1126	.2251	.3377	.4503	.5629	.6754
.500	.065	.0968	.1937	.2906	.3874	.4843	.5812
.750	.049	.1707	.3414	.5121	.6828	.8535	1.0241
.750	.095	.1466	.2932	.4398	.5864	.7330	.8796
1.000	.035	2435	.4870	.7304	.9739	1.2174	1.4608
1.000	.049	.2361	.4723	.7084	.9446	1.1807	1.4168
1.000	.065	.2277	.4555	.6833	.9111	1.1388	1.3666
1.000	.095	.2116	.4232	.6348	.8464	1.0580	1.2696
1.250	.035	.3089	.6178	.9268	1.2357	1.5446	1.8535
1.250	.049	.3016	.6032	.9048	1.2064	1.5080	1.8096
1.250	.065	.2932	.5864	.8796	1.1728	1.4660	1.7562

Continued on page 17

Table V. Rigid tubing inside surface area chart (sq. ft.) (cont'd)

O.D.	Wall thk.	Surface area for lengths specified						
		7 ft.	8 ft.	9 ft.	10 ft.	20 ft.	30 ft.	100 ft.
.125	.020	.1557	.1780	.2002	.2225	.4450	.6675	2.225
.250	.020	.3848	.4398	.4947	.5497	1.0995	1.6492	5.497
.250	.035	.3298	.3769	.4240	.4711	.9422	1.4135	4.711
.250	.049	.2786	.3183	.3581	.3979	.7959	1.1938	3.979
.375	.028	.5846	.6681	.7516	.8351	1.6703	2.5054	8.351
.375	.035	.5589	.6388	.7186	.7985	1.597	2.3955	7.985
.375	.049	.5076	.5801	.6526	.7251	1.4503	2.1755	7.251
.500	.035	.7880	.9006	1.0132	1.1257	2.2515	3.3772	11.257
.500	.065	.6780	.7749	.8717	.9685	1.9371	2.9057	9.685
.750	.049	1.1948	1.3655	1.5362	1.7069	3.4138	5.1207	17.069
.750	.095	1.0267	1.1728	1.3194	1.4660	2.9321	4.3982	14.660
1.000	.035	1.7043	1.9478	2.1913	2.4347	4.8695	7.2992	24.347
1.000	.049	1.6529	1.8891	2.1252	2.3614	4.7228	7.0842	23.614
1.000	.065	1.5944	1.8221	2.0499	2.2777	4.5553	6.8330	22.777
1.000	.095	1.4812	1.6928	1.9044	2.1160	4.2320	6.3480	21.160
1.250	.035	2.1625	2.4714	2.7803	3.0892	6.1785	9.2677	30.892
1.250	.049	2.1112	2.4127	2.7143	3.0159	6.0319	9.0478	30.159
1.250	.065	2.0525	2.3457	2.6389	2.9321	5.8643	8.7964	29.321

3.4.4.3 Cleaning procedure 3.

3.4.4.3.1 Corrosion-resistant steel tubing or pipe.

(a) Circulate a solution of 10 (plus or minus 2.0) percent, by weight, trisodium phosphate through the tubing or pipe for a minimum of 10 minutes (see tables III, IV, and V for circulation data). Maintain the solution at a temperature within the range of 170 through 190 degrees F.

(b) Flush the tubing or pipe thoroughly ~~with prefiltered~~ tap water for a minimum of 10 minutes (see tables III, IV, and V for flushing data). The tap water used for flushing shall be at room temperature.

(c) Circulate a solution of 10 (plus or minus 2.0) percent, by weight, nitric acid through the tubing or pipe for a minimum of 5 minutes to a maximum of 10 minutes (see tables III, IV, and V for circulation data). Maintain the solution at a temperature within the range of 170 through 190 degrees F.

(d) Flush tubing or pipe thoroughly with demineralized water in the manner described in step (b) above.

(e) Dry tubing thoroughly with gas. A vacuum drying process is an acceptable substitute.

(f) Flush tubing or pipe thoroughly with trichloroethylene for a minimum of 15 minutes (see tables III, IV, and V for flushing data).

(g) Test cleaned and flushed surfaces for acidity and alkalinity with pH indicating paper while the surfaces are wet. If surfaces are dry, wet with a few drops of distilled water and perform test. Test results shall be within a range of 6.0 to 8.0 pH. If conformance is not obtained, repeat steps (a) through (f) ~~as necessary~~ and retest.

(h) Dry tubing or pipe thoroughly with gas. A vacuum drying process is an acceptable substitute drying method.

3.4.4.4 Cleaning procedure 4.

3.4.4.4.1 Aluminum alloy tubing or pipe.

(a) Circulate a solution of 20 ± 2.0 percent by volume of Oakite No. 33, or an approved equal, through the tubing or pipe for a minimum of 5 minutes (see tables III, IV, and V for circulation data). Maintain the solution at a temperature within the range of 130 to 140 degrees F.

(b) Flush surfaces thoroughly with prefiltered tap water for a minimum of 10 minutes (see tables III, IV, and V for flushing data). The tap water used for flushing shall be at 70 to 90 degrees F.

(c) Circulate a solution of 12 ounces per gallon of Oakite 34, or an approved equal, through the tubing or pipe for a minimum of 10 minutes (see tables III, IV, and V for circulation data). Maintain the solution at a temperature within the range of 70 to 90 degrees F.

(d) Flush the tubing or pipe thoroughly with demineralized water for a minimum period of 10 minutes (see tables III, IV, and V for flushing data). The demineralized water shall be at room temperature when used.

(e) Dry tubing or pipe thoroughly with gas. A vacuum drying process is an acceptable substitute.

(f) Flush tubing or pipe thoroughly with trichloroethylene for a minimum of 15 minutes (see tables III, IV, and V for flushing data).

(g) Test cleaned and flushed surfaces for acidity and alkalinity with pH indicating paper while the surfaces are wet. If surfaces are dry, wet with a few drops of distilled water and perform test. Test results shall be within a range of 6.0 to 8.0 pH. If conformance is not obtained repeat steps (a) through (f) as necessary and repeat test.

(h) Dry tubing or pipe thoroughly with gas. A vacuum drying process is an acceptable substitute method.

3.4.4.5 Cleaning procedure 5.

3.4.4.5.1 Flexible hose (all metal).

(a) Clean hose in an ultrasonic cleaning tank equipped with a recirculating system utilizing a 10 μ filter. The cleaning agent shall be detergent and demineralized water.

(b) Flush with demineralized water for a minimum of 10 minutes (see tables III, IV, and V for flushing data).

(c) Vacuum dry or dry with gas.

(d) Flush the hose with trichloroethylene for a minimum of 15 minutes (see tables III, IV, and V for flushing data).

(e) Test cleaned and flushed surfaces for acidity and alkalinity with pH indicating paper while the surfaces are wet. If surfaces are dry, wet with a few drops of distilled water and perform test. Test results shall be within a range of 6.0 to 8.0 pH. If conformance is not obtained repeat steps (a) through (d) as necessary and repeat test.

(f) Purge the hose with gas.

(g) Vacuum dry internal and external surfaces.

3.4.4.6 Cleaning procedure 6.

3.4.4.6.1 Field parts only.- Clean field parts by a recirculating system utilizing cleaning procedures 1 through 5, as applicable, except as noted in 3.4.4.6.2.

3.4.4.6.2 Special requirements. - The field setup shall be in accordance with figure 1.

(a) Lines, pipe, or tubing having a 2 percent or greater rise require flushing with a downward stream.

(b) The flow shall be controlled or balanced by the use of control valves, metering valves, capillaries, or other suitable means.

3.5 Protection. - Unless otherwise specified by the procuring activity, the procedure for the protection of cleaned parts, field parts, assemblies, subsystems, and systems shall be as specified herein.

3.5.1 Tubes, hoses, pipes, control assemblies, and miscellaneous items.

3.5.1.1 Pneumatic components not requiring LOX compatibility.

3.5.1.1.1 Small components.

(a) All critical surfaces or openings to these surfaces, shall be protected by covering the surfaces or openings with two layers of Saran Wrap, or 1 Mil Nylon C (see 6.4 and 6.6) or approved equal. Protective caps of materials compatible to the system requirements may be used when available.

(b) Place one layer of 5 Mil Nylon C, for abrasion protection, over the Saran Wrap or Nylon C (see 6.6).

(c) Secure and reinforce the plastic with tape.

(d) Place the cleaned and protected item in a clean Nylon C bag, purge the interior with clean nitrogen and seal the open end of the bag. Use thermal impulse sealing equipment.

(e) Insert the sealed component and identification tag in a polyethylene or Nylon C bag and seal.

3.5.1.1.2 Large components, tubes, hoses, pipes and miscellaneous installed nonpackageable items.

(a) All critical surfaces, or openings to these surfaces, shall be protected by suitable caps; material of caps shall be compatible with the system requirements, or one layer of 5 Mil Nylon C or approved equal. (see 6.6). Reinforce plastic with tape.

(b) Place one layer of 7.5 Mil Nylon C, for abrasion protection, over the 5 Mil Nylon C.

(c) Secure and reinforce the plastic with tape and tag per paragraph 3.6.

3.5.1.2.1 Pneumatic systems requiring LOX compatibility.

CAUTION

ACLAR FILMS PRODUCE A HIGHLY REACTIVE AND TOXIC GAS WHEN ALLOWED TO DECOMPOSE BY EXCESSIVE HEAT (ABOVE 390°F). DO NOT ALLOW TO CONTACT FLAME DIRECTLY.

CAUTION

DO NOT USE ANY CHLORONATED SOLVENTS WITH ACLAR. USE REAGENT GRADE ACETONE AND/OR BUTYL ALCOHOL ON ACLAR 33C FOR CLEANING PURPOSES.

3.5.1.2.2 Small components.

(a) All critical surfaces, or openings to these surfaces, shall be protected by Teflon caps or two layers of 1 Mil Aclar 33C (see 6.7) and reinforced with tape.

(b) Place one layer of 5 Mil or 7.5 Mil Aclar 33C over the 1 Mil Aclar and reinforce with tape.

(c) Place the clean and protected item in a clean Aclar 33C bag, purge the interior with clean nitrogen and seal the open end of the bag. Use thermal impulse sealing equipment.

(d) Insert the sealed component and identification tag in an Aclar 33C bag and seal.

3.5.1.2.3 Large components, tubes, hoses, pipes and miscellaneous installed nonpackageable items.

(a) All critical surfaces, or openings to these surfaces, shall be protected by Teflon caps or one layer of 5 Mil Aclar 33C or approved equal. Reinforce with tape.

(b) Place one layer of 5 Mil or 7.5 Mil Aclar 33 C over the first layer of 5 Mil Aclar 33C.

(c) Secure and reinforce with tape.

3.5.2 Containers (cleaned).

(a) Cover openings with approved covers that have been cleaned to the extent that the cover cleanliness is compatible with cleanliness of the container.

(b) Secure covers in a manner that will prevent detachment from, or damage to, the container under normal handling and storage conditions.

(c) The covers used shall permit venting, but shall not permit recontamination of the opening or the container.

3.5.3 Field parts, tubing and pipe (cleaned). - All openings of field parts, tubing, and pipe shall be closed with caps or covers compatible with the requirements for cleanliness of the field part. Where practical, pressurize the field part, pipe, or tubing with nitrogen to a pressure of 20 $\pm$ 15 psi and cap.

3.6 Marking. - Unless otherwise approved by the procuring activity, cleaned parts, field parts, assemblies, subsystems, and systems shall be marked with tags conforming to type C, Specification UU-T-81, and shall be placed between the inner and outer wrappers where practical, and shall contain the following information:

(a) Part number or identification number.

(b) Contractor identification.

(c) Method of cleaning and μ level.

(d) The wording, "SPECIAL CLEANING," in bold type across the face of the tag.

(e) Date of cleaning.

(f) Title, number, and date of this specification.

(g) Service medium or intended use of the item.

(h) Manufacturer's serial number.

4. QUALITY ASSURANCE PROVISIONS.

4.1 The supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own, or any other inspection facilities and services acceptable to NASA. Inspection records of the examination and tests shall be kept complete and available to NASA as specified in the contract of order. NASA reserves the right to perform any of the inspection set forth in this specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2 Quality control system - The quality control system shall be in accordance with NASA Quality Publications NPC 200-2 or NPC 200-3 as specified in the contract or order (see 6.2).

4.3 Sampling.

4.3.1 Visual inspection sample. - The sample for the inspections of 4.4.1 and 4 4.2, as applicable, shall consist of 100 percent of the items cleaned.

4 3.2 Quality control sample - Unless otherwise specified by the procuring activity, the quality control sample shall consist of a minimum of 5 percent of the items cleaned, but not less than one sample for each group of 20 or less of the items cleaned. The quality control sample shall be selected at random from the items that have been examined in accordance with 4.4.1 and 4.4.2, and found acceptable. The sample shall be selected in a manner that will provide maximum representation of the affected lot.

4.3.2.1 Small components. - The quality control sample representing items that have a critical surface area of less than 1.0 square foot shall consist of a sufficient number of items to make up 1.0 square foot (minimum) of critical surface area. When the total quantity of items procured have a combined critical surface area less than 1.0 square foot, a quantity (sufficient to make up 1.0 square foot of critical surface area) of clean stock items shall be used to make up the quality control sample. When clean stock items are not available, the small items shall be tested as specified in 4.4.3.2.1.

4.3.3 Acceptance samples. - Unless otherwise specified by the procuring activity, the acceptance sample shall consist of all of the samples selected for the examinations and tests specified in 4.3.1 and 4.3.2.

4.4 Acceptance inspection. - Unless otherwise specified by the procuring activity, acceptance inspection shall be performed as specified herein.

4.4.1 Examinations. - Surfaces of all cleaned items that will contact the service medium shall be visually inspected for the presence of moisture and foreign matter such as corrosion, scale, dirt, oil, grease, and similar foreign matters. A flashlight or borescope may be required to examine internal surfaces. Items, such as small diameter tubing (1/2-inch diameter or less), having limited accessibility for visual examinations shall be accepted or rejected on the basis of the quality control inspection. The presence of visible contamination shall be cause for rejection and shall necessitate recleaning of the item. Scale-free discoloration due to welding and passivation is permitted. All items shall also be examined to determine conformance to 3.6.

4.4.2 Acidity and alkalinity test. - All surfaces that have been cleaned and flushed shall be tested for acidity and alkalinity with pH indicating paper while surfaces are wet from the final rinse. When surfaces are dry a few drops of distilled water will satisfactorily wet the surfaces to permit testing. When tested, the pH shall be within a range from 6.0 to 8.0 pH.

4.4.3 Quality control test (method A). - Cleaned parts, field parts, assemblies, subsystems, or systems selected for solvent-flush quality control tests shall be subjected to all examinations and tests specified herein. The visual examinations of 4.4.1 and 4.4.2, as applicable, shall precede the quality control tests.

4.4.3.1 Solvent control check. - Within 24 hours prior to performance of the critical surface cleanliness test, the following check for particulate limitations and nonvolatile residue, as applicable, shall be performed on a sample of the solvent.

(a) Collect a control sample of a minimum of 500 ml.

(b) Filter solvent to remove particles greater than the particulate limit specified for the item to be tested.

(c) Evaporate the solvent to 10 to 20 ml volume in a steam bath.

(d) Transfer the solvent to a constant weight (within 0.3 mg) tared, 30 ml, weighing bottle, weighed to the nearest 0.1 mg.

(e) Continue the evaporation by placing the weighing bottle inside a constant temperature oven that has normalized at a temperature within the range of 221 through 230 degrees F. Allow weighing bottle to remain inside the oven for a maximum of 1.5 hours or until the solvent is evaporated to dryness.

(f) Remove weighing bottle from the oven, and place in a desiccator for cooling.

(g) After cooling, remove the weighing bottle from the desiccator, and weigh the bottle to the nearest 0.1 mg. Record the weight.

4.4 3.2 Preparation of test solution. - Preparation of test solution (see 3.2.1.2) for use in testing quality control samples shall be as specified herein.

4.4.3.2.1 Items with surface area of 1.0 square foot or less. - A test solution of 500 ml (minimum) shall be used to determine particle population (and size as specified in tables I and II), and the nonvolatile residue on the critical surfaces of the quality control samples. The sample shall be selected from items having critical surface areas of less than one square foot and combined with other clean stock items and/or clean tubing sufficient to make up one square foot of critical surface area.

4.4.3.2.2 Items over 1.0 through 5.0 square feet in surface area. - A test solution of 500 ml (nominal) shall be used to determine particle population and size as specified in tables I and II, and the nonvolatile residue on the critical surfaces of the quality control samples. The samples shall be selected from items having critical surface areas over 1.0 through 5.0 square feet.

4.4.3.2. Items with surface area greater than 5.0 square feet. - A maximum of 100 ml of test solution for each square foot of surface area shall be used to determine conformance to particle population and size and nonvolatile residue content requirements, specified in tables I and II, for critical surfaces of quality control samples selected from items having critical surface areas greater than 5.0 square feet. If more than 500 ml of test solution is used, the total solution used shall be thoroughly agitated and a 500 ml sample shall be taken for the analyses of 4.4.3.6.1 and 4.4.3.6.2.

4.4.3.3 Test procedure. - Unless otherwise approved by the procuring activity, the testing procedure specified herein shall be used in the solvent-flush method of testing. Alternate methods or materials, not within the scope of this specification, shall be used only after written approval from the cognizant activity of NASA is obtained. Conduct the test as follows:

(a) Flush all surfaces uniformly with test solution.

(b) Trap all test solution after assuring that all surfaces have been flushed.

(c) Repeat flushing process a minimum of three times.

(d) Dry tested items in accordance with procedures of 4.4.3.4.

4.4.3.3.1 Acidity and alkalinity test. - All surfaces that have been tested by the solvent-flush method, shall be tested for acidity and alkalinity with pH indicating paper while the surfaces are wet from testing. When the surfaces are dry a few drops of distilled water will satisfactorily wet the surfaces to permit testing. When tested, the pH shall indicate within a range from 6.0 to 8.0 pH.

4.4.3.4 Drying procedures. - Immediately following cleanliness tests the items shall be dried as specified herein.

4.4.3.4.1 Metallic and polytetrafluoroethylene items.

(a) Dry in a vacuum oven set at 20 inches of mercury and at a temperature of 250 degrees F for a minimum of one hour.

(b) Remove the parts from the oven and completely dry with gas.

4.4.3.4.7 Nonmetallic items (except polytetrafluoroethylene). - Gas dry for 30 minutes.

4.4.3.5 Drying procedure reliability test. - The reliability of the drying procedure, for all items subjected to contact with liquids during testing, shall be determined by testing the samples of 4.3.2 before and after performance of the test of 4.4.3.3. Unless otherwise specified by the procuring activity, surface moisture shall be determined by passing prefiltered drying gas through, or over, the affected surfaces of the item and monitoring the dew point of the gas entering and leaving the test item.

4.4.3.6 Analyses of test solution.

4.4.3.6.1 Particle size analysis. - Each sample of test solution from 4.4.3.2, used in testing quality control samples, shall be filtered to the extent necessary to determine conformance to particle size and population requirements specified in 3.3.1. The examination of the residue shall be accomplished with 10 to 45 power stereomicroscope. The larger particles (175 μ and greater, in any dimension) shall be measured with a filar micrometer and contamination for each square foot of surface area shall be calculated to determine the reliability of the visual examination of 4.4.1 and conformance to the applicable cleanliness level. Alternate methods of determining acceptability may be used by the contractor with prior approval of the procuring activity.

4.4.3.6.2 Nonvolatile residue analysis. - The filtered sample, 500 ml nominal volume from 4.4.3.6.1 shall be analyzed for nonvolatile residue content to determine the reliability of the examination of 4.4.1 and conformance to the applicable cleanliness level as follows:

(a) Transfer 500 ml of the solvent into a clean, degreased, 800 ml beaker.

(b) Evaporate the solvent to 10 to 20 ml volume on a steam bath.

(c) Transfer the solvent to a constant-weight (within 0.3 mg), tared, 30 ml, weighing bottle; weighed to the nearest 0.1 mg.

(d) Continue evaporation by placing the weighing bottle inside a constant temperature oven which has normalized at 221 to 230 degrees F. Allow weighing bottle to remain inside the oven for a maximum of 1.5 hours, or until the solvent is evaporated to dryness.

(e) Remove weighing bottle from the oven, and place in a desiccator for cooling.

(f) After cooling, remove the weighing bottle from the desiccator and weigh the bottle to the nearest 0.1 mg. Record the weight.

(g) After cooling, remove the weighing bottle from the desiccator and weigh the bottle to the nearest 0.1 mg. Reject the sample only if the difference between the control sample of (4.4.3.1) and the analysis sample exceeds the following:

(1) 1.0 0.1 mg for levels I through III.

(2) 2.0 0.2 mg for levels IV through V.

(3) 3.0 0.3 mg for level VI.

4.4.3.6.3 Alternate nonvolatile residue analysis. - For an alternate procedure to determine nonvolatile residue analysis refer to drawing 75M13965 "Flash Evaporation Method of Determining Non-Volatile Residue Content in Freon and Trichloroethylene Solvents, Procedure For."

4.4.4 Quality control test (method B). - Cleaned parts, field parts, assemblies, subsystems, or systems selected for gas analysis quality control tests shall be subjected to all examinations and tests specified herein. The visual examinations of 4.4.1 and 4.4.2, as applicable, shall precede the quality control tests.

4.4.4.1 Test gases. - Test gases shall be tested regularly to determine that the gas conforms to type I, class 1, grade A of Specification BB-N-411.

4.4.4.1.1 Preparations for analysis of test gas for condensable hydrocarbons.

4.4.4.1.1.1 Preparation of carbon tetrachloride. - Preparation of carbon tetrachloride shall be as follows:

(a) Distill carbon tetrachloride at the rate of 300 ml per hour until 3 liters have been collected. The first 50 ml of distillate shall be discarded. The collecting bottle shall be rinsed carefully with portions of the distilled carbon tetrachloride prior to collection of distilled carbon tetrachloride.

(b) Thoroughly clean and degrease an 800 ml beaker with distilled carbon tetrachloride. Evaporate 600 ml of distilled carbon tetrachloride to approximately 2 ml in the 800 ml beaker. Quantitatively transfer the carbon tetrachloride to a cleaned and degreased 5 ml volumetric flask. Wash the beaker with small quantities of the distilled carbon tetrachloride. Allow the carbon tetrachloride to come to room temperature and refill to volume if necessary.

(c) Use a degreased hypodermic syringe to transfer the sample to a 3 mm sodium chloride sealed cell. Place the sealed cell in the infrared spectrophotometer and record the absorption at 2920 CM^{-1} (wavenumbers) or (3.42 μ). There shall be no absorption at the above wavenumber. If absorption is observed, the carbon tetrachloride shall be redistilled.

4.4.4.1.1.2 Preparation of standards. - Standards shall be prepared as follows:

(a) Transfer 0.1000 g of oil to a thoroughly cleaned liter volumetric flask. Dilute the oil to the volume of the flask with blanked carbon tetrachloride (1 ml equals 0.1 mg). Extreme care shall be taken not to contaminate the standard.

NOTE

The oil used in the standard shall be collected from the gas that is to be analyzed. This is accomplished by scrubbing the gas with blanked carbon tetrachloride. The carbon tetrachloride is then evaporated and the oil retained. If extreme accuracy is not required, an alternate standard may be prepared using oil from the lubricator portion of the compressor.

(b) From this standard solution, prepare several samples containing varying amounts of oil in 5 ml volumetric flasks. If the volume of these samples is in excess of 5 ml, evaporate the carbon tetrachloride to approximately 2 ml. Transfer the sample quantitatively to a 5 ml volumetric flask, and fill to capacity with distilled carbon tetrachloride.

(c) Determine the net absorbency of each of the standard samples using the 2920 CM^{-1} (3.42 μ) band, and prepare a working curve on absorbency versus mg of oil. The 3 mm sealed cell shall be blanked before each determination. At least two determinations shall be made on each standard and the average value taken as the absorbency.

NOTE

If using an automatic infrared spectrophotometer, the same slit opening, speed, and conditions shall be used for all determinations.

(d) Check the calibration curve in step (c) periodically to ensure the accuracy of the analysis.

(e) Use extreme care in handling all samples.

4.4.4.2 Pressurization and flow rate. - Except as specified herein, designed pressures and flow rates applicable to the parts, field parts, assemblies, subsystems, and systems (as shown on documentation of the applicable item) shall be used, when feasible, to test parts, assemblies, subsystems, or systems.

4.4.4.3 Purge. - Unless otherwise specified by the procuring activity, purging of the test unit with gas, prior to performance of test, is permissible and suggested. The volume of gas suggested for use in purging is approximately three times the capacity of the item to be tested.

4.4.4.4 Test procedure. - Unless alternate equipment and test procedures are approved by the procuring activity, prior to performance of tests, the test gas shall be passed through or over the test item as specified herein.

4.4.4.4.1 Particulate contamination.

(a) Attach the compressed gas source to the inlet port of the part, field part, assembly, subsystem, or system to be tested.

(b) Flow a minimum of 10 standard cubic feet (SCF) of compressed gas, at a flow rate of 7 (plus or minus 1.0) cubic feet per minute, through or over the test part, assembly, subsystem, or system.

(c) Thoroughly wash the Millipore filter holder and the Millipore filter membrane with an approved prefiltered solvent (prefiltered trichloroethylene or an approved equal).

(d) Using precleaned forceps with unserrated tips, insert the Millipore filter membrane into the Millipore filter holder.

(e) Attach the Millipore filter holder to the outlet port of the part, assembly, subsystem, or system to be tested.

(f) Attach flowmeter to the test item on the downstream side of the Millipore filter holder.

(g) Unless otherwise specified in applicable documentation, flow the compressed gas sample (30 SCF minimum) through the test item, at a flow rate of 7 (plus or minus 1.0) SCF per minute.

(h) Remove Millipore filter holder from sampling point and carefully remove the filter membrane from the Millipore filter holder.

(i) Using a microscope, ocular micrometer with movable stage and illuminating lamp; analyze the filter membrane to determine the particle population, by size ranges (see tables I and II), on the entire surface of the membrane.

(j) When the part, field part, assembly, subsystem, or system is found to be excessively contaminated, repeat the purge procedures, steps (g) through (i), for a maximum of two times.

(k) When two purges fail to render acceptable test results, reject the part, field part, assembly, subsystem, or system, and reclean the item in accordance with the applicable procedures within this specification.

4.4.4.4.2 Condensable hydrocarbon contamination

(a) Clean the three gas washing bottles with liquid detergent, and rinse thoroughly with demineralized or distilled water. Rinse again with acetone, dry, and rinse at least three times with previously blanked carbon tetrachloride. Do not dry with compressed air.

(b) Fill the gas scrubbing bottles with 100 ml of blanked distilled carbon tetrachloride and seal the tops with rubber bands. Connect the bottles in series with new rubber tubing. The tubing shall be approximately 1-1/2 inches long to prevent having excess tubing exposed to carbon tetrachloride vapor.

4.4.4.4.2 Condensable hydrocarbon contamination.

(c) The gas supply, that is to be sampled, shall have a flow rate of approximately four liters per minute when the test is first started. After a few minutes, increase the gas flow rate to five or six liters per minute, or as prescribed by the procuring activity. Use care to prevent the carbon tetrachloride from blowing from one scrubber to the other. If this occurs, begin test again using new rubber tubing for the connections.

(d) Connect the wet test meter to the exit side of the scrubbers before the test is started. The exhaust from the wet test meter shall be vented to out-of-doors because of the toxicity of carbon tetrachloride.

(e) Do not permit the carbon tetrachloride to evaporate to less than 50 ml. When adding carbon tetrachloride to the scrubbers, release the rubber band on scrubber number 1, detach the inlet line, and immediately separate the top and bottom sections of the scrubber. This prevents the carbon tetrachloride in the scrubbers from blowing over due to internal pressure. Carbon tetrachloride can be added without completely removing the fritted tube from the scrubber. Reseal scrubber number 1 and proceed to scrubbers numbered 2 and 3 in the same manner.

(f) Record the temperature shown on the wet test meter at the beginning and end of the test, and use the average value in the calculation of step (k). Record the barometric pressure in mm of mercury.

(g) After approximately 600 liters of gas have been scrubbed, release the pressure as in step (e), and remove all rubber connections from the bottles. Cover the bottles with aluminum foil until the solution is transferred to the beaker.

(h) Clean an 800 ml beaker in the same manner used to clean the gas scrubbing bottles. Transfer the sample quantitatively to the beaker by washing each section of the bottles at least three times with the blanked carbon tetrachloride.

(i) Evaporate the sample to approximately 2 ml, using a low heat near the end of the evaporation cycle, and transfer the sample to a 5 ml volumetric flask.

(j) Dilute the sample to a volume of 5 ml with distilled carbon tetrachloride, and determine the net absorption on an infrared spectrophotometer using the 2920 CM^{-1} (3.42 μ) band. Determine the concentration of oil in the sample by comparing the absorption value of the sample to the working curve established in 4.4.4.1.1.2 (c).

(k) Correct the volume of gas to standard conditions and calculate the weight from its density. Calculate the quantity of oil in the gas in ppm, by weight. Use the following calculations to find the volume of gas at standard temperature and pressure, weight of gas, and ppm of oil in the gas:

(1) Volume of gas in liters x $\frac{\text{barometric pressure in mm} \times \frac{273.1}{760 \text{ mm}}}{273.1 + \text{average temperature (degrees centigrade)}}$ = Volume of gas at standard temperature and pressure.

(2) Volume of gas at standard temperature and pressure times density of gas = weight of gas.

(3) $\frac{\text{g of oil times } 1{,}000{,}000}{\text{weight of gas (g)}}$ = ppm of oil in gas

4.4.4.5 Gas analysis.

4.4.4.5.1 Particle size and population. - When tested, as specified in 4.4.4.4.1, the particle size and population shall conform to the applicable cleanliness level requirements specified in 3.3.1. Any test unit that fails to meet the particulate limitations shall be rejected.

4.4.4.5.2 Condensable hydrocarbon content. - When tested as specified in 4.4.4.4.2, the condensable hydrocarbon content shall conform to table I, as applicable. Any test unit that fails to meet the condensable hydrocarbon requirements shall be rejected.

4.4.4.6 Rejection and resubmittal.

4.4.4.6.1 Individual rejection. - Parts, field parts, assemblies, subsystems, or systems that fail the visual inspection of 4.4.1 and 4.4.2, or the test of 4.4.3 and 4.4.4, as applicable, shall be rejected and reprocessed.

4.4.4.6.2 Lot rejection. - If any acceptance sample fails to meet the requirements specified herein, a second sample, twice the size of the first, shall be selected and tested. If any item from the second sample fails to meet the requirements specified herein, the entire lot represented by the sample shall be rejected.

4.4.4.6.3 Resubmittal. - Before resubmittal of rejected lots, full particulars concerning previous rejection and corrective measures taken to prevent recurrence of the failure shall be made available to the procuring activity.

5. PREPARATION FOR DELIVERY

Not applicable to this specification. Details of packaging, and packing shall be covered in the applicable detail specification.

6. NOTES

6.1 Intended use. - The cleaning procedures, cleanliness levels, testing methods, and protection methods covered by this specification are intended for use in cleaning, inspecting, and protecting the parts, field parts, assemblies, subsystems, and systems of the pneumatic systems of support equipment for space vehicles.

6.2 Ordering data. - Procurement documents should specify the following:

(a) Title, number, and date of this specification.

(b) Cleanliness level, cleaning procedure, and test procedure required.

6.3 Definitions.

6.3.1 Surface area. - The standard unit (area) used for determination of contamination levels is 1.0 square foot of significant surface area (surfaces that will contact the service medium). Exact calculations of surface areas are not mandatory. Approximate surface area calculations acceptable to the procuring activity may be used.

6.3.2 Tubing. - Tubing, as defined for the purpose of this specification, shall include rigid tubing in sizes up through 6 inches outside diameter.

6.3.3 Flexible hose. - Flexible hose, as defined for the purpose of this specification, shall include braided hose in sizes up through 2 inches as commercially rated.

6.3.4 Control assemblies. - Control assemblies, as defined for the purpose of this specification, shall include such items as valves, regulators, pressure switches, and temperature control switches.

6.3.5 Piping. - Piping, as defined for the purpose of this specification, shall include rigid piping in sizes up through 6 inches inside diameter.

6.3.6 Part. - For the purpose of this specification, a part is defined as one piece, or two or more pieces joined together, which are not normally subject to disassembly without destruction for designed use (e.g., O-ring, poppet, valve housing, and fittings are parts of a valve assembly). A length of flared and formed tubing with sleeves and fittings assembled that cannot be disassembled by normal means without destruction for designed use, should be considered as a part rather than an assembly. Integral parts, press fits, etc., not normally disassembled but which contain both metallic and nonmetallic materials should be considered as nonmetallic (except parts containing only polytetrafluoroethylene) and cleaned and tested accordingly. Parts containing only polytetrafluoroethylene as the nonmetallic material should be cleaned as metallic parts.

6.3.7 Field parts. - For the purpose of this Specification a field part is defined as a single or multiple series of tubing or pipe interconnected to form one or more parts as assembled in the field. A field part normally is not cleaned in a laboratory environment nor is it installed as precleaned under field conditions.

6.3.8 Assembly. - For the purpose of this specification, an assembly is defined as a unit consisting of two or more replaceable parts (e.g., filter element, filter housing and fittings are parts of a filter assembly) having a common mounting; and which is, within its physical make-up, capable of performing a definite function. (Examples: filter assembly, regulator assembly, and valve assembly).

6.3.9 Subsystem. - For the purpose of this specification, a subsystem is defined as a unit consisting of two or more assemblies joined together to perform a definite function. The subsystem should be capable of independent operation and checkout when interconnected with a simulated complete system.

6.3.10 System. - For the purpose of this specification, a system is defined as a series of subsystems joined together to perform a definite function.

6.3.11 Flush. - For the purpose of this specification, flush is a sudden flowing; a rush that fills or overflows, as of water for cleaning purposes.

6.4 Saran Wrap.- Saran Wrap, manufactured by the Dow Chemical Co., Midland, Michigan, has been found to be an acceptable protective covering for cleaned items.

6.5 Detergent. - Detergent, Dowell F-33, manufactured by the Dow Chemical Co., Midland, Michigan, has been found to be an acceptable detergent for use in cleaning procedures. Oakite 33 and 34, manufactured by Oakite Products, Inc., New York 6, N. Y., has been found to be an acceptable detergent for use in cleaning aluminum.

6.6 Nylon C. - Nylon C is an abrasive resistant plastic film used to package components which have critical surfaces that are not subject to LOX compatibility. Approved source is Specialty Converting Co., 4125 Downman Rd., New Orleans, La.

6.7 Aclar 33C. - Aclar is a Fluorohalocarbon plastic film and the only approved film for protective covering of LOX components, parts, field parts, subsystems, and systems. Approved source for this material is Allied Chemical, General Chemical Division, Box 70, Morristown, N.J.

Custodian:

NASA - John F. Kennedy Space Center

Preparing Activity:

John F. Kennedy Space Center
Launch Support Equipment
Engineering Division.

END OF REFERENCE
10

REFERENCE
II

ANON.: PROPOSED SPECIFICATION FOR SURFACE CLEANLINESS OF FLUID SYSTEMS. NASA KENNEDY SPACE CENTER.

JOHN F. KENNEDY SPACE CENTER, NASA

(PROPOSED)

SURFACE CLEANLINESS OF FLUID SYSTEMS,

SPECIFICATION FOR

NOTE: THIS SPECIFICATION, IN ITS PRESENT FORM, IS NOT AVAILABLE FOR DISTRIBUTION THROUGH KSC. AT THE DATE OF PUBLICATION OF THE "CLEANING REQUIREMENTS, PROCEDURES AND VERIFICATION TECHNIQUES" OF THE ASRDI OXYGEN TECHNOLOGY SURVEY THIS PROPOSED SPECIFICATION IS BEING REVIEWED FOR ISSUANCE AS A FORMAL KSC SPECIFICATION. DECEMBER 1971

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1. SCOPE

1.1 Scope. - This specification establishes the cleanliness levels, cleaning, protection, and inspection procedures for any surface in contact with fluids used for NASA-oriented activities. These surfaces pertain to parts, components, assemblies, subsystems, systems or other related equipment in contact with any service medium.

1.2 Classification. - The cleaning procedures, cleanliness levels, and testing methods applicable to parts, components, assemblies, subsystem, systems, or other related equipment (as applicable, see 6.2) are classified as specified herein.

1.2.1 Cleanliness Levels

CLEANLINESS LEVEL	MAXIMUM PARTICLE SIZE (MICRONS)	SOLVENT SOLUBLE ORGANIC RESIDUE (MG/SQ FT)	CONDENSABLE HYDROCARBONS (PPM/WT TEST GAS)
A	50	1	0.2
B	150	1	0.2
C	250	1	1
D	500	1	2
E	700	2	2
F	1500	3	3

1.2.2 Cleaning Procedures

MATERIAL	PICKLING	PASSIVATION	CLEANING
Corrosion Resistant Steel	-	Formula III (3.10.1.3)	Formula I (3.10.1.1)
Corrosion Resistant Steel	Formula II (3.10.1.2)	Formula III (3.10.1.3)	Formula I (3.10.1.1)
Aluminum, Bare or Clad	-	-	Formula IV (3.10.1.4)
Aluminum, Bare or Clad	Formula V (3.10.1.5)	-	Formula IV (3.10.1.4)
Aluminum, Bare or Clad	-	Formula V (3.10.1.5)	Formula IV (3.10.1.4)
Copper & Copper Alloys	-	-	Formula VI (3.10.1.6)
Copper & Copper Alloys	Formula VII (3.10.1.7)	-	Formula VI (3.10.1.6)
Copper & Copper Alloys	-	Formula VII (3.10.1.7)	Formula VI (3.10.1.6)

MATERIAL	PICKLING	PASSIVATION	CLEANING
Nonmetallic Items	-	-	Detergent Solution
Aluminum, Anodized or Chemical Conversion Coated	-	-	Detergent Solution

1.2.3 Suggested Applications. - The following suggested applications are based on cleanliness levels that have been previously specified for spacecraft, launch vehicle, or ground support equipment.

CLEANLINESS LEVEL	SUGGESTED APPLICATION
A	Critical systems such as gas bearing and slosh measuring systems; spacecraft pressurization systems; reaction control propellant systems.
B	Ground support equipment parts and assemblies for critical vehicle applied systems (fluid); spacecraft electrical power systems.
C	Ground support equipment liquid oxygen and fuel systems, parts, assemblies, and subsystems; spacecraft small propulsion systems, facilities equipment supplying fluids to and interfacing with spacecraft ground support equipment except for spacecraft environmental control systems.
D	Ground support equipment parts and assemblies (flow through) and vehicle applied systems (fluid).
E	Ground support equipment parts and assemblies for dead end services such as gauges, pressure switches, and relief valves; main propulsion systems; facilities equipment supplying fluids to and interfacing with spacecraft ground support equipment for environmental control systems.
F	Facility type systems not affiliated with or oriented with vehicle and vent systems downstream of relief valves and check valves toward atmosphere.

1.2.3.1 Suggested Cleanliness Levels for Design Applications. - The following maximum critical clearances relative to each cleanliness level are given as a guide to selecting a cleanliness level sensitive to the requirements of a specific design application.

CLEANLINESS LEVEL	MAXIMUM CRITICAL CLEARANCE (MICRONS)
A	150
B	350
C	500
D	750
E	1000
F	2000

1.2.4 Test Methods. -

Method	Description
A	Solvent flush test for particle population and solvent soluble organic residues remaining on critical surfaces of items cleaned in a controlled environment.
B	Gas flow test for particles and volatile hydrocarbons that will condense at ambient temperature and pressure.
C	Fluid flow test for monitoring particle population and water rinseable residues during the cleaning cycle, and for particle population and solvent soluble organic residues remaining on critical surfaces of items cleaned in the field.
D	Gas flow test for moisture remaining on critical surfaces after cleaning.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on the date of invitation for bids or requests for proposals form a part of this specification.

SPECIFICATIONS

Federal

BB-N-411	Nitrogen
O-H-350	Nitric Acid, Technical
O-S-639	Sodium Phosphate, Dibasic, Anhydrous, Technical
O-O-670	Orthophosphoric (Phosphoric) Acid, Technical
O-S-809	Sulfuric Acid, Technical
TT-I-735	Isopropyl Alcohol
UU-T-81	Tags, Shipping and Stock
PPP-T-66	Tape, Pressure Sensitive Adhesive, Vinyl Plastic Film

Military

MIL-D-16791	Detergents, General Purpose, Liquid, Nonionic
MIL-E-17555	Electronics and Electrical Equipment and Associated Repair Parts, Preparation for Delivery of

Manned Spacecraft Center

MSC-SPEC-C-3	Decals, Certification of Cleanliness

Marshall Space Flight Center

MSFC-SPEC-217	Trichloroethylene, Technical, Specification for
MSFC-SPEC-234	Nitrogen, Space Vehicle Grade
MSFC-SPEC-237	Solvent, Precision Cleaning Agent, Specification for
MSFC-SPEC-456	Film, Transparent, Plastic, LOX Compatible, Gas and Contamination Barrier

STANDARDS

Federal

FED-STD-141	Paint, Varnish, Lacquer, and Related Materials, Methods of Inspection, Sampling and Testing

FED-STD-209	Clean Room and Work Station Requirements, Controlled Environment

Military

MIL-STD-129	Marking for Shipment and Storage
MIL-STD-794	Parts and Equipment, Procedures for Packaging and Packing of
MS 33586	Metals, Definition of Dissimilar

Marshall Space Flight Center

MSFC-STD-105	Synthetic Rubber, Age Control of, Standard for

PUBLICATIONS

National Aeronautics and Space Administration

NPC 200-2	Quality Program Provisions for Space System Contractors
NPC 200-3	Inspection System Provisions for Suppliers of Space Materials, Parts, Components, and Services

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other Publications. - The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on the date of invitation for bids shall apply.

American Society for Testing and Materials Standards

ASTM D257-61	Electrical Resistance of Insulating Materials
ASTM D1069-64	Particulates and Dissolved Matter in Industrial Waste Water, Tests for
ASTM D1078-63	Distillation Range of Volatile Organic Liquids, Test for
ASTM D1173-53	Foaming Properties of Surface-Active Agents, Test for
ASTM D1310-63	Flash Point of Volatile Flammable Materials by Tag Open-Cup Apparatus, Test for

ASTM D1613-64	Acidity in Volatile Solvents and Chemical Intermediates Used in Paint, Varnish, Lacquer, and Related Products, Test For
ASTM E168-64T	General Techniques of Infrared Quantitative Analysis
ASTM F25-63T	Sizing and Counting Airborne Particulate Contamination in Clean Rooms and Other Dust Controlled Areas Designed for Electronic and Similar Applications
ASTM F51-65T	Sizing and Counting Particulate Contaminant in and on Clean Room Garments

(Copies may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania, 19103.)

3. REQUIREMENTS

3.1 General. - All parts, components, assemblies, subsystems, systems, or related equipment requiring cleaning shall be cleaned and inspected in conformance with this specification. Detailed production cleaning, preservation, and protection processes require prior approval of the procuring activity (see 3.2). Quality Assurance provisions of inspection and testing for the acceptance of parts, components, assemblies, subsystems, systems, or other related equipment that have been cleaned to a specific level of cleanliness shall be performed as specified herein; there shall be no exceptions or deviations. Subsystems and systems may require disassembly to permit cleaning. Any part or component that might be damaged during cleaning shall be removed before cleaning, and cleaned as a separate item. Cleaning or disassembly operations on precision components that might affect the tolerances or impair the calibration of such components shall be performed only by personnel qualified in the necessary operations.

3.2 Production Cleaning and Preservation Process Approval. - The detailed procedures for cleaning, preservation, and protection to be used shall be as specified herein; however, the contractor may use other materials and processes provided written approval of the materials and processes to be used is obtained from the procuring activity prior to cleaning, preservation, and protection. The utilization of the procedures specified herein, or of any other process or procedure approved for use by the contractor will not guarantee acceptance of the end product. The contractor shall be required to submit to the procuring activity a statement in writing containing the following information for all production cleaning and preservation process procedures:

(a) Processing materials to be used. This shall include, as applicable, trade names, specifications, chemical, and physical properties.

(b) Processing equipment and cleaning procedures to be used.

REFERENCE II CONTINUED ON CARD 4

Card #4

(c) Preservation processes and protection methods and materials to be used.

(d) In-process control procedures to control built-in contamination or latent corrosion resulting from the application of processing materials or procedures.

(e) The implementation of the quality assurance provisions specified herein that are applicable to the item being cleaned.

(f) Sequence of valving, fluid flow patterns, sampling ports, and other pertinent cleaning data for subsystems, systems, storage vessels, and other related equipment.

3.3 Sequence of Operations. - All steps in any procedure shall progress in an uninterrupted series of operations through the final rinse and drying operation. Precautions shall be taken to protect items after final rinse and drying until inspection, assembly, and packaging are completed.

3.4 Reassembly and Functional Testing. - All items that have been disassembled for cleaning shall be reassembled and functionally tested prior to final acceptance of the cleaned item. All soft-goods parts such as o-rings, diaphragms, etc. shall be replaced with new parts cleaned to the same level as the disassembled item. Cure dates of soft-goods shall be in conformance with Specification MSFC-STD-105. Prior written approval of the procuring activity shall be required for the waiver of any of the requirements of 3.4.

3.5 Materials. - Processing and protecting materials used shall be as specified herein, or on the drawings, or shall be of a quality approved by the procuring activity (see 3.2).

3.5.1 2-Butoxyethanol (ethylene glycol monobutyl ether). - The material for use in cleaning formulas shall meet the following requirements:

(a) Boiling point - the boiling point of at least 99 percent by weight of the compound at 760 mm of mercury pressure shall be between 169 degrees and 172 degrees Centigrade (C) as determined by ASTM Method D1078-63. The remaining one percent of the material shall have a boiling point of not less than 166 degrees C nor more than 173 degrees C.

(b) Specific gravity - the apparent specific gravity shall be between 0.900 and 0.905 as determined by Test 5 of Method 4183 of Standard FED-STD-141.

(c) Flash point - the flash point shall be 157 degrees plus or minus 8 degrees Fahrenheit (F) as determined by ASTM Method D1310-63 using the Tag open cup.

(d) Solubility in water - the solubility of 2-butoxyethanol in water and water in 2-butoxyethanol shall be infinite (complete) at 20 degrees C.

(e) Acidity - total free acid calculated as acetic acid shall be not more than 0.01 percent by weight, equivalent to 0.1 mg of potassium hydroxide per gram of sample as determined by ASTM Method D1613-64.

3.5.2 Certification Decal. - Certification of cleanliness level decals for precision clean packaging shall conform to Specification MSC-SPEC-C-3 except that the initials of the specific procuring activity shall be imprinted on the decal as applicable. (See 3.11.2.8).

3.5.3 Deionized Water. - Deionized water shall be deionized to a degree that the minimum specific resistance shall be 50,000 ohms and shall be checked and certified daily. The pH shall be maintained between 6.0 and 8.0 as measured by narrow range pH indicating paper. The pH shall be checked and certified daily. Deionized water for flushing and testing operations shall be prefiltered to remove all particles larger than the limits specified for the item being flushed or tested. Total solids shall not exceed 10 parts per million by weight as determined by ASTM Method D1069-64.

3.5.4 Detergent. - Detergents used for detergent degreasing operations shall conform to MIL-D-16791.

3.5.5 Dibasic Sodium Phosphate (Disodium Hydrogen Phosphate). - Dibasic sodium phosphate shall conform to Specification O-S-639.

3.5.6 Filter Membrane. - The filter membrane used for particle removal shall be 47 mm diameter with a 3.08 mm imprinted grid, black or green. The filter shall be capable of particle removal as required by the cleanliness level applicable to the item being tested.

3.5.7 Gases

3.5.7.1 Drying Gas for Nonprecision Cleaned Items. - Nitrogen gas for drying of nonprecision cleaned items during precleaning in a light industrial atmosphere as specified herein shall conform to Type I, Class 1, Grade B of Specification BB-N-411.

3.5.7.2 Drying, Purging, or Testing Gas for Precision Cleaned Items. - Nitrogen gas for drying, purging, preserving, or testing of precision cleaned items as specified herein shall conform to Specification MSFC-SPEC-234 except that it shall be prefiltered to the applicable cleanliness level.

3.5.8 Hydrofluoric Acid. - Hydrofluoric acid used in Formula II for pickling corrosion resistant steel shall be technical grade with a minimum hydrogen fluoride content of 48 percent by weight in water.

3.5.9 Nitric Acid. - Nitric acid shall conform to Specification O-N-350.

3.5.10 Packaging Films

3.5.10.1 Polyethylene. - Polyethylene film for precision clean packaging shall meet the requirements specified in 3.11.2 of this specification.

3.5.10.2 Polyamide. - Polyamide films such as Nylon 6 or equivalent for precision clean packaging shall meet the requirements specified in 3.11.2 of this specification.

3.5.10.3 Fluorohalocarbon. - Fluorohalocarbon films such as Aclar 33C or equivalent for precision clean packaging shall conform to Specification MSFC-SPEC-456 and 3.11.2 of this specification.

3.5.11 pH Indicating Test Paper. - pH indicating test paper for making pH measurements as specified herein shall be the fractional range type. Wide range pH paper shall not be used. The pH range of 6.0 to 8.0 shall be covered by using two pH papers with overlapping ranges; e.g., one with a range of 4.5 to 7.5 and the other with a range of 6.8 to 8.4. A single paper with a pH range of 6.0 to 8.0 shall not be used.

3.5.12 Phosphoric Acid. - Phosphoric acid shall conform to Specification O-O-670.

3.5.13 Test and Analytical Equipment. - The following equipment is required to accomplish the tests and analyses specified herein:

(a) Petri dishes, disposable, plastic, 48 mm I.D.

(b) Forceps, unserrated tips.

(c) Microscope, binocular, with ocular-objective combinations to obtain 40 to 45 X and 90 to 150 X magnification.

(d) Lamp, microscope, 6 volt, 5 ampere, high intensity.

(e) Scale, ocular micrometer.

(f) Micrometer, stage.

(g) Holder, filter, for filter membrane.

(h) Flasks, filter, one liter and four liter capacity.

(i) Flasks, boiling, two to five liter capacity.

(j) Column, Claisen fractionating, with 20/40 standard taper joints or equivalent filled with Raschig rings.

(k) Condenser, Liebig or Allison, 400 mm jacket with 24/40 standard taper joints.

(l) Adapter, collecting, 105 degrees angle with 24/40 standard taper joint.

(m) Meter, wet test gas, calibrated.

(n) Bottles, gas washing, 250 ml capacity with coarse or medium frits.

(o) Flasks, volumetric, 5, 10, and 100 ml capacity.

(p) Pipettes, volumetric, 1, 5, and 10 ml capacity.

(q) Bottle, wash.

(r) Spectrophotometer, infrared.

(s) Cells, infrared, sealed, sodium chloride, one for single beam instrument, or two (matched pair or one variable) for double beam instrument.

(t) Syringe, hypodermic, Luer-Lok, five ml capacity.

(u) Funnels, separatory, one liter capacity.

(v) Beakers, 50, 100, 500, and 800 ml capacity.

(w) Holder, filter, flow-through, four bolts for 0 to 6000 psig, six bolts for 6000 to 10,000 psig.

3.5.14 Solvents

3.5.14.1 Vapor Degreasing Solvent. - Type II, trichloroethylene conforming to Specification MSFC-SPEC-217 or trichlorotrifluoroethane conforming to Specification MSFC-SPEC-237 shall be used in vapor degreasing processes.

3.5.14.2 Degreasing Solvent. - Type II, trichloroethylene conforming to Specification MSFC-SPEC-217 or trichlorotrifluoroethane conforming to Specification MSFC-SPEC-237 shall be used in solvent degreasing operations.

3.5.14.3 . Test Solvents

3.5.14.3.1 Trichlorotrifluoroethane. - Trichlorotrifluoroethane used as a test solvent in the solvent-flush procedure (Method A) or the fluid-flow procedure (Method C) shall conform to Specification MSFC-SPEC-237 when procured. Prior to its use, the solvent shall be filtered to meet the particulate population requirements of 4.3.3.1.1.1 or 4.3.4.1.1.1, as applicable. The solvent may be reused as long as the particle population requirements of 4.3.3.1.1.1 or 4.3.4.1.1.1, as applicable, are met; and the solvent soluble residue does not exceed 0.013 milligrams per milliliter as specified in 4.3.3.1.1 and 4.3.4.1.1.

3.5.14.3.2 Trichloroethylene. - Trichloroethylene used as a test solvent in the fluid-flow procedure (Method B) shall conform to Specification MSFC-SPEC-217, Type I, when procured. Prior to its use, the solvent shall be filtered to meet the particle population requirements of 4.3.4.1.1.1. The solvent may be reused as long as the particle population requirements of 4.3.4.1.1.1 are met, and the solvent soluble organic residue does not exceed 0.013 milligrams per milliliter as specified in 4.3.4.1.1.

3.5.14.3.3 Isopropyl Alcohol. - Isopropyl alcohol used as a test solvent in the solvent-flush procedure (Method A) shall conform to Specification TT-I-735, Grade A, except that the maximum nonvolatile residue shall be 0.001 percent when procured. Prior to its use, the solvent shall be filtered to meet the particle population requirements of 4.3.3.1.1.1. The solvent may be reused as long as the particle population requirements of 4.3.3.1.1.1 are met, and the solvent soluble organic residue does not exceed 0.013 milligrams per milliliter as specified in 4.3.3.1.1.

3.5.14.3.4 Carbon Tetrachloride. - Carbon tetrachloride used in the gas-flow test procedure (Method B) shall be spectrograde carbon tetrachloride procured with no infrared absorption at 3.42 microns for a three millimeter depth of liquid.

3.5.14.4 Acetone. - Acetone used for cleaning analytical glassware shall be spectrograde acetone.

3.5.15 Sulfuric Acid. - Sulfuric acid used in Formula VII for pickling and brightening copper alloys shall conform to the requirements for Type I, Class I, of Specification O-S-809.

3.5.16 Surfactant. - The surfactant for use in cleaning formulas shall meet the following requirements:

(a) Type - the surfactant shall be a liquid, nonionic surface active agent of the alkyl aryl polyethylene glycol ether type. The hydrophobe group shall be octyl, nonyl, or dodecyl phenol.

(b) Purity - the surfactant shall contain a minimum of 99 percent active ingredient and shall contain no builders, soaps, or addition agents of any kind.

(c) Appearance - the surfactant shall be a dispersible liquid at 70 degrees F.

(d) Volatiles - the volatiles content shall not exceed 1.0 percent when tested in accordance with 4.4.1 of MIL-D-16791.

(e) Ash content - the ash content shall not exceed 0.25 percent when tested in accordance with 4.4.2 of MIL-D-16791.

(f) Nitrogen, Sulfur, and Phosphorus Content - the surfactant shall give no test for these elements when tested in accordance with 4.4.3 of MIL-D- 16791.

(g) Cloud point - the cloud point of a one percent aqueous solution of the surfactant shall be between 70 degrees and 212 degrees F when tested in accordance with 4.4.5 of MIL-D-16791.

(h) Compatibility - no cloudiness, precipitation, or sedimentation shall be formed when the surfactant is mixed with anionic and cationic surfactants when tested in accordance with 4.4.6 of MIL-D-16791.

(i) Chemical stability - the surfactant shall be chemically stable to acid and oxidation when tested in accordance with 4.4.7 of MIL-D-16791 except that the temperature for observing cloudiness or precipitation after testing shall be 68 degrees F.

(j) pH value - the pH of a one percent solution of surfactant at 70 degrees F shall be between 6.0 and 8.0 when tested in accordance with 4.4.9 of MIL-D-16791.

(k) Solubility in 2-Butoxyethanol - the surfactant shall be completely soluble in 2-butoxyethanol when tested as follows:

(1) Add 20 ml of surfactant to 80 ml of 2-butoxyethanol meeting the requirements of 3.5.1 in a 100 ml glass stoppered graduated cylinder.

(2) Stopper the cylinder and shake vigorously for three minutes.

(3) Allow the cylinder to stand undisturbed for one hour.

(4) Examine the solution. Any turbidity, separation of layers, or other evidence of incomplete solubility shall be cause for rejection.

3.5.17 Tags. - Tags for marking of precision cleaned items in accordance with 3.12 shall conform to the requirements for Type C, Style 1 or 2, Class 2, of Specification UU-T-81 and shall contain the information required in 3.12.

3.5.18 Tape. - Tape used in precision clean packaging shall conform to Specification PPP-T-66, Type I, Class B.

3.6 Cleanliness Requirements

All items that are cleaned in accordance with this specification shall comply with the minimum surface cleanliness requirements as specified in Table I, as applicable.

3.7 Contamination Control

3.7.1 Environmental Control. - Excluding precleaning, all cleaning and inspection operations for parts, components, and other items as required shall be accomplished within a clean room conforming to Specification FED-STD-209. The clean room level shall be consistent with the cleanliness level requirements of the cleaned item.

3.7.2 Handling. - Neoprene rubber gloves shall be worn during all solvent cleaning operations in the clean room. Clean, low-lint, white nylon gloves shall be worn in the clean room when handling cleaned items. Care shall be taken not to recontaminate cleaned items.

3.7.3 Garments

3.7.3.1 General. - All personnel entering a clean room shall wear clean room garments specifically designed to prevent contamination of the clean area by lint, dust, dandruff, and other contaminants from clothing, shoes, hair, and skin. Clean room garments shall afford adequate coverage of the body as applicable.

3.7.3.2 Garment Construction. - Garments shall be of a continuous filament, 100 percent polyester fiber such as Dacron. The fabric weave shall be taffeta or herringbone twill. The color may be white or pastel.

3.7.3.2.1 Garments shall be of a simple design with no pockets and a minimum of seams. All sewn seams shall be closed, double-stitched, and free of loose threads. Thread shall be 100 percent polyester continuous filament, stranded, 200-denier minimum, and shall be of the same color as the garment. Garments may have thermally fused seams. Thermal fusion shall

TABLE I.

SURFACE CLEANLINESS REQUIREMENTS OF FLUID SYSTEMS

CLEANLINESS LEVEL	PARTICLE SIZE RANGE (MICRONS)	PARTICLES[a] (NO. PER SQ FT MAX)	SOLVENT SOLUBLE ORGANIC RESIDUE (MG PER SQ FT) MAX)	CONDENSABLE HYDROCARBONS (PPM BY WT OF TEST GAS)
A	<10	unlimited[b]	1	0.2
	10-15	46		
	16-25	9		
	26-50	1		
	>50	0		
B	<25	unlimited[b]	1	0.2
	25-50	132		
	51-100	12		
	101-150	1		
	>150	0		
C	<50	unlimited[b]	1	1
	50-100	69		
	101-150	20		
	151-200	9		
	201-250	1		
	>250	0		
D	<100	unlimited[b]	1	2
	100-200	60		
	201-300	18		
	301-400	4		
	401-500	1		
	>500	0		
E	<150	unlimited[b]	2	2
	150-300	41		
	301-450	6		
	451-600	1		
	601-700	1		
	>700	0		
F	<300	unlimited[b]	3	3
	300-600	81		
	601-900	24		
	901-1200	10		
	1201-1500	1		
	>1500	0		

(a) Fibers shall be counted as particles. Fiber size shall be determined by the length (larger dimension when viewed in the direction perpendicular to the plane in which it lies).

(b) Unlimited except that no silting shall be permitted. Silting shall be defined as an accumulation of minute particles of sufficient quantity to cause a haze or obscuring of any portion of a grid line or any portion of the grid of a filter membrane, when viewed visually or under 40 power maximum magnification.

result in seams that are continuously welded the entire length of the seam with no unfused gaps. There shall be no loose threads or rough edges of fabric at the fused seams.

3.7.3.2.2 Fastening of garments may be accomplished by either snaps, ties, or zippers. Snaps and zippers shall be corrosion resistant. Buttons shall be unacceptable as a means of fastening. All collars and cuffs shall be adjustable to give a snug, but comfortable fit.

3.7.3.2.3 When the generation of static electricity is a problem, an anti-static agent may be added to the material. The acceptability of an anti-static agent shall be based upon the fabric meeting the cleanliness level specified in 3.7.3.5.1 prior to and after treatment of the fabric with the anti-static agent.

3.7.3.2.4 Garments shall be available in the following sizes:

Extra Small	- 30-32
Small	- 34-36
Medium	- 38-40
Large	- 42-44
Extra Large	- 46-48

3.7.3.3 Accessory Construction

3.7.3.3.1 Head Coverings. - Head coverings may be either caps or hoods that match the garments in fabric and color.

3.7.3.3.1.1 Caps for men shall be surgeon's style with three position fasteners: small, medium, and large. Snood caps with drawstring shall be provided for women.

3.7.3.3.1.2 Hoods shall completely cover the head and neck except for the face. Hoods shall fit inside the neck of coveralls. Sizes shall be: small, medium, and large.

3.7.3.3.2 Shoe Coverings. - Tops of shoe covers shall be made of the same material as the basic garment, be high enough to cover the coverall pants leg, and be secured to the pants leg by a tie or snaps. All seams shall be turned inside and double-stitched. Soles shall be made of a skid resistant plastic. Sizes shall be: medium, large, and extra large.

3.7.3.3.3 Gloves. - Gloves shall be form-fitting nylon, one-size design, with complete coverage of the hand.

3.7.3.4 Laundering of Clean Room Garments. - All processing shall be accomplished in a properly constructed and operated facility conforming to class 100,000 or better clean room conditions as established in Specification FED-STD-209.

3.7.3.4.1 Cleaning may be performed by washing, dry cleaning, or a combination of the two methods. Either method or a combination of the two is acceptable as long as the cleanliness level specified in 3.7.3.5.1 is achieved.

3.7.3.5 Cleanliness Level

3.7.3.5.1 Particulate Contamination. - The particulate contamination level of garments and accessories shall not exceed the limits of Table II.

TABLE II. GARMENT CLEANLINESS REQUIREMENTS

MAXIMUM CONTAMINATION PER SQUARE FOOT OF GARMENT TESTED	
SIZE RANGE (MICRONS)	NUMBER
Particles:	
< 5	unlimited[a]
5-100	1000
> 100	2
Fibers:	
100-1000	10
> 1000	0

[a] Particles under 5 microns in size are not counted. However, an accumulation of minute particles of sufficient quantity to cause a haze or obscuring of any portion of a grid line or any portion of the grid on a test filter membrane, when viewed visually or under 40 power maximum magnification, shall be cause for rejection.

3.7.3.5.2 Hydrocarbons. - Garments and accessories shall have no visible hydrocarbons such as oil stains and grease.

3.7.3.6 Quality Assurance Provisions for Garments

3.7.3.6.1 Visual Examination Prior to Laundering. - Each garment and accessory shall be examined for needed repairs, missing fasteners, and broken zippers. Garments showing evidence of fabric breakdown such as loose fiber ends protruding from the surface or areas of wear or fraying shall be rejected.

3.7.3.6.2 Sampling. - Garments and accessories shall be examined and tested to determine compliance with 3.7.3.5 in accordance with 3.7.3.6. Testing shall be conducted in an environment conforming to class 100,000 or better clean room conditions as established in Specification FED-STD-209.

3.7.3.6.2.1 All garments of one type, or all accessories of one type offered by one supplier at one time shall be considered one lot. Each lot of laundered items may be tested upon receipt, or procured clean providing that the requirements of 3.7.3.5, 3.7.3.6, and 3.7.3.9 are met.

3.7.3.6.2.2 A sample for certification of the cleanliness level of one lot shall consist of five percent of the total number of items in that lot except that no less than one item in any one lot shall be tested.

3.7.3.6.3 Verification of Cleanliness Level. - The following procedure shall be used to determine the particulate population of garments and accessories:

(a) A filter assembly and adapter of the configuration specified in Specification ASTM F51-65T shall be used to determine the particulate population.

(b) Clean the filter assembly and adapter with trichlorotrifluoroethane that conforms to Specification MSFC-SPEC-237.

(c) Connect the filter holder to a source of vacuum adequate to produce an air flow rate of 13.9 to 14.1 liters per minute. A limiting orifice or a flowmeter may be used to determine the flow rate.

(d) Using clean forceps, place a black, 0.80 micron pore size, 47 mm diameter membrane filter with a 3.08 mm imprinted grid on the support screen of the filter holder with the grid side up. Twist the locking ring in place after placing the tapered adapter in position.

(e) Place a pre-filter in the top portion of the adapter by removing the o-ring from the adapter top, placing a 47 mm diameter, white, 5.0 micron pore size membrane filter on the support screen, and replacing the o-ring. The 5.0 micron pre-filter may be used for a number of tests before replacement is necessary.

(f) Place the outer surface of the test garment over the tapered, male adapter. Lock into test position by placing the air filter, tapered, female adapter over test portion of the fabric.

(g) Apply vacuum and sample the area for one minute at an air flow rate of 13.9 to 14.1 liters per minute. Sample the required number of areas specified in step (h) by repeating steps (f) and (g).

(h) Five areas shall be sampled for garments in the following approximate locations: breast, arm pit, waist or bench level, and knee on the front of the garment and the seat on the rear of the garment. Two areas shall be sampled on all accessories.

(i) Remove the filter from the holder and count the particles and fibers in conformance with 4.3.3.1.4.1 of this specification. Particles shall be counted in the size ranges of 5 to 100 microns and greater than 100 microns. Fibers shall be counted in the size ranges of 100 to 1000 microns and greater than 1000 microns.

(j) To calculate the number of particles per square foot, multiply the total count of particles or fibers on the filter in each size range by 20 for garments for which five areas were counted. For accessories, multiply the total filter count in each size range by 50.

3.7.3.7 Packaging. - All garments shall be packaged individually in polyethylene bags which shall be hermetically sealed in the clean room prior to exposure to an uncontrolled environment. The method of final packaging for shipment or delivery shall provide protection to prevent tearing or rupture of the inner bags.

3.7.3.8 Marking. - The garment size shall be clearly marked on each garment. Garments shall be folded in such a way that the size is clearly visible through the inner bag.

3.7.3.9 Certification. - Certification showing evidence of compliance with 3.7.3.5 of this specification shall be submitted by the supplier with each lot procured clean. A statement to the effect that garments were inspected in accordance with this specification and are in compliance with 3.7.3.5 shall not constitute an adequate certification. Actual particle count data shall be included in the certification.

3.7.4 Systems Contamination Control During Repair, Replacement or Maintenance Operations

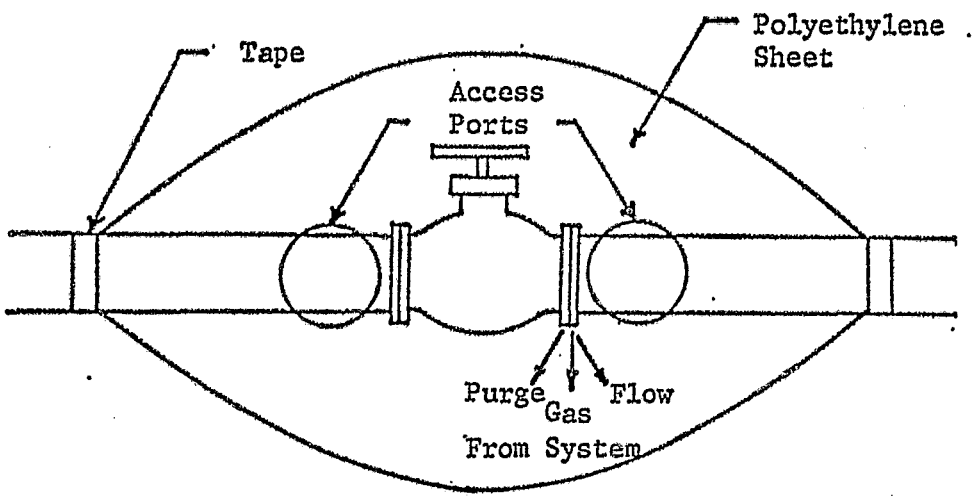
3.7.4.1 Environmental Control. - The cleanliness of a spacecraft, launch vehicle or ground support equipment system is compromised during any operation in which a system is opened in an uncontrolled environment. Minimum contamination control requirements shall be met for repair, replacement, or maintenance operations performed on installed systems that have been previously cleaned. A temporary enclosure shall be constructed around that portion of a system of which repair, replacement, or maintenance operations are to be performed to provide a controlled environment consistent with the cleanliness level requirements of the system. Additionally, a purge with

a inert gas cleaned to a level equal to or greater than the system cleanliness requirement shall be maintained on the system during such operations.

3.7.4.2 Controlled Environment Enclosures. - A controlled environment shall be provided around that portion of the system to be opened so as to preclude contamination of the system or replacement parts by exposure to the normal working environment. The controlled atmosphere shall be provided by construction of a temporary enclosure in which the repair, replacement, or maintenance operation shall be performed. The enclosure may be a small "dry-box" design, a laminar flow bench design, or a large, walk-in tent type design, or any other type approved by the procuring activity, depending upon the size of the components and the complexity of the operation.

3.7.4.2.1 "Dry-Box" Enclosures. - "Dry-box" enclosures may be fabricated from polyethylene sheet. The enclosure shall be sufficiently large to enclose the work area. Provisions shall be made to admit the hands and forearms by a suitable opening such as a zipper, ports, etc. The interior of the enclosure shall be wiped visibly clean using a clean wipe cloth and trichlorotrifluoroethane. The controlled environment within the enclosure shall be provided by the flow of purging gas as specified in 3.7.4.4 from the system into the enclosure during the repair, replacement, or maintenance operation. Once the gas flow has been established in the enclosure during the initial phase of the operation, all work within the enclosure shall be stopped for a period of ten minutes to permit the enclosure to be thoroughly purged. The gas flow into the enclosure shall be maintained until the operation is completed. The gas flow rate shall be adequate to prevent contaminants from entering the enclosure. See Figure 1 for a typical enclosure.

3.7.4.2.2 Laminar Flow Enclosures. - A temporary enclosure based upon the principle of a laminar flow bench may be constructed from a filter assembly composed of a HEPA filter, a pre-filter, and blower mounted as an integral unit and polyethylene sheet for the walls of the enclosure. An enclosure of this type, while providing a controlled environment, has the added advantage of affording personnel performing the operation an unobstructed view and work area. The filter assembly shall be located behind that portion of the system to be opened. The filter assembly shall be supported on a rigid base that forms the bottom of the enclosure. The base shall be adjusted to a convenient working level for personnel and shall be covered with polyethylene sheet or other suitable covering that can be wiped visibly clean. The sides and top of the enclosure shall be made of polyethylene sheet supported by a framework to form a rectangular enclosure with an open front. Air flow shall be from the back of the enclosure, out of the open front toward personnel to preclude entry of contaminants into the enclosure. All seams and joints in the enclosure shall be sealed to prevent leakage of air into the enclosure and to ensure that air flow is out the front of the enclosure. All interior surfaces of the enclosure shall be wiped visibly clean with a clean wiping cloth and trichlorotrifluoroethane. See Figure 2 for a typical enclosure.



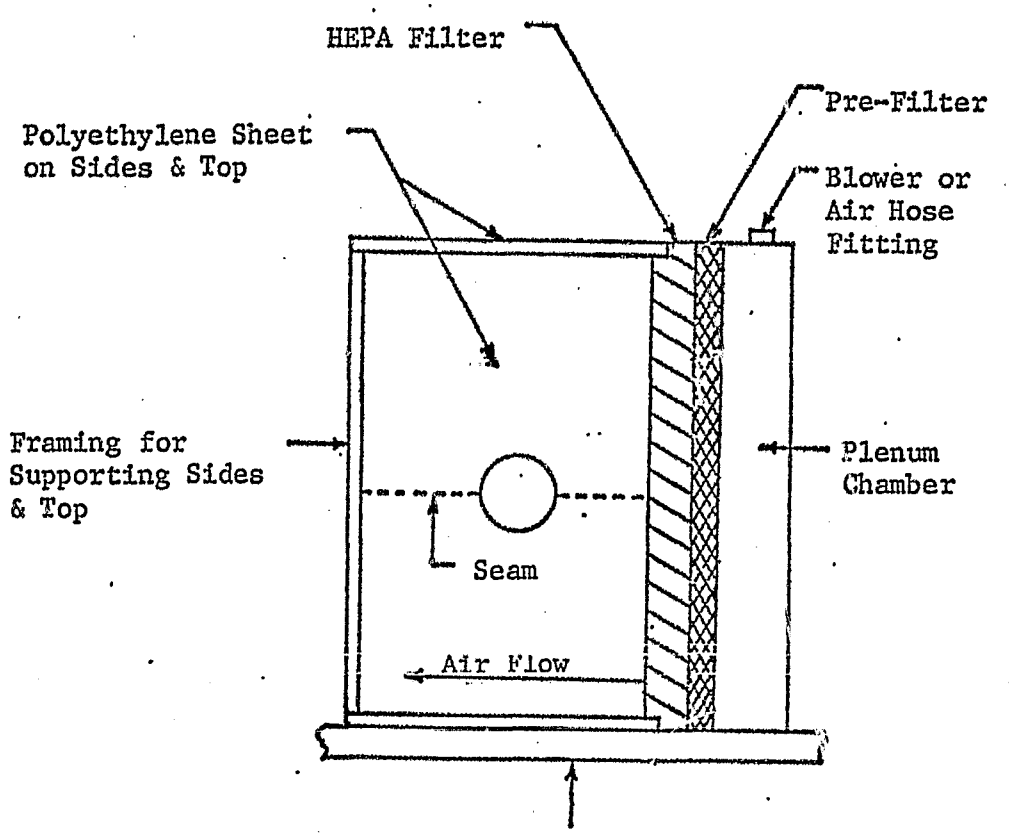
NOTES: (1) Polyethylene sheet is wrapped around that portion of system to be protected. Butting edges of polyethylene are sealed with tape to form a cylinder.

(2) Polyethylene sheet is gathered around pipe and taped firmly to provide a seal.

(3) Access ports are cut in polyethylene at convenient locations.

(4) Atmosphere in enclosure is provided by flow of purge gas from system.

Figure 1 DRY BOX ENCLOSURE



NOTES: (1) Filter assembly is pre-assembled in a suitable housing that provides a plenum chamber and mountings for pre-filter and HEPA filter.

(2) All seams and joints at mating surfaces between polyethylene sheet, framing, and filter assembly shall be sealed with tape, so air flow is out of front of enclosure.

Figure 2 LAMINAR FLOW ENCLOSURE

3.7.4.2.3 Tent Enclosures. - Large, walk-in enclosures may be constructed from polyethylene sheet and suitable framing and reinforcement. The polyethylene sheet shall be wiped visibly clean prior to use with a clean wiping cloth and trichlorotrifluoroethane. Air of a cleanliness level consistent with that of the system shall be supplied to the enclosure by a properly operating HEPA filter assembly with temperature and humidity controls as required. Air flow to the enclosure shall be adequate to prevent contaminants from entering the enclosure. However, the air flow shall not be so great as to force contaminants into the opened system. See Figure 3 for a typical enclosure.

3.7.4.3 Pre-Cleaning. - All exposed noncritical system surfaces within the temporary enclosure shall be cleaned of all visible soils such as dust, grit, scale, oil, and grease prior to opening the system for repair, replacement, or maintenance operations. Cleaning shall be accomplished by thoroughly vacuuming the surfaces followed by wiping with a clean wiping cloth and trichlorotrifluoroethane. All tools and other equipment required for the operation shall be cleaned to a level consistent with the system cleanliness level prior to placement within the controlled environment enclosure.

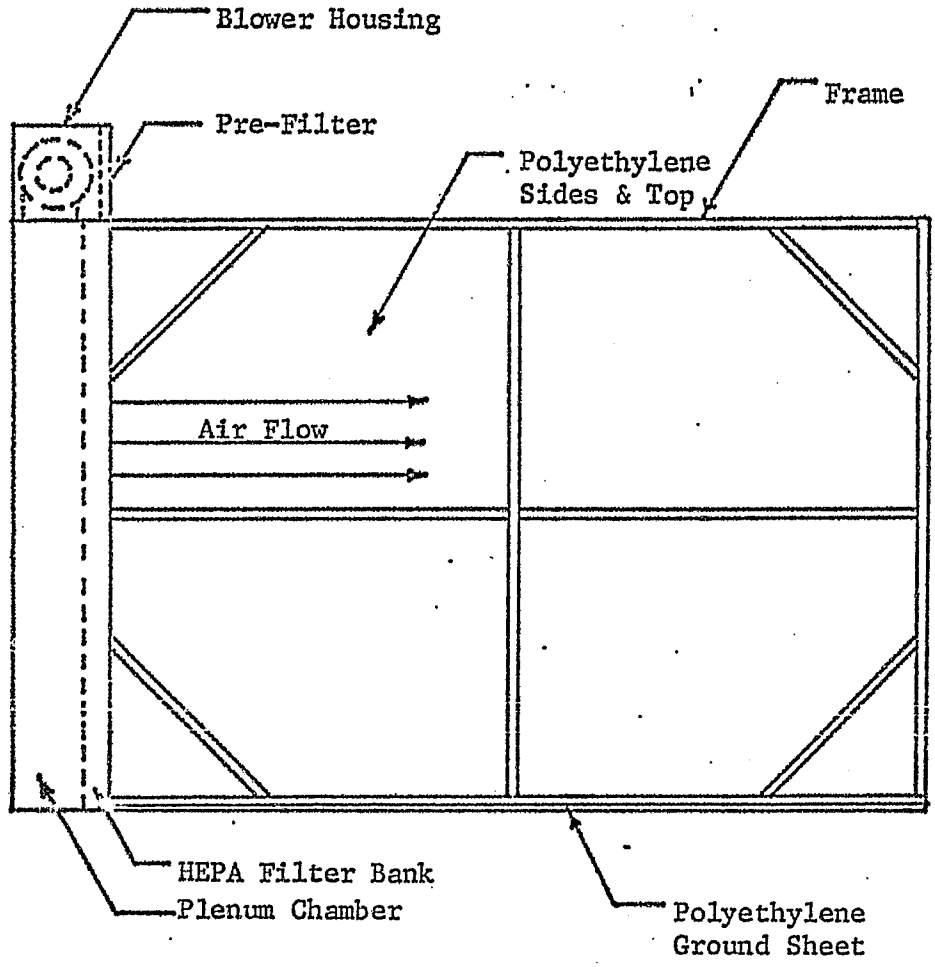
3.7.4.4 System Purge. - A purge with an inert gas shall be maintained on a system during all repair, replacement, or maintenance operations. Purging gas shall meet or exceed the cleanliness level requirements for the system with respect to particulate and condensable hydrocarbon contents. Dew point of the purging gas shall be minus 65 degrees F minimum. The gas flow rate shall be such that a positive pressure from the system to the environment is maintained. Whenever a system is opened and maintenance of a gas purge is impossible, all openings in the system shall be protected by an appropriate method in conformance with 3.11.

3.7.4.5 Repair, Replacement, or Maintenance Operations

3.7.4.5.1 Clothing. - Personnel within the controlled environment enclosure during repair, replacement, or maintenance operations shall be attired in clean room clothing to maintain cleanliness level requirements within the enclosure consistent with the system cleanliness level. Clean room clothing shall meet the requirements of 3.7.3.

3.7.4.5.2 Tools and Equipment. - Tools, equipment, replacement components, and all other items used in the controlled environment enclosure shall be cleaned to a level consistent with the system cleanliness level prior to placement within the enclosure. All cleaned items shall be protected in accordance with 3.11. Opening of cleaned and packaged items or tools shall be accomplished only in the controlled environment.

3.7.4.5.3 Operation Log. - A log of all items and equipment entering or leaving the controlled environment enclosure shall be maintained. All items and equipment shall be accounted for upon completion of any repair, replacement, or maintenance operation.



NOTES: (1) Front of enclosure may be open or may be equipped with a screen containing a suitable door to control personnel access. Air flow must be unrestricted.

(2) Air supplied to HEPA filter may be conditioned by the use of refrigeration and humidity control equipment as required.

Figure 3 WALK-IN ENCLOSURE

3.7.4.5.4 Enclosure Operation. - No operations shall be accomplished within a controlled environment enclosure unless the system purge and filtered air input are on. The system purge and filtered air input shall be maintained until all operations are completed and the system is secured.

3.7.4.6 Approvals

3.7.4.6.1 Equipment and Procedure Approval. - Prior to beginning repair, replacement, or maintenance operations, approval of the procuring activity in writing shall be obtained for the equipment and procedures to be used in accomplishing these operations. The contractor shall be required to submit a statement in writing to the procuring activity containing the following information:

(a) Method of environmental control.

(b) Processing materials to be used.

(c) Processing equipment to be used.

(d) Repair, replacement, or maintenance procedures to be used.

(e) Quality assurance provisions to be used.

3.7.4.6.1.1 Certification of Equipment. - Unless otherwise specified by the procuring activity, the equipment to be used in accomplishing repair, replacement, or maintenance operations shall be certified by the procuring activity for compliance with this specification prior to beginning these operations. Compliance shall include functional tests where applicable.

3.7.4.6.2 On-Site Approvals. - Prior to the beginning of repair, replacement, or maintenance operations, all cognizant activities or on-site agencies having jurisdiction shall be advised of the scheduled procedures and the necessary approvals obtained.

3.7.4.7 Quality Assurance Provisions

3.7.4.7.1 Surveillance. - Repair, replacement, and maintenance operations shall be continuously monitored to ascertain compliance with 3.7.4 and the procedure approved by the procuring activity.

3.7.4.7.2 Leak Test. - Unless otherwise specified by the procuring activity, the integrity of the system shall be validated by a system leak check at working pressure after completion of repair, replacement, or maintenance operations.

3.7.4.7.3 Verification of System Cleanliness. - The procuring activity shall determine the necessity for verification of the cleanliness level of a system after completion of repair, replacement, or maintenance operations.

If specified by the procuring activity, the system cleanliness level shall be determined in accordance with the applicable procedures of 4.1, 4.2, 4.3, and 4.4.

3.7.4.7.4 Recleaning. - If the cleanliness level of the system has been compromised by the repair, replacement, or maintenance operations, recleaning shall be accomplished in accordance with the applicable procedures of 3.8, 3.9, and 3.10. Verification of the cleanliness level shall be in accordance with 4.1, 4.2, 4.3, and 4.4.

3.8 Preparation Prior to Field Cleaning

3.8.1 Component Removal. - All subsystem, system, or other related field equipment components that would be harmed if subjected to the cleaning process when left in place shall be removed prior to cleaning. All removed components shall be replaced by temporary hardware. Decontamination of the subsystem, system or other related field equipment may be accomplished as applicable prior to removal (see 3.5.1).

3.8.2 Installation of Temporary Hardware. - All temporary hardware necessary to perform the cleaning process shall be compatible with the processing materials, and the subsystem, system or other related field equipment that is to be cleaned. All openings resulting from the removal of permanent components shall be visibly cleaned of contamination such as dirt, scale, grease, etc., prior to the installation of temporary hardware.

3.8.3 Field Cleaning Equipment

3.8.3.1 Closed-Loop Cleaning Equipment. - The following equipment shall be provided for cleaning and testing subsystems, systems, or other related field equipment by circulation of cleaning media in a closed-loop:

(a) Containers of sufficient capacity to store, retain, or recirculate the process materials utilized on the item being cleaned.

(b) Heating and heat transfer equipment having sufficient capacity to control and maintain the specified temperatures of the process materials at the applicable flow rates. There shall be no dilution of solutions during heating.

(c) Circulating pumps, valves, and other components of sufficient size and capacity to minimize pressure losses in the cleaning system and to be capable of maintaining the flow rates specified in Tables III and IV, and 3.10.3.

(d) Filtration equipment capable of maintaining the applicable cleanliness level as specified in Table I.

TABLE III TUBING DATA

TUBE SIZE (IN.)	WALL THICKNESS (IN.)	INTERNAL DIAMETER (IN.)	VOLUME PER FOOT (GAL)	FLOW RATE AT 4 FPS VELOCITY (GPM)	INTERNAL AREA PER FOOT (SQ FT)	WEIGHT PER FOOT (LB) (1)		
						WATER	TRICHLORO-ETHYLENE	TRICHLORO-TRIFLUORO-ETHANE
1/4	0.020	0.210	0.0018	0.432	0.0549	0.0150	0.0220	0.0237
1/4	0.035	0.180	0.0013	0.317	0.0471	0.0110	0.0161	0.0174
1/4	0.049	0.152	0.0009	0.226	0.0398	0.0078	0.0115	0.0124
3/8	0.028	0.319	0.0041	1.00	0.0835	0.0346	0.0507	0.0546
3/8	0.035	0.305	0.0038	0.91	0.0798	0.0316	0.0463	0.0499
3/8	0.049	0.277	0.0031	0.75	0.0725	0.0261	0.0382	0.0412
1/2	0.035	0.430	0.0075	1.81	0.1126	0.0628	0.0921	0.0992
1/2	0.049	0.402	0.0066	1.58	0.1500	0.0549	0.0805	0.0857
1/2	0.065	0.370	0.0056	1.34	0.0966	0.0463	0.0683	0.0736
3/4	0.049	0.652	0.0173	4.2	0.1707	0.1444	0.2119	0.2282
3/4	0.065	0.620	0.0157	3.8	0.1623	0.1306	0.1916	0.2063
3/4	0.095	0.560	0.128	3.1	0.1466	0.1065	0.1563	0.1683
1	0.049	0.902	0.0332	8.0	0.2361	0.2765	0.4056	0.4368
1	0.065	0.870	0.0309	7.4	0.2277	0.2572	0.3774	0.4064
1	0.095	0.810	0.0268	6.4	0.2121	0.2230	0.3271	0.3523
1 1/4	0.049	1.152	0.0542	13.0	0.3016	0.4511	0.6617	0.7126
1 1/4	0.065	1.120	0.0512	12.3	0.2932	0.4263	0.6254	0.6735
1 1/4	0.095	1.060	0.0458	11.0	0.2775	0.3818	0.5602	0.6033
1 1/2	0.065	1.370	0.0766	18.4	0.3590	0.6379	0.9358	1.0078
1 1/2	0.095	1.310	0.0700	16.8	0.3420	0.5833	0.8556	0.9215
2	0.065	1.870	0.143	34.2	0.4870	1.1884	1.7434	1.8775
2	0.095	1.810	0.134	32.1	0.4740	1.1134	1.6333	1.7590

(1) Static pressure per foot is the same for all tubing sizes: water, 0.433 psi; trichloroethylene, 0.635 psi; trichlorotrifluoroethane, 0.684 psi.

TABLE IV PIPE DATA

NOMINAL PIPE SIZE (IN.)	PIPE SCHEDULE	INTERNAL DIAMETER (IN.)	VOLUME PER FOOT (GAL)	FLOW RATE AT 4 FPS VELOCITY (GPM)	INTERNAL AREA PER FOOT (SQ FT)	WEIGHT PER FOOT (LB)(1)		
						WATER	TRICHLORO-ETHYLENE	TRICHLORO-TRIFLUORO-ETHANE
1/4	40	0.364	0.0054	1.30	0.095	0.045	0.066	0.071
1/4	80	0.302	0.0037	0.90	0.079	0.030	0.045	0.049
1/2	40	0.622	0.0158	3.80	0.163	0.132	0.193	0.208
1/2	80	0.546	0.0122	2.93	0.143	0.102	0.149	0.161
1/2	160	0.466	0.0089	2.24	0.122	0.074	0.109	0.117
3/4	40	0.824	0.0278	6.66	0.216	0.232	0.340	0.366
3/4	80	0.742	0.0226	5.42	0.194	0.188	0.276	0.297
3/4	160	0.614	0.0154	3.70	0.161	0.128	0.188	0.203
3/4	XX	0.434	0.0077	1.85	0.113	0.064	0.094	0.101
1	40	1.049	0.0450	10.8	0.275	0.375	0.550	0.592
1	80	0.957	0.0374	8.97	0.251	0.311	0.457	0.492
1	160	0.815	0.0272	6.53	0.214	0.227	0.332	0.358
1	XX	0.599	0.0145	3.49	0.157	0.121	0.177	0.191
1 1/4	40	1.380	0.0779	18.7	0.361	0.649	0.950	1.025
1 1/4	80	1.278	0.0664	15.9	0.335	0.553	0.811	0.874
1 1/4	160	1.160	0.0550	13.2	0.304	0.458	0.672	0.723
1 1/4	XX	0.846	0.0292	7.0	0.224	0.243	0.359	0.384
1 1/2	40	1.610	0.1060	25.4	0.421	0.883	1.295	1.395
1 1/2	80	1.500	0.0923	22.1	0.393	0.769	1.128	1.215
1 1/2	160	1.338	0.0730	17.5	0.350	0.608	0.892	0.961
1 1/2	XX	1.100	0.0485	11.9	0.295	0.404	0.593	0.638
2	40	2.067	0.1750	42.0	0.542	1.46	2.14	2.30
2	80	1.939	0.1540	37.0	0.507	1.28	1.88	2.03

(1) Static pressure per foot is the same for all pipe sizes: water, 0.433 psi; trichloroethylene, 0.635 psi; trichlorotrifluoroethane, 0.684 psi.

TABLE IV PIPE DATA (CONT'D)

NOMINAL PIPE SIZE (IN.)	PIPE SCHEDULE	INTERNAL DIAMETER (IN.)	VOLUME PER FOOT (GAL)	FLOW RATE AT 4 FPS VELOCITY (GPM)	INTERNAL AREA PER FOOT (SQ FT)	WEIGHT PER FOOT (LB)(1)		
						WATER	TRICHLORO-ETHYLENE	TRICHLORO-TRIFLUORO-ETHANE
2	160	1.689	0.1170	28.1	0.442	0.97	1.43	1.54
2	XX	1.503	0.0924	22.2	0.398	0.77	1.13	1.22
2 1/2	40	2.469	0.2500	60.0	0.646	2.08	3.06	3.29
2 1/2	80	2.323	0.2220	53.3	0.600	1.85	2.71	2.92
2 1/2	160	2.125	0.1850	44.4	0.556	1.54	2.26	2.43
2 1/2	XX	1.770	0.128	30.7	0.464	1.07	1.56	1.68
3	40	3.068	0.386	92.5	0.804	3.22	4.72	5.08
3	80	2.900	0.354	85.0	0.758	2.95	4.33	4.66
3	160	2.625	0.283	68.0	0.687	2.36	3.46	3.72
3	XX	2.250	0.207	49.7	0.589	1.72	2.53	2.72
3 1/2	40	3.548	0.516	124	0.929	4.30	6.31	6.79
3 1/2	80	3.364	0.464	111	0.882	3.87	5.67	6.11
3 1/2	XX	2.728	0.304	72.9	0.195	2.53	3.71	4.00
4	40	4.026	0.664	159	1.055	5.53	8.11	8.74
4	80	3.826	0.598	144	1.00	4.98	7.31	7.87
4	160	3.438	0.484	116	0.90	4.03	5.91	6.37
5	40	5.047	1.04	245	1.32	8.66	12.71	13.69
5	80	4.813	0.946	227	1.26	7.88	11.56	12.45
5	160	4.313	0.762	183	1.13	6.35	9.31	10.03
6	40	6.065	1.55	372	1.59	12.9	18.9	20.4
6	80	5.761	1.36	326	1.51	11.3	16.6	17.9
6	160	5.189	1.10	264	1.36	9.2	13.4	14.5
8	40	7.981	2.61	625	2.09	21.7	31.9	34.3
8	80	7.625	2.38	570	2.00	19.8	29.1	31.3

(1) Static pressure per foot is the same for all pipe sizes: water, 0.433 psi; trichloroethylene, 0.635 psi; trichlorotrifluoroethane, 0.684 psi.

TABLE IV PIPE DATA (CONT'D)

NOMINAL PIPE SIZE (IN.)	PIPE SCHEDULE	INTERNAL DIAMETER (IN.)	VOLUME PER FOOT (GAL)	FLOW RATE AT 4 FPS VELOCITY (GPM)	INTERNAL AREA PER FOOT (SQ FT)	WEIGHT PER FOOT (LB)(1)		
						WATER	TRICHLORO-ETHYLENE	TRICHLORO-TRIFLUORO-ETHANE
8	160	6.813	1.90	456	1.79	15.8	23.2	25.0
10	40	10.020	4.10	985	2.62	34.1	50.1	54.0
10	80	9.564	3.74	898	2.51	31.2	45.7	49.2
10	160	8.500	2.96	710	2.23	24.7	36.2	39.0
12	40	11.938	5.83	1400	3.13	48.6	71.2	76.7
12	80	11.376	5.29	1270	2.98	44.1	64.6	69.6
12	160	10.126	4.64	1110	2.66	38.7	56.7	61.1
14 OD	10	13.500	7.46	1790	3.54	62.1	91.2	98.2
14 OD	20	13.376	7.30	1750	3.50	60.8	89.2	96.1
14 OD	40	13.126	6.97	1670	3.44	58.1	85.2	91.7
16 OD	10	15.500	9.84	2360	4.06	82.0	120.2	129.5
16 OD	20	15.376	9.63	2310	4.02	80.2	117.7	126.7
16 OD	40	15.000	9.23	2220	3.92	76.9	113.8	121.5
18 OD	10	17.500	12.50	3000	4.58	104.1	152.8	164.5
18 OD	20	17.376	12.35	2960	4.55	102.9	150.9	162.5
18 OD	40	16.876	11.65	2800	4.42	97.0	142.4	153.3

(1) Static pressure per foot is the same for all pipe sizes: water, 0.433 psi; trichloroethylene, 0.635 psi; trichlorotrifluoroethane, 0.684 psi.

(e) Calibrated flow meters of sufficient size to measure the liquid flow rates specified in Tables III and IV, and 3.10.3, and the flow rates of purging and testing gases as specified in 3.10.3 and 4.3.4.

(f) Calibrated pressure gauges capable of interpretation in the middle eighty percent of the scale and accurate to one percent of full-scale.

3.8.3.2 Spray Equipment. - In addition to the equipment specified in 3.8.3.1, spray equipment such as spray wands and rotating head spray machines shall be provided for impinging process solutions on and wetting all internal surfaces of large items such as storage vessels that cannot be cleaned by closed-loop circulation. Closed-loop cleaning cannot be used on items for which either the total volume cannot be filled or the flow rates specified in Tables III and IV cannot be maintained.

3.8.3.2.1 Equipment Requirements. - Spray equipment shall be capable of delivering process solutions at a minimum flow rate of six gallons per minute per foot of diameter at a pressure of 150 to 200 psig. Spray equipment shall provide a spray pattern that forcibly impinges process solutions on and completely wets the interior surface of the item being cleaned. Impingement of process solutions on the surface as a mist or fog shall not be permitted. Rotating spray wands that deliver a spiral spray pattern over the full length of the wand or rotating head spray machines shall be used. Fixed spray wands shall not be used.

3.8.4 Precleaning Validation. - Unless otherwise specified by the procuring activity, the integrity of the subsystem, system, or other related field equipment shall be validated by a pressure test after the installation of all temporary hardware and prior to the beginning of the cleaning process. The test pressure shall be 110 percent of the maximum anticipated cleaning process working pressure and it shall be held for a minimum of five minutes. Under no circumstances shall the proof test pressure of the original subsystem, system, or other related field equipment be exceeded without prior written approval of the procuring activity.

3.8.5 Marking. - All temporary hardware installed in, on, or attached to an item to be cleaned shall be legibly marked as temporary hardware to ensure its removal from the item prior to final acceptance by the procuring activity.

3.8.6 Approvals. - Prior to the beginning of validation or cleaning processes, all cognizant activities or on-site agencies having jurisdiction shall be advised of the scheduled procedures and the necessary approvals obtained.

3.9 Precleaning

3.9.1 Decontamination. - All components and equipment which have been exposed to hypergolic propellants such as nitrogen tetroxide oridizer and hydrazine - unsymmetrical dimethyl hydrazine, and monomethylhydrazine fuels shall be decontaminated prior to accomplishing cleaning operations. Under no circumstances shall propellant contaminated item be transported directly to the cleaning facility. Decontamination shall be accomplished by the use of established and proven methods for the removal and neutralization of propellant residues in an area specifically devoted to decontamination operations. Decontaminated items shall be clearly and legibly marked to indicate that they have been decontaminated. No items shall be accepted at the cleaning facility without proof of decontamination.

3.9.1.1 Items accepted at the cleaning facility which are suspected of residual propellant contamination shall be further decontaminated by use of deionized water. Items which contain closed end sections such as gauges and transducers are most likely to contain propellant residues. Items which may be immersed in water shall be soaked in deionized water for a period of thirty minutes followed by thorough rinsing with unused deionized water. Items which cannot be immersed such as gauges, transducers, and electromechanical devices shall be encased in polyethylene and sealed in such a manner that only the system media entry or exit ports are exposed. The interior of ports and sensing chambers or compartments shall be flushed with deionized water. All items shall be dried with warm, dry nitrogen gas.

3.9.2 Mechanical Descaling. - This method shall be used only when contaminants so generated can be removed and when physical damage to the item being cleaned will not occur. Mechanical descaling may be accomplished by brushing, shot peening, grit blasting, tumbling, or grinding. Corrosion resistant steel surfaces shall be cleaned by brushing with a corrosion resistant steel brush, grinding, or using an abrasive material. Abrasive materials used on corrosion resistant steel surfaces shall contain no ferrous or ferric materials. The use of the same corrosion resistant steel brush for corrosion resistant steels and carbon steels shall be forbidden. All loose dirt, scale, and other debris shall be completely removed from the item by vacuum cleaning, brushing, blowing, or flushing with clean water.

3.9.3 Degreasing

3.9.3.1 Vapor Degreasing. - Items to be vapor degreased shall be processed in such a way that degreasing vapors from trichloroethylene, Type II, conforming to Specification MSFC-SPEC-217, or trichlorotrifluoroethane conforming to Specification MSFC-SPEC-237 shall be blown on, over, or into the component parts that the vapor will condense on and properly degrease all surfaces. Operation of commercial vapor degreasers shall be in accordance with the manufacturer's recommendations.

3.9.3.2 Solvent Degreasing. - Items to be solvent degreased shall be immersed in or partially filled with trichloroethylene, Type II, conforming to Specification MSFC-SPEC-217, or trichlorotrifluoroethane conforming to Specification MSFC-SPEC-237. Items shall be rolled or rocked to ensure that the solvent washes all surfaces requiring degreasing. Solvent degreasing can also be accomplished in a sonic cleaner in accordance with the manufacturer's recommendations.

3.9.3.3 Detergent Degreasing. - Items to be detergent degreased shall be filled, immersed, sprayed, or scrubbed with a 0.5 percent solution of a detergent conforming to Specification MIL-D-16791 and deionized water. Brush, spray, or soak as required for a period of five to fifteen minutes. The temperature of the detergent-water solution shall be maintained at 110 degrees to 130 degrees F.

3.9.3.3.1 Detergent - water solutions that show evidence of cloudiness, haze, or precipitation shall be immediately discarded.

3.9.4 Pickling. - Pickling effectively removes corrosion, rust, weld spatter, or other foreign material not soluble in degreasing solutions.

3.9.4.1 Corrosion Resistant Steel. - Corrosion resistant steel may be pickled in Formula II of 3.10.1 at ambient temperature for a period of 15 minutes to one hour as required. Softened foreign material not actually soluble in the pickling solution may be removed by brushing with a corrosion resistant steel brush as required.

3.9.4.2 Aluminum. - Corrosion may be removed from aluminum by immersion in Formula V of 3.10.1 at ambient temperature for a period of 10 minutes to one hour as required. The use of this solution results in a light, chemical etch of the parent metal.

3.9.4.3 Cupro-Nickel Alloys. - Corrosion may be removed from cupro-nickel alloys by immersion in Formula VII of 3.10.1 at ambient temperature for a period of 10 to 30 minutes as required. The use of this solution results in a light, chemical etch of the parent metal.

3.9.5 Passivation. - Passivation is a supplementary treatment to surfaces that have been acid and mechanically cleaned to prevent corrosion. Care shall be taken to prevent damage to passivated surfaces from scratching, nicking, and abrasion.

3.9.5.1 Corrosion Resistant Steel. - Corrosion resistant steel may be passivated by immersion in Formula III of 3.10.1 at ambient temperature for a period of 30 minutes to two hours as required.

3.9.5.2 Aluminum. - Aluminum may be passivated by immersion in Formula V of 3.10.1 at ambient temperature for a period of 10 to 30 minutes as required.

3.10 Cleaning

3.10.1 Preparation of Cleaning Formulations

3.10.1.1. Formula I for Cleaning Corrosion Resistant Steel. - Formula I, as used in actual cleaning, shall consist of the following composition:

Percent by Volume	Material
5 ± 0.5	85% ortho phosphoric acid
10 ± 0.5	2-butoxyethanol solvent (ethylene glycol monobutyl ether)
0.5 ± 0.05	surfactant (alkyl aryl polyethylene glycol ether)
Remainder	deionized water

3.10.1.1.1 Mixing. - The mixing procedure shall be in accordance with 10.1. The final dilution of Formula I shall result in a clear, colorless, homogeneous solution. Evidence of precipitation, undissolved material, or the development of color shall be cause for rejection.

3.10.1.1.2 Cloud Point. - The cloud point of Formula I shall be between 115 degrees and 200 degrees F.

3.10.1.1.3 Verification of Composition and Cloud Point. - When Formula I is used for field cleaning in accordance with 3.10.3, the composition and cloud point shall be verified, within 24 hours of each use, to 3.10.1.1 and 3.10.1.1.2 when tested in accordance with 4.5.

3.10.1.1.3.1 When Formula I is used for continuous batch cleaning in accordance with 3.10.2, the composition and cloud point shall be verified prior to the initial use of each lot.

3.10.1.1.4 Use. - When Formula I is used for cleaning in accordance with 3.10.2, a single batch shall be used for a maximum of 15 days. The used material shall then be discarded.

3.10.1.1.5 Filtration. - Prior to use, Formula I shall be prefiltered to meet the limits specified for the level of cleanliness of the item to be cleaned when tested in accordance with 4.5.2.

3.10.1.1.6 Storage. - The storage of unused Formula I, when diluted to or manufactured to the composition limits of 3.10.1.1, shall not exceed 60 days.

3.10.1.1.6.1 The storage of unused, concentrated Formula I manufactured in accordance with 3.10.1.1.7, shall not exceed 120 days from the date of manufacture.

3.10.1.1.6.2 The storage of used Formula I shall not exceed 15 days.

3.10.1.1.6.3 The storage temperature shall be maintained between 32 degrees and 100 degrees F. All storage shall be out of direct sunlight.

3.10.1.1.6.4 After storage, Formula I shall meet the clarity requirements of 3.10.1.1.1 prior to use.

3.10.1.1.7 Commercial Preparation. - Formula I may be prepared commercially as a concentrated solution to be diluted on site.

3.10.1.1.7.1 The commercial solution shall consist of the following composition:

Percent by Volume	Material
25 ± 0.5	85% ortho phosphoric acid
50 ± 0.5	2-butoxyethanol solvent (ethylene glycol monobutyl ether)
2.5 ± 0.05	surfactant (alkyl aryl polyethylene glycol ether type)
Remainder	deionized water

3.10.1.1.7.2 The concentrated Formula I shall be diluted by volume in the proportion of one part concentrated solution to four parts dionized water for use in actual cleaning.

3.10.1.1.7.3 The concentrated Formula I shall be packaged in containers not subject to attack by the chemicals used in preparation of the solution.

3.10.1.1.7.4 The date of manufacture of Formula I shall be supplied for each lot of material offered by one manufacturer at one time.

3.10.1.1.7.4.1 Each container shall be clearly and legibly marked to show the date of manufacture.

3.10.1.1.7.5 Final acceptance of a lot of concentrated Formula I shall depend upon the solution diluted in accordance with 3.10.1.1.7.2 meeting all the requirements of 3.10.1 applicable to Formula I when tested in accordance with 4.5.

3.10.1.1.7.5.1 Final acceptance of a lot of concentrated Formula I shall also depend upon at least 90 days of the maximum 120 days storage time still being available for on-site cleaning use at the time of delivery of the lot to the procuring activity.

3.10.1.2 Formula II for Pickling Corrosion Resistant Steel. - Formula II shall consist of the following composition:

Percent by Volume	Material
12 ± 0.5	61% nitric acid
1.5 ± 0.5	48% hydrofluoric acid
Remainder	deionized water

3.10.1.2.1 Verification of Composition. - The composition of Formula II shall be verified to 3.10.1.2 when tested in accordance with 4.5.

3.10.1.3 Formula III for Passivating Corrosion Resistant Steel. - Formula III shall consist of the following composition:

Percent by Volume	Material
15 ± 0.5	61% nitric acid
Remainder	deionized water

3.10.1.3.1 Verification of Composition. - The composition of Formula III shall be verified to 3.10.1.3 when tested in accordance with 4.5.

3.10.1.3.2 Filtration. - Prior to use, Formula III shall be prefiltered to meet the limits specified for the level of cleanliness of the item to be cleaned when tested in accordance with 4.5.2.

3.10.1.4 Formula IV for Cleaning Aluminum Alloys. - Formula IV shall consist of the following composition:

Percent by Weight	Material
9 ± 0.4	2-butoxyethanol solvent (ethylene glycol monobutyl ether)
1.5 ± 0.1	sodium phosphate, dibasic, anhydrous (Na_2HPO_4)
0.5 ± 0.05	surfactant (alkyl aryl polyethylene glycol ether)
Remainder	deionized water

3.10.1.4.1 Mixing. - The mixing procedure shall be in accordance with 10.1. The final dilution of Formula IV shall result in a clear, colorless, homogeneous solution. Evidence of precipitation, undissolved material, or the development of color shall be cause for rejection.

3.10.1.4.2 Cloud Point. - The cloud point of Formula IV shall be between 100 degrees and 180 degrees F.

3.10.1.4.3 Verification of Composition and Cloud Point. - When Formula IV is used for field cleaning in accordance with 3.10.3, the composition and cloud point shall be verified, within 24 hours of each use, to 3.10.1.4 and 3.10.1.4.2 when tested in accordance with 4.5.

3.10.1.4.3.1 When Formula IV is used for continuous batch cleaning in accordance with 3.10.2, the composition and cloud point shall be verified prior to the initial use of each lot.

3.10.1.4.4 Use. - When Formula IV is used for cleaning in accordance with 3.10.2, a single batch shall be used for a maximum of 15 days. The used material shall then be discarded.

3.10.1.4.5 Filtration. - Prior to use, Formula IV shall be prefiltered to meet the limits specified for the level of cleanliness of the item to be cleaned when tested in accordance with 4.5.2.

3.10.1.4.6 Storage. - The storage of unused Formula IV shall not exceed 120 days from the date of manufacture.

3.10.1.4.6.1 The storage of used Formula IV shall not exceed 15 days.

3.10.1.4.6.2 The storage temperature shall be maintained between 32 and 95 degrees F. All storage shall be out of direct sunlight.

3.10.1.4.6.3 After storage, Formula IV shall meet the clarity requirements of 3.10.1.4.1 prior to use.

3.10.1.4.7 Commerical Preparation. - Formula IV may be prepared commercially in accordance with 3.10.1.4. A concentrated formulation cannot be prepared because of the formation of an inhomogeneous solution.

3.10.1.4.7.1 Formula IV shall be packaged in containers not subject to attack by the chemicals used in preparation of the solution.

3.10.1.4.7.2 The date of manufacture of Formula IV shall be supplied for each lot of material offered by one manufacturer at one time.

3.10.1.4.7.2.1 Each container shall be clearly and legibly marked to show the date of manufacture.

3.10.1.4.7.3 Final acceptance of a lot of Formula IV shall depend upon the solution meeting all the requirements of 3.10.1 applicable to Formula IV when tested in accordance with 4.5.

3.10.1.4.7.3.1 Final acceptance of a lot of Formula IV shall also depend upon at least 90 days of the maximum 120 days storage time still being available for on-site cleaning use at the time of delivery of the lot to the procuring activity.

3.10.1.5 Formula V for Brightening and Passivating Aluminum. - Formula V shall consist of the following composition:

Percent by Volume	Material
23 ± 0.5	61% nitric acid
Remainder	deionized water

3.10.1.5.1 Verification of Composition. - The composition of Formula V shall be verified to 3.10.1.5 when tested in accordance with 4.5.

3.10.1.5.2 Filtration. - Prior to use, Formula V shall be prefiltered to meet the limits specified for the level of cleanliness of the item to be cleaned when tested in accordance with 4.5.2.

3.10.1.6 Formula VI for Cleaning Copper and Copper Alloys. - Formula VI shall consist of the following composition:

Percent by Volume	Material
15 ± 0.5	85% ortho phosphoric acid
10 ± 0.5	2-butoxyethanol solvent (ethylene glycol monobutyl ether)
0.5 ± 0.05	surfactant (alkyl aryl polyethylene glycol ether)
Remainder	deionized water

3.10.1.6.1 Mixing. - The mixing procedure shall be in accordance with 10.1. The final dilution of Formula VI shall result in a clear, colorless, homogeneous solution. Evidence of precipitation, undissolved material, or the development of color shall be cause for rejection.

3.10.1.6.2 Cloud Point. - The cloud point of Formula VI shall be between 115 and 200 degrees F.

3.10.1.6.3 Verification of Composition and Cloud Point. - When Formula VI is used for field cleaning in accordance with 3.10.3, the composition and cloud point shall be verified, within 24 hours of each use, to 3.10.1.6 and 3.10.1.6.2 when tested in accordance with 4.5.

3.10.1.6.3.1 When Formula VI is used for continuous batch cleaning in accordance with 3.10.2, the composition and cloud point shall be verified prior to the initial use of each lot.

3.10.1.6.4 Use. - When Formula VI is used in accordance with 3.10.2, a single batch shall be used for a maximum of 15 days. The used material shall then be discarded.

3.10.1.6.5 Filtration. - Prior to use, Formula VI shall be prefiltered to meet the limits specified for the level of cleanliness of the item to be cleaned when tested in accordance with 4.5.2.

3.10.1.6.6 Storage. - The storage of unused Formula VI, when diluted to or manufactured to the composition limits of 3.10.1.6, shall not exceed 60 days.

3.10.1.6.6.1 The storage of unused, concentrated Formula VI manufactured in accordance with 3.10.1.6.7 shall not exceed 120 days from the date of manufacture.

3.10.1.6.6.2 The storage of used Formula VI shall not exceed 15 days.

3.10.1.6.6.3 The storage temperature shall be maintained between 32 and 100 degrees F. All storage shall be out of direct sunlight.

3.10.1.6.6.4 After storage, Formula VI shall meet the clarity requirements of 3.10.1.6.1 prior to use.

3.10.1.6.7 Commercial Preparation. - Formula VI may be prepared commercially as a concentrated solution to be diluted on site.

3.10.1.6.7.1 The commerical solution shall consist of the following composition:

Percent by Volume	Material
30 ± 0.5	85% ortho phosphoric acid
20 ± 0.5	2-butoxyethanol solvent (ethylene glycol monobutyl ether)
1 ± 0.05	surfactant (alkyl aryl polyethylene glycol ether type)
Remainder	deionized water

3.10.1.6.7.2 The concentrated Formula VI shall be diluted by volume in the proportion of one part concentrated solution to one part deionized water for use in actual cleaning.

3.10.1.6.7.3 The concentrated Formula VI shall be packaged in containers not subject to attack by the chemicals used in preparation of the solution.

3.10.1.6.7.4 The date of manufacture of Formula VI shall be supplied for each lot of material offered by one manufacturer at one time.

3.10.1.6.7.4.1 Each container shall be clearly and legibly marked to show the date of manufacture.

3.10.1.6.7.5 Final acceptance of a lot of concentrated Formula VI shall depend upon the solution diluted in accordance with 3.10.1.6.7.2 meeting all the requirements of 3.10.1 applicable to Formula VI when tested in accordance with 4.5.

3.10.1.6.7.5.1 Final acceptance of a lot of concentrated Formula VI shall also depend upon at least 90 days of the maximum 120 days storage time still being available for on-site cleaning use at the time of delivery of the lot to the procuring activity.

3.10.1.7 Formula VII for Pickling and Brightening Copper Alloys. - Formula VII shall consist of the following composition:

Percent by Volume	Material
6.5 ± 0.5	93% sulfuric acid
17 ± 0.5	61% nitric acid
Remainder	deionized water

3.10.1.7.1 Verification of Composition. - The composition of Formula VII shall be verified to 3.10.1.7 when tested in accordance with 4.5.

3.10.1.7.2 Filtration. - When Formula VII is used as a brightening agent, it shall be prefiltered prior to use to meet the limits specified for the level of cleanliness of the item to be cleaned when tested in accordance with 4.5.2.

3.10.2 Controlled Environment Cleaning

3.10.2.1 Special Problems. - The configuration of some items such as tubing and hoses present special handling problems. Other special problems are created by the composition of the item to be cleaned such as nonmetallics for o-rings and gaskets.

3.10.2.1.1 Tubing and Hoses. - Tubing or hoses of such a size as to be conveniently cleaned in a controlled environment shall be cleaned as follows:

(a) Clean the exterior surfaces and the end fittings of the tubing or hoses with a detergent solution conforming to 3.9.3.3 and nylon brushes as required.

(b) Rinse with warm water (90 to 100 degrees F) for a minimum of five minutes.

(c) Rinse with deionized water for a minimum of two minutes.

(d) Dry with warm gaseous nitrogen (120 to 140 degrees F).

(e) Flush the end fittings with trichlorotrifluoroethane solvent conforming to Specification MSFC-SPEC-237 for one minute.

(f) Dry with warm gaseous nitrogen (120 to 140 degrees F).

(g) Proceed to the correct method of 3.10.2 for cleaning in accordance

with the specific construction material of the tubing or hose. The following exceptions shall apply to the procedures of 3.10.2 when tubing or hose is cleaned:

(1) Tubing or hose shall be cleaned by the use of a nylon brush and the required cleaning solutions or by the closed-loop circulation of the solutions. Sonic energy shall not be used for cleaning tubing or hose.

(2) Tubing or hose may be treated as a single item, or as grouped items in accordance with 4.2.1.1.

(3) If closed-loop circulation is used as the method of cleaning, the flow rates of Tables III and IV shall apply. The minimum flow rate shall be determined by the largest diameter tubing or hose to be cleaned.

(4) If closed-loop circulation is used as the method of cleaning, closed-loop cleaning equipment shall be furnished in accordance with 3.8.3.1.

(5) All water used for rinsing shall be dumped overboard while the flow rates of Tables III and IV are maintained.

3.10.2.1.2 Nonmetallic Materials

3.10.2.1.2.1 Removal. - Nonmetallic parts may be removed from the item to be cleaned and cleaned as a separate item in accordance with 3.10.2.1.2 as applicable. Nonmetallic parts that cannot be removed from the item to be cleaned shall cause that item to be cleaned as a nonmetallic. Permission for the removal of nonmetallic items may be granted at the discretion of the procuring activity.

3.10.2.1.2.2 The cleaning procedure shall be as follows:

(a) Clean with a solution of detergent and water, prepared in accordance with 3.9.3, for five to fifteen minutes. Upon prior approval of the procuring activity, prefiltered tap water may be substituted for deionized water in the preparation of the detergent-water solution. The temperature of the solution shall be maintained at 110 degrees to 130 degrees F. Cleaning may be accomplished by flushing, spraying, soaking, or by sonic energy. Limited brushing with a nylon bristle brush may be allowed; however, brushing time shall be limited to a maximum of five minutes.

(b). Rinse with warm water (90 to 110 degrees F) for a minimum of five minutes.

(c) Rinse with deionized water for a minimum of five minutes. Items that are cleaned in an ultrasonic unit shall be rinsed for an additional ten minutes in an ultrasonic unit.

(d) Immediately upon the completion of step (c), test the cleaned and flushed surfaces for pH. The pH of the cleaned surfaces shall be between 6.0 and 8.0 as tested with narrow-range pH paper in accordance with 4.3. If conformance is not obtained, repeat steps (a) through (d).

(e) Dry with warm gaseous nitrogen (100 to 120 degrees F). A vacuum drying oven is an acceptable substitute.

(f) Flush with trichlorotrifluoroethane or isopropyl alcohol as applicable from Table V for a minimum of one minute. Denatured ethyl alcohol shall not be used as a test solvent.

CAUTION

Most plastics are compatible with trichlorotrifluoroethane while most elastomers are compatible with isopropyl alcohol for short term exposures to these solvents. See Table V for a guide to the solvent compatibility of nonmetallic materials. While solvents other than trichlorotrifluoroethane and isopropyl alcohol are listed in Table V, they shall not be used as test solvents. Listings in Table V serve to caution the user as to the detrimental effects of solvents on nonmetallics. If doubt exists as to the solvent compatibility of a nonmetallic material, a preliminary test shall be made by immersing a test coupon in the test solvent for four hours at ambient temperature.

(g) After flushing, collect a sample of test solvent for verification of the level of cleanliness of the item being cleaned in accordance with 4.3.

(h) Immediately upon the completion of step (g), dry with warm gaseous nitrogen (100 to 120 degrees F) until all traces of solvent have been removed. A vacuum drying oven is an acceptable substitute.

TABLE V. GUIDE TO SOLVENT COMPATIBILITY OF NONMETALLIC MATERIALS

CHEMICAL TYPE	COMMON NAME OR TYPICAL TRADENAME	RESISTANCE TO SOLVENT							
		Trichloro-trifluoro-ethane	Trichloro-ethylene	Carbon Tetra-chloride	Ethyl Alcohol	Isopropyl Alcohol	Acetone	Benzene	Cleaning[a] Solution
Plastics									
Acetal	Delrin	S	S	S	S	S	S	S	-
Acrylic	Lucite, Plexi-glas	S	U	U	U	U	U	U	
Chlorotrifluorcethylene	Kel F, CTFE	S	S	S	S	S	S	S	S
Polyamide	Nylon	S	S	S	U	-	S	S	S
Polyethylene		S	U	U	S	S	U	U	S
Polystyrene		S	U	U	S	S	U	U	-
Polytetrafluoroethylene	Teflon, TFE	S	S	S	S	S	S	S	S
Polyvinyl Alcohol		S	S	S	U	U	U	S	-
Polyvinyl Chloride		S	U	-	S	S	U	S	-
Elastomers									
Butadiene/Acrylonitrile	Buna N, NBR, Nitrile	S	U	U	S	S	U	U	-
Butadiene/Styrene	Buna S, SBR, GR-S	U	U	U	S	S	U	U	-
Chloroprene	Neoprene, CR, GR-M	S	U	U	S	S	U	U	-
Chlorosulfonated Poly-ethylene	Hypalon, CSM	S	U	U	S	S	U	U	-
Hexafluoropropylene/ Vinylidene Fluoride	Viton A, FPM	S	S	S	S	S	U	S	S
Isoprene	Natural Rubber	U	U	U	S	S	S	U	S
Polysiloxane	Silicone	U	U	U	S	S	U	U	-
Polysulfide	Thiokol, GR-P	S	U	U	S	S	U	S	-
Polyurethane	Adiprene	S	U	U	U	U	U	U	-

S - Satisfactory for short term exposure, i.e., up to four hours, to indicated solvent
U - Unsatisfactory for exposure to indicated solvent
- No data
(a) 10% 2-butoxyethanol + 0.5% surfactant in water

3.10.2.2 Corrosion Resistant Steel

3.10.2.2.1 Items not Requiring Pickling

(a) Solvent or vapor degrease in accordance with 3.9.3 as required for the removal of heavy oily soil only. Normal atmospheric soil does not require degreasing prior to the use of Formula I. Items not requiring degreasing shall be wiped or vacuumed to remove all loose contamination prior to entry into a controlled environment.

(b) Dry with gaseous nitrogen as required.

NOTE

Steps (a) and (b) may be accomplished in a light industrial atmosphere. Steps (c) through (m) shall be accomplished in a controlled environment with a level of cleanliness adequate to ensure the final level of cleanliness of the cleaned item. All fluids used in steps (c) through (m) shall be prefiltered prior to use to meet the limits specified for the level of cleanliness of the item to be cleaned when tested in accordance with 4.5.2.

(c) Clean with Formula I, prepared in accordance with 3.10.1, for 30 minutes to two hours. The temperature of the solution shall be maintained at 80 to 105 degrees F. Cleaning may be accomplished by flushing, soaking, and brushing, or by sonic energy. Items that are cleaned by soaking shall be agitated at least once every ten minutes to ensure that fresh solution reaches all surfaces. Cleaning by closed-loop circulation shall be considered a special problem in accordance with 3.10.2.1.

CAUTION

All mixtures containing organic solvents have a tendency to give off vapors. Formula I should be used with adequate ventilation. Tanks used for storage of Formula I shall be provided with covers to prevent loss of solvent and to ensure the cleanliness of the solution.

(d) Rinse with warm water (90 to 110 degrees F) for a minimum of five minutes.

(e) Rinse with deionized water for a minimum of three minutes. Items that are cleaned in an ultrasonic unit shall be rinsed for an additional ten minutes in an ultrasonic unit.

(f) Passivate with Formula III, prepared in accordance with 3.10.1, for 15 minutes to one hour. The temperature of the solution shall be maintained at ambient.

CAUTION

Corrosion resistant steel joints that have been silver-brazed, or components that have been silver plated shall not be immersed in nitric acid solutions.

(g) Rinse with warm water (90 to 110 degrees F) for a minimum of five minutes.

(h) Rinse with dionized water for a minimum of five minutes.

(i) Immediately upon the completion of step (h), test the cleaned and flushed surfaces for pH. The pH of the cleaned surfaces shall be between 6.0 and 8.0 as tested with narrow-range pH paper in accordance with 4.3. If conformance is not obtained, repeat steps (g) and (h).

(j) Dry with warm gaseous nitrogen (120 to 140 degrees F). A vacuum drying oven is an acceptable substitute.

(k) Flush with trichlorotrifluoroethane solvent conforming to Specification MSFC-SPEC-237 for a minimum of one minute.

(l) After flushing, collect a sample of trichlorotrifluoroethane solvent for verification of the level of cleanliness of the item being cleaned in accordance with 4.3.

(m) Dry with warm gaseous nitrogen (120 to 140 degrees F). A vacuum drying oven is an acceptable substitute.

3.10.2.2.2 Items Requiring Pickling

(a) Solvent or vapor degrease in accordance with 3.9.3.

(b) Dry with gaseous nitrogen as required.

(c) Detergent degrease in accordance with 3.9.3 as required.

(d) Rinse with warm water (90 to 110 degrees F) for a minimum of five minutes if step (c) is used.

(d) Pickle with Formula II, prepared in accordance with 3.10.1, for 15 minutes to one hour. The temperature of the solution shall be maintained at ambient.

CAUTION

Corrosion resistant steel joints that have been silver-brazed, or components that have been silver plated shall not be immersed in nitric acid solutions.

(e) Rinse with warm water (90 to 120 degrees F) for a minimum of five minutes.

(f) Rinse with deionized water for a minimum of three minutes.

(g) Dry with warm gaseous nitrogen (120 to 140 degrees F).

NOTE

Steps (a) through (g) may be accomplished in a light industrial atmosphere. Step (h), and steps (c) through (m) of 3.10.2.1.1 shall be accomplished in a controlled environment with a level of cleanliness adequate to ensure the final level of cleanliness of the cleaned item All fluids used in step (h) and steps (c) through (m) of 3.10.2.1.1 shall be prefiltered prior to use to meet the limits specified for the level of cleanliness of the item to be cleaned when tested in accordance with 4.5.2.

(h) Proceed with steps (c) through (m) of 3.10.2.1.1.

3.10.2.3 Aluminum. - The cleaning procedure shall be as follows:

(a) Solvent or vapor degrease in accordance with 3.9.3 as required for the removal of heavy oily soil only or prior to corrosion removal. Normal atmospheric soil does not require degreasing prior to the use of Formula IV. Items not requiring degreasing shall be wiped or vacuumed to remove all loose contamination prior to entry into a controlled environment.

(b) Dry with gaseous nitrogen as required.

(c) Corrosion may be removed by immersion in Formula V prepared in accordance with 3.10.1.5, at ambient temperature for a period of ten minutes to one hour as required.

(d) Rinse with warm water (90 to 110 degrees F) for a minimum of five minutes.

(e) Rinse with deionized water for a minimum of three minutes.

(f) Dry with warm gaseous nitrogen (120 to 140 degrees F).

NOTE

Steps (a) through (f) may be accomplished in a light industrial atmosphere. Steps (d) through (f) shall be required if step (c) has been used. Steps (g) through (q) shall be accomplished in a controlled environment with a level of cleanliness adequate to ensure the final level of cleanliness of the cleaned item. All fluids used in steps (g) through (q) shall be prefiltered prior to use to meet the limits specified for the level of cleanliness of the item to be cleaned when tested in accordance with 4.5.2.

(g) Clean with Formula IV, prepared in accordance with 3.10.1.4, for 30 minutes to two hours. The temperature of the solution shall be maintained at 80 to 95 degrees F. Cleaning may be accomplished by flushing, soaking, and brushing, or by sonic energy. Items that are cleaned by soaking shall be agitated at least once every ten minutes to ensure that fresh solution reaches all surfaces. Cleaning by closed-loop circulation shall be considered a special problem in accordance with 3.10.2.1.

CAUTION

All mixtures containing organic solvents have a tendency to give off vapors. Formula IV should be used with adequate ventilation. Tanks used for storage of Formula IV shall be provided with covers to prevent loss of solvent and to ensure the cleanliness of the solution.

(h) Rinse with warm water (90 to 110 degrees F) for a minimum of five minutes.

(i) Rinse with deionized water for a minimum of three minutes. Items that are cleaned in an ultrasonic unit shall be rinsed for an additional ten minutes in an ultrasonic unit.

(j) Items may be brightened and additionally passivated by immersion in Formula V prepared in accordance with 3.10.1.5, for ten to thirty minutes. The temperature of the solution shall be maintained at ambient. Cleaning with Formula IV provides light passivation that is sufficient for most applications.

(k) Rinse with warm water (90 to 110 degrees F) for a minimum of five minutes.

(l) Rinse with deionized water for a minimum of five minutes.

NOTE

Steps (k) and (l) shall be required if step (j) has been used. If step (j) has not been used, proceed from step (i) to step (m).

(m) Immediately upon the completion of the rinse cycle (step (i) or step (l)), test the cleaned and flushed surfaces for pH. The pH of the cleaned surfaces shall be between 6.0 and 8.0 as tested with narrow-range pH paper in accordance with 4.3. If conformance is not obtained, repeat steps (a) through (l).

(n) Dry with warm gaseous nitrogen (120 to 140 degrees F). A vacuum drying oven is an acceptable substitute.

(o) Flush with trichlorotrifluoroethane solvent conforming to Specification MSFC-SPEC-237 for a minimum of one minute.

(p) After flushing, collect a sample of trichlorotrifluoroethane solvent for verification of the level of cleanliness of the item being cleaned in accordance with 4.3.

(q) Dry with warm gaseous nitrogen (120 to 140 degrees F). A vacuum drying oven is an acceptable substitute.

3.10.2.4 Copper and Copper Alloys. - The cleaning procedure shall be as follows:

(a) Solvent or vapor degrease in accordance with 3.9.3 as required for the removal of heavy oily soil only, or prior to the removal of heavy corrosion and excessive oxidation. Normal atmospheric soil, light corrosion, and oxidation are removed by the use of Formula VI. Items not requiring degreasing shall be wiped or vacuumed to remove all loose contamination prior to entry into a controlled environment.

(b) Dry with gaseous nitrogen as required.

(c) Heavy corrosion may be removed by immersion in Formula VII, prepared in accordance with 3.10.1.7, at ambient temperature for a period of ten to thirty minutes as required.

(d) Rinse with warm water (90 to 110 degrees F) for a minimum of five minutes.

(e) Rinse with deionized water for a minimum of three minutes.

(f) Dry with warm gaseous nitrogen (120 to 140 degrees F).

NOTE

Steps (a) through (f) may be accomplished in a light industrial atmosphere. Steps (d) through (f) shall be required if step (c) has been used. Steps (g) through (q) shall be accomplished in a controlled environment with a level of cleanliness adequate to ensure the final level of cleanliness of the cleaned item. All fluids used in steps (g) through (q) shall be prefiltered prior to use to meet the limits specified for the level of cleanliness of the item to be cleaned when tested in accordance with 4.5.2.

(g) Clean with Formula VI, prepared in accordance with 3.10.1.6, for 60 to 90 minutes. The temperature of the solution shall be maintained at 80 to 105 degrees F. Cleaning may be accomplished by flushing, soaking, and brushing, or by sonic energy. Items that are cleaned by soaking shall be agitated at least once every ten minutes to ensure that fresh solution reaches all surfaces. Cleaning by closed-loop circulation shall be considered a special problem in accordance with 3.10.2.1.

CAUTION

All mixtures containing organic solvents have a tendency to give off vapors. Formula VI should be used with adequate ventilation. Tanks used for storage of Formula VI shall be provided with covers to prevent loss of solvent and to ensure the cleanliness of the solution.

(h) Rinse with warm water (90 to 110 degrees F) for a minimum of five minutes.

(i) Rinse with deionized water for a minimum of three minutes. Items that are cleaned in an ultrasonic unit shall be rinsed for an additional ten minutes in an ultrasonic unit.

(j) Cupro-nickel alloys and silicon bronzes may be brightened by immersion in Formula VII, prepared in accordance with 3.10.1.7, at ambient temperature for a period of ten to thirty minutes as required.

(k) Rinse with warm water (90 to 110 degrees F) for a minimum of five minutes.

(l) Rinse with deionized water for a minimum of five minutes.

NOTE

Steps (k) and (l) shall be required if step (j) has been used. If step (j) has not been used, proceed from step (i) to step (m).

(m) Immediately upon the completion of the rinse cycle (step (i) or step (l)), test the cleaned and flushed surfaces for pH. The pH of the cleaned surfaces shall be between 6.0 and 8.0 as tested with narrow-range pH paper in accordance with 4.3. If conformance is not obtained, repeat steps (a) through (i).

(n) Dry with warm gaseous nitrogen (120 to 140 degrees F). A vacuum drying oven is an acceptable substitute.

(o) Flush with trichlorotrifluoroethane solvent conforming to Specification MSFC-SPEC-237 for a minimum of one minute.

(p) After flushing, collect a sample of trichlorotrifluoroethane solvent for verification of the level of cleanliness of the item being cleaned in accordance with 4.3.

(q) Dry with warm gaseous nitrogen (120 to 140 degrees F). A vacuum drying oven is an acceptable substitute.

3.10.2.5 Coated Aluminum

3.10.2.5.1 Aluminum that has an anodized or chemically converted coated surface shall be considered a nonmetallic material and shall be cleaned in accordance with 3.10.2.1.2 except that brushing shall not be allowed.

3.10.3 Cleaning in the Field. - Field cleaning becomes complex because the size and configuration of large items make it difficult to circulate

or spray solutions and to remove them completely. Whenever possible, precleaning operations such as pickling and passivating should be accomplished prior to installation. Final welds should be made under inert atmosphere to minimize scale formation, and they should be individually precleaned, pickled and passivated as required in accordance with 3.9.3. Major corrosion problems in used systems should be treated as subsystems or assemblies whenever possible. Only upon prior written approval of the procuring activity shall an entire field system be pickled or passivated at one time. Preparation prior to field cleaning shall be in accordance with 3.8.

3.10.3.1 Precleaning. - All critical surfaces of subsystems, systems, storage vessels, or other items in the field shall be visibly free of corrosion, dirt, grease, scale or other foreign matter prior to final cleaning in accordance with 3.10.3. Precleaning to remove gross contamination, and to pickle and passivate final welds as required shall be in accordance with 3.9.3. ← should this be 3.9.4 ?

3.10.3.2 Corrosion Resistant Steel Cleaned by Closed-Loop Circulation of Solutions. - The circulation of Formula I in accordance with step (a) provides sufficient passivation for a system precleaned in accordance with 3.10.3.1 so that an additional passivation step is not required. The final cleaning procedure shall be as follows:

(a) Circulate Formula I, prepared in accordance with 3.10.1, through the system for one hour to two hours at a minimum fluid velocity of four feet per second. See Tables III and IV of 3.8.3 for circulation data.

NOTE

All fluids used in 3.10.3.2 shall be prefiltered prior to use to meet the limits specified for the level of cleanliness of the item to be cleaned when tested in accordance with 4.5.2.

(b) The temperature of Formula I shall be maintained at 85 to 105 degrees F during circulation. If immersion heaters are used to warm the solution, their surface temperature shall not exceed 350 degrees F.

CAUTION

Do not heat Formula I above 110 degrees F as part of the solvent may be lost.

(c) Upon prior approval of the procuring activity, a thorough 15-minute overboard flush of the system with tap water at ambient temperature and prefiltered to meet the limits specified for the level of cleanliness of the item being

cleaned in accordance with 4.5.2, may be substituted in place of the first 15 minutes of the flush with deionized water of step (d). The overboard flush shall be at a minimum fluid velocity of four feet per second. See Tables III and IV of 3.8.3 for circulation data.

(d) Flush the system thoroughly with deionized water at ambient temperature for a minimum of thirty minutes (or an additional 15 minutes provided step (c) was used) at a minimum fluid velocity of four feet per second. All water used for flushing shall be dumped overboard.

(e) At the end of the 30-minute water flush, continue to flush at a velocity of four feet per second in order to obtain a 2500 milliliter sample of flush water in a dry, cleaned sampler. The water sample shall be obtained from the lowest point in the system.

NOTE

Care shall be taken in obtaining the water sample not to contaminate the sample with the surrounding environment.

(f) The water sample shall be analyzed in accordance with 4.3. If the desired level of cleanliness has not been reached, drain the remaining water from the system, and repeat steps (a) through (f).

(g) Immediately, upon completion of step (e), test the effluent water for pH. The pH of the effluent water shall be between 6.0 and 8.0 as tested with narrow-range pH paper in accordance with 4.3. If conformance is not obtained, continue to flush with deionized water for another 15 minutes and retest for pH. A second failure of conformance to pH range shall be cause for rejection, and the system shall be recleaned in accordance with steps (a) through (g).

(h) Dry the system with gaseous nitrogen to a dew point of minus 65 degrees F at all critical ports as tested in accordance with 4.3. The final five minutes of the gaseous nitrogen purge shall be at the system normal operating pressure when it can be attained. If the system normal operating pressure cannot be attained, the minimum gaseous nitrogen purge velocity at the fartherest downstream exit port shall be 35 SCFM as measured with a calibrated flowmeter.

(i) Circulate trichloroethylene or trichlorotrifluoroethane (see 4.3.4.1.1) at a minimum fluid velocity of four feet

per second. Circulation shall be maintained until a minimum of one system volume of test solvent passes through the item, or for a minimum of thirty minutes, whichever time is longer. All instrument measurement, gauge, and vent ports shall have the test solvent flushed through them a minimum of two times during circulation.

(j) At the end of the circulation period, obtain a 2500 milliliter sample of the test solvent in a dry, cleaned sampler. The test solvent sample shall be obtained from the lowest point in the system while the solvent is circulating.

NOTE

Care shall be taken in obtaining the solvent sample not to contaminate the sample with the surrounding environment.

(k) The solvent sample shall be analyzed in accordance with 4.3. If the desired level of cleanliness has not been reached, the system shall be recleaned in accordance with steps (a) through (k).

(l) Dry the system with gaseous nitrogen to a dew point of minus 65 degrees F at all critical ports in accordance with 4.3. The final five minutes of the gaseous nitrogen purge shall be at the system normal operating pressure when it can be attained. If the system normal operating pressure cannot be attained, the minimum gaseous nitrogen purge velocity at the fartherest downstream exit port shall be 35 SCFM as measured with a calibrated flowmeter.

3.10.3.3 Corrosion Resistant Steel Cleaned by Solution Spraying. - Items having a size or configuration that cannot be cleaned by circulating a fluid through the item at a minimum fluid velocity of four feet per second shall be cleaned by the use of spray equipment. Spray equipment shall meet the requirements of 3.8.3.2. Preparation prior to field cleaning shall be in accordance with 3.8. The final cleaning procedure shall be as follows:

(a) Spray Formula I, prepared in accordance with 3.10.1, over the critical surfaces of the item for one hour to two hours at a minimum flow rate of six gallons per minute per foot of item maximum internal diameter at a spray head delivery pressure of 150 to 200 psig. (Example: an item with a maximum internal diameter of five feet shall require a minimum flow rate of 30 gallons per minute at a spray head

delivery pressure of 150 to 200 psig). Care shall be taken to impinge on and wet all critical surfaces. The solution may be returned to the reservoir.

(b) The temperature of Formula I shall be maintained at 85 to 105 degrees F during spraying. If immersion heaters are used to warm the solution, their surface temperature shall not exceed 350 degrees F.

CAUTION

Do not heat Formula I above 110 degrees F as part of the solvent may be lost.

(c) Upon prior approval of the procuring activity, a thorough 15-minute overboard rinse of the item by spraying with tap water at ambient temperature and prefiltered to meet the limits specified for the level of cleanliness of the item being cleaned in accordance with 4.5.2, may be substituted in place of the first 15 minutes of rinse with deionized water of step (d). The overboard rinse shall be at the delivery rate of step (a).

(d) Rinse the system thoroughly by spraying at the delivery rate of step (a) with deionized water at ambient temperature for a minimum of 30 minutes (or an additional 15 minutes provided step (c) was used) at the delivery rate of step (a). All water used for rinsing shall be dumped overboard. Continue rinsing as required until all visible evidence of surfactant has disappeared from the rinse water. Care shall be taken to impinge on and wet all critical surfaces.

(e) Upon the completion of step (d), stop the rinsing and allow the item being cleaned to drain thoroughly. Proceed to step (f) if a rotating head spray machine is used, or proceed to step (g) if a full-length rotating spray wand is used to flush the critical surfaces for the level of cleanliness test.

(f) Lower the spray head to the lowest point of the item being cleaned. Start to spray deionized water at a delivery rate of two to 2.2 gallons per minute per foot of item maximum internal diameter at a spray head delivery pressure of 150 to 200 psig. The spray head shall be raised vertically at a rate of one foot per minute during testing. Test samples shall be taken from a sampling port located at the lowest point of the item being cleaned. The sampling port valve shall be opened sufficiently to allow a 2500 ml sample to be obtained in 58 to 62 seconds. The delivery rate of the

solution through the spray head, the vertical travel of the spray head, and the sampling time must be correlated as specified so that a 2500 ml test sample will represent one square foot of critical surface area. Collect the following test samples of rinse water in dry, cleaned samplers:

(1) Begin to collect the first 2500 ml sample as soon as the solution starts to be sprayed by the rotating head.

(2) Collect a second 2500 ml sample when the spray head has traversed approximately 50 percent of the vertical distance.

(3) Collect a third 2500 ml sample as the spray head approaches the highest point of vertical travel.

(g) Insert the rotating spray wand into the item being cleaned so that the entire critical surface shall be flushed at one time. Start to spray deionized water at a delivery rate of two to 2.2 gallons per minute per foot of item maximum internal diameter at a delivery pressure of 150 to 200 psig. Test samples shall be taken from a sampling port located at the lowest point of the item being cleaned. The sampling port valve shall be opened sufficiently to allow a 2500 ml sample to be obtained in 58 to 62 seconds. The delivery rate of the solution and the sampling time must be correlated as specified so that a 2500 ml test sample will represent one square foot of ciritical surface area. Allow the solution to impinge on the item being cleaned for six minutes, and collect the following test samples of rinse water in dry, cleaned samplers:

(1) Start collecting the first 2500 ml sample at the beginning of the first minute of spraying.

(2) Start collecting the second 2500 ml sample at the beginning of the third minute of spraying.

(3) Start collecting the third 2500 ml sample at the beginning of the fifth minute of spraying.

(h) The water sample shall be analyzed in accordance with 4.3. If the desired level of cleanliness has not been reached, drain the remaining water from the system, and repeat steps (a) through (g).

(i) Immediately upon the completion of step (g), test the effluent water for pH. The pH of the effluent water shall be between 6.0 and 8.0 as tested with narrow-range pH paper in accordance with 4.3. If conformance is not obtained, continue to flush with deionized water for another 15 minutes, and retest for pH. A second failure of conformance to pH range shall be cause for rejection and the system shall be recleaned in accordance with steps (a) through (g).

(j) Dry the system with gaseous nitrogen to a dew point of minus 65 degrees F at all critical ports as tested in accordance with 4.3. The final five minutes of the gaseous nitrogen purge shall be at the system normal operating pressure when it can be attained. If the system normal operating pressure cannot be attained, the minimum gaseous nitrogen purge velocity at the fartherest downstream exit port shall be 35 SCFM as measured with a calibrated flowmeter.

(k) Spray trichloroethylene or trichlorotrifluoroethane (see 4.3. 4.1.1) over the critical surfaces of the item for a minimum of 15 minutes at a minimum flow rate of six gallons per minute per foot of item maximum internal diameter at a spray head delivery pressure of 80 to 100 psig. Care shall be taken to impinge on and wet all critical surfaces.

(l) Upon the completion of step (k), stop the spray and allow the item being cleaned to drain thoroughly.

(m) Repeat step (f) or step (g) for the test solvent except that the delivery pressure shall be 80 to 100 psig.

(n) The test solvent shall be analyzed in accordance with 4.3. If the desired level of cleanliness has not been reached, the system shall be recleaned in accordance with steps (a) through (m).

(o) Dry the system with gaseous nitrogen to a dew point of minus 65 degrees F at all critical ports in accordance with 4.3. The final five minutes of the gaseous nitrogen purge shall be at the system normal operating pressure when it can be attained. If the system normal operating pressure cannot be attained, the minimum gaseous nitrogen purge velocity at the fartherest downstream exit port shall be 35 SCFM as measured with a calibrated flowmeter.

3.10.3.4 Aluminum Cleaned by Closed-Loop Circulation of Solutions. - Formula IV, prepared in accordance with 3.10.1.4, shall be used to clean closed-loop aluminum systems in the field. The cleaning procedure shall be in accordance with 3.10.3.1 and 3.10.3.2, except that the temperature of Formula IV shall be maintained at 80 to 95 degrees F.

3.10.3.4.1 Aluminum alloys that contain high percentages of silicon, copper, or manganese may develop a black deposit (smut) during cleaning. The following cleaning procedure shall apply for aluminum alloys requiring brightening:

(a) Preclean in accordance with 3.10.3.1.

(b) Clean in accordance with steps (a) through (d) of 3.10.3.2, except that Formula IV, maintained at 80 to 95 degrees F shall be used.

(c) If smut has developed, brighten the aluminum by circulating Formula V, prepared in accordance with 3.10.1.5, for 20 to 40 minutes at ambient temperature and at a minimum fluid velocity of four feet per second.

(d) Rinse in accordance with steps (c) and (d) of 3.10.3.2.

(e) Proceed with steps (e) through (1) of 3.10.3.2.

3.10.3.5 Aluminum Cleaned by Solution Spraying. - Formula IV, prepared in accordance with 3.10.1.4, shall be used to clean aluminum items requiring the use of the solution spray technique. The cleaning procedure shall be in accordance with 3.10.3.1 and 3.10.3.3 except that the temperature of Formula IV shall be maintained at 80 to 95 degrees F.

3.10.3.5.1 Aluminum alloys that contain high percentages of silicon, copper, or manganese may develop a black deposit (smut) during cleaning. The following cleaning procedure shall apply for aluminum alloys requiring brightening:

(a) Preclean in accordance with 3.10.3.1.

(b) Clean in accordance with steps (a) through (d) of 3.10.3.3 except that Formula IV, maintained at 80 to 95 degrees F, shall be used.

(c) If smut has developed, brighten the aluminum by spraying Formula V, prepared in accordance with 3.10.1.5, for 20 to 40 minutes at the delivery rate of step (a) of 3.10.3.3, and at ambient temperature.

(d) Rinse in accordance with steps (a) and (d) of 3.10.3.3.

(e) Proceed with steps (e) through (o) of 3.10.3.3.

3.11 Protection

3.11.1 Environmental Control. - All packaging operations shall be accomplished within the same controlled environment as that in which the item to

be packaged was cleaned. Cleaned items shall not be removed from a clean room without being adequately protected in conformance with 3.11. Items cleaned in the field shall be protected in conformance with 3.11 while the environment is controlled according to 3.7.4.

3.11.2 Materials. - Materials shall be compatible with the item to be protected and shall withstand the specified environment for the storage period and mode of delivery.

3.11.2.1 Packaging Films. - All plastic films used for precision packaging shall be procured to the requirements of Table VI. The cleanliness level of Table VII shall prevail for all plastic films procured clean. Acceptance inspection for conformance to the requirements of Tables VI and VII shall be in accordance with 4.6.

TABLE VI. PACKAGING MATERIALS THICKNESS AND SERVICE REQUIREMENTS

FILM	THICKNESS RANGE (MILS)	USE
Polyethylene[a]	5.4 - 6.6	Overwrap only
Nylon 6, or equivalent polyamide[b]	1.7 - 2.3	Precision packaging, NOT for LOX and GOX service
Aclar 33c or equivalent fluorohalocarbon[c]	1.7 - 2.3	Precison packaging, suitable for LOX and GOX service

(a) May be impregnated with antistatic compound for use where static generation is a hazard. Antistatic polyethylene shall have a surface resistivity of not over 10^{12} ohms when measured by Specification ASTM D257-61.

(b) This film has a high resistance to sloughing particles.

(c) This film provides a good barrier to moisture vapor and gas permeability.

TABLE VII. PACKAGING MATERIALS SURFACE CLEANLINESS REQUIREMENTS

PARTICLE SIZE RANGE (MICRONS)	PARTICLES (NO./SQ FT, MAX)	SOLVENT SOLUBLE ORGANIC RESIDUE (MG/SQ FT, MAX)
0-5	Unlimited[a]	1
6-15	50	
16-25	25	
26-50	10	
51-100	5	
> 100	0	

(a) Particles under five microns in size are not counted. However, an accumulation of minute particles of sufficient quantity to cause a haze or obscuring of any portion of a grid line or any portion of the grid on a test filter membrane, when viewed visually or under 40 power maximum magnification, shall be cause for rejection.

3.11.2.1.1 Selection of a specific film shall be dictated by compatibility with the specified service medium. All LOX and GOX parts, components, subsystems, and systems shall be protected with an inner bag or layer(s) of a fluorohalocarbon film such as Aclar 33c conforming to Specification MSFC-SPEC-456 and the requirements of 3.11.2.1. Other parts, components, subsystems, and systems shall be protected with an inner bag or layer(s) of a polyamide film or a fluorohalocarbon film. Polyamide films have a higher resistance to sloughing particles, while fluorohalocarbon films provide a better barrier to moisture vapor and gas permeability. Cognizance of these additional characteristics may be taken by the procuring activity at its discretion.

3.11.2.1.2 Inner bags or layer(s) of film shall be protected by an outer bag or layer(s) of polyethylene.

3.11.2.1.3 All plastic films shall be cleaned to or procured to the cleanliness level of Table VII except that films used to package critical surfaces cleaned to cleanliness levels more restrictive than Table VII shall be cleaned, immediately prior to use, to the cleanliness level of the critical surface.

3.11.2.1.4 Cleaning, whether on-site or prior to procurement, shall be accomplished by dipping, rinsing, or immersing the film in trichlorotrifluoroethane solvent conforming to Specification MSFC-SPEC-237. No other solvent shall be used. There shall be no exceptions.

NOTE

Contact time of trichlorotrifluoroethane with fluorohalocarbon films such as Aclar 33c shall be limited to a maximum of 15 minutes including drying time. Solvent-wet films shall be dried by simple solvent evaporation or purged until dry with nitrogen conforming to Specification MSFC-SPEC-234 and prefiltered, to meet the cleanliness level of the item being precision packaged. Longer contact times between solvent and fluorohalocarbon films result in the film becoming unduly flexible and plasticized.

3.11.2.1.5 All cleaned film, including bags, sheeting, tubing, and roll stock, that is not used immediately after cleaning, shall be overwrapped and sealed in an inner bag made from film of the same type and cleaned to the requirements of 3.11.2.1. All film procured clean shall be overwrapped with a second bag of clean, six mil, antistatic polyethylene prior to packaging for shipment. Roll stock shall be wound on clean cores made from nondusting plastic or metal.

3.11.2.2 Pressure Sensitive Tape. - When tape is specified, the material shall be pressure sensitive, vinyl, and shall conform to Specification PPP-T-66, Type I, Class B.

3.11.2.3 Purging Gas. - When purging gas is specified, the material shall be nitrogen conforming to Specification MSFC-SPEC-234. The gas shall be prefiltered to meet the cleanliness level of the item being precision packaged.

3.11.2.4 Metallic Closures. - When closure plates are specified to seal flanged items, the materials shall be precut and drilled aluminum alloy or stainless steel of 0.125-inch minimum thickness. To prevent electrolytic corrosion, metals dissimilar to item flanges shall not come in contact with the flange under any circumstances. Refer to Specification MS-33586 for definition of dissimilar metals.

3.11.2.4.1 All metallic closures shall be separated from the flanged item with gaskets. Gaskets shall be precut from a minimum of two layers of plastic film conforming to 3.11.2.1 or from a sheet of polytetrafluoroethylene of 0.062-inch minimum thickness.

3.11.2.4.2 Prior to use, all metallic closures and gaskets shall be cleaned to the level of cleanliness of the cleaned item being protected.

3.11.2.5 Plastic Closures. - Plastic closures such as caps, and plugs shall not be used to seal openings of items with precision cleaned internal surfaces. The insertion and removal of plastic closures generate particles that can invalidate the level of cleanliness of the precision cleaned surfaces.

3.11.2.6 Preservatives. - Preservative materials shall not be used on items that have been precision cleaned.

3.11.2.7 Desiccants. - Desiccant materials shall not be sealed within the inner bag containing the precision cleaned item. Upon prior written approval of the procuring activity, an additional layer of polyethylene or a second polyethylene bag may be added over the outer clean bag, and packaged desiccants may be sealed within this extra protective covering.

3.11.2.8 Certification Decal. - A certification of cleanliness level decal(s) shall be applied to the outside of the inner bag in such a manner that the decal(s) shall be destroyed when the integrity of the package or closure is violated. The decals shall conform to Specification MSC-SPEC-C-3 except that the initials of the specific procuring activity shall be imprinted on the decal as applicable. See Table I and Figure 2 of Specification MSC-SPEC-C-3. See 3.12 of this specification for the special information cleaning tags that may be included within the outer clean bag.

3.11.3 Detail Packaging Technique

3.11.3.1 Cutting. - When clean plastic film is to be cut, stainless steel scissors shall be used. The scissor cut shall be started, and the scissor shall be pushed carefully through the film. Sawing and hacking actions resulting from opening and closing the scissors shall be avoided to prevent the generation of particles. Razor blades or other single blade type instruments shall not be used to cut plastic film.

3.11.3.2 Sealing. - An all-purpose impulse sealer shall be used to produce effective seals with plastic films. The recommendations of the manufacturer shall be followed for temperature setting and dwell time.

3.11.3.2.1 Fluorohalocarbon films such as Aclar 33c shall be sealed on all sides when fabricating bags. Fluorohalocarbon films shall not be centerfolded. Centerfolding may generate particles since fluorohalocarbon films tend to be somewhat brittle.

3.11.3.3 Purging. - Purging shall be accomplished by directing a stream of inert gas into the inner protective bag and over the item. Sufficient purging time shall be allowed to replace the air within the bag. Minimum purging time on small items shall be five seconds.

3.11.3.3.1 Items that require storage under an inert atmosphere shall be sealed while the purge is being maintained on the inner bag. The volume of gas sealed in the bag shall be kept to a minimum to allow for expansion of the gas during shipment.

3.11.3.3.2 Items not requiring storage under an inert atmosphere shall be sealed immediately after purging. Items requiring that the motion of the part in relation to the bag must be restricted during handling shall have

the inner bag purged, evacuated, and then sealed while the vacuum is maintained on the bag.

3.11.3.4 Cushioning. - Items having sharp corners, threads, points, or other configurations that may damage the protective packaging, shall be overwrapped with a minimum of two layers of plastic film to form a cushion. The choice of film shall be compatible with the service medium. Each layer of film shall be secured in place with tape conforming to Specification PPP-T-66, Type I, Class B. The adhesive backing on the tape shall not come in contact with the body of the item. One corner of the end of the tape shall be folded over for easy removal. The cushioned item shall then be placed in an inner and an outer bag as applicable.

3.11.4 Detail Requirements

3.11.4.1 Small Items (Completely Cleaned). - Small items that have all surfaces precision cleaned shall be cushioned as applicable, bagged, purged, and sealed in an inner bag in accordance with 3.11.3.

3.11.4.1.1 Certification decal(s) shall be applied to the inner bag in accordance with 3.11.2.8.

3.11.4.1.2 Sandwich packaging may be applied to identical light items such as o-rings and gaskets. A sandwich package consists of heat sealing a number of identical items between two sheets of plastic film in such a manner that each item is in a separate purged and heat sealed compartment. Each compartment must be able to be separated from the others by cutting without violating the integrity of the remaining compartments.

3.11.4.1.3 Each inner bag shall be placed in an outer bag of polyethylene. The outer bag shall be purged and sealed in accordance with 3.11.3. Marking shall be in accordance with 3.12.

3.11.4.2 Small Items (Internally Cleaned). - Small items that have only internally cleaned surfaces shall be purged and all fittings or other orifices leading to the internally cleaned surfaces shall be sealed with two layers of plastic film. The plastic film shall be secured in place with tape conforming to Specification PPP-T-66, Type I, Class B. The adhesive backing on the tape shall not come in contact with the body of the item.

3.11.4.2.1 Certification decal(s) shall be implied to the sealed fittings or other orifices in accordance with 3.11.2.8.

3.11.4.2.2 The sealed fittings or other orifices may be cushioned with protective film as applicable.

3.11.4.2.3 The sealed, cleaned item shall be placed in an outer bag of polyethylene, purged, and sealed in accordance with 3.11.3. Marking shall be in accordance with 3.12.

3.11.4.3 Large or Heavy Items (Internally Cleaned). - Large or heavy items that have only internally cleaned surfaces shall be purged and sealed in accordance with 3.11.4.2, 3.11.4.2.1 and 3.11.4.2.2.

3.11.4.3.1 Each sealed fitting or other orifice shall be overwrapped with polyethylene. The plastic film shall be secured in place with tape conforming to Specification PPP-T-66, Type I, Class B. The adhesive backing on the tape shall not come in contact with the body of the item. Marking shall be in accordance with 3.12.

3.11.4.4 Flanged Items. - Flanged items that have only internally cleaned surfaces shall be sealed with gaskets and closures conforming to 3.11.2.4.

3.11.4.4.1 The cleaned gasket shall be placed over the flange face.

3.11.4.4.2 The closure shall be placed over the gasket. Attachment hardware shall be inserted through all the flange holes, and tightened to the recommended torque value for the type and size of attachment bolt use.

3.11.4.4.3 The complete closure shall be overwrapped with polyethylene and secured with tape according to 3.11.4.3.1.

3.11.4.4.4 Certification decal(s) shall be applied to the sealed overwrapping in accordance with 3.11.2.8. Marking shall be in accordance with 3.12.

3.11.4.5 Electrical and Electronic Items. - Electrical and electronic items that require testing after cleaning shall be packaged in an inner bag. The inner bag shall be sealed in a manner that will permit access to leads, connectors, etc., for testing without violating the integrity of the inner bag.

3.11.4.5.1 Certification decal(s) shall be applied to the inner bag in accordance with 3.11.2.8.

3.11.4.5.2 Exposed leads, connectors, etc., shall be cushioned as applicable in accordance with 3.11.3.4.

3.11.4.5.3 Each inner bag shall be placed in an outer bag of polyethylene, sealed, and marked in accordance with 3.12.

3.11.4.6 Hose and Tube Assemblies. - Hose and tube assemblies that have only internally cleaned surfaces shall be purged, sealed and protected in accordance with 3.11.4.3.

3.11.4.6.1 The entire hose or tube assembly may be overwrapped with polyethylene film as applicable.

3.11.5 Plastic Scrap Disposal. - All plastic waste including unused scrap and discarded protective bags shall be treated as garbage. The plastic waste shall be mixed with other wastes that are considered garbage and disposed of in the normal manner. Plastic waste shall not be disposed of by burning in an open incinerator. The burning of plastic waste constitutes somewhat of a hazard in that toxic fumes can be generated by numerous classes of plastic compounds.

3.12 Marking of Cleaned Items. - Unless otherwise specified by the procuring activity, cleaned items shall be marked with tags conforming to Type C, Style 1 or Style 2, Class 2 of Specification UU-T-81. Class 1 tags with metal bound edges shall not be used. Tags shall be placed between the inner and outer bags or layers of protective packaging film where practical. Where the tag cannot be placed between the inner and outer packaging film, the tag shall be enclosed in a plastic bag or between layers of plastic film and securely taped to the outside of the package. Tags shall be of sufficient size to contain the following information:

(a) Part or identification number.

(b) Contractor identification.

(c) Cleaning method and cleanliness level.

(d) Date of cleaning.

(e) Title, date, and number of this specification.

(f) Service medium or intended service.

(g) Manufacturer's serial number.

(h) The wording, SPECIAL CLEANING, imprinted boldly across the face of the tag.

4. QUALITY ASSURANCE PROVISIONS

4.1 Inspection Requirements. - The supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own or any other inspection facilities and services acceptable to NASA that are covered by an inspection or quality control plan as required by the applicable NASA Quality Publication NPC 200-2 or NPC 200-3 as referenced in the contract. Unless otherwise specified, the inspection plan as required by NASA Quality Publication NPC 200-3 shall be submitted for review with the supplier's bid or proposal. Inspection and test records shall be kept complete and upon request, made available to the procuring activity or its designated representative in accordance with NASA Quality Publication NPC 200-2, NPC 200-3, or other

provisions of the contract or procurement document. The procuring activity, or its designated representative, reserves the right to perform any or all of the inspections set forth in the specification to assure that the end item conforms to the prescribed requirements.

4.2 Sampling

4.2.1 Controlled Environment Cleaning. - Items cleaned in a controlled environment in accordance with 3.10.2, shall be sampled for acceptance inspection as specified herein.

4.2.1.1 Grouped Lot. - A grouped lot shall be those items cleaned as a batch at one time. The lot shall consist of one of the following categories for grouped items:

(a) Parts, as defined in 6.3, constructed of the same material and of the same or similar configuration such as fittings, o-rings, washers, etc.

(b) Individual lengths of tubing, pipe, or hose, with an outside diameter up to 1.0-inch, that have been combined for cleaning so that the total critical surface area shall not exceed one square foot.

(c) Individual lengths of tubing, pipe, or hose with an outside diameter greater than one inch and including two inches, that have been combined for cleaning so that the total critical surface area shall not exceed three square feet.

4.2.1.2 Single Items. - Each individual component, subassembly, assembly, or other item composed of two or more parts, as defined in 6.3, shall be tested as a single item. Individual lengths of tubing, pipe, or hose may be tested as single items.

4.2.1.3 Visual Inspection Sample. - The sample for the inspections of 4.3.1 and 4.3.2 shall consist of 100 percent of the items cleaned.

4.2.1.4 Quality Assurance Sample for Grouped Lots. - The quality assurance sample shall consist of a minimum of 25 percent of the items cleaned in a grouped lot of 20 or more items. The following sampling shall apply for a grouped lot of less than 20 items:

Number of Items in One Lot	Number of Items to be Tested
10-19	4
4-9	3
less than 4	All

The quality assurance sample for grouped lots shall be selected at random from items that have been examined in accordance with 4.3.1 and 4.3.2 and found acceptable. The sample shall be selected in a manner that will provide maximum representation of the affected lot.

4.2.1.5 Quality Assurance Sample for Single Items. - The quality assurance sample for single items shall consist of 100 percent of the items cleaned.

4.2.1.6 Acceptance Samples. - The acceptance sample shall consist of all the samples selected for testing as specified in 4.2.1.3, 4.2.1.4, and 4.2.1.5.

4.3 Acceptance Inspection. - Unless otherwise specified by the procuring activity, acceptance inspection shall be performed as specified herein.

4.3.1 Visual Inspection. - The surfaces of all cleaned items that will contact the service medium shall be visually inspected for the presence of moisture, corrosion, scale, dirt, grease, and other foreign matter. A flashlight or borescope may be required to examine internal surfaces. Items having limited accessibility for visual inspection shall be accepted or rejected on the basis of the quality assurance inspections of 4.3.2, 4.3.3, and 4.3.4. The presence of visible contamination shall be cause for rejection and shall necessitate recleaning of the item. Discoloration of a surface due to welding and passivation shall be permitted as long as no scale or other objectionable films such as LOX sensitive residues remain. All items shall also be examined to determine conformance of 3.11 and 3.12 as applicable.

4.3.2 Acidity and Alkalinity Test. - All surfaces that have been cleaned shall be tested for acidity and alkalinity with narrow-range pH paper while the surfaces are wet from the final water rinse. Dry surfaces of completed items may be wet with a few drops of distilled water to permit testing as required. When tested, the pH shall range from 6.0 to 8.0.

4.3.2.1 Narrow-Range pH Paper. - The pH paper used in conformance with 4.3.2 shall be narrow-range, indicating paper that is sensitive to each 0.1 pH unit change. The paper shall have a minimum sensitivity range of pH 5.6 to 8.4. The paper shall not be used within 0.2 pH unit of its minimum or maximum reading because of the difficulty in ascertaining small color changes. It may be necessary to obtain two papers to include the pH 5.6 to 8.4 range such as paper "A" sensitive to pH 4.5 to 7.5, and paper "B" sensitive to pH 6.8 to 8.4 so that paper "A" is useable from pH 4.7 to 7.3, and paper "B" from 7.0 to 8.2.

4.3.3 Items Cleaned in Controlled Environment

4.3.3.1 Solvent-Flush Procedure (Method A). - Items cleaned in a controlled environment shall be tested for conformance to the applicable cleanliness level of Table I by the solvent-flush procedure.

4.3.3.1.1 Solvent. - The test solvent shall be trichlorotrifluoroethane, conforming to Specification MSFC-SPEC-237, whenever it is compatible with the cleaned item. Nonmetallic items shall be tested with trichlorotrifluoroethane or isopropyl alcohol (see 3.10.2.1.2 for solvent compatibility). Water shall not be used as a test solvent for solvent soluble organic residues. Test solvents shall be procured to the material specifications of 3.5. However, test solvents may be reused in the laboratory as long as the particle population requirements of 4.3.3.1.1.1 are met, and the solvent soluble organic residue does not exceed 0.013 milligrams per milliliter of test solvent when tested in accordance with 4.3.3.1.4.2.

4.3.3.1.1.1 Particle Population. - All test solvents shall be filtered to the extent necessary for a 500 milliliter sample to meet the particle size and population requirements of the applicable cleanliness level of Table I. Blank particle corrections (subtraction of test solvent particle count from the final particle count) shall not be allowed. It is advisable to maintain a minimum particle population in a test solvent so that the rejection of satisfactorily cleaned items does not occur.

4.3.3.1.1.2 Solvent Quality Assurance. - Within 24 hours of use, the test solvent shall be tested in accordance with 4.3.3.1.4 for conformance to particle population and solvent soluble organic residue (see 4.3.3.1.1).

4.3.3.1.2 Solvent Volume. - The volume of test solvent to be used for flushing relative to the critical surface area of the cleaned items shall be in accordance with Table VIII.

TABLE VIII. SOLVENT VOLUME RELATIVE TO CRITICAL SURFACE AREA

CRITICAL SURFACE AREA (SQ FT)	SOLVENT VOLUME (ML)
0 - 0.20	100
0.21 - 0.50	250
0.51 - 1.00	500
1.01 - 3.00	500/sq ft
> 3.00	250/sq ft

4.3.3.1.2.1 Solvent Sample for Analysis. - When the total solvent volume used for testing is greater than 500 milliliters, the total solution shall be thoroughly agitated and a 500 milliliter representative sample shall be taken for analysis of particle population and solvent soluble organic residue.

4.3.3.1.3 Test Procedure. - The following solvent-flush procedure shall be used:

(a) Ascertain the total volume of test solvent necessary to flush the cleaned item or items. Items may be grouped in accordance with 4.2.

NOTE

Unused test solvent shall be retained to be used as a blank for infrared analysis (see 4.3.3.1.4.2.1 for trichlorotrifluoroethane, and 4.3.3.1.4.2.2 for other solvents). If more than one lot of test solvent is used, a blank sample shall be retained from each lot.

(b) Divide the total volume of test solvent into three equal portions.

(c) Flush all the critical surfaces uniformly with one portion of the test solvent.

(d) Catch the used test solvent in a precision cleaned container.

(e) Repeat steps (a) through (d) for the other two portions of test solvent, combining all of the used test solvent in the same container.

(f) Immediately upon the completion of step (e), dry the tested items in accordance with the applicable cleaning procedure.

4.3.3.1.4 Analyses of Test Solvent

4.3.3.1.4.1 Particle Population Analysis. - The total volume of test solvent, or a 500 milliliter representative sample of the test solvent (see 4.3.3.1.2.1) shall be analyzed as follows:

(a) Assemble a precision cleaned filtration apparatus.

(b) Using clean forceps with nonserrated tips, place a filter membrane (47 mm diameter with 0.45 micron pores) in position in the filter holder. The filter membrane shall be compatible with the test solvent.

NOTE

Prior to insertion, the filter membrane may be rinsed with filtered test solvent to remove any adherent contamination.

(c) Fill the filter funnel approximately three-fourths full of test solvent and turn on the vacuum pump.

(d) Add the remaining test solvent to the filter funnel at a rate necessary to maintain the funnel more than half full until all of the test solvent has been added.

CAUTION

Do not allow the test solvent to pour directly on to the filter membrane after filtration has started.

(e) When filtration is completed, remove the filter membrane from the holder and place it in a disposable Petri dish or equivalent until the particles are counted.

(f) Retain the filtrate for analysis of the solvent soluble organic residue in accordance with 4.3.3.1.4.2.

(g) Place the filter membrane under the microscope.

(h) Direct the high intensity light source on to the filter membrane from an oblique postion to obtain maximum definition for sizing and counting. High intensity illumination is a critical requirement.

(i) Use a magnification of approximately 40 X for counting particles 50 microns or larger and approximately 100 X for particles smaller than 50 microns.

(j) Count the particles in accordance with the method of Specification ASTM F25-63T except that when the total number of particles of a given particle size range is to be between one and 135, the number of particles over the entire effective filtering area of the membrane shall be counted.

4.3.3.1.4.2 Solvent Soluble Organic Residue. - The flushing of a critical surface with a test solvent such as trichlorotrifluoroethane, trichloroethylene, or alcohol assumes that any organic material remaining on that surface will be soluble in the solvent. Water is automatically eliminated as a test solvent since organic residues are not soluble in it. Organic materials that contain carbon to hydrogen bonding (hydrocarbons) are impact sensitive to liquid oxygen. These materials include a variety of substances such as lubricating, cutting, and compressor oils, surfactants, waxes, fingerprints, etc. However, these materials have a common infrared absorption band at 3.42μ (2924 cm^{-1}) that results from the carbon to hydrogen bonding. The quantitative measurement of this infrared absorption can be related to the organic residue remaining on the critical surface.

4.3.3.1.4.2.1 Trichlorotrifluoroethane. - When used as the test solvent, trichlorotrifluoroethane shall be analyzed for solvent soluble organic residue by infrared absorption spectrophotometry as follows:

(a) Ascertain that the used test solvent (analytical sample) has been filtered through a 0.45 micron filter membrane so that particles will not contaminate the infrared cell. Test solvent obtained from step (f) of 4.3.3.1.4.1 has been filtered.

(b) Unused test solvent of the same lot (see 4.3.3.1.3) shall be employed as the reference standard.

NOTE

Care shall be taken not to contaminate samples and standards. Analytical glassware shall be cleaned by washing in detergent and water, rinsing with distilled or deionized water, rinsing with spectrograde acetone and drying. A final rinse of spectrograde carbon tetrachloride or unused trichlorotrifluoroethane shall be used.

(c) Use a precision cleaned hypodermic syringe to transfer the reference standard to an infrared sealed cell with sodium chloride windows.

NOTE

The nominal cell path length is 3 mm; however, longer cell paths may be desirable depending upon the sensitivity of the infrared spectrophotometer.

(d) If a single beam infrared spectrophotometer is used, record the absorption of the reference standard at 3.42μ (2924 cm^{-1}) as A.

(e) Repeat steps (c) and (d) for the analytical sample using the same cell and record the absorption of the sample as B.

NOTE

If an automatic infrared spectrophotometer (single or double beam) is used, the same slit opening, speed, and conditions shall be used for all determinations.

(f) If a double beam infrared spectrophotometer is used, transfer the analytical sample to another cell with a matched path length. Cells may be procured as matched pairs, or the reference standard may be placed in a variable-path cell. Follow manufacturer's directions for matching cell path lengths for variable-path cells.

(g) Insert the reference standard and the analytical sample into the spectrophotometer and record the net absorption at 3.42μ (2924 cm^{-1}) for the analytical sample as C.

(h) Calculate the absorbance ($Log_{10}\frac{Io}{I}$) of A and B, or C by the standard infrared base-line method (see Specification ASTM E168-64T, section 7b).

(i) Refer to the previously prepared analytical curve to obtain the milligrams of solvent soluble organic residue (SSOR) per milliliter of trichlorotrifluoroethane from the absorbances of step (h).

(j) Calculate the milligrams of SSOR per square foot of critical surface area as follows:

(1) Single beam instrument

$$\text{mg/sq ft} = \frac{(F)(E-D)}{G}$$

where

D = mg SSOR/ml reference standard (calculated from A).
E = mg SSOR/ml analytical sample (calculated from B).
E-D = net concentration of test solvent in mg SSOR/ml.
F = total volume of test solvent used expressed in milliliters.
G = total area of critical surface tested expressed in square feet.

(2) Double beam instrument

$$\text{mg/sq ft} = \frac{(F)(H)}{G}$$

where

F = total volume of test solvent used expressed in milliliters.
H = net concentration of test solvent in mg SSOR/ml (calculated from C)

G = total area of critical surface tested expressed in square feet.

4.3.3.1.4.2.2 Other Solvents. - When trichloroethylene or isopropyl alcohol is used as the test solvent, it shall be analyzed for solvent soluble organic residue as follows:

(a) Ascertain that the used test solvent (analytical sample) has been filtered through a 0.45 micron filter membrane so that particles will not contaminate the infrared cell.

(b) Evaporate the total volume of the analytical sample (see 4.3.3.1.2.1) to dryness on a steam bath or hot plate adjusted so that the solvent evaporates gently.

(c) Evaporate an equal volume of unused test solvent to dryness for a reference standard.

(d) Dissolve the residues from step (b) and (c) in spectrograde carbon tetrachloride or trichlorotrifluoroethane, and transfer each of them to a suitable size volumetric flask with small increments of solvent. Adjust the sample to volume with solvent.

(e) Determine the solvent soluble organic residue content in accordance with 4.3.3.1.4.2.1.

(f) Multiply the final results in milligrams of solvent soluble organic residue per square foot by a factor of 1.54 to compensate for an average loss of hydrocarbons during evaporation of the test solvent.

4.3.3.1.4.2.3 Preparation of Analytical Standard Curves

4.3.3.1.4.2.3.1 The standard curve for trichlorotrifluoroethane shall be prepared as follows:

(a) Prepare a standard hydrocarbon mixture of 90 percent by weight of U.S.P. heavy white mineral oil and 10 percent by weight of reagent grade triolein [glycerol trioleate, formula: $(C_{17}H_{33}COO)_3C_3H_5$].

NOTE

Store mixture in the dark; sunlight decomposes it.

(b) Transfer exactly 0.1000 gram of the standard hydrocarbon mixture to a 100 ml volumetric flask and dilute to 100 ml with unused trichlorotrifluoroethane conforming to Specification MSFC-SPEC-237. Care shall be taken not to contaminate the standard.

(c) Dilute the standard solution of step (b) in proportionate amounts to include the analytical range of 0.001 to 0.3 mg standard hydrocarbon mixture per milliliter of trichlorotrifluoroethane.

(d) Determine the absorbance, $\text{Log}_{10}\frac{Io}{I}$, of each standard solution at 3.42μ (2924 cm^{-1}) in accordance with 4.3.3.1.4.2.1. At least two determinations shall be made on each standard, and the average value taken as the absorbance.

(e) Prepare an analytical curve by plotting the absorbance versus the milligrams of standard hydrocarbon mixture per milliliter of trichlorotrifluoroethane on arithematical graph paper (10 by 10 cm).

(f) Check the analytical curve of step (e) periodically to ensure the accuracy of the analysis.

4.3.3.1.4.2.3.2 The standard curves, prepared in accordance with 4.3.3.1.4.2.3.1, may be used to determine the solvent soluble organic residue in trichloroethylene or isopropyl alcohol test solvents providing the residue remaining after the evaporation of these solvents is dissolved in trichlorotrifluoroethane. A new standard curve, using carbon tetrachloride and prepared in accordance with 4.3.3.1.4.2.3.1, shall be determined if spectrograde carbon tetrachloride is employed to dissolve the residues. The loss of hydrocarbons during the evaporation of an actual test sample of trichloroethylene or isopropyl alcohol is adjusted in the final analytical calculations (see step (f) of 4.3.3.1.4.2.2).

4.3.3.2 Gas Flow Procedure (Method B). - When assemblies, subsystems, or systems are fabricated in a controlled environment from precision cleaned items, the assemblies, subsystems, or systems shall be tested for conformance to the requirements of the particle population for the applicable cleanliness level by the gas flow procedure. Condensable hydrocarbons of the applicable cleanliness level may be tested by the gas flow procedure at the discretion of the procuring activity. Failure of compliance with the applicable condensable hydrocarbon requirement is indicative of a lack of sufficient cleanliness of the item. However, compliance with the applicable hydrocarbon requirement does not necessarily indicate cleanliness of the item since some hydrocarbons may not volatilize sufficiently into the gas stream to provide detectability.

4.3.3.2.1 Test Gas. - The test gas shall conform to Specification MSFC-SPEC-234 and be filtered to the extent necessary to meet the particle population requirements of the applicable level of cleanliness as required. Certification of condensable hydrocarbon content shall accompany each lot.

4.3.3.2.2 Pressurization and Flow Rate. - Except as specified herein, designed pressures and flow rates applicable to the assemblies, subsystems,

and systems, as shown on documentation of the applicable item, shall be used, when feasible, to test the assemblies, subsystems, and systems.

4.3.3.2.3 Purge. - Unless otherwise specified by the procuring activity, purging of the test item with gas prior to the performance of the gas flow procedure is permissible and suggested. The volume of gas suggested in purging is approximately three times the capacity of the item to be tested.

4.3.3.2.4 Particulate Contamination Test Procedure

(a) All applicable safety regulations for personnel and equipment as specified by the cognizant safety office shall be rigidly enforced.

(b) All sampling apparatus shall be cleaned to a level consistent with the test being performed. This will preclude contaminating the analytical sample and causing the rejection of satisfactorily cleaned test items.

(c) The filter membrane shall be inserted into the filter holder and the filter holder shall be properly assembled and bolted.

NOTE

Four-bolt filter holders may be used up to 6,000 psig. Pressures from 6,000 to 10,000 psig require six-bolt filter holders.

(d) The filter holder shall be capped and placed in a sealed plastic bag until used as applicable.

(e) Attach a compressed gas source with an appropriate regulator panel to the inlet port of the item to be tested.

CAUTION

Ascertain that the compressed gas has a free flow path.

(f) Wash the fitting of the sampling port with trichlorotrifluoroethane and purge the sample source valve with approximately 10 cubic feet of gas.

(g) Attach the filter holder to the sampling port. Ascertain that the inlet of the filter holder is facing the sampling port. Use caution to prevent any generated particles from falling into the filter.

(h) Attach a calibrated flowmeter to the downstream side of the filter holder.

CAUTION

Ascertain that the outlet port of the flowmeter is open.

(i) Flow a minimum volume of 100 SCF of gas through the test item at a minimum flow rate of 35 SCFM, or at the normal system operating flow rate if it is lower than 35 SCFM. If the normal system operating flow rate is 3 SCFM or less, the total volume of test gas used may be reduced to 35 SCF.

(j) Depressurize the system and remove the filter holder from the sampling port.

(k) Recap the filter holder, and replace the filter holder in its protective plastic bag as applicable.

(l) Transport the filter holder to the laboratory for analysis.

CAUTION

The filter holder must be kept in a vertical position while being transported to the laboratory.

(m) The particle population shall be determined in accordance with 4.3.3.1.4.1. The critical surface area tested shall be calculated to the nearest one-tenth of a square foot.

(n) The presence of a stain on the filter membrane shall be cause for rejection of the test item.

(o) When the test item is found to be excessively contaminated with particles, repeat the purge procedure in accordance with 4.3.3.2.3, increasing the total volume of purging gas as required.

(p) Repeat the test for particulate contamination in accordance with 4.3.3.2.4.

(q) A second failure of an item to meet the particulate requirements of the applicable cleanliness level shall be cause for rejection of the item. The item shall be recleaned in accordance with the applicable procedures of this specification.

4.3.3.2.5 Condensable Hydrocarbons Test Procedures

4.3.3.2.5.1 Preparation of Carbon Tetrachloride. - Commercially available spectrograde carbon tetrachloride usually contains a small amount of hydrocarbons that will be sufficient to cause absorption at 3.42μ (2924 cm^{-1}) when it is concentrated during the condensable hydrocarbon analysis. It is necessary to redistill the carbon tetrachloride before use. The preparation of the carbon tetrachloride shall be as follows:

(a) Distill carbon tetrachloride at the rate of 300 ml per hour until three liters have been collected. The first 50 ml of distillate shall be discarded. The collecting bottle shall be rinsed carefully with portions of the distilled carbon tetrachloride prior to collection of distilled carbon tetracloride.

(b) Evaporate 600 ml of distilled carbon tetrachloride to approximately 2 ml on a steam bath or controlled hot plate. Quantitatively transfer the carbon tetrachloride to a cleaned five ml volumetric flask. Wash the beaker with small quantities of the distilled carbon tetrachloride. Allow the carbon tetrachloride to come to room temperature and refill to volume if necessary.

(c) Use a cleaned hypodermic syringe to transfer the sample to a 3 mm sodium chloride sealed cell. Place the sealed cell in the infrared spectrophotometer and record the absorption at 3.42μ (2924 cm^{-1}). There shall be no absorption at the above bandhead. If the absorption is observed, the carbon tetrachloride shall be redistilled.

4.3.3.2.5.2 Preparation of Standards. - Standards shall be prepared in accordance with 4.3.3.1.4.2.3 using carbon tetrachloride as the solvent, and the standard hydrocarbon mixture to represent the total condesnable hydrocarbons.

4.3.3.2.5.3 Carbon Tetrachloride Scrubber Method

(a) All applicable safety regulations for personnel and equipment as specified by the cognizant safety office shall be rigidly enforced.

(b) The effects of carbon tetrachloride are cumulative in human tissues. All care shall be taken to prevent inhalation of the vapors or contact with the liquid. Vaporized carbon tetrachloride from the vent of the wet test gas meter shall be properly vented to an approved vent.

(c) Three gas washing bottles (250 ml capacity) shall be precision cleaned and rinsed three times with the redistilled carbon tetrachloride.

(d) Fill each gas washing bottle with 150 ml of redistilled carbon tetrachloride and seal the top with rubber bands. Connect the bottles in series with new rubber tubing. The tubing shall be approximately one and one-half inches long to prevent excess tubing being exposed to carbon tetrachloride vapor. Do not connect the bottles to the sampling port at this time.

(e) Attach a compressed gas source with an appropriate regulator panel to the inlet port of the item to be tested.

CAUTION

Ascertain that the compressed gas has a free flow path.

(f) Wash the fitting of the sampling port with CCl_4 if required, and purge the sampling valve and port for one minute. Close sampling valve.

(g) Attach the wet test gas meter to the sampling port and cautiously open the sampling valve. Establish a flow rate of four liters per minute through the wet test gas meter.

(h) Disconnect the wet gas meter from the sampling port, but allow the test gas to continue to flow.

(i) Attach the wet test gas meter to the downstream side of the third gas washing bottle, and vent the wet test gas meter to an approved vent.

(j) Record the volume reading of the wet test gas meter or adjust it to zero.

(k) Connect the upstream side of the first gas washing bottle to the sampling port and begin the test.

(l) Record the barometric pressure.

(m) Record the wet test gas meter temperature at the beginning and end of the test. Use an average value for calculations in step (x).

(n) Adjust the test gas flow rate to five or six liters per minute and allow 600 liters of gas to flow through the gas washing bottles.

CAUTION

Do not allow the CCl_4 to blow from one gas washing bottle to another. If this occurs, begin the test again with another set of bottles and tubing.

(o) Do not allow the CCl_4 to evaporate below the surface of the glass frits of the gas washing bottles. If it is necessary to add CCl_4, release the rubber band on the first bottle, detach the inlet line, and immediately separate the top and bottom sections of the bottle. This releases the internal pressure in the gas washing bottle. This procedure requires coordination, and it should be practiced prior to use. Carbon tetrachloride may be added to the bottle without completely removing the fritted tubes. Repeat the procedure for the other two bottles.

(p) Continue to flow the test gas until the 600 liters have been completed, and record the wet test gas meter reading.

(q) Disconnect the gas washing bottles in accordance with the procedure of step (o).

(r) Depressurize the system, cover the open ports of the bottles with clean aluminum foil, and transport the sample to the laboratory for analysis.

(s) Quantitatively transfer the sample to a 800 ml beaker, rinsing each gas washing bottle with redistilled CCl_4.

(t) Evaporate the CCl_4 to approximately two milliliters, transfer the sample to a five ml volumetric flask, and dilute it to volume.

(u) Determine the infrared absorbance of the condensable hydrocarbons in accordance with the procedure of 4.3.3.1.4.2.1 through step (h).

(v) Refer to the previously prepared analytical curve (see 4.3.3..2.5.2) to obtain the milligrams of condensable hydrocarbons per milliliter of carbon tetrachloride.

(w) Calculate the total condensable hydrocarbons as follows:

$$A = \frac{(B)(C)\ (1.54)}{1000}$$

where

A = total condensable hydrocarbons expressed in grams.

B = milligrams condensable hydrocarbons per milliliter CCl_4.
C = total volume CCl_4 expressed in milliliters.
1.54 = compensating evaporation factor.

(x) Calculate the condensable hydrocarbons in ppm by weight as follows:

$$D = \frac{(E)(F)\ (273.1)}{(760)(273.1+G)}$$

where

D = volume of test gas in liters at standard temperature and pressure.
E = volume of test gas used expressed in liters.
F = barometric pressure expressed in millimeters of mercury.
G = average wet test gas meter temperature expressed in degrees centigrade.

and

$$H = (D)(I)$$

where

H = weight of test gas expressed in grams.

I = density of test gas expressed in grams/liter

then

$$J = \frac{A \times 10^6}{H}$$

where

J = condensable hydrocarbons expressed in ppm by weight of test gas.
A = total condensable hydrocarbons obtained in step (w).

(y) Items that have been tested for condensable hydrocarbons and fail to meet the condensable hydrocarbon requirement of the applicable cleanliness level shall be rejected. Rejected items shall be recleaned in accordance with the cleaning procedures of this specification.

4.3.4 Items Cleaned in the Field

4.3.4.1 Fluid Flow Procedure (Method C). - Items cleaned in the field shall be tested for conformance to the applicable cleanliness level of Table I by the applicable fluid flow procedure as specified in 3.10.3. Testing procedures are determined by the configuration of the item being cleaned and by the method of dispensing the test fluid.

4.3.4.1.1 Test Fluids. - The test fluids shall be trichlorotrifluoroethane, trichloroethylene, or water as applicable. Test fluids shall be procured to the material specifications of 3.5. However, trichlorotrifluoroethane and trichloroethylene may be reused as long as the particle population requirements of 4.3.4.1.1.1 are met, and the solvent soluble organic residue does not exceed 0.013 milligrams per milliliter when tested in accordance with 4.3.3.1.4.2.

CAUTION

Compatibility of nonmetallic materials with the applicable test fluid shall be determined prior to testing. Permission to remove nonmetallic materials prior to testing shall be granted at the discretion of the procuring activity.

4.3.4.1.1.1 Particle Population. - All test fluids shall be filtered to the extent necessary for a 2500 milliliter sample to meet the particle size and population requirements of the applicable cleanliness level of Table I. Blank particle corrections (subtraction of test solvent particle count from the final particle count) shall not be allowed. It is advisable to maintain a minimum particle population in a test fluid so that rejection of satisfactorily cleaned items does not occur.

4.3.4.1.1.2 Quality Assurance. - Within 24 hours of use, a 2500 ml sample of test fluid shall be tested in accordance with the procedure of 4.3.3.1.4.1 for conformance to particle population. Solvent soluble organic residue shall be tested in accordance with 4.3.3.1.4.2.

4.3.4.1.2 Items Cleaned by Closed-Loop Circulation

4.3.4.1.2.1 Fluid Ratio to Critical Surface Area. - Each 2500 ml sample of test fluid collected in accordance with 3.10.3.2 shall be related to the proportional critical surface area flushed by the test fluid FOR EACH SYSTEM TESTED. If there is more than one size tubing, or other items in the system being cleaned, the total volume of the system shall be related to the nearest 0.1 unit. Tube and pipe volume and surface area data are found in Tables III and IV of 3.8.3.1. An example of calculations is as follows:

(a) A system contains 100 feet of 1.0 inch O.D. tubing with 0.049 wall thickness and a 5 gallon vessel with 3 square feet of critical surface area.

(b) 100 feet of 1-inch tubing has a volume of 3.4 gallons and 23.6 square feet critical surface area from Table III.

(c) Total volume and surface area relationship FOR THIS SYSTEM:

Total Volume	Total Surface Area
3.4 gallons (tubing)	23.6 sq ft (tubing)
5.0 gallons (vessel)	3.0 sq ft (vessel)

$$\frac{(8.4 \text{ gallons})(3.78 \text{ liters/gallon})}{26.6 \text{ sq ft}} = 1.2 \text{ liters/sq ft}$$

(d) Therefore, 2500 ml sample represents:

$$\frac{2.5 \text{ liters}}{1.2 \text{ liters/sq ft}} = 2.1 \text{ square feet}$$

4.3.4.1.2.2 Particle Population. - Each 2500 ml sample, if it represents one square foot or less, or a proportional volume of sample shall be tested for particle population in accordance with the procedure of 4.3.3.1.4.1. Particle population per square foot shall be determined on the basis of the proportional critical surface area calculated in accordance with 4.3.4.1.1.

4.3.4.1.2.3 Solvent Soluble Organic Residue

4.3.4.1.2.3.1 Extraction of Water Sample. - A 500 ml portion of each water sample shall be extracted with carbon tetrachloride for the determination of the solvent soluble organic residue. The procedure shall be as follows:

(a) Place the 500 ml water sample in a 1000 ml separatory funnel.

(b) Add 10 ml spectrograde carbon tetrachloride with a volumetric pipette.

(c) Shake the sample for 15 minutes to extract the hydrocarbons.

(d) Allow the two layers to separate completely and drain the carbon tetrachloride layer into a 10 ml flask.

NOTE

It is not necessary to recover exactly 10 ml of carbon tetrachloride as the distribution coefficient of hydrocarbons between the two phases is determined by the original volume of carbon tetrachloride added in step (b).

(e) Add 2 or 3 crystals of indicating silica gel to absorb any water that may have been entrained in the carbon tetrachloride during shaking. Do not allow the sample to remain in contact with the silica gel more than one hour.

(f) Transfer the carbon tetrachloride to an infrared cell for solvent soluble organic residue analysis in accordance with 4.3.3.1.4.2.

(g) Solvent soluble organic residue per square foot shall be determined on the basis of the proportional critical surface area calculated in accordance with 4.3.4.1.2.1.

4.3.4.1.2.3.2 Organic Solvent Sample. - If the organic solvent is trichlorotrifluoroethane, the solvent soluble organic residue shall be determined directly by infrared analysis in accordance with 4.3.3.1.4.2.1.

4.3.4.1.2.3.2.1 If the organic solvent is trichloroethylene, a 500 ml portion shall be analyzed in accordance with 4.3.3.1.4.2.2.

4.3.4.1.2.3.2.2 Solvent soluble organic residue per square foot shall be determined on the basis of the proportional critical surface area calculated in accordance with 4.3.4.1.2.1.

4.3.4.1.3 Items Cleaned by Solution Spraying

4.3.4.1.3.1 Fluid Ratio to Critical Surface Area. - Each 2500 ml sample of fluid represents one square foot of critical surface area when the flow rates and times are maintained as specified in 3.10.3.3.

4.3.4.1.3.2 Particle Population. - Each 2500 ml sample (representing one square foot) shall be tested for particle population in accordance with the procedure of 4.3.3.1.4.1.

4.3.4.1.3.3 Solvent Soluble Organic Residue

4.3.4.1.3.3.1 Extraction of Water Sample. - The solvent soluble organic residue present in the water samples shall be determined in accordance with the procedure of 4.3.4.1.2.3.1. A 500 ml portion of sample shall be used for analysis, and the solvent soluble organic residue per square foot

shall be calculated on the basis of a 2500 milliliter sample representing one square foot of critical surface area.

4.3.4.1.3.3.2 Organic Solvent Sample. - If the organic solvent is trichlorotrifluoroethane, the solvent soluble organic residue shall be determined directly by infrared analysis in accordance with 4.3.3.1.4.2.1.

4.3.4.1.3.3.2.1 If the organic solvent is trichloroethylene, a 500 ml portion shall be analyzed in accordance with 4.3.3.1.4.2.2.

4.3.4.1.3.3.2.2 The solvent soluble organic residue per square foot shall be calculated on the basis of a 2500 milliliter sample representing one square foot of critical surface area.

4.3.4.2 Gas Flow Procedure (Method B). - Items cleaned in the field may be tested for conformance to the requirements of particle population and condensable hydrocarbons for the applicable cleanliness level by the gas flow procedure at the discretion of the procuring activity. When the gas flow procedure is applicable, testing shall be in accordance with 4.3.3.2.

4.3.4.3 Dew Point (Method D). - Items cleaned in the field shall be tested for surface moisture by passing test gas through or over the affected surfaces of the items and monitoring the dew point of the gas leaving the test item.

4.3.4.3.1 Test Gas. - The test gas shall conform to Specification MSFC-SPEC-234 and be filtered to the extent necessary to meet the particle population requirements of the applicable level of cleanliness as required. Certification of condensable hydrocarbon content shall accompany each lot.

4.3.4.3.2 Test Procedure. - The dew point of the effluent test gas shall be monitored by a suitable instrument. The principle of operation of the instrument shall be one of the following:

(a) Moisture is absorbed from the test gas by phosphorous pentoxide and the change in electrical conductivity of the phosphorous pentoxide is monitored.

(b) The test gas is rapidly cooled below its dew point so that the moisture in the test gas will condense as an observable fog in a "cloud chamber". The exact dew point temperature is computed by means of the equation for adiabatic expansion.

(c) Manufacturer's directions shall be followed for operation of the specific instrument.

4.4 Recleaning Operational Systems. - Systems that have successfully passed the specified quality assurance tests for initial acceptance and have been placed in operation shall be recleaned when analyses of fluid

samples show that the delivered fluid is contaminated. Operational systems that are delivering fluids of an acceptable level of cleanliness shall be recleaned only at the discretion of the procuring activity. Contamination usually increases in areas of fluid stagnation and restricted flow such as sharp tubing bends, orifices, abrupt changes in component internal diameters, filters, etc. Systems containing such configurations may be surveyed by the use of the gas flow procedure in accordance with 4.3.3.2 for particle population and condensable hydrocarbons. An alternate survey may be made by removing one or more restrictive items such as tubing containing a right-angle bend or a filter and testing these items for particle population and solvent soluble organic residue by the solvent flush procedure in accordance with 4.3.3.1.

4.5 Acceptance Inspection for Cleaning Formulations

4.5.1 Sampling. - The quality assurance sample shall consist of 2500 milliliters of solution obtained from each batch of material formulated in the "ready-for-use" composition in accordance with 3.10.1.

4.5.1.1 Concentrated Formulations. - A one quart representative sample of commercially prepared concentrated formulation shall be taken from one drum out of each 10 drums or less of material submitted for acceptance by the vendor as having been manufactured from the same lot of material on the same date.

4.5.1.1.1 The sample of concentrated formulation shall be diluted as specified herein to produce the "ready-for-use" composition prior to analysis in accordance with 4.5.

4.5.1.2 The sampling of static tanks or drums shall be such that approximately one-third of the sample is taken in each of the lower, middle, and upper one-third areas of the tank or drum.

4.5.2 Particle Population. - The total volume of sample obtained in accordance with 4.5.1 shall be thoroughly agitated and a 500 milliliter portion taken for the analysis of the particle population in accordance with 4.3. The particle population shall not exceed the limits specified in Table I for one square foot of surface area at the applicable cleanliness level.

4.5.3 Cloud Point. - The cloud point of all cleaning formulations that contain surfactants shall be tested in accordance with 4.4.5 of Specification MIL-D-16791.

4.5.4 Special Acceptance Inspections Relative to Formula I

4.5.4.1 Acid Content. - The phosphoric acid content of Formula I shall be determined as follows:

(a) Pipette 10 ml of sample into a clean 250 ml Erlenmeyer flask.

(b) Add 90 ml distilled water.

(c) Add 1 ml of phenolphthalein indicator (0.05% in 50% ethyl alcohol).

(d) Titrate with standard one normal sodium hydroxide to the phenolphthalein end point (colorless to pink).

(e) Record the milliliters of standard sodium hydroxide used (A) for calculations of step (1).

(f) Pipette another 10 ml sample into a clean 250 ml Erlenmeyer flask.

(g) Add 90 ml distilled water.

(h) Add 1 ml of bromphenol blue indicator (0.04% in aqueous solution).

(i) Titrate with standard one normal sodium hydroxide to the bromphenol blue end point (yellow or blue).

(j) Record the milliliters of standard sodium hydroxide used (B) for calculations of step (1).

(k) Then $\frac{1}{2}A = B \pm 0.5$ ml for ortho phosphoric acid. When the above relationship does not exist there is evidence of an acid other than phosphoric acid. Such evidence shall be cause for rejection of the lot.

(l) Calculate the normality of the phosphoric acid in Formula I by:

$$10 \times N = (A + B)C$$

where A = ml of standard sodium hydroxide used for the phenolphthalein end point

B = ml of standard sodium hydroxide used for the bromphenol blue end point

C = normality of standard sodium hydroxide

10 = ml of Formula I used for analysis

N = calculated normality of phosphoric acid

NOTE

The 10 ml of Formula I is used only once in the calculations as phosphoric acid has three available hydrogen ions that are neutralized only by double titration.

(m) Refer to the previously prepared analytical curve (steps (n) through (p) to obtain the percent by volume of 85% ortho phosphoric acid in Formula I.

(n) Prepare standard samples of varying percentages of 85% ortho phosphoric acid in Formula I in the laboratory. The percent by volume of 85% ortho phosphoric acid shall range from 3.5 to 6.5.

(o) Titrate the standard samples according to steps (a) through (1).

(p) Prepare an analytical curve by plotting the normality of the ortho phosphoric acid in Formula I vs. the percent by volume of 85% ortho phosphoric acid in Formula I on arithematical graph paper (10x10 to the cm.). See 10.2 for sample calculations.

4.5.4.2 Solvent Content. - The solvent content for Formula I shall be determined as follows:

(a) Transfer 500 ml of sample into a clean 1000 ml separatory funnel.

(b) Weigh out 100 grams of anhydrous trisodium phosphate (Na_3PO_4).

(c) Add small portions of the Na_3PO_4 to the sample and shake until all of the Na_3PO_4 has been added and dissolved in the blend.

(d) Shake the solution for 10 minutes.

(e) Two immiscible layers will form. Allow the solution to stand until the two layers separate (approximately 10 to 30 minutes).

(f) The 2-butoxyethanol is a complex addition product in the top layer.

(g) Measure the volume of the top layer to the nearest 0.1 ml after it has been separated from the bottom layer.

(h) Refer to the previously prepared analytical curve (steps (i) through (k) to obtain the percent by volume of 2-butoxyethanol in Formula I.

(i) Prepare standard samples of varying percentages of 2-butoxyethanol in Formula I in the laboratory. The percent by volume of 2-butoxyethanol shall range from 7 to 13.

(j) Extract the standard samples according to steps (a) through (g).

(k) Prepare an analytical curve by plotting the volume of the 2-butoxyethanol layer vs. the percent by volume of 2-butoxyethanol in Formula I on arithematical graph paper (10x10 to the cm).

4.5.4.3 Foam Height. - The surfactant of Formula I shall have a ratio of initial foam height to final foam height of less than 3.0. The test procedure shall be that of Specification ASTM D1173-53 except that the following analytical requirements shall apply:

(a) Distilled water shall be used as the solvent.

(b) The surfactant concentration shall be 0.48 to 0.52 percent by volume.

NOTE

It is easier to weigh surfactant then to measure small volumes. Calculate the weight of a specific surfactant required from its density.

(c) The temperature of the test shall be 110°F.

(d) An average value, expressed in millimeters, shall be reported as the initial and final (after 5 minutes) foam height.

(e) $\frac{\text{Initial foam height (mm)}}{\text{Final foam height (mm)}}$ = less than 3.0

4.5.4.3.1 Certification. - Certification showing evidence of compliance with 4.5.4.3 of this specification may be submitted by the original manufacturer of the surfactant with each procured lot of surfactant. A statement to the effect that the surfactant was tested in accordance with this specification and is in compliance with 4.5.4.3 shall not constitute an adequate certification. Actual data shall be included in the certification statement.

4.5.5 Special Acceptance Inspections Relative to Formula II

4.5.5.1 Acid Content. - The nitric and hydrofluoric acid contents of Formula II shall be determined as follows:

(a) Pipette 10 ml of sample into a clean 250 ml Erlenmeyer flask.

(b) Add 90 ml of distilled water.

(c) Add one (1) ml of thymol blue indicator (0.04% in aqueous solution).

(d) Titrate with standard one normal sodium hydroxide to the first thymol blue end point (red to orange or yellow). This end point represents the neutralization of all the nitric acid plus 22 percent of the hydrofluoric acid.

(e) Record the milliliters of standard sodium hydroxide used (A) for calculations in steps (h) and (j).

(f) Continue titrating until the second thymol blue end point is reached (orange or yellow to blue). If the Formula II solution has been used so that it contains dissolved metal salts, a permanent precipitate will form. For used solutions, titrate to the formation of a permanent precipitate. This is the total acid end point.

(g) Record the milliliters of standard sodium hydroxide used (B) for calculations in steps (h) and (j).

(h) Calculate the normality of the hydrofluoric acid in Formula II by:

$$10 \times N_1 = (B-A) \times 1.28 \times C$$

where:

A = ml of standard sodium hydroxide used for first end point.

B = ml of standard sodium hydroxide used for second end point.

C = normality of standard sodium hydroxide

N_1 = calculated normality of hydrofluoric acid

10 = ml of Formula II used for analysis.

(i) Refer to the previously prepared analytical curve (steps (l) through (n) to obtain the percent by volume of 48 percent hydrofluoric acid in Formula I.

(j) Calculate the normality of the nitric acid by:

$$10 \times N_2 = B - (B-A) \times 1.28 \times C$$

where:

A = ml of standard sodium hydroxide used for first end point

B = ml of standard sodium hydroxide used for second end point

C = normality of standard sodium hydroxide

N_2 = calculated normality of nitric acid

10 = ml of Formula II used for analysis

(k) Refer to the previously prepared analytical curve (steps (1) through (n) to obtain the percent by volume of 61 percent nitric acid in Formula II.

(l) Prepare standard samples of varying percentages of 61 percent nitric acid and 48 percent hydrofluoric acid in Formula II in the laboratory. The percent by volume of 61 percent nitric acid shall range from 10.0 to 13.0. The percent by volume of 48 percent hydrofluoric acid shall range from 0.5 to 2.5.

CAUTION

Hydrofluoric acid is a very corrosive acid. Use protective safety equipment. Store hydrofluoric acid in plastic or other inert containers.

(m) Titrate the standard samples according to steps (a) through (j).

(n) Prepare one analytical curve by plotting the normality of nitric acid in Formula II versus the percent by volume of 61 percent nitric acid in Formula II. Prepare a second curve by plotting the normality of hydrofluoric acid in Formula II versus the percent by volume of 48 percent hydrofluoric acid in Formula II. See 10.2 for sample calculations.

4.5.6 Special Acceptance Inspections Relative to Formula III

4.5.6.1 Acid Content. - The nitric acid content of Formula III shall be determined as follows:

(a) Pipette 10 ml of sample into a clean 250 ml Erlenmeyer flask.

(b) Add 90 ml distilled water.

(c) Add 4 to 6 drops of phenolphthalein indicator (0.05% in 50% ethyl alcohol).

(d) Titrate with standard one normal sodium hydroxide to the phenolphthalein end point (pink color).

(e) Record the milliliters of standard sodium hydroxide used (A) for calculations in step (f).

(f) Calculate the normality of the nitric acid in Formula III by:

$$10 \times N = A \times C$$

where:

A = ml of standard sodium hydroxide used for the phenolphthalein point

C = normality of standard sodium hydroxide

10 = ml of Formula III used for analysis

N = calculated normality of nitric acid

(g) Refer to the previously prepared analytical curve (steps (h) through (n) to obtain the percent by volume 61 percent nitric acid in Formula II.

(h) Prepare standard samples of varying percentages of 61 percent nitric acid in Formula III in the laboratory. The percent by volume of 61 percent nitric acid shall range from 13.0 to 16.0.

(i) Titrate the standard samples according to steps (a) through (f).

(j) Prepare an analytical curve by plotting the normality of nitric acid in Formula III versus the percent by volume of 61 percent nitric acid in Formula III. See 10.2 for sample calculations.

4.5.7 Special Acceptance Inspection Relative to Formula IV

4.5.7.1 Solvent Content. - The solvent content of Formula IV shall be determined in accordance with 4.5.4.2 except that the percent by weight of 2-butoxyethanol in the standard samples of Formula IV shall vary from 8 to 10.

4.5.7.2 Anhydrous Dibasic Sodium Phosphate. - The dibasic sodium phosphate content shall be determined as follows:

(a) Weigh a 10g sample accurate to 0.1 g into a 250 ml Erlenmeyer flask.

(b) Add 10 ml of distilled water to the flask.

(c) Add 4 to 6 drops of methyl orange indicator.

(d) Titrate with standard 0.1 normal hydrochloric acid to the methyl orange end point (yellow to red).

(e) Record the milliliters of standard hydrochloric acid used (A) for calculations in step (f).

(f) Calculate the percent by weight (P) of dibasic sodium phosphate by:

$$P = \frac{AxCxE}{W} \times 100$$

where:

P = percent by weight of dibasic sodium phosphate

A = ml of standard hydrochloric acid

C = normality of hydrochloric acid

E = 0.1420g - gram-milliequivalent weight of dibasic sodium phosphate

W = weight of sample

$$P = \frac{AxCx0.1420}{W} \times 100$$

$$P = \frac{AxCx14.2}{W}$$

(g) See 10.2 for sample calculations.

4.5.7.3 Foam Height. - The foam height of the surfactant used in Formula IV shall be determined in accordance with 4.5.4.3. The ratio of initial foam height to final foam height shall be less than 3.0.

4.5.8 Special Acceptance Inspections Relative to Formula V

4.5.8.1 Acid Content. - The nitric acid content of Formula V shall be determined in accordance with 4.5.6.1 except that the percent by volume of 61 percent nitric acid in the standard samples of Formula V shall range from 22.0 to 25.0.

4.5.9 Special Acceptance Inspections Relative to Formula VI

4.5.9.1 Acid Content. - The acid content of Formula VI shall be determined in accordance with 4.5.4.1 except that the percent by volume of 85 percent ortho phosphoric acid shall range from 14.0 to 16.0.

4.5.9.2 Solvent Content. - The 2-butoxyethanol solvent content of Formula VI shall be determined in accordance with 4.5.4.2.

4.5.9.3 Foam Height. - The foam height of the surfactant used in Formula VI shall be determined in accordance with 4.5.4.3. The ratio of initial foam height to final foam height shall be less than 3.0.

4.5.10 Special Acceptance Inspections Relative to Formula VII

4.5.10.1 Acid Content. - The nitric and sulfuric acid contents of Formula VII shall be determined as follows:

(a) Pipette 10 ml of sample (Y) into a clean 250 ml Erlenmeyer flask.

(b) Add 90 ml of distilled water.

(c) Add 4 to 6 drops of phenolphthalein indicator (0.05% to 50% ethyl alcohol).

(d) Titrate with standard 2.5 normal sodium hydroxide (C_1) to the phenolphthalein end point (pink color)

(e) Record the milliliters of standard sodium hydroxide used (A) for calculations in step (t). This represents the total acid, nitric and sulfuric, content.

(f) Pipette another 1 ml of sample (Z) into a clean 500 ml beaker for the sulfuric acid determination.

(g) Add 100 ml of distilled water.

(h) Adjust the pH of the solution in the beaker to 6.5 to 7.0 using 2.5 normal sodium hydroxide.

CAUTION

The solution must be neutral or slightly acid in order to precipitate the sulfate with the benzidine reagent added in step (j). Adjust the pH carefully. Do not allow the pH to exceed 7.0

(i) Place the beaker in an ice bath.

(j) Add 200 ml of benzidine reagent (see step (k)) to the beaker and allow the beaker to stand in the ice bath for 5 minutes. A crystalline precipitate of benzidine sulfate is formed.

(k) To prepare the benzidine reagent, make a paste of 40g of benzidine with 40 ml of distilled water. Rinse the paste into a liter volumetric flask with about 750 ml of distilled water. Shake well. Allow the flask to stand until the benzidine dissolves forming a brown solution. Invert the flask and shake to thoroughly mix the solution. Pipette 10 ml of the stock solution into a clean beaker. Add 190 ml of distilled water.

(l) Place two pieces of filter paper in a 43 mm diameter Buchner funnel inserted into a suction bottle. Moisten the filter paper with distilled water and apply gentle suction.

(m) Remove the beaker from the ice bath and pour the liquid above the precipitate through the Buchner funnel. Rinse the precipitate into the funnel using distilled water from a wash bottle.

(n) Wash the precipitate on the filter paper with 15 ml of distilled water added in small portions.

(o) Gently remove the filter paper from the funnel taking care not to lose any of the precipitate.

(p) Place the filter paper and precipitate in a 250 ml Erlenmeyer flask. Add 50 ml of distilled water. Stopper the flask and shake until a smooth paste is obtained.

(q) Remove the rubber stopper from the flask, rinse off with water, add a drop of phenolphthalein solution, heat to 50°C, and titrate with 0.1 normal sodium hydroxide (C_2).

(r) When the end point is nearly reached, boil the liquid for 5 minutes, and then finish the titration.

(s) Record the milliliters of standard sodium hydroxide used (B) for calculations in step (t). This represents the sulfuric acid content.

(t) Calculate the normalities of the sulfuric acid and nitric acid as follows:

Sulfuric Acid

$$Z \times N_2 = B \times C_2$$

where:

B = ml of standard sodium hydroxide used in sulfuric acid titration

C_2 = normality of standard sodium hydroxide used in sulfuric acid titration

N_2 = calculated normality of sulfuric acid

Z = ml of Formula VII used for sulfuric acid analysis

Nitric Acid

$$Y \times N_1 = (A - \frac{B \times C_2 \times Y}{C_1}) C_1$$

where:

A = ml of standard sodium hydroxide used in total acid determination

B = ml of standard sodium hydroxide used in sulfuric acid titration

C_1 = normality of standard sodium hydroxide used in total acid determination

C_2 = normality of sodium hydroxide used in sulfuric acid titration

N_1 = calculated normality of nitric acid

Y = ml of Formula VII used for total acid analysis

(u) Refer to the previously prepared analytical curves (steps (v) through (x)) to obtain the percent by volume of 93 percent sulfuric acid and 61 percent nitric acid.

(v) Prepare standard samples of varying percentages of 93 percent sulfuric acid and 61 percent nitric acid in Formula VII in the laboratory. The percent by volume of 93 percent sulfuric acid shall range from 4.5 to 7.5; of 61 percent nitric acid, 15.0 to 18.0.

(w) Analyze the standard samples according to steps (a) through (t).

(x) Prepare an analytical curve for 61 percent nitric acid by plotting the normality of nitric acid versus the percent by volume of

61 percent nitric acid in the standard samples. Prepare an analytical curve for 93 percent sulfuric acid by plotting the normality of sulfuric acid versus the percent by volume of 93 percent sulfuric acid in the standard samples. Refer to 10.2 for sample calculations.

4.6 Acceptance Inspection for Packaging Materials

4.6.1 Environmental Control. - All quality assurance operations shall be accomplished within a clean room conforming to Specification FED-STD-209 which is consistent with or cleaner than the packaging material being inspected. Care shall be taken not to contaminate the packaging materials.

4.6.2 Sampling. - Packaging materials shall be examined and tested to determine compliance with the cleanliness requirements of 3.11.2.1 in accordance with 4.6.

4.6.2.1 All the plastic film of one type, one size, and one configuration such as tubing, flat roll stock, sheet, and fabricated bags offered by one manufacturer at one time shall be considered one lot.

4.6.2.2 A sample for certification of one lot shall consist of the following:

(a) Three (3) sheets out of every one hundred (100) sheets, of one size and type of film.

(b) Three (3) fabricated bags out of every one hundred (100) bags of one size and type of film.

(c) A sufficient length for testing from one (1) roll out of every five (5) rolls of continuous length of film of one size and type.

4.6.3 Visual Inspection. - No evidence of oil, solvents, paints, grease, dirt, ink, metal chips, or other foreign matter shall be permitted on either the external surfaces or the internal surfaces of packaging materials when inspection is made with the unaided eye.

4.6.4 Thickness of Packaging Film. - The thickness of plastic films used for precision packaging shall conform to the limits specified in Table VI of 3.11.2.1.

4.6.4.1 Thickness measurements shall be made with a certified, calibrated micrometer caliper having a flat anvil and capable of being read to the nearest 0.0001-inch.

4.6.4.2 Sheet stock and tubing stock shall be measured across the transverse film direction at two (2) inch intervals. A second set of measurements shall be made across another transverse section of the film located at least twenty-four (24) inches from the first transverse section. A minimum of nine (9) thickness measurements shall be made, and the arithmetical mean value shall be reported as the thickness of the material. For narrow width stock, it may be necessary to measure more than two transverse sections in order to obtain a minimum of nine (9) measurements; however, each transverse section shall be separated by a twenty-four (24) inch interval from the previous section. Three or more measurements with a thickness value of less than the specified minimum thickness of 3.11.2.1 shall be cause for rejection of that sample. The original lot of material shall be resampled and evaluated. Rejection of a second sample of material shall be cause for rejection of the entire lot.

4.6.4.3 Each of the three (3) fabricated bags that constitute one sample of one lot shall be measured across the transverse film direction at two (2) inch intervals. A minimum of three (3) thickness measurements shall be made on each bag. The arithmetical mean value of the combined individual measurements made on the three bags of one lot shall be reported as the thickness of the material for that lot. Three or more measurements with a thickness value of less than the specified minimum thickness of 3.11.2.1 shall be cause for rejection of that sample. The original lot of material shall be resampled and evaluated. Rejection of a second sample of material shall be cause for rejection of the entire lot.

4.6.5 Verification of Cleanliness Level. - All plastic films of one lot shall have the cleanliness level verified prior to use.

4.6.5.1 Minimum Critical Surface Area for Test. - The minimum interior critical surface area for verification of cleanliness level shall be one (1) square foot. Sampling shall be according to 4.6.2.2 except that additional sample material from the offered lot shall be used when necessary to make one square foot. There shall be no exceptions.

4.6.5.2 Sample Preparation. - Fabricated bags shall be sealed across the open end. Tubing shall be fabricated into a bag by cutting off a length conforming to the requirements of 4.6.5.1 and sealing both ends. Flat roll stock and sheet shall be fabricated into a bag by cutting out a section with an area conforming to the requirements of 4.6.5.1, folding the section, and sealing the section as necessary. The cutting technique shall be in accordance with 3.11.3.1. The sealing technique shall be in accordance with 3.11.3.2. All items shall be handled in such a manner as to minimize exposure of the interior critical surfaces to airborne particles.

4.6.5.2.1 One corner of the completely sealed test bag shall be cut off so that an opening of a maximum of 0.75-inch in length is created.

4.6.5.3 Rinsing. - Trichlorotrifluoroethane, that conforms to the cleanliness level of 4.3.3.1.1, shall be used as the test solvent in the ratio of 500 ml of solvent per square foot of critical surface area.

4.6.5.3.1 The following rinsing procedure shall be used for single bags of one square foot or more of surface area:

(a) Divide the total volume of test solvent into three equal portions.

(b) Introduce one portion of test solvent into the sealed bag through the previously cut opening.

(c) Close the bag by folding over the cut corner.

(d) Rinse the exterior of the bag to remove extraneous particles.

(e) Rapidly agitate the test solvent within the bag a minimum of 6 times.

(f) Pour the used test solvent into a precision cleaned beaker taking care to exclude airborne contamination.

(g) Repeat steps (a) through (f) for the other two portions of test solvent, combining all of the used test solvent in the same beaker.

(h) Analyze the test solvent for particulate population and solvent soluble organic residue in conformance with 4.3.1.4 of this specification.

4.6.5.3.2 The following rinsing procedure shall be used when two or more bags constitute the test sample:

(a) Divide the total volume of test solvent into separate portions equal to the number of bags constituting the test sample. (Example: For 3 bags, divide the total volume of test solvent into 3 separate portions).

(b) Divide each separate portion of test solvent from (a) into two equal parts.

(c) Rinse each bag with test solvent in accordance with steps (b) through (e) of 4.6.5.3.1.

(d) Combine the entire volume of test solvent from all of the bags in one beaker.

(e) Analyze the test solvent for particulate population and solvent soluble organic residue in conformance with 4.3.1.4 of this specification.

5. PREPARATION FOR DELIVERY

5.1 Preservation and Packaging. - Preservation and packaging of cleaned items shall be accomplished in accordance with 3.11.

5.2 Packing

5.2.1 Intraplant and On-Site Transportation of Small Items. - Precision cleaned small items protected in accordance with 3.11 shall be removed from the clean room and placed in snug-fitting corrugated fiberboard boxes to protect the plastic bags and contents during handling in-plant or on-site. When the shape or size of an item does not afford a snug-fit in the box, cushioning material shall be used to immobilize the item in the box and prevent damage to the packaging. When a number of small individually packaged items are packed in a single box, cushioning material shall be used to separate the packages and to immobilize the packages within the box. Cushioning materials such as excelsior, shredded newspaper, and similar materials that generate large numbers of particles and fibers shall not be acceptable. Boxes shall be closed with tape.

5.2.2 Intraplant and On-Site Transportation of Large Items. - Large or heavy items protected in accordance with 3.11 shall be placed on skids or pallets designed to support and protect the items from damage during handling. All items shall be secured to the skids or pallets by bolts, suitably tensioned and cushioned steel straps, tie-down rods, or lumber hold downs. Cushioning shall be placed between the item and all support points and the base of the skid or dolly to prevent physical damage to the item.

5.2.3 Interplant and Off-Site Shipment. - Packing of precision cleaned items for interplant or off-site shipment shall be in accordance with level A or B of Specifications MIL-STD-794 or MIL-E-17555 as applicable to the type of item being packed. Level A packing shall be used when storage conditions are indeterminate and may involve outdoor storage. Level B packing shall be used when handling under cover and warehouse storage are possible.

5.3 Marking for Shipment

5.3.1 Intraplant and On-Site. - Copies of the special information cleaning tags of 3.12 shall be affixed by taping to the outside of the corrugated fiberboard boxes containing small precision cleaned items and to the skid or pallet for large or heavy items.

5.3.2 Interplant and Off-Site. - Shipping containers shall be marked in accordance with Standard MIL-STD-129 and shall include special marking, in addition to that specified in Standard MIL-STD-129, to the effect that precision-cleaned items are contained therein.

6. NOTES

6.1 Intended Use. - This specification establishes the cleanliness levels, cleaning, protection, and inspection procedures for surfaces of parts, components, assemblies, subsystems, systems, or other related equipment in contact with service media of launch vehicles, spacecraft, and associated ground support equipment.

6.2 Ordering Data. - Procurement documents should specify the following:

(a) Title, number, and date of this specification

(b) Cleanliness level, cleaning procedure, and testing procedure required.

(c) Whether preproduction approval is required (See 3.2, 3.7.4.6).

(d) Whether functional testing is required on items disassembled for cleaning (See 3.4).

(e) Whether special preservation, packaging, packing and marking are required beyond the requirements of 5.

6.3 Definitions

6.3.1 Assembly. - Two or more parts having a common mounting and being capable of performing a definite function. Filter element, housing, and o-rings become part of a filter assembly.

6.3.2 Component. - An article which is normally a combination of parts, sub-assemblies, or assemblies and is a self-contained element within a complete operating equipment.

6.3.3 Condensable Hydrocarbon. - A hydrocarbon capable of going from a gaseous to a liquid or solid state at ambient temperature and prevailing pressure.

6.3.4 Critical Surface. - Any surface of an item that contacts the critical service medium (LOX, pneumatic gases, etc) is considered a critical surface. A critical surface is subject to the cleaning procedures and cleanliness requirements of this specification.

6.3.5 Dew Point. - The temperature at which condensation of water vapor in a gas takes place at prevailing pressure (usually atmospheric pressure).

6.3.6 Fiber. - A particle having a length of 100 microns or greater with a length to width ratio of 10 to one or greater.

6.3.7 Fluid. - For purpose of this specification, a fluid is defined as a gas or liquid.

6.3.8 High-Efficiency Particulate Air (HEPA) Filter. - A HEPA filter is a filter that is at least 99.97 percent efficient by volume on 0.3 micron particles as determined by the dioctyl phthalate test.

6.3.9 Hydrocarbon. - A hydrocarbon is a chemically identifible compound of carbon and hydrogen. Frequently, hydrogen atoms of hydrocarbons are substituted by inorganic atoms, the resulting compounds being generally referred to as organic compounds. As a class, the hydrocarbons are neutral, insoluble in water, and combustible.

6.3.10 Hypergolic Fuel. - A fuel that ignites spontaneously upon contact with an oxidizer.

6.3.11 Micron. - 0.001 millimeter, 0.000001 meter, or 0.0000394-inch. The lower limit of visibility with the naked eye is approximately 40 microns.

6.3.12 Part. - One piece; or two or more pieces joined together in such a way that it is not normally disassembled without destruction of the designed use. Fittings, o-rings, and poppet are parts of a valve.

6.3.13 Parts per Million by Weight (PPM/WT.). - An absolute weight relationship expressed on an equivalent basis in any weight unit. The user may employ a weight unit that is convenient for him. One part per million may be one gram per million grams, one pound per million pounds, etc. In chemical usage, one part per million by weight usually refers to one microgram (one-millionth of a gram) per gram.

6.3.14 Particle. - A minute unit of matter whose size and shape depend on the forces of cohesion. The dimensions of particle of interest in precision cleaning are measured in microns.

6.3.15 pH. - pH is a measure of the acidity or alkalinity of a substance on an arbitrary chemical scale, ranging from 0 to 14. A pH reading up to 7 is acid; pH 7 is neutral; and above pH 7 is alkaline. A pH of 0 has the greatest acidity, and a pH of 14 has the greatest alkalinity.

6.3.16 Silting. - Silting shall be defined as an accumulation of minute particles of sufficient quantity to cause a haze or obscuring of any portion of a grid line or any portion of the grid of a filter membrane, when viewed visually or under 40 power maximum magnification.

6.3.17 Solvent Soluble Organic Residue (SSOR). - Solvent soluble organic residue is that organic residue, usually hydrocarbons, remaining on a surface after cleaning. The presence of this residue is detected by flushing a test solvent, such as trichloroethylene or trichlorotrifluoroethane, over

the surface and then analyzing the solvent for residue content. Evaporating the test solvent at 212°F and weighing the nonvolatile material is the familiar NVR test. Quantitative analysis of the solvent for organic materials can be made more rapidly and more accurately by infrared spectrophotometry.

6.3.18 Subsystem. - Two or more assemblies joined together to perform a definite function. A subsystem should be capable of independent operation when interconnected into a system.

6.3.19 System. - A series of subsystems joined together to perform a definite function.

6.3.20 Visibly Clean. - For purposes of this specification, visibly clean shall mean freedom of a surface from particulate matter approximately 40 microns and larger in size and from all films other than known innocuous films. The lower limit of visibility with the unaided eye is approximately 40 microns.

Notice. - When KSC drawings, specifications, or other data are used for any purpose other than in connection with a definitely related KSC procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever and the fact that KSC may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

APPENDIX

10.1 Mixing Procedures for Cleaning Formulations

10.1.1 On-Site Preparation of Formula I for Cleaning Corrosion Resistant Steel. - Formula I, as used in actual cleaning, shall consist of the following composition as specified in 3.10.1.1:

Percent by Volume	Material
5 ± 0.5	85% ortho phosphoric acid.
10 ± 0.5	2-butoxyethanol solvent (ethylene glycol monobutyl ether)
0.5 ± 0.05	surfactant (alkyl aryl polyethylene glycol ether)
remainder	deionized water

10.1.1.1 Sample Calculations. - Sample calculations for 300 gallons of Formula I are as follows:

15 gallons of 85% ortho phosphoric acid
30 gallons of 2-butoxyethanol solvent
1.5 gallons of surfactant
deionized water as required to make a final volume of 300 gallons

10.1.1.2 Mixing Procedure. - The mixing procedure shall be as follows:

(a) Add 200 gallons of deionized water to a clean tank in which Formula I is to be mixed.

(b) Slowly add 15 gallons of 85 percent ortho phosphoric acid while throughly agitating the solution.

CAUTION

Always add acid to water. Never add water to acid as the heat generated by diluting the acid will cause it to spatter. Use protective clothing as required.

(c) Pour approximately 28 gallons of 2-butoxyethanol solvent into a separate clean container (approximately 50 gallons capacity).

(d) Slowly add 1.5 gallons of surfactant to the 2-butoxyethanol solvent while thoroughly agitating the solution. The surfactant must completely dissolve in the solvent.

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(e) Rinse the surfactant container with a small portion of the remainder of the 2-butoxyethanol solvent and add it to the bulk of the mixture of step (d). Continue rinsing the surfactant container with small portions of solvent until all of the surfactant is removed and the total 30 gallons of 2-butoxyethanol is in the mixture.

(f) Slowly add the solvent - surfactant mixture to the acid-water solution of step (b) while thoroughly agitating the solution.

(g) Adjust the final volume of Formula I to 300 gallons with deionized water and throughly agitate the solution. The final result shall be a clear, colorless, homogeneous solution.

10.1.2 On-Site Preparation of Formula IV for Cleaning Aluminum. - Formula IV shall consist of the following composition as specified in 3.10.1.4:

Percent by Weight	Material
9 ± 0.4	2-butoxyethanol solvent (ethylene glycol monobutyl ether)
1.5 ± 0.4	sodium phosphate, dibasic, anhydrous (Na_2HPO_4)
0.5 ± 0.05	surfactant (alkyl aryl polyethylene glycol ether)
Remainder	deionized water

10.1.2.1 Sample Calculations. - Sample calculations for 2500 pounds of Formula IV are as follows:

225 pounds of 2-butoxyethanol solvent
37.5 pounds of sodium phosphate, bibasic, anhydrous
12.5 pounds of surfactant
deionized water as required to make a final weight of 2500 pounds of solution (1 gallon of water weighs 8.34 pounds).

10.1.2.2 Mixing Procedure. - The mixing procedure shall be as follows:

(a) Add approximately 1700 pounds of deionized water to a clean tank in which Formula IV is to be mixed.

(b) Slowly add 37.5 pounds of anhydrous, dibasic sodium phosphate (not trisodium phosphate) while throughly agitating the solution. Continue to agitate the solution until all the dibasic sodium phosphate is dissolved.

CAUTION

Dibasic sodium phosphate is a mild alkali. Use eye protection and safety clothing as required.

(c) Pour approximately 200 pounds of 2-butoxyethanol solvent into a separate clean container (approximately 50 gallons capacity).

(d) Slowly add 12.5 pounds of surfactant to the 2-butoxyethanol solvent while thoroughly agitating the solution. The surfactant must completely dissolve in the solvent.

(e) Rinse the surfactant container with a small portion of the remainder of the 2-butoxyethanol solvent and add it to the bulk of the mixture of step (d). Continue rinsing the surfactant container with small portions of solvent until all of the surfactant is dissolved and the total 225 pounds of solvent is in the mixture.

(f) Slowly add the solvent - surfactant mixture to the water - phosphate solution of step (b) while thoroughly agitating the solution.

(g) Adjust the final weight of Formula IV to 2500 pounds with deionized water and thoroughly agitate the solution. The final result shall be a clear, colorless, homogeneous solution.

10.1.3 On-Site Preparation of Formula VI for Cleaning Copper and Copper Alloys. - Formula VI shall consist of the following composition as specified in 3.10.1.6:

Percent by Volume	Material
15 ± 0.5	85% ortho phosphoric acid
10 ± 0.5	2-butoxyethanol solvent (ethylene glycol monobutyl ether)
0.5 ± 0.05	surfactant (alkyl aryl polyethylene glycol ether)
Remainder	deionized water

10.1.3.1 Mixing Procedure. - The mixing procedure shall be in accordance with 10.1.1.2 while using the proportions of materials specified by 10.1.3.

10.2 Sample Calculations

10.2.1 Determination of Acid Content of Formula I and Formula VI. - In the titration for determining the phosphoric acid content of Formula I and Formula VI in accordance with 4.5.4.1, assume that 14.7 ml of 1.0 normal

sodium hydroxide are required to reach the phenolphthalein end point and 7.3 ml of 1.0 normal sodium hydroxide are required to reach the bromphenol blue end point. The calculations proceed as follows:

(a) Data - 10 = Sample size = 10 ml

A = Volume of sodium hydroxide to reach phenolphthalein end point = 14.7 ml

B = Volume of sodium hydroxide to reach bromphenol blue end point = 7.3 ml

C = normality of standard sodium hydroxide = 1.0

N = normality of phsophoric acid

(b) Substitute data in (a) in the following formula and calculate

$$10 \times N = (A+B)C$$

$$10 \times N = (14.7 + 7.3)(1)$$

$$10 \times N = 22$$

$$N = \frac{22}{10}$$

$$N = 2.2$$

(c) Refer to the analytical curve in Figure 4. Locate a normality of 2.2 on the axis labled Normality of Phosphoric Acid. Move up the line for a normality of 2.2 and locate the point of intersection with the curve. Move to the left to the axis labeled Percent by Volume of 85 Percent Phosphoric Acid and read 5 percent by volume.

10.2.2 Determination of Acid Content of Formula II. - In the determination of the nitric and hydrofluoric acids in Formula II in accordance with 4.5.5.1, assume that 16.9 ml of standard 1 Normal sodium hydroxide are required to reach the first (nitric acid) end point and 20.1 ml of standard 1 Normal sodium hydroxide are required to reach the second (total acid) end point in titrating a 10 ml sample of Formula II. The calculations proceed as follows:

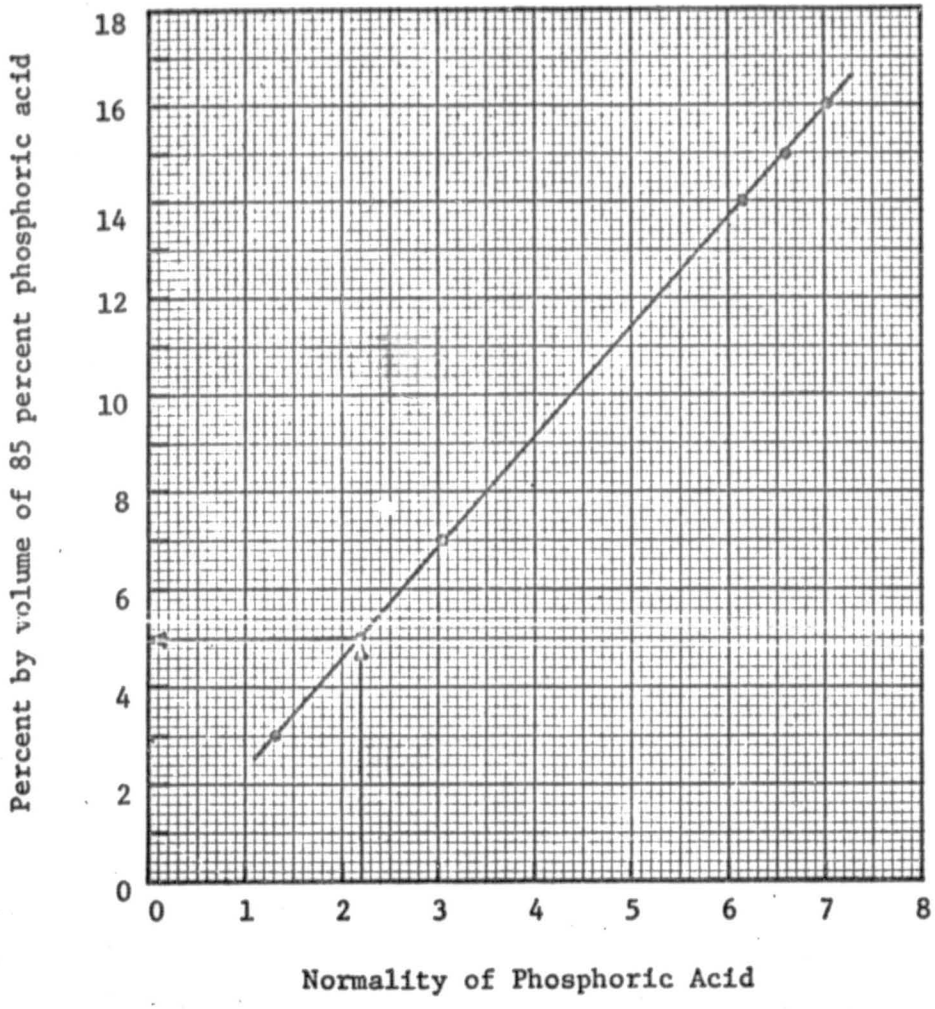


Figure 4 TYPICAL ANALYTICAL CURVE FOR 85 PERCENT PHOSPHORIC ACID

(a) Data: A = ml of standard sodium hydroxide used for first end point = 16.9 ml

B = ml of standard sodium hydroxide used for second end point = 20.1 ml.

C = Normality of standard sodium hydroxide = 1.0 N

N_1 = Calculated normality of hydrofluoric acid

N_2 = Calculated normality of nitric acid

10 = ml of sample of Formula II = 10 ml

(b) Calculate the normality of hydrofluoric acid in Formula II by substituting the data in (a) in the following formula:

$$10 \times N_1 = (B-A) \times 1.28 \times C$$

$$10 \times N_1 = (20.1-16.9) \times 1.28 \times 1$$

$$10 \times N_1 = 3.2 \times 1.28 \times 1$$

$$10 \times N_1 = 4.1$$

$$N_1 = 0.41$$

(c) Refer to the analytical curve in Figure 5. Locate a normality of 0.41 on the axis labeled Normality of Hydrofluoric acid. Move up the 0.41 normality line to the intersection with the curve. Move to the left to the axis labeled Percent by Volume of 48 Percent Hydrofluoric Acid and read 1.5 percent by volume.

(d) Calculate the normality of nitric acid in Formula II by substituting the data in (a) in the following formula:

$$10 \times N_2 = B - [(B-A) \times 1.28] \times C$$

$$10 \times N_2 = 20.1 - [(20.1-16.9) \times 1.28] \times 1$$

$$10 \times N_2 = 20.1 - 4.1$$

$$10 \times N_2 = 16.0$$

$$N_2 = 1.6$$

(e) Refer to the analytical curve in Figure 6. Locate a normality of 1.6 on the axis labeled Normality of Nitric Acid. Move up the 1.6 normality line to the intersection with the curve. Move to

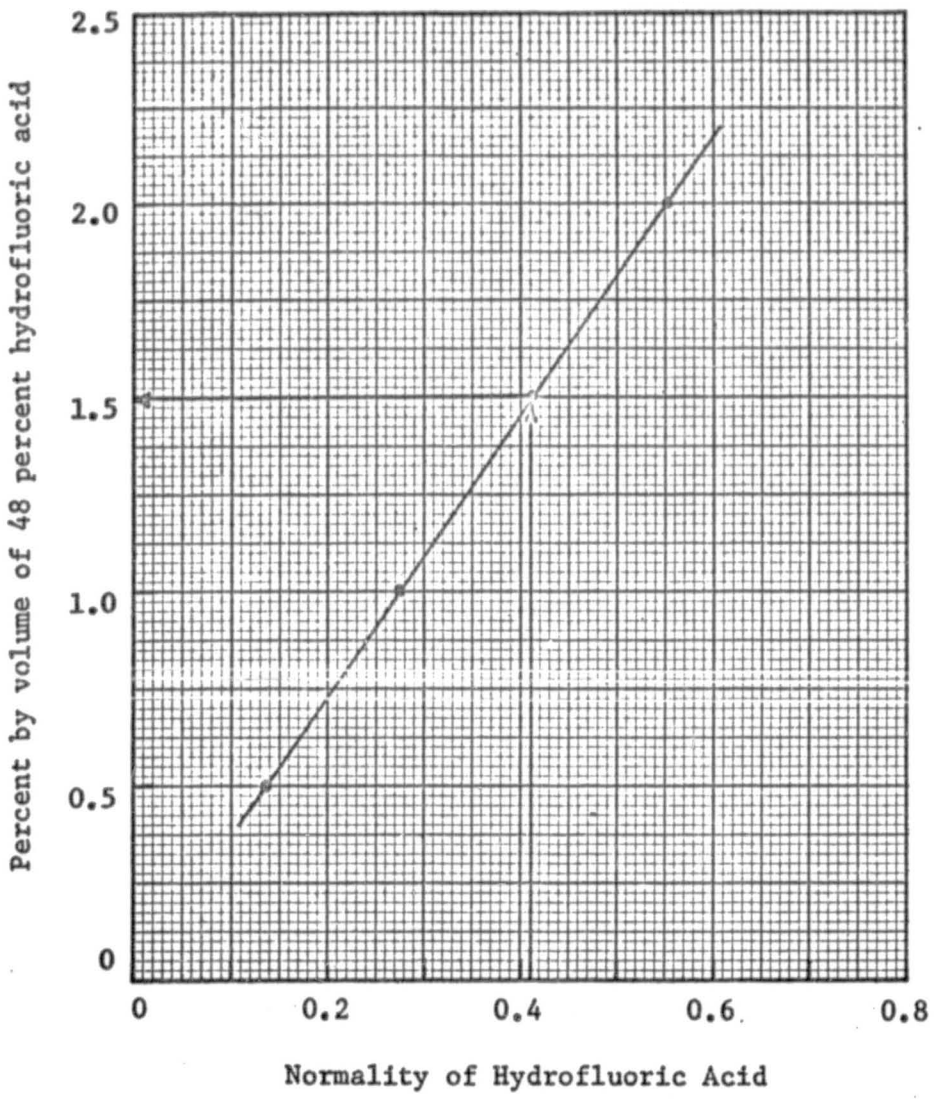


Figure 5 TYPICAL ANALYTICAL CURVE FOR 48 PERCENT HYDROFLUORIC ACID

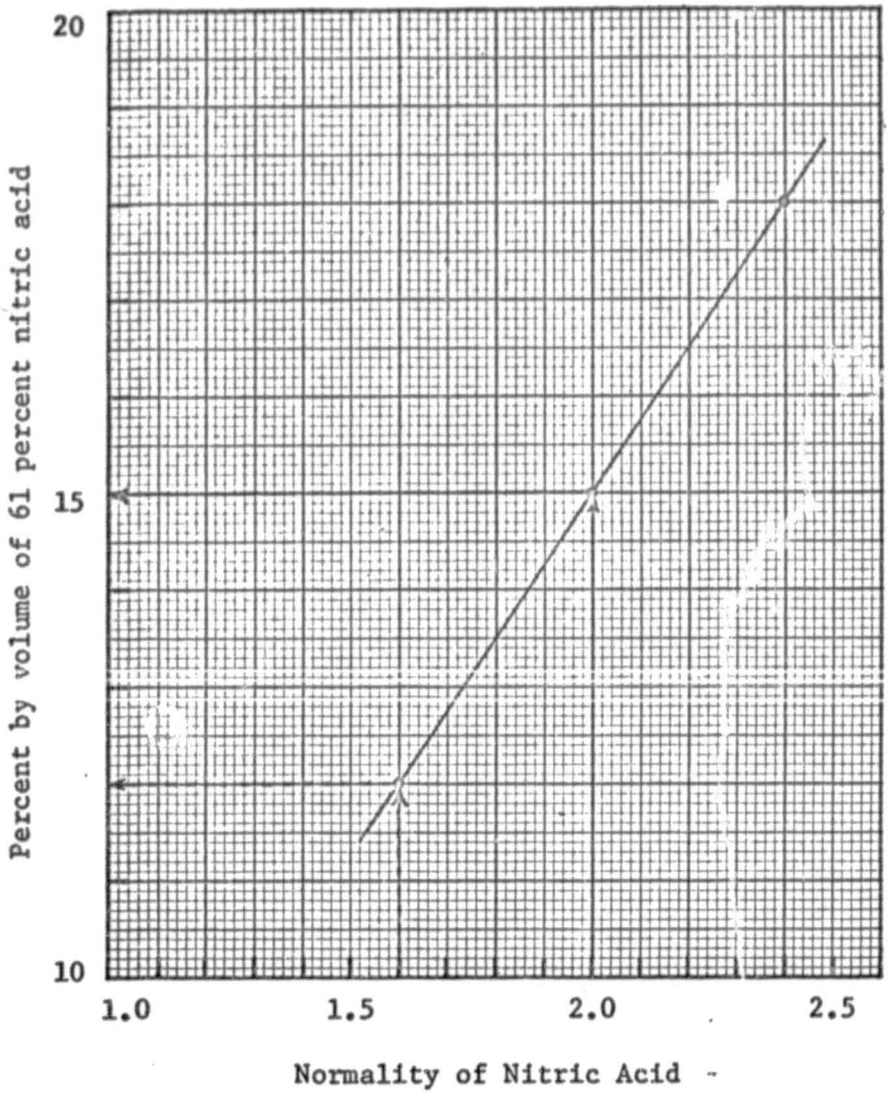


Figure 6 TYPICAL ANALYTICAL CURVE FOR 61 PERCENT NITRIC ACID

the left to the axis labeled Percent by Volume of 61 Percent Nitric Acid and read 12 percent by volume.

10.2.3 Determination of Acid Content of Formula III and Formula V. - In the titration for determining the nitric acid content of Formula III and Formula V in accordance with 4.5.6.1, assume that 20 (20) milliliters of 1.0 normal standard sodium hydroxide are required to neutralize the nitric acid present in the ten (10) milliliter sample. The calculations proceed as follows:

(a) Data - 10 = Sample Size = 10 ml

A = Volume of sodium hydroxide = 20 ml

C = Normality of standard sodium hydroxide = 1.0

N = Normality of nitric acid

(b) Substitute data in (a) in the following formula and calculate N.

$$10 \times N = A \times C$$

$$10 \times N = 20 \times 1$$

$$N = \frac{20}{10}$$

N = 2 = normality of nitric acid

(c) Refer to the analytical curve in Figure 6. Locate a normality of 2 on the axis labeled Normality of Nitric Acid. Move up the normality of 2 line and locate the point of intersection with the curve. Move to the left to the axis labeled Percent by Volume of 61 Percent Nitric Acid and read 15 percent by volume.

10.2.4 Determination of Dibasic Sodium Phosphate Content of Formula IV. - In determining the dibasic sodium phosphate content of Formula IV in accordance with 4.5.7.2, assume that 10 ml of 0.1 N hydrochloric acid are required to reach the methyl orange end point for a 10g sample of Formula IV. The calculations proceed as follows:

(a) Data: A = ml of standard hydrochloric acid = 10

C = normality of standard hydrochloric acid = 0.1

W = weight of sample of Formula IV = 10

P = percent by weight of dibasic sodium phosphate.

(b) Substitute data in (a) in the following formula and calculate P:

$$P = \frac{AxCx14.2}{W}$$

$$P = \frac{10x0.1x14.2}{10}$$

P = 1.42 percent by weight

10.2.5 Determination of Acid Content of Formula VII. - In determining the sulfuric acid and nitric acid contents of Formula VII in accordance with 4.5.10.1, assume that 18.1 ml of 2.5 N sodium hydroxide are required to neutralize the total acid content of a 10 ml sample of Formula VII. Further, 22.6 ml of 0.1 N sodium hydroxide are required to neutralize the sulfuric acid in a one (1) ml sample of Formula VII. The calculations proceed as follows:

(a) Data - A = ml of standard sodium hydroxide used in total acid determination = 18.1 ml

B = ml of standard sodium hydroxide used in sulfuric acid determination = 22.6 ml

C_1 = normality of standard sodium hydroxide used in total acid determination = 2.5N

C_2 = normality of standard sodium hydroxide used in sulfuric acid determination = 0.1N

N_1 = calculated normality of nitric acid

N_2 = calculated normality of sulfuric acid

Y = ml of Formula VII used for total acid analysis = 10 ml

Z = ml of Formula VII used for sulfuric acid analysis = 1 ml

(b) Substitute the data in the following formula and calculate N_2, the normality of sulfuric acid.

$$Z \times N_2 = B \times C_2$$

$$1 \times N_2 = 22.6 \times 0.1$$

$$N_2 = 2.26$$

(c) Refer to the analytical curve in Figure 7. Locate a normality of 2.26 on the axis labeled Normality of Sulfuric Acid. Move up the line for a normality of 2.26 and locate the intersection with the curve. Move to the left to the axis labeled Percent by Volume of 93 Percent Sulfuric Acid and read 6.5 percent by volume.

(d) Substitute the data in the following formula and calculate N_1, the normality of nitric acid.

$$Y \times N_1 = AxC_1 - BxC_2xY$$

$$10 \times N_1 = 18.1 \times 2.5 - 22.5 \times 0.1 \times 10$$

$$10 \times N_1 = 45.3 - 22.6$$

$$N_1 = \frac{22.7}{10}$$

$$N_1 = 2.27$$

(e) Refer to the analytical curve in Figure 6. Locate a normality of 2.27 on the axis labeled Normality of Nitric Acid. Follow the 2.27 normality line up to the intersection with the curve. Move to the left to the axis labeled Percent by Volume of 61 Percent Nitric Acid and read 17 percent by volume.

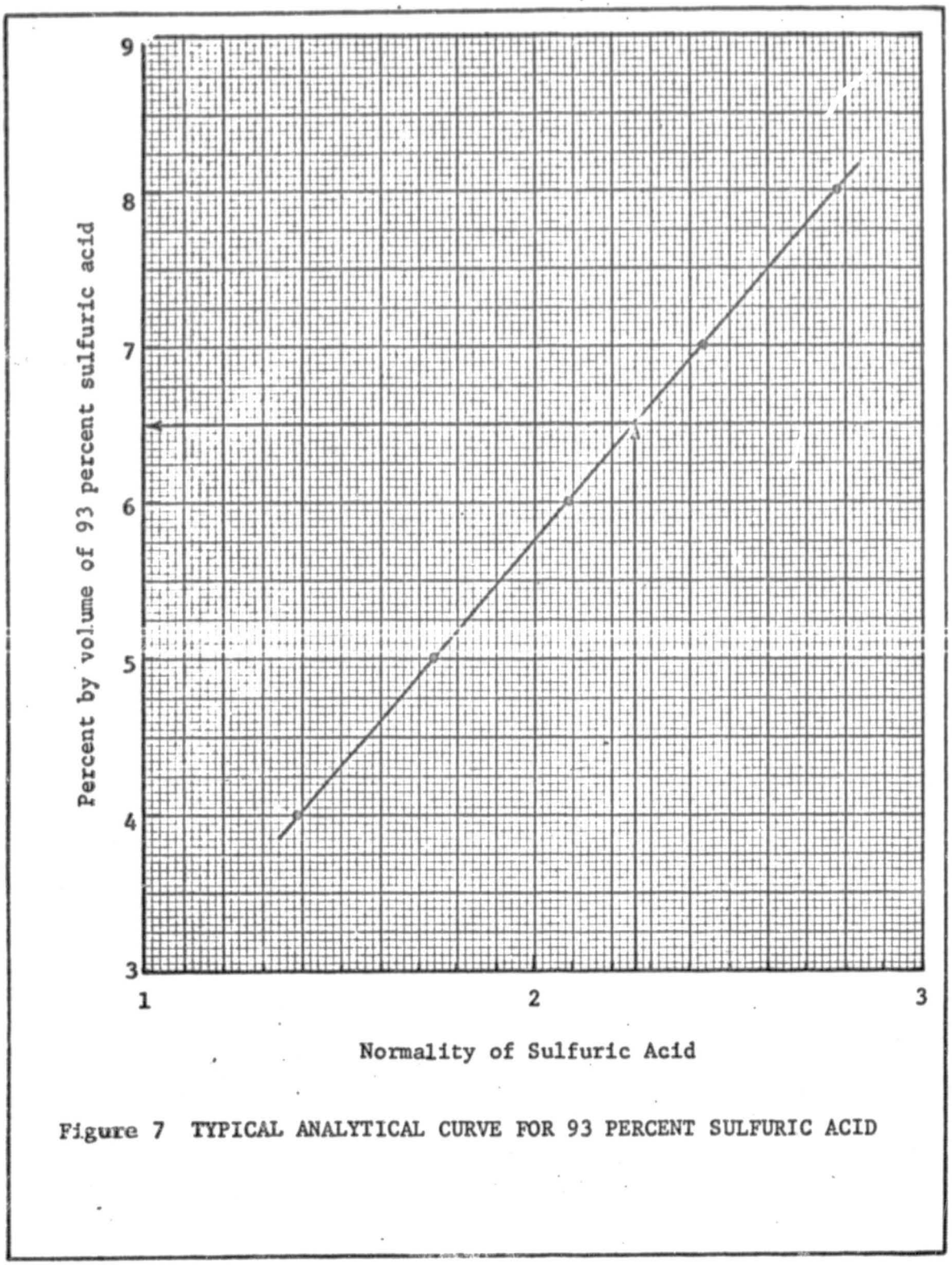


Figure 7 TYPICAL ANALYTICAL CURVE FOR 93 PERCENT SULFURIC ACID

END OF REFERENCE
II

REFERENCE
12

ANON.: CLEANING AND INSPECTION PROCEDURES FOR BALLISTIC MISSILE SYSTEMS, CHANGE 2. USAF T.O. 42C-1-11, NOV. 15, 1967.

7.4-0-0

T. O. 42C-1-11

LEWIS RESEARCH CENTER
Aerospace Safety Research
and Data Institute
MAY 20 1971
CLEVELAND, OHIO

TECHNICAL MANUAL

CLEANLINESS STANDARDS

CLEANING AND INSPECTION PROCEDURES FOR BALLISTIC MISSILE SYSTEMS

AF 04(607)-8912
F41608-67-D-7509

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AIR FORCE 16/12/68 - 500 REPRINT

15 JUNE 1965

CHANGE 2 – 15 NOVEMBER 1967

SECTION III
GENERAL CLEANING PROCEDURES

3-1. SCOPE

3-2. This section includes general policies and procedures for cleaning all components, end items, subsystems, and systems used in missile and ground systems having surfaces that will be in contact with liquid or gaseous oxygen, liquid or gaseous nitrogen, helium, hydrocarbon fuels, nitrogen tetroxide, unsymmetrical dimethylhydrazine (UDMH)/hydrazine (N_2H_4) fuel blend, hydraulic fluids, and other propulsion system fluids.

3-3. This section covers general cleaning procedures which will be accomplished at Base maintenance areas and Depot facilities. It is intended that the processes and standards in this manual also apply to cleaning of specialized equipment, and are to be supplemented with detailed step-by-step disassembly and reassembly procedures in the applicable maintenance manuals. Missile propellant tanks, other tanks, and rocket engines are examples of specialized equipment. Whereas processes indicated in this manual are applicable to the cleaning of tanks, all equipment shall be operated or disassembled and reassembled in accordance with its applicable weapon system manual.

3-4. TYPES OF MATERIALS TO BE CLEANED.

3-5. The procedures contained herein are intended for cleaning of materials and liquids in the following categories:

a. Stainless steels.

b. Carbon steels.

c. Aluminum and aluminum alloys.

d. Copper and copper alloys.

e. Non-metallics.

f. Plated parts.

g. Hydraulic fluids.

3-6. DECONTAMINATION, TITAN II EQUIPMENT.

3-7. Equipment and components which have been used in or with the Titan II missile fuel or oxidizer systems will contain residue of UDMH/hydrazine or nitrogen tetroxide, and shall be decontaminated as prescribed in Section V, prior to cleaning.

WARNING

Under no circumstances shall contaminated components be transported directly to the cleaning area or shall cleaning operations be attempted if any evidence of residual propellant contamination is present. Titan II propellants are hypergolic and will explode or ignite on contact. Mixtures of oxidizer and solvents can be shock sensitive.

Adequate protective clothing shall be worn when threshold limit value (TLV) or maximum allowable concentration (MAC) limits are exceeded. (See Section II.)

3-8. GENERAL CLEANING PROCEDURES.

3-9. The cleaning operation consists of two general operations: (1) pre-cleaning, and (2) final cleaning. Parts shall be pre-cleaned, where possible, to remove the major amount of surface contaminants. This makes the final cleaning operation more effective and reduces excessive amounts of contamination in final cleaning solutions. Cleaning will be accomplished using chemical solutions of acids, alkaline materials, solvents or detergents, and demineralized water rinses. In addition to detailed material cleaning processes, this section includes standard procedures such as drying, rinsing, etc, for each function. The final cleaning and inspection operation shall be conducted in an environmentally controlled room to permit enforcement of prescribed cleanliness standards. (See Reference Document Item 59, Section XI, as applicable.)

3-10. SELECTION OF CLEANING PROCEDURES AND MATERIALS.

3-11. Cleaning procedures selected by the cleaning supervisor shall be based upon the type of contaminant, condition of the part to be cleaned, and the type

of material. The chart in Figure 3-1 should be used in making this selection. The general cleaning procedures for various materials are tabulated in Figures 3-2 through 3-9. The recommended cleaning steps for non-metallic and electro-plated parts are shown in Figures 3-6 and 3-7, respectively. Anodized or chemical film coated parts shall be cleaned in accordance with Figure 3-1.

3-12. Alkaline cleaning or acid pickling and passivating solutions specified herein are suitable for general use. However, due to the variety of metals and conditions encountered, selection of alternate solutions and adjustment of the chemical concentration may be required to obtain the most effective results. Excessive etching of the part is to be avoided. Strong alkaline or acid solutions may attack or etch the metal part to such an extent that it will become unfit for use. Suggested factors of temperatures, time, and concentration of the chemical cleaning agents are given in the following paragraphs.

Note

If type of material of construction of the equipment to be cleaned cannot be readily identified, refer to the manufacturer's drawings for positive identification.

3-13. MAINTENANCE OF CLEANING SOLUTIONS. Periodic sampling of solutions shall be conducted. Solution samples shall be chemically tested to insure that the proper concentration exists.

CAUTION

Prior to cleaning components which require leak testing, pressure proof testing, or functional testing, determine whether local testing equipment or skill level permits follow-on testing as required. If required test capability is not available, the unclean or contaminated item shall be packaged and shipped to the appropriate decontamination, cleaning, and testing activity in accordance with detailed instructions obtained from the responsible AMA.

3-14. HYDRAULIC FLUIDS. Where cleaning of hydraulic fluids is required, see Sections IV, V, VI and IX of this manual, as applicable.

3-15. CRYOGENIC PROPELLANT SYSTEM COMPONENTS. Solution H, Paragraph 3-29, shall be used for pre-cleaning components associated with cryogenic liquid systems (reference Paragraph 1-8). Solution K, Paragraph 3-32, may be used as an alternate in pre-cleaning.

3-16. STORABLE PROPELLANT SYSTEM COMPONENTS. Solution O, Paragraph 3-36, shall be used for pre-cleaning components associated with storable propellant liquid systems (reference Paragraph 1-9). Solution G, Paragraph 3-27, may be used as an alternate in pre-cleaning.

3-17. CHEMICAL CLEANING LIQUIDS.

3-18. The following chemical solutions are recommended for the general cleaning procedures outlined in Figures 3-1 through 3-9. When local regulations prohibit the use of these chemicals or any procurement problems exist, the AMA responsible for this manual should be contacted for alternate solutions. References to specific solutions throughout this document are the solutions defined in Paragraphs 3-19 through 3-38.

WARNING

Always add acid to water when preparing solutions, not water to acid. Failure to follow this instruction will result in a violent chemical reaction.

WARNING

Always add alkali slowly to water. Extreme heat is generated when an alkali reacts with water. Failure to follow this instruction could result in fumes or chemical reaction injurious to personnel.

3-19. SOLUTION A - Alkaline Cleaner. Cleaning Compound (Federal Specification P-C-436), Alkaline Type, for ferrous and non-ferrous metal parts. Use 5 to 10 ounces per gallon of tap water at 150° to 175°F.

3-20. SOLUTION B - Pickle. For 300 Series Stainless Steel, except free machining grades such as Types 303 and 347F.

Nitric Acid (Federal Specification O-N-350)	-	20% by volume
Hydrofluoric Acid (FSN 6810-237-2917)	-	3% by volume
Tap Water	-	Balance

3-21. SOLUTION C - Pickle. For Series 400 Stainless Steel, free machining grade 300 series stainless steel, and aluminum.

Nitric Acid (Federal Specification O-N-350)	-	12% by volume
Hydrofluoric Acid (FSN 6810-237-2917)	-	1% by volume
Tap Water	-	Balance

3-22. SOLUTION D - Pickle. For Carbon Steel.

Hydrochloric Acid (Federal Specification O-H-765)	-	15 to 20% by volume
Inhibitor (Rodine No. 50 or equivalent)	-	0.25 to 0.50% by volume
Tap Water	-	Balance

3-23. SOLUTION D, ALTERNATE - Pickle. For Carbon Steel.

Phosphoric Acid (85%)- (FSN 6810-753-4777)		47% by volume
Detergent (Tritan X-100, Igepal CA-630, Atlas G-1690, or Tergitol NPX)	-	2% by volume
Tap Water at 60° to 100°F	-	Balance

3-24. SOLUTION E - Phosphoric Pickle (Military Specification MIL-M-10578). Phosphoric Acid Solution (Corrosion Removing Compound), Type 3 Inhibited. One part solution to one part tap water at room temperature.

3-25. SOLUTION F - Chromate Dip Passivate (Federal Specification O-S-595). (Sodium Dichromate.) Four grams to one gallon of demineralized water at room temperature.

3-26. SOLUTION F, ALTERNATE - Corrosion Preventative (Military Specification MIL-C-15074).

3-27. SOLUTION G - Detergent Solution (Military Specification MIL-D-16791, Type I). Use 1/2 to 1 ounce of solution per gallon of tap water at 120° to 140°F.

3-28. SOLUTION G, ALTERNATE - An alternate to the above solution is steam and steam cleaning compound (Cleaning Compound, High Pressure), (Federal Specification P-C-437).

3-29. SOLUTION H - Trichloroethylene (Military Specification MIL-T-27602).

3-30. SOLUTION I - Rinse Water. Tap water.

3-31. SOLUTION J - Rinse Water. Demineralized water.

3-32. SOLUTION K - Trichlorotrifluoroethane (FSN 6850-681-5688).

3-33. SOLUTION L - Aluminum Alkaline Cleaner.

Sodium Carbonate (Federal Specification O-S-571)	-	3 ounces per gallon
Trisodium Phosphate (Sodium Phosphate, Tribasic) (Federal Specification O-S-642)	-	3 ounces per gallon
Tap Water	-	Balance, to one gallon of solution.

3-34. SOLUTION M - Pickle for Copper and Copper Alloys.

Sulfuric Acid (Federal Specification O-S-809)	-	8.6% by volume
Nitric Acid (Federal Specification O-N-350)	-	1.4% by volume
Demineralized Water	-	90% by volume

3-35. SOLUTION M, ALTERNATE - Pickle for Copper and Copper Alloys.

Hydrochloric Acid (Federal Specification O-H-765)	-	10 to 15% by volume
Demineralized Water	-	85 to 90% by volume

Note

Solution N designation is intentionally omitted.

3-36. SOLUTION O - Detergent (Military Specification MIL-D-16791, Type I). Dissolve 1/2 to 1 ounce of detergent in one gallon of demineralized water.

3-37. SOLUTION O, ALTERNATE - Detergent (Degreasing only).

Trisodium Phosphate (Sodium Phosphate, Tribasic) (Federal Specification O-S-642)	- 1/3 pound
Detergent Military Specification MIL-D-16791, Nonionic Type 1)	- 1/2 ounce
Tap Water	- 1 gallon

3-38. SOLUTION O, SECOND ALTERNATE - Steam or pressurized hot tap water, either of which is combined with steam cleaning compound, (Cleaning Compound, High Pressure) (Federal Specification P-C-437).

3-39. DESCALING OF METALS.

3-40. Chemical or mechanical abrasive means may be used to remove rust, scale, welding flux, smut, discoloration (corrosion), and light soil. Chemical procedures are preferred because abrasive methods usually leave foreign deposits on the cleaned part. Also the shape of the part may prevent use of effective abrasive methods.

3-41. MECHANICAL ABRASIVE METHODS.

3-42. These methods involve wire brushing, shot blasting, grinding, or sand blasting. When wire brushes are used, the brush shall be composed of stainless steel or the same metal as that being cleaned. Sand used for sand blasting shall be high grade, washed silica sand containing no ferrous or ferric materials.

3-43. After required descaling, all loose dirt, sand, scale, or other particles will be removed from components by vacuum cleaning, blowing, brushing, or flushing with water. Chemical methods may be required to remove foreign deposits if appropriate weapon system cleanliness standards cannot be met.

3-44. CHEMICAL METHODS.

3-45. These methods involve acid pickling and alkaline cleaning or descaling.

3-46. PICKLING AND PASSIVATION.

Note

The oxide and scale formations of metal may be removed by the use of acids. If the part is soiled with dirt or grease, pre-cleaning with solvents or detergents is recommended. If severe scaling (incrustations) or deposits of welding scale are present, mechanical cleaning shall be employed prior to pickling. Passivation is required on stainless steel only.

CAUTION

Parts with fine tolerance, plating, filter elements, and other equipment which may be damaged during acid treatment must be removed from the component prior to acid pickling.

3-47. 300 SERIES STAINLESS STEEL. Solution B is recommended for both pickling and passivation of 300 Series stainless steel except for free machining grades such as Types 303 and 347F.

3-48. Solution B is used in conjunction with the following procedure:

a. Immerse parts and pickle 15 minutes at 60° to 100°F. Rinse with Solution I, inspect and hand brush to remove loose scale as required, and repeat if necessary. Time may be reduced or increased as required.

b. Flush with Solution I until the effluent has a pH equal to the influent as determined by using pH paper (Litmus) (Military Standard MS 36253-3).

c. Final rinse with Solution J.

(Text continued on page 3-16)

NOTE: (1) "X" symbol in the block denotes a recommended process for the surface condition indicated, and will normally be accomplished in consecutive order from left to right.

(2) *Trichloroethylene shall not be used for cleaning elastomers. (Elastomer is elastic rubber-like substance; a resilient, springy material such as natural rubber or synthetic rubbers, such as buna, neoprene butyl, silicone, or ethylene propylene.)

(3) **Solutions are defined in paragraphs 3-19 through 3-38.

(4) Ultrasonic rinsing is also required for Titan II components except non-metallic parts, transducers, and other dead-end cavities.

(5) Only applicable to Copper and Copper Alloys.

MATERIAL	REF FIG	SURFACE CONDITION	PRE-CLEANING PROCESS													FINAL CLEANING					
			Mechanical Descale	Degrease	Alkaline Clean	Rinse (Solution I)**	Detergent Rinse or Detergent Clean	Rinse (Solution I)**	Pickle	Rinse (Solution I)**	Rinse (Solution J)**	Protective Coat	Rinse (Solution J)**	Dry	Transport to Final Cleaning Area	Ultrasonic Clean, Solvent or Detergent Rinse (4)	Flush (Solution J)**	Inspect	Dry	Seal and Package	Certify
Aluminum Brass Bronze Copper	3-2	Bare or machined, free of heat oxidation		X	X	X	X	X	X				X	X	X	X	X	X	X	X	X
		Anodized or chemical film coating		X		X	X	X					X	X	X	X	X	X	X	X	X
		Weld scale, corrosion, or heat oxidation	X	X	(5)	X	X	X	X				X	X	X	X	X	X	X	X	X
Stainless Steel	3-3 and 3-4	Free of scale		X	X	X	X	X					X	X	X	X	X	X	X	X	X
		Weld scale, corrosion, or heat oxidation	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X
Carbon Steel and Carbon Steel Alloys	3-5	Free of scale		X	X	X						X	X	X	X	X	X	X	X	X	X
		Weld scale, corrosion, or heat oxidation	X	X	X	X			X	X	X	X		X	X	X	X	X	X	X	X
Non-Metallic Parts, Elastomers*	3-6	As received					X	X					X	X	X	X	X	X	X	X	X
Electroplated Parts and Dissimilar Metals	3-7	As received		X	X	X							X	X	X	X	X	X	X	X	X
Metal Filter Elements	3-8	As received			X		X						X	X	X	X	X	X	X	X	X
Transducers, Pressure Gages & Other Dead-end Cavities	3-9	As received														X	X	X	X	X	X

Figure 3-1. Selection Chart for Cleaning Processes

STEP	PROCESS	SOLUTION (Ref Para 3-17)	TIME (MINUTES)	TEMP (DEG F)	REMARKS	REF PARA
1	Mechanical Descale	-	As required	-		3-39
2	Degrease	G, H, K, or O	As required	Ambient	Hand wash using stiff bristle brush or clean cheese cloth, or by fill and drain methods.	3-15 3-16 3-75 3-76
3	Vapor Degrease	H or K	As required	Boiling	Immerse parts in vapor until condensation ceases. Flush with degreaser liquid solvent	3-15 3-16 3-64
4	Alkaline Clean	See remarks	See referenced paragraphs	150	**WARNING** Parts shall be completely free of Solution H before immersion in Solution A. Solution H and Solution A can form an explosive mixture. Aluminum and aluminum alloys, use Solution L. Copper, brass, and bronze, use Solution A.	3-56 3-59
5	Rinse	I	5-10	150	After rinsing, examine for "waterbreak". If necessary, repeat Steps 4 and 5.	
6	Pickle	See remarks	See referenced paragraphs	Solution C Ambient; Solution M or M Alternate 120 to 130	Copper, brass, and bronze use Solution M or M Alternate. Aluminum and aluminum alloys, use Solution C. Use this step only if corrosion or scale exists. Immerse until contamination is removed. **CAUTION** Anodized aluminum parts are normally not pickled since the pickling process would remove the anodization.	3-58 3-59
7	Rinse	J	5-10	150	Final pre-cleaning rinse to remove residues from previous rinses.	

Figure 3-2. Cleaning Procedures for Aluminum, Brass, Copper, and Bronze (Sheet 1 of 2)

STEP	PROCESS	SOLUTION (Ref Para 3-17)	TIME (MINUTES)	TEMP (DEG F)	REMARKS	REF PARA
8	Dry	See referenced paragraph	As required	See referenced paragraph		3-87
9	Transport to Final Cleaning Area				Use extreme care to prevent recontamination of parts. Seal and package as required.	
10	Detergent Rinse or	G or O	15-25	120-140		3-86
	Solvent Rinse	H	As required	As required		3-85
11	Flush	J	As required to wet all surfaces	150	Flush component after detergent rinsing. Do not flush after solvent rinsing. See Step 10.	
12	Inspect					3-89
13	Dry	See referenced paragraph	As required	See referenced paragraph		3-87
14	Package					3-98
15	Certify					3-91 3-102

GENERAL NOTES:

1. The Cleaning supervisor will determine which steps listed above will be used, based on the condition of the part and the applicable weapon system requirements.
2. Steps 1 through 8 may be accomplished at Base Support Shops.

Figure 3-2. Cleaning Procedures for Aluminum, Brass, Copper, and Bronze (Sheet 2 of 2)

STEP	PROCESS	SOLUTION (Ref Para 3-17)	TIME (MINUTES)	TEMP (DEG F)	REMARKS	REF PARA
1	Mechanical Descale		As required			3-39
2	Degrease	G, H, K, or O	As required	Ambient	Hand wash using stiff bristle brush or clean cheese cloth, or by fill and drain methods.	3-15 3-16 3-75 3-76
3	Vapor Degrease	H or K	As required	Degreaser operating temperature	Immerse parts in vapor until condensation ceases. Flush with freshly condensed degreaser solvent.	3-15 3-16 3-64

Figure 3-3. Cleaning Procedures for 300 Series Stainless Steel Except Free Machining Grade Parts (Sheet 1 of 3)

STEP	PROCESS	SOLUTION (Ref Para 3-17)	TIME (MINUTES)	TEMP (DEG F)	REMARKS	REF PARA
4	Alkaline Clean	A	15-25	150-175	**WARNING** Parts shall be completely free of Solution H before immersion in Solution A. Solution H and Solution A can form an explosive mixture.	3-77
5	Detergent Rinse	G or O	15-25	120-140		3-86
6	Rinse	I	5-10	150	After rinsing, examine for waterbreak. If necessary repeat Step 4, 5, and 6.	3-84
7	Pickle	B See remarks	15	60-100	If the specific alloy cannot be identified, Solution C shall be used.	3-47
8	Rinse	I	5-7	150	Rinse to remove acid solution from parts. Then brush with stiff bristle brush to remove loose scale. Repeat Steps 7 and 8 until all scale is removed.	3-84
9	Rinse	J	5-10	150	Final pre-cleaning rinse to remove residues from previous rinses.	3-84
10	Dry	See referenced paragraph	As required	See referenced paragraph		3-87
11	Transport to Final Cleaning Area				Use extreme care to prevent recontamination of parts. Seal and package as required.	
12	Detergent Rinse or	G or O	15-25	120-140		3-86
	Solvent Rinse	H	As required	As required		3-85
13	Flush	J	As required to wet all surfaces	150	Flush component after detergent rinsing. Do not flush after solvent rinsing in Step 12.	

Figure 3-3. Cleaning Procedures for 300 Series Stainless Steel Except Free Machining Grade Parts (Sheet 2 of 3)

STEP	PROCESS	SOLUTION (Ref Para 3-17)	TIME (MINUTES)	TEMP (DEG F)	REMARKS	REF PARA
14	Inspect					3-89
15	Dry	See referenced paragraph	As required	See referenced paragraph		3-87
16	Package					3-98
17	Certify					3-91 3-102

GENERAL NOTES:

1. The cleaning supervisor will determine which steps listed above will be used, based on the condition of the part and the applicable weapon system requirements.
2. Steps 1 through 10 may be accomplished by Base Support Shops.

Figure 3-3. Cleaning Procedures for 300 Series Stainless Steel Except Free Machining Grade Parts (Sheet 3 of 3)

STEP	PROCESS	SOLUTION (Ref Para 3-17)	TIME (MINUTES)	TEMP (DEG F)	REMARKS	REF PARA
1	Mechanical Descale		As required			3-39
2	Degrease	G, H, K or O	As required	Ambient	Hand wash using stiff bristle brush or clean cheese cloth, or by fill and drain methods.	3-15 3-16 3-75 3-76
3	Vapor Degrease	H or K	As required	Degreaser operating temper-ature	Immerse parts in vapor until condensation ceases. Flush with freshly condensed degreaser solvent.	3-15 3-16 3-64
4	Alkaline Clean	A	15-25	150-175	**WARNING** Parts shall be completely free of Solution H before immersion in Solution A. Solution H and Solution A can form an explosive mixture.	3-77
5	Detergent Rinse	G or O	15-25	120-140	--	3-86

Figure 3-4. Cleaning Procedures for 400 Series Stainless Steel and Free Machining Grades 300 Series Parts (Sheet 1 of 2)

STEP	PROCESS	SOLUTION (Ref Para 3-17)	TIME (MINUTES)	TEMP (DEG F)	REMARKS	REF PARA
6	Rinse	I	5-10	150	After rinsing, examine for "waterbreak". If necessary repeat Steps 4, 5 and 6.	3-84
7	Pickle	C	10	60-100	--	3-49
8	Rinse	I	5-7	150	Rinse to remove acid solution from parts. Then brush with stiff bristle brush to remove loose scale. Repeat Steps 7 and 8 until all scale is removed.	3-84
9	Rinse	J	5-10	150	Final pre-cleaning rinse to remove residues from previous rinses.	3-84
10	Dry	See referenced paragraph	As required	See referenced paragraph		3-87
11	Transport to Final Cleaning Area				Use extreme care to prevent recontamination of parts. Seal and package as required.	
12	Detergent Rinse or	G or O	15-25	120-140		3-86
	Solvent Rinse	H	As required	As required		3-85
13	Flush	J	As required to wet all surfaces	150	Flush component after detergent rinsing. Do not flush after solvent rinsing. See Step 12.	
14	Inspect					3-89
15	Dry	See referenced paragraph	As required	See referenced paragraph		3-87
16	Package					3-98
17	Certify					3-91 3-102

GENERAL NOTES:

1. The cleaning supervisor will determine which steps listed above will be used, based on the condition of the part and the applicable weapon system requirement.
2. Steps 1 through 10 may be accomplished by Base Support Shops.

Figure 3-4. Cleaning Procedures for 400 Series Stainless Steel and Free Machining Grades 300 Series Parts (Sheet 2 of 2)

STEP	PROCESS	SOLUTION (Ref Para 3-17)	TIME (MINUTES)	TEMP (DEG F)	REMARKS	REF PARA
1	Mechanical Descale		As required			3-39
2	Degrease	G, H, K or O	See remarks	Ambient	Hand wash using stiff bristle brush or clean cheese cloth, or by fill and drain methods.	3-15 3-16 3-75 3-76
3	Vapor Degrease	H or K	See remarks	Degreaser operating temperature	Immerse parts in vapor until condensation ceases. Flush with degreaser liquid solvent.	3-15 3-16 3-64
4	Alkaline Clean	A	15-20	150	**WARNING** Parts shall be completely free of Solution H before immersion in Solution A. Solution H and Solution A can form an explosive mixture.	3-77
5	Rinse	I	5-10	150	After rinsing, examine for "waterbreak". If necessary, repeat Steps 4 and 5.	3-84
6	Pickle	D	15-30	Ambient	Use this step only if rust, corrosion, or scale exists after Step 5. Immerse until contamination is removed or loosened.	3-51
7	Rinse	I	5-7	150	Rinse at this temperature to remove acid from parts. Omit this step if step 6 is omitted.	3-84
8	Rinse	J	3-5	150	Rinse at this temperature.	3-84
9	Bake	--	180	375 $\pm$25	This is required only for steels harder than Rockwell C32 to prevent hydrogen embrittlement.	
10	Protective Coat	F Alternate	As required to wet all surfaces	Ambient		3-55
11	Dry	See referenced paragraph	As required	See referenced paragraph		3-87

Figure 3-5. Cleaning Procedures for Carbon Steel and Carbon Steel Alloys (Sheet 1 of 2)

STEP	PROCESS	SOLUTION (Ref Para 3-17)	TIME (MINUTES)	TEMP (DEG F)	REMARKS	REF PARA
12	Transport to Final Cleaning Area				Use extreme care to prevent recontamination of parts. Seal and package as required.	
13	Detergent Rinse or	G or O	15-25	120-140		3-86
	Solvent Rinse	H	As required	As required		3-85
14	Flush	J	As required to wet all surfaces	150	Rinse component after detergent cleaning. Do not flush after solvent rinse. See Step 13.	
15	Inspect					3-89
16	Dry	See referenced paragraph	As required	See referenced paragraph	**CAUTION** Immediately proceed to packaging to prevent or reduce corrosion.	3-87
17	Package					3-98
18	Certify					3-91 3-102

GENERAL NOTES:

1. The cleaning supervisor will determine which steps listed above will be used, based on the condition of the part and the applicable weapon system requirements.
2. Steps 1 through 11 may be accomplished at Base Support Shops.

Figure 3-5. Cleaning Procedures for Carbon Steel and Carbon Steel Alloys (Sheet 2 of 2)

STEP	PROCESS	SOLUTION (Ref Para 3-17)	TIME (MINUTES)	TEMP (DEF F)	REMARKS	REF PARA
1	Detergent Clean	G or O	5-10	120-140	**CAUTION** Do Not Use Solvent Cleaning Immerse parts in detergent for 3-5 minutes. Remove and brush with a soft bristle brush. Re-immerse for 5 minutes.	3-86

Figure 3-6. Cleaning Procedures for Non-Metallic Parts and Components Containing Non-Metallic Parts (Sheet 1 of 2)

STEP	PROCESS	SOLUTION (Ref Para 3-17)	TIME (MINUTES)	TEMP (DEG F)	REMARKS	REF PARA
2	Rinse	I	5-10	150	Rinse to remove residual detergent solution.	3-64
3	Rinse	J	As required	150	Rinse component to remove cleaning chemicals and loose contaminants.	3-64
4	Dry	See referenced paragraph	As required	See referenced paragraph		3-87
5	Transport to Final Cleaning Area				Use extreme care to prevent recontamination of parts. Seal and package as required.	
6	Detergent Rinse	G or O	15-20	120-140		3-86
7	Inspect					3-89
8	Dry	See referenced paragraph	As required	See referenced paragraph		3-87
9	Package					3-98
10	Certify					3-91 3-102

Figure 3-6. Cleaning Procedures for Non-Metallic Parts and Components Containing Non-Metallic Parts (Sheet 2 of 2)

STEP	PROCESS	SOLUTION (Ref Para 3-17)	TIME (MINUTES)	TEMP (DEG F)	REMARKS	REF PARA
1	Degrease	G, H, K, or O	See remarks	Ambient	Hand wash using stiff bristle brush or clean cheese cloth, or by fill and drain methods.	3-15 3-16 3-75 3-76
2	Vapor Degrease	H or K	See remarks	Boiling	Immerse parts in vapor until condensation ceases. Flush with freshly condensed degreaser solvent.	3-15 3-16 3-64

Figure 3-7. Cleaning Procedures for Electroplated Parts and Components Containing Dissimilar Metals (Sheet 1 of 2)

STEP	PROCESS	SOLUTION (Ref Para 3-17)	TIMES (MINUTES)	TEMP (DEG F)	REMARKS	REF PARA
3	Alkaline Clean	A	15-25	150-175	**WARNING** Parts shall be completely free of Solution H before immersion in Solution A. Solution H and Solution A can form an explosive mixture.	3-77
4	Rinse	I	5-10	150	After rinsing, examine for waterbreak. If necessary, repeat Steps 3 and 4.	3-84
5	Rinse	J	5-10	150	Final pre-cleaning rinse to remove residues from previous rinses.	3-84
6	Dry	See referenced paragraph	As required	See referenced paragraph		3-87
7	Transport to Final Cleaning Area				Use extreme care to prevent recontamination of parts. Seal and package as required.	
8	Detergent Rinse or	G or O	15-25	120-140		3-86
	Solvent Rinse	H	As required	As required		3-85
9	Flush	J	As required	150	Flush component after detergent rinsing. Do not flush after solvent rinsing. See Step 8.	
10	Inspect					3-89
11	Dry	See referenced paragraph	As required	See referenced paragraph		3-87
12	Package					3-98
13	Certify					3-91 3-102

GENERAL NOTE:
The cleaning supervisor will determine which steps listed above will be used, based on the condition of the part and the applicable weapon system requirements.

Figure 3-7. Cleaning Procedures for Electroplated Parts and Components Containing Dissimilar Metals (Sheet 2 of 2)

STEP	PROCESS	SOLUTION (Ref Para 3-17)	TIME (MINUTES)	TEMP (DEG F)	REMARKS	REF PARA
1	Vapor Degrease	H or K	As required	Boiling	Immerse filter elements in vapor until condensation ceases. Omit this step for Titan II filter elements.	3-64
2	Rinse	I	5-7	150	Do not use with solvent in Step 1.	3-84
3	Rinse	J	3-5	150	Do not use with solvent in Step 1.	3-84
4	Dry	See referenced paragraph	As required	See referenced paragraph		3-87
5	Transport to Final Cleaning Area				Use extreme care to prevent recontamination of parts. Seal and package as required.	
6	Ultrasonic Clean	G or O	3-5	120-140	Use detergent solution for Titan II filter elements.	3-15 3-16 3-79
	Ultrasonic Clean	H or K	3-5	Approx. 10^{O}F below boiling pt		
7	Solvent Rinse or	H	5-7	Ambient	To follow ultrasonic cleaning with solvent.	3-85
	Water Rinse (Ultrasonic Rinse for Titan II)	J	5-7	150	To follow ultrasonic cleaning with detergent. Do not use with solvent solutions H or K in Step 6.	3-84
8	Repeat Steps 2 and 3 and test effluent to the cleanliness standards of the applicable weapon system.					
9	Inspect					3-89
10	Dry	See referenced paragraph	As required	See referenced paragraph		3-87
11	Package					3-98
12	Certify					3-91 3-102

GENERAL NOTES:

1. Filter elements used in Titan II Propellant service shall be cleaned in detergent solutions after being decontaminated. Other filter elements shall be cleaned with solvents.
2. Filter elements shall be back-flushed when equipment is available.

Figure 3-8. Cleaning Procedures for Metal Filter Elements

STEP	PROCEDURE	REF PARA
1	Fill component with cleaning solutions G, H, or O.	3-15 3-16
2	Tilt and tap component sufficiently to allow fluid to flow into tube or dead-end cavities, and repeat operation until tube is approximately three-fourths full.	
3	Rotate gently using a circular motion to circulate fluid in tube and pour out fluid.	
4	Repeat Steps 1, 2, and 3 two times	
5	Repeat Steps 1, 2, and 3 two times using Solution J for rinsing in lieu of Solutions G or O, and petroleum ether in lieu of Solution H.	
6	Inspect.	3-89
7	Dry.	3-87
8	Package.	3-98
9	Certify.	3-91 3-102

GENERAL NOTES:

1. For Solutions, refer to paragraphs 3-19 through 3-38.
2. This work shall be conducted in the final cleaning area.
3. Critical temperature sensitivities of transducers, gages, etc, shall be determined from component overhaul manuals, and cleaning solution temperatures shall be limited accordingly.

Figure 3-9. Cleaning Procedures for Transducers, Pressure Gages, and Other Dead-end Cavity Parts

(Text continued from page 3-4)

3-49. 400 SERIES STAINLESS STEEL AND FREE MACHINING GRADE 300 SERIES STAINLESS STEEL. Solution C is recommended for both pickling and passivation of 400 Series stainless steel and free machining grades of 300 Series stainless steel such as Types 303 and 347F.

3-50. Solution C is used in conjunction with the following procedures:

a. Immerse parts and pickle 10 minutes at 60° to 100°F. Rinse with Solution I, inspect and hand brush to remove loose scale as required. Repeat once if necessary.

b. Flush with Solution I until effluent has a pH equal to the influent as determined by using pH paper (Litmus) (Military Standard MS 36253-3).

c. Final rinse with Solution J.

3-51. CARBON STEEL. Carbon steel (mild steel alloys) is pickled in the same manner as stainless steel except for the choice of pickling acids and the protective coating treatment. Within 5 minutes after removal of part from pickling acids, protective coating is required in accordance with Paragraph 3-55. An inhibited acid is used to reduce attack on the base metal. Solution D is recommended for use with carbon steel.

3-52. Solution D is used in conjuncation with the following procedures:

a. Immerse parts in pickling solution at room temperature for approximately 15 minutes. Inspect to determine extent of soil removal. Time may be reduced or increased as required.

b. Rinse with Solution I heated to approximately 150°F.

c. Rinse with Solution J heated to approximately 150°F.

Note

Steels harder than Rockwell C32 shall be baked for three hours at a temperature of 375 ±25°F to prevent hydrogen embrittlement.

3-53. An alternate pickling solution for carbon steel consists of Solution D, Alternate.

3-54. Solution D, Alternate, is used in conjunction with the following procedure:

a. Immerse parts in pickling solution at room temperature for approximately 30 minutes. Time may be reduced or increased as required.

b. Rinse with Solution I heated to approximately 150°F.

c. Rinse with Solution J heated to approximately 150°F.

Note

Steels harder than Rockwell C32 shall be baked for three hours at a temperature of 375 ±25°F to prevent hydrogen embrittlement.

3-55. Within 5 minutes after removal of part from pickling acids (reference Paragraph 3-52 or 3-54), the following protective finish shall be applied:

a. Continually dip using Solution F Alternate, as required to wet all surfaces (5 to 10 minutes).

3-56. ALUMINUM AND ALUMINUM ALLOYS. After degreasing but prior to pickling, the part must be pre-cleaned in a mild alkaline cleaner as indicated in Figure 3-1. Solution L should be used at a temperature of 140° to 180°F.

3-57. Solution C is recommended for pickling aluminum and aluminum alloys.

3-58. The following procedure is used for pre-cleaning and pickling aluminum and aluminum alloys.

CAUTION

When acid pickling solutions are used for aluminum, the immersion time must be closely monitored. Anodized aluminum parts are normally not to be pickled since the pickling process would remove the anodization.

a. Immerse part in the alkaline cleaner (Solution L) for 1 to 3 minutes.

b. Rinse in Solution I heated to approximately 150°F.

c. Immerse part in pickling solution (Solution C) for 3 to 5 seconds.

d. Rinse in Solution J heated to approximately 150°F.

3-59. COPPER AND COPPER ALLOYS. After degreasing but prior to pickling, the part must be pre-cleaned in a mild alkaline cleaner as indicated in Figure 3-1. Alkaline cleaning shall use Solution A. Solution M should be used for pickling copper and copper alloys.

3-60. An alternate solution for pickling copper and copper alloys is Solution M Alternate.

3-61. The Solutions M and M Alternate are to be used in conjunction with the following procedure:

a. Determine the solution temperature and immersion time by testing coupons of identical material prior to pickling the part.

b. Pickle the part as determined by Step a.

c. Rinse the metal surface with Solution J heated to approximately 150°F.

3-62. DEGREASING.

3-63. Several methods of degreasing may be used. These include vapor degreasing, solvent degreasing, detergent degreasing, and alkaline cleaning. Ultrasonic cleaning may be used in conjunction with degreasing.

3-64. VAPOR DEGREASING. Vapor degreasing, or vapor rinsing, involves the use of a solvent in vapor form to remove oil and grease from parts. The solvent is heated in a vapor degreaser to the boiling point and until vapor is formed above the liquid. The part (at ambient temperature) is suspended in the vapor. The condensation of the vapor on the part dissolves and carries away the oil or grease. This action continues until the part reaches the temperature of the vapor at which time condensation ceases. Additional degreasing action may be obtained by providing spray facilities using freshly condensed vapor or by flushing with degreaser liquid solvent.

CAUTION

Vapor degreasers are constructed for use of specific solutions. Solutions must not be interchanged. For example, a vapor degreaser constructed for use of trichloroethylene shall not be used with trichlorotrifluoroethane and a vapor degreaser constructed for use of trichlorotrifluoroethane shall not be used with trichloroethylene.

3-65. Vapor degreasers constructed for the use of trichloroethylene use Solution H. Depots or activities having the capability to handle triethylamine may use trichloroethylene (Military Specification MIL-T-7003) as a vapor degreasing solvent. When the latter is used, addition of the contamination inhibitor (triethylamine) shall be in accordance with instructions contained in Reference Document Item 2, Section XI. Handling of triethylamine is extremely hazardous.

WARNING

Trichloroethylene is classified as a toxic material and must be used with caution. Avoid excessive inhalation and repeated or prolonged contact with the skin. For further information on toxic effects of trichloroethylene, refer to Reference Document Item 29, Section XI. The operation of any vapor degreaser shall be in accordance with the applicable technical manual or the manufacturer's instructions.

3-66. Vapor degreasers constructed for the use of trichlorotrifluoroethane shall use Solution K.

WARNING

Trichlorotrifluoroethane is toxic and shall be used with adequate ventilation. Operation of any vapor degreaser shall be in accordance with the applicable maintenance manual or the manufacturer's instructions.

3-67. SOLVENT CONTAMINATION - Solution H. During operation of the vapor degreaser, Solution H gradually becomes contaminated with hydrocarbon materials, with particulate matter, and water. The presence of these contaminants must be kept within limits to insure proper cleaning of components. Solvents and types of solvent contamination are discussed in more detail in Paragraphs 3-68 through 3-70, along with some possible tests which will help determine presence of contaminants.

3-68. Hydrocarbon Contamination - Solution H - As the degreaser is used, the hydrocarbons that are dissolved contaminate the solvent. As trichloroethylene becomes contaminated with dissolved hydrocarbons, its boiling point will gradually increase. If the boiling temperature increases 8 °F over its initial boiling point in the clean state, the solvent shall be replaced and the degreaser cleaned. A daily check of solvent boiling temperature shall be made on degreasers used continuously. A weekly check of solvent boiling temperatures shall be made on degreasers used periodically to insure that the contamination limit is not exceeded. Another method for determining contamination is with a specific gravity check. Clean Solution H has a specific gravity of 1.47 at 68 °F, whereas thirty (30) percent contaminated Solution H will have a specific gravity of 1.17 at 68 °F. When Solution H in the boiling chamber exceeds 30 percent contamination, the degreaser shall be cleaned as required in accordance with applicable maintenance manuals or manufacturer's instructions and the solvent distilled or replaced.

3-69. Particulate Contamination - Solution H - If globules of flocculent materials, floating debris, or other foreign materials are observed floating on the solvent, the solvent shall be filtered or the floating material otherwise removed. If the floating material cannot be removed, the degreaser shall be cleaned as required in accordance with applicable maintenance manuals or manufacturer's instructions and the solvent distilled or replaced. Filters, in degreasers having a built-in filtration system, shall be maintained in proper operating condition.

3-70. Water Contamination - Solution H - Water may contaminate a degreaser as the result of moisture condenstion in the atmosphere if the vapor condensing coils are not operated at the proper temperature, or moisture may be introduced by being carried in on the equipment. The presence of water in a vapor degreaser is indicated by cloudy vapors as compared to transparent vapors when the condensing temperature is maintained within the range of 90° to 120°F. Solution H hydrolyzes with water to form hydrochloric acid. Because of the detrimental chemical reaction of hydrochloric acid on metal, the pH of the solvent shall be checked weekly. Free hydrochloric acid in the degreaser may be detected by a biting odor in the vapors; however, chemical analysis shall be the basis for determining the acid condition. Determine the acid content as follows:

a. Obtain a 100 ml sample from the degreaser.

b. Allow sludge to settle.

c. To 25 ml of Solution H sample, add 25 ml of distilled water and 3 to 5 drops of methyl orange (FSN 6810-264-8958).

d. Add 10 ml of 0.02 normal (n) sulfuric acid. Shake well and observe color.

e. If color is yellow-orange, the solvent is suitable for use. If color is pink-red, solvent shall be replaced or inhibitor added (1 quart of triethylamine FSN 6810-281-8805) for each 300 gallons of solvent in the degreaser). The alkalinity of the inhibited solvent will be 0.06 percent and not less than 0.01 percent.

3-71. SOLVENT CONTAMINATION - Solution K. During operation of the vapor degreaser, Solvent K gradually becomes contaminated with hydrocarbon materials, with particulate matter, and possibly with water. The presence of these contaminants must be kept within limits to insure proper cleaning of components.

3-72. Hydrocarbon Contamination - Solution K - The maximum allowable hydrocarbon contamination in trichlorotrifluoroethane should not exceed 10% by volume for pre-cleaning nor 5% by volume for final cleaning, using a direct volume-reading Goetz bulb (GSA-GS-005-47741) (Centrifuge tube) to make the determination. When Solution K becomes contaminated, the degreaser shall be cleaned as required in accordance with applicable maintenance manuals or manufacturer's instructions and the solvent distilled or replaced.

3-73. Particulate Contamination - Solution K. If globules of flocculent materials, floating debris, or other foreign materials are observed floating on the solvent, the solvent shall be filtered or the floating material otherwise removed. If the floating material cannot be removed, the degreaser shall be cleaned. Cleaning is accomplished by removing the contaminated solvent, drying the tank with dry nitrogen gas, and vacuum cleaning as required. The degreaser then shall be filled with clean Solution K. Filters, in degreasers having a built-in filtration system, shall be maintained in proper operating condition.

3-74. Water Contamination - Solution K - The presence of moisture in vapor degreasers using Solution K results in degradation of the cleaning process and loss of solvent. To prevent condensation of moisture in the atmosphere, the condenser should be operated at a temperature higher than the dew point of the room in which the degreaser is located. For most temperature controlled areas, this can be accomplished by throttling the condenser water flow so as to maintain an exit water temperature of 85° to 90°F. If cloudy vapors appear indicating the presence of moisture in the degreaser, the solvent should be circulated through a water separator until all free water is removed.

3-75. SOLVENT DEGREASING. Solvent degreasing of components may be accomplished by hand washing using a stiff bristle brush (FSN 7920-269-1263); or cheese cloth (Federal Specification CCC-C-448, Type I), or by the following fill and drain procedure.

a. Immerse the component in or fill it with Solution H or Solution K at ambient temperature.

b. Roll, rotate, or agitate the component, making certain that the solvent washes all surfaces and dead-end cavities requiring degreasing.

Note

When solvent is used to flush component, maintain turbulent flow conditions.

3-76. DETERGENT DEGREASING. A hot solution (approximately 140°F) is most effective. Solution O Alternate or Solution O Second Alternate may be used.

3-77. ALKALINE CLEANING OR DESCALING.

3-78. Heavy duty alkaline cleaners or descalers consist of combinations of alkaline salts such as sodium hydroxide (caustic soda) (Federal Specification O-S-598, Type 1) sodium orthosilicate (Federal Specification P-S-651), sodium metasilicate (Federal Specification O-S-604, Type 2), sodium metaborate (Federal Specification O-C-265, Sodium Borate), sodium carbonate (soda ash) (Federal Specification O-S-571), sodium tetraborate (sodium borate) (Federal Specification O-C-265) (borax) and sodium polyphosphates (sodium phosphate, tribasic) (Federal Specification O-S-642, Type 1). Frequently two or more of these chemicals are blended together to provide an effective cleaner. The components shall be filled, immersed, sprayed, or scrubbed with these solutions as required. After alkaline descaling, the components shall be flushed with Solution I at 150°F. A final flush shall be made with Solution J at 150°F.

WARNING

Extreme heat is generated when an alkali reacts with water.

Note

When preparing an alkaline cleaning solution, heat the water to approximately 140°F and agitate it while sprinkling in the alkaline salt. This procedure will prevent the salts from falling to the bottom where they tend to form a solid mass that dissolves very slowly.

3-79. ULTRASONIC CLEANING.

3-80. This cleaning process uses ultrasonic frequency sound waves generated by a transducer. These sound waves produce alternating pressure waves. The pressure waves alternately generate bubbles and cause the bubbles to collapse. The scrubbing effect produced by this action loosens soils from the part and disperses it into the liquid cleaning agent.

3-81. Many cleaning solutions can be used as ultrasonic cleaning media. These liquids may be either detergent solutions G or O or solvent Solutions H or K. Process time, temperature, and the condition of the part shall be monitored to insure that the solution shall not attack or erode the parts being cleaned. Solvents shall be utilized approximately 10°F below boiling point. Detergents shall be utilized at approximately 120° to 140°F.

WARNING

Personnel required to work for prolonged periods of time in close proximity to ultrasonic cleaners may be exposed to excessive amounts of acoustical noise. Under normal circumstances for most equipment presently in use, personnel would not be exposed to excessive amounts of noise. A few ultrasonic cleaners, however, may produce acoustical noise at a level where ear protective devices are required to prevent injury to personnel. In view of the above, it is recommended that all units be periodically evaluated by the Bioenvironmental Engineer.

3-82. RINSING.

3-83. Rinsing operations are critical functions to obtain a part free of residue from the chemical cleaning operation.

3-84. WATER RINSING. When water is used, at least two rinsing steps are required. The first water rinse may be Solution I to remove the major portion of the cleaning solution residue and loose particles. Where equipment is available, a power spray is preferred over the dip-tank method. The second, or final rinse, shall be Solution J. All water used in rinsing operations should be heated to approximately 150°F.

3-85. FINAL SOLVENT RINSING. For final solvent rinsing where a high degree of cleanliness is required, filtered Solution H shall be used. The solvent shall be filtered through a 10 micron, nominal, rated filter prior to use.

3-86. DETERGENT RINSING. Detergent rinsing may be used for pre-cleaning or for final cleaning. Solution G or Solution O shall be used for those components that cannot be subjected to solvent rinsing. The detergent should be filtered through a 10 micron, nominal, rated filter prior to use.

3-87. DRYING.

CAUTION

Non-metallic gaskets or parts, such as "O" rings, shall not be subjected to temperatures higher than 150°F.

3-88. Metallic components and systems may be dried by heating them in an oven at 180°F to 200°F, by purging them with heated nitrogen (140°F), (Military Specification MIL-P-27401), or by vacuum evacuation. Pressure or temperature sensitive components shall be identified by the use of the applicable maintenance or overhaul manuals, and drying for these components will be regulated accordingly. Non-metallic parts shall use the same processes except that the maximum temperature shall be 150°F. The gas used for purging and drying shall be filtered through a 10 micron, nominal, rated filter.

3-89. FINAL INSPECTION.

3-90. Equipment shall be inspected in accordance with the applicable portions of Section IV through VIII pertaining to cleanliness and moisture requirements when tested per the applicable inspection methods of Section IX.

3-91. CLEANLINESS CERTIFICATION.

3-92. The following definitions shall be used by a responsible inspector for cleanliness certification of cleaned components and systems.

3-93. LIQUID OXYGEN "LOX" CLEAN. Components of liquid oxygen systems and associated pneumatic systems which come into contact, directly or indirectly, with liquid oxygen shall be cleaned, tested, inspected and certified in accordance with the instructions contained in this manual. These items shall be certified to be free of hydrocarbon soils and to meet the particulate, fiber, and total solids cleanliness requirements indicated in the applicable sections of this manual. Refer to Section IV for Atlas, Titan I, and Thor Weapon Systems, and Section V for Titan II Weapon Systems.

3-94. PROPELLANT TRANSFER SYSTEM (HYPERGOLIC) "PTS(HGC)" CLEAN. Components of Titan II Storable Propellant Transfer Systems and associated pneumatic systems which come into contact directly or indirectly with the hypergolic commodities shall be cleaned, tested, inspected, and certified in accordance with the instructions contained in this manual. Refer to Sections V, VII and VIII.

3-95. SPECIAL CLEAN "SC". Components of the RP-1 fuel systems and associated pneumatic systems shall be cleaned, tested, inspected, and certified in accordance with the instructions contained in this manual. The cleanliness of these components shall conform to the particulate, fiber, and total solids cleanliness requirements indicated in

Sections IV, VI, VII and VIII. Ultraviolet inspection is not required; however, a visual inspection shall be made and the presence of oil, grease, paints, preservatives, or other foreign material shall be cause for rejection unless otherwise stated in this manual.

3-96. HYDRAULIC CLEAN "HC". Components of missile, AGE, launcher, and facility hydraulic systems shall be cleaned, tested, inspected and certified in accordance with the instructions contained in this manual. The cleanliness of these components shall conform to the particulate, fiber, and total solids cleanliness requirements indicated in Sections IV, V, VI, and VIII, for the specific weapon systems.

3-97. NORMAL CLEAN "NC". Components requiring the removal of "gross contamination" only shall be cleaned and certified in accordance with the instructions contained in this manual.

3-98. SEALING AND PACKAGING.

3-99. All components, after inspection and having reached ambient temperature, shall be assembled and then sealed as outlined in the following steps:

a. Use clean polyethylene bags and sealing materials.

b. Seal adequately enough to prevent contamination. Sealing tape conforming to Military Specification MIL-T-22085 shall be applied so as not to leave any residue on connections or mating surfaces.

Note

An alternate method of sealing plastic bags is by the heat sealing method. If appropriate equipment is available and approved for use in the sealing and packaging area, this alternate method may be used in accordance with applicable heat sealing equipment operations manual or manufacturer's instructions.

c. Seal flanged openings with plugs or caps specified in the applicable maintenance manuals. Use no thread compounds, plastic plugs, or plastic caps except as designated by the detailed technical orders.

d. Seal other openings with polyethylene sheets and fasten with vinyl or nylon cord, (Military Specification MIL-C-5040, Type I) or plastic tape (Military Specification MIL-T-22085).

CAUTION

Prevent surfaces which will be wetted by liquid oxygen from coming in contact with the tape or its residual adhesive when packaging LOX clean parts.

e. Mark sealed components per Paragraph 3-102 to indicate the cleanliness standard to which the component was cleaned as specified in Paragraph 3-91.

3-100. Tanks and vessels shall be dried, pressurized to 5 psig, and maintained at 5 ± 2 psig with nitrogen (Military Specification MIL-P-27401) which has been filtered through a 10 micron, nominal, rated filter.

3-101. Final packaging and pressurization for storage or shipment will be accomplished by the appropriate Air Force personnel.

3-102. IDENTIFICATION AND MARKING.

3-103. Each cleaned component or equipment which has been processed in accordance with this manual shall be marked on exterior of the package indicating the cleanliness standard to which it was cleaned. Markings shall consist of a locally approved tag, label, or stamp which shall be invalidated or destroyed when the contamination seal is broken or removed. Paragraphs 3-91 through 3-97 describe the standards to be used for identification of component cleanliness.

3-104. DISPOSAL OF RESIDUAL CHEMICALS AND SOFT CONSUMABLES.

3-105. The use of chemical cleaning and decontamination solutions has presented serious waste disposal problems in certain localities. Prior to installing a chemical process, the disposal problem must be investigated and provisions made for safe disposal of chemical solutions without causing personnel hazards or water polution problems. Various localities have set limits for the amount of certain chemicals that may be discharged into a water source. These limits vary with the locality and circumstances.

3-106. It is extremely important that the discharge of waste from the chemical solutions be carefully controlled to avoid drainage of concentrated chemicals into the sewer system where it might pollute streams or damage the sewer system, etc.

3-107. All concentrated waste solutions not discharged in a separate industrial waste sewer system will be collected and stored in suitable marked barrels or tanks provided for bulk pick-up by a collection agency. The discarding agency will insure that the different solutions are not intermixed and that containers of wastes are properly labeled. Also, special attention will be given to insure that proper containers are used.

3-108. The discarded waste will be segregated according to the following classification:

a. Chromium. This includes chromic acid, dichromate, chromates and rinse water containing chromium.

b. Acids. This includes all acids other than chromic acid.

c. Alkali. This includes all alkaline solutions.

d. Miscellaneous. This includes all other bulk waste such as soak tank sludge. If miscellaneous wastes are disposed of by burning, trichloroethylene degreaser sludge will be excluded from this classification and shall be disposed of separately (because of the toxic decomposition products of trichloroethylene).

e. It is imperative that the Titan II fuel and oxidizer waste products not be allowed to mix in the industrial and sanitary sewer systems provided for the decontamination area in order to eliminate the obvious fire and explosion hazard. Removal of waste products from the underground residual drain tanks shall be accomplished by the Base Civil Engineer and the Bioenvironmental Engineer.

3-109. Additional information regarding the disposal of chemicals will be found in Reference Document Items 30 and 31, Section XI.

3-110. The Base Civil Engineer is responsible for the collection, disposal and treatment of industrial wastes.

3-111. The Base Industrial Hygiene Engineer is responsible for making investigations and recommendations concerning environmental sanitary conditions pertaining to collection, disposal treatment, and abatement of industrial wastes. Disposal or storage and subsequent dilution into a receiving body of water will not be accomplished without the approval of the Base Surgeon.

3-112. Since soft consumables (seals, gaskets, etc) can absorb contaminants, the same precautions apply to soft consumables as to chemicals.

3-113. Installation commanders shall cooperate with state and local authorities in the prevention of stream, air, ground, sewage or water supply pollution caused by industrial wastes.

END OF REFERENCE
12

REFERENCE
13

ANON.: SPACECRAFT CHEMICAL AND FLUID CLEANLINESS REQUIREMENTS. MSC-SPEC-C-6B, NASA, JAN. 14, 1969.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MSC-SPEC-C-6B
January 14, 1969
Superseding
MSC-SPEC-C-6A
June 26, 1967

SPECIFICATION

Spacecraft Chemical and Fluid Cleanliness Requirements

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

Enclosure 12

MSC-SPEC-C-6B
January 14, 1969
Superseding
MSC-SPEC-C-6A
June 26, 1967

This specification has been approved by the NASA Manned Spacecraft Center (MSC) and is available for use by the NASA MSC and associated contractors.

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1.0 SCOPE

This specification establishes the chemical and particulate cleanliness requirements for fluids supplied to the Apollo spacecraft (command module, service module, and lunar module). The intent and requirements of this specification shall apply equally to affluents used in manufacturing and checkout test operations to the extent that protection is provided for all subassemblies which cannot subsequently be effectively cleaned by fluid flushing. Subassembly manufacturing closeout and/or spacecraft installation operations shall have affluents controlled to the requirements identified in tables I and II.

2.0 APPLICABLE DOCUMENTS

The specified issues of the following documents form a part of this specification to the extent indicated herein.

2.1 STANDARDS.

2.1.1 Government.

FED-STD-209A	Clean Room and Work Station Requirements, Controlled Environments

2.1.2 Manned Spacecraft Center.

MSC-STD-C-1	Definitions for Contamination Programs

2.2 SPECIFICATIONS.

2.2.1 Manned Spacecraft Center.

MSC-PPD-2B	Propellant, Inhibited Nitrogen Tetroxide
MSC-SPEC-C-14	Spacecraft Fluid Analysis
MSC-PF-SPEC-1	Water, High Purity (Potable)
MSC-SPEC-SE-C-0034	Trichlorotrifluoroethane
MSC-SPEC-SN-W-0040	Ethylene Glycol-Water

MSC-SPEC-SE-V-0024	Lunar Module Pressure Vessel Operating Criteria
MSC-SPEC-SN-C-0037	Trichlorotrifluoroethane Solvent Use Requirements
MSC-SPEC-SE-V-0028	Apollo Command and Service Module Pressure Vessel Operating Criteria
MSC-SPEC-SE-C-0035	Determination of Electrical Conductivity of 50-percent Hydrazine/ 50-percent Unsymmetrical Dimethylhydrazine

2.2.2 George C. Marshall Space Flight Center.

MSFC-SPEC-234	Nitrogen — Space Vehicle Grade
MSFC-SPEC-237A	Solvent, Precision Cleaning Agent
MSFC-SPEC-356A	Hydrogen, Liquid
MSFC-SPEC-364B	Helium
MSFC-SPEC-399A	Oxygen
MSFC-PROC-404	Gases, Drying and Preservation Cleanliness Level and Inspection Methods

2.2.3 Military.

MIL-O-27210-C (ASG)	Oxygen, Aviator Breathing, Liquid and Gas
MIL-P-27402A	Propellant, Hydrazine-Unsymmetrical Dimethylhydrazine
MIL-P-27404	Propellant, Monomethylhydrazine
MIL-P-27407	Propellant, Pressuring Agent, Helium

2.2.4 Federal.

TT-I-735A	Isopropyl Alcohol, Grade B

2.2.5 American Society for Testing and Materials.

ASTM D 512-62T (Method C)	Method of Test for Chloride Ion in Industrial Water and Industrial Waste Water
ASTM D 1125-64	Methods of Test for Electrical Conductivity of Industrial Water and Industrial Waste Water
ASTM D 1293-62T	Methods of Test for pH of Industrial Water and Industrial Waste Water
ASTM D 1590-60	Surface Tension of Industrial Water and Industrial Waste Water
ASTM D 2109-64	Nonvolatile Matter in Halogenated Organic Solvents and Their Admixtures

2.2.6 Other.

ARP 599	Filter Cleanliness Test Method
ARP 901	Bubble Point Test Method

3.0 DEFINITIONS

3.1 GENERAL. The definitions used in the NASA Manned Spacecraft Center (MSC) contamination control program are listed in MSC-STD-C-1. The following definitions are included to clarify this specification.

3.1.1 Filter Rating.

3.1.1.1 Absolute Filter Rating. The absolute filter rating is the size designation applied to a filter unit which requires that filter to retain all spherical particles equal to or greater in size than the absolute rating while tested under rated flow conditions.

3.1.1.2 Contaminant Transmission Rating. The contaminant transmission rating is the maximum particle size that is permitted as a result of the extrusion of particulate through the filter media under the rated flow and maximum working pressure of the filter being tested.

3.1.2 Maximum Bubble Point. The maximum bubble point is the initial bubble point of a filter that successfully passes the absolute filter rating requirements using the test method of ARP 901.

3.1.3 Silting. Silting is an accumulation of minute particles, in the size range normally not counted, of sufficient quantity to cause a haze, or partial or complete obscuring of gridlines or any portion of the grid on a test filter membrane when viewed visually or under 40-power (maximum) magnification.

3.1.4 Checkout Fluid. Checkout fluid is a fluid other than operational fluid used in evaluating performance of a system; also called test fluid.

3.1.5 Referee Propellant. A referee propellant is a liquid other than a propellant which is flowed through a propulsion system for the purpose of system verification or for any operation in which simulated propellant flow is required; also called substitute propellant.

3.1.6 Final Filter. A final filter is a filter used at the interface between the spacecraft and the fluid distribution system to provide spacecraft (SC) fluid cleanliness as specified herein. Spacecraft final interface filters shall not contain any bypasses.

3.1.7 Final Filter Certification. Certification of the ground support equipment/spacecraft (GSE/SC) interface filter requires verification of the contaminant transmission rating and the absolute filter rating by the test method of ARP 901 to the maximum bubble point as defined by para. 3.1.2, and certification of the filter/quick disconnect assembly cleanliness according to ARP 599, modified for two 500 ml samples, with intermediate drying. Certification shall further include leakage tests of the filter/QD assembly.

3.1.8 Final Filter Qualification. For this specification, qualification of a GSE/SC interface filter shall mean, as demonstrated through tests, that the filter can provide fluids meeting the spacecraft (SC) system particulate level requirements after shipment and storage for a minimum of six months and that the use and installation of this filter has been approved by NASA MSC. Qualification shall be in accordance with MSC-SPEC-C-(to be defined).

3.1.9 Fiber. A fiber is a material whose length is at least 10 times its width (minimum length of 100 microns), and whose size is indicated by its length.

4.0 REQUIREMENTS

4.1 GENERAL. Materials and processes used for cleaning, purging, testing, flushing, or checkout shall be chosen so as not to be detrimental to the performance or design requirements of the subsystem. All potentially harmful residues of these materials shall be removed from the subsystem.

4.2 SAMPLING. Sampling frequencies and techniques shall provide representative samples of liquid or gas being tested. Spacecraft fluid cleanliness may be assured if the following requirements are met:

a. When qualified final filters are used to insure cleanliness of fluids being serviced, sampling is not required. The filters shall be qualified as defined in 3.1.8, and the filter-interface connections shall be certified as a unit as defined in 3.1.7. The filters shall deliver fluids certified to the particulate requirements as specified in tables I and II.

b. When qualified final filters are not used, sampling at the interface between the spacecraft and the servicing equipment is required. The fluids must meet the requirements as listed for spacecraft fluid cleanliness as indicated in table I and II before servicing is initiated. Sampling of cryogenic fluids for particulate matter is not required; however, chemical sampling and analysis is required.

4.3 SPACECRAFT FLUIDS. Fluids supplied to the spacecraft shall be sampled and verified as meeting the chemical requirements of the appendix in accordance with the procedures of the respective procurement specification in addition to the particulate requirements in tables I and II.

4.4 CONTAMINANT TRANSMISSION RATING. The contaminant transmission rating established under maximum flow rate conditions shall not exceed three times the absolute filter rating, using three dimensional contaminants such as AC coarse dust, up to the maximum differential pressure to be encountered during service.

4.5 ABBREVIATIONS.

bp	barometric pressure
C	Centigrade
cm	centimeter
C.P.	chemically pure
F	Fahrenheit
gm	gram
max.	maximum
mg	milligram
min.	minimum
ml	milliliter
para.	paragraph
ppm	parts per million
Q.D.	quick disconnect
std cu ft	standard cubic feet
wt.	weight
µmhos	micromhos

4.6 CHANGES TO MSC-SPEC-C-6A. Appendix B provides a comparison of the requirements of this specification with MSC-SPEC-C-6A.

TABLE I

LUNAR MODULE SYSTEMS FLUID REQUIREMENTS

Fluid	Chemical composition as shown in appendix	Particulate level allowable[a]
Reaction Control System		
Helium[a]	Table A-I or A-II, as applicable	0-50 microns[b] 50-75 microns — 20 >75 microns — 0
N_2H_4-UDMH	Table A-IV	0-25 microns[b] 25-50 microns — 90 50-100 microns — 75 >100 microns — 0
N_2O_4	Table A-V	Same as N_2H_4-UDMH
Primary Propulsion Systems		
Helium[a]	Table A-I	0-50 microns[b] 50-75 microns — 20 >75 microns — 0
N_2H_4-UDMH	Table A-IV	0-50 microns[b] 50-100 microns — 100 100-250 microns — 15 >250 microns — 0
N_2O_4	Table A-V	Same as N_2H_4-UDMH

TABLE I.- Continued

LM SYSTEMS FLUID REQUIREMENTS

Fluid	Chemical composition as shown in appendix	Particulate level allowable[a]
Environmental Control System		
Water-glycol (Service with a filter having a rating of 25μ absolute)	Table A-VI, Type 1	0-5 microns[b] 5-15 microns - 250 15-25 microns - 85 25-50 microns - 90 50-100 microns - 75 >100 microns - 0
Oxygen	Table A-VII or A-IX, as applicable	0-5 microns[b] 5-15 microns - 250 15-25 microns - 85 25-50 microns - 90 50-100 microns - 75 >100 microns - 0
Nitrogen	Table A-III	Same as oxygen
Potable water		Refer to latest issue of MSC-PF-SPEC-1

TABLE I.- Continued

LUNAR MODULE SYSTEMS FLUID REQUIREMENTS

Fluid	Chemical composition as shown in appendix	Particulate level allowable[a]
Cleaning, Test, Flush and Substitute Fluids[c]		
Solvent	Table A-XIV	Same as system operational fluid
Trichloro-trifluoroethane	Table A-XIV	Same as system operational fluid
Isopropyl alcohol (not to be used in propulsion systems)	Table A-XIII	Same as system operational fluid
ECS water	Table A-VIII	Same as system operational fluid
Propulsion water[d]	Table A-VIII	Same as system operational fluid
Nitrogen[a]	Table A-IV	Same as system operational fluid
Helium[a]	Table A-I or A-II, as applicable	Same as system operational fluid

[a]Particulate levels are per 500 ml liquid or 35 std cu ft gas. Gaseous sample shall be at normal system flow rate and dynamic pressure for a volume of 35 std cu ft. Particulate values are based on the maximum particle size specified and a normal distribution probability line of figure 1.

[b]No silting as defined by 3.1.3 of this specification; no count required.

TABLE I.- Concluded

LUNAR MODULE SYSTEMS FLUID REQUIREMENTS

[c]Fluids used as referee propellants shall, as a minimum, meet particulate requirements of the operational propellants. Fluids utilized for recirculation or system cleaning on a continuous basis shall be sampled and analyzed at least every 8 hours, and controlled in accordance with MSC-SPEC-SN-C-0037.

[d]For propulsion systems, the water must comply with the following:

(1) At the vehicle interface, the water must comply with the property limits of table A-VIII. This requirement must be verified by analyses using water sampled within 3 days of the start of each test sequence. For comparison purposes, similar analyses must be made on the water sampled from the vehicle interface at the completion of each test sequence.

(2) At the vehicle interface, the water must have a flaw growth threshold in titanium that complies with the requirements of MSC-SPEC-SE-V-0024. This requirement must be verified by sustained load tests using water sampled from the vehicle interface no earlier than 7 days before the start of each test sequence.

TABLE II

COMMAND AND SERVICE MODULES SYSTEMS FLUID REQUIREMENTS

Fluid	Chemical composition as shown in appendix	Particulate level allowable[a]
Reaction Control System		
Helium[a]	Table A-I or A-II, applicable	0-50 microns[b] 50-75 microns — 20 >75 microns — 0
MMH	Table A-XI	0-25 microns[b] 25-50 microns — 90 50-100 microns — 75 >100 microns — 0
N_2O_4	Table A-V	Same as MMH
Service Propulsion System		
Helium[a]	Table A-I or A-II as applicable	0-50 microns[b] 50-100 microns — 75 >100 microns — 0
Nitrogen[a]	Table A-III	0-50 microns[b] 50-75 microns — 20 >75 microns — 0
N_2H_4-UDMH	Table A-IV	0-50 microns[b] 50-100 microns — 115 100-180 microns — 7 180-350 microns — 13 >350 microns — 0 Fibers 0-350 microns — 5 >350 microns — 0
N_2O_4	Table A-V	Same as N_2H_2-UDMH

TABLE II.- Continued

COMMAND AND SERVICE MODULES SYSTEMS FLUID REQUIREMENTS

Fluid	Chemical composition as shown in appendix	Particulate level allowable[a]
Electrical Power System		
Liquid and gaseous hydrogen	Table A-XII	0-50 microns[b] 50-75 microns — 40 75-100 microns — 35 >100 microns — 0
Liquid oxygen	Table A-VII	0-50 microns[b] 50-75 microns — 40 75-100 microns — 35 >100 microns — 0
Oxygen (gaseous)[a]	Table A-VII	Same as hydrogen
Nitrogen (gaseous)	Table A-III	Same as hydrogen
Water-glycol[c] (200 ml sample)	Table A-VI, Type III	0-50 microns[b] 50-100 microns — 124 100-175 microns — 8 >175 microns — 14 (including 5 fibers)

TABLE II.- Continued

COMMAND AND SERVICE MODULES SYSTEMS FLUID REQUIREMENTS

Fluid	Chemical composition as shown in appendix	Particulate level allowable[a]
Environmental Control Systems		
Water-glycol (Service with a filter having a rating of 25μ absolute)	Table A-VI, Type II	0-50 microns[b] 50-100 microns — 85 100-175 microns — 10 >175 microns — 0
Oxygen	Table A-VII or A-IX	0-50 microns[b] 50-75 microns — 40 75-100 microns — 35 >100 microns — 0
Cabin atmosphere	Table A-X	Refer to appendix
Potable water		Refer to latest issue of MSC-PF-SPEC-1
Cleaning, Test, Flush and Substitute Fluids[d]		
Solvent	Table A-XIV	Same as operational fluid
Trichloro-trifluoroethane	Table A-XIV	Same as operational fluid
Isopropyl alcohol (not to be used in propulsion systems)	Table A-XIII	Same as operational fluid
ECS water	Table A-VIII	Same as operational fluid
propulsion water[e]	Table A-VIII	Same as operational fluid

TABLE II.- Continued

COMMAND AND SERVICE MODULES SYSTEMS FLUID REQUIREMENTS

Fluid	Chemical composition as shown in appendix	Particulate level allowable[a]
Environmental Control Systems		
Nitrogen	Table A-III	Same as operational fluid
Helium	Table A-I or A-II, as applicable	Same as operational fluid

[a]Gaseous sample shall be at normal system flow rate and dynamic pressure for a volume of 35 std cu ft. Particulate values are based on the maximum particle size specified and a normal distribution probability line of figure 1.

[b]No silting as defined by 3.1.3 of this specification; no count required.

[c]EPS water-glycol shall be sampled every 45 days maximum and the particulate level of the sample shall be in accordance with this table, except that the sample quantity shall not exceed 200 ml.

[d]Referee propellants shall meet particulate requirements of the operational propellants. Fluids utilized for recirculation or system cleaning on a continuous basis shall be sampled and analyzed at least every 8 hours, and controlled in accordance with MSC Specification SN-C-0037.

[e]For propulsion systems, the water must comply with the following:

(1) At the vehicle interface, the water must comply with the property limits of Table A-VIII. This requirement must be verified by analyses made using water sampled within 3 days of the start of each test sequence. For comparison purposes, similar analyses must be made on the water sampled from the vehicle interface at the completion of each test sequence.

TABLE II.- Concluded

COMMAND AND SERVICE MODULES SYSTEMS FLUID REQUIREMENTS

(2) At the vehicle interface, the water must have a flaw growth threshold in titanium that complies with the requirements of MSC-SPEC-SE-V-0028. This requirement must be verified by sustained load tests using water sampled from the vehicle interface no earlier than 7 days before the start of each test sequence.

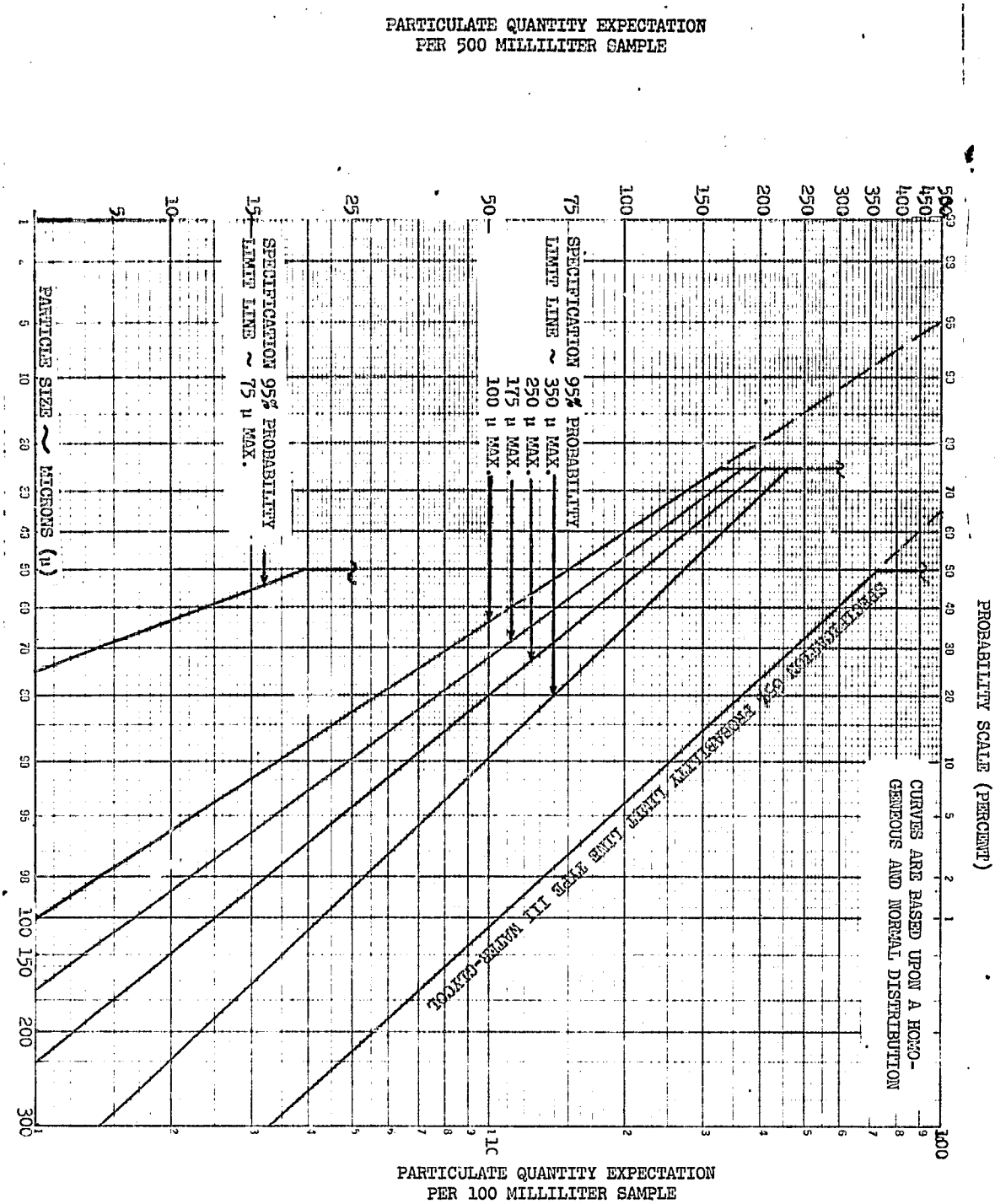


Figure 1.- Particulate sampling probability.

APPENDIX A

CHEMICAL AND PHYSICAL CHARACTERISTICS OF SPACECRAFT FLUIDS

10.0 SCOPE

This appendix contains physical and chemical characteristics of fluids that will be used in subsystems of the Apollo spacecraft (command module, service module, and lunar module). The characteristics of these fluids as delivered to the appropriate spacecraft subsystem interface will be found in tables A-I through A-XIV as follows:

Fluid	Table
Helium	A-I
Propellant pressurizing agent, helium	A-II
Gaseous and liquid nitrogen	A-III
Propellant, 50-percent hydrazine/50-percent unsymmetrical dimethylhydrazine	A-IV
Propellant, inhibited nitrogen tetroxide	A-V
Ethylene glycol-water	A-VI
Gaseous and liquid oxygen	A-VII
High purity and distilled water	A-VIII
Oxygen, aviator's breathing, liquid and gas	A-IX
Cabin atmosphere	A-X
Propellant, monomethylhydrazine	A-XI
Liquid hydrogen	A-XII
Isopropyl alcohol	A-XIII
Tank pressurant, trichlorotrifluoroethane	A-XIV

TABLE A-I.- HELIUM

[Procurement shall be to Specification MSFC-SPEC-364B]

Characteristic	Requirement as delivered to spacecraft interface
Purity	99.990 percent by vol. min.
Total impurities	94 ppm
Hydrogen content	1 ppm by vol. max.
Nitrogen content	50 ppm by vol. max.
Other gases	19 ppm by vol. max.[a]
Oxygen and argon	10 ppm by vol. max. (oxygen only)
Moisture content[b]	9.0 ppm by vol. max.
Total hydrocarbon content (as methane)	5.0 ppm by vol. max.

[a]The total of other gases such as carbon dioxide, neon, and krypton, and specific impurities of hydrogen, nitrogen, moisture, total of oxygen and argon, and total hydrocarbons shall be such that the total gaseous impurities shall be not greater than 94 ppm by volume. For example: Should hydrogen, nitrogen, moisture, total of oxygen and argon, and total hydrocarbons be at the maximum permissible values, then only 19 ppm other gases could be permitted.

[b]Specification MSFC-PROC-404 shall be used to test total hydrocarbons, moisture and particulate of gases as delivered to spacecraft. Liquid helium is normally not filtered.

TABLE A-II.- PROPELLANT PRESSURIZING AGENT, HELIUM

[Procurement shall be to Specification MIL-P-27407]

Characteristic	Requirement as delivered to spacecraft interface
Purity	99.990 percent by vol. min.
Total hydrocarbon content (as methane)	5.0 ppm by vol. max.
Oxygen content	10.0 ppm by vol. max.
Nitrogen	50.0 ppm by vol. max.
Other gases	19.0 ppm by vol. max.[a]
Moisture[b]	9.0 ppm by vol. max
Total impurities	93 ppm by vol. max.

[a]The total of other gases such as carbon dioxide, neon, hydrogen, argon, and krypton, and the specific impurities of nitrogen, moisture, oxygen, and total hydrocarbons shall be such that the total gaseous impurities shall not be greater than 93 ppm by volume. For example: Should hydrocarbons, moisture, and oxygen be at the maximum permissible values, then only 19 ppm other gases could be permitted.

[b]Specification MSFC-PROC-404 shall be used to test total hydrocarbons, moisture, and particulate of gases as delivered to spacecraft. Liquid helium is normally not filtered.

TABLE A-III.- GASEOUS AND LIQUID NITROGEN

[Procurement shall be to Specification MSFC-SPEC-234A]

Characteristic	Requirement as delivered to spacecraft interface
Purity	99.983 percent by vol. min.
Total impurities	170 ppm by vol. max.
Oxygen content	150 ppm by vol. max.
Total hydrocarbon content[a] (as methane)	5 ppm by vol. max.[b]
Moisture content	11.5 ppm by vol. max.

[a]Specification MSFC-PROC-404 shall be used to test total hydrocarbons, moisture, and particulate of gases as delivered to spacecraft.

[b]When hydrocarbons exceed 5 ppm (as methane), the test conductor shall be notified so that corrective action can be taken.

TABLE A-IV.- PROPELLANT, 50-PERCENT HYDRAZINE/

50-PERCENT UNSYMMETRICAL DIMETHYLHYDRAZINE

[Procurement shall be to Specification MIL-P-27402A]

Characteristic	Requirement as delivered to spacecraft interface
Hydrazine/unsymmetrical-dimethylhydrazine (N_2H_4-UDMH):	
N_2H_4	51.0 ± 0.8 percent
UDMH plus amines	47.0 percent min.
Water plus other soluble impurities	1.8 percent max.
N_2H_4 plus amines	98.2 percent min.
Conductivity	10μ mhos per cm at 40° F (min.)[a]
Density	(b)
Transmittancy (colorimeter)[c]	90 percent min.

[a]Conductivity shall be determined per MSC-SPEC-SE-C-0035.

[b]Density shall be determined to a precision of ±0.003 gm per ml (3σ).

[c]The method of MIL-P-27404, par. 4.5.5, shall be used. This requirement (transmittancy) shall be satisfied for operational fluids only.

TABLE A-V.- PROPELLANT, INHIBITED NITROGEN TETROXIDE

[Procurement shall be to Specification MSC-PPD-2B]

Characteristic	Requirement as delivered to spacecraft interface
Nitrogen tetroxide assay (N_2O_4)	98.50 percent by weight[a] min.
Nitric oxide assay (NO)	0.60 min to 1.0 max. percent by weight[a]
Water equivalent	0.20 percent by weight max.
Chloride as nitrosyl chloride (NOCl)	0.08 percent by weight max.
Density	(b)

[a]The summation of N_2O_4 and NO will not be less than 99.5 percent by weight.

[b]Density shall be determined to a precision of ±0.003 gm/ml (3σ).

TABLE A-VI.- ETHYLENE GLYCOL-WATER

[Procurement shall be to Specification MSC-SPEC-SN-W-0040]

Characteristic	Requirement as delivered to spacecraft interface		
	Type I	Type II	Type III
Ethylene glycol (C. P. or Reagent Grade)	35.00 ± 0.50 percent[a]	62.50 ± 0.50 percent[a]	62.50 ± 0.50 percent[a]
Distilled water (MSC-SPEC-C-20A)	As necessary to make 100 percent[a]	As necessary to make 100 percent[a]	To make up to 100 percent[a]
Triethanolamine phosphate (TEAP)	1.60 ± 0.10 percent[a]	1.60 ± 0.10 percent[a]	----
Sodium mercaptobenzothiazole	0.09 ± 0.02 percent[a]	0.09 ± 0.02 percent[a]	----
Potassium phosphate, diabasic (C. P. or Reagent Grade)	----	----	0.50 percent[a] min.
Potassium tetraborate, (C. P. or Reagent Grade)	----	----	0.70 ± 0.07 percent[a]
Viscosity at 75° ± 0.5° F	2.25 ± 0.15 centistokes	No requirement	No requirement
Specific gravity at 75° ± 0.5° F	1.048 ± 0.002	1.082 ± 0.002	1.082 ± 0.002
pH	8.5 ± 0.1	7.5 ± 0.3	7.8 ± 0.3

TABLE A-VI.- ETHYLENE GLYCOL-WATER - Concluded

Characteristic	Requirement as delivered to spacecraft interface		
	Type I	Type II	Type III
Silting	None	None	None
Silver and copper	----	----	1.7 ppm max.
Chloride ions	----	----	5.0 ppm max.

[a]By weight.

TABLE A-VII.- GASEOUS AND LIQUID OXYGEN

[Procurement shall be to Specification MSFC-SPEC-399]

Characteristic	Requirement as delivered to spacecraft interface	
	Grade A for fuel cells	Grade B for breathing
Purity[a]	99.995 percent by vol. min.	99.60 percent by vol. min.
Methane and ethane	Methane 10 ppm Ethane 2.0 ppm	Methane 25.0 ppm Ethane 2.0 ppm
Propane and higher hydrocarbons	1 ppm as propane	1 ppm as propane
Alkyne hydrocarbons	0.05 ppm as acetylene	0.05 ppm as acetylene
Total hydrocarbons	14.0 ppm as methane	29.0 ppm as methane
Moisture	3.0 ppm	3.0 ppm
Nitrous oxide	1.0 ppm	1.0 ppm
Halogenated hydrocarbons	1.0 ppm	1.0 ppm
Odor	No odor	No odor
CO and CO_2	1.0 ppm total	5.0 ppm CO 5.0 ppm CO_2

[a]For grade A oxygen, all other impurities including inert gases and nitrogen shall be 30 ppm maximum.

TABLE A-VIII

TEST WATER

Characteristic	Requirement as delivered to spacecraft interface		Test procedures
	Propulsion water	ESC water	
Conductivity	2.0×10^{-6} ohm^{-1}cm^{-1} at 25° C (77° F)	1.0×10^{-6} ohm^{-1}cm^{-1} at 25° C (77°F)	ASTM D 1125-64
pH	6.00 to 7.50	6.00 to 7.50	ASTM D 1293-62T
Nonvolatile residue	1.0 mg per 100 ml (max.)	0.2 mg per 100 ml (max.)	ASTM D 2109-64
Halides	1.0 ppm (max.)	1.0 ppm (max.)	ASTM D 512-62T method C.
Surface tension	72.72 ± 1.0 dynes per cm	72.72 ± 1.0 dynes per cm	ASTM D 1590-60
Particulate[a]	See table I or II as applicable	See table I or II as applicable	MSC-SPEC-C-14
Silting	See table I or II as applicable	No evidence of silting	ASTM D 2109-64

[a]The particulate limits for water being introduced to a spacecraft system shall be equal to or better than the particulate limits of the system being tested.

TABLE A-IX

OXYGEN, AVIATOR'S BREATHING, LIQUID AND GAS

[Procurement shall be to Specification MIL-O-27210C (ASG)]

Characteristic	Requirement as delivered to spacecraft interface
Purity	99.5 percent vol. min.
Odor	None
Moisture	0.005 mg per liter max. at 70° F and 760 mm Hg
Carbon dioxide	5.0 ppm by vol. max.
Methane	25.0 ppm by vol. max.
Acetylene	0.05 ppm by vol. max.
Ethylene	0.2 ppm by vol. max.
Ethane and hydrocarbons (as ethane)	3.0 ppm by vol. max.
Nitrous oxide	1.0 ppm by vol. max.
Refrigerants (freons, etc,)	1.0 ppm by vol. max.
Solvents, trichloroethylene, carbon tetrachloride and halogenated solvents	0.1 ppm by vol. max.
Other, each discernible from background noise on infrared spectrophotometer	0.1 ppm by vol. max.

TABLE A-X

LAUNCH COMPLEX CABIN ATMOSPHERE

(KSC PRE-FLIGHT APPLICATION ONLY)

[Procurement shall be to Specifications MSFC-SPEC-399A (Oxygen) and MSFC-SPEC-234A (Nitrogen)]

Characteristic	Requirement as sampled from spacecraft cabin
Oxygen	65 ± 1 percent by volume
Nitrogen	Remainder of atmosphere
Hydrocarbons	25 ppm, pentane equivalent
Particulate level	Class 100 000, FED-STD-209

TABLE A-XI

PROPELLANT, MONOMETHYLHYDRAZINE

[Procurement shall be to Specification MIL-P-27404]

Characteristic	Requirement as delivered to spacecraft interface
Monomethylhydrazine assay	98.0 percent by wt. min.
Density at 77° F (25° C.)	0.872 ± 0.004 gms per ml
Water plus soluble impurities	2.0 percent by wt. max.

TABLE A-XII

LIQUID HYDROGEN

[Procurement shall be to Specification MSFC-SPEC-256A]

Characteristic	Requirement as delivered to spacecraft interface
Purity	99.995 percent by vol, min.
Gaseous impurities	50 ppm by vol, max.
Selected impurities (nitrogen, water, and volatile hydrocarbons)	9.0 ppm by vol, max.
Specific impurities[a]	
Oxygen and argon	1.0 ppm by vol, max.
Helium	39.0 ppm vol, max.
Carbon bearing gases (Carbon monoxide and carbon dioxide)	1.0 ppm by vol
Selected impurities[b]	
Nitrogen	2.0 ppm by vol, max.
Methane	2.0 ppm by vol, max.
Specific impurities[b]	
Carbon monoxide	0.5 ppm by vol, max.
Oxygen plus argon	1.0 ppm by vol, max.

[a]Sample subjected to complete analysis.

[b]Restricted sample analysis.

TABLE A-XIII

ISOPROPYL ALCOHOL

[Procurement shall be to Specification TT-I-735A, Grade B]

Characteristic	Requirement as delivered to spacecraft interface
Acidity, percent as CH_3COOH	0.002 max.
Nonvolatile matter	0.8 max. gm per 100 ml
Water content, percent	0.40 max.
Color, platinum cobalt scale	10 max.
Specific gravity	0.7873 max. and 0.7862 min. at 20° C or 68° F
Distillation range:	
Initial boiling point	81.3° C or 178.3° F min.
Dry point	83.0° C or 181.4° F

TABLE A-XIV

TANK PRESSURANT, TRICHLOROTRIFLUOROETHANE

[Procurement shall be Specification MSC-SPEC-SE-C-0034 or MSFC-SPEC-237A]

Characteristic	Requirement as delivered to spacecraft interface
Appearance	Clear, colorless liquid
Purity	99.5 percent by wt, min.
Boiling point	47.6° ± 0.2° C (117.6° ± 0.4 F) at standard barometric pressure. Initial bp to 98 percent.
Evaporation range	Evaporation shall not exceed 0.28° C (0.5° F)
Acid number	0.003 mg KOH per gram of sample, max.
Other chemical components no more than 0.1 percent of other chlorofluorocarbons	0.2 percent by wt, max.[a]
Moisture content	60 ppm by wt, max.
Chloride ion	Less than 0.1 ppm
Residue, soluble and insoluble	2 ppm by wt, max.
Alcohols	0.3 percent by weight, max.[a]

[a]The summation of other chemical components and alcohols shall not exceed 0.5 percent by weight.

APPENDIX B

A COMPARISON OF THE REQUIREMENTS OF MSC-SPEC-C-6A AND MSC-SPEC-C-6B (SPACECRAFT FLUID REQUIREMENTS)

For the convenience of the user, the following tables present a comparison of MSC-SPEC-C-6A, June 26, 1967, hereby superseded by MSC-SPEC-C-6B, January 14, 1969. Additionally, table B-VI presents a list of filters which are currently qualified in accordance with paragraph 3.1.8 of this document.

TABLE B-I.- PROCUREMENT — CHEMICAL REQUIREMENTS

Item	MSC SPEC C-6A	1-14-79 MSC SPEC C-6B
Helium	MSFC SPEC 364A Mod	MSFC SPEC 364B
Helium Pressurant	MIL-P-27407	Same
Nitrogen	MSFC SPEC 234	Same
Nitrogen Pressurant	MIL-P-27401B	Omitted
N_2O_4	MSC-PPD-2A	MSC-PPD-28
Aerozine 50	MIL-P-27402-A	Same
MMH	MIL-P-27404	MSC-PPD-2B
O_2	MSFC SPEC 399	MSFC SPEC 399A
Breathing O_2	MIL-O-27210	Same
Potable Water	MSC SPEC C21A	MSC PF SPEC 1
High Purity H_2O	MSC SPEC C20A	Same
Water Glycol	MSC SPEC C22A	MSC SPEC SN-W-0040
PCH	MSFC SPEC 237A	Same
Freon MF	MSC-PPD-1	Same
Freon	BB-F-671A	Omitted
IPA	TT-I-735A	Same
Ethyl Alcohol	O-E-760B	Omitted
CO_2	BB-C-101A	Omitted
Hydrogen	--	MSC SPEC 356A

TABLE B-II.- USE — CHEMICAL REQUIREMENTS

Item	MSC-SPEC-C-6A	1-14-69 MSC-SPEC-C-6B
Helium	Same as procured	Relaxed
Helium Pressurant	Same as procured	Other gases; 19 ppm vs 39 ppm procured[a]
Nitrogen	Same as procured	Relaxed other than HC which are equal to procure
Nitrogen Pressurant	Same as procured	Omitted
N_2O_4	Same as procured	Relaxed
Aerozine 50	Same as procured	Same as procured
MMH	Same as procured	Relaxed
O_2	Same as procured	Same as procured
Breathing O_2	Same as procured	Same as procured
Potable H_2O	Same as procured	PF-SPEC-1
High Purity H_2O	Same as procured	Same as procured
Water Glycol	Same as procured	Controls chlorides and silver
PCA	Same as procured	Relaxed to SN-C-0037
Trich	Same as procured	Relaxed SN-C-0034
Freon	Same as procured	Omitted
IPA	Same as procured	Relaxed
Methanol	Same as procured	Omitted
Ethyl Alcohol	Same as procured	Omitted
CO_2	Same as procured	Omitted
Hydrogen	Same as procured	Relaxed

[a]The use requirement stipulating 19 ppm as maximum "other gases" is based on the fact that all Helium is produced and/or controlled by the Bureau of Mines. Historically, helium has never exceeded the 19 ppm requirement whether procured to MSFC-SPEC-364A or MIL-P-27407.

TABLE B-III.- CHEMICAL COMPOSITION USE REQUIREMENTS

MSC-SPEC-C-6A	1-14-69 MSC-SPEC-C-6B
No degradation permitted from procurement to use point	Degredation limits established

TABLE B-IV.- FLUID REQUIREMENTS

	Chemical	Particulate	Sampling point
MSC-SPEC-C-6A	Equal to procurement	GSE requirements[a]	GSE — valve box
Jan. 14, 1969 MSC-SPEC-C-6B	Degradation factors incorporated	Spacecraft system requirements[b]	GSE/spacecraft interface

[a]Particulate allowables at GSE valve box based on empirical sampling data provided by KSC.

[b]Spacecraft System requirements established by MSC-engineering.

TABLE B-V.- SAMPLING POINTS AND REQUIRED ANALYSIS

	MSC-SPEC-C-6A	1-14-69 MSC-SPEC-6B
No qualified filters		
At spacecraft interface		Particulate Chemical
At GSE valve box	Particulate Chemical	
Qualified filters		
At spacecraft interface		Chemical only
At GSE valve Box		No requirement

TABLE B-VI.- QUALIFIED FILTER[a] DATA

System	Fluid type	Part no. and vendor	Surface area	Micron rating (abs)
CSM				
RCS	Fuel	[b]15241-606	50 sq in.	15μ
	Oxidizer	[b]15241-607	50 sq in.	15μ
SPS	Fuel	[b]15241-621	500 sq in.	15μ
	Oxidizer	[b]15241-622	500 sq in.	15μ
EPS	Water glycol	10276-1 Capital Westward	150 sq in. [c](375 × 2400)	15μ
ECS	Water glycol	10367 Capital Westward	150 sq in. [c](375 × 2400)	15μ
EPS	Cryogenics	(14410-3011 Beech) 19563-2 Western	31 sq in. [c](325 × 2300)	10μ
LM				
DPS	Fuel	[b]15267-553	100 sq in.	15μ
	Oxidizer	[b]15267-554	100 sq in.	15μ
APS	Fuel	[b]15267-555	50 sq in.	15μ
	Oxidizer	[b]15267-556	50 sq in.	15μ
ECS	Supercritical helium	19665 Western	25 sq in. [c](325 × 2300)	10μ
ECS	Oxygen	[d](Air 902337-1 Vacco TI 81308)	Stacked disk	10μ
		Vacco TL 82063	Stacked disk	10μ
		Air 902311-1	Stacked disk	10μ
ECS	Water glycol	FL 2391-1 or FL 2391-02 Fluid Dynamics	45 sq in. [c](325 × 2300)	10μ

[a]Interface or final fluid filter.

[b]Wintec part number.

[c]CRES wire mesh rating.

[d]Separated from spacecraft interface by 60 to 100 feet of Teflon hose, braided Teflon hose, or stainless-steel convoluted hose.

END OF REFERENCE
13

REFERENCE
14

ANON.: GENERAL SPECIFICATION FOR CLEANLINESS OF ENVIRONMENTAL TEST CHAMBERS (OXYGEN RICH, PHYSIOLOGICAL OR VACUUM). MSC-SN-C-0024, NASA, MAR. 3, 1969.

SN-C-0024

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

GENERAL SPECIFICATION

CLEANLINESS OF ENVIRONMENTAL TEST CHAMBERS

(OXYGEN RICH, PHYSIOLOGICAL, OR VACUUM)

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
March 31, 1969

SN-C-0024
March 31, 1969

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MANNED SPACECRAFT CENTER

Houston, Texas

GENERAL SPECIFICATION

Cleanliness of Environmental Test Chambers

(Oxygen Rich, Physiological, or Vacuum)

SN-C-0024
March 31, 1969

This specification has been approved by the Manned Spacecraft Center (MSC) and is available for use by MSC and associated contractors.

Prepared by Dorothy T. Lizzey
MSC Engineering Branch, ND5

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MSC Quality Assurance Division, ND

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MSC Reliability and Quality Assurance Office

SN-C-0024
March 31, 1969

Foreword: Cleanliness is considered essential to a high order of reliability for simulated space and atmospheric environments. This document recognizes the need for implementing requirements consistent with that reliability.

1.0 SCOPE. This specification establishes basic requirements for the contamination control of manned/unmanned Environmental Test Chambers (such as vacuum or hyperbaric chambers, or variations thereof) during operational periods. Housekeeping procedures, personnel controls, and contaminant-generation constraints are specified to obtain and maintain an acceptable level of chamber cleanliness and to protect, as applicable, test item cleanliness. For the purposes of this specification, Environmental Test Chambers shall be considered Controlled Work Areas only during operational periods. This specification is not applicable to altitude physiological training chambers where the partial pressure of oxygen does not exceed 3.2 psia.

2.0 APPLICABLE DOCUMENTS.

2.1 STANDARDS.

MSC-STD-C-1 Definitions for Contamination Programs

2.2 SPECIFICATIONS.

MSC-SPEC-C-2A Garments, Clean Room, Specification for

3.0 DEFINITIONS. MSC-STD-C-1 lists definitions used in the MSC Contamination Control Program. The following definitions are included to clarify this specification.

3.1 ENVIRONMENTAL TEST CHAMBER. A vessel in which simulated space environments and/or atmospheric conditions can be established.

3.2 OPERATIONAL PERIODS. That period of time when an Environmental Test Chamber is classified as a Controlled Work Area. Such periods will normally commence with cleaning and inspection, or inspection to the requirements of 4.1, and continue to the completion of test.

4.0 REQUIREMENTS.

4.1 OPERATIONAL READINESS. Prior to the installation of test item or the start of a test, the chamber shall meet the following requirements.

4.1.1 Chamber Interior: The interior of the chamber shall be visibly clean. Where feasible, floors and walls shall be thoroughly vacuumed, wiped down, or scrubbed to remove visible soils.

4.1.1.1 Starting at the extreme top of the chamber, an adequate air hose with sufficient air pressure, a control valve, a flexible extension, and a nozzle for directing a concentrated air flow shall be used to blow out debris from all accessible crevices, ledges, pockets, etc.

4.1.1.2 Upon completion of 4.1.1.1, starting at the extreme top of the chamber, all accessible surfaces shall be vacuumed.

4.1.1.3 Upon completion of vacuuming, starting at the extreme top of the chamber, all accessible surfaces shall be wiped down with clean low-lint wiping cloths or polyurethane wipers. Stubborn soils, greases, etc., may require wiping with wipers or cloths dampened with a water solution of TSP (trisodium phosphate), followed by a rinse wipe with water.

4.1.1.4 Starting at the extreme top of the chamber, all accessible surfaces shall be vacuumed as in 4.1.1.2 above.

4.1.2 Chamber Surface Inspection: Subsequent to cleaning as required, all accessible interior chamber surfaces shall be visually examined; all surfaces shall be visibly clean. A black light may be used to aid visual inspection. Any evidence of contamination shall be cause for localized recleaning as required, according to the procedures of 4.1.1.

4.1.3 Operational Classification: Following cleaning, inspection, and approval, or inspection and approval only, the chamber shall be classified "Operational" as a Controlled Work Area.

4.2 FACILITY REQUIREMENTS.

4.2.1 A personnel clothes changing area shall be provided adjacent to the chamber for storage and changing of clean garments.

4.2.2 A mechanical shoe cleaner shall be provided at the chamber entrance; if not available, shoe covers or booties shall be worn.

4.2.3 The area adjacent to the chamber shall be suitably marked or otherwise designated as requiring special clothing (Paragraph 4.4.1).

4.2 4 The chamber shall be air-conditioned, that is, provided with clean filtered air whenever personnel require access during operational or nonoperational periods. Filters in the system may be of the commercial throwaway type.

4.2.5 All cabinets, stools, tables, etc., required for use in the chamber, shall be constructed of minimum particle-generating material such as metal or hard plastic. Upholstered chairs, wooden items, etc., are not permitted.

4.3 SPECIAL GARMENTS.

4.3.1 Special Clothing: All assigned personnel shall wear smocks and caps in accordance with MSC-SPEC-C-2A. Garments shall be changed at least weekly, or whenever they become visibly soiled. Personnel shall not wear clean garments beyond the marked area; garments worn out of these areas shall be discarded and replaced.

4.4 PERSONNEL CONTROLS.

4.4.1 A personnel access list shall be maintained and only assigned personnel shall be allowed entrance. If there is a definite need for entrance by nonassigned personnel, an access waiver may be granted by the cognizant office. The access list and waivers should minimize the number of personnel in the interest of maintaining chamber cleanliness.

4.4.2 A contamination control guard or Quality Assurance personnel shall be responsible for access control requirements whenever personnel require access during operational periods.

4.5 MAINTENANCE OF THE TEST CHAMBER WORK AREAS.

4.5.1 Sweeping or sweeping compounds shall not be permitted in chambers.

4.5.2 Floors shall be vacuumed at least once each 8-hour shift. The vacuum source shall be located outside the chamber with only the hose and pickup attachment inside, or the vacuum exhaust shall be filtered.

4.5.3 Floors, walkways, etc., shall be damp mopped at least weekly with nylon or Dacron mops dampened with water. TSP (trisodium phosphate) water solution may be necessary to remove stubborn soils.

4.5.4 In addition to the above minimum requirements, chamber surfaces (walls, floors, etc.) shall be subject to constant surveillance and cleaned by vacuuming or damp mopping whenever they become visibly soiled.

4.5.5 Routine cleaning will not be permitted in the chamber in the immediate vicinity of a spacecraft or other contaminant-sensitive test item while contaminant-sensitive parts or assemblies are being removed or replaced.

4.6 OPERATIONS.

4.6.1 Smoking, eating, or beverages shall not be permitted in the chamber or personnel entrance area.

4.6.2 Cleanup of parts, test equipment, or test hardware shall be accomplished in airlock or other outside facility prior to being moved into the chamber.

4.6.3 All tools shall be constructed of corrosion-resistant metals (e.g., stainless steel) or minimum particle-generating materials (e.g., hard plastic). Tools containing rubber, wood, etc., shall not be used.

4.6.4 All tools shall be verified clean prior to use and they shall be maintained visibly clean. Only approved lubricants may be used.

4.6.5 Only approved, clean, low-lint wiping cloths or clean polyurethane wipers shall be used for cleaning operations.

4.6.6 The chamber shall be free from all oil and grease not authorized. Operations causing oil or grease deposits shall not be permitted.

4.6.7 No metal or abrading tool of any sort shall be used except as authorized in 4.7. All serrated or knurled-jaw holding tools, such as pliers, pipe wrenches, vise grips, and vises, shall have their jaws padded with soft metal or other suitable protection. The use of adjustable tools, such as crescent wrenches, shall be minimized.

4.6.8 Tools shall be kept in drawers, wire baskets, or other suitable containers. Tools shall not be kept in toolboxes, felt-lined cases, or leatherette cases. Tools may be kept on clean polyurethane foam wipers.

4.6.9 There shall be no contaminant-generating operations allowed; for example, drilling, reaming, sanding, filing, deburring, welding, etc., except as authorized in 4.7.

4.6.10 Compressed gas shall be supplied from a source which is equipped with properly maintained dehydrators and filters for removing contamination.

4.6.11 All entrances and closures to the vacuum chamber shall be sealed during times of inactivity such as holidays, weekends, etc.

4.7 CHAMBER CONTAMINATION-GENERATION CONTROL. Contaminant-generating operations, such as sanding, grinding, chipping, welding, drilling, etc., shall not be permitted unless specifically approved by the cognizant office. These operations shall be scheduled or limited to nonoperational periods. The following controls shall then be exercised and monitored by Quality Control personnel.

4.7.1 A temporary enclosure shall be made of suitable plastic material to entrap contaminants around the immediate area of the contaminant-generating operation.

4.7.2 All chips, shavings, dirt, fillings, etc., shall be vacuumed immediately, as they are generated.

4.7.3 Immediately after the contaminant-generating operation, the area affected shall be wiped clean, vacuumed, and inspected to assure removal of all contaminants.

4.8 NONOPERATIONAL PERIODS. Chambers shall have all doors, entrances, closures, etc., sealed at all times during nonoperational periods except for necessary work, refurbishment, or other required functions. The cognizant office shall determine the necessity of the function, and personnel shall be restricted to those having a need to enter to perform the function. All such functions shall be conducted in such a manner to minimize contaminants in the interests of a future or subsequent operational period.

5.0 QUALITY ASSURANCE PROVISIONS. The Quality Control organization shall determine compliance with the following.

5.1 Operational readiness

5.2 Facility requirements

5.3 Special garments

5.4 Personnel controls

5.5 Maintenance requirements

5.6 Operational requirements

5.7 Chamber contamination-generation control

5.8 Nonoperational requirements

END OF REFERENCE
14

CONTINUED ON CARD 6

Card #6

REFERENCE
15

ANON.: CLEANLINESS OF NON-AIRBORNE BREATHING SYSTEMS.
MSC-SPEC-9A, NASA, JUNE 9, 1967.

MSC-SPEC-C-9A
June 9, 1967
Supersedes
MSC-SPEC-C-9
Dated October 10, 1966

MANNED SPACECRAFT CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HOUSTON, TEXAS

CLEANLINESS OF NONAIRBORNE BREATHING SYSTEMS, SPECIFICATION FOR,

This specification has been approved by the Manned Spacecraft Center (MSC) for use by MSC contractors, MSC, and other Centers, as appropriate.

1. SCOPE

This specification establishes the minimum contamination control requirements for the permanently installed portions of nonairborne breathing systems.

2. APPLICABLE DOCUMENTS

The following documents form a part of this specification to the extent indicated herein. In case of conflict between referenced documents and this specification, this specification shall prevail.

STANDARDS

Manned Spacecraft Center

MSC-STD-C-1	Definitions for Contamination Programs

SPECIFICATIONS

Manned Spacecraft Center

MSC-SPEC-C-10	Systems Contamination Control During Repair, Replacement or Maintenance

Enclosure 11

3. DEFINITIONS

3.1 MSC-STD-C-1 lists definitions used in the MSC contamination control program. In case of conflict, the MSC-STD-C-1 will govern, unless specified otherwise. The following definitions are included to clarify this specification.

3.1.1 Visibly Clean

Visibly clean shall be construed to mean the freedom of the surface from particulate matter approximately 50 microns and larger in size and from all films other than known innocuous films.

3.1.2 Critical Surface

That surface of a component which directly contacts the service media.

4. REQUIREMENTS

4.1 OPERATIONS DURING REPAIR, REPLACEMENT OR MAINTENANCE

MSC-SPEC-C-10 describes overall requirements for contamination control during these operations. The cleanliness of precision-cleaned, contaminant-critical systems can be compromised by improper contamination control techniques during any operation in which the system is opened to an uncontrolled environment. MSC-SPEC-C-10 defines requirements compatible with proper contamination control practices.

4.2 COMPONENT CLEANING

Components shall be cleaned to the applicable manufacturer's specification according to the requirements of MSC-SPEC-C-11A.

4.3 MATERIALS

All materials used in the permanently installed portions of nonairborne breathing systems shall be compatible with the fluids used in the systems.

HYDROCARBONS AND NONVOLATILE RESIDUE

Nitrogen should be used for initial cleaning and purging following by the system gas until the effluent meets the hydrocarbon requirements of the system gas. When using a cleaning solution to clean the nonairborne breathing system, the maximum nonvolatile residue of the effluent solution shall be 1.0 mg. per 100 ml.

PARTICULATE

Nonairborne breathing systems shall be cleaned to the following requirements:

SIZE RANGE OF PARTICLES	NO./FT. OF CRITICAL SURFACE[1]
0-175 microns	Unlimited[2]
175-700 microns	6
> 700 microns	0
SIZE RANGE OF FIBERS	
700-1500 microns	1
> 1500 microns	0

NOTE 1 - A 100 ml sample of flush fluid is normally used for each square foot of critical surface.

NOTE 2 - Unlimited means that particles in this size range are not counted; however, any obscuring of the filter grid lines shall be cause for rejection.

MOISTURE

The moisture content of the purge gas effluent snall not exceed that of the system gas procurement specification.

DETAILED PROCEDURAL REQUIREMENTS

Section 2. of this specification references other MSC specifications containing requirements for various details of the contamination control operations. These shall be followed, as necessary, to assure adequate cleanliness operations.

5. QUALITY ASSURANCE PROVISIONS

Quality Assurance shall monitor the operations to ascertain compliance with the requirements of this specification.

Notice. -When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may be related thereto.

Custodian:

NASA Manned Spacecraft Center

Prepared by:

MSC Flight Safety Office, AR
and Apollo RQ&T Division, PR

END OF REFERENCE
15

REFERENCE
16

ANON.: SPACECRAFT ON-BOARD EQUIPMENT CLEANLINESS. MSC-SPEC-C-8, NASA, JAN. 5, 1967.

MSC-SPEC-C-8
January 5, 1967
AMENDMENT 1

MANNED SPACECRAFT CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HOUSTON, TEXAS

SPACECRAFT ON-BOARD EQUIPMENT, CLEANLINESS,

SPECIFICATION FOR

This amendment forms a part of the Manned Spacecraft Center specification, MSC-SPEC-C-8, dated September 1966.

Page 3, Section 4.2, First paragraph: Delete and substitute:

All packaging material which will be exposed to the oxygen environment of the crew-bay shall be GOX compatible. Packaging removed prior to exposure to the cabin flight environment need not be GOX compatible.

Enclosure 10

MSC-SPEC-C-8
September 1966

MANNED SPACECRAFT CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HOUSTON, TEXAS

SPACECRAFT ON-BOARD EQUIPMENT, CLEANLINESS, SPECIFICATION FOR

This specification has been approved by the Manned Spacecraft Center (MSC) for use by MSC contractors, MSC, and other Centers, as appropriate.

Foreword: Present cleanliness requirements for spacecraft interiors specify no visible dirt, soil or hydrocarbons. These requirements, coupled with the ground support equipment (GSE) which provides the prescribed environment for the interior of the spacecraft are considered adequate to ensure a practicable level of spacecraft cleanliness. The intent of this specification will be met if the above described conditions are not compromised by the cleanliness of equipment carried on-board the spacecraft.

1. SCOPE

This specification establishes the minimum cleanliness requirements for portable equipment and supplies brought on-board the spacecraft (CM and LM) at any time that spacecraft interior contamination control is being exercised. It includes all government-furnished equipment (GFE) such as spacesuits, experimental hardware, packaged food, survival equipment, tools, umbilicals, adaptors and connectors. Methods and procedures for attaining cleanliness levels are not considered within the scope of this document but shall be the responsibility of the organization providing the equipment; these methods and procedures, however, must meet the requirements of the referenced documents.

1.1 CLASSES OF EQUIPMENT

Two classes of on-board equipment are recognized.

1.1.1 Class A

This equipment does not interface with any other spacecraft fluid system. A tool is an example of Class A equipment.

1.1.2 Class B

This equipment interfaces with other fluid systems in the spacecraft. The spacesuit is an example of Class B equipment.

2. APPLICABLE DOCUMENTS

2.1 The following documents form a part of this specification. In case of conflict between the referenced documents and this specification, this specification shall prevail.

STANDARDS

Manned Spacecraft Center

MSC-STD-C-1	Definitions for Contamination Programs
MSC-STD-C-4	Clean Rooms and Work Stations

SPECIFICATIONS

Manned Spacecraft Center

MSC-SPEC-C-7	Apollo Spacecraft Fluid Systems Surface Cleanliness
MSC-SPEC-C-11	Precision Cleaning
MSC-SPEC-C-12	Precision Clean Packaging

3. DEFINITIONS

3.1 MSC-STD-C-1 lists definitions used in the MSC contamination program. In case of conflict, the MSC-STD-C-1 definition will govern, unless otherwise specified. The following definition is included to clarify this specification:

3.1.1 Visibly Clean

Visibly clean shall be construed to mean the freedom of the surface from particulate matter approximately 50 microns and larger in size and from all films other than known innocuous films.

4. GENERAL REQUIREMENTS

4.1 CLEANING

Detailed methods and procedures are the responsibility of the organization providing the equipment; requirements for cleaning are delineated in MSC-SPEC-C-11.

4.1.1 Class A Equipment

Surfaces exposed to the crew-bay environment shall be cleaned to a visibly clean condition (including the absence of visible hydrocarbons). This cleaning shall be accomplished in a clean room or clean work station of Class 100,000 or better, as defined in MSC-STD-C-4.

4.1.2 Class B Equipment

4.1.2.1 Interior.- The internal contaminant-sensitive surfaces are to be cleaned to the same cleanliness level as the fluid system with which they interface. Fluid system cleanliness levels are contained in MSC-SPEC-C-7.

4.1.2.2 Exterior.- Same as 4.1.1.

4.2 PACKAGING

All packaging material which will be exposed to the oxygen environment of the crew-bay shall be LOX compatible. Packaging removed prior to exposure to the cabin flight environment need not be LOX compatible.

Packaging materials, especially those used to cover ports of on-board equipment interfacing with fluid systems, shall be chosen to minimize particulate generation which might be detrimental to the system and/or LOX incompatible. Detailed packaging methods and procedures are the responsibility of the organization responsible for providing the equipment; requirements for packaging are given in MSC-SPEC-C-12.

5. QUALITY ASSURANCE PROVISIONS

The cognizant Quality Assurance organization will determine compliance with the following requirements.

5.1 EQUIPMENT CLEANLINESS (4.1)

5.2 PACKAGING (4.2)

Notice: When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any person or corporation.

Custodian:

NASA - Manned Spacecraft Center

Prepared by:

MSC Flight Safety Office, AR,
and Apollo RQ&T Division, PR

END OF REFERENCE
16

REFERENCE
17

ANON.: APOLLO SPACECRAFT FLUID SYSTEMS SURFACE CLEANLINESS. MSC-SPEC-C-7, NASA, NOV. 17, 1966.

MSC-SPEC-C-7
November 17, 1966
AMENDMENT 1

MANNED SPACECRAFT CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HOUSTON, TEXAS

APOLLO SPACECRAFT, FLUID SYSTEMS SURFACE CLEANLINESS,

SPECIFICATION FOR,

This amendment forms a part of the Manned Spacecraft Center specification, MSC-SPEC-C-7, dated October 24, 1966.

Page 1, Paragraph 1.1: Delete and substitute:

This specification establishes the minimum fluid systems surface cleanliness requirements for the Apollo spacecraft. The specification covers Command Module, Service Module and LM surface cleanliness requirements for the assembled fluid systems (or for the most complete subassemblies practicable). Surface cleanliness requirements for assemblies below the system level shall be those delineated in the applicable specification as established by the appropriate contractor. Cleanliness requirements for flush, rinse, test and referee fluids sampled from any part in the spacecraft are also covered by this specification. This specification does not include effluent cleanliness requirements for continuously circulating system fluids in a GSE-spacecraft loop. This specification does not include cleanliness requirements for systems (or portions of systems) not normally flushed with a liquid.

Enclosure 8

MSC-SPEC-C-7
October 24, 1966

MANNED SPACECRAFT CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRACTION

HOUSTON, TEXAS

APOLLO SPACECRAFT, FLUID SYSTEMS SURFACE CLEANLINESS, SPECIFICATION FOR

This specification has been approved by the Manned Spacecraft Center (MSC) for use by MSC contractors, MSC, and other Centers, as appropriate.

1. SCOPE

1.1 SCOPE

This specification establishes the minimum fluid systems surface cleanliness requirements for the Apollo spacecraft. The specification covers Command Module, Service Module and LM surface cleanliness requirements for the assembled fluid systems (or for the most complete subassemblies practicable). Cleanliness requirements for fluids sampled from any port in the spacecraft are also covered by this specification. Surface cleanliness requirements for assemblies below the system level shall be those delineated in the applicable specification as established by the appropriate contractor.

2. APPLICABLE DOCUMENTS

2.1 The following documents form a part of this specification to the extent indicated herein.

STANDARDS

Manned Spacecraft Center

MSC-STD-C-1	Definitions for Contamination Programs

3. DEFINITIONS

3.1 MSC-STD-C-1 lists definitions used in the MSC contamination program. In case of conflict, the MSC-STD-C-1 will govern, unless specified otherwise. The following definitions are included to clarify this specification.

3.1.1 Critical Surface

That surface of a component which directly contacts the service media.

3.1.2 Visibly Clean

The freedom of the surface from particulate matter approximately 50 microns and larger in size and from all films other than known innocuous films.

3.1.3 Nonvolatile Residue (NVR)

Soluble (or suspended) material and insoluble particulate remaining after controlled evaporation (temperature not to exceed 220°F) of a filtered volatile liquid, usually measured in grams. Filtration is normally through a 0.45 micron or 0.8 micron membrane filter.

4. REQUIREMENTS

4.1 The Apollo spacecraft fluid system surface requirements are listed in Table I (LM) and in Table II (CM/SM). Requirements for associated GSE are listed in the appropriate table. Equipment that interfaces with a fluid subsystem, such as the spacesuit or the associated GSE will be cleaned to the same requirements as that subsystem. Components shall be cleaned to at least that level required for the assembled system.

4.2 Cleanliness levels shown in Tables I and II are for the effluent fluids from the test point closest to the spacecraft tanks or other on-board storage.

TABLE I

LM Fluid System Surface Cleanliness Requirements[1]

SYSTEM	PARTICULATE DISTRIBUTION PER SQ. FT. OF CRITICAL SURFACE[2] SIZE RANGE	QUANTITY (MAX.)	NONVOLATILE RESIDUE PER SQ. FT. OF CRITICAL SURFACE[2] (MAX.)
RCS			
Helium Pressurization System	0-50 microns	Unlimited[3]	1 mg
	>50 microns	0	
Propellant Subsystem	Same as above.		1 mg
PROPULSION			
Helium Pressurization Subsystem	Same as above.		1 mg
Propellant Subsystem	0-50 microns	Unlimited[3]	1 mg
	50-100 microns	100	
	100-250 microns	4	
	>250 microns	0	
Environmental Control System			
ECS			
Oxygen Cabin Pressure	0-50 microns	Unlimited[3]	1 mg
	50-75 microns	100	
	75-100 microns	10	
	>100 microns	0	
Other Subsystems	0-50 microns	Unlimited[3]	1 mg
	50-100 microns	100	
	100-250 microns	4	
	>250 microns	0	
GSE			
Subsystems Downstream of GSE-Vehicle Interface Filter	Same as vehicle subsystem		Same as vehicle subsystem

NOTE 1 - Nonsignificant surfaces shall be visibly clean.

NOTE 2 - A 100 ml minimum sample of rinse fluid is normally used for each sq. ft. of critical surface.

NOTE 3 - Unlimited means that particles in this range are not counted; however, any obscuring of the filter grid lines shall be cause for rejection.

TABLE II

CM/SM FLUID SYSTEM SURFACE CLEANLINESS REQUIREMENTS[1]

SYSTEM	PARTICULATE DISTRIBUTION PER SQ. FT. OF CRITICAL SURFACE[2] SIZE RANGE	QUANTITY (MAX.)	NONVOLATILE RESIDUE PER SQ. FT. OF CRITICAL SURFACE[2] (MAX.)
RCS - CM/SM			
Pressurization Subsystem	0-50 microns	Unlimited[3]	1 mg
	>50 microns	0	
Propellant Subsystem	0-50 microns	Unlimited[3]	1 mg
	50-75 microns	100	
	75-100 microns	10	
	>100 microns	0	
SPS			
Pressurization Subsystem	0-50 microns	Unlimited[3]	1 mg
	50-100 microns	200	
	100-200	32	
	>200 microns	0	
	Fibers:		
	100-200 microns	5	
	> 200 microns	0	
Propellant System	0-50 microns	Unlimited[3]	1 mg
	50-100 microns	100	
	100-180 microns	20	
	180-350 microns	5	
	> 350 microns	0	
	Fibers:		
	100-350 microns	5	
	> 350 microns	0	
EPS			
Cryogenic Distribution Subsystem	0-50 microns	Unlimited[3]	1 mg
	50-100 microns	100	
	100-175 microns	10	
	>175 microns	0	
Cryogenic Tanks	0-175 microns	Unlimited[3]	1 mg
	175-700 microns	6	
	> 700 microns	0	
	Fibers:		
	700-1500 microns	1	
	> 1500 microns	0	

SYSTEM	PARTICULATE DISTRIBUTION PER SQ. FT. OF CRITICAL SURFACE[2] SIZE RANGE	QUANTITY (MAX.)	NONVOLATILE RESIDUE PER SQ. FT. OF CRITICAL SURFACE[2] (MAX.)
Other (nitrogen)	0-50 microns	Unlimited[3]	1 mg
	50-75 microns	100	
	75-100 microns	10	
	> 100 microns	0	
Water-Glycol	0-50 microns	Unlimited[3]	
	50-100 microns	100	
	100-175 microns	10	
	> 175 microns	0	
ECS			
NAA Subsystems	0-160 microns	Unlimited[3]	1 mg
	160-200 microns	5	
	200-250 microns	1	
	> 250 microns	0	
Other Subsystems	0-175 microns	Unlimited[3]	1 mg
	175-700 microns	6	
	> 700 microns	0	
	Fibers:		
	700-1500 microns	1	
	> 1500 microns	0	
GSE			
Subsystems Downstream of GSE-Vehicle Interface Filter	Same as Vehicle Subsystem		Same as Vehicle Subsystem

NOTE 1 - Nonsignificant surfaces shall be visibly clean.

NOTE 2 - A 100 ml minimum sample of rinse fluid is normally used for each sq. ft. of critical surface.

NOTE 3 - Unlimited means that particles in this range are not counted; however, any obscuring of the filter grid lines shall be cause for rejection.

Notice. -When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any person or corporation.

Custodian:	Prepared by:
NASA-Manned Spacecraft Center	MSC Flight Safety Office, AR, and Apollo RQ&T Division, PR

END OF REFERENCE
17

REFERENCE
18

ANMUTH, M.: CLEANING OF OXYGEN PRESSURE GAGE COMPONENTS. NAVAL BOILER AND TURBINE LAB., MAR. 26, 1965.

60463

X65 16260
(ACCESSION NUMBER)
22
(PAGES)
AD460463
(NASA CR OR TMX OR AD NUMBER)
(THRU)
40
(CODE)
15
(CATEGORY)
FACILITY FORM 602

CLEANING OF OXYGEN PRESSURE GAGE COMPONENTS

Final Evaluation Report
NBTL Project A-570
SR007-08-04, Task 0614

by

M. Anmuth

"Available to U.S. Government Agencies and U. S. Government Contractors Only"

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CLEANING OF OXYGEN PRESSURE GAGE COMPONENTS

Final Evaluation Report
NBTL Project A-570
SR007-08-04, Task 0614
26 March 1965

by

M. Anmuth

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ABSTRACT

Methods of cleaning high pressure oxygen gages were evaluated. Optimal results were obtained when a Bourdon tube-type gage with an attached capillary bleeder is flushed with a fluorinated hydrocarbon solvent utilizing a procedure prescribed by the Laboratory. A definitive test for residual oil in the system may be demonstrated by the absence of detectable fluorescence under long wave ultraviolet light examination of the final flushings. This gage configuration modification and cleaning procedure will eliminate dead-ended systems and possible explosion hazards.

Author

SUMMARY PAGE

The Problem

What method can be used to clean a high pressure oxygen gage to render it safe from explosion hazards? This problem is part of the general problem of the removal of oil from metal surfaces.

Findings

The most effective cleaning method is converting the Bourdon tube component to a two-port system by attaching an external bleeder at the distal end. Fluorinated hydrocarbons have been found to provide the highest level of cleanliness with the least toxic effects.

Recommendations

A cleaning procedure utilizing Freon PCA and the long wave ultraviolet oil detector lamp in conjunction with a bleeder type gage has been offered as the most ideal method at this time to provide a clean high pressure oxygen gage.

ADMINISTRATIVE INFORMATION

Tests to investigate the use of various organic and inorganic solvents for removal of oil contamination from metal surfaces were authorized by BuShips ltr R007-08-04 Ser 634A-16 of 17 Jan 1962 and BuShips ltr R007-08-04 Ser 634-345 of 22 Jul 1963. In addition the Laboratory was subsequently requested by the Bureau of Ships to survey cleaning procedures for oxygen gages. The investigation under NBTL Project No. A-411 -"Investigation of Procedures for Removal of Oil Contamination from Metal Surfaces" was terminated and a final report issued on 30 June 1964. The work on cleaning of high pressure oxygen gage components was continued under NBTL Project A-570 in accordance with the NBTL Semi-Annual Program Summary of 1 May 1964 (SR007-08-04, Task 0614). The cost of the project is chargeable to Allotment No. 24995. Aprop. 17X1319.2451 RDI&E. The Navy Index Number is R007-08-04, Task 0614.

REFERENCES

(a) BuShips Instruction 9510.35A of 16 May 1961

(b) BuShips Instruction 9230.12A Ser 648F-188 of 8 Feb 1961

(c) "Investigation of Procedures for Removal of Oil Contamination from Metal Surfaces", Progress Report of NBTL Project A-411(SR007-08-04, Task 0615) of 25 June 1963

(d) "Investigation of Procedures for Removal of Oil Contamination from Metal Surfaces", Progress Report of NBTL Project A-411(SR007-08-04, Task 0615) of 17 Sept 1963

(e) Visits to US Gauge Co. and Hoke Valve Co. to observe cleaning facilities for oxygen gages - Enclosure (1) of NBTL ltr Code 2764/10330(A-411) of 14 Nov 1963

(f) Vacuum-Pressurization Method for Cleaning Components of Oxygen Systems-Electric Boat Division ltr U 412-62-C22 of 21 Feb 1962

(g) Cleaning Procedures for Oil-Contaminated Oxygen Gages, recommendations for NBTL ltr Code 2764/10330(A-411) of 3 Dec 1963

(h) Grade "A" gage cleaner R.D. 3560, information concerning, Electric Boat Division, "Vacuum-Pressurization Method for Oxygen System Cleaning and Grade "A" (Nuclear & Critical) System Cleaning, 20 Dec 1963

(i) "Investigation of Procedures for Removal of Oil Contamination from Metal Surfaces", Progress Report of NBTL Project A-411(SR007-08-04, Task 0614) of 27 Dec 1963

(j) Visit to General Dynamics Corp, Electric Boat Division, Groton, Conn. to observe operation of Automatic Grade "A" Gage Cleaner, Enclosure (1) of NBTL ltr Code 2764/10330 (A-411) of 5 Mar 1964

(k) Visit to National Ultrasonic Corporation, Somerville, N. J. to witness Ultrasonic Vapor Degreasing Equipment, Enclosure (1) of NBTL ltr Code 2764/10330 (A-411) of 19 Mar 1964

(l) "Investigation of Procedures for Removal of Oil Contamination from Metal Surfaces", Progress Report of NBTL Project A-411 (SR007-08-04, Task 0614) of 31 Mar 1964

REFERENCES (Cont'd)

(m) "Specification for Degreasing for Oxygen Service", Treadwell Corporation, New York City Spec No. EC-OG-3 of 10 May 1964

(n) "Investigation of Procedures for Removal of Oil Contamination from Metal Surfaces", Final Report of NBTL Project A-411(SR007-08-04, Task 0614) of 30 June 1964

(o) "Cleaning of Oxygen Pressure Gage Components," Progress Report No. 1 of NBTL Project A-570(SR007-08004 Task 0614) of 19 Aug 1964

(p) "Cleaning of Oxygen Pressure Gage Components", Progress Report No.2 of NBTL Project A-570(SR007-08-04, Task 0614) of 23 Nov 1964

(q) "Cleaning of Oxygen Pressure Gage Components", Progress Report No.3 of NBTL Project A-570(SR007-08-04, Task 0614) of 19 Feb 1965

NBTL PROJECT A-570

REPORT OF INVESTIGATION

Introduction

The Bourdon tubes of all pressure gages and regulators used in compressed gas installations represent ideal areas for the creation of ignition-combustion reactions. The dead-end configuration lends itself to a natural depository for contaminants with no possibility of drainage or purging without damage to the tube. Among these contaminants are minute amounts of oil which, when present in shipboard compressed air systems as well as in oxygen-nitrogen systems (resulting possibly from pumps and compressors), are potential explosion hazards and must be removed. Another contributing factor to rupture by explosion is the reduced cross-sectional area of the Bourdon tube which tends to accelerate the entering shock waves with a resultant increase in temperature upon impact at the dead-end. Furthermore, where hydraulic fluids are used in dead weight gage calibration, some of the liquid is trapped at the extreme or distal end making the entire tube a wetted perimeter of oil. When this film surface reacts with heat under pressure, a combustion reaction occurs in the Bourdon element, causing fragmentation of the gage or an explosion in the weakest portion of the system such as the air flask or accumulator. In an effort to prevent the hazards attending contaminated gages, the Laboratory was authorized to develop methods to clean them.

Description of Material and Equipment

The Bourdon tube is a thin walled flattened tube of elastic metal bent into a circular arc whose application to certain pressure gages depends upon the fact that increase of pressure inside the tube tends to straighten it. Bourdon tube gages are generally considered dead-end devices, i.e., entrapped air is forced to the end of the tube by the pressure medium where it remains pocketed.

A Bourdon tube with a 0.032 "i.d." stainless steel permanent external bleeder attached to the distal end was procured from the Ashcroft Gage Co., (subsidiary of Manning, Maxwell and Moore of Stratford, Conn.).

"White room" facilities were available in the field and in the Laboratory in the form of Microhoods to control and limit dust and other particulate interferences. In addition, this area could be "blacked-out" for the detection of residual oil by long wave ultraviolet light (3600-3900 Angstrom units).

A Grade A Gage Cleaner No. R.D. 3560 incorporating vacuum-pressurization components and manufactured and patented by Electric Boat Division of General Dynamics Corp. of Groton, Conn. was offered as suitable for nuclear and critical system cleaning. The cleaning principle utilized:

a. Alternate evacuation and filling of the gage to be cleaned.

b. Counting the number of evacuations and fillings performed.

c. Rotating gage clockwise to insure complete evacuation and filling of the Bourdon tube.

d. Discharging the evacuated solvent into a collection bomb for analysis.

A Cahn Electrobalance for fine gravimetric determinations.

An ultrasonic vapor degreaser equipped with a 25 KC Lead Zirconate Crystal transducer manufactured by the National Ultrasonic Corporation of Somerville, N. J. was evaluated. A 1000 KC crystal transducer owned by the Laboratory was also used.

A Beckman IR-8 was utilized to demonstrate trace quantities of oil dissolved in carbon tetrachloride (Spectrograde).

The following solvents were evaluated:

a. Freon PCA (trichlorotrifluoroethane) manufactured by E.I. Dupont Co., Wilmington, Delaware.

b. Dowclene WR (1,1,1, trichloroethane) manufactured by Dow Chemical Co., Midland, Michigan and containing a stabilizer in the same boiling range as the methyl chloroform. It is to be noted that the stabilizer is inactivated by moisture and care must be exercised to prevent its breakdown.

c. Carbon tetrachloride (Spectrograde) and Methylene Choride(CP) were utilized in infrared spectrophotometry and long wave ultraviolet detection studies.

Various 2190 TEP lubricating oils available to the Navy Department under the Qualified Products Listing were examined for detectability by long wave ultraviolet light.

Fats,oils, greases, and synthetic lubricants such as the phosphate esters were examined for limits of detectability by long wave ultraviolet light.

Methods and Results

As a preliminary procedure to further the investigation of oil removal from high pressure oxygen gages, the Laboratory was requested to determine the smallest quantity of oil that could be detected by the use of the long wave ultraviolet light. When serial dilutions of a known amount of 2190 TEP lubricating oil were prepared in non-fluorescent methylene chloride and portions evaporated to dryness in a glazed procelain dish in a dust-free room, quantities as little as 0.01 milligrams of oil could be detected. These findings have been reported by reference (c). Serial dilutions of various mineral, animal, vegetable and synthetic base oils (such as phosphate ester lubricants) in methylene chloride were made so that 1 ml. would contain 0.001 mg. These oils were selected as being typical of gage contaminants that can occur during the gage manufacture or assembling of the piping system. All of the hydrocarbons so examined exhibited some degree of fluorescence with the exception of a highly refined straight chain saturated paraffinic mineral oil (Nujol). These results were reported by references (p) and (q). Since some question had arisen concerning the fluorescent response of the 2190 TEP lubricating oils, available to the Navy Department under the Qualified Products List, the extent of their detectability was investigated when these were serially diluted in carbon tetrachloride (CP). The results of these findings were reported by reference (q) wherein it was indicated that as little as 0.01 mg. was detectable by long wave ultraviolet light.

In an attempt to affect cleanliness of the Bourdon tube component from a high pressure oxygen gage, the Laboratory devised a piping system whereby a solvent could be forced into the tube which had previously been evacuated. Various organic solvents were utilized but the fluorinated hydrocarbons were considered better suited due to their low surface tension, low toxicity, non-flammability and high affinity for hydrocarbonaceous contaminants. Freon 11 was first suggested but then rejected due to its low boiling point (75°F) and subsequent loss due to vaporization. Freon PCA with a higher boiling point (117°F) was substituted for better adaptation for vacuum-pressurization cleaning. When a "C" tube was coated with a known amount of 2190 TEP lube oil and subjected to the vacuum-pressurization cleaning process with Freon PCA as the solvent, only 34 to 77% of the contaminant was recovered. This demonstration of the ineffectiveness of this system was reported by reference (d). Vaporizing the Freon PCA before its introduction into the valved piping system to increase its penetrability into the dead-ended Bourdon tube proved only slightly more effective (81% of the original oil was recovered). The flushings from the piping system were examined for fluorescence under ultraviolet light with negative results but it was apparent some oil was still entrapped in the tube.

By reference (a), it was suggested that a 0.036" opening be made in the Bourdon tube tip to effect cleaning. Following this procedure, fresh Freon PCA was manually introduced into the connection end of the tube and flushed through the newly created distal opening. The balance of the original contaminant was recovered. The resultant "clean" Bourdon tube was effected by the mechanical action of a through flushing by Freon PCA.

A more sophisticated self-contained vacuum-pressurization apparatus developed and patented by the Electric Boat Division has been previously described and thought to be more efficient due to a high internal vacuum and a swivel rotational gage attachment. Its evaluation was made at Groton, Conn. and reported by references (f), (h) and (j). It was felt by the Laboratory that this Grade A gage cleaner did not offer any advantage over the Laboratory devised manually operated vacuum-pressurization piping system where complete oil removal was not effected.

In an attempt to evaluate additional gage cleaning techniques described in the literature, ultrasonic devices were investigated. Accordingly, the hole in the "C" tube was resealed and the Bourdon tube was reconverted to a single port system. It was subsequently contaminated with 2190 TEP oil and subjected to the Laboratory owned 1000 KC transducer with Freon PCA in the bath. Sufficient cavitation was provided to completely free the tube from its oil content. This was confirmed by manual flushing via the two-port system. The procedure was described by reference (d) and pointed to the potentiality of ultrasonic transducers as cleaning devices for dismantled gages with the Bourdon tube intact. Moreover, bench model ultrasonic devices have lower rated transducers (25 to 40 KC), are automatically tuned and are less costly. Various manufacturers were contacted and their equipment was evaluated in the field and in the Laboratory. Results obtained were reported by references (i,k and l) and indicated none of the lower rated equipment was effective in completely removing the oil from a contaminated Bourdon tube.

Since satisfactory or practical cleanliness of an intact single port Bourdon tube was not effected by the methods previously described, a high pressure, 4½" "C" tube with an external bleeder attached was obtained from the Ashcroft Gage Co. for Laboratory evaluation. Following its contamination with 2190 TEP oil and gentle rotation to distribute the oil, the tube was clamped on a ring stand and Freon PCA under pressure was forced into the connection end and out of the capillary end of the 0.032" bleeder attachment. The procedure has been described and diagrammed in references (g) and (o). A more detailed procedure, including the diagram is presented in Appendix A of this report. An examination of the tube flushings demonstrated a stage when no greater fluorescence was discernable than that exhibited by evaporation of the same volume of fresh Freon PCA.

The "C" tube with external bleeder attached was re-contaminated with 2190 TEP and flushed with Dowclene WR (the original material was fluorescent-free). After 8 successive flushings of 100 ml each, and examination of portions of the evaporated effluent, residual oil was still detectable by the ultraviolet light. An additional 100 ml flushing followed by a reverse flush (i.e. adding the solvent through the bleeder end) was sufficient to render the Bourdon tube completely free of oil contamination. These findings were reported by reference (q).

A bleeder type Bourdon tube was contaminated with 2190 TEP oil and thoroughly flushed with Freon PCA in accordance with the Laboratory suggested procedure. The first and second 250 ml flushings were discarded but the third portion was collected, evaporated to a low volume and transferred to

a tared aluminum foiled dish. The residue was evaporated to dryness on a steam bath in a dust free area, and dried in an oven at 105°C. Following cooling, the dish and residue were weighed on a Cahn Electrobalance (on which a residue as little as 0.005 mg can be accurately weighed). The resultant net weight of 0.060 mg of residual oil and particulate matter based on a 0.024 sq.ft. internal gage surface indicated an impurity 2½ times greater than could be tolerated as desirable in a clean oxygen system per reference (m). This procedure was reported by reference (p) and is indicative of the high level of cleanliness desired but not attainable except through tedious procedures.

As described in reference (b), the use of the infrared spectrophotometer has been suggested to facilitate the detection of trace quantities of oil recovered during gage cleaning operations. Here, too, purity of chemicals and careful operative technique are of the utmost importance. Since Spectrograde carbon tetrachloride has no carbon-hydrogen bonds, a mixture of carbon tetrachloride and a contaminant whose spectrogram shows a carbon-hydrogen stretch would reveal the presence of a hydrocarbon. Utilizing this theory and with the aid of the IR8 it has been possible to demonstrate the presence of 0.001 mg of 2190 TEP lube oil dissolved in spectrograde carbon tetrachloride. This procedure and possible applications have been discussed and reported in reference (q).

Discussion

Since all of the oils under study with the exception of highly purified mineral oil exhibited varying degrees of fluorescence, their detection is

made possible by the use of long wave ultraviolet light. The shop practice of using extenders such as light lubricating oil or kerosene in thinning animal origin cutting oils adds to their ease of detection where there is accidental contamination. It is the Laboratory's opinion that the use of ultraviolet equipment in conjunction with appropriate "white room" facilities is more practical than the gravimetric method using the Cahn Electrobalance as a device for assessing final cleanliness achievement of a Bourdon tube gage. In addition, because the gravimetric method includes particulate matter as well as oil, erroneous and high results are obtained by this procedure.

Of the various cleaning or flushing media investigated by the Laboratory, Freon PCA appears to be more effective than Freon 11, Freon 113, Freon TF or stabilized Dowclene WR. To minimize the cost of the solvent an effective recovery system can be instituted. In the Laboratory, the Freon PCA recovered from contaminated solution had a non-volatile residue of 0.4 ppm which makes it as good or better than fresh Freon PCA delivered by Dupont Co.

Because of the inherent difficulty encountered in filling and evacuating an intact Bourdon tube, the cleaning of helical or spiral type gages was not attempted during this study. If BuShips Instruction 9510.35A for drilling an opening in the free end of the Bourdon tube for cleaning purposes is followed, care must be taken in resealing before calibration and restoring the gage reliability. This method requires complete dismantling of the gage and additional handling costs.

The general use of ultrasonic equipment is not justified in cleaning Bourdon tubes in spite of manufacturer's claims. The use of 1000 KC transducers is unwieldy and probably too expensive to routinely operate. Any ultrasonic method would require the complete gage disassembly and make this operation impractical.

The highest degree of accuracy of residual oil detection can be attained by the use of infrared spectrophotometry. The chief objection would be unavailability of equipment and technical knowledge encountered only in sophisticated shore establishments and missile centers. This is definitely not a shipboard or shop procedure.

As a result of the Laboratory's experience with vendors of oxygen gages and piping systems (reference (e)), it was evident that cleaning or certifying the cleanliness of a single port gage was illusory. The presence of particulate matter is not demonstrable in an intact gage because of possible entrapment and withdrawal of solvent through the single port entry. The rigid requirements of a maximum of 1 mg per 500 ml of solvent per square foot of surface area (reference (m)) could only be proved in a two-port system gage as created by an external bleeder. The long wave ultraviolet light oil detection method is adaptable in a two-port system cleaning operation and can be utilized by ship or shop personnel with a minimum of training.

Conclusions

Based on the above evaluations, it is concluded that:

1. The most efficient procedure for cleaning Bourdon type oxygen gages comprises a two-port system with flushing by Freon PCA. A detailed procedure is given in Appendix A. (Conversion to a two-port system was also recommended for other "dead-end" piping systems, reference (n)).

2. Long wave ultraviolet light is the practical method of choice in detecting the extent of impurities, if any are present.

3. Because this method of detection is sensitive to quantities as low as 0.01 mg of residual oil, a gage that exhibits negative fluorescence after being subjected to this cleaning method, is considered oil-free.

Recommendations

To attain maximum cleanliness in an oxygen service, it is recommended that the two-port pressure gage component be subjected to the cleaning procedure set forth in Appendix A before installation into the piping system. It is also recommended that the long wave ultraviolet light detection method be employed under "white room" conditions and that flushing of the gage be continued until no fluorescence is discerned in the final evaporated effluent.

APPENDIX A

CLEANING PROCEDURE FOR BLEEDER TYPE BOURDON "C" TUBE GAGES

1. Disconnect oxygen gage from cylinder or high pressure piping system.

2. Remove the back of the gage. Carefully elongate the coil of capillary tubing to extend the free tip of the tube outside the gage case.

3. Open the capillary by filing off the tip, or by notching and bending no more than 1/8" of distal portion. Clear the opening with a small drill or probe.

4. Immobilize the gage in a horizontal position supported by a ring stand and clamp so that the exit port of the capillary bleeder can drain freely into an Erlenmeyer receiving flask.

5. Adapt a length of teflon tubing properly fitted to the threaded entrace port of the gage and connected to a 1/4" glass tube extending below the level of the Freon PCA contained in a 250 ml suction flask.

6. Connect an air pressure line to the side arm of the suction flask. The incoming air should be passed through a scrubber containing Freon PCA to remove any trace of oil which may be admixed with the air from the compressor system.

7. Place 150 ml of Freon PCA into the suction flask.

8. Adjust incoming air pressure (5 psig) to permit a flow rate of approximately 50 ml per minute to force the Freon PCA through the gage connection and out of the bleeder exit port into the collecting container.

9. Repeat with two additional 125 ml portions of Freon PCA.

10. Reverse flush with 100 ml of solvent.

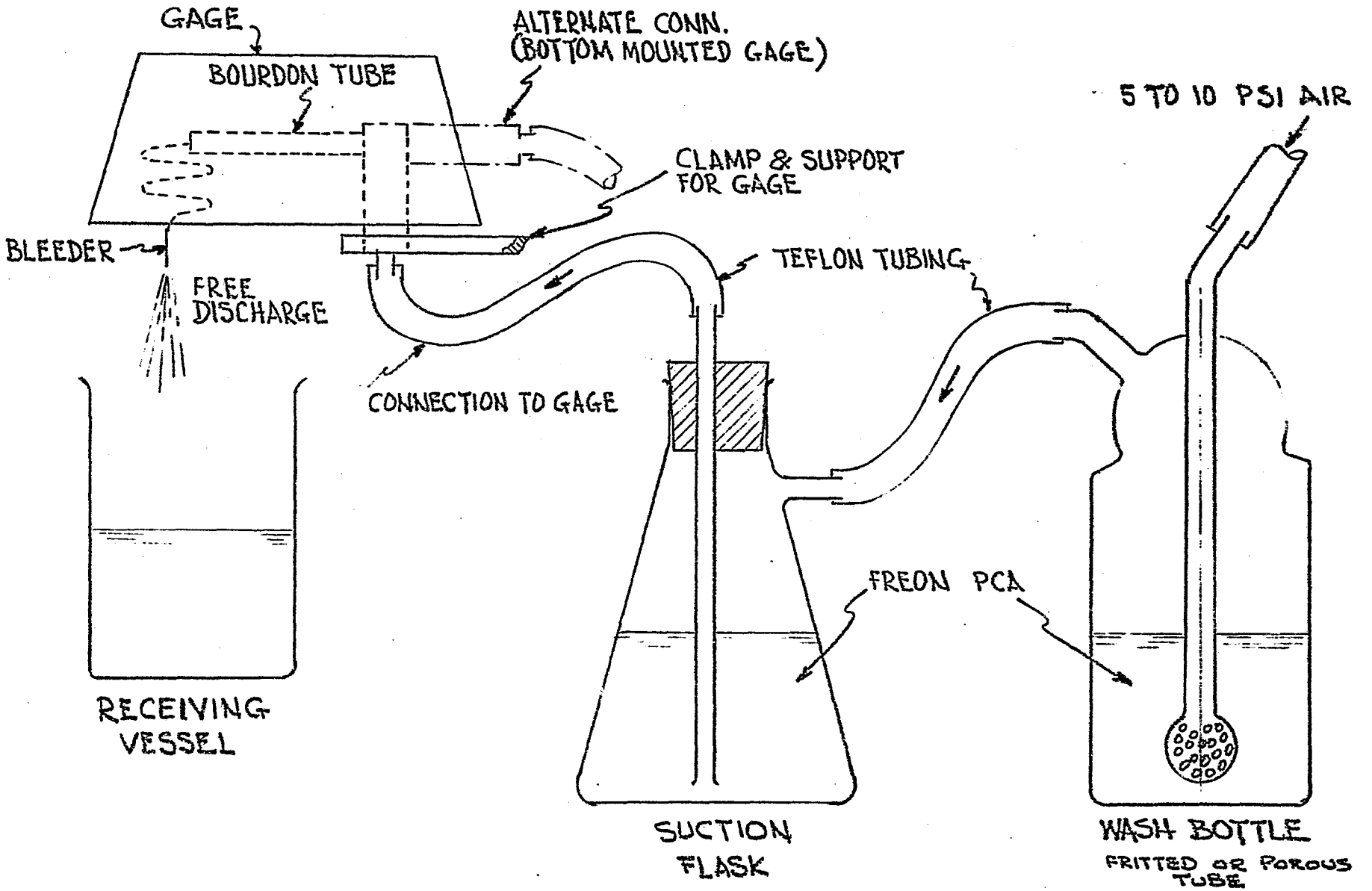
11. Introduce 50 ml of solvent through connection end of gage and collect effluent in a clean white porcelain dish. Evaporate to dryness and check for fluorescence in a dark room with a long wave ultraviolet light (3600 to 3900 Angstrom units).

12. If no fluorescence is discernable, gage is free of oil. Continue flushing if any fluorescence is evident.

13. When gage is declared free of oil, disassemble cleaning apparatus and force dry, oil-free nitrogen through the gage and out the bleeder port to remove the last traces of solvent.

14. Reseal tip of capillary bleeder by welding or silver brazing. Carefully recompress the capillary coil to clear gage cover and mechanism.

15. Replace cleaned gage into high pressure system.



GAGE CLEANING DIAGRAM.

ENCL 1

END OF REFERENCE
18

REFERENCE
19

ANON.: CLEANLINESS CRITERIA, CRITICAL COMPONENTS. SPEC. NO. 075192B, GENERAL DYNAMICS/CONVAIR, DEC. 13, 1967.

GENERAL DYNAMICS
Convair Division
CODE IDENT NO.
14170

SPECIFICATION NO.	REV
0-75192	B
DATE	
12-13-67	
CONTRACT NO.	
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NO. OF PAGES 18

CLEANNESS CRITERIA, CRITICAL COMPONENTS - SPECIFICATION FOR

PREPARED BY /s/K. M. Hendricks

APPROVED BY /s/H. H. Rosenbaum

CHECKED BY /s/H. R. Stone

Original issue 2/21/67

SPECIFICATION CHANGE NOTICES—INCORPORATED IN SPEC REVISIONS

SCN NO(S)	INCORP BY	CHECK BY	APPRVD BY	DATE	SPEC REV.	REVISION PACKAGE NO.		
Amend A	H. Stone	[illegible]	H.H.Rosenbaum	1/25/68	B			
1								

INITIAL PACKAGE NO.			RELEASE	DOC	DISTR
6151	572-4	—	[illegible] 5-31-68		42-2

TRACE? WITHOUT CHANGE

FORM 4951

☐ PRELIMINARY ☒ FINAL	**GENERAL DYNAMICS** *Convair Division* CODE IDENT NO. 14170 **SPECIFICATION CHANGE NOTICE** SCN NO. 1	PAGE 1 OF 6 DATE 12-13-67 SUPERSEDING SCN DATED

ECP NO. N/A	CONTRACT END ITEM NO. N/A	SPECIFICATION NO. 0-75192 B
CONTRACT NO. ALL	CONTRACTUAL AUTHORITY N/A	FILE OPPOSITE SPEC PAGE NO. 1
EFFECTIVITY N/A		

TEXT CHANGE

Paragraph 3.2.1, Page 2:

Change from:

3.2.1 Cleanness criteria. - Types I through VII component and material surfaces shall have a uniformly clean appearance. There shall be no visible evidence of contamination such as cleaning material residue, grit, sand, metal chips, scale, corrosion, oil, grease, paint, preservatives, decals, or other foreign residue indicative of unsatisfactory cleaning. The presence of petroleum-type hydrocarbons, particles, and fibers on cleaned surfaces shall be within the limits specified in the following paragraphs. The nonvolatile hydrocarbon contamination for any surface examined by the referee test shall not exceed 2.5 milligrams per square foot of test surface area of Types II through VI components, or 2.0 milligrams per square foot of test surface area of Type VII barrier or seal material.

Change to:

3.2.1 Cleanness criteria. Types I through VII component and material surfaces shall have a uniformly clean appearance. There shall be no visible evidence of contamination such as cleaning material residue, grit, sand, metal chips, scale, corrosion, oil, grease, paint, preservatives, decals, or other foreign residue indicative of unsatisfactory cleaning. The presence of petroleum-type hydrocarbons, particles, and fibers on cleaned surfaces shall be within the limits specified in the following paragraphs. The nonvolatile hydrocarbon contamination for any surface examined by the Referee Test shall not exceed 2.5 milligrams per square foot of test surface area of Types II through VI components, or 2.0 milligrams per square foot of test surface area of Type VII barrier or seal material. The acceptable level of contamination upon examination by the Referee Test for Internal Soluble Contamination shall be 125 micrograms per milliliter of effluent for Type III Components.

PREPARED	DATE	CHECK	DATE	APPROVED	DATE
[signature]	12-14-67	[signature]	2/9/68	[signature]	1/19
GROUP ENGR	DATE		DATE		DATE
[signature]	1/25/68	[signature]	1/19/68	D. E. Allen	1-19-68

EC GROUP	DATE	WAP/CIC NO.	GROUP NO.	SUPPL	RELEASE	DOC	DISTR
tl & Processes Spec.	12/13/67	6151	572-4	195	37 12-28-8		42-2

A4187 (3-66)

☐ PRELIMINARY ☒ FINAL	**GENERAL DYNAMICS** *Convair Division* CODE IDENT NO. 14170 **SPECIFICATION CHANGE NOTICE** SCN NO. 1	PAGE 2 OF 6 DATE 12-13-67 SUPERSEDING SCN DATED

ECP NO. N/A	CONTRACT END ITEM NO. N/A	SPECIFICATION NO. 0-75192 B
CONTRACT NO. ALL	CONTRACTUAL AUTHORITY N/A	FILE OPPOSITE SPEC PAGE NO. 1
EFFECTIVITY N/A		

TEXT CHANGE

Page 7, Paragraph 3.2.1.3, Table Five:

Change from:

Table Five (Type III components)

Cleanness ascertained by rinse test

Transducers with a surface area of 1 square foot or greater in contact with an operating fluid

Item	Limits	
	Size-Microns	Max. number
Particles	300-500	4 per sq ft
Particles	over 500	0
Fibers	over 2000	0

Hydrocarbons - No fluorescence (4.3.1.5)

Transducers with a surface area less than 1 square foot in contact with an operating fluid

Item	Limits	
	Size-Microns	Max. number
Particles	300-500	2 per sq ft
Particles	over 500	0
Fibers	over 2000	0

Hydrocarbons - No fluorescence (4.3.1.5)

PREPARED DATE s/H. H. Rosenbaum 12-14-67	CHECK DATE s/J. F. Haskins 1/19/68	APPROVED DATE s/R. Bailey 1-19-68	
GROUP ENGR DATE s/H. H. Rosenbaum 1/25/68	DATE s/James F. Haskins 1/19/68	DATE s/D. E. Diller 1-19-68	
SPEC GROUP DATE Matl & Processes Spec. 12/13/67	WAP/CIC NO. 6151	GROUP NO. 572.4	SUPPL 195
RELEASE	DOC	DISTR 42.2	

AA187 (3-65)

☐ PRELIMINARY ☒ FINAL	**GENERAL DYNAMICS** *Convair Division* CODE IDENT NO. 14170 **SPECIFICATION CHANGE NOTICE** SCN NO. 1	PAGE 3 OF 6 DATE 12-13-67 SUPERSEDING SCN DATED

ECP NO.	CONTRACT END ITEM NO.	SPECIFICATION NO.
N/A	N/A	0-75192 B
CONTRACT NO.	**CONTRACTUAL AUTHORITY**	**FILE OPPOSITE SPEC PAGE NO.**
ALL	N/A	1

EFFECTIVITY

N/A

TEXT CHANGE

Page 7, Paragraph 3.2.1.3, Table Five (continued):

Change to:

Table Five (Type III components)
Cleanness ascertained by rinse test

Transducers with a surface area of 1 square foot or greater in contact with an operating fluid

Item	Limits	
	Size-Microns	Max. number
Particles	300-500	4 per sq ft
Particles	over 500	0
Fibers	over 2000	0

Hydrocarbons - No fluorescence (4.3.1.5)

Transducers with a surface area less than 1 square foot in contact with an operating fluid

Item	Limits	
	Size-Microns	Max. number allowed
Particles	300-500	2
Particles	over 500	0
Fibers	over 2000	0

Hydrocarbons - No fluorescence (4.3.1.5)

PREPARED	DATE	CHECK	DATE	APPROVED	DATE
[illegible]	12-19-67	[illegible]	1/19/68	s/R. Bailey	1-19-68
GROUP ENGR	**DATE**		**DATE**		**DATE**
s/H. H. Rosenbaum	1/25/68	s/James F. Hopkins	1-19-68	s/D. E. Diller	1-19-68

SPEC GROUP	DATE	WAP/CIC NO.	GROUP NO.	SUPPL	RELEASE	DOC	DISTR
Matl & Processes Spec.	12/13/67	6151	572-4	195			42-2

A4187 (3-66)

☐ PRELIMINARY ☒ FINAL	**GENERAL DYNAMICS** *Convair Division* CODE IDENT NO. 14170 **SPECIFICATION CHANGE NOTICE** SCN NO. 1	PAGE 4 OF 6 DATE 12-13-67 SUPERSEDING SCN DATED

ECP NO. N/A	CONTRACT END ITEM NO. N/A	SPECIFICATION NO. 0-75192 B
CONTRACT NO. ALL	CONTRACTUAL AUTHORITY N/A	FILE OPPOSITE SPEC PAGE NO. 1
EFFECTIVITY N/A		

TEXT CHANGE

Paragraph 3.2.1.3.1.a, Page 7:

Change from:

a. Pressure transducers with pressure ranges of 0 to 50 psia, psig, psid, or lower, when measured at one point within their range, shall have an output which is within ± 1 percent of full scale output as shown on the transducer's calibration record.

Change to:

a. Pressure transducers with pressure ranges of 0 to 50 psig, psid, or lower, or those with 0 to 50 psia down to 0 to 20 psia, shall have their output checked after cleaning. This shall be at one point within their range. Output shall be within ± one percent of full scale output of the corresponding value as shown on the transducer's calibration record.

Paragraph 3.2.2.2, Page 12:

Change from:

3.2.2.2 Functional testing, Types III and VII. - The requirements for Type III components (transducers) are specified in 3.2.1.3.1. Functional testing of Type VII material is not a requirement of this specification.

Change to:

3.2.2.2 Functional testing, Types III and VII. - The requirements for Type III components (transducers) are specified in 3.2.1.3.1 and the Quality Assurance Provisions Section. Functional testing of Type VII material is not a requirement of this specification.

Page 14, Add paragraph as follows:

4.3.1.7 Referee test, Type III with internal cavities. This test shall be performed where the level of internal soluble contamination is questioned. Testing shall consist of filling the internal cavity of the transducer with a suitable solvent (as recommended by engineering), allowing a 15 minute soak period, removing solvent and analyzing for contaminant residue using the gravimetric method. Criteria for acceptance shall be as specified in 3.2.1.

PREPARED	DATE	CHECK	DATE	APPROVED	DATE
[illegible]	12-19-67	[illegible]	2/7/1	s/R. Bailey	1-19-68
GROUP ENGR	DATE		DATE		DATE
s/H. H. Rosenbaum	1-25-68	s/James F. Haskins	1-19-68	s/D. E. Diller	1-19-68

SPEC GROUP	DATE	WAP/CIC NO.	GROUP NO.	SUPPL	RELEASE	DOC	DISTR
Matl & Processes Spec.	12/13/67	6151	572-4	195			42-2

A4187 (3-66)

☐ PRELIMINARY / ☒ FINAL	GENERAL DYNAMICS *Convair Division* CODE IDENT NO. 14170	PAGE 5 OF 6
		DATE 12-13-67
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ECP NO.	CONTRACT END ITEM NO.	SPECIFICATION NO.
N/A	N/A	0-75192 B
CONTRACT NO.	**CONTRACTUAL AUTHORITY**	**FILE** OPPOSITE SPEC PAGE NO.
ALL	N/A	1

EFFECTIVITY

N/A

TEXT CHANGE

Paragraph 4.3.2, Pages 14 and 15:

Change from:

4.3.2 Performance reverification tests, Type III. - Type III components only (transducers) shall be subjected to these tests. After the completion of all cleaning and inspection processes and prior to packaging, the performance of transducers shall be reverified. Pressure transducers with pressure ranges of 0-50 psia, psig, psid, or lower shall have their output checked at one point within their range. The zero psid output shall be an acceptable check point for reluctive, d-c output, differential pressure transducers. Performance reverification is not required for transducers other than those described herein.

Change to:

4.3.2 Performance reverification tests, Type III. Type III components only (transducers) shall be subjected to these tests. After the completion of all cleaning and inspection processes and prior to packaging, the performance of transducers as specified below shall be reverified. Pressure transducers with pressure ranges of 0 to 50 psig and psid or lower, or those with 0 to 50 psia down to 0 to 20 psia, shall have their output checked after cleaning; this shall be done at one point within their range. The zero psid output shall be an acceptable check point for reluctive, d-c output, differential pressure transducers. Performance reverification is required only for transducers described herein.

Paragraph 4.3.2.2, Page 15:

Change from:

4.3.2.2 Absolute pressure test, Type III components. - Transducers with 0 to 20 psia or higher range may be tested on the bench.

Change to:

4.3.2.2 Absolute pressure transducer test, Type III components. Subject transducers may be tested on the bench.

Paragraph 4.3.2.3, Page 15:

Change title to read:

4.3.2.3 Gage pressure transducer test, Type III components.

PREPARED	DATE	CHECK	DATE	APPROVED	DATE
M. P. Stone	12-14-67		2/7/d	s/R. Bailey	1-19-68
GROUP ENGR	**DATE**		**DATE**		**DATE**
s/H. H. Rosenbaum	1-25-68	s/James F. Haskins	1-19-68	s/D. E. Diller	1-19-68

SPEC GROUP	DATE	WAP/CIC NO.	GROUP NO.	SUPPL	RELEASE	DOC	DISTR
Matl & Processes Spec.	12/13/67	6151	572-4	195			42-2

A4167 (3-66)

☐ PRELIMINARY ☒ FINAL	**GENERAL DYNAMICS** *Convair Division* CODE IDENT NO. 14170 **SPECIFICATION CHANGE NOTICE** SCN NO. 1	PAGE 6 OF 6 DATE 12-13-67 SUPERSEDING SCN DATED

ECP NO.	CONTRACT END ITEM NO.	SPECIFICATION NO.
N/A	N/A	0-75192 B
CONTRACT NO.	**CONTRACTUAL AUTHORITY**	**FILE OPPOSITE SPEC PAGE NO.**
ALL	N/A	1
EFFECTIVITY		
N/A		

TEXT CHANGE

Paragraph 4.3.2.4, Page 15:

Change title to read:

4.3.2.4 Differential pressure transducer test, Type III components.

Paragraph 4.3.2.5, Page 15:

Change from:

4.3.2.5 Other tests, Type III components. - Temperature transducers, flow transducers, and resistive liquid-level transducers shall have the resistance of the transducer element measured with a resistance bridge, Weatstone bridge, or a high-impedance digital ohmeter (Hycon or equivalent) while the transducer is on the bench.

Change to:

4.3.2.5 Tests on other transducers (Type III components). Probe type resistive temperature transducers, turbine-type flow transducers, and resistive liquid-level transducers shall have the resistance of the transducer element measured with a resistance bridge, Wheatstone bridge, or a high-impedance digital ohmeter (Hycon or equivalent) while the transducer is on the bench.

Paragraph 6.1, Page 16:

Change from:

6.1 Intended use. - This specification is intended to be applied to the components listed in 1.1 for which precise control of cleanness is required. The transducers covered (1.1.e) are temperature (resistive, probe type), liquid level, flow, and instrument and control transducers. Type VII material (1.1.i) includes films, plastic caps, and metal closures used for packaging or sealing of precision cleaned components.

Change to:

6.1 Intended use. This specification is intended to be applied to the components listed in 1.1 for which precise control of cleanness is required. The transducers covered (1.1.e) are temperature (resistive, probe type), pressure (except absolute units with ranges of 0 to 15 psia or lower), liquid level, and flow; these may be instrumentation or control transducers. Type VII material (1.1.i) includes films, plastic caps, and metal closures used for packaging or sealing of precision cleaned components.

PREPARED	DATE	CHECK	DATE	APPROVED	DATE
[signature]	12-14-67	[signature]	2/5/68	s/R. Bailey	1-19-68
GROUP ENGR	**DATE**		**DATE**		**DATE**
s/H. H. Rosenbaum	1-25-68	s/James F. Haskins	1-19-68	s/D. E. Diller	1-19-68

SPEC GROUP	DATE	WAP/CIC NO.	GROUP NO.	SUPPL	RELEASE	DOC	DISTR
Matl & Processes Spec.	12/13/67	6151	572-4	195			42-2

1. SCOPE

1.1 Scope. - This process specification establishes the requirements governing the contamination limits for the following:

a. RP-1 fuel system components
b. Liquid oxygen system components
c. Liquid hydrogen system components
d. Liquid helium system components
e. Fluid system transducers
f. Pneumatic system components
g. Propellant utilization system components
h. Standard parts used interchangeably in the following systems:

1. RP-1 fuel
2. Liquid oxygen
3. Liquid hydrogen
4. Liquid helium
5. Pneumatic
6. Hydraulic

i. Contamination barrier and seal material

1.2 Classification. - Component cleanness criteria shall be classified as follows:

Type I - RP-1 fuel system components

Type II - Liquid oxygen, liquid hydrogen, and liquid helium systems components

Type III - Fluid system transducers

Type IV - Pneumatic system components

Type V - Propellant utilization system components

Type VI - Interchangeable standard parts

Type VII - Contamination barrier and seal material

1.3 Classification identification. - For classification identification of the processes furnished under this specification see 6.3.3.

2. APPLICABLE DOCUMENTS

2.1 Except where a specific issue is indicated, the following documents of the issue in effect on date of Convair's request for quotation form a part of this specification to the extent specified herein. In the event of conflict between documents shown and any content of this specification, this specification shall supersede.

SPECIFICATIONS

Convair

0-75019	Sealing and Packaging of Precision Cleaned Missile, Space Vehicle, and Ground System Components
0-75050	Contamination Control Requirements for Hydrogen Peroxide Components and Ground Systems

PUBLICATIONS

Society of Automotive Engineers (SAE)

ARP 598	Procedure For the Determination of Particulate Contamination of Hydraulic Fluids by the Particle Count Method

(Copies of documents required by suppliers in connection with specific procurements should be obtained from Convair or as prescribed in the contract or order.)

3. REQUIREMENTS

3.1 General requirements. - The components and materials covered herein shall be cleaned to the extent necessary for compliance with the requirements specified herein. Cleaning methods, or any subsequent handling prior to installation, shall not impair the physical and functional condition of components cleaned to meet the requirements specified herein.

3.2 Detail requirements.

3.2.1 Cleanness criteria. - Types I through VII component and material surfaces shall have a uniformly clean appearance. There shall be no visible evidence of contamination such as cleaning material residue, grit, sand, metal chips, scale, corrosion, oil, grease, paint, preservatives, decals, or other foreign residue indicative of unsatisfactory cleaning. The presence of petroleum-type hydrocarbons, particles, and fibers on cleaned surfaces shall be within the limits specified in the following paragraphs. The nonvolatile hydrocarbon contamination for any surface examined by the reference test shall not exceed 2.5 milligrams per square foot of test surface area of Types II through VI components, or 2.0 milligrams per square foot of test surface area of Type VII barrier or seal material.

3.2.1.1 Type I (RP-1 fuel system) components. - Components to be used in RP-1 fuel systems shall comply with the limits specified in Tables One and Two when tested as specified in the tables.

Table One (Type I components)

Cleanness ascertained by wipe test

A. Contamination limits immediately after cleaning and prior to installation

Item	Limits
Propellant tanks	No particles greater than 300 microns
	No fibers greater than 4000 microns in length.
All other components	No particles greater than 175 microns
	No fibers greater than 2000 microns in length.

B. Contamination limits when an installed component is removed for cleanness validation only

Item	Limits
All components including propellant tanks	No particles greater than 750 microns
	No fibers greater than 6000 microns in length.

Table Two (Type I components)

Cleanness ascertained by flush or solvent rinse test
(all Type I components including propellant tanks)

A. Contamination limits immediately after cleaning and prior to installation

Item	Limits	
	Size-Microns	Max. number
Particles	300-500	10 per sq ft
	500-1000	2 per sq ft
	>1000	0
Fibers	750-2000	20 per sq ft
	2000-6000	2 per sq ft
	> 6000	0
Total solids		2 milligrams per sq ft

B. Contamination limits when an installed component is removed for cleanness validation only

Item	Limits	
	Size-Microns	Max. number
Particles	300-500	25 per sq ft
	500-1000	5 per sq ft
	> 1000	0
Fibers	750-2000	50 per sq ft
	2000-6000	5 per sq ft
	> 6000	0
Total solids		5 milligrams per sq ft

3.2.1.2 Type II components. - Components which are to be used in liquid oxygen, liquid hydrogen, and liquid helium systems shall comply with the limits specified in Tables Three and Four when tested as specified in the tables.

Table Three (Type II components)

Cleanness ascertained by wipe test

A. Contamination limits immediately after cleaning and prior to installation

Item	Limits
Propellant tanks	No particles greater than 300 microns
	No fibers greater than 4000 microns in length.
	No hydrocarbons (4.3.1.2)
All other components	No particles greater than 175 microns
	No fibers greater than 2000 microns in length.
	No hydrocarbons (4.3.1.2)

B. Contamination limits when an installed component is removed for cleanness validation only

Item	Limits
All components including propellant tanks	No particles greater than 750 microns
	No fibers greater than 6000 microns in length.
	No hydrocarbons (4.3.1.2)

Table Four (Type II components)

Cleanness ascertained by flush or solvent rinse test

(All components including propellant tanks)

A. Contamination limits immediately after cleaning and prior to installation.

Item	Limits	
	Size-Microns	Max. number
Particles	300-500	10 per sq ft
	500-1000	2 per sq ft
	>1000	0
Fibers	750-2000	20 per sq ft
	2000-6000	2 per sq ft
	>6000	0
Total solids		2 milligrams per sq ft
Hydrocarbons - No fluorescence (4.3.1.5)		

B. Contamination limits when an installed component is removed for cleanness validation only

Item	Limits	
	Size-Microns	Max. number
Particles	300-500	25 per sq ft
	500-1000	5 per sq ft
	>1000	0
Fibers	750-2000	50 per sq ft
	2000-6000	5 per sq ft
	>6000	0
Total solids		5 milligrams per sq ft
Hydrocarbons - No fluorescence (4.3.1.5)		

3.2.1.3 Type III components (transducers). - Except as otherwise specified herein, cleaning and cleanness inspection tests shall be performed after the completion of transducer assembly and all acceptance and functional tests. Transducers shall be cleaned to comply with the limits specified in Table Five.

Table Five (Type III components)

Cleanness ascertained by rinse test

Transducers with a surface area of 1 square foot or greater in contact with an operating fluid

Item	Limits	
	Size-Microns	Max. number
Particles	300-500	4 per sq ft
Particles	over 500	0
Fibers	over 2000	0
Hydrocarbons - No fluorescence (4.3.1.5)		

Transducers with a surface area less than 1 square foot in contact with an operating fluid

Item	Limits	
	Size-Microns	Max. number
Particles	300-500	2 per sq ft
Particles	over 500	0
Fibers	over 2000	0
Hydrocarbons - No fluorescence (4.3.1.5)		

3.2.1.3.1 Performance after cleaning and inspection. - Transducer cleaning and inspection processes required to assure cleanness as specified herein shall not affect the performance requirements for a transducer. Performance of transducers after cleaning and inspection shall be as follows:

a. Pressure transducers with pressure ranges of 0 to 50 psia, psig, psid, or lower, when measured at one point within their range, shall have an output which is within ± 1 percent of full scale output as shown on the transducer's calibration record.

b. Resistive (probe type) temperature transducers shall show a reading which is within ± 5 percent of their nominal resistance when measured at 77°F.

c. Resistive liquid-level transducers (hot-wire type) shall exhibit electrical continuity, and turbine flow transducers shall exhibit electrical continuity of their sensing coils.

3.2.1.3.2 Hydrogen peroxide service. - Transducers which are to be used in hydrogen peroxide service shall be passivated, conditioned, activity tested, and identified in compliance with Specification 0-75050 immediately after cleaning.

3.2.1.4 Type IV components. - Components which are to be used in pneumatic systems shall comply with the limits specified in Tables Six and Seven when tested as specified in the tables.

Table Six (Type IV components)

Cleanness ascertained by wipe test

A. Contamination limits immediately after cleaning and prior to installation

No particles greater than 175 microns

No fibers greater than 2000 microns in length

No hydrocarbons (4.3.1.2)

B. Contamination limits when an installed component is removed for cleanness validation only

No particles greater than 400 microns

No fibers greater than 2000 microns in length

No hydrocarbons (4.3.1.2)

Table Seven (Type IV components)

. Cleanness ascertained by flush or solvent rinse test.

A. Contamination limits immediately after cleaning and prior to installation

Item	Size-Microns	Max. number
Particles	300-500	6 per sq ft
	>500	0
Fibers	>2000 length	0
Total solids		2 milligrams per sq ft

Hydrocarbons - No fluorescence (4.3.1.5)

B. Contamination limits when an installed component is removed for cleanness validation only

Item	Size-Microns	Max. number
Particles	300-500	15 per sq ft
	>500	0
Fibers	>2000 length	0
Total solids		2 milligrams per sq ft

Hydrocarbons - No fluorescence (4.3.1.5)

3.2.1.5 Type V components. - Components which are to be used in propellant utilization systems shall comply with the limits specified in Table Eight when tested as specified in the table.

Table Eight (Type V components)

Propellant utilization system components contamination limits

Cleanness ascertained by the wipe test

Nonmetallic	Size-Microns	Max. number
Particles	over 175	0
Fibers	over 2000	0
Metallic		
Particles	over 75	0
Fibers	None allowed	

Hydrocarbons - No fluorescence (4.3.1.2)

Cleanness ascertained by the rinse and ultraviolet light tests

Nonmetallic	Size-Microns	Max. number
Particles	300-500	4 per sq ft
Particles	over 500	0
Fibers	1000-2000	2 per sq ft
Fibers	over 2000	0
Metallic		
Particles	50-75	8 per sq ft
Particles	75-100	6 per sq ft
Particles	over 100	0
Fibers	None allowed	
Total solids (metallic and nonmetallic)		2 milligrams per sq ft

Hydrocarbons - No fluorescence (4.3.1.5)

3.2.1.6 Type VI components. - Interchangeable standard parts shall be cleaned to comply with the limits specified in Table Nine. Interchangeable standard parts which are to be used in hydrogen peroxide systems shall be passivated, conditioned, activity tested, and identified in compliance with Specification 0-75050 immediately after cleaning.

Table Nine (Type VI components)

Cleanness ascertained by flush or solvent rinse test

A. Contamination limits immediately after cleaning and prior to installation

Item	Limits	
	Size-Microns	Max. number
Particles	300-500	4 per sq ft
	> 500	0
Fibers	1000-2000	2 per sq ft
	> 2000	0
Total solids		2 milligrams per sq ft
Hydrocarbons - No fluorescence (4.3.1.5)		

B. Contamination limits when an installed part is removed for cleanness validation only

Item	Limits	
	Size-Microns	Max. number
Particles	300-500	15 per sq ft
	> 500	0
Fibers	> 2000	0
Total solids		2 milligrams per sq ft
Hydrocarbons - No fluorescence (4.3.1.5)		

3.2.1.7 Type VII (material). - Contamination barrier and seal material shall meet the requirements of Table Ten when tested as specified in the table.

Table Ten

Cleanness ascertained by the rinse test and ultraviolet light test

Non-Metallic	Size-Microns	Max. No./Ft.^{2} Sur. Area
Particles	300-500	4
	> 500	0
Fibers	1000-2000	2
	> 2000	0
Metallic		
Particles	50-75	8
	75-100	6
	> 100	0
Fibers	None allowed	

Total solids (metallic and non-metallic) 2.0 Milligram Per Sq Ft of Surface area.

Hydrocarbon - no fluorescence (4.3.1.5)

3.2.2 Control of cleanness.

3.2.2.1 Functional testing, Types I, II, IV, V, and VI. - Where engineering requirements exist for tests such as calibration, pressure, or leak testing, such tests may be made before or after cleaning, subject to the disapproval of Convair. A functional test shall not impair the operational cleanness status or functional capability of a material or component.

3.2.2.2 Functional testing, Types III and VII. - The requirements for Type III components (transducers) are specified in 3.2.1.3.1. Functional testing of Type VII material is not a requirement of this specification.

3.2.2.3 Inspection processes. - Inspection processes shall not impair the operational cleanness status or functional capability of a component or material.

3.2.2.4 Cleanness protection. - Cleanness preservation and the protection of cleaned component surfaces shall be accomplished in accordance with the requirements of Specification 0-75019. Cleaned and packaged components shall be delivered to Convair in such a manner that the level of cleanness specified herein is maintained.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. - Unless otherwise specified in the contract or order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may use his own facilities or any commercial laboratory acceptable to Convair. Convair reserves the right to perform any or all of the inspections set forth herein where such inspections are deemed necessary to assure that the requirements of this specification have been met.

4.2 Inspection records. - Inspection records of examinations and tests shall be kept complete and available to Convair. These records shall contain all data necessary to determine compliance with the requirements of this specification.

4.3 Classification of inspections. - The inspection testing of cleaned material and components shall be classified as "acceptance tests", and "performance reverification tests."

4.3.1 Acceptance tests. - For Type VII materials, acceptance tests shall be made on a sample of material being processed for use. For Types I through VI components, acceptance tests shall be made on the detail parts, or after assembly of a component, at the option of a supplier, but subject to disapproval by Convair. Acceptance tests shall consist of the visual, wipe, rinse, ultraviolet light, and referee tests which shall meet the following requirements.

4.3.1.1 Visual test. - Types I through VI components and Type VII materials shall be examined visually to determine conformance to the applicable requirements of 3.2.1. On normally accessible surfaces, visual inspection shall be performed with the unaided eye. Special devices shall be used to visually examine normally inaccessible areas.

4.3.1.2 Wipe test. - This test shall not be performed on Types III and VI components and Type VII barrier materials. For Types I, II, IV, and V components, the wipe test shall be performed only when the rinse test is impractical or impossible to accomplish. When used, this test shall be performed to detect the size and quantity of particles and fibers. This test shall consist of at least two wiping movements of a new, clean filter paper (Whatman No. 42, S and S No. 602, or equivalent) across the surface being tested. No more than one square foot of surface area shall be sampled with a single filter paper. As much of the total surface area shall be sampled as is practical to perform a thorough inspection. The filter papers shall be examined under a microscope for particulate contamination. The filter papers shall also be examined visually with an ultraviolet light to determine the presence of hydrocarbons for Types II, IV, and V components.

4.3.1.3 Rinse test, Types I through VI. - This test shall be performed to detect the size and quantity of particles and fibers. This test shall be performed with 200 milliliters of rinse fluid per square foot of component inner (or effective) surface area to be rinsed. Any component with less than one square foot of internal surface shall be considered to have one square foot. The rinse test shall be performed by either sloshing or agitating the fluid around the inside surface of the component to insure entrainment of particles. The effluent of a rinse test shall be examined for solids in accordance with SAE-ARP 598, with counting done only in the ranges specified in applicable table of this specification.

4.3.1.4 Rinse test, Type VII. - This test shall be performed to detect the size and quantity of particles and fibers. This test shall be performed with 200 milliliters of rinse solution per square foot of surface area to be rinsed. Contamination barrier bags with less than one square foot of internal (critical) surface area shall be considered as one square foot. A minimum of ten contamination seals (plastic caps) shall be considered as one square foot of surface area. The rinse test shall be performed by either sloshing or agitating the fluid around the inside surface of the contamination barrier bag or by placing the contamination seals or sheet stock in a precleaned and acceptance-tested barrier bag and sloshing or agitating the fluid. The effluent of the rinse test shall be examined for particulates in accordance with SAE ARP 598, with counting done only in the ranges specified in Table Ten.

4.3.1.5 Ultraviolet light test, Types II through VII. - Except for Type I components, this test shall be used on all accessible surfaces to determine the presence of petroleum-type hydrocarbons. This test shall consist of a visual inspection with the aid of an ultraviolet light source. The equipment shall consist of a 100 watt, mercury arc spot bulb, 3200 to 3800 angstrom units, with a minimum intensity of 500 microwatts per square centimeter at 24 inches. A standard ultraviolet light filter shall be mounted in its usual position over the spot bulb.

4.3.1.6 Referee test, Types II through VII. - This test shall be performed where the level of hydrocarbon contamination is questioned after completion of the wipe test or the ultraviolet light test. When used, this test shall be performed with 200 milliliters of solvent rinse fluid per square foot of surface area under test. Any component with less than one square foot of surface area under test shall be considered to have one square foot. The effluent solvent shall be analyzed with an infrared spectrophotometer. An acceptable equivalent test shall consist of analyzing the evaporated residue of the rinse effluent using the gravimetric method. This test shall not be performed on Type I components. Test results shall be compared to the requirements specified in 3.2.1.

4.3.2 Performance reverification tests, Type III. - Type III components only (transducers) shall be subjected to these tests. After the completion of all cleaning and inspection processes and prior to packaging, the performance of transducers shall be reverified. Pressure transducers with pressure ranges of 0-50 psia, psig, psid, or lower shall have their output checked at one point within their range. The zero psid output shall

be an acceptable check point for reluctive, d-c output, differential pressure transducers. Performance reverification is not required for transducers other than those described herein.

4.3.2.1 Readout equipment for Type III components. - A voltage-ratio meter or resistance-ratio meter with built-in excitation supply, or with external battery (6 volts, with 1.5 K series resistor) shall be used for transducer excitation to read the output of potentiometric pressure transducers. A digital voltmeter shall be used to read the output of reluctive or capacitive, d-c output transducers and straingage type transducers which are excited from a regulated d-c power supply adjustable from 0 to 30 volts d-c.

4.3.2.2 Absolute pressure test, Type III components. - Transducers with 0 to 20 psia or higher range may be tested on the bench.

4.3.2.3 Gage pressure test, Type III components. - Gage pressure transducers shall be tested while in the vacuum oven. A section of cleaned stainless steel tubing shall be attached to the transducer port. The stainless steel tubing shall protrude from the oven after the transducer has been dried. The pressure in the clean room and in the vacuum oven shall be monitored. The pressure difference is the gage pressure applied to the transducer.

4.3.2.4 Differential pressure test, Type III components. - Reluctive and capacitive d-c output transducers and strain-gage type transducers may be tested on the bench with both ports open. Potentiometric transducers shall be tested while in the vacuum oven (after the transducer has been dried) with a portion of cleaned stainless steel tubing connected to the transducer's "high" port. The tubing shall protrude from the oven. The difference between the "high" port pressure and "low" port pressure should be about 50 percent of the transducer's range.

4.3.2.5 Other tests, Type III components. - Temperature transducers, flow transducers, and resistive liquid-level transducers shall have the resistance of the transducer element measured with a resistance bridge, Wheatstone bridge, or a high-impedance digital ohmeter (Hycon or equivalent) while the transducer is on the bench.

4.4 Sampling plans. - Where cleanness inspection sampling is performed by the supplier, the cleanness inspection sampling plans shall be determined by the supplier, and shall be established in accordance with military approved standards. These sampling plans shall be subject to disapproval by Convair.

4.5 Inspection rejections. - Components and materials (Types I through VII) which are inspection rejected as the result of nonconformance to the requirements specified herein shall be recleaned before being re-inspected.

4.6 Evidence of inspection acceptance.

4.6.1 Type I, II, IV, V, and VI components. - Each component or component package shall have attached evidence of inspection acceptance if the requirements of this specification are met. Evidence shall consist of an inspection tag or stamp incorporating the date of acceptance and the identity of the responsible inspector. The inspection acceptance tag or stamp shall become invalid if the package or seal is broached or damaged prior to installation of the component.

4.6.2 Type III components. - Each transducer or transducer package shall have attached evidence of inspection acceptance if the requirements of this specification are met. Transducers which are used in hydrogen peroxide systems shall have attached evidence of inspection acceptance if the Activity Test (passivity) requirements of Specification 0-75050 are met in addition to meeting the cleanness requirements of this specification. Evidence shall consist of an inspection tag or stamp incorporating the date of acceptance and the identity of the responsible inspector. The inspection acceptance tag or stamp shall be invalid if the package or seal is broached or damaged prior to installation of the transducer. The calibration record of each transducer shall be annotated to indicate post-cleaning performance acceptance and shall be signed, dated, and inspection-stamped.

5. PREPARATION FOR DELIVERY

Not applicable

6. NOTES

6.1 Intended use. - This specification is intended to be applied to the components listed in 1.1 for which precise control of cleanness is required. The transducers covered (1.1.e) are temperature (resistive, probe type), liquid level, flow, and instrument and control transducers. Type VII material (1.1.i) includes films, plastic caps, and metal closures used for packaging or sealing of precision cleaned components.

6.2 Definitions.

a. Component: A component is an integral unit portion of an assembly or system. Examples are tubes, ducts, tanks, valves, actuators, reservoirs, housings, and accumulators.

b. Standard part: For the purposes of this specification, a standard part is an integral unit portion of an assembly or system. Examples are "O" rings, gaskets, seals, unions, tees, elbows, and crosses which are manufactured to the applicable AN, MS, or NAS Design Standards.

c. Interchangeable: When two or more parts possess such functional and physical characteristics as to be equivalent in performance and durability and capable of being exchanged one for the other without alteration of the parts themselves or of adjoining components except for adjustments, and without selection for fit or performance, the parts are interchangeable.

d. Fiber: A fiber is defined as any material having a diameter of 40 microns or less and a length to diameter ratio of 10 to 1 or greater.

e. Particle: A particle is defined as any solid material which cannot be classified as a fiber. The size of a particle shall be determined by its largest dimension.

f. Micron: One micron is defined as one one-millionth of an international meter, or 0.00003937 inch.

g. Contamination barrier material: Heat-sealable, transparent, flexible barrier material applied for the retention of precision cleanness.

h. Contamination seals: Caps, flange closure plates, and other devices which prevent contamination of precision cleaned surfaces.

i. Precision cleaned: Cleaning which complies with the contamination limits specified herein.

j. Instrumentation transducers: Transducers used for airborne and ground support equipment test purposes in RP-1 fuel, liquid oxygen, liquid hydrogen, hydraulic, and pneumatic systems.

k. Control transducers: Transducers used as a part of a closed loop control system for airborne and ground support systems. A human integrated into the control system as a functioning unit may be considered to be the closing element in the loop.

l. Rinse test: For the purpose of this specification, the term "rinse test", is used to mean any test where the rinse effluent is examined by the Millipore method or equivalent.

6.3 Miscellaneous notes.

6.3.1 Notes to be incorporated on drawings. - This specification shall be referenced on drawings by the following:

"Clean to comply with the requirements of Specification 0-75192 (and applicable dash number from 6.3.3)"

6.3.2 Order of precedence of this specification. - This specification supersedes all others of the same scope. This specification conforms to the requirements of AFBS 61-3C but only expands upon and does not lessen any requirements therein.

6.3.3 Cleanness criteria identification number. - The identification number for cleanness criteria shall consist of this specification number, 0-75192, and the applicable dash number as shown below:

TYPE	CATEGORY	DASH NUMBER
I	RP-1 Fuel System Components	-1
II	Liquid Oxygen, Liquid Hydrogen, and Liquid Helium Components	-2
III	Fluid System Transducers	-3
IV	Pneumatic System Components	-4
V	Propellant Utilization System Components	-5
VI	Interchangeable Standard Parts	-6
VII	Contamination Barrier and Seal Material	-7

END OF REFERENCE
19

REFERENCE
20

ANON.: CLEANING AND TESTING OF OXYGEN AND NITROGEN GAS PIPING SYSTEMS. MIL-STD-1330 (SHIPS), MAY 10, 1968.

MIL-STD-1330 (SHIPS)
10 May 1968

MILITARY STANDARD

CLEANING AND TESTING OF OXYGEN AND NITROGEN GAS PIPING SYSTEMS



FSC 4730

DEPARTMENT OF THE NAVY

NAVAL SHIP ENGINEERING CENTER

WASHINGTON, D.C. 20360

Cleaning and Testing of Oxygen and Nitrogen
Gas Piping Systems

MIL-STD-1330(SHIPS)

1. This Military Standard shall be mandatory effective on the date of issue to Naval shipyards or repair facilities and private firms performing services as prime or subcontractors for the Naval Ship Engineering Center.

2. Recommended corrections, additions or deletions including improvements in the procedures described herein and changes in this standard which can result in less costly methods without sacrificing the level of quality desired should be addressed to Commander, Naval Ship Engineering Center, Department of the Navy, Washington, D. C. 20360.

FORWARD

Explosions are known or suspected to have occurred in high pressure oxygen and nitrogen systems which were not properly maintained. To insure safe operation of these systems, the accumulation of hydrocarbons in the system must be eliminated.

This standard will provide a procedure for cleaning and testing both oxygen and nitrogen systems in place. Any part of this standard which does not apply to a particular system or ship should be deleted accordingly.

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1. SCOPE

1.1 This standard covers the requirements governing the procedure for cleaning and testing oxygen and nitrogen system piping. This procedure is intended for use by Navy approved private contractors and by Naval shipyards.

1.2 Application.

(a) Oxygen - That part of the ship's piping and component arrangement required for loading, storage, generating (excepting the oxygen generator itself) and distribution of high purity oxygen.
(b) Nitrogen - That part of the ship's piping and component arrangement required for loading, storage and distribution of oil-free nitrogen used to purge the oxygen generators.

2. REFERENCED DOCUMENTS

2.1 The issues of the following documents in effect on the date of invitation for bids form a part of this standard to the extend specified herein.

GOVERNMENTAL

SPECIFICATIONS

BB-N-411	- Nitrogen, Technical.
QQ-N-281	- Nickel-Copper-Alloy Bar, Plate, Rod, Sheet, Strip, Wire, Forgings, and Structural and Special Shaped Sections.
MIL-E-15090	- Enamel, Equipment, Light-Gray (Formula No. 11).
MIL-P-15328	- Primer, Pretreatment (Formula No. 117, For Metals).
MIL-P-15930	- Primer Coating, Shipboard, Vinyl-Zinc Chromate (Formula No. 120, For Hot Spray).
MIL-F-22606	- Flask, Compressed Gas and End Plugs For Air, Oxygen and Nitrogen.
MIL-C-81302	- Cleaning Compound, Solvent, Trichlorotrifluoroethane.

STANDARD

MIL-STD-271	- Nondestructive Testing Requirements for Metals.

DRAWINGS

86004-501-4304426	- Inplace Removal of Oxygen Plugs.
86004-501-4304427	- Inplace Cleaning and Testing of Oxygen Systems.
86004-501-4304428	- Ultrasonic Test of Oxygen Piping.
86004-501-4304429	- Inplace Gage Calibration.
86004-501-4304430	- Ultrasonic Test of Hydrogen Overboard Discharge Piping.
86004-501-4305034	- Oxygen System Drop Test.
80090-501-4306010	- Pressure Correction Chart.

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

NONGOVERNMENTAL

OTHER PUBLICATIONS

COMPRESSED GAS ASSOCIATION (CGA)
Pamphlet C-1 - Methods for Hydrostatic Testing of Compressed Gas Cylinders.

(Application for copies should be addressed to the Compressed Gas Association,Inc., 500 Fifth Avenue, New York, New York 10036).

(Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

3. DEFINITIONS

3.1 General terminology.

3.1.1 Clean. Being free of all loose scale, rust, grit, filings and other foreign substances; and free of oil, grease and other organic materials.

3.1.2 Components. As used in this standard shall be valves, gages, regulators and flasks for the system.

3.1.3 Cleaning solvent or compound. As used in this standard shall refer to trichlorotrifluoroethane complying with MIL-C-81302 type I - ultra-clean. Used solvent may be reused if it has been redistilled to meet the requirements of MIL-C-81302.

3.1.4 Laboratory. Refers to a certified chemical laboratory capable of making all analyses required in this standard.

4. REQUIREMENTS

4.1 General requirements.

4.1.1 This standard will be applicable to all nuclear and nonnuclear surface ships and submarines which have oxygen or nitrogen piping systems.

4.1.2 This standard is not applicable to gas generating plants as they will be cleaned and tested according to the procedures set forth by the manufacturer.

4.1.3 Trichlorotrifluoroethane, complying with MIL-C-81302, type I, will be used as the cleaning and testing medium for oxygen and nitrogen gas piping systems. This cleaning compound has a strong attraction for hydrocarbons and samples of this compound can be inspected for total contamination to furnish positive indication that the hydrocarbon residue is within allowable limits. The allowable contamination limit in the cleaning compound after the final flush is five parts per million (ppm) or less (by weight).

4.1.3.1 This cleaning compound must not be used in rubber, plastic, nylon, or other flexible hose or tubing with which it is not compatible. Incompatibility may result in changes in polymer structure and molecular weight, dissolution of plasticizers and an increase in temperature, brittleness, swelling, etc.

4.1.3.2 This cleaning compound is primarily to be used in all metal systems, but may be used in approved compatible flexible hose for transferring the compound and testing. Approved teflon flexible hose may be used for transferring the compound.

4.1.4 Oxygen or nitrogen system components which are received from a manufacturer with a certification that they have been cleaned for oxygen service need not be recleaned provided that the means for protecting the components are intact.

4.1.5 Temporary piping and components, as required for system flushing and testing, shall be cleaned as specified for system piping prior to each use and tested to 1-1/2 times the system pressure.

4.1.6 All interconnected piping and components in the oxygen and nitrogen piping systems shall be cleaned and maintained clean. All piping to and from the oxygen generator with the exception of the cooling services shall be cleaned as herein specified for oxygen and nitrogen systems.

4.1.7 A certified laboratory will sample all gaseous nitrogen prior to use in the oxygen and nitrogen piping systems and will analyze it for liquid nitrogen pump lubricant (e.g. cosmodyne), and any other hydrocarbons which may be present. Only dry oil-free nitrogen in accordance with BB-N-411, type I, class 1, grade A or B approved by the laboratory will be used.

4.1.7.1 If shipboard conditions are such that a particular system cannot be flushed or tested as a single unit, this system may be divided into sections and flushed or tested accordingly. Also, portions of these systems may be flushed or tested as required by production to facilitate interference problems, shipboard schedule event completion, etc.

4.1.7.2 Proper valve line-up will be provided by the shop conducting the flushing, testing and seat leakage requirements of this standard. Caution should be used to insure portions of the system which have been certified clean by the laboratory will not be flushed with contaminated solvent.

4.1.7.3 Upon completion of partial test or flush, the system line-up sheet shall be signed by the Pipe Shop and the Quality and Reliability Assurance Department Inspector.

4.1.8 All personnel involved with flushing and testing shall become familiar with applicable safety precautions and regulations.

4.2 Safety and precautions.

4.2.1 High pressure gas systems constitute a hazard in themselves in addition to the hazards involved when hydrocarbons are present. The failure of a container charged with high pressure gas may result in an explosion with associated fragmentation of the container.

4.2.1.1 Therefore, high pressure gases must have particular attention to provide a safe system. As a gas is compressed, energy is added and it heats due to several factors; i.e., compression itself and frictional forces associated with container boundaries. If a hydrocarbon lubricant is present, a condition is approached not dissimilar to that found in diesel engines.

4.2.1.2 The only sure way to eliminate the possibility of ignition; i.e., fire and explosions, is to eliminate the fuels in high pressure gas systems.

4.2.2 The noise associated with "bleed off" or pressure relief of high pressure gas reservoirs through a small orifice can reach sound pressure levels of sufficient intensity to cause acute damage to the ear with resultant loss of hearing. Since acoustical control of this noise is impractical aboard ship or at dockside, protection of personnel is dependent upon the use of ear protective devices.

4.2.3 Trichlorotrifluoroethane is a nonflammable solvent. The American Conference of Governmental Industrial Hygienists states that the threshold limit value (a concentration of solvent vapor in air to which nearly all workers may be repeatedly exposed, day after day, without adverse (effect) for this solvent is 1,000 ppm. Normal air movement is usually sufficient to keep vapors below this threshold limit.

4.2.3.1 Although this solvent is exceptionally safe, it should still be used with adequate ventilation and prolonged breathing of vapors should be avoided. The solvent should not be used near open flames or heat; the products or decomposition are toxic and very irritating.

4.2.3.2 Since this solvent dissolves natural oils and is absorbed through the skin, contact with the skin should be avoided. Neoprene gloves, may be worn. If the solvent is taken internally, consult a physician immediately.

4.2.3.3 Under no circumstances should the concentration of vapor in air exceed 25 percent by volume even for a brief period of time. At this point, the concentration of oxygen is reduced to a hazardous level. If adequate ventilation cannot be supplied, portable blowers should be used and the atmosphere monitored to insure safe limits are not exceeded.

4.2.3.4 The chemicals prescribed herein, except those used in connection with ultrasonic cleaning, shall not be stored onboard submarines nor used in a closed submarine hull.

4.3 Material/equipment.

4.3.1 Flushing and testing equipment. The flushing and testing equipment shall consist of the following:

(a) Vacuum pumps - Lieman Model 295-B-2 or equivalent. Pump shall be capable of pulling a 20-inch vacuum.

NOTE: Vacuum pump design shall preclude pump lubricant from being drawn into system being cleaned in the event of a pump failure or stoppage, and must be compatible with the cleaning compound vapor.

(b) High pressure pumps - McFarland Engine and Pump Company Model P-38 (nonoil lubricated pistons) or equivalent.
(c) Transfer pumps - Krogh Model 1000 (nonoil lubricated pistons) or equivalent.
(d) Gages - Heise 5000 or 1000 pounds per square inch gage (psig) (graduated in 2 pounds per square inch (psi) increments) or equivalent.
(e) Hoses - Conforming to Naval Ship Engineering Center (NAVSEC) requirements (see also 4.1.3.2).

4.3.2 Materials. Materials shall be as follows:

(a) Sampling containers (glass - 1 gallon).
(b) General Electric Model H-10 leak detector, or equivalent.
(c) Supply of dry, certified oil-free nitrogen in accordance with BB-N-411, type I, class 1, grade A or B.
(d) Supply of cleaning compound (MIL-C-81302, type I).
(e) Black light lamp, Magna Flux Model ZB26 (3600 Anstrom) or equivalent.
(f) Lubricants - Flurolube GR-544 or LG-160, Molykote Type "Z" Powder or other lubricants which are approved by NAVSEC (Piping System Branch).

4.4 Cleaning and certifying system components.

4.4.1 Components which are to be repaired, cleaned and certified for oxygen service will be sent to the appropriate shop (does not include flasks. For inplace oxide removal from flask interior, obtain procedure from NAVSEC) (Auxilliary Equipment Branch).

4.4.1.1 Each component will be tagged with proper identifications.

4.4.1.2 Disassemble, inspect and repair as required each component to place it in proper working order. Reassemble each component and check for proper operation.

4.4.1.3 The chemical laboratory will clean all parts of the component as required using an approved cleaning compound.

4.4.1.4 If lubrication of parts is required, the lubricant used must be as approved by NAVSEC (Piping Systems Branch). Several lubricants which may be used as given in the material list (see 4.3.2 (f)).

4.4.1.5 The component will be reassembled under oxygen clean conditions and tested according to the applicable test document.

4.4.1.6 After completion of assembly and successful testing, the component will be sent back to the laboratory for final cleaning and certification. Place the component in an oxygen clean polyethylene bag with proper identification and seal the bag.

4.4.1.7 Oxygen clean conditions will be maintained during installation of the component onboard ship to prevent any contamination from entering the component or system piping.

4.4.2 Pressure gages will be cleaned and tested according to procedures in 4.5.

4.5 Cleaning and testing Bourdon "C" tube pressure gages.

4.5.1 The cleaning procedure, if required, for bleeder type Bourdon "C" tube indicators shall be as specified in 4.5.1.1 through 4.5.1.14.

4.5.1.1 Disconnect indicators from cylinders or high pressure piping if they are known to be defective or if they have failed a gage calibration test.

4.5.1.2 Remove the back of the indicator, carefully elongate the coil of capillary tubing to extend the free tip of the tube outside the indicator.

4.5.1 3 Open the capillary by filing off the tip or by notching and bending no more than 1/8 inch of the distal portion. Clear the opening with a small drill or probe.

4.5.1.4 Immobilize indicator in a horizontal position supported by a ring stand and clamp so that the exit port of the capillary bleeder drains freely into an Erlenmeyer receiving flask.

4.5.1.5 Adapt a length of teflon tubing properly fitted to the threaded entrance port of the indicator and connected to a 1/4 inch glass tube extending below the level of the cleaning solvent contained in a 250 milliliter (ml) suction flask.

4.5.1.6 Connect an air pressure line to the side arm of the suction flask. The incoming air should be passed through a scrubber containing cleaning solvent to remove any trace of hydrocarbons which may be admixed with the air supply system.

4.5.1.7 Place 150 ml of cleaning solvent in a suction flask.

4.5.1.8 Adjust incoming air pressure (5 psig) to permit a flow rate of approximately 50 ml per minute to force the cleaning solvent through the indicator connection and out of the bleeder exit port in the collecting container.

4.5.1.9 Repeat with two additional 125 ml portions of cleaning solvent.

4.5.1.10 Introduce 50 ml of cleaning solvent through connection end of indicator and collect effluent in a clean white porcelain dish. Evaporate to dryness and check for fluorescence with a long wave ultraviolet light (3600 - 3900 angstrom units). If no fluorescence is discernable, indicator is free of hydrocarbons. Continue flushing if fluorescence is evident.

4.5.1.11 When indicator is free of hydrocarbons, disassemble cleaning apparatus and force dry oil-free nitrogen (certified by the laboratory) through the indicator and out the bleeder port to remove the last traces of solvent.

4.5.1.12 Reseal tip of capillary bleeder by welding. Carefully recompress the capillary coil to clear indicator cover and mechanism.

4.5.1.13 The pressure gage should be tested with dry oil-free nitrogen to insure proper working order prior to installation.

4.5.1.14 Replace cleaned indicator into high pressure system maintaining oxygen clean conditions at all times.

4.5.2 The procedure specified in 4.5.1 or an approved procedure (by the chemical laboratory) shall be used to clean and test Bourdon "C" tube pressure gages.

4.6 Flushing silver brazed piping.

4.6.1 To remove residual flux remaining in the system piping after fabrication, it is necessary to apply a flush. Any one of the procedures specified in 4.6.1.1 through 4.6.1.3 may be used to flush out the flux (the hot water flush and the hot water circulation methods are preferred).

4.6.1.1 Hot flush for one hour using supply water at temperature sufficiently high to insure that the temperature at any part of the system does not go below 110°F.

4.6.1.2 As an alternate to the hot flush procedure, a hot recirculating procedure may be conducted for a period of one hour. Water temperature should not fall below 110°F. at any part of the system. Following the recirculation, the system should be cold flushed for 15 minutes.

4.6.1.3 Cold soak the system for 12 hours using water at a minimum of 60°F. At the completion of the 12 hour soak, flush with water at a minimum of 60°F. for four hours.

4.6.2 For all flushing procedures specified in 4.6.1.1 through 4.6.1.3, the minimum flow requirements shall be one foot/second.

4.6.2.1 For all flushing procedures specified in 4.6.1.1 through 4.6.1.3, the system should be full of water so that joints are completely submerged at all times.

4.6.2.2 Following the hot or cold water flushes, the flushing water may be used for any system testing which may be required.

4.6.3 Removing of flux from silver brazed piping will be according to procedure specified in 4.6.1 or an equivalent NAVSEC (Piping Systems Branch) approved procedure.

5. FLUSHING

5.1 System preparation.

5.1.1 Prior to shipboard flushing, all repairs to the piping system shall have been completed.

5.1.2 Attach a temporary valve and adapter as required on each piping end terminating at the following locations:

(a) Connections to each pressure reducing manifold.
(b) Connections to each oxygen generator.
(c) Connections to each oxygen and nitrogen flask.

5.1.2.1 Attach a temporary valve and adapter as required to the test connection or gage connection, as applicable.

5.1.2.2 If the system will be flushed in sections, install temporary valves, adapters, and blanks, as required, in addition to those already specified to permit pressurization and where practicable, unobstructed flushing.

5.1.2.3 When possible, jumpers may be used to connect two open end pieces of pipe in order to provide more circulation. Flasks' piping connections may also be connected by jumpers.

5.1.3 Disconnect pressure regulators from system at inlet union joint and cover with oxygen clean polyethylene. If regulators are seal welded, disassemble high pressure chamber and remove the nozzle. Place removed parts in a clean plastic bag.

5.1.4 Containers, certified by the chemical laboratory for oxygen service, will be used to retain samples of the cleaning compound as it is pumped through the system from test connection, regulators, bleed-off lines, oxygen generator union connections or other appropriate sample locations.

5.1.5 Disconnect piping from any components which may be deteriorated by the cleaning solvent and install jumpers as required. Oil removal filter elements should be disconnected or removed and jumpers installed as required.

5.1.6 All new silver brazed piping will be flushed according to procedures specified in 4.6.

5.1.7 Remove internals from check valves to provide unrestricted flow, if required.

5.2 Oxygen system flush.

5.2.1 If any flasks in the oxygen system do not have Monel plugs (class A, form 2 of QQ-N-281) obtain authorization to remove the existing plugs and replace with ones made of Monel. Drawing 86004-501-4304426 or an equivalent procedure should be used for removing and reinstalling plugs in place.

5.2.1.1 If in place removal or oxygen flask plugs is not feasible, consult NAVSHIPS for authorization to remove the flasks from the ship.

5.2.2 All oxygen generator discharge piping (including the hydrogen overboard discharge piping) shall be ultrasonically tested. MIL-STD-271 or an approved ultrasonic test procedure; i.e., Drawings 86004-501-4304428 and 86004-501-4304430, should be used.

5.2.2.1 If the pipe wall thickness is less than the minimum allowed, this section of pipe shall be renewed according to the applicable ship's drawing. Table I contains the minimum allowable pipe wall thicknesses for several pipe sizes and materials.

Table I - Typical minimum wall thickness.

Pipe material	Nominal size (inches)	Nominal wall thickness (inches)	O.D. (inches)	Minimum allowable wall thickness
Monel 1/	1/2	0.147	0.840	0.082
1/ Cres type 304	1/4 1/2	.140 .147	.540 .840	.050 .077
1/ Cres type 316L	1/4 1/2 1	.140 .147 .179	.540 .840 1.315	.050 .077 .121

1/ Applicable ship's drawings should be checked for pipe material, size, service, location, etc., prior to testing. Drawings 86004-501-4304428 or 86004-501-4304430 should be consulsted for other pipe material and sizes other than those specified in table I.

5.2.3 Remove the valve bonnet and internal assembly from all stop and check valves in the oxygen system. (This is accomplished to prevent damage to the soft seats during flushing). Place the internals in a clean plastic bag and replace the oil diaphragms with new ones. Install blanking caps on body of valves for flushing.

5.2.3.1 The oxygen hull stop valves shall not be disassembled until the inboard piping has been cleaned and certified by the laboratory.

5.2.3.2 Close all oxygen hull stop valves (if applicable) and plug or gag the oxygen system relief valve(s).

5.2.4 Connect the flushing equipment to the system at the charging connection.

5.2.4.1 Flush the system (inboard piping only) with the cleaning solvent for a minimum of 30 minutes and then sample the flush from test connections regulators, bleed-off lines, oxygen generator union connections and any other appropriate sampling locations.

5.2.4.2 The samples will be analyzed by the laboratory for total contamination; at 5 ppm or less the system is considered clean. If more than 5 ppm total contamination is found, repeat the flush until acceptable contamination level is reached.

5.2.5 When the inboard piping is certified clean, make-up union nut on regulators and seal weld, if applicable. Disassemble high pressure chamber and remove the nozzle and plug port.

5.2.5.1 If the regulator is seal welded and nozzle removed, plug the port.

5.2.6 Remove the internals from oxygen system hull stop valves, renew diaphragms and reinstall internals according to applicable drawings.

5.2.6.1 Remove the blanking caps from all other valves and reinstall valve internals.

5.2.7 All dead end system piping shall be flushed according to the procedures specified in 5.4.

5.3 Nitrogen system flush.

5.3.1 If the system can be flushed by circulation, connect the flushing equipment and cleaning solvent supply at the charging connection or a convenient low point in the system.

5.3.1.1 Circulate the cleaning solvent for 30 minutes. Collect the solvent from the drains in receiving tanks or pipe the solvent back into the piping system, if possible.

5.3.1.2 For sections of the system which cannot be cleaned by flushing, procedures for flushing dead end system piping as specified in 5.4 should be used.

5.3.1.3 Collect a sample of the removed solvent from all exhausts. The laboratory will analyze the cleaning solvent for total contamination. To consider the system clean, total contamination of the cleaning solvent should be 5 ppm or less. If a second flushing or soaking is required, the procedures specified above should be repeated.

5.3.1.4 When a section of piping is certified clean by the laboratory, the solvent will be completely removed by draining and by either blowing the system piping with dry, certified oil-free nitrogen or air or by using a vacuum pump.

5.3.1.5 Using a halide leak detector, check the exhaust for traces of the cleaning solvent. Continue evacuating or purging until no trace of the solvent is detectable.

5.3.1.6 Clean all piping by the same procedures used above and keep all clean piping isolated and free of contamination while flushing associated piping.

5.3.1.7 After the nitrogen system piping has been cleaned and certified, any further work on the system shall be accomplished under oxygen clean conditions. If the system will not be tested immediately after cleaning, pressurize the system to 10-15 psig with dry certified oil-free nitrogen and maintain this pressure until testing can be accomplished.

5.4 Dead end system flush.

5.4.1 Evacuate the system to at least 25 inches of mercury vaccum and break the vacuum with the cleaning solvent. A moderate pressure may be applied, if necessary, to insure complete filling of system.

5.4.1.1 After a minimum of one hour drain the system by using a vacuum pump or by blowing out with dry, certified oil-free nitrogen. The cleaning solvent shall be sampled and analyzed by the laboratory for total contamination content. If the acceptable level has not been reached, repeat the above flushing procedure.

5.4.1.2 If the dead end system piping requires testing, proceed with the testing procedures. If no testing is required at this time, evacuate the system to 0.2 inch mercury absolute and check the exhaust gas with a leak detector.

6. TESTING

6.1 Oxygen systems.

6.1.1 The following paragraphs will provide a sufficient test (eight hour hydrostatic) that the seven day drop test will not be required. However, if this eight hour hydrostatic test cannot be performed, then see 6.2 for an alternate test procedure. This eight hour hydrostatic is the preferred test and should always be used when possible and practicable. Other methods for hydrostatic and leakage tests will be considered upon submission for approval to NAVSEC (Piping Systems Branch).

6.1.2 Measure all oxygen flasks with micrometers. Take two readings 90 degrees apart at the top, middle and bottom of the longitudinal section of the flasks. The area where readings are to be taken will be cleaned and marked to insure all readings are taken from the same location. If testing is not feasible in place, consult NAVSHIPS for authorization to remove the flasks for cleaning and testing.

6.1.3 Close all oxygen system bleed-off valves. Evacuate the system to 29 inches mercury vacuum with a vacuum pump. Break the vacuum with the cleaning solvent and gradually pressurize the entire system to 1500 psig in 500 psig increments. Check the system at each 500 psig increment for leaks.

6.1.3.1 Hold this test pressure for eight hours. During this time inspect the entire system, each joint and valve bonnet, with the halide leak detector at least three times by three independent inspectors.

6.1.3.2 Measure all flasks as specified in 6.1.2 after about seven hours of testing.

6.1.3.3 If leaks are found, continue the test until the entire system has been investigated (unless a rupture occurs) and then drain the cleaning compound from the system. Purge the system with dry, certified oil-free nitrogen until no cleaning solvent is present. Repair leaks and repeat test for affected portion of the system.

6.1.3.4 If no leaks are found, relieve pressure and collect a sample of cleaning solvent for chemical analysis from each drain line. The chemical analysis must show a total contamination content of 5 ppm or less to consider the system clean. If the analysis reveals the system is not clean, reflush according to procedures specified above.

6.1.3.5 When the pressure is relieved, measure each flask as specified in 6.1.2.

6.1.3.6 Using the following equation, calculate the maximum allowable flask diameter permissible after the hydrostatic test and compare it with the measured diameter.

$$D_2 = (.06D_1^2 + .94D^2)^{.5}$$

Where: D = Original diameter (before hydrostatic).
D_1 = Expanded diameter (during hydrostatic).
D_2 = New diameter (after hydrostatic).

Example: D = 18.000 inches.
D_1 = 18.153 inches.
D_2 = 18.003 inches.

$$D_2 \leqq (.06D_1^2 + .94D^2)^{.5}$$

$$D_2 \leqq (.06(18.153)^2 + .94(18.000)^2)^{.5}$$

$$D_2 \leqq 18.009$$

$$18.003 \leqq 18.009 \text{ flask passes hydrostatic}$$

6.1.4 If there are no leaks and the total contamination content is 5 ppm or less, drain all the cleaning solvent from the system. Purge with dry certified oil-free nitrogen until there is no trace of cleaning solvent. Check exhaust with halide leak detector.

6.1.4.1 The laboratory will certify cleaning solvent free conditions exist. Also, the laboratory will check the exhaust gas with the black light for hydrocarbons.

6.1.4.2 Under oxygen clean conditions, remove the flask portable drain and install drain plug in the flask plug. Seal weld using certified seal welding procedure.

6.1.4.2.1 Maintain a small nitrogen purge on each flask (5-10 psig) during installation of drain plug.

6.1.4.3 Remove the plug from the high pressure chamber and reinstall nozzle in pressure regulator. Reassemble high pressure chamber.

6.1.5 With the system prepared as specified in 6.1.3, evacuate the system to 29 inches of mercury vacuum and break the vacuum with the cleaning solvent. Pressurize the system to 4500 psig and hold this pressure for two hours (minimum) or long enough to inspect each seal weld three times with the halide leak detector by three independent inspectors.

6.1.5.1 If this two hour hydrostatic cannot be accomplished as stated, the system should be pressurized to 3500 psig with dry oil-free nitrogen and the seal welds soaped to check for leaks. The new welds should be checked using 5X magnification.

6.1.6 Remove the cleaning solvent from the system. Take three random samples of the cleaning solvent during draining of the system and compare the contamination content average with the flush in 6.1.3.4. The laboratory will certify the system is clean for oxygen service.

6.1.6.1 Evacuate the system to 29 inches mercury vacuum until all cleaning solvent is removed. Check the vacuum exhaust with the halide leak detector.

6.1.6.2 If leaks are found in the flask drain plug seal welds, repair leaks and test affected portion of systems.

6.1.6.3 After the system is certified clean for oxygen service, charge the system with certified oil-free nitrogen to 100 psig or to 3000 psig if the valve seat leakage test will be conducted. Calibration of gages may be conducted at this time in accordance with Drawing 86004-501-4304429 or an equivalent procedures.

6.1.7 Each oxygen system is to be subjected to a five minute seat tightness test at 3000 psig with "Zero" allowable leakage. The test will be conducted in an orderly fashion and all valves will be tested.

6.1.7.1 After completion of the seat tightness test, bleed the system down to 100-125 psig. The laboratory will inspect the discharging gas with the black light for hydrocarbons during bleed-off. Also, the laboratory will sample the discharging gas at 100 psi and will analyze for the cleaning solvent using gas chromatographic or other approved procedures. The allowable limit is 10 ppm. If a particular activity does not have a standard procedure for analyzing gas samples using the gas chromatograph, the Director, Naval Research Laboratory, Washington, D. C. 20390 should be contacted for a procedure. If more than 10 ppm of cleaning solvent is found, the system should be purged with nitrogen until the system is within allowable limit.

6.1.8 Maintain 100-125 psig nitrogen pressure and charge the system with this nitrogen present. If the pressure should drop below 100 psig prior to charging, the ship's Superintendent shall be notified immediately. The ship's Superintendent shall investigate circumstances associated with drop in nitrogen pressure to assure that no contamination could have possibly entered the system, which would require repeating the cleanliness proof flush.

6.2 Oxygen system drop test.

6.2.1 All oxygen flasks shall have been tested to 4500 psig with the cleaning compound after installation of new Monel plugs. If Monel plugs are presently installed, disconnect the flasks from the system and test them to 4500 psig. Record all micrometer readings (before, during and after the hydrostatic test) (see 6.1.3.6).

6.2.1.1 Reconnect all flasks to system piping.

6.2.2 Prior to the drop test, the system shall have been satisfactorily inspected, repaired and cleaned.

6.2.2.1 A 15 minute hydrostatic test for strength and porosity at 4500 psig will be conducted on the entire oxygen system with the cleaning solvent.

6.2.2.2 All personnel involved in the pressure drop test must be familiar with the equipment and precautions necessary to insure a safe test.

6.2.2.3 Install precision thermometers on the top of each oxygen flask in the system with putty. Also one thermometer will be placed in each ballast tank for ambient temperature readings.

6.2.3 A six hour drop test will be conducted to test for leaks prior to the seven day drop test. Pressure and temperature readings will be taken once every hour.

6.2.3.1 Back off oxygen regulator adjusting screw for 0 psig pressure drop. Install a precision gage and a thermometer at the charging connection.

6.2.3.2 The system will be charged with a dry certified oil-free nitrogen-Freon 12 mixture. The Freon 12 will be charged first and the supply bottle disconnected after charging. The amount of Freon 12 to use may be calculated (see 6.3.4.1) or obtained from Drawing 80064-501-4305034.

6.2.3.3 Increase the pressure on the system gradually to 3000 psig with nitrogen. Let the pressure equalize throughout the system as the pressure is increased.

6.2.3.3.1 When the gage at the charging connection reads 3000 psig, record the temperature at each flask, at each ballast tank and at the charging connection.

6.2.3.4 Inspect the entire system for leaks with the leak detector. If a leak is found which in the opinion of the inspector is large enough to affect the accuracy of the leak detector in determining small leaks in the same area, record its location and make repairs immediately.

6.2.3.4.1 If possible, isolate the faulty section of piping, reduce the pressure and make repairs. During the repairing, oxygen clean conditions must be maintained or the system must be recleaned.

6.2.3.4.2 If the leak cannot be isolated, reduce the system pressure to 0 psig (evacuate or purge with nitrogen to remove the Freon 12 or both) and make necessary repairs.

6.2.3.4.3 After a leak has been repaired, continue the inspection with the system under pressure.

6.2.3.4.4 If a leak is not large enough to affect the accuracy of the leak detector, record its position and inspect for further leaks. Repair these small leaks at the end of the inspection.

6.2.3.5 After all repairs are completed, the system will again be tested in accordance with 6.2.3.

6.2.3.6 When no leaks are found after six hours, record the temperature and pressure. Correct the pressure reading using a pressure correction graph, i.e., Drawing 80090-501-4306010, or an approved procedure. No pressure drop is allowed.

6.2.3.7 Upon successful completion of the six hour drop test, the seven day drop test will begin in accordance with 6.2.4.

6.2.4 Record pressure and all temperature readings at this time. Further readings will be taken at midnight for seven consecutive nights.

6.2.4.1 Using the procedure specified in 6.2.3.6, correct the pressure. A 5 psig pressure drop is allowed.

6.2.4.2 After satisfactory completion of the seven day drop test, reduce the system pressure to 0 psig. Evacuate to 29 inches mercury vacuum. Check the vacuum exhaust with a leak detector to determine if any Freon 12 is present.

6.2.4.3 If the exhaust contains Freon 12 throughout the exhaust period, purge the system with dry, oil-free nitrogen at 100-125 psig and hold for 30 minutes. Relieve pressure and evacuate. Check exhaust for traces of Freon 12.

6.2.4.4 When the vacuum exhaust is free of Freon 12, charge the system to 100 psig with dry oil-free nitrogen. If the seat leakage test or the in place gage calibration tests will be conducted, charge the system to 3000 psig. Drawing 86004-501-4304427 and 86004-501-4304429 or an equivalent procedure should be used for the seat leakage test and the in place gage calibration test.

6.3 Nitrogen system test.

6.3.1 All nitrogen or air must be vented from the system prior to conducting the hydrostatic test. Ball valves will not be used for boundaries during the hydrostatic test and if they are in the system during testing, they will be in the fully opened position.

6.3.1.1 All newly installed piping or repaired piping shall have been flushed in accordance with 4.6.

6.3.1.2 Relief valves, reducing valves, gages, drains, open ended vents and valve discharges shall receive operational tests only.

6.3.2 If the nitrogen flasks can be measured with micrometers in place, the same general procedures used to test the oxygen system shall be applicable; i.e., the system may be tested to 1-1/2 times the operating pressure for eight hours, flasks measured prior, during, and after hydrostatic test (see 6.1.3.6), and all joints checked with the halide leak detector. Also, if 40 ft.^{3} nitrogen domes are in the system, dial indicators should be used instead of the micrometers for measuring the domes for permanent set. The equation for calculating the permanent set requirements is shown in 6.3.2.1.

6.3.2.1 The following equation should be used in calculating the maximum allowable diameter after the hydrostatic test for the 40 ft.^{3} nitrogen domes:

$$D_2 \leq \left(\frac{9D^3 + D_1^3}{10} \right)^{1/3}$$

Where: D = Original diameter.
D_1 = Expanded diameter.
D_2^1 = Retracted diameter.

6.3.3 If the above test cannot be accomplished, then the system piping should be tested to 1-1/2 times the operating pressure. The nitrogen flasks shall be tested in place, if possible, using distilled water and one of the test methods specified in the Compressed Gas Association Pamphlet C-1 (see 6.4.2).

6.3.3.1 If the flasks cannot be tested in place, they should be removed from the ship and tested in accordance with 6.4.

6.3.3.2 Connect a test pump and a supply of cleaning solvent at a convenient low point in the system. Piping to the flask plugs should be blanked. A thorough check should be made to insure that all piping is tested to the prescribed test pressure. Start pump and gradually build up pressure in the system in 500 psig increments. Examine the entire system at each pressure increment. After the desired test pressure has been reached, hold it for a minimum of 15 minutes. Maintain this pressure and check entire system for leaks using the halide detector. No leakage is allowed. If leaks are found, continue inspection (unless a rupture occurs) of system and then drain all the cleaning solvent from the system. Purge with dry, certified oil-free nitrogen and check the exhaust with the halide detector for traces of cleaning solvent. Make necessary repairs and repeat the hydrostatic test for only the affected portions.

6.3.4 After satisfactory completion of the strength test, the system shall be tested for tightness. The entire system, up to the first isolation valve upstream of the pressure regulator and to the oxygen generators shall be tested in accordance with the methods specified in 6.3.4.1.

6.3.4.1 Seven day drop test. The system will be tested with a mixture of dry certified oil-free air or nitrogen and Freon 12. The amount of Freon 12 to be used can be calculated from the following equation:

$$W = \frac{P_p \times V_s \times (MW)}{RT}$$

Where: T = Ambient temperature at time of test (°R=460+°F.).
P_p = Partial pressure of Freon 12 (psi) at "T", see table II.
V_s = Volume of system (ft.^{3}).
MW = Molecular weight of Freon 12 (MW=120 lb/lb mole).
R = Gas constant 10.73 $\frac{(\text{lb - force/in}^2)\ (\text{ft.}^3).}{(\text{lb - mole})\ (°R)}$.
W = Weight of Freon 12 required (lbs).

Table II - Partial pressure (P_p) Freon 12 versus temperature (T).

TEMP. °F.	P_p	TEMP. °F.	P_p
30	43.148	60	72.433
32	44.76	62	74.807
34	46.417	64	77.239
36	48.12	66	79.729
38	49.87	68	82.279
40	51.667	70	84.888
42	53.513	72	87.559
44	55.407	74	90.292
46	57.352	76	93.087
48	59.347	78	95.946
50	61.394	80	98.870
52	63.494	82	101.86
54	65.646	84	104.92
56	67.853	86	108.04
58	70.115	88	111.23
60	72.433	90	114.49

6.3.4.2 Install precision thermometers on the top of each nitrogen flask in the system with putty. Also, one thermometer will be placed at each ballast tank for ambient temperature readings.

6.3.4.3 Charge the system with the proper amount of Freon 12 as calculated above and then disconnect the Freon 12 source from the system. Connect nitrogen supply to the system and pressurize to 3000 psig. All joints shall be inspected for tightness with the halide leak detector. The pressure variation at the end of seven days shall not exceed 5 psi (see 6.2.3.6).

6.3.4.4 The overhaul activity is permitted to perform preliminary tightness testing by the method described above for a lesser time period to more nearly assure satisfactory completion of the final tightness test.

6.3.4.5 The untested portions of the system (downstream of the pressure regulator isolation valve and that portion of the nitrogen system which is subjected to nitrogen supply pressure intermittently) shall be open to the tested portion of the system, and the complete system shall be charged to the design working pressure and checked for leaks. The allowable pressure variation shall not exceed 1 percent of the design working pressure in 24 hours.

6.3.4.6 If leak repair introduces foreign matter into the system the affected portions shall be re-cleaned and re-tested for tightness.

6.3.4.7 After satisfactory completion of the tightness test, bleed the system to atmospheric pressure and evacuate to 29 inches mercury vacuum. Check the exhaust gas with the haiide leak detector for traces of Freon 12. After the laboratory certifies the system free of halides, pressurize the system to the design working pressure and conduct an operational test if required.

6.3.4.8 The chemical laboratory should sample the nitrogen and using gas chromatographic procedures or equivalent, analyze for the cleaning solvent or Freon 12. The allowable limit is 10 ppm or less.

6.4 Shop test of oxygen and nitrogen flasks.

6.4.1 The testing medium for oxygen and nitrogen flasks will be the cleaning solvent. Test pumps, gages, valves and other test equipment shall meet the same standards as specified for testing oxygen systems.

6.4.2 The water jacket leveling burette method of hydrostatic testing flasks will be used as outlined in the Compressed Gas Association Pamphlet C-1. The water jacket will be tested to 1-2/3 times the working pressure of the flasks prior to testing any flasks and will be in proper working order.

6.4.2.1 However, if the water jacket is not functioning properly, micrometers may be used the procedures specified in 6.1.2 used.

6.4.3 Flasks to be used in the oxygen and nitrogen systems will not be coated internally, and flasks that are coated internally will have the coating removed prior to installation in the system. New flasks will be made in accordance with MIL-F-22606.

6.4.4 Inspection. Visually inspect the flask exterior for damage such as wire cuts, dents, weld splatter, or burned places. Remove the inlet-outlet plugs and inspect the flask interior with a borescope for evidence of paint, oil, combustion or excessive rust. A report will be made of the results found according to the following standards:

(a) Excellent - No observed rust or corrosion.
(b) Good - 10 percent of the interior surface rusted or corroded.
(c) Fair - 20 percent of the interior surface rusted or corroded.
(d) Poor - More than 20 percent of the interior surfaces rusted or corroded.

6.4.4.1 Flasks and plugs whose threads are badly galled will be scrapped. The flasks will be drilled to prevent further use.

6.4.4.2 Remachine the flask and plug threads as required.

6.4.4.3 Replace oxygen flask plugs which are not Monel as specified in 5.2.1.

6.4.5 Cleaning. Install a brass or copper nipple to protect the full length of the threads in the flask. Flasks classed "excellent" or "good" will be wire-brushed to remove all interior corrosion. Flasks classed other than "excellent" or "good" will be sand-blasted using SAE#14 angular grit or its equivalent under 90 psi using a 1/2 inch diameter nozzle opening or by spinning in a lathe with loose material inside the flask. A clean interior metal surface will be obtained.

6.4.5.1 Remove grit and residue from the interior by dumping and vacuum cleaning. Rinse the flask with fresh hot water (190°F. minimum) and then dry the flask with dry, certified oil-free air or nitrogen.

6.4.5.2 Inspect the flask with a borescope and mark the outside of the flasks to indicate any pits deeper than 1/16 inch. Use marking bluing to circle the areas in question. Ultrasonically test the wall thickness according to MIL-STD-271. The minimum allowable wall thickness is 0.0625 inches less than the minimum new wall thickness. Defects reducing the wall thickness below these standards will be reason for rejecting the flasks. Remaining defects not deeper than 1/16 inch will be faired by grinding into an adjacent area at least four times the area of the defect.

6.4.6 Install the flask plug into the flask (wrap male threads with an approved teflon tape) with a torque of 800 $\pm$ 200 ft./lbs. Seal weld the plug, if applicable, using an approved seal welding procedure.

6.4.6.1 Immediately after the flask inlet-outlet plug is installed and seal welded, if applicable, charge the flask to 25 psig with dry certified oil-free nitrogen. If the flask can be tested after installation of the flask plug, the 25 psig charge with nitrogen can be eliminated. Test flask in accordance with 6.4.7.

6.4.7 Connect the cleaning solvent supply to the flask by use of an approved flexible hose. Fill the flask with the cleaning solvent and vent the air through the drain plug opening. If the flask plug has no drain plug, evacuate the flask to 29 inches mercury vacuum and break the vacuum with the clean solvent. Completely fill the flask.

6.4.7.1 Place the flask in the water jacket test stand. Raise the pressure gradually to 1-2/3 times the flask operating pressure. Hold this pressure for five minutes (minimum) or until the change in water level is ended. Record the expanded water volume. Reduce the pressure to atmospheric pressure and record the final water volume. The final water volume minus the original water volume is the "permanent set". If the permanent set is

equal or less than 10 percent of the total volumetric expansion, the flask is satisfactory. If the permanent set is greater than 10 percent of total volumetric expansion, the flask will be rejected.

6.4.7.2 Remove the flask from the test stand and pressurize to 1-1/2 times the flask working pressure with the cleaning solvent. All welded joints, the solid plug end and inlet-outlet plug will be inspected for leakage with the halide leak detector. Allowable leakage - none.

6.4.7.2.1 Flasks requiring repair of welds will not require another expansion test in the water jacket. Welds will be repaired under the direction of the Welding engineer. Flasks undergoing weld repair must be solvent free. Repeat test specified in 6.4.7.2.

6.4.7.3 Remove the solvent by draining or blowing with dry certified oil-free nitrogen. The chemical laboratory will examine samples of the removed solvent and certify the flask as suitable for oxygen or nitrogen service. Contamination content must be 5 ppm or less. Reflush the flask if necessary.

6.4.7.3.1 Remove residual cleaning solvent from the flask by either blowing with dry certified oil-free nitrogen or evacuate the flask to 29 inches mercury vacuum. Check the exhaust with the halide detector until no trace of cleaning solvent is detectable. After completion of testing, conduct a magnetic particle inspection of flasks hemispherical ends in accordance with MIL-STD-271.

6.4.8 Install an inerting cap and then evacuate the flask to 20 inches mercury vacuum. Break the vacuum with dry certified oil-free nitrogen, and pressurize the flask to 10-12 psig. Cover the flask plug(s), its seal weld and repair the flask exterior surfaces as specified in 6.4.8.1.

6.4.8.1 If more than 20 percent of the exterior surface is rusted or corroded or otherwise unsatisfactory, remove all paint and corrosion by using rotary wire brush or sandblasting. If less than 20 percent of the exterior surface is deteriorated, remove the corrosion and paint in the affected areas and tough up flask surfaces as required.

6.4.8.1.1 Flask exterior will be given one coat of wash primer, formula 117 in accordance with MIL-P-15328; followed by a number of coats of vinyl zinc chromate, formula 120 in accordance with MIL-P-15930, sufficient to give an average thickness of three mils with not less than two mils dry film thickness. In addition, flasks which will be used inside the ship will be coated with equipment enamel, MIL-E-15090, type II, class 2. Flasks used outside of the ship will be painted the same as adjacent surface after formulate 117 and 120 have been applied.

6.4.8.2 If the flasks are to be installed within 60 days of completion of testing, there will be no need to monitor the gas pressure of flasks. When monitoring is required, it will be accomplished every two weeks and the inerting gas pressure will not be allowed to fall below 10 psig.

Preparing activity:
Navy - SH
(Project 4730-N0775)

END OF REFERENCE
20

REFERENCE
21

ANON.: LIQUID PROPELLANT HANDLING, STORAGE AND TRANSPORTATION. VOL. 3 OF CHEMICAL ROCKET/PROPELLANT HAZARDS. REP. CPIA PUBL. 194, VOL. 3, APPLIED PHYSICS LAB., JOHNS HOPKINS UNIV. (AD-870259L), 1970.

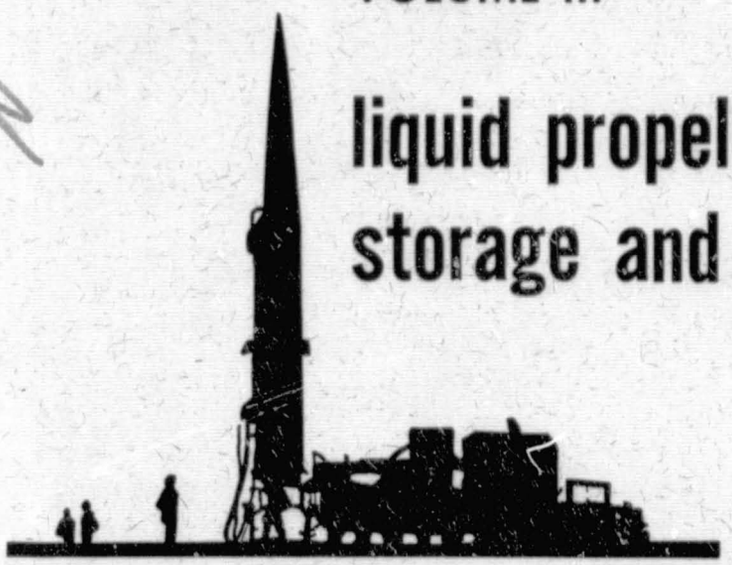
CPIA PUBLICATION NO. 194
MAY 1970

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CHEMICAL ROCKET/PROPELLANT HAZARDS

VOLUME III

liquid propellant handling, storage and transportation



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Card #7

CHEMICAL ROCKET/PROPELLANT HAZARDS

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liquid propellant handling, storage and transportation



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longitudinal and lateral tie rods or spacers within each outer shell. The space between the shells is filled with a specially prepared insulating material; also, the chamber between the two shells is evacuated to minimize loss of liquid from heat transfer and evaporation. Tank trucks and semi-trailers may be equipped with liquid-oxygen pumps, necessary valving, instrumentation, pressure-relief devices, vacuum pumps, and pressurizing coils for transferring the chemical by means of gaseous-oxygen pressure.

18-5.2.4 Location of Tanks. All main storage tanks and containers shall be located with regard to the quantity-distance tables established by the Department of Defense. Appendix E gives the quantity-distance requirements for liquid propellants.

18-6 RUN TANKAGE

The design of run tankage will be similar to that of main storage. Liquid oxygen tanks and fuel tanks should be separated in accordance with intra-line distance criteria established by the Department of Defense. (See appendix E.) The test requirements will determine the nature and extent of the hazards involved.

18-7 SYSTEMS AND EQUIPMENT CLEANING

Since many special problems and circumstances are encountered when systems are prepared for use with propellants, no absolute cleaning procedure can be specified. The following are recommended procedures; also, they offer an insight into the general quality and thoroughness of cleaning that is necessary.

Cleanliness, in the usual sense, is not a sufficient criterion when dealing with high purity liquid oxygen systems. The highly reactive nature of organic material in contact with liquid oxygen limits the quantity of organic material permitted and prohibits the presence of solid particles over a specified micron size. Cloth or brushes, which may lose lint or bristles, shall never be used in any cleaning operation.

Before being used, tanks, containers, piping, etc., should be degreased by washing with approved grease-removing solvents. Equipment taken out of service for maintenance or modification shall be inspected and degreased before being returned to use. Appendix B contains a recommended list of solutions and materials to be used in the cleaning process.

NOTE

The fumes of acids and degreasing solvents used in this cleaning procedure are toxic, and work areas should be well ventilated. Nitric acid pickling vats should be covered and externally vented for protection from nitrogen dioxide (NO_2) fumes which are highly toxic. Iron accidentally placed in nitric acid produces nitrogen dioxide fumes.

18-7.1 COMPONENTS MADE OF ALUMINUM, ALUMINUM ALLOYS, AND STAINLESS STEEL. These components include valves, fittings, tubing, regulators, etc.

18-7.1.1 Disassembly. The units are disassembled into their component parts, except for plastic inserts that might be damaged by removal. Aluminum parts are separated from stainless steel parts to prevent marring aluminum or causing galvanic corrosion.

18-7.1.2 Solvent Degreasing. Exceedingly greasy or dirty parts are wiped free of loose dirt and grease. The parts are degreased by perchloroethylene vapor or solvent for 30 minutes. Remove all parts containing plastics and clean separately at about 120°F (49°C) in accordance with paragraph 18-7.2. Certain plastics may be cleaned with solvents at 120° F without danger of solvent absorption; however in general it will be found preferable to avoid the possibility of solvent contamination. Degreased parts are rinsed well with alcohol and then with water. Handle all parts with clean gloves after the degreasing procedure is completed.

18-7.1.3 Detergent Cleaning. Stainless steel parts are placed in a 4 percent detergent solution for 30 minutes, with the temperature controlled at 120° F. The temperature may be raised if no plastic parts are present, but it should never be over 150° F. Rinse the parts several times with water. Aluminum parts are cleaned in a similar manner with a 4 percent solution of aluminum cleaner for 30 minutes, and then rinsed thoroughly with water. Handle all parts with clean gloves.

18-7.1.4 Acid Pickling. Place stainless steel parts in a bath of 40 to 50 percent nitric acid for at least 1 hour. Castings and rough finished parts should remain in the nitric acid for a longer time. After pickling remove parts and wash them thoroughly with water several times.

Rinse parts thoroughly with distilled or deionized water, or steam them clean.

18-7.1.5 Final Treatment. For metal parts continue with the following steps:

a. Steam parts clean

b. Blow parts absolutely dry with nitrogen gas

c. Package each small part in a plastic bag, and close the bag securely until the part is to be used. Polychlorotrifluoroethylene (ACLAR Number 33C or equivalent) plastic bags are recommended (MSFC-SPEC-456), on the basis of freedom from shredded particle impact sensitivity. Cover the opening and the clean areas of each large part with plastic film of this material and tape until the part is to be used.

18-7.2 PLASTIC PARTS (O-RINGS, GASKETS, ETC.) Use the following procedure:

a. Clean parts with a 4 percent detergent solution for 30 minutes at 120° F.

b. Rinse parts with distilled water several times.

c. Blow parts dry with nitrogen gas.

d. Package parts in plastic bags until they are to be used.

18-7.3 STAINLESS STEEL TANKS. Clean per paragraphs 18-7.3.1 thru 18-7.3.4.

18-7.3.1 Preparation.

a. Inspect tank for rust, dirt, scale, etc.

b. Remove rust and scale mechanically or with a nitric acid/hydrofluoric acid mixture.

18-7.3.2 Cleaning.

a. Degrease tank with solvent at 150° F.

b. Rinse tank thoroughly with alcohol.

c. Rinse tank thoroughly with water or steam clean.

d. Fill tank partially with 4 percent detergent solution and heat to 150° F for 30 minutes. Rinse with potable water.

18-7.3.3 Welds.

a. Inspect all welds inside of tank. If welds are blackened, add a nitric acid/hydrofluoric acid mixture (enough to cover welds) for 30 minutes and rinse with potable water.

b. Inspect welds again. If they are still black, repeat step a. If they are clean, rinse tank thoroughly with water, or steam it clean.

18-7.3.4 Final Treatment.

a. Fill tank completely and wash it thoroughly with particle-free deionized or distilled water.

b. Blow tank dry with nitrogen and cover all openings with SPEC-456 plastic film. Polyethylene caps or plugs should not be used where there is a possibility of the plastic material shearing off and contaminating the system.

18-7.4 ALUMINUM AND ALUMINUM-ALLOY TANKS. Clean as follows:

a. Inspect inside of tank and remove burrs, grease, dirt, scale, etc.

b. Degrease tank with vapor or liquid solvent for 30 minutes.

c. Rinse with alcohol.

d. Wash thoroughly with water.

e. Add 4 percent aluminum cleaning solution for 20 minutes at room temperature. Revolve tank thoroughly so that solution covers the entire tank, or scrub tank walls.

f. Wash tank thoroughly with water, or steam clean.

g. Blow tank dry with nitrogen, and cover all openings with SPEC-456 plastic film.

18-7.5 ASSEMBLY OF PROPELLANT SYSTEMS

18-7.5.1 General. In assembling the system, only clean, degreased tools should be used. The operator should wear clean, lint-free gloves and outer garments. Small components should be assembled in a clean, dust-free room. Insofar as possible, keep all openings and clean surfaces covered with plastic film until the system has been assembled.

END OF REFERENCE
21

REFERENCE
22

ANON.: CLEANING METHODS. PROCESS SPECIFICATION 20-1, NASA FLIGHT RESEARCH CENTER.

Manual No. _____

Original:	9/16/63
Reissue:	7/15/65
Change:	1/12/68
Change:	11/1/70

NASA FRC

PROCESS SPECIFICATION NO. 20-1

CLEANING METHODS AND PROCESSES

Changes	
Page	Date
7,9	1/12/68
Contents, 2, 9	11/1/70

Approved

10/29/70

10/29/70

10/28/70

NASA FRC
PROCESS SPECIFICATION NO. 20-1 11/1/70

CLEANING METHODS AND PROCESSES

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July 15, 1965

NASA FRC
PROCESS SPECIFICATION NO. 20-1
CLEANING METHODS AND PROCESSES

1.0 PURPOSE

To provide approved minimum requirements for cleaning and processing materials, parts, and assemblies for use with various liquids and gases.

2.0 SCOPE

Procedures listed herein are applicable to air vehicle, test stand, aerospace ground equipment (AGE), support, testing, and any other item or system concerned with the referenced gases and/or liquids.

This specification is applicable to all NASA Flight Research Center operations and activities, and when specified directly or included as a part of pertinent requirements, is applicable to non-FRC individuals and organizations performing services or work for NASA FRC.

Deviations or exceptions from the requirements stated herein will require prior approval of NASA FRC Engineering and/or Quality Assurance.

3.0 GENERAL

3.1 Specification Description

This specification establishes requirements, procedures, and materials for surface cleaning and preparation for further processing, and provides Quality Assurance requirements.

3.2 Methods

Cleaning processes described herein are based on intended use (service medium or system installation), and the type of material being cleaned (metallic or non-metallic).

3.3 Material Substitution

Where "trichlorethylene" is specified herein, cleaning materials which are at least wholly equivalent to trichlorethylene in all performance and characteristics may be used.

4.0 APPLICABLE DOCUMENTS

4.1 General

The following documents form a part of this specification to the extent specified herein.

4.1.1 Material Specifications

Only materials specified herein shall be used for operations performed within the scope of this specification. Materials shall conform to the latest revision of the following:

MIL-T-27602 - Trichlorethylene, Oxygen Propellant Compatible
MIL-D-16791 - Detergent, General Purpose (Liquid, Nonionic)
MIL-P-27401 - Propellant Pressurizing Agent, Nitrogen
MIL-A-6091 - Alcohol, Ethyl, Specially Denatured

4.1.2 Reference NASA FRC Process Specifications

No. 05-4 Methods of Treatment for Hydrogen Peroxide Components
No. 05-5 Acceptance Standards for H_2O_2 Conditioning of Components and Parts
No. 20-2 Packaging, Contamination Control, and Storage Procedures

5.0 BASIC CLEANING PROCESSES (Method I and Method II)

The basic cleaning processes consist of two "methods". Method I is for "metallic" articles, and Method II is for "non-metallic" articles. Choice of the correct Method is determined by the type of material of the article to be cleaned, subject to the limitations and exceptions indicated in the following detail requirements for each Method.

5.1 Method I - Basic Cleaning Process for Metallic Articles

Except for metallic filter elements (Para. 6.4) and pressure transducers (Para. 6.5), the following procedure shall be utilized for cleaning all metallic articles intended for use with the materials indicated:

Helium (Gaseous and Liquid)
Nitrogen (Gaseous and Liquid)
Hydrogen (Gaseous and Liquid)
Propellant Liquid Oxygen (LOX)
Anhydrous Ammonia
Alcohol (including water-alcohol combinations)
Hydraulic Fluid
Other fuels, gases, and materials after NASA FRC Quality Assurance approval.

CAUTION:

Non-metallic articles or materials (gaskets, seals O-rings, etc.) shall not be subjected to the deleterious effects of trichlorethylene or other cleaning materials, or to temperatures in excess of 140 degrees F.

Step 1

Preparatory cleaning if required. (Hand clean by wiping, brushing, scraping, descaling, rinsing, etc. to remove external and excess grease, oil, and contaminants)

Step 2

Ultrasonic clean with trichlorethylene, or vapor degrease with trichlorethylene, or flush with filtered (5 micron nominal) trichlorethylene, at a circulation rate of twenty (20) component volumes per minute, minimum flow for five (5) minutes.

(When "flush" procedure is used, heated trichlorethylene of 120°F. to 140°F. is desired, but in no case shall temperature be less than 60°F.

CAUTION: (Continued next page)

5.1 Method I - Basic Cleaning Process for Metallic Articles (Cont.)

CAUTION:

Trichlorethylene becomes explosive when mixed with strong alkalies.

NOTE: Step 3 (following) is applicable if "ultrasonic cleaning" or "vapor degreasing" methods were utilized in Step 2 above. If "flush" method was used in Step 2, the requirements of Step 3 may be omitted.

Step 3

Rinse in fresh, filtered (5 micron nominal) trichlorethylene.

Step 4

Purge and dry with filtered (5 micron nominal), dry nitrogen gas and/or by heating. (180°F. Max.)

NOTE: It is essential that the purging operation of Step 4 be thorough and complete. All traces of trichlorethylene must be removed.

Step 5

Package and tag in accordance with the requirements of NASA FRC Process Specification No. 20-2.

5.2 Method II - Basic Cleaning Process for Non-metallic Articles

The following procedure shall be utilized for cleaning all non-metallic articles.

Step 1

Preparatory cleaning if required. (Hand wipe with clean, approved paper wiping material in order to remove visible grease, oils, contaminants, etc.)

Step 2

Using a hot (140°F. max.) one-percent (1%) solution of nonionic detergent and water (approximately 1 ounce of detergent per gallon of water), thoroughly clean the part by utilization of one of the following procedures:

a. Scrub with a non-metallic brush, in the detergent solution.

b. Flush with the detergent solution at a flow rate of twenty (20) component volumes per minute for 3 minutes minimum, or longer if necessary to assure proper cleaning.

c. Ultrasonic clean in the detergent solution.

Method II - Continued next page

5.2 Method II - Basic Cleaning Process for Non-metallic Articles (Continued)

Step 3

Remove from the detergent solution and immediately blow dry with clean, oil-free, dry nitrogen gas or air.

Step 4

Rinse thoroughly in heated demineralized or distilled water. (140°F. max.)

Step 5

Thoroughly dry by use of one of the following methods:

a. Purge with dry, oil-free nitrogen gas filtered through a 5 micron nominal rated filter.

b. Heat in a temperature-controlled oven at 120°F. to 140°F. max.

c. Vacuum evacuation.

NOTE: Non-metallic gaskets or parts, such as O-rings, shall not be subjected to temperatures above 140°F.

Step 6

Package and tag in accordance with the requirements of NASA FRC Process Specification No. 20-2.

6.0 SPECIFIC CLEANING PROCESSES

6.1 Hydraulic Fluid Components

Except for metallic filter elements (Para. 6.4) and pressure transducers (Para. 6.5), all components which are intended for use in conventional and standard hydraulic fluids shall be cleaned in accordance with the requirements of BASIC CLEANING PROCESS (Para. 5.0), Method I or Method II, whichever is applicable, with the added requirement that the component shall be flushed with the particular type of hydraulic fluid to be utilized, and then drained.

NOTE: Special care must be observed in performing the flushing and draining operations in order to assure that all of the cleaning solution, and particularly trichlorethylene, is completely removed.

After all processing is complete, package and tag in accordance with the requirements of NASA FRC Process Specification No. 20-2

6.2 Hydrogen Peroxide Components

Except for metallic filter elements (Para. 6.4) and pressure transducers (Para. 6.5), all material and components which are to be used in hydrogen peroxide (H_2O_2) systems, or which may be exposed to hydrogen peroxide, shall be cleaned, passivated, and conditioned for H_2O_2 use in accordance with the requirements of NASA FRC Process Specifications 05-4, 05-5, and 20-2.

6.3 Breathing Oxygen Components

Except for metallic filter elements (Para. 6.4) and pressure transducers (Para. 6.5), all material and components which are utilized in any portion of a personnel breathing oxygen assembly or system shall be cleaned and processed as follows:

6.3.1 Metallic Breathing Oxygen Components, Parts, and Assemblies.

Step 1: Perform BASIC CLEANING PROCESS: Method I (Para. 5.1)

Step 2: Thoroughly flush with filtered (5 micron nominal) ethyl alcohol.

Step 3: Rinse thoroughly with demineralized or distilled water.

Step 4: Dry thoroughly with a stream of oil-free filtered (5 micron nominal), dry nitrogen gas, or by heating to 180 deg. F. for a suitable period until completely dry.

NOTE: (Continued next page)

6.0 SPECIFIC CLEANING PROCESSES

6.3.1 Step 4: (Continued)

NOTE: After above operation, perform "halogen detector" sniff check, or equivalent check by other approved means, to assure that all traces of trichlorethylene or other halogen vapors are removed. See paragraph 6.6.

In those cases where equipment is not available for properly sniff-checking breathing oxygen components processed by non-FRC vendors and suppliers for delivery to NASA FRC, such components, when subject to the requirements of this specification, shall be clearly identified as not having had the required sniff check.

Step 5: Package and tag in accordance with the requirements of NASA FRC Process Specification No. 20-?.

6.3.2 Non-metallic Breathing Oxygen Components, Parts and Assemblies.

Step 1: Perform BASIC CLEANING PROCESS: Method II (Paragraph 5.2)

NOTE: After above operation, perform "halogen detector" sniff check, or equivalent check by other approved means, to assure that all traces of trichlorethylene or other halogen vapors are removed. See paragraph 6.6.

In those cases where equipment is not available for properly sniff-checking breathing oxygen components processed by non-FRC venodrs and suppliers for delivery to NASA FRC, such components, when subject to the requirements of this specification, shall be clearly identified as not having had the required sniff check.

Step 2: Package and tag in accordance with the requirements of NASA FRC Process Specification No. 20-2.

6.4 Metallic Filter Elements

6.4.1 Metallic filter elements shall be cleaned by means of approved ultrasonic cleaning equipment in accordance with the methods prescribed by the equipment manufacturer or other methods approved by NASA FRC Quality Assurance.

Continued

6.0 SPECIFIC CLEANING PROCESSES

6.4 Metallic Filter Elements - Continued

6.4.2 After cleaning, the elements shall be visually inspected for any large particles still lodged in the element. If present, such particles shall be removed with care, preferably utilizing a pointed wooden or plastic instrument. DO NOT use sharp metallic tools or instruments.

6.4.3 The cleaned filter elements, as applicable, shall be subjected to bubble point/pressure drop tests, and must meet the established pore size and pressure drop/flow rate standards for the particular item.

6.4.4 Filter elements that do not meet the requirements of Para. 6.4.3 shall be recleaned and retested per Para. 6.4.3 requirements.

6.4.5 Filter elements that have obvious tears or defects that could affect efficient filtration shall be rejected.

6.4.6 Serviceable filter elements shall be dried in a temperature-controlled oven at 150±10°F. (approximately one (1) hour), or by purging with dry nitrogen filtered through a 5 micron nominal rated filter.

6.4.7 Package and tag in accordance with the requirements of NASA FRC Process Specification No. 20-2.

6.5 Pressure Transducers and Bourdon Tubes

The procedure listed below shall be utilized for cleaning and processing pressure transducers and bourdon tubes utilized in systems subject to use with the following service media:

Helium (Gaseous and Liquid)
Nitrogen (Gaseous and Liquid)
Hydrogen (Gaseous and Liquid)
Oxygen (Gaseous and Liquid)
Anhydrous Ammonia (Gaseous and Liquid)
Hydraulic Fluid - Petroleum Base (MIL-H-5606)
Hydraulic Fluid - Non-Petroleum Base (MIL-H-8446)
Alcohol - (including Water-Alcohol combination)
Hydrogen Peroxide (SEE CAUTION BELOW)
Other materials, fuels, lubricants, etc. after NASA FRC Quality Assurance approval.

CAUTION

Pressure transducers used in hydrogen peroxide systems shall be cleaned in the same manner as applicable for the gases and liquids listed above, and shall then be prepared for use with hydrogen peroxide in accordance with applicable requirements of NASA FRC Process Specifications 05-4, 05-5, and 20-2.

6.5 Pressure Transducers and Bourdon Tubes - Continued

6.5.1 Required Equipment: Two beakers or containers of filtered (5 micron nominal) trichlorethylene, with the contents of one container maintained at a temperature of 180 ± 5° F., and the other container at ambient temperature, or

Ø vapor-degreasing equipment utilizing filtered (5 micron nominal) trichlorethylene maintained at a temperature of 180 ± 5° F., and a single beaker or container with filtered(5 micron nominal) trichlorethylene at ambient temperature.

NOTE: Syringing the pressure transducer or bourdon tube with hot trichlorethylene prior to starting the cleaning process is advisable.

Step 1: Immerse the bourdon tube completely, or immerse just the cavity of the pressure transducer in the container of hot trichlorethylene, if used, or in the vapors of hot trichlorethylene when
Ø the vapor-degreaser is used. In either case, allow to remain immersed for a minimum of one (1) minute.

Step 2: Transfer the bourdon tube or transducer to the ambient-temperature trichlorethylene container, and allow to remain until cold, or about one minute.

Step 3: Repeat the above "transfer cycle" ten (10) times. DO NOT let the ambient-temperature trichlorethylene become warm, or above 85° F.

Ø Step 4: Dry the bourdon tube in a temperature-controlled oven at 250 ± 10° F. for 2 1/2 hours.

Dry the pressure transducer in a temperature-controlled oven at 180 ± 10° F. for 2 1/2 hours.

Step 5: Package and tag in accordance with the requirements of NASA FRC Process Specification No. 20-2.

6.6 Use of Leak Detector

6.6.1 When using a leak detector for indication of presence of trichlorethylene or other halogen compounds in breathing oxygen articles or systems, set up the detector per manufacturer's instructions and perform tests with range selector on "high", balance control on "automatic", and ammeter balanced to 0.1 amps. Any rise in ammeter reading during the "sniff check" is cause for non-acceptance of the item under test.

Corrective action may include redrying, partial reprocessing, or any combination of actions resulting in an acceptable item which passes the "sniff check".

7.0 QUALITY ASSURANCE PROVISIONS

7.1 Performance Acceptance

The cleaning procedures described in this specification have been established to provide acceptable end-item results, if performed completely and in the proper manner.

Visual monitoring, by Quality Assurance personnel, of the processes and procedures previously outlined, and quality verification of total compliance with the stated requirements, shall constitute Quality Assurance approval of the applicable processing, with no further testing required.

7.2 Test Acceptance

Where the requirements of Paragraph 7.1 are not met, or whenever specified by particular requirements (on drawings, specifications, procedures, etc.), the following test procedures will be performed, as applicable, to verify the cleanliness of components, assemblies, and/or systems:

7.2.1 Particulate Inspection - Method I (Solvent Rinse)

Components, assemblies, and/or systems composed of all-metallic structure shall be inspected in accordance with the "Solvent Rinse Method" following:

Step 1: Determine the square feet of inner area of the component, assembly, or system to be tested. (NOTE: Any component having less than one (1) square foot area of inner surface shall be considered as being one (1) square foot.)

Step 2: Obtain 100 milliliters of filtered (5 micron nominal or less) trichlorethylene for each square foot of inner surface area to be tested.

Step 3: Rinse the surface area to be tested by completely flushing the surface with the amount of filtered trichlorethylene determined in Step 2 above.

Step 4: After thorough flushing with the rinse fluid, obtain samples directly from the component, assembly, or system, into a pre-cleaned sample bottle. (NOTE: A minimum sample of 500 milliliters of used rinse fluid is required for each sample bottle. In those cases where the amount of rinse fluid used is less than 500 milliliters, as determined by Step 2 above, the total amount of the used rinse fluid shall be contained in the sample bottle.)

Step 5: (Continued next page)

7.0 QUALITY ASSURANCE PROVISIONS

7.2 Test Acceptance - Continued

Step 5: Label the sample bottle to include the following information:

Name, and part number of component assembly, or system.

Serial number, if applicable

"Method I (Solvent Rinse)", and date sample taken.

Quality verification of correct sampling technique, and date.

Step 6: Process the samples per FRC-approved laboratory particulate count methods, or per Federal Test Method Standard No. 791a, Method 3009T, with the added requirement that the filter disc will be inspected under ultra-violet light (2500 to 3700 angstrom units). Any evidence of fluorescence of filter pad stains or entrapped globules will be cause for recleaning. Fluorescence of fibers and solid particles which do not exceed the maximum size and count criteria will not be cause for rejection.

NOTE: The referenced ultra-violet light inspection is required for rocket, missile, and personnel breathing oxygen components and systems, and related AGE. Unless otherwise specified, it is not required for hydraulic systems, jet engine systems, or other conventional flight vehicle systems or components.

7.2.1.1 Acceptance Criteria - Particle size limitations, per 100 milliliter of sample fluid, shall be as indicated in Paragraph 7.2.3 of this specification.

7.2.2 Particulate Inspection - Method II (Gas Blowdown)

CAUTION: Components, assemblies, or systems that have contained hydrogen peroxide or other hypergolic fluids shall not be subjected to the Gas Blowdown Method. Cleanliness of such articles shall be determined only by approved procedures for the particular fluid, gas, or chemical.

Particulate Inspection - Method II - Continued next page

7.0 QUALITY ASSURANCE PROVISIONS

7.2.2 Particulate Inspection - Method II (Gas Blowdown) (Continued)

Components, assemblies, and/or systems containing non-metallic materials shall be inspected in accordance with the "Gas Blowdown Method" using a blowhorn or similar device to hold a millipore filter disc (0.45 ± 0.02 micron pores, 47 mm diameter, white 3.08 mm grid, capable of filtering 80cc of distilled water per square centimeter per minute at 70 cm of Mercury = 13.5 psia, at 25°C.) as follows:

Step 1: Attach a pre-cleaned sampling valve, suitable for the operating conditions and pressure requirements, to the component, assembly, or system outlet.

Step 2: Pressurize the component, assembly, or system with filtered (5 micron nominal) nitrogen gas to its normal working pressure as rapidly as practical to raise the temperature to the maximum allowable for the component, assembly, or system.

Step 3: Bleed down the pressure, through the sampling valve, to a pressure value no greater than 75% of the rated operating pressure of the filter disc holder.

Step 4: Connect the millipore filter disc holder, with filter installed, to the sampling valve outlet.

Step 5: Bleed the remaining nitrogen gas through the filter disc holder for a minimum of five (5) minutes. (NOTE: At the end of the five minute sampling period, source gas pressure shall be no less than 5 psig. Components, assemblies, or systems that will not provide a minimum of five (5) minutes bleed through the filter disc, shall have a regulated pressurizing source attached to insure a minimum of five minutes purge through the test article.)

Step 6: Close the sampling valve, and remove the filter disc holder.

Step 7: Bleed the remaining gas to zero, and remove the sampling valve.

Step 8: Examine the millipore filter disc per Para. 7.2.1, Step 6, of this specification.

7.2.2.1 Acceptance Criteria - Particle size limitations shall be as indicated in paragraph 7.2.3 of this specification.

7.0 QUALITY ASSURANCE PROVISIONS

7.2 Test Acceptance - Continued

7.2.3 Particle size limitations are as follows:
(Particulate Inspection - Method I or Method II)

a. No particle greater than 1500 microns in any dimension.

b. One (1) particle between 750 and 1500 microns.

c. Five (5) particles between 100 and 750 microns.

d. Particles between 26 and 100 micron size shall not exceed 250 per filter disc, or per 100 milliliters of sample solvent, depending upon Particulate Inspection Method used.

e. Particles between 10 and 26 micron size shall not exceed 6000 per filter disc, or per 100 milliliters of sample solvent, depending upon Particulate Inspection Method used.

f. Visible evidence of possible contamination, excessive silting or sludging, unidentified discoloration or staining, and similar inconsistencies or questionable areas, shall be reason for withholding acceptance or approval until adequate evaluation and disposition.

END OF REFERENCE
22

REFERENCE
23

ANON.: CLEANLINESS LEVEL REQUIREMENTS FOR PNEUMATIC AND HYDRAULIC COMPONENTS: SERVICE ARM SYSTEMS, COMPLEX 39. REP. MCR-69-484, MARTIN MARIETTA CORP. (NASA CR-107216), SEPT. 1969.

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FINAL REPORT

STUDY FOR CLEANLINESS LEVEL REQUIREMENTS FOR PNEUMATIC AND HYDRAULIC COMPONENTS - SERVICE ARM SYSTEMS, COMPLEX 39

SEPTEMBER 1969

Contract NAS10-5935

N70-17368
(ACCESSION NUMBER) (THRU)
363 1
(PAGES) (CODE)
NASA-CR-107316 15
(NASA CR OR TMX OR AD NUMBER) (CATEGORY)
FACILITY FORM 602

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FINAL REPORT

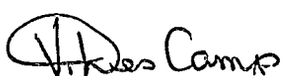
CLEANLINESS LEVEL REQUIREMENTS FOR PNEUMATIC AND HYDRAULIC COMPONENTS - SERVICE ARM SYSTEMS, COMPLEX 39

September 1969

Prepared For

National Aeronautics and Space Administration
J. F. Kennedy Space Center
Kennedy Space Center, Florida

Approved By



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Program Manager

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Denver, Colorado 80201

I. INTRODUCTION

The primary purpose of the study conducted under this contract was to determine, by analysis and testing, the minimum levels of cleanliness that would permit the Launch Complex 39 Service Arm Control Systems to meet all functional and reliability requirements.

The cleanliness levels specified for the service arm systems were originally based upon the best judgment of the system designers, and as a result of subsequent launch operations experience all indications were that they were unnecessarily stringent. Considerable expense is involved in cleaning system components to these levels, in addition to other indirect costs associated with logistics, inspection, maintenance, and delays in test operations. It was therefore desirable to reduce these costs if possible.

The objectives of this program were accomplished in four phases: (1) an in-depth review of the system, (2) a critical analysis of components with respect to contamination, (3) a literature/industry search to compile pertinent data and experience, and (4) a test program to demonstrate component compliance versus contamination. This final report describes the work performed in each phase of the program, together with all findings, test data, and conclusions.

The secondary purpose of the study was to derive basic data contributing to the general body of information on part cleanliness requirements. In addition to the data contained in this final report, a separate handbook was prepared as part of the contract requirements. The Contamination Control Handbook for Ground Fluid Systems, Martin Marietta report number MCR-69-485, was prepared as a guideline of contamination control practices for those persons engaged in the design of aerospace ground hydraulic and pneumatic systems.

END OF REFERENCE
23

REFERENCE
24

ANON.: STANDARD CLEANLINESS SPECIFICATION, PHASE II, FINAL REPORT. DOWELL DIV., DOW CHEMICAL CO. (NASA-JFK-TR-1137), SEPT. 1970.

TR-1137

SEPTEMBER 1970



JOHN F. KENNEDY
SPACE CENTER

FINAL REPORT

STANDARD CLEANLINESS SPECIFICATION

PHASE II

CONTRACT NAS10-6141

PREPARED FOR

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

JOHN F. KENNEDY SPACE CENTER

BY

DOWELL DIVISION OF THE DOW CHEMICAL CO.

TULSA, OKLAHOMA

KSC FORM 16-12 (4/66)

DOWELL DIVISION OF THE DOW CHEMICAL COMPANY

STANDARD CLEANLINESS SPECIFICATION

PHASE II

Final Report

September 1970

Contract NAS10 - 6141

Prepared for

National Aeronautics and Space Administration

John F. Kennedy Space Center

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In the test loop used in the experimental portion of this work as well as in any operating system, an uninterrupted path of sufficient length to insure fully developed turbulent flow does not exist. This will have an effect on the fluid forces near the wall since in undeveloped flow there is more turbulence near the wall than in fully developed flow. An increase in turbulence will aid momentum transfer, and one would expect an increase in fluid forces on the particles attached to the wall. Thus, the calculated forces given above should represent a lower limit on the fluid forces on particles in a non-steady state region.

The results given above seem to be sufficiently reliable to draw the conclusion given in Section I-A-2.

B. Derivation of a Cleanliness Level Specification

1. Purpose

In this section equations are given which may be used to derive acceptable contamination levels.

2. Conclusions

a. Filtration mechanism equations may be applied to a system containing an orifice to yield conservative estimates of allowed particulate contamination.

b. A standard particle distribution equation (MIL-STD-1246A) (18) can be utilized to obtain total particle volume for given cleanliness level.

c Comparison of allowed particulate contamination for given orifice with total particle volume for a given cleanliness level yields

the cleanliness level required for the system.

3. Discussion

a. Model of a Particle

Particle size is usually defined in terms of the "projected" diameter of the particle. "Projected" diameter is the diameter of a circle having the same area as the projected image of the particle when viewed in the direction perpendicular to the plane of greatest stability (19). The arithmetic mean for a number of particles is called "mean projected" diameter, d_p. If particle size is expressed in terms of the projected diameter, d_p, shape factors can be defined such that

$$\text{Average volume of particle} = a_v d_p^3 \qquad (1\text{-}22)$$

$$\text{Average surface area of particle} = a_s d_p^2 \qquad (1\text{-}23)$$

where, a_v = volume shape factor

a_s = surface shape factor.

The values of a_s and a_v depend on the type of particle being considered and its shape. Some representative values may be found in Reference 19.

b. Filtration Mechanism Equation

By applying filtration mechanism equations to a system containing an orifice, one can derive equations relating contamination volume in the orifice to a pressure rise across the opening. Only standard blocking which is the blocking that occurs when contaminant particles adhere to the pore wall will be considered. Complete blocking which occurs when an individual particle sufficiently

large to completely block the pore is deposited need not be considered since the cleanliness levels derived will not allow particles of such size in the system.

The approach in this section will parallel that given in Engineering Report No. 1527 prepared for NASA by Hayes International Corporation (16). The calculations are repeated since Reference 16 apparently contains an error in interpretation of the standard blocking equation which leads to erroneous allowed particle volumes.

Grace has shown (17) that the standard blocking mechanism can be described for a constant flow rate mode by

$$\left(\frac{\Delta P_o}{\Delta P}\right)^{1/2} = 1 - \left[\frac{a/(1-\epsilon)}{NAhr^2\pi}\right] \qquad (1\text{-}24)$$

where, ΔP_o = pressure drop across the clean pore

ΔP = pressure drop across the pore after volume $\underline{a}$ of solid particles have been deposited

A = surface area of the filter medium

h = pore length

r = initial pore radius

N = number of pores per unit area of filter medium

ϵ = porosity of the deposited contamination.

The filtration mechanism given by Grace contains several assumptions which should be examined before presentation of the results based on this mechanism.

The first assumption in the treatment by Grace is that the mechanism of contaminant retention is by direct interception of particles from streamlines adjacent to pore walls. This is only

partially true and the equations derived by Grace probably overestimate the amount of particulate contamination that will be retained by the pore. For a small pore only a mm or so in length, laminar flow would not be developed completely. In fact, one would expect considerable turbulence due to end effects. This turbulence will serve to diminish the amount of contamination retained in the pore which implies that the rate of blockage will be lower than predicted by Grace's equation.

The second assumption is that particle retention on the walls occurs in such a way that the volume of flow through the pore (at constant pressure) diminishes in direct proportion to the volume of fluid that passes through. This requires that the initial pore size must be several times the particle diameter. Cleanliness levels can be defined such that this is true; thus, no problem should be encountered with this assumption

The third approximation is that Poiseuille's law is valid. For flow rates of more than a few cm/sec this is certainly not true, but as for assumption one above, the equations derived should overestimate the rate of particle deposition. Thus, from consideration of these three assumptions behind the pore blocking equation to be given below, one would expect the equation to overestimate the amount of blockage. Hence, cleanliness levels based on these assumptions should be conservative ones.

If only one pore is considered for a unit volume and if the porosity of the contaminant is zero, then equation (1-24) may be written as

$$\left(\frac{\Delta P_o}{\Delta P}\right)^{1/2} = 1 - \left(\frac{a}{\pi hr^2}\right) \qquad (1\text{-}25)$$

The choice of the value of $\Delta P_o / \Delta P$ which can be tolerated depends on the particular system or mechanical device involved. Assuming a 75% rise in pressure across some critical orifice will still allow the part to function properly (16), we can calculate the particle volume required in the pore to give this pressure rise (defined as one standard block) from equation (1-26).

$$a = \pi hr^2 \quad [1 - (\Delta P_o / \Delta P)^{1/2}] \qquad (1\text{-}26)$$

For pores 1.00 mm in length with different diameters, the particle contamination required for one standard block ($\Delta P / \Delta P_o = 1.75$ in this case) is given in Table 1-6. For systems in which a smaller or larger pressure rise across a critical orifice is allowed, the volume of particle contamination that can be tolerated in the orifice can be found from Figure 1-3 which is a nomograph relating particle volume allowed in the pore to give a certain pressure rise for different pore volumes. Figure 1-3 is applicable for pressure increases from 10% to 100%. By use of Figure 1-3, one can determine the maximum amount of contamination that can be tolerated in each orifice or restriction in the system. The smallest maximum can then be taken as the maximum volume of contamination allowed in the system as a whole. This volume can be used along with the figure derived below (Figure

1-4) to determine the cleanliness level required for the system.

TABLE 1-6 - Volume of Particulate Contamination Required to Give One Standard Block of a Pore 1.00 mm in Length*

Pore Diameter (microns)	Particle Volume ($\times 10^{-3}$ mm^3)
150	4.31
200	7.67
350	23.48
500	47.91
750	107.8
1000	191.7
2000	766.6

* One standard block in this case is defined as an increase in pressure of 75%.

c. Cleanliness Levels

The approach used to derive cleanliness levels in this section is based on experimentally determined distributions of particulate contamination as given in MIL-STD-1246A (18). Since completion of this work, a similar approach by E. C. Fitch (22) has been brought to the attention of the author. Comparison of the two methods will be made following presentation of the cleanliness levels based on MIL-STD-1246A.

The approach in this section differs from that given in Reference 16 for several reasons. The first is the apparent misinterpretation of the standard blocking mechanism equations. Other criticisms of the method employed in Reference 16 can be found

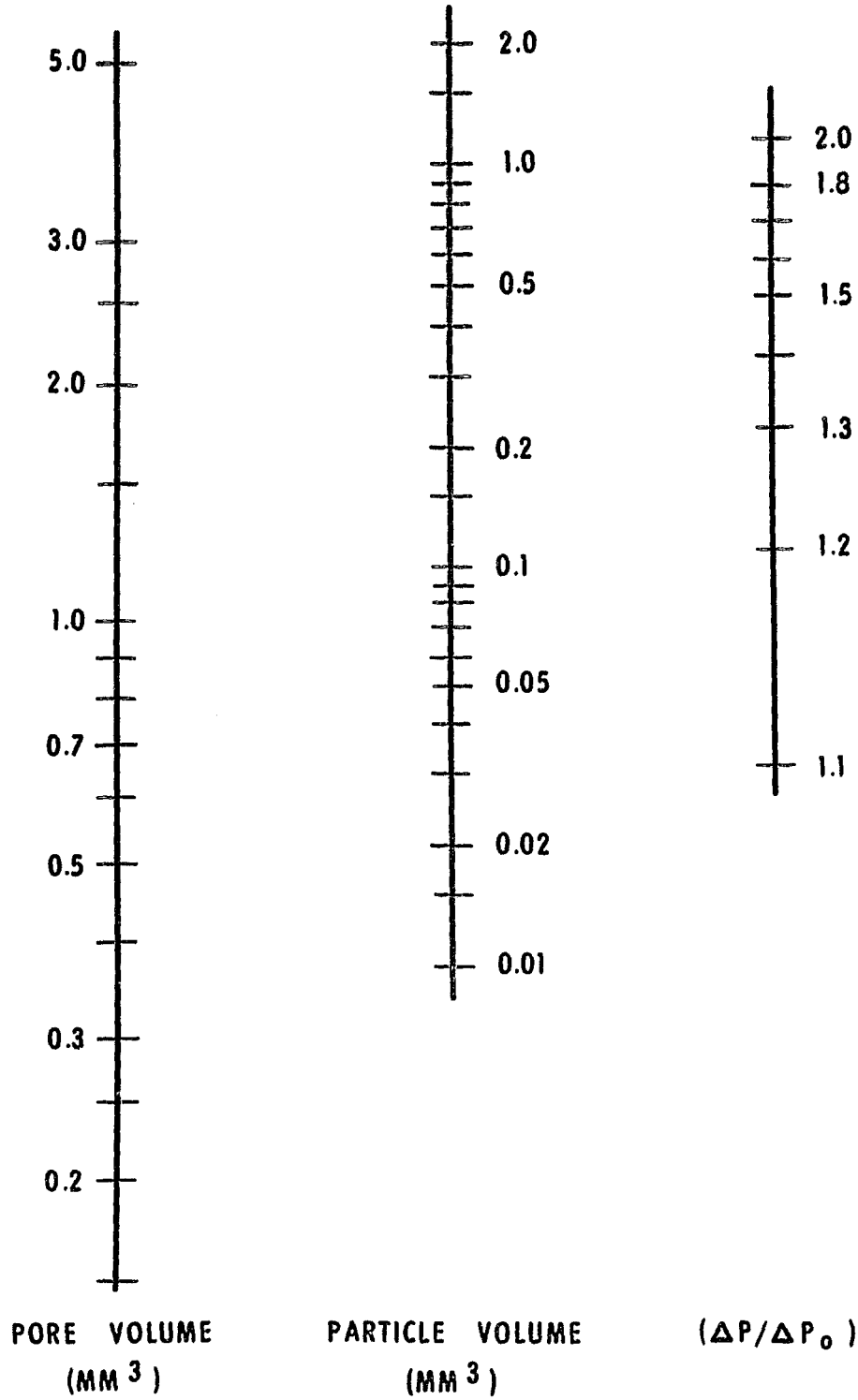


Figure 1-3

Nomograph Relating Particle Volume Required for Given Pressure Rise ($\Delta P / \Delta P_o$) and Given Pore Volume

in the Appendix.

The method employed is as follows:

Step 1 - n_i, the number of particles above a given size is calculated from equation (1-27).

$$\log n_i = 0.9260 \, (\log {}^2X_a - \log {}^2X_i) \qquad (1\text{-}27)$$

where, X_a is the cleanliness level of interest (18), and X_i is the particle size defined by the projected diameter (19).

Step 2 - $N_{i,i+1} = n_i - n_{i+1}$, the number of particles in the size range i to i+1, is calculated (a one-micron range was chosen for this calculation).

Step 3 - The volume of the largest particle in the range is calculated by equation (1-28).

$$V_{i+1} = a_v d_p^3 = a_v X_{i+1}^3 \qquad (1\text{-}28)$$

where, V_{i+1} is the volume of the largest particle in the size range i to i+1, $X_{i+1} = d_p$ is the particle size as projected diameter, and a_v is a volume shape factor (19).

Step 4 - The total volume of particles in a given size range is calculated by

$$V_{i,\,i+1} = N_{i,\,i+1} \, V_{i+1} \qquad (1\text{-}29)$$

Step 5 - The total volume of particles corresponding to a given cleanliness level (18), X_a, is given by

$$V_{total} = \sum_{i=1}^{X_a-1} V_{i,i+1} = \sum_{i=1}^{X_a-1} N_{i,\,i+1}\, V_{i+1} \qquad (1\text{-}30)$$

Combining equations (1-30) and (1-28) yields

$$V_{total} = \sum_{i=1}^{X_a-1} (N_{i,\,i+1})(a_v\, X_{i+1}^3)$$

or

$$V_{total} = a_v \sum_{i=1}^{X_a-1} N_{i,i+1}\, X_{i+1}^3 \qquad (1\text{-}31)$$

where, X_{i+1} is the projected diameter of the largest particle in a given range i to i+1

The value of the volume shape factor (19), a_v, must be chosen after the type of particulate contamination has been determined. Table 1-7 and Figure 1-4 contain the results for several values of a_v using 1-micron increments for i.

TABLE I-7 - Total Particle Volume for Various Cleanliness Levels for Several Values of a_v*

Cleanliness Level	Total Particle Volume (mm^3)			
	$a_v = 0.14$	$a_v = 0.30$	$a_v = 0.45$	$a_v = 0.60$
100	0.00118	0.00253	0.00380	0.00507
150	0.00658	0.01411	0.02116	0.02822
200	0.02330	0.04993	0.07489	0.09986
250	0.06403	0.1372	0.2058	0.2744
300	0.1494	0.3201	0.4802	0.6403
400	0.5939	1.273	1.909	2.545
500	1.800	3.857	5.786	7.714

* The maximum value of a_v is $\pi/6$ for a spherical particle.

These results can now be used to determine the cleanliness level applicable to a system containing a given size critical orifice. The following steps are required to obtain the cleanliness level.

(1) Find the maximum allowed pressure increases ($\Delta P/\Delta P_o$) across each component to insure reliable operation of the component.

(2) Use $\Delta P/\Delta P_o$ for each component, the corresponding orifice volumes and Figure I-3 to obtain the allowed particle volumes in each component.

(3) Choose the smallest allowed particle volume in (2) as the maximum particulate contamination in the system.

(4) Select a volume shape factor, a_v, for the type of contamination of interest (see Reference 19).

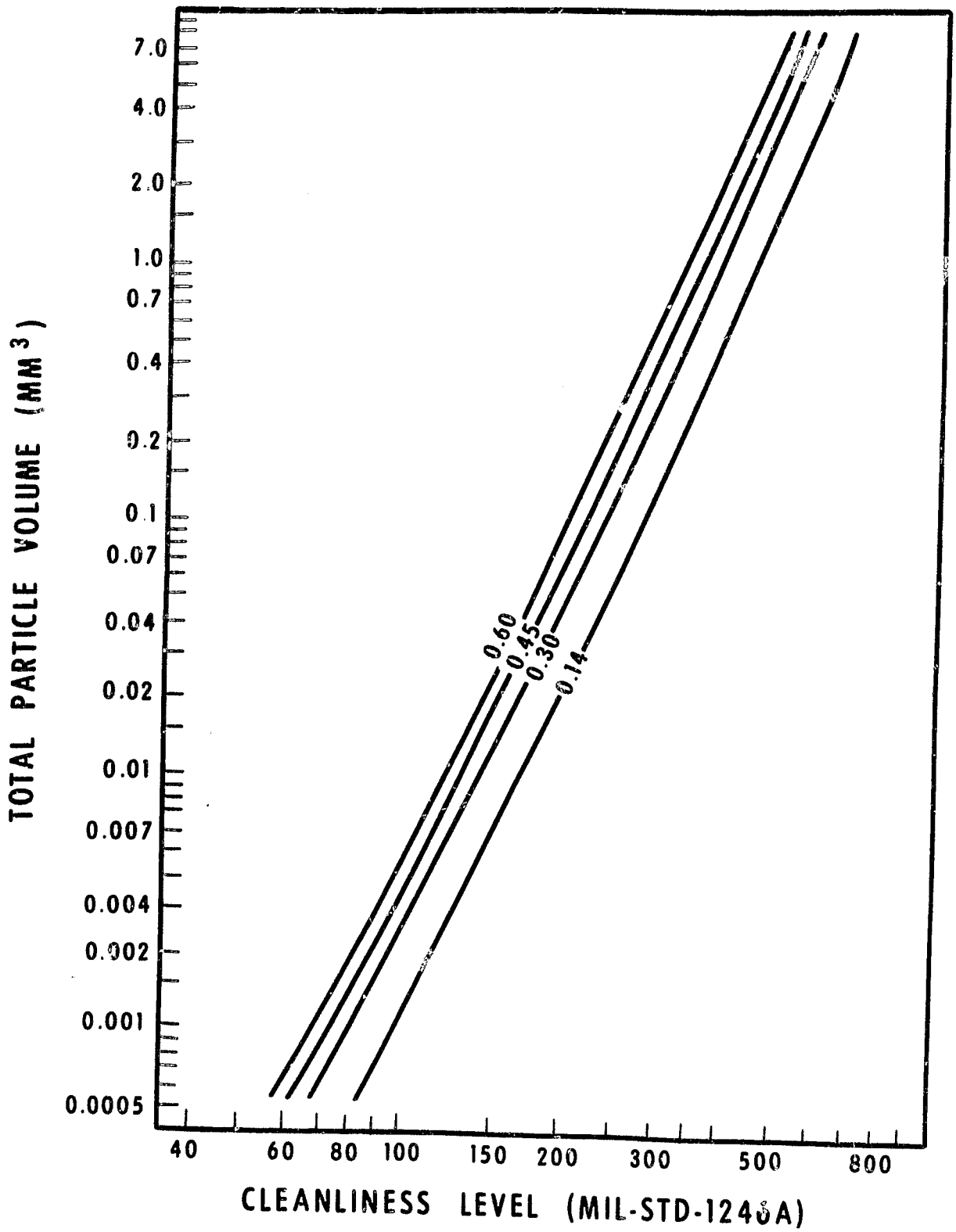


Figure 1-4 Total Particle Volume vs. Cleanliness Level as a Function of a_V

(5) Use Figure 1-4, the allowed particle volume (from (3)) and a_v to obtain the cleanliness level required for the system as defined in MIL-STD-1246A (18).

(6) Use MIL-STD-1246A to determine allowed particle populations.

One now has the required cleanliness level that insures reliable operation of the most critical component in the system. The cleanliness level obtained is rather a conservative one due to the assumptions given in Section B-3-b and to the implicit assumption that all particles on the surface will be entrained into the fluid stream and presented to the critical opening during the operation of the system. The smaller particles, in fact, probably will not be dislodged but the larger ones, which are more effective in their blocking, probably will. Hence, to insure reliable operation, the conservative levels given by steps (1-6) above are recommended.

The development given by Fitch (22) is more general in one case and less general in another. Fitch assumes spherical particles which limits his results to some extent. However, he does use a general equation for the particulate contamination distribution which makes the results more general. Probably, a detailed study in which a combination of Fitch's method and the method given in this report is in order. Such a combination should yield a very generally applicable cleanliness level specification.

C. Estimation of Fluid Flow Parameters Required to Attain Given Cleanliness Level

Sufficient data are not available to estimate the fluid flow parameters required in the cleaning operation to insure the attainment of the above levels. The following steps are required:

1. A solvent flush must be used to remove oil and grease from the system.

2. The velocity required to flush particles larger than allowed by the cleanliness level derived above can be found as follows:

   a. Choose the smallest particle to be flushed from the system from the cleanliness level derived above (this will be the largest allowed particle in the system).

   b. Estimate the average force of adhesion for type of particles and substrate involved.

   c. From the particle size in a., the force of adhesion in b., the fluid kinematic viscosity, and Figure 1-2 determine the approximate laminar sublayer depth required to give a drag force equal to or greater than the assumed force of adhesion.

   d Use the approximate laminar sublayer depth, the fluid kinematic viscosity, the largest pipe size in the system and Figure 1-1 to obtain the average flow speed required to flush the particle from the system.

   As an example, assume there is a component containing an orifice with a volume of 0.5 mm^3 which can tolerate a pressure rise of

of 50% ($\Delta P/\Delta P_o$ = 1.5) and still function properly. Figure 1-3 indicates for these conditions a particle volume of about 0.095 mm^3 is allowed. Assume also that the volume shape factor is a_v = 0.30. Figure 1-4 then gives a cleanliness level of 225 meaning only one particle larger than 225 microns is allowed in the system.

It is possible to find the fluid parameters necessary to flush a 225-micron particle from the system after all oil and grease have been removed. If the solvent used is water (kinematic viscosity = 1.06×10^{-5} ft^2/sec), and the force of adhesion is assumed to be 0.04 dynes, Figure 1-2 indicates a laminar sublayer depth of about 230 microns is required to give a fluid force of 0.04 dynes (obtained by rough extrapolation in Figure 1-2). Figure 1-1 indicates that only a very small flow rate (< 1.5 ft/sec) is required even for a three-inch pipe. Thus a 225-micron particle should be flushed from the system with no difficulty.

If oil or grease are not removed first, particles can still be flushed from the system if sufficient flow speed is attained. Data in Reference 16 indicate that a laminar sublayer depth of about 50% of the projected particle diameter is required to flush particles attached to the wall by oil or grease For the 225-micron particle considered above, this indicates a laminar sublayer depth of about 110 microns. With water as the flushing fluid a 3-inch pipe would require a flow speed of about 3 ft/sec (Figure 1-1) and a 1-inch pipe would require a flow speed of about 2.5 ft/sec. Thus, it is possible to remove most particles of this size (225) with reasonable flow conditions. However, for par-

ticles much smaller than 200 micron, excessive flow speeds would be required. In this case, oil or grease must be removed prior to particle flushing.

Thus, given a particular critical orifice size and an allowed pressure rise across the opening, Figure 1-3 can be used to obtain the allowed particulate volume. Then Figure 1-4 can be used to give the cleanliness level specification for the system. If the force of adhesion for the largest particle allowed in the system can be estimated, then Figures 1-1 and 1-2 can be used to determine the fluid flow parameters needed to insure that the system will meet the cleanliness level desired.

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END OF REFERENCE
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REFERENCE
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ANON.: TECHNICAL INSTRUCTION 5-4-3, AIR FORCE ROCKET PROPULSION LAB.

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Technical Instruction

CLEANING OF CRYOGENIC TANKS FOR LO_2, LN_2 AND LH_2 SERVICE

1. PURPOSE AND SCOPE. This instruction establishes the requirements and procedures for the internal cleaning of cryogenic vessels. This instruction does not apply to cryogenic vessels designed and used for liquid fluorine, liquid fluorides or liquid helium.

2. GENERAL. Utilization of cryogenic tanks is divided into two categories, critical and noncritical (see para 4). Three basic cleaning procedures are suggested; one for tanks which may be opened and manually entered, and two for tanks which cannot be opened.

3. DEFINITIONS.

a. NON VOLATILE RESIDUE (NVR): The residue remaining including hydrocarbons and particulates from evaporation of a fluid sample.

b. PARTICULATE: The insoluble particles remaining on a filter paper after filtration of a sample.

4. REQUIREMENTS.

a. CRITICAL TANKS: Cryogenic tanks shall be deemed critical when used under any of the following applications:

(1) The contained product is shock sensitive with contaminants, i.e. Lox.

(2) The product, as liquid or gas, is used in contact with propellant, i.e. gaseous nitrogen.

(3) The product is used in systems with small orifices, etc., where particulate build-up is likely to cause system malfunction.

b. NONCRITICAL TANKS: Cryogenic tanks shall be deemed noncritical when none of the critical applications apply. To maintain control of noncritical tank initial and subsequent usage, the using organization shall state the conditions and circumstances for use or change over including a statement of acceptance of responsibility in writing to Test Operations (RPPO) obtaining their prior approval.

c. CLEANING:

(1) Critical cryogenic tanks shall be cleaned or recleaned when any of the following conditions exist:

(a) When a product analysis or an internal visual inspection reveals contamination, either NVR or particulate or both, has passed permissible limits and emptying and reloading of the product if tried does not correct the problem.

(b) When a tank from extended storage status with reasonable record of acceptable cleanliness level and proper storage is to be placed in service, it shall be exempt provided the responsible user with knowledge of the history is willing to accept and assume responsibility for the tank in the "as is" condition in writing to Test Operations (RPPO) obtaining their prior approval.

(c) When a tank of unknown origin or cleanliness level is to be placed in service.

(2) Noncritical cryogenic tanks shall be cleaned or recleaned when any of the following conditions exist:

(a) When product contamination levels are great enough to cause operational problems.

(b) When a tank of unknown origin or cleanliness level is to be placed in service and a visual inspection of the ports or internally if possible reveals contamination which could likely cause operational problems.

5. CLEANING METHODS.

a. Cryogenic tanks which can be manually opened and entered shall be entered only in accordance with TI 1-7-3 and T.O. 00-25-235 and cleaned or recleaned in accordance with Method 1 or an acceptable equivalent.

b. Cryogenic tanks which are manufactured as closed tanks and cannot be opened or entered shall be cleaned or recleaned in accordance with Methods 2 or 3 or an acceptable equivalent.

6. CLEANING PROCEDURES.

a. METHOD NO. 1 - MANUAL CLEANING.

(1) Vacuum clean, if necessary, as much of the solid material in the vessel as possible. DO NOT SWEEP, as this raises large quantities of dust that cannot be removed from the vessel.

(2) Inspect condition of vessel and make any necessary repairs at this time.

(3) Cleaning solvents if not certified as to cleanliness, shall be passed through a 10 micron filter before use. Other types of cleaning solutions should also be passed through a 10 micron filter, if feasible. Potable or demineralized rinse water shall be passed through a 10 micron filter before use.

(4) Clean all outlets of the vessel using a snug fitting rag wad, go-devil or brushes soaked with cleaning solution. Water rinse if required. Manual scrubbing action shall be thorough enough to remove all material attached to wall surfaces. Bottom outlets only may be deferred until after the main vessel walls are cleaned.

(5) Clean 100% of internal surfaces of the vessel. Spray type solutions may be used; however, surfaces shall be thoroughly wiped or scrubbed with rags or brushes in all cases. Cleaning operations shall start at the top and proceed to the bottom. Water rinse if required. All puddles in the bottom shall be wiped up and a final cleaning of the bottom shall be made.

(6) Final inspection for cleanliness and closure shall be made at this point. Inspection and test methods, cleanliness levels, and acceptance limits shall be as specified in TI 5-1-5. If the tank does not meet the specified cleanliness level, local or complete re-cleaning shall be specified by the inspector.

(7) Close the vessel and pressurize to operating pressure with filtered (10 micron) clean dry nitrogen. The pressure shall hold over a 24-hour period within 3 PSIG, corrected for temperature. Closures shall not leak when leak test solution is applied.

(8) When pressure tests are satisfactory and using the same GN_2 supply:

(a) Purge the vessel by repeatedly pressurizing and dumping pressure until effluent gas smells sweet (no evidence of characteristic odors of the cleaning solution used) and the dew point registers -63°F or less.

(9) If the vacuum annulus had to be disturbed, replace insulation as necessary (see TI 2-2-2), close outer covers and obtain a vacuum of at least 1000 microns. Five-hundred microns or less is preferred. If vacuum annulus was not disturbed, replace insulation plug(s) and close outer cover(s).

(10) If feasible, reconnect piping and cold check by servicing with propellant.

b. METHOD NO. 2 - DETERGENT OR ALKALINE SOLUTION CLEANING.

(1) Connect flexible piping from a heated solution storage tank to the vessel to be cleaned. If possible, the fill line should be attached to a bottom vessel outlet and the return line should be attached to a top vessel (vapor phase) outlet.

CAUTION

DO NOT clean Aluminum Alloy vessels with caustic or alkaline solutions unless specifically approved.

(2) Pump in hot solution, 175 degrees to 180 degrees F, or as recommended by the manufacturer, to fill the vessel. Circulate solution for one half an hour. There shall also be a 10 micron filter in the return side of the system to remove particulate.

(3) While solution is circulating shake or rock vessel to slosh solution around the ullage space or up-end vessel in such a manner as to eliminate the entrapped air at the top of the vessel.

(4) Pump solution back to solution storage tank.

Note

Do not allow solution to "set-on" because of delay in proceeding with next operation.

(5) Fill vessel with ambient filtered (10 micron) demineralized water through the bottom outlet allowing the overflow to exit the top outlet. Shake vessel again to assure rinsing of the ullage space.

(a) For alkaline solutions - Periodically draw a sample of the emerging water into a glass beaker. Test the sample with a pH meter and examine it through transmitted light. The vessel is sufficiently rinsed when the alkalinity of the sample is the same as the inlet water and the sample is clear and free from suspended matter or sediment.

(b) For neutral solutions - Flow a volume (at least 6 times the capacity of the vessel) of demineralized water through the vessel. Draw a sample of water into a glass beaker and let settle for 10 minutes. The vessel is sufficiently rinsed when the sample is clear and free from suspended matter or sediment.

(6) Drain the vessel and purge with filtered (10 micron) warm, dry nitrogen gas until the escaping gas registers a dew point or -63°F or less.

(7) Inspection and test methods, cleanliness levels and acceptance limits shall be as specified in TI 5-1-5. Failure to pass inspection and test may require additional purging or recleaning as determined necessary.

(8) Reassemble vessel closures and piping as required.

c. METHOD NO. 3 - HOT SOLVENT VAPOR CLEANING.

(1) Inject hot solvent vapors into the vessel through a top outlet (vapor phase) until the escaping vapors from a bottom outlet (drain) are within 5 degrees F of the inlet temperatures.

Note

Solvent condensate should have stopped flowing from the outlet at this time. The condensate should be decanted or filtered before reuse.

(2) Drain the vessel and purge with filtered (10 micron) warm, dry nitrogen gas until the escaping gas smells sweet (no evidence of characteristic solvent fumes) and registers a dew point of -63°F or less.

(3) Inspection and test methods, cleanliness levels and acceptance tests shall be as specified in TI 5-1-5. Failure to pass this test may require additional purging or recleaning as determined necessary.

(4) Reassemble vessel closures and piping as required.

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ANON.: CONTAMINATION CONTROL HANDBOOK. NASA SP-5076, 1969.

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NASA SP-5076

TECHNOLOGY UTILIZATION

CONTAMINATION CONTROL HANDBOOK



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA SP-5076

CONTAMINATION CONTROL HANDBOOK

Prepared by Sandia Laboratories
under NASA Order Number H-13245A
for Marshall Space Flight Center



Technology Utilization Division
OFFICE OF TECHNOLOGY UTILIZATION 1969
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C.

CONTAMINATION CONTROL HANDBOOK

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NOTICE

COMMERCIAL NAMES AS USED HEREIN ARE FOR IDENTIFICATION ONLY AND THEIR MENTION DOES NOT CONSTITUTE ENDORSEMENT BY THE AUTHORS OR ANY GOVERNMENT AGENCY.

SECTION 2

CONTAMINATION CONTROL IN PRODUCT DESIGN

The objective of considering contamination control at the product design stage is to eliminate contamination that might constitute a hazard or interfere with the intended function of the product. All too often, contamination control procedures are not developed until after a product failure has taken place. It is difficult to foresee every potential contaminant in every case; but many costly rejects caused by contamination might have been prevented if contamination control had been a factor in product design. At this stage, features can be incorporated in the design to:

a. Minimize or eliminate sources of contaminant generation

b. Render the product least susceptible to contamination

c. Facilitate contamination removal and monitoring.

2.1 Control of Contaminants Through Product Design

To create a truly effective design, the product designer must be aware of more than just the function and reliability requirements; he must also be aware of the following factors of the total product life:

a. Cleanliness requirements

b. Manufacturing and processing environments

c. Manufacturing processes

d. Test procedures and equipment

e. Storage and use conditions.

In taking specific steps to control contamination, the designer should

a. Consider all possible sources, types, and amounts of contamination which the product may encounter

b. Be aware of the different control techniques available

TABLE 3-32

Effects of Common Cleaning Solvents on Materials

		EFFECT ON MATERIALS OF CONSTRUCTION			
		Plastics			
Chlorinated Hydrocarbons	Federal or MIL Specification	Polystyrene	Polyvinyl Chloride	Polyethylene	Bakelite (Phenolic)
Methylene chloride (dichloromethane, technical)	MIL-D-6998A-1 Grade A - 0.005% max acidity Grade B - 0.010% max acidity	Dissolves	Will damage	Will damage on prolonged contact	None
Trichloroethylene, technical	O-T-634a Type I - Regular Type II - Stabilized for vapor degreasing (Supersedes MIL-T-7003)	Dissolves	4 hours - swollen	4 hours - slight effect	None
1, 1, 1-trichloroethane, technical inhibited (inhibited methyl chloroform)	O-T-620a-2 (Supersedes Safety Solvent MIL-S-18718(Aer)-1 which consisted of 70% mineral spirits, 25% methylene chloride, 5% perchloroethylene)	Dissolves	1 hour - none 4 hours - slight swell	1 hour - none 4 hours - slight swell	None
Carbontetrachloride, technical grade (tetrachloromethane)	O-C-141 (Canceled)	Dissolves	5 min - none	5 min - slight swell	None
Blend of chlorinated solvents (composition proprietory)		Dissolves	10 min - none	1 hour - none 4 hours - slight swell	None
Perchloroethylene (tetrachloroethylene, technical grade)	O-T-236a (Supersedes O-P-191a)	Dissolves on long exposure	4 hours - none	4 hours - slight effect	None
Aromatic Petroleum					
Benzene, technical (benzol)	VV-B-231c Grade A - Industrial-grade benzene Grade B - Industrial-90 benzene	Dissolves			
Toluene, technical (toluol)	TT-T-548c	Dissolves			
Xylene (xylol)	TT-X-916b	Dissolves			
Naptha, aromatic (distilled from petroleum)	TT-N-97b Type I - Boiling range (190°-284°F) Grade A - high solvent power Grade B - low solvent power Type II - Boiling range (265°-376°F) Type III - Boiling range (340°-425°F)				

TABLE 3-32
(continued)

EFFECT ON MATERIALS OF CONSTRUCTION								
Elastomers			Wire Coatings, Insulating Varnishes, and Marking Inks					
Teflon TFE	Neoprene Rubber	Silicon Rubber	Formvar Polyvinyl Formal	Bondar	Glyptal 1201 Air-Dried	Glyptal 1202 Air-Dried	GE 9740 Baked	Ink
None	Swells	Swells	Severe crazing	Slight effect	Lifted	Lifted	Lifted	Removed
None	Swells	Swells	Will soften	None	Lifted	Lifted	Lifted	Removed
None	3 min - none 5 min - slight swell	3 min - none 5 min - swell	5 min - none	5 min - none	5 min - none	5 min - lifted	5 min - lifted	Some removed (will not remove epoxy-based ink
None	5 min - swell	Swells	Slight effect	None	Slight effect	Slight effect	Slight effect	Partially removed
None	5 min - slight swell	Swells	5 min - none	5 min - none	5 min - none	5 min - lifted	5 min - lifted	Partially removed
None	Swells on prolonged contact	Swells	None	None	None	Slight effect	Slight effect	Partially removed
	Dissolves							
	Dissolves		1 hour - softened					
			1 hour - solvent discolored indicating resin extraction					

TABLE 3-32
(continued)

		EFFECT ON MATERIALS OF CONSTRUCTION			
		Plastics			
Fluorinated Hydrocarbons	Federal or MIL Specification	Polystyrene	Polyvinyl Chloride	Polyethylene	Bakelite (Phenolic)
Trichloromonofluoromethane (fluorocarbon 11) (solvent grade)		Dissolves on long exposure	Slight effect	Slight effect	None
Trichlorotrifluoroethane (fluorocarbon 113) (solvent grade)	MIL-C-81302 Wep (Covers Freon PCA and equivalent grade solvents; is being revised to also cover Freon TF and equivalent grade solvents)	4 hours at 75°F - none 4 hours boiling - cracked and brittle	4 hours - none	4 hours - none	None
Aliphatic Petroleum					
Naptha, aliphatic (petroleum naptha)	TT-N-95a Type I - For organic coating Type II - For cleaning acrylic Type plastics				
Stoddard solvent (dry cleaning solvent)	P-D-680 (Supersedes P-S-661b) Type I - 100°F min flashpoint Type II - 140°F min flashpoint	5 min - none	None	None	
Mineral spirits Thinner; paint, volatile spirits (petroleum spirits)	TT-T-291c Grade 1 - Light thinner Grade 2 - Heavy thinner				
Oxygenated Solvents*					
Isopropyl alcohol (antiicing fluid and solvent)	TT-1-735c (Supersedes MIL-F-5566 and MIL-1-10428A) Grade A - 0.1% max water; for use in manufacturing Grade B - 0.4% max water; for use as antiicing fluid and solvent	5 min - none	5 min - extracts plasticizer	None	None
Methyl alcohol (methanol)	O-M-232d Grade A - 99.8% synthetic (solvent use) Grade AA - 99.8% synethetic ($H\text{-}CO_2$ generators) Grade B - 99% technical (solvent use) Grade C - wood alcohol (denaturing grade)	5 min - None	5 min - extracts plasticizer	None	None
Ethyl alcohol (ethanol)	O-E-760b (Supersedes O-A-396)	5 min - none	5 min - extracts plasticizer	None	None
Acetone, technical	O-A-51d	Dissolves	Dissolves	None	Dissolves

Source: "Cleaning Electronic Components," Jennings, R. L., Digest of Naval Aviation Wespons Systems; June 1966.

*Effects data determined by Sandia Laboratory, Albuquerque, New Mexico.

TABLE 3-32
(continued)

EFFECT ON MATERIALS OF CONSTRUCTION								
Elastomers			Wire Coatings, Insulating Varnishes, and Marking Inks					
Teflon TFE	Neoprene Rubber	Silicon Rubber	Formvar Polyvinyl Formal	Bondar	Glyptal 1201 Air-Dried	Glyptal 1202 Air-Dried	GE 9740 Baked	Ink
None	Slight swell	Slight swell						
None	1 hour - none	1/2 hour - 6% swell	100 hours - none	100 hours - none	Unknown	Unknown	Unknown	None
None	None	None	None	None	None	None	None	None
None	None	None	None	5 min - none none	5 min - none	5 min - none	10 min - none	Varies with ink
None	None	None	None	5 min - none	5 min - none	5 min - none	10 min - none	Varies with ink
None	None	None	None	5 min - none	5 min - none	5 min - none	5 min - none	Varies with ink
None	Swells	Extracts plasti-cizer	None	5 min - none	Dissolves	Dissolves	Dis-solves	Removes

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ELLENBURG, JANUS Y.: MONITORING CLEANING PROCESSES AND PROCEDURES. CONTAMINATION CONTROL: CURRENT AND ADVANCED CONCEPTS IN INSTRUMENTATION AND AUTOMATION. REP. SC-M-68-94, SANDIA CORP. (NASA CR-95657), SEPT. 1967.

AEC/NASA SYMPOSIUM

on

CONTAMINATION CONTROL

Current and Advanced Concepts in Instrumentation and Automation

Held at

HOLIDAY INN
Albuquerque, New Mexico

September 12-14, 1967

N 68-29333

3. MONITORING CLEANING PROCESSES AND PROCEDURES

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The cleaning of corrosion-resistant steel tubing for LOX and pneumatic service is specified by the same technique in MSFC-SPEC-10M01671 and KSC-C-123(D). A cleaning study program[1] was initiated to evaluate the cleaning process and media of these specifications and to revise the procedure as necessary to advance the present state-of-the-art of field cleaning. Level III cleanliness was proposed as a realistic goal for field systems.

Two test facilities were constructed for this program. Preliminary testing of cleaning media was accomplished with a laboratory pumping station. Clean-media that were successful in the laboratory were then evaluated with a closed-loop field pumping station. The field pumping station was designed for heavy duty service. It contained a removable 100-foot test specimen with two 30-inch sections for hydrocarbon and particle analyses in the laboratory.

Solutions were circulated through inlet 2-micron filters and returned to the storage tanks through outlet 10-micron filters. A bypass system was available to adjust fluid flow rates without involving the test specimen. Winter conditions were simulated by passing GN_2 through cooling coils immersed in the solutions. The test specimens and return line were cooled with an ice water bath or dry ice as required. There was a sampling port with an attached Millipore filter bomb at the downstream end of the 100-foot test specimen. The filter bomb was used to obtain particle analyses of the circulating fluids. The 30-inch sections were returned to the laboratory for an ultimate cleanliness check on the specimen itself.

Both laboratory and field tubing specimens were artifically contaminated with a mixture of 90% by weight heavy mineral oil and 10% triolein. This mixture was representative of typical lubrication compositions[2] used for working corrosion-resistant steels. The contamination mixture included 300 mg of the hydrocarbon mixture per square

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[1]Research was supported in part by NASA, EDV-151 Division, under contract NAS8-2483. NASA Rpt. No. 10911, Vol. I Dec. 1965: Vol II Aug. 1966.

[2]Forbes, W. G., "Lubricants and Cutting Oils for Machine Tools", John Wiley & Sons, Inc., New York, New York 1943.

foot of critical surface area plus the addition of 4% of the total hydrocarbon weight as A.C. spark plug dust and salt (1:1), and 3 milligrams of red cotton linters (20-1000μ in length).

After the pumping stations were fabricated, the sequential operation of cleaning, rinsing, and purging was performed according to the cleaning procedure under study. The various media were monitored for their efficiency in removing hydrocarbons and particles during the cleaning and rinsing cycles in addition to the test sections being checked for particles and hydrocarbons remaining on the tubing after the cleaning procedure was completed.

Analytical Procedures

Monitoring the cleaning efficiency of various procedures necessitated the validation of Test Methods A and B of MSFC-SPEC-10M01671 and KSC-C-123(D), as well as the development of an analytical procedure for the aqueous cleaning media. The nonvolatile residue (NVR) of Test Method A was limited to a maximum of 1 mg/sq. ft. of critical surface area for Level III cleanliness. Prior clean room experience with the NVR procedure had often led to negative or erratic results. Erratic results could be anticipated since the NVR residue was often less than 1 mg, and it was subjected to 220°F for approximately 4 hours.

In 1957, Istomina[3] showed that an evaluation of this gravimetric NVR method was characterized by low sensitivity and accuracy. For residues containing 3 mg or more, the error was 42%. For NVR samples of less than 3 mg, the loss of residue during treatment of the sample on a steam bath was 52%, as shown in Table 1. The observations were supported by the work of Gebhart and Reynolds[4] on the fundamentals of the evaporation of hydrocarbons. They demonstrated the Langmuir-Knudsen correlation of the proportionality of the rate of evaporation to the number of molecules on the surface, i.e., total surface area covered with molecules at any instant. The evaporation coefficient for hydrocarbons was a function of experimental conditions and not a characteristic property. In the determination of hydrocarbons in oil field waste waters, Kirschman and Pomery[5] measured the rate of hydrocarbon loss per hour during the evaporation of solvent extract on a steam bath. The average rate of hydrocarbon loss was 8 percent per hour for diethyl ether, methylene chloride, chloroform, and benzene solvents. These published findings correlated with the results obtained in this study that a minimum of a 35 percent evaporation loss could be expected and that the losses were dependent upon actual experimental parameters. The evaporation of the trichloroethylene solvent on a steam bath with a resultant nonreproducible residue was discarded as an unsatisfactory procedure.

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[3]Istomina, K. E., Trudy Gosurdarst. Nauch. Issledovatel. i Proekt. Inst. Azot. Prom. 1957, No. 8, 248.

[4]Gebhart, H. J., Jr., and Reynolds, W. W., Am. Chem. Soc. Div. Petrol. Chem., Preprints 5, No. 3, 83 (1960).

[5]Kirschman, H. D., and Pomeroy, R., Anal. Chem. 21, 793 (1949).

TABLE 1

HYDROCARBON EVAPORATION LOSSES ON A STEAM BATH

Investigator	Sample Size (milligram)	Average % Loss
Istomina	>3	42
	<3	52
Kirschman & Pomeroy	1-5	8/hour
Ellenburg	2	35
	1	54

Since the cleaning of the corrosion resistant steel tubing required the use of a trichloroethylene rinse, it was still necessary to find some way to determine the hydrocarbon content of the rinse. The next analytical approach was the concentration of the hydrocarbons by evaporation of the trichloroethylene at reduced pressure. This technique produced some interesting anomalies. Ten milligrams of U.S.P. mineral oil was added to 500 ml aliquots of commercially stabilized trichloroethylene. The contaminated solvent was then evaporated at 83°C and a reduced pressure of 500 mm of mercury produced by a water aspirator. The experimental apparatus was similar to Buchler system. The evaporation time was 30 minutes in contrast to the usual 4 hours that were necessary for evaporation on a steam bath. The evaporation was interrupted at about 25 ml total volume so that the samples could be analyzed by infrared differential absorption spectrophotometry. During the 30 minutes necessary to effect a 1:20 concentration of the solvent, approximately 40% of the mineral oil was lost, as noted in Table 2. The reason for the loss was the volatility of the mineral oil. All organic compounds have significant partial vapor pressures. Dalton's law that the total vapor pressure of a system is the sum of the effective partial pressures must be satisfied. During the evaporation of the samples, the ratio of the stabilizer to trichloroethylene was found to increase. The exact nature of stabilizers used in commercial trichloroethylene are proprietary; however, they are organic compounds with identifiable infrared absorption characteristics. Infrared absorption at the 2924 cm^{-1} band equivalent to 19 mg of paraffinic hydrocarbons was gained from the increase in the ratio of stabilizer to trichloroethylene in these experiments. This represented an average gain of 190% over the originally added mineral oil; therefore, the two sets of errors tended to compensate each other. When the experiments were repeated, the contaminated solvent was evaporated on a steam bath for about 4 hours to a constant volume of 25 ml. There was a range of 32 to 54% loss of hydrocarbons and a gain of 16 mg from the stabilizer. These experiments again support the literature that the evaporation of solvent-hydrocarbon systems are erratic and a function of specific analytical conditions.

It was impossible to analyze quantitatively the trichloroethylene for contamination by evaporating the solvent as required in Test Method A. The next step was to attempt to find an analytical method that

TABLE 2

Variation in Composition During Evaporation of 0.05% Stabilized Trichloroethylene

Method	Oil Added (mg)	Oil Remaining at 25 ml Total Volume (mg)	% Loss of Oil	Apparent Gain of oil From Stabilizer (mg)	% Gain
Reduced	10	5.75	42.5	20	200
Pressure	10	6.00	40.0	18	180
Steam	10	4.62	53.8	15	150
Bath	10	6.17	38.3	17	170

TABLE 3

Hydrocarbon Recovery From 13X Molecular Sieve at 26°C

Hydrocarbons Added (γ/ml trichloroethylene)	Percent Recovery
10	87
10	91
50	92
50	86
100	90
100	92
	Average 89.7

would use the solvent in its original state. The hydrocarbon contamination was separated from the trichloroethylene by adsorption with Type 13X molecular sieves. The sieves were eluted with carbon tetrachloride at 26°C, and the eluate was analyzed for hydrocarbon content by infrared differential analysis. The method showed 90% recovery of as little as 10 γ/ml of hydrocarbons in trichloroethylene (Table 3). The time required for the sieves to come to adsorption and desorption equilibrium was 24 hours; therefore, the method was not suitable for routine analysis.

Infrared spectrophotometry would be an ideal solution to the problem of analyzing the contaminated trichloroethylene. Only about 45 minutes of analytical time would be required per sample, and no laboratory manipulations would result in the loss of hydrocarbons. Missile degreasing grade trichloroethylene, by differential analysis, was analyzed in the "as received" condition to a lower limit of sensitivity of 150 micrograms of hydrocarbons per milliliter of solvent with a

Perkin-Elmer Model 237 infrared spectrophotometer. This arbitrary lower limit of sensitivity was imposed by the loss of differentiation of the signal-to-noise ratio of the hydrocarbon infrared absorption peak at 2924 cm^{-1} imposed over a major absorption peak of the stabilizer present in the trichloroethylene. The signal-to-noise ratio was improved by the use of a scale expansion accessory to expand a selected portion of the total radiant energy output of the instrument. In this case, it was possible to expand the instrument output between 72 and 82% transmission at 3000 to 2900 cm^{-1} to lower the limit of sensitivity of the infrared differential analysis to 10 micrograms of hydrocarbons per milliliter of stabilized trichloroethylene, as shown in Table 4. The absorbances followed Beer's Law and had satisfactory precision.

TABLE 4

Infrared Analysis of Trichloroethylene

(Differential Absorption and Scale Expansion)

Hydrocarbons (γ/ml of trichloroethylene)	Log I_o/I at 2924 cm^{-1}
150	0.274 ; 0.275
100	0.176 ; 0.177
50	0.095 ; 0.097
10	0.024 ; 0.021

Scale expansion provided a suitable method for the infrared analysis of the bulk quantities of trichloroethylene that were to be used in the field pumping station. However, the test sections of cleaned tubing were checked in the laboratory after the cleaning procedure was completed. If they were rinsed with a solvent having solvency capabilities equivalent to trichloroethylene, but not having carbon-hydrogen bonding to interfere with the 2924 cm^{-1} infrared band, the limit of sensitivity for detecting hydrocarbons could be significantly lowered. The lack of carbon-hydrogen bond in the molecule limited the solvents to carbon tetrachloride and trichlorotrifluoroethane.

A comparison of solvent properties as listed in Table 5. Carbon tetrachloride whould be selected on the basis of the comparison of the Kauri-butanol values, which are a measure of the solvent efficiency of a material evaluated on a volume basis. The fluorocarbon solvent would be selected on the basis of personnel safety. Since these checks were to be performed by qualified laboratory personnel in a well exhausted hood, the concern for safety was no greater than that for normal laboratory operations. In addition, the carbon tetrachloride had a higher boiling point which approximated that of trichloroethylene.

Type 304 stainless steel panels, 3-1/4 by 1-1/4 inches, were coated on one side with 10 mg of the contamination oil mixture. A panel was then rinsed with 1 ml increments of one solvent for four successive times. Each rinsing was collected separately and analyzed for total hydrocarbon content by infrared differential analysis. The average removal rate of 7 tests for each solvent is shown in Table 6. The distribution coefficient for the fluoronated hydrocarbon was 0.85 while that

of carbon tetrachloride was 0.98. The actual minimum volumes of solvent necessary to effect these distribution coefficients were in the ratio of 1 volume carbon tetrachloride to 4 volumes fluorocarbon. These results were supported by the same approximate ratio of Kauri-butanol values. Material balance studies of rinsing contaminated tubing with carbon tetrachloride showed that 99.5 per cent of the contamination was recovered from the tubing.

TABLE 5

COMPARISON OF SOLVENT PROPERTIES

Compound	Maximum Boiling Pt. ^{o}F	Kauri-Butanol Value	Toxicity (ppm by volume)
$C_2H_2Cl_3$	190	130	200
CCl_4	172	114	25
$C_2Cl_3F_3$	118	31	1000

TABLE 6

RESULTS OF PANEL DEGREASING TESTS[a]

Rinse No.	Mg Oil Removed Per Rinse (avg. 7 tests)	
	$C_2Cl_3F_3$	CCl_4
1	8.50	9.81
2	1.10	0.18
3	0.24	N.D. < 0.01
4	0.13	N.D. < 0.01
Total	9.97	9.99

(a) 10 mg oil on 3-1/4 by 1-1/4 inches Type 304 steel panels

The investigations of Rather[6], Lecomte[7], and Simard[8] had all shown that the determination of total hydrocarbon matter in refinery effluent water was best accomplished by extracting the waste water with carbon tetrachloride and quantitatively determining the hydrocarbons by infrared absorption at 3.5 to 3.38 microns. Therefore, the final analytical technique for this program consisted of using carbon tetrachloride as the extraction medium for monitoring the aqueous solutions and as the flushing solvent for the test sections used to determine hydrocarbon residues. Since the carbon tetrachloride was required to be of spectrophotometric grade, cost considerations dictated the use of the fluorocarbon solvent or trichloroethylene for the larger flushing volumes necessary for particle analyses. Hydrocarbons were determined by infrared differential analysis at 2924 cm^{-1} with a Perkin-Elmer Model 237 double-beam automatic spectrophotometer. The absorbances followed Beer's Law and the overall analytical method had 99.5 percent recovery of hydrocarbons in the 1 to 10 milligram range. Typical data for ten complete analyses showed excellent precision with a coefficient of variation of 0.5.

Particle populations were determined as directed by Test Method A and Level III cleanliness of MSFC-SPEC-10M01671. While the manual counting of particles leaves much to be desired, no commercially available automatic particle counters appear to be able to perform the task with precision and accuracy and at reasonable cost. Laboratory technicians trained until they were able reproducibly to count standard filters seemed to be the best solution of the problem for this program. There were over 15,000 particle counts consisting of samples of circulating fluids taken in the field with Millipore filter bombs and those of the cleaned tubing taken in the laboratory by solvent flush. The filter bombs were limited to manual counting. There is some interest in a commercially developed television-microscope combination for counting filters. The projected television image of the filter can then be electronically scanned. However, this instrumentation has not yet progressed to being a useful tool.

The volume of solvent to flush cleaned tubing should be maintained at 500 ml/sq. ft. The reduction of volume to 100 ml/sq. ft. that is allowable in MSFC-SPEC-10M01671 for larger parts was unsatisfactory, as shown in Table 7. Several 2-inch diameter tubes were contaminated, cleaned, and then checked with successive 300 ml portions of solvent. Each particle count was an average of 7 tests. While this was not extensive testing, it was indicative of a situation that could not be ignored. The larger volume of solvent was particularly necessary for the fluorocarbon solvents with their lower solvency power since it was first necessary to solvate any hydrocarbon "glue" that held particles to the wall of the tubing before they could be rinsed out.

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[6]Rather, J. B., Jr., et. al., Anal. Chem. 30, 36 (1958).

[7]Lecomte, J., Bull. soc. chim. France 1949, 923.

[8]Simard, R. G., Hasegawa, T., Bandaruk, W., and Headington, C. E., Anal. Chem. 23, 1384 (1951).

TABLE 7

Particle Removal From Three Square Feet Surface Area

Rinse No.	Volume Used (ml)	Average Particle Count[(a)] > 35 Microns	
		$C_2H_2Cl_3$	$C_2F_3Cl_3$
1	300	82	55
2	300	31	26
3	300	10	32
4	300	5	27
5	300	2	18

(a) Series of 7 tests

The following conclusions can be drawn from this study:

1. The NVR procedure is an unreliable method of analysis. This unreliability is the result of a thermodynamically inherent error since the effective partial vapor pressures of the organic constituents cannot be eliminated.

2. Infrared differential spectrophotometric analysis of the solvent test solution is a reproducible and precise substitute method of analysis.

3. The infrared technique is simple enough to be adapted to on-stream automated control with existing present state-of-the-art equipment.

4. Fluorocarbon solvents cannot be indiscriminately substituted for trichloroethylene in Test Method A since they have less capability for dissolving hydrocarbons. They require a comprehensive study and revision of the test procedure before use.

5. The minimum value of 500 ml of solvent per square foot of critical surface area is essential for effective particle removal even for large parts.

Cleaning Studies

Once the analytical procedures were determined, Procedure 3 of MSFC-SPEC-10M01671 for cleaning corrosion-resistant steel tubing was evaluated. It was soon evident that the excessively high solution temperature and the highly alkaline trisodium phosphate specified in Procedure 3 created numerous technical and economic problems. Various new cleaning media and procedures were then investigated in order to develop a new procedure for cleaning corrosion-resistant steel tubing in closed-loop systems.

During the course of this investigation, 9,300 linear feet of tubing was cleaned by using various formulations in the field pumping station. The tubing could be field cleaned to Level III cleanliness under diverse environmental conditions. The following generalizations were developed from the reduction of this data:

1. Particles and fibers were removed more efficiently by the cleaning cycles than by the rinsing cycles. Cleaning removes approximately 2 to 5 times as many particles and fibers as rinsing.

2. The rinsing cycles show a maximum in particle and fiber removal 5 to 10 minutes after the start of the filtered tap water rinse.

3. The first 10 minutes of the filtered tap water rinse removed at least 90% of the hydrocarbons.

4. The rinseability of surfactants and surfactant-soil micelles are temperature sensitive in closed-loop circulating system. Increased temperature results in increased rinseability. At any given temperature, low foaming surfactants rinse more easily than moderate or high foaming surfactants.

5. The particle content of circulating media is not necessarily a measure of the final level of cleanliness of the system. Each system must be evaluated under anticipated operating conditions.

6. The final hydrocarbon level of cleanliness of a system can be related to the angle formed by the cleaning solution in contact with the contaminated metal surface. This equation is

$$C = k \tan \theta$$

where c = hydrocarbon residue remaining after cleaning in mg/sq. ft.
k = experimental constant for the system
θ = contact angle

Velocity Studies

The evaluation of the GN_2 purge of Test Method B of MSFC-SPEC-10M01671 was requested in the original work statement of this study. The 7 SCFM rate of Test Method B was to be compared to a maximum feasible GN_2 velocity purge for the same time after the tubing specimens were cleaned and dried. Test Method B required a GN_2 purge of 7 SCFM for 3 minutes and a 0.45μ Millipore filter downstream of the test specimen to retain the dislodged particles. This low flow rate of GN_2 probably did not dislodge all of the particles remaining in the tubing after cleaning. To test the validity of this assumption, a maximum feasible velocity GN_2 purge for 3 minutes was used immediately after Test Method B. The maximum flow rate attainable without extensive

alterations in the present cleaning system was 35 SCFM at 350 psig. In addition to counting the particles retained by the Millipore filters from Test Method B and the maximum feasible velocity test, the 30-inch test section was returned to the laboratory for an additional particle check. The test section was rinsed with solvent and the particles checked as usual by Test Method A. Thus, the test section provided an additional check on the effectiveness of the 35 SCFM purge for dislodging particles. Although the testing by Test Method B was satisfactory to Level III particle population, the additional 3 minute maximum velocity purge always dislodged almost three times as many more particles and fibers as shown in Table 8. After extensive testing of cleaned tubing, it was evident that the nitrogen velocity of Test Method B was not sufficient to provide an adequate particle population check. At this point in the study, an additional 0.45μ Millipore filter was added immediately upstream of the specimen. This eliminated the necessity of a blank count on the purging nitrogen. It also provided assurance that all particles retained by the downstream filter were generated by the specimen.

TABLE 8

Typical Evaluation of the Effectiveness of Test Method B

Tubing Size (Inches)	Contamination Range (microns)	Test Method B	3 min Max Velocity Purge	Test Method A After Purges
	Particles			
3/8	0-35	263	567	15
	36-60	6	13	12
	61-95	0	4	2
	96-135	1	0	1
	136-170	1	2	0
	171-350	1	3	0
	350+	0	5	1
	Fibers			
	0-35	0	10	2
	36-350	2	10	5
	351-700	1	5	2
	701+	0	3	2
	Particles			
1-1/2	0-35	100	275	20
	36-60	2	12	14
	61-95	0	6	5
	96-135	0	0	5
	136-170	0	1	0
	171-350	0	0	1
	350+	0	2	0
	Fibers			
	0-35	4	2	5
	36-350	8	13	11
	351-700	0	0	0
	701+	0	2	1

The variation of GN_2 velocity with tubing size could be calculated to a first approximation. By combining the equation of Continuity and the Perfect Gas Law, a useful equation for the velocity of the nitrogen was derived in terms of quantities that could be determined during actual testing:

$$V = \frac{0.0849\ QT}{Pd^2}$$

where

V = velocity in ft/sec
Q = flow in SCFM at exit of 100 foot test specimens
T = temperature in or at point of measurement
P = pressure in psia at point of measurement
d = inside diameter of tube in inches

A reasonable approximation of the variation in actual tubing velocities could then be obtained by measuring the temperature and pressure of the gas at points located 10 and 90 feet downstream of the beginning of the test specimen. Calculations were made for exit velocities of 5, 10, 15, 20, 30, and 40 SCFM. These experiments showed some interesting anomalies, as presented in Table 9. By the time the tubing diameter had increased to 1 inch, the exit gas velocity had had decreased by a factor of 20. The velocity had decreased by a factor of 80 with 2-inch tubing. This variable is not recognized in Test Method B, and it is one reason why the test is not reliable.

TABLE 9

Observed Tubing Velocities

Tubing Size (inch)	Flow Rate (SCFM)	Tubing Inlet Velocity (ft/sec)	Tubing Outlet Velocity (ft/sec)
1/4	5	44.0	80.5
	30	81.8	166.0
3/8	5	30.5	35.6
	30	70.5	87.0
1	5	3.87	3.92
	30	9.5	9.6
2	5	1.035	1.035
	30	2.60	2.66

Preliminary experiments with purging the cleaned tubing had indicated that a longer purge time might eliminate most of the particles. A new procedure was initiated for the remaining 80 experiments. After the tubing was cleaned and dried, it was

1. Checked by Test Method B
2. Checked by 3-minute maximum feasible velocity purge
3. Purged for 30 minutes at maximum feasible velocity
4. Rechecked with 3-minute maximum feasible velocity purge
5. Checked in laboratory by Test Method A (30-inch test section).

Typical results of the total counts of these experiments are shown in Table 10. The following conclusions may be drawn from these experiments:

1. Test Method B was not an effective check for particle population.
2. Gaseous purging of a system after cleaning was advantageous in removing particulate contamination. The minimum effective parameters for dislodging particles were a 30-minute purge of GN_2 at a minimum flow of 35 SCFM in 2-inch or smaller diameter tubing. A higher flow rate of GN_2 with the resulting greater turbulence within the tubing should be used whenever possible.
3. A more meaningful gaseous test method would consist of a 10-minute purge with a specified minimum velocity, expressed in ft/sec, determined at the point where the filter is located for collecting the particles. A recommended minimum velocity would be 10 ft/sec.
4. The use of Test Method A (liquid flush) to check the particle population was preferred rather than any type of GN_2 purge if it is feasible to adapt Method A to the system being checked.
5. A satisfactory Level III particle check by Test Method A on the 30-inch test section used in this Cleaning Study Program was representative of the level of cleanliness of the entire 100-foot test specimen.

There was no direct correlation between the velocity of the GN_2 and the total number of particles removed by purging the tubing cleaned in this study. However, there was an uncontrolled variable in the experiments since the tubing was already cleaned before purging. The total number and size distribution of the particles remaining after cleaning were purely chance. Additional experiments would be necessary to ascertain the maximum particle size of a specific density that could be moved by specific velocities, as well as to determine what correlation existed between total particles dislodged and the velocity of the purging gas. The removal of hydrocarbons from tubing by purging is another problem that must be discussed another time. However, it is sufficient to note that anomalies also exist in this field and that this technique merits extensive investigation.

TABLE 10

Test Method B and Maximum Feasible Velocity Particle Checks

Exp	Blend	Tubing Size (inches)	Test Method B Total Count		1st 3-Minute Max Velocity Purge Total Count		30-Minute Max Velocity Purge Total Count		2nd 3-Minute Max Velocity Purge Total Count		Test Method A 30" Test Section	
			Particles	Fibers	Particles	Fibers	Particles	Fibers	Particles	Fibers	Particles	Fibers
175	VII	1	1264	34	1820	21	3838	31	492	2	61	17
182	VII	2	157	10	1480	25	3100	25	505	9	539	23
184	VII	3/8	81	1	535	7	776	25	233	8	45	12
189	V A	1/4	2494	22	279	15	6181	16	815	1	220	10
193	V A	1-1/2	1590	21	3908	21	7512	23	1203	10	721	3
197	V A	1	2139	6	3202	21	6561	32	1818	22	630	7
201	X	1	8231	19	9731	18	8933	12	3023	4	214	4
204	X	2	836	29	1111	7	2939	50	754	8	90	10
206	X	3/8	970	20	916	13	869	9	363	7	91	14
213	X A	2	867	25	1139	25	5447	52	1365	13	818	13
214	X A	3/8	859	22	3229	18	5461	77	1527	25	923	13
219	X A	1-1/2	713	9	1434	19	-	-	-	-	516	9

Summary

Monitoring the cleaning efficiency of various procedures necessitated the validation of Test Methods A and B. Both methods, per se, proved to be inaccurate. Evaporation of the test solvent of Method A for nonvolatile residue content was erratic. This procedure incorporated a thermodynamically inherent error since effective partial vapor pressures of the organic constituents could not be ignored. Infrared differential absorption spectrophotometric analysis of the solvent test solution provided a reproducible and accurate substitute method of analysis. Other sophisticated analytical methods of instrumental analysis, such as gas chromatography, could be incorporated into the monitoring system. For Test Method B, extensive development is necessary to correlate purging parameters with the intrinsic volatility characteristics of contaminating hydrocarbons, and with the size and specific density of particles. In conclusion, it must be emphasized that there is a great gap between recognizing that a test method is inadequate and defining the basic theoretical parameters necessary to upgrade that test to a meaningful and accurate method.

END OF REFERENCE
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REFERENCE
28

ANTHONY, H. V.; MCDONALD, J. P.; AND PICCONE, M.: AUTOMATED FINAL CLEANING, RINSING, AND DRYING STATION. CONTAMINATION CONTROL: CURRENT AND ADVANCED CONCEPTS IN INSTRUMENTATION AND AUTOMATION. REP. SC-M-68-94, SANDIA CORP. (NASA CR-95657), SEPT. 1967.

AEC/NASA SYMPOSIUM

on

CONTAMINATION CONTROL

Current and Advanced Concepts in Instrumentation and Automation

Held at

HOLIDAY INN
Albuquerque, New Mexico

September 12-14, 1967

N68-29334

4. AUTOMATED FINAL CLEANING, RINSING, AND DRYING STATION

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Introduction

All existing methods for final cleaning, rinsing, and drying of aerospace vehicle fluid system components require a rinse and a transfer of the sampling fluid to another position or location for analysis. Aerospace industries have relied on criteria that have not been dimensionally defined, at least in the areas of force of impingement, velocity, orientation of the surface being sampled, accessory sampling energy, and other characteristics that vitally affect the validity of results. Due to this lack of definition, the results have been almost totally dependent on operator interpretation. As a result, reproducibility of final rinse results and hence specification conformance have been inconsistent from program to program and, in some cases, from component to component.

This paper discusses a means of completely quantifying and automating the evaluation rinsing, sample collection, and sample preparation (filtration, evaporation, drying, etc.) operations necessary for the qualification of hardware to aerospace vehicle fluid system cleanliness criteria for particl and nonvolatile residue content.

In addition to providing this unique capability, the equipment discussed would permit all of the operations from final cleaning through sealing to be performed in a normal factory environment. This last ability is not essentially novel, but the elimination of the requirement to perform separate manual evaluation rinses and to remove the effluents to another location for analysis would provide a new dimension of practicality.

Thus, commercially clean hardware could be placed in a chamber and, with no further handling, be removed as qualified hardware into a clean environment for assembly or sealing with no delays due to laboratory support activities, or the extra rinsing and processing preparatory to these support activities.

Adoption of the method would offer significant savings in personnel time and handling costs. However, the convenience and cost-savings factors are clearly secondary to increased reliability of sampling and analysis, reduced number of rejects, the use of much more stringent particle level criteria, and the capability of defining and programming the exact evaluation rinsing conditions.

Soluble Versus Particulate Contamination

One can develop many classification systems of the sampling methods, analytical methods, and tests (including visual inspections) that are applicable to the contamination control of fluid-conducting surfaces and operational or service fluids that constitute Aerospace Vehicle and Spacecraft Operational Fluid Systems. Probably in initial, fundamental division is the separation of the contaminant being evaluated into its nature of occurrence; that is, whether it is particulate contamination or is essentially fluid contamination. The latter category includes contaminants dissolved in the flush or operational fluid, as well as colloids, sols, gels and particulate suspensions which are not filterable by the membranes specified for particulate analysis and which are invisible as a separate phase in the specified methods of examination of the fluid.

Sampling of fluid or condensable gaseous contaminants from hardware is usually performed by a solvent flush which has a known solvency for the contaminants of interest or by absorption or absorption on a media through which a gaseous test fluid effluent from the surfaces being evaluated is passed.

The flow rates and input energy conditions, other than temperature, usually are not critical to the sampling operation for the reason that the solvent and the time of contact will usually assure that a homogenous distribution of the soluble contaminant will be achieved in the effluent, or that a sufficient indication will be achieved to flunk the criteria. The condensable gaseous contaminants are commonly assumed to be homogenously distributed in the gaseous test media by molecular diffusion and by the nominal turbulence of minimal sampling flow rates so that any portion of the effluent may be regarded as an aliquot. Indeed, it is common practice to limit severely the flow rates and pressure in the latter determination and to require a quiescent soak time to ensure a representative or significant indication of the gaseous condensables. Thus severe energy inputs in the sampling process (other than temperature) are usually not necessary, and are sometimes regarded as detrimental to the process.

These considerations for hardware are based also upon the premise that fluid or dissolved contaminants in the test medium are normally residual -- that is, they were built into the hardware in the act of manufacture and will not accrue by transport into the system in the operational fluids. Also, they will not ordinarily be generated by the system itself once it is closed up and experience only operational or blanketing fluid for the remainder of the operational period (before system entry for modification, servicing, or component replacement).

The considerations of optimum sampling parameters for particulate contaminants, however, dictate the use of a diametrically opposed approach for this operation. For particulate sampling, temperature is not important since molecular diffusion is not involved; also, the maximum mechanical energy input conditions attendant to the process that can be practicably achieved are desired. Efforts are made to tap the system with hammers during sampling, vibrate it with air hammers or electric vibrators, produce cryogenic shock by filling it with cryogenic fluids, produce maximum turbulence by high-velocity test fluid flow (through as large a sampling orifice as possible), and deliberately slam fast-acting valves open and closed to produce hydrostatic or inertial shock.

Why? Because it is known that mechanical energy is the only efficient way of dislodging particles and fibers to permit their removal. Whereas the migration of the fluid contaminants is caused by their own molecular and atomic energies, all of the motivating energy for the diffusion and transport of particulates must come from sources exterior to the contaminants.

In the size-ranges and types of particulates normally encountered, the chief concern is with frictional or mechanical entrapment of particle matter existent prior to sampling and with materials of construction which become particulates during normal operational life of the system. The former category includes: casting sand, abrasive blasting media and machining tool fragments embedded in metallics, inclusions in elastomers, and foreign particles cemented by corrosion products or processing fluid residues. The latter category includes in-place corrosion products, heat treat scale, weld scale, deteriorating conversion coatings, plating or nonmetallic coatings, and fragments of the construction materials. These fragments are generated by shearing, spalling, friction, and fracture due to impact and abrasion, structural stress, chattering, vibration, thermal and hydraulic shock, hydrostatic pressure, or by any conceivable change of potential-to-kinetic energy in the system during operation.

The facts are that systems designed with even the most compatible materials and sound engineering principles wear out. They wear out by distortion of or loss of material, some of which moves downstream as particulates in the operational fluid.

Although this function is cumulative and partially time-dependent with respect to the aging characteristics of the materials subjected to daily and seasonal variation of temperature, operational cycles, seismic shock, etc. a representative indication of the particle generating potential of systems can best be obtained by an accelerated, vigorous energy-input schedule during the evaluation purge or flush for particulates.

This operation is intended to knock the obstinate particles loose from significant surfaces and produce that efflux of particulates, qualitatively and quantitatively representative of those which will be spawned by the system in service.

As already stated the sampling needs of "soluble" contaminants are well provided for by the selection of suitable solvents or miscible gases and by temperature regulation. This is true for the significant surfaces of details and assemblies and for operational fluids.

For particulates however, although some attention is given to suitable kinetic energy inputs for operational fluid and for system hardware sampling, the parameters of sampling of particles and fibers at the detail part level are totally neglected unless the part is a conducting component, such as a hose subject to minimum sampling flow rates, or a tank subject to defined impingement and flush procedures.

It is also important to consider that the components for which no energy input requirements are defined (that is essentially monolithic details with exterior or partially exposed and unshielded significant surfaces) comprise probably in excess of 98% of the flyable hardware and substantially all of the dynamic hardware -- that is

surfaces which are required to move differentially to perform their required function in flight. Outside of orifice plugging considerations then, these latter components are the very ones that we can least afford particle contamination on. They include critical sliding and rolling surfaces of valves, pumps, regulators, and actuators which take the most mechanical punishment in flight and during transfer operations in the ground support equipment.

The failure to supply energy-input requirements for sampling parameters for detail parts and components is a very serious error. For assembled components and subsystems, it is recommended that these be sampled for particulates only when they are experiencing the total spectrum and amplitude of launch and flight vibration (or worst-service impact for ground equipment) and while they are simultaneously being flowed with test fluids that adequately simulate the physical and chemical forces of operational flow. In most instances, this is the operational fluid itself. In addition effluents should be examined in total for particulate content, or representatively sampled by means of turbulence-producing or isokinetic sampling devices, and processed for analysis by microscopic examination of membrane-filtered deposits.

For detail parts, the solution to the problem is for the industry to adopt automated final rinse methods in a cabinet-type operation, with programmed, universally established energy inputs, automatic processing of effluent for determination of particulates, and possibly, automatic processing of effluent for fluid contaminant determination.

Some of the Automatic Final Cleaning Cabinet manufacturers have taken steps to integrate automatic particle monitoring devices in the fluid streams of their equipment. As yet, however, there is no indication that any of them have placed this capability where it will be most significant, in the effluent stream from the chamber.

Also, none has provided the capability for microscopic examination of membrane-filtered effluent particulates as a portion of the device. This capability is vital because the diagnostic and qualitative information afforded by microscopic observation of the filtered particulates cannot be obtained from any automated counting machines existent or conceptual. The zone-sensing devices for counting particles in fluids provide information for flowing operational fluid streams that microscopic methods cannot, since the microscopic method is necessarily a batch type sampling device. In this application however, this limitation does not apply since the automated final rinse cabinet operation is also a batch method and the entire effluent from it may conveniently and practicably be routed through the membrane. The In Line Filter Holder and Counter (ILFHC) is regarded as an important portion of this concept.

In Line Filter Holder And Counter

Figure 1 shows an earlier configuration of the ILFHC proposed specifically for automated Final Rinse application. It is designed for extremely rapid replacement of the filter medium, low hydrostatic pressure application, and simplicity of operation. These are oriented toward its intended operation in a semi-fixed, sheltered location on a fast, repetitive cycle.

The sampling fluid stream enters the apparatus through the upper flexible tubing (A), which may be any inert, nonfriable, abrasion-resistant plastic such as Teflon, Tygon, or Kel-F. This tubing must be sufficiently long to permit the rotatable portion of the assembly (all portions except mounting bracket (O) and the microscope attached to it) to rotate on bearings (M) about the axis in an arc of 180 degrees in either direction from the neutral position without collapsing the tubing.

The sampling stream is then conducted through the inlet tube (B) into the upper filtration chamber and through the filter (D) supported on the backup screens (E, F). The fluid then passes out of the assembly through the outlet tube (H) and is returned to the source system through the flexible tube (I).

Note that fluid flow through the filter (D) is permitted only through an annular area with an inside diameter governed by an impervious concentric circular area (F) in the backup screen (E) and an outside diameter governed by either the chamber walls or by a similar impervious area in the backup screen (E) as required by the microscopic field.

The chamber is dried by valving-off the sample fluid stream upstream of inlet tube (B) and downstream of outlet tube (H) and introducing a vacuum through (H) sufficient to cause the vapor pressure of the fluid being sampled to exceed the absolute gas pressure in the filtration chamber.

An alternative method is to purge the filtration chamber by introducing a clean, dry inert gas such as nitrogen into the inlet tube (B) to carry the sample fluid vapor and liquid residue through the outlet tube (H).

The particle matter retained on the filter (D) is examined, counted, and sized by means of the long-focal-length, approximately 50-power angle microscope (T, P, S), which views the material through the optical window (C). The window forms an optical quality glass top to the filtration/counting chamber.

The microscope is provided with a traversing mechanism (Q, R, V) that provides controlled linear movement in at least one horizontal direction in a plane coincident with the axis of the total assembly so the movement of the objective tube (S) traverses the diametric lines of the filter (D). The crank arm and screw (V) turning through the fixed, matching, internally threaded opening in the bracket (Q) moves the yoke (R) to which the microscope (P) is horizontally gimbaled.

The ability of the rotatable portion of the assembly to rotate 180 degrees in either direction from the neutral position, coupled with the traversing capability of the microscope, allows all portions of the filtration surface to be microscopically examined.

Used filters are replaced by pulling vertically downward on the outlet tube (H), thus compressing the spring (J) and allowing access to the filter in the opening between the seal plate (N) and the lower chamber elements (G, E, F). The spring retainer (L) is sufficiently slotted vertically to allow manual access to the filter and backup screen when the elements of the lower chamber (G, E, F) are depressed.

During lowering and resealing, the guide rods (K), which pass through guide holes in the lower chamber wall (G), maintain the concentric and azimuth alignment of the lower chamber with the upper chamber.

Since the spring (J) must exert sufficient force to effect a fluid-tight seal between the lower chamber elements and the seal plate and attached elastomer seal (N), mechanical aids can be added to assist in compressing this spring during membrane exchange (e.g., a foot pedal mechanically linked to the outlet tube (H) or the lower filtration chamber elements).

By means of this tool a quantity of the fluid being sampled for particles may be passed through the assembly and the final rinse chamber. A preliminary particle count of the filter may then be made, by the methods previously described, to determine background contamination. The fluid being sampled is again flowed through the assembly for a controlled total volume of flow, the chamber is again vacuum-dried or dried by a clean inert gas purge, and a second particle size and count made. The size and count data obtained from the initial filtration are subtracted from those obtained from the second filtration, thus eliminating the particle contribution from all sources except that suspended in the sample stream. The preliminary equipment flush and count may be eliminated when the background contamination is not significant.

In-Line Nonvolatile Residue Sampler Evaporator

Figure 2 shows a concept of an automated Nonvolatile Residue sample collecting and processing device. In this form, automatic readout is not illustrated although it could be provided.

Since this configuration was proposed further investigation has disclosed that the vacuum-jacketed Cahn electrobalance offers ready adaptability to completely automated NVR sampling, analysis, readout and recording on either a drop-wise or milliliter sample quantity basis in cycle times less than a minute.

Recent literature references indicate that some new types of automatic NVR analysis machines for on-stream use have been developed. However, there seems to be some ambiguity in the term NVR. In the past some commercial devices have been referred to as NVR removal or processing devices whereas a closer inspection revealed that they were capable only of mechanical filtration and hence unable to do anything about the nonvolatile soluble contaminants which often constitute the substantial total of the NVR. In any event any satisfactory NVR analysis device can be used in this application.

The cycling principle of the device shown in Figure 2 is described below.

The fluid to be sampled leaves the process or operating fluid stream (A) at supply port (B) and is conducted in a freely falling stream by an inert, nonfriable, abrasion-resistant, plastic flexible tubing (C) such as Teflon, Tygon, or Kel-F through the chamber inlet

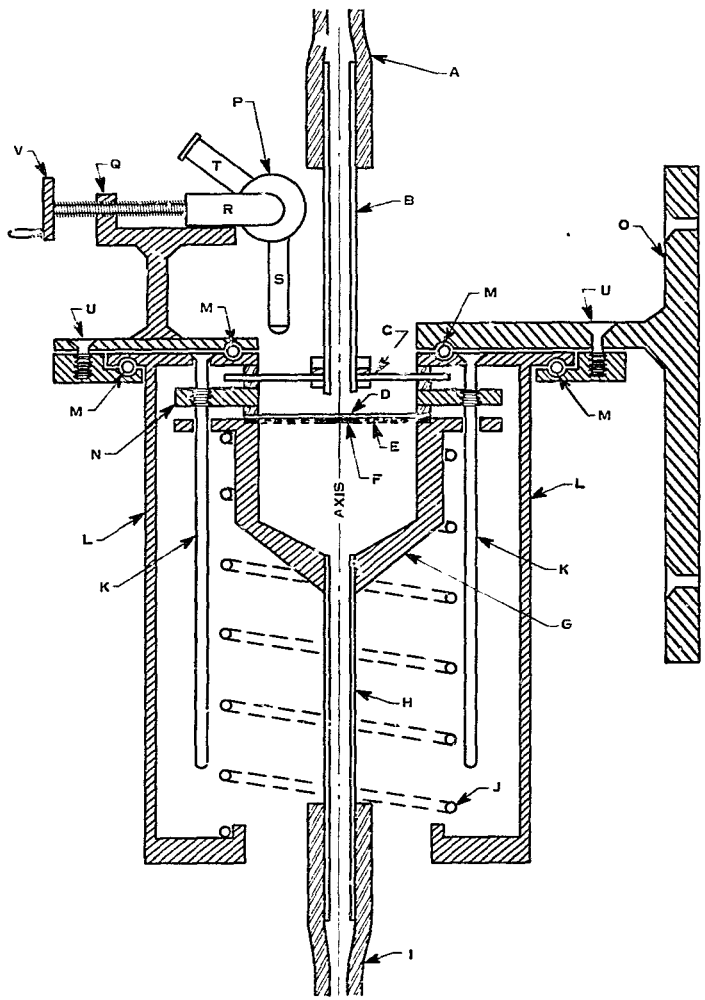


Figure 1. In-line filter holder/counter

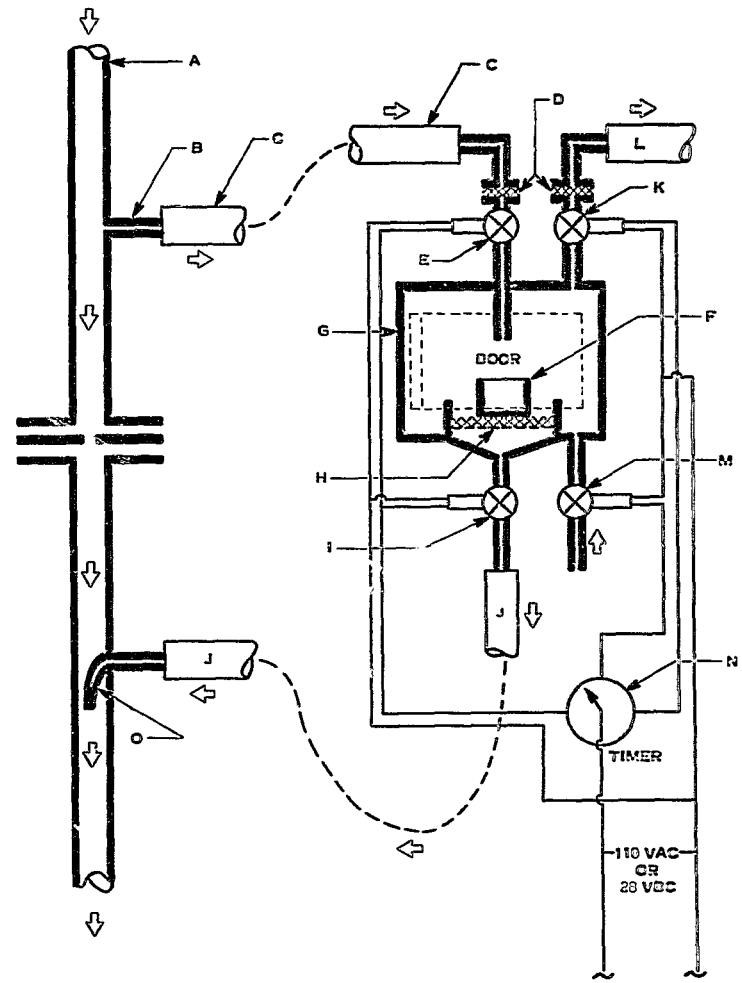


Figure 2. In-line nonvolatile residue sampler/evaporator

tube, filter orifice (D), and solenoid valve (E) into the NVR cup (F). The configuration and capacity of this cup are critical to the concept only in the capability of entrapping and retaining a known volume of fluid and reproducing the process under repeated cycling of the apparatus.

The overflow from the cup drains through the support screen (H), through the solenoid drain valve (I), through the flexible tubing (J), to the aspirator (O). The flexible tubing (J) has characteristics identical to those of the inlet flexible tubing (C).

The amount of suction produced in relation to the flow of stream (A) can be adjusted either by rotating the aspirator (O) about an axis perpendicular to the axis of the fluid stream (A), or by using an adequate metering valve.

The rate of sample fluid stream flow through the NVR chamber (G) must be great enough that the NVR cup (F) overflows during one cycle and small enough that the NVR cup does not overflow from the force of impingement (sloshing).

The height of the inlet nozzle to the chamber (from valve E) above the level of the liquid in the NVR cup is not critical and it may extend to the liquid level to prevent spattering.

Valves (E, I) are programmed shut by timer (N) and valve (K) is opened to vacuum line (L), which conducts to a vacuum source capable of evacuating the NVR chamber (G) to an absolute pressure less than the vapor pressure of the fluid being sampled at the sampling temperature.

The rate of vacuum application is controlled by orifice (D) in the vacuum line so that the chamber evacuation rate is not sufficient to cause the NVR cup to boil over. Since more rapid boiling of the sample fluid in the NVR cup is permissible as the level of liquid in the cup falls because of the increased "free-board," the evaporation is initiated at a very slow rate and proceeds to a quite vigorous termination point. Timer (N) then closes valve (K) and opens valve (M), which readmits atmosphere to the NVR chamber (G).

The door (shown in phantom view in Figure 2) is then opened and the now dry NVR cup (F) is removed by forceps to the pan of an analytical balance for weighing. The difference between this weight and the cup's precycle weight factored by the volume of the cup or the weight of liquid entrapped in the cup (determined by multiplying the volume of the cup by the density of the sampled fluid) gives the NVR of the sampled fluid. The NVR cup is then replaced in the NVR chamber and the sampling cycle is complete.

The timer (N) may be appended to the apparatus as shown, or it may be the main sequencing timer of a commercial automatic final cleaning/rinsing/drying machine for which the in-line NVR sampler/evaporator is expected to be an accessory. Under the latter condition, the in-line NVR sampler/evaporator will sample both the influent and effluent processing streams of the final cleaning/rinsing chambers of the commercial machine, or will sample the effluent processing stream alone. It also will, in conjunction with the in-line filter holder/counter, be used as an accessory to the commercial machine to permit this machine to be used as an automated cleanliness testing machine.

With present methods, it is necessary to draw a liquid sample; transport it to a heated surface, bath, vacuum chamber, or some combination of the three; cool the container in a desiccator; and reweigh the sample.

The in-line NVR sampler/evaporator eliminates the extra liquid handling and transfer operations by catching the sample and boiling it off directly. Increased reliability is inherent in the reduction of surfaces that the sample and NVR container touch during processing, and there is a corresponding time saving.

Whatever the configuration, at least a portion of the chamber (probably the door) should be transparent so filling, draining, and evaporation may be observed without unsealing the chamber.

To update this concept to current technology, chamber G would be the hangdown tube of the Cahn electrobalance and the sample inlet valve solenoid E would receive its closing signal from the electrobalance output instead of from the timer. The Cahn electrobalances are extremely sensitive and rugged instruments which can be programmed for fast sensitivity and capacity changes. Consequently the timer will place the balance in the high capacity-low sensitivity mode for the sample influx operation (which will now be weight-measured rather than volume-measured by the means already described) and will then program to high sensitivity for weight of the residue after the evaporation step. Decimal proportion of NVR can be displayed and recorded with auxiliary equipment.

Automated Final Cleaning, Rinsing, and Drying Station

A typical automated final cleaning, rinsing, and drying station (Figure 3) includes an in-line filter holder/counter and an in-line nonvolatile residue sampler/evaporator installed in a laminar flow bench. These devices are plumbed to the fluid lines of a commercial, automatic final cleaning, rinsing, and drying machine.

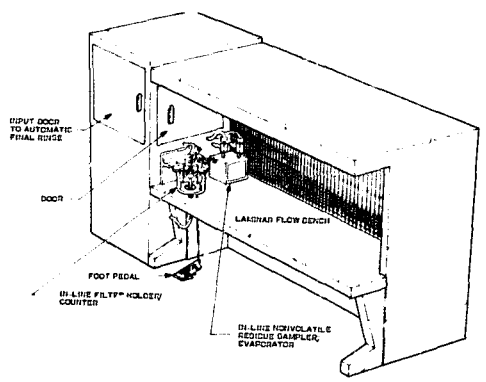


Figure 3. Automated final cleaning, rinsing and drying station

The characteristics of this machine are

1. An enclosed chamber has doors for access both to an uncontrolled environment and to a controlled environment adjacent to the machine. If the machine is used in a controlled environment rather than connected to one as shown in Figure 3, only one door is necessary. The controlled environment is a commercial laminar flow bench abutted to the final rinse machine.

2. Components placed in the enclosed chamber are subjected to a preprogrammed sequence of operations. These operations consist of forceful impingement of solvents or solutions, ultrasonic or sonic energy applied to the components while immersed in some energy-transmission liquid (which may also be a solvent or solution streams impinging on the components), flushing by chamber fill and drain, clean solvent rinse by immersion or spray, vapor degreasing, drying by heat and/or evacuation, and cooling to approximately environmental conditions. The machine need not incorporate all the energy input capabilities. Only one processing fluid stream impingement operation and one sonic or ultrasonic energy input operation in the cleaning sequence are necessary. Either or both of these operations must be applied to the final rinse or rinses. The particular combination of operations is not critical to the concept if the energy inputs are preprogrammed, and controlled as to nature, intensity, and duration.

3. The chamber drains at a selected rate into a storage reservoir during the final solvent rinses. Draining is complete after the rinses.

The NVR sampler/evaporator is installed (in terms of fluid flow) on the cleaning machine in series with or parallel to the filter/counter. Some agencies consider the filterable solids to be a portion of the NVR while others stipulate that the NVR will consist only of materials soluble in the carrier fluid. The decision to remove filterable solids by the filter/counter before or after the sample stream enters the NVR sampler/evaporator governs whether the flow shall be in series with or in parallel to the analytical equipment.

If the NVR is defined as consisting only of solubles and or particles smaller than some specified size that have passed through an absolute rated filter, the filter medium will be used in the filter/counter and the NVR sampler/evaporator will be plumbed in series with the filter/counter downstream of the latter.

The automated final cleaning machine can be used with the combined filter/counter and NVR sampler/evaporator or with either item separately.

NVR determination or particle contamination determination may be separate definitive criteria parameters of some specifications, while both criteria may be applicable to others.

The automated final cleaning, rinsing and drying station operates as follows:

1. The operator places the equipment to be cleaned in the cleaning chamber of the machine and initiates the automatic sequencing of the machine.

2. The operator, as necessary, installs a clean filter medium in the filter/counter and a clean, preweighted, NVR cup in the sampler/evaporator.

3. When the cleaning and rinsing sequences are completed, the operator examines the filter surface for particle matter in accordance with the applicable contamination control criteria specification, removes the processed NVR cup from the NVR sampler/evaporator, and weighs it (or only reads the result if a completely automated NVR device is used).

4. If the determined contamination levels meet the applicable criteria, he removes the equipment from the cleaning chamber of the machine through the door opening into the clean environment. He then proceeds with the assembly and/or sealing operations pertinent to the equipment being processed.

5. If the determined levels do not meet the applicable criteria, the operation is repeated.

Depending on the number of particles permitted, per size range, by the criteria specification, it may not be necessary for the operator to replace the filter medium in the filter/counter between cleaning/evaluation cycles. He may, instead, subtract each determined count from the preceding count and qualify the cleanliness of the equipment by the difference. The same procedure may apply to the successive weighings of the NVR cup.

The automatic sampling/sample-preparation equipment that is integrated with the machine is installed in a laminar flow bench abutted to the machine. However, the bench is not an inseparable portion of the concept. The sampling assembly could, for instance, be in any environment sufficiently clean to allow qualified parts to be removed from the chamber without being recontaminated by the environment above the level permitted by the applicable criteria. This environment could be a laminar flow clean room, a conventional clean room, or simply a controlled manufacturing or processing area depending on the stringency of the applicable contamination control criteria specification. The equipment may be installed anywhere, at any distance from the machine, on any surface, providing that the evaluation-rinsing effluent stream is delivered to it at a velocity sufficient to transport the largest and heaviest particles of interest to the applicable contamination control criteria specification.

The type of commercially available cleaning machine shown in Figure 3 is the upright, front and side loading, cabinet type. However, any configuration that will provide the minimum capabilities may be used.

A separate vacuum pump for the NVR sampler/evaporator or for the filter/counter may be provided, or the vacuum capability already existent in a commercial machine may be used. The only requirement is that the vacuum pump be protected from solvent fumes by scrubbers and absorbers.

Summary

Although development of automated final cleaning, rinsing, and drying has progressed, no one has taken the very logical step of making these operations the parameters of particle contamination evaluation and rinsing. It is not a well understood fact (outside of contamination-control circles) that the sole quantitative content of all vehicle fluid system cleanliness criteria specifications for components lies in the content of the final rinse, the parameters for which have never been quantitatively defined. All effort expended on this activity in the vehicle aerospace field has relied on criteria that have not been dimensionally defined by determinative parameters, at least with regard to force of impingement, velocity (or "volume" of flow), orientation of surface being sampled, accessory sampling energy (e.g., insonation), or other characteristics that vitally affect the validity of results. The effort has depended almost totally on operator interpretation. As a result, reproducibility of final rinse results (and hence specification conformance) has been very unsatisfactory from program to program and, in some cases from component to component. The method described in this paper should provide pushbutton reproducibility for the entire space vehicle industry, thus permitting interprogram interchangeability of cleaned components. The method would also offer significant savings in personnel time and handling costs, and increased reliability. Finally, the method would permit the use of more stringent particle level criteria.

END OF REFERENCE
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