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APOLLO SPACECRAFT

NONMETALLIC MATERIALS REQUIREMENTS

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I. PURPOSE

The purpose of this document is to establish nonmetallic materials selection and acceptance guidelines and test requirements for control of flammability and toxicity of nonmetallic materials used in the Apollo Spacecraft and in applicable test equipment used internal to the Apollo Spacecraft during closed hatch testing.

II. REQUIREMENTS

The control and verification of material and assembly flammability and toxicity to the guidelines of this document are based on the following requirements:

A. Reduction in the probability of ignition.

B. Restriction of any fire to a definable area.

C. Limitation of the rate and magnitude of the rise of temperature and pressure from any fire to prevent the loss of structural integrity.

D. Protection of the crew from the flammability and toxicity effects caused by the effects of any fire.

E. Implementation of design features concerned with controlling flame propagation and the effects of any fire.

III. SCOPE

The scope of this document covers the control of flammability and toxicity hazards of: (1) nonmetallic materials exposed to the crew compartment atmosphere; (2) nonmetallic materials exposed to the suit loop atmosphere; (3) nonmetallic materials used in high pressure oxygen systems; (4) nonmetallic materials used in sealed container in the spacecraft atmosphere; (5) nonmetallic materials used in the uninhabited portions of the spacecraft. These guidelines shall apply to all spacecraft equipment used during closed hatch tests and all flights. All nonmetallic materials selected for use shall meet the guidelines of this document before installation. Standard tests required by these guidelines shall be conducted and success determined in accordance with the several procedures and requirements of Appendix 1.

IV. IMPLEMENTATION

A. Contractors supplying equipment for use in Apollo manned spacecraft shall implement a materials identification control and verification program to assure the requirements of this document are met. This program shall be documented in a contractor program plan to be submitted to the Apollo Spacecraft Program Office, Manned Spacecraft Center, Houston, Texas for approval. This document as implemented by the contractors approved program plan shall be the contractual requirement for Apollo Spacecraft nonmetallic materials control and verification.

B. The contractor program plan as a minimum shall contain detailed procedures to be followed in accomplishing the following program elements:

(1) Material Usage Identification
(2) Materials Usage Categorization and Acceptability Status Determination
(3) Material and Assembly Test Procedures
(4) Identification and Disposition of Material Action Items
(5) Material Deviations
(6) As Built Materials Control
(7) Vehicle Readiness Reviews
(8) Data and Documentation Submittal

C. This specification implements the intent and purpose of SN-P-0003, "Procedures and Requirements for the Flammability and Offgassing Evaluation of Spacecraft Nonmetallic Materials," for the Apollo Spacecraft Program.

D. Applied configuration tests conducted to demonstrate the acceptability of material configurations for the Command Module shall be conducted at 16.5 psia oxygen. If the test results show that the configuration does not meet the applicable acceptance criteria, a retest shall be accomplished in a mixed gas atmosphere of 60 percent oxygen - 40 percent nitrogen at 16.5 psia. A configuration which is demonstrated to be acceptable under one of the above test conditions shall not be considered to deviate from the requirements of this document. The design goal remains demonstrated acceptability when tested in a 16.5 psia oxygen atmosphere. This requirement is applicable to the following tests:

(1) Category A, Item 3, page 4
(2) Category B, Item 3, page 7
(3) Category E, Item 2, page 10
(4) Category F, Items A3 and B3, pages 10 and 11
(5) Electrical Wire Insulation and Accessory Flammability Test, page 37
(6) Electrical Potting and Coatings Flammability Test, page 43

V. SELECTION AND VERIFICATION REQUIREMENTS

Non-combustible materials shall be used wherever possible. All nonmetallic materials shall be categorized primarily by functional application and spatial distribution. They shall be tested to determine flammability characteristics in accordance with the guidelines of this document. Tests for odor, carbon monoxide, and total organics shall be performed on materials or assemblies they have passed the flammability test requirements for their applicable category of usage or that have been otherwise approved for spacecraft usage. Success criteria shall be defined by the test plan when assembly level outgassing tests are applied.

Outgassing tests (Test 6 and 7) require evaluation of materials when exposed to a temperature of 155°F. Where the environmental and operational requirements of a material application are determined by analysis or tests to be in excess of 155°F., test data shall be developed to simulate the actual exposure conditions. The contractor shall identify all materials or assemblies usages in excess of 155°F. and submit requirements for testing to the NASA for approval.

A. Category A - Major Exposed Materials

This category shall include the material applications that are unlimited with respect to quantity, proximity to ignition sources, or exposure to oxygen and are used over wide areas of the spacecraft. To prevent flame propagation, these materials or their applications must be self-extinguishing as defined below:

1. Functional Description

   a. Debris traps or nets

   b. Outer space suit materials

   c. Couch cushions

   d. Webbing and harness

   e. Spacecraft electrical wire bundles and accessories*

   f. Other functions shall be considered subject to these requirements if a fire propagation pattern is identified.

   g. Paints

2. Material Testing Requirements

   Materials in this Category shall be subjected to the following standard tests defined in Appendix 1.

   a. Propagation - Appendix 1 - Test No. 1

   b. Combined Thermogravimetric Analyses and Space Ignition Test - Appendix 1 - Test No. 3.

   c. Odor - Appendix 1 - Test No. 6

   d. Carbon Monoxide and Total Organics Determination Appendix 1 - Test No. 7

* Accessories are defined as wire bundle spot ties, cable clamps, wire bundle chafeguards, shrink/tubing sleeving, ID tags and conformal coatings.

3. Applied Configuration Testing Requirements

When applications in this Category contain materials which fail the self-extinguishing requirements to Appendix 1 - Test No. 1 (in the applicable environment), they shall be demonstrated to be self-extinguishing in the usage configuration. The contractor shall identify applications to be tested, the specific test configuration, ignition sources, and test conditions for each test and submit test results for NASA approval. Requirements for applied configuration tests are as follows:

a. Test selection - Each application in this Category containing materials which fail Appendix 1 - Test No. 1 shall be subjected to an applied configuration test or analysis. Tests shall be conducted in the worst case oxygen pressure to which the assembly shall be exposed in its application.*

b. Test configuration - The test configuration shall be representative of the flight configuration. All possible propagation paths shall be defined and critical propagation paths included in the test article configuration.

c. Ignition - Ignition shall be accomplished by overloading with electrical current the spacecraft wiring representative of that used in proximity to the assembly to be tested or by nichrome ignitor. A flammable material which is used in the assembly under test, such as an adhesive, potting compound or shrink-fit tubing, shall be placed in contact with the wire to provide the flame source. The ignitor (flame source) shall be placed in contact with the assembly to be tested.

d. Acceptance criteria - The applied configuration shall self-extinguish before burning more than 3 inches in any direction from the ignition source. All combustion must cease within a 90 sec. period from the moment the ignitor inflames. No dripping, sputtering or sparking that causes the transfer of burning mass is permitted.

e. Electrical wire insulation and accessory flammability test - Appendix 1 - Test No. 4. This test must be conducted in addition to the materials test defined in paragraph 2 (a) for electrical wiring or accessories.

* Test configurations which do not meet the acceptability criteria for the CM at 16.5 psia oxygen shall be retested in an atmosphere of 60 percent oxygen - 40 percent nitrogen at 16.5 psia.

f. Electrical potting and coatings flammability test - Appendix - 1 - Test No. 5. This test must be conducted in addition to the test defined in paragraph 2 (a) for any potting/coating materials.

4. Full Scale Flammability Mockup Testing

A full scale mockup incorporating high fidelity representations of the appropriate S/C non-metallic materials shall be tested to demonstrate the final acceptability of S/C flammability characteristics. The tests shall be conducted in all planned flight oxygen concentrations. Deliberate positive ignition sources shall be located in all critical areas.

B. Category B - Special Applications and Minor Exposed Materials

This Category includes those materials applications in the spacecraft arranged in discrete locations and exposed to the oxygen atmosphere. The specific amount and arrangement of materials at any discrete locations shall be limited so as to prevent the spread of fire to any other discrete locations in the pressurized vehicle. It shall be demonstrated that the installation meets the requirements of paragraph 3 through tests or analyses.

1. Functional Description

Those materials located and contained as described above shall be subjected to the testing requirements of this Category. Typical functions performed by discrete material applications in this Category may be as follows:

a. Isolated electrical connectors including inserts, potting compounds, shells, and mounts.

b. Electrical components including discrete located terminal boards, and potting compounds.

c. Discrete located control knobs, dial faces, paints and coatings.

d. Batteries including associated equipment.

e. Miscellaneous materials

(1) Discretely isolated shock absorber materials

(2) Discretely isolated thermal insulation materials

(3) Tapes

(4) Seals and/or sealants

(5) Adhesives

(6) Lubricants

f. Other material applications - All material applications and functions not included in other categories shall be considered subject to the requirements of Category B.

2. Materials Testing Requirements

These tests shall be considered screening tests only. The data shall be utilized for comparisons of candidate materials and for predictions of performance in applied configuration tests.

a. Propagation rate - Appendix 1 - Test No. 2

b. Combined Thermogravimetric Analysis and Spark Ignition - Appendix 1 - Test No. 3

c. Odor - Appendix 1 - Test No. 6

d. Total Organics and Carbon Monoxide - Appendix 1 - Test No. 7

e. Electrical Potting and Coatings Flammability Test - Appendix 1 - Test No. 5

3. Applied Configuration Testing Requirements

Materials in this Category shall be subjected to special tests to demonstrate that fire control criteria are met in the usage configuration. The contractor shall identify applications to be tested, the specific test configuration, ignition sources, and test conditions for each test and submit test results for NASA approval.

a. Test selection - The "worst case" configurations of each generic class of equipment and materials shall be tested to determine acceptability. The contractor shall furnish rationale or analysis to support the selections.

b. Test configuration - The equipment tested shall be representative of the flight article. All potential propagation paths shall be simulated. Geometric and spatial proximity to spacecraft panels and enclosures shall be simulated.

c. Ignition source - The ignition source may be either by an overload on a test specimen wire or a nichrome ignitor, whichever is judged the "worst case."

d. Test conditions - All tests shall be conducted in an oxygen atmosphere representative of the "worst case" application and at a starting ambient temperature of 75 ± 5°F. The test set-up shall simulate the ventilation condition available to the test specimen in the flight conditions. Sufficient instrumentation shall be used to evaluate heat transfer characteristics of the fire. *

e. Acceptance criteria - The fire shall not propagate to adjacent equipment by radiation, conduction, or mass transfer.

4. Installation Protection

The following methods are among those that may be evaluated to provide a non-propagating configuration of materials in Category B.

(1) Installation of non-flammable covers, panels, or other fire breaks over or between adjacent combustion materials.

(2) Reduction in potting compound, conformal coating, and paint quantities.

(3) Covering the flammable material with a fire-resistant inorganic coating or other appropriate fire inhibitor.

* Test configurations which do not meet the acceptability criteria for the CM at 16.5 psia oxygen shall be retested in an atmosphere of 60 percent oxygen - 40 percent nitrogen at 16.5 psia.

(4) Covering flammable materials with aluminum foil or Teflon sleeving.

(5) Covering flammable materials with non-combustible foams.

Implementation of any of these methods does not eliminate the requirements for applied configuration testing.

C. Category C - Crew Oyxgen Supply Materials

This Category shall include those materials used in the suit loop and the emergency oxygen masks (20 psia oxygen or less).

1. Functional Description

Materials within the ECS suit loop and interior of the space suit such as hoses, helmets, flex joints, couplings, valve seats and seals, including regulators and check valves, inner garment materials, and emergency oxygen masks shall be subject to the requirements of this Category.

Internal suit loop wiring and electrical components such as biomedical or communication harness, signal conditioners, connectors, transducers, witness sensor, and thermocouples shall also be subject to the requirements of this Category.

2. Material Testing Requirements

a.	Propagation Rate	Appendix 1 - Test No. 1
b.	Thermogravimetric Analysis & Spark Ignition Test	No test required except as defined in paragraph 3.
c.	Total Organic and Carbon Monoxide	Appendix 1 - Test No. 7
d.	Odor	Appendix 1 - Test No. 6

3. Design Requirements

The requirements for combustion rate shall be applicable to all materials in this Category except those wherein no ignition source is possible. Any electrical wiring of components within 1 inch of the material shall be considered an ignition source. The contractor shall specifically identify those ensconced materials and shall present appropriate analytical and test rationale before eliminating any requirements for combustion rate. Flash and fire point Appendix 1 - Test No. 3, shall be determined for those materials so identified.

D. Category D - Material Applications in High Pressure Oxygen Systems

This Category shall include those materials used in greater than 20 psia oxygen systems. Materials shall have been qualified for use in oxygen service as a result of assembly level off-limits and qualification testing.

1. Functional Description

Materials for such applications as filters, seals, valve seats, and pressure bladders shall be covered by this Category.

2. Material Testing Requirements

a.	Propagation Rate	No test required
b.	Thermogravimetric Analysis & Spark Ignition Test	Appendix 1 - Test No. 3
c.	Odor	Appendix 1 - Test No. 6
d.	Total Organics and Carbon Monoxide	Appendix 1 - Test No. 7
e.	Friction and Impact Ignition	Appendix 1 - Supplementary Test No. A

3. Material Application Verification

The contractor shall provide substantiating information including identification of qualification and certification tests accomplished which demonstrate the suitability of the material.

E. Category E - Material Applications in Sealed Containers

This Category shall include those material applications inside sealed (with inert gas, air, and/or potting with no method of receiving or replenishing a supply of oxygen) containers.

1. Functional Description

Applications such as electrical wiring, tie wraps, potting compounds, and electronic compounds shall be subject to the requirements of this Category.

2. Applied Configuration Testing Requirements

The sealed container shall not rupture as a result of internal temperature or pressure increases caused by internal electrical malfunction. Verification by test that "worst case" configurations meet this condition shall be required. The contractor shall identify applications to be tested and the specific test configuration, ignition sources, and test conditions for each test and submit test results for NASA approval. Rationale shall be furnished to support the selected test configuration.

a. Test Selection - Representative "worst case" configurations of sealed containers containing ignition or heat sources shall be tested to verify acceptability. The contractor shall provide analysis to support the selection of test configuration.

b. Test Configuration - Test equipment shall be representative of the flight article.

c. Ignition Source - The ignition of sealed containers which are filled with inert gas shall be by electrical overload to failure of circuits located in the most combustible areas of the container. In all other containers 22 gage nichrome coils shall be placed on the most combustible materials in the container and energized until the material is ignited or ignitor failure is verified.

d. Test Conditions - Tests shall be conducted in 16.5 psia oxygen atmosphere for the CM and 6.2 psia oxygen atmosphere for the LM. The container temperature shall be ambient at the start of testing. *

e. Acceptance Criteria - The sealed container shall not rupture or allow visible flame outside the container.

F. Category F - Materials in Vented Containers

This category shall include those materials stored inside unsealed containers with or without an internal ignition source.

A. Containers without Internal Ignition Sources

Those materials stored inside unsealed containers without internal ignition source shall be subject to the requirements of this paragraph. Removal of stowage materials from containers shall be permitted for operational use only.

Flammable materials in this Category which are used during mission operations shall be identified. Each identification shall include an estimated usage timeline for all flammable stowed equipment with appropriate rationale for usage.

* Test configurations which do not meet the acceptability criteria for the CM at 16.5 psia oxygen shall be retested in an atmosphere of 60 percent oxygen - 40 percent nitrogen at 16.5 psia.

1. Functional Description

Applications shall include foams, food bags, flight data books, survival equipment, personal equipment, etc., stored inside unsealed containers.

2. Material Testing Requirements

a.	Combined Thermogravimetric Analysis and Spark Ignition Test	Appendix 1 - Test No. 3
b.	Odor	Appendix 1 - Test No. 6
c.	Total Organics and Carbon Monoxide	Appendix 1 - Test No. 7

3. Applied Configuration Testing Requirements

The contractor shall identify worst case configuration test specimens and flame impingement test conditions representative of spacecraft. Specimens shall be subjected to flame impingement representative of that possible in actual S/C operation and test results submitted for NASA approval.

B. Containers with Internal Ignition Sources

Those materials inside unsealed containers with an internal ignition source shall be subject to the requirements of this paragraph. The containers shall allow over-pressure to be vented and a fire inside shall not propagate outside the container.

1. Functional Description

Applications shall include foams, printed circuit boards, wiring, potting compounds, and electrical components.

2. Materials Testing Requirements

a.	Combined Thermogravimetric Analysis and Spark Ignition Test	Appendix 1 - Test No. 3
b.	Odor	Appendix 1 - Test No. 6
c.	Total Organics and Carbon Monoxide	Appendix 1 - Test No. 7

3. Applied Configuration Testing Requirements

The container shall not rupture as a result of internal temperature or pressure increases caused by internal ignition. Verification by test that "worst case" configurations meet this condition shall be required. The contractor shall identify applications to be tested and the specific test configuration ignition sources, and test conditions for each test and submit test results for NASA approval. Rationale shall be furnished to support the selected test configuration.

a. Test selection - Representative "worse case" configurations of sealed containers containing ignition or heat sources shall be tested to verify acceptability. The contractor shall provide analysis to support the selection of test configuration.

b. Test configuration - The equipment tested shall be representative of the flight article.

c. Ignition source - 22 gage nichrome coils shall be placed at the most combustible materials in the container and energized until ignition or ignitor failure is verified.

d. Test conditions - Tests shall be conducted in 16.5 psia oxygen atmosphere for the CM and 6.2 psia oxygen atmosphere for the LM. The container temperature shall be ambient at the start of testing.*

e. Acceptance criteria - The container shall not rupture or allow visible flame outside the container.

G. Category G - Materials Applications in Non-flight Equipment

This Category shall include those materials applications in non-flight equipment involved in closed hatch power-on tests.

Materials used in oxygen atmosphere tests must meet the applicable Category A through F test requirements.

The contractor shall identify and submit a list of applicable non-flight equipment with the rationale supporting its use in a flammable environment. Gross material applications subject to the requirements of this Category shall be checked during vehicle walk-through inspections and man-rating proceedings.

Test and acceptance criteria shall be determined jointly by the contractor and the NASA for each specific application identified as falling into this Category.

* Test configurations which do not meet the acceptability criteria for the CM at 16.5 psia oxygen shall be retested in an atmosphere of 60 percent oxygen - 40 percent nitrogen at 16.5 psia.

H. Category H - Materials in Uninhabited Portions of the Spacecraft

The material applications included in this Category shall be those in uninhabited portions of the spacecraft.

Material applications subject to the requirement of this Category shall be identified during vehicle walk-through review.

Test and acceptance criteria shall be determined jointly by the contractor and the NASA for each specific application identified as falling into this Category.

APPENDIX I

INTRODUCTION

The detailed procedures and equipment specified in this document may not be replaced by contractor procedures or equipment unless they are first reviewed and approved by NASA.

Procedures and acceptance criteria for the following tests are defined:

1. Upward Propagation Rate

2. Downward Propagation Rate

3. Combined Thermogravimetric Analysis (TGA) and Spark Ignition

4. Electrical Wire Insulation and Accessory Flammability

5. Electrical Potting and Coatings Flammability

6. Odor

7. Carbon Monoxide and Offgassing Products

Other material characteristics shall be determined as necessary in accordance with the procedures for the following tests:

A. Friction and Impact Ignition

B. Flash Point and Fire Point Test

Quality assurance requirements for the above tests are as follows:

a. All instrumentation utilized in these tests shall be in current calibration and shall bear appropriate documentation to this effect from an approved calibration laboratory.

b. All materials tested shall have tracability equivalent to that required for materials used in the construction of flight spacecraft.

c. If assemblies or sub-assemblies are to be tested the supplier shall certify that the test article is equivalent to that produced for use in flight spacecraft.

d. Test laboratories involved in testing to the requirements of this document shall be certified as to competency by conducting tests of standard materials under step-by-step quality assurance surveilance. Such certification shall be required yearly.

e. Upon completion of tests, test engineers shall certify that all required procedures were followed and that the results reported are correct.

f. At random intervals (not to exceed three months) quality assurance shall observe selected portions of all procedures to verify routine conformance to test procedures.

g. Daily surveilance or step-by-step quality assurance sign off on procedures is neither required nor desired.

TEST NO. 1

UPWARD PROPAGATION RATE TEST

1.0 PURPOSE

The purpose of this test is to identify spacecraft crewbay materials which allow the spread of fire.

2.0 TEST CONDITIONS - PRESSURES

The pressurized test environment for each material shall be determined from the applicable usage category and vehicle effectivity. The following table relates environmental test conditions to category and module combinations:

Category	Module	PSIA Oxygen
A	CM	16.5
A	LM	6.2
C	CM	20.0
C	LM	8.7
G	CM and LM	16.5
H	CM and LM	14.7 PSIA AIR (Unless otherwise specified)

3.0 TEST DISCIPLINE

3.1 Each test shall be directed by the cognizant Test Engineer or his appointed alternate.

3.2 The cognizant Test Engineer shall affix this signature to all test data sheets and verify adequate identification of test sample.

4.0 CRITERIA OF ACCEPTABILITY

Materials shall be self-extinguishing within a one inch diameter circle when ignited at the bottom of test specimen. All combustion shall cease within 30 seconds of the removal of the ignition source.

5.0 TEST EQUIPMENT

5.1 Test chamber shall have a volume sufficient to provide a minimum of 12 liters per gram of sample materials. It shall be suitably constructed and protected to insure safe operation. A window or viewing port for visual observations shall be included. The test chamber shall contain inlets for vacuum, an ignition wire, air, and oxygen. The chamber is to be fully protected against the possibility of operator injury in the event of explosive rupture.

Organic materials used in the construction of the chamber such as gaskets and seals shall be of types which contribute little or no outgassing to the chamber or which can be pre-outgassed by vacuum cycling to a minimal identifiable amount, i.e., less than 10 ppm based on the chamber volume. A vertical sample holder shall be included and positioned within the test chamber.

5.2 Pressure Gauge - A pressure gauge capable of measuring absolute pressures with an accuracy of ±5 Torr, or a pressure transducer and recorder with comparable capability shall be used. These gauges must cover the pressure range of the required test.

5.3 Oxygen Supply - The oxygen shall be commercially available oxygen conforming to specification MIL-O-27210, Type 1. Efficient and safe equipment shall be used for measuring the flow and for transferring the oxygen to the test chamber.

5.4 Sample Holder - The sample holder shall consist of a vertically mounted steel clamp which overlaps one fourth inch on each side of a specimen along the full five inch length of the sample, leaving a two inch wide by five inch long exposed center section.

5.5 Ignition Source - Ignition of the sample shall be accomplished by employing a regulated energy flux. The ignition source shall be a nichrome wire wrapped around its center portion with a 1" x 2" piece of facial type tissue and placed in contact with the bottom edge of the sample. Both wire and paper shall be in contact with sample. The power supply to the wire shall provide sufficient voltage, controlled by means of a variable transformer, to ignite the tissue and sample.

5.6 Propagation Rate Indicators

5.6.1 Motion Pictures - Motion Picture records shall be kept of each burning test where appropriate.

5.6.2 In lieu of motion pictures, supporting data from a vertical bank of thermocouple indicators combined with a recorder may be used. However, a precision of at least five percent shall be obtained with the measuring device. If the thermocouples are used a minimum of four thermocouples shall be installed. Loss of more than one thermocouple or loss of either end point thermocouple shall invalidate the test.

6.0 SAMPLE PREPARATION

6.1 All material specimens shall be free of cuts, abrasions, or other flaws as determined by close visual inspection without magnification. Before the test the samples shall be cleaned by brushing or by flowing an inert gas over them to remove loose surface contamination.

6.2 Films and fabrics shall be tested in their "as received" condition. Specimens shall be cut out in the form of rectangles two and one half inches wide and five inches long. Foams or other thick materials shall be used in the applied thickness and be two and one half inches wide and five inches long.

6.3 Primers, coating materials, and paints shall be applied on the substrate material actually used in the spacecraft whenever possible. The coatings shall be applied in a thickness equivalent to normal usage and post cured in accordance with prescribed manufacturing practices.

6.4 Materials and components which will be used in an irregular size or shape shall be tested in the "as purchased" configuration. They shall be attached to the sample holder in such manner as not to affect the test results.

7.0 PRETEST PROCEDURE

7.1 Verify that all test equipment is in current calibration.

7.2 Verify oxygen certification (MIL-0-27210, Type 1)

7.3 Verify material identification by one of the following:

7.3.1 Manufacturer's Certification

7.3.2 NASA Certification

7.3.3 Contractor Certification

7.3.4 Definite identification not available

7.4 Prepare three samples per appropriate paragraph in section 6 above.

7.5 If irregularly shaped samples are tested, describe the shapes.

7.6 Visually inspect each sample. (There shall be no cuts, abrasions or other flaws).

7.7 Clean samples by brushing or by flowing an inert gas to remove loose surface contamination.

7.8 Weigh the samples and record the weight.

7.9 Record the volume of the test chamber in liters.

7.10 Verify that the test chamber has a volume equal to or greater than 12 liters per gram of sample material.

7.11 Mount the sample in the sample holder and verify that the exposed center section is 2.0 ± 0.1 inches wide.

7.12 Position sample holder within the chamber.

7.13 Place the ignition wire horizontally in contact with the sample at the midpoint of its two inch width at the bottom.

8.0 TEST PROCEDURE

8.1 Evacuate the chamber to less than five (5) Torr.

8.2 Isolate the chamber and monitor pressure for one (1) minute. Testing may not begin until all leaks are corrected. (A leak is indicated if an increase in pressure of more than (1) Torr occurs.)

8.3 Pressurize the chamber to the required psia with oxygen.

8.4 After the chamber has stabilized at the test psia, soak the samples as follows: Ten (10) minutes for dense materials and thirty (30) minutes for porous materials. Record soak time.

8.5 Verify chamber pressure is the test psia and isolate the chamber.

8.6 Start Motion Picture Camera and other applicable instruments.

8.7 Apply current to ignition wire.

8.8 Record whether sample is self extinguishing.

8.9 Note combustion characteristics (nature and color of flame, soot, residue and other pertinent observations).

8.10 Identity of the testing organization or agency.

8.11 Secure the chamber.

9.0 REPORTING

9.1 Name of the material (generic).

9.2 Vendor designation and vendor.

9.3 Self extinguishing (yes or no).

9.4 Combustion Characteristics - Distance that flame progressed before extinguishing; flame phenomena and temperature; mass transfer by dripping, sputtering or sparking; etc.

9.5 Rate of pressure rise and final pressure.

9.6 Disposition or status, dimension, and size of sample material.

9.7 Name and number of test procedure.

9.8 Date of test.

9.9 Test Number.

9.10 Identity of the testing organization or agency.

9.11 Name of test conductor.

9.12 Names and signatures of Test Engineers.

TEST NO. 2

DOWNWARD PROPAGATION RATE TEST

1.0 PURPOSE

The purpose of this test is to identify spacecraft crew bay materials which could allow the spread of fire.

2.0 TEST CONDITIONS - PRESSURES

The pressurized test environment for each material shall be determined from the applicable usage category and vehicle effectivity. The following table relates environmental test conditions to category and module combinations:

Category	Module	PSIA Oxygen
A	CM	16.5
A	LM	6.2
C	CM	20.0
C	LM	8.7
G	CM and LM	16.5
H	CM and LM	14.7 PSIA AIR (Unless otherwise specified)

All Category "B" materials used in the Lunar Module shall be tested at 6.2 psia oxygen and the results reported if they fail the 16.5 psia test. Materials passing the 16.5 test shall qualify without further test.

3.0 TEST DISCIPLINE

3.1 Each test shall be directed by the cognizant Test Engineer or his appointed alternate.

3.2 The cognizant Test Engineer shall affix his signature to all test data sheets and verify adequate identification of test samples.

4.0 CRITERIA OF ACCEPTABILITY

The propagation rate measured downward shall not exceed 0.3 inches/sec.

5.0 TEST EQUIPMENT

5.1 Test chamber shall have a volume sufficient to provide a minimum of 12 liters per gram of sample materials. It shall be suitably constructed and protected to insure safe operation. A window or viewing port for visual observation shall be included. The test chamber shall contain inlets for vacuum, an ignition wire, air, and oxygen. The chamber is to be fully protected against the possibility of operator injury in the event of explosive rupture.

Organic materials used in the construction of the chamber such as gaskets and seals shall be types which contribute little or no outgassing products to the chamber or which can be preoutgassed by vacuum cycling to a minimal identifiable amount, i.e., less than 10ppm based on the chamber volume. A vertical sample holder shall be included and positioned within the test chamber.

5.2 Pressure Gauge - A pressure gauge capable of measuring absolute pressures with an accuracy of ± 5 Torr, or a pressure transducer and recorder with comparable capability shall be used. These gauges must cover the pressure range of the required test.

5.3 Oxygen Supply - The oxygen shall be commercially available oxygen conforming to specification MIL 0-27210, Type I.

5.4 Sample Holder - The sample holder shall consist of a vertically mounted steel clamp which will overlap one fourth inch on each side of a specimen along the full five inch length of the sample, leaving a two inch wide by five inch long exposed center section.

5.5 Ignition Source - Ignition of the samples shall be accomplished by employing a regulated energy flux. The ignition source shall be a nichrome wire wrapped around its center portion with a 1" x 2" piece of facial type tissue and the wire placed in contact with the top edge of the sample. The power supply to the wire shall provide sufficient voltage, controlled by means of a variable transformer, to ignite the specimen.

5.6 Propagation Rate Indicators

5.6.1 High Speed Movie - A high speed movie shall be kept of each burning test where appropriate. The equipment shall be calibrated to assure that burning rates can accurately be determined from the films.

5.6.2 In lieu of motion pictures, supporting data from a vertical bank of thermocouple indicators combined with a recorder may be used. However, a precision of at least five percent shall be obtained with the measuring device. If the thermocouples are used a minimum of four thermocouples shall be installed. Loss of more than one thermocouple or loss of either end point thermocouple shall invalidate the test.

6.0 SAMPLE PREPARATION

6.1 All material specimens shall be free of cuts, abrasions, or other flaws as determined by close visual inspection without magnification. Before the test, the samples shall be cleaned by brushing or by flowing an inert gas to remove loose surface contamination.

6.2 Films and fabrics shall be tested in their "as received" condition. Specimens shall be cut out in the form of rectangles two and one-half inches wide and five inches long. Foams or other thick materials shall be tested in the applied thickness and be two and one-half inches wide and five inches long. Width shall be specified on the report.

6.3 Primers, coating materials, and paints shall be applied on the substrate material actually used in the spacecraft whenever possible. The coatings shall be applied in a thickness equivalent to normal usage and post cured in accordance with prescribed manufacturing practices.

6.4 Materials and components which will be used in an irregular size or shape shall be tested in the "as purchased" configuration. They shall be attached to the sample holder by fiberglass or metal threads.

7.0 PRETEST PROCEDURE

7.1 Verify that all test equipment is in current calibration.

7.2 Witness high speed movie camera setup.

7.3 Witness thermocouple setup and checkout.

7.4 Verify oxygen certification MIL 0-27210, Type 1.

7.5 Verify material identification by one of the following:

7.5.1 Manufacturer's Certification

7.5.2 NASA Certification

7.5.3 Contractor Certification

7.5.4 Definite identification not available.

7.6 Prepare three samples per appropriate paragraph of Section 6 above.

7.7 If irregularly shaped samples are tested, describe the shapes.

7.8 Visually inspect each sample. (There shall be no cuts, abrasions or other flaws).

7.9 Clean samples by brushing or by flowing an inert gas to remove loose surface contamination.

7.10 Weigh the samples and record the weight.

7.11 Record the volume of the test chamber in liters.

7.12 Verify that the test chamber has a volume equal to or greater than twelve liters per gram of sample material.

7.13 Mount the sample in sample holder and verify that the exposed center section is 2.0 ± 0.1 inches wide.

7.14 Position sample holder within the chamber.

7.15 Place the ignition wire horizontally in contact with the sample at the midpoint of its two-inch width at the top.

8.0 TEST PROCEDURE

8.1 Evacuate the chamber to less than five (5) Torr.

8.2 Isolate the chamber and monitor pressure for one (1) minute. Testing may not begin until all leaks are corrected. (A leak is indicated if an increase in pressure occurs.)

8.3 Pressurize the chamber to 16.5 ± 0.1 (or 6.2 ± 0.1) psia with oxygen.

8.4 After the chamber has stabilized at 16.5 ± 0.1 (or 6.2 ± 0.1) psia, soak the samples for Ten (10) minutes.

8.5 Verify chamber pressure is 16.5 ± 0.1 (or 6.2 ± 0.1) psia and isolate the chamber.

8.6 Start propagation rate measurement and other applicable instruments.

8.7 Apply current to ignition wire.

8.8 Record peak chamber pressure after ignition.

8.9 Note combustion characteristics (nature and color of flame, soot, residue and other pertinent observations).

9.0 POST TEST PROCEDURES

9.1 Record propagation rate determined by the Photographic Method.

or

Record propagation rate determined by the Thermocouple Method.

10.0 REPORTING

Unless otherwise specified the following test data and pertinent information concerning the materials shall be reported.

10.1 Name of material (generic).

10.2 Vendor designation and vendor.

10.3 Propagation rate in inches per second.

10.4 Dripping, sputtering or sparking that causes the transfer of burning mass.

10.5 Combustion characteristics.

10.6 Rate of pressure rise and final pressure.

10.7 Disposition of status, dimension, and size of sample material.

10.8 Name and number of test procedure.

10.9 Date of test.

10.10 Test number.

10.11 Identity of the testing organization or agency.

10.12 Name of test coordinator.

10.13 Name and signature of Test Engineer.

10.14 Identify sputter or dripping of the material.

TEST NO. 3

COMBINED THERMOGRAVIMETRIC ANALYSIS (TGA) AND SPARK IGNITION TEST

1.0 PURPOSE

The purpose of this test is to determine the combined weight loss and spark ignition characteristics of materials which may be used in the habitable areas of manned spacecraft.

2.0 TEST CONDITIONS - PRESSURES

The pressurized test environment for each material shall be determined from the applicable usage category and vehicle effectivity. The following table related environmental test conditions to category and module combinations:

Category	Module	PSIA Oxygen
A	CM	16.5
A	LM	6.2
C	CM	20.0
C	LM	8.7
G	CM and LM	16.5
H	CM and LM	14.7 PSIA AIR (Unless otherwise specified)

3.0 TEST DISCIPLINE

3.1 Each test shall be directed by the cognizant Test Engineer or his appointed alternate.

3.2 The cognizant Test Engineer shall affix his signature to all test data sheets and verify the adequacies of sample material identification.

4.0 DEFINITIONS

4.1 Flash Point - The flash point temperature will be indicated in this test by a discernible rise from the base line on the recorder using a photoelectric cell as a sensor, focused on the sample tube. Visual determination of a nonself-sustaining flash or flame and the temperature at which it is initiated shall also be acceptable.

4.2 Fire Point - The fire point is the lowest temperature at which the mixture of vapors from the surface of a material and oxygen or other gases continue to burn after ignition. The fire point will be indicated in this method by a discernible sustained rise from the base line on the recorder using a photoelectric cell as a sensor, focused on the sample tube, by visual determination, or by a substantial thermocouple increase.

4.3 CRITERIA OF ACCEPTABILITY

4.3.1 A material that evolves significant vapors verified by TGA weight loss and having a visible flash at a temperature of less that 400°F shall be construed as failing the flash requirement and shall constitute the rejection of materials being tested.

4.3.2 A material that shows evidence of charring, self-sustaining combustion, or other signs of pyrolysis at a temperature less that 450°F shall be considered unacceptable for use in the manned spacecraft crew bay areas.

5.0 TEST EQUIPMENT

5.1 Thermogravimetric Analyzer (TGA)

The sample chamber shall be constructed of glass or quartz. A quartz chamber shall be used in tests where temperatures are expected to exceed 100°F. The TGA shall have separation flanges on the TGA column assembly to provide a means of entry for spark ignition wires. Protection shall be provided against the possibility of operator injury in the event of explosive rupture by means of an adequate metal shield with a viewing port or its equivalent.

5.2 An electric circuit and apparatus shall be provided to furnish timed electric power to a spark mechanism within the chamber.

5.2.1 The minimum energy supplied by the spark source shall be 30 millijoules.

5.2.2 The spark electrodes shall be made of platinum or any other suitable materials which will not influence the combustion process.

5.2.3 The electrodes shall have a .004 inch radius tip. The spark gap shall be 1/8 inch. The electrodes shall be held in one fixed position during the testing by a suitable fixture and shall be placed 1/4 of an inch above the material.

5.3 Oxygen Supply - The oxygen shall be commercially available oxygen conforming to specification MIL-0-27210, Type 1. Suitable equipment for transferring oxygen to the test chamber shall be provided.

5.4 Pressure Gauge - A pressure gauge capable of measuring pressures from 0-900 Torr with an accuracy of ±1 Torr, or a pressure transducer and recorder with comparable capability shall be used.

5.5 Oxygen or Gas Systems - The oxygen system of the sample chamber shall consist of any suitable tubing to safety conduct oxygen into the sample chamber through a tube and to exhaust oxygen directly from the chamber to a vented hood. The gas flow, chamber pressure and composition of gas (mixtures of oxygen and another gas may sometimes be employed) will vary from test to test.

5.6 Recorders - Two recorders shall be used. The first recorder shall plot the temperature of the sample chamber on its X-axis. The same recorder shall plot the corresponding weight loss of the material on the Y-axix. The second recorder plots the temperature of the sample chamber on its X-axis exactly as the temperature scale on the first X-axis. The Y-axis of the second recorder plots any ignition light sensed by the photoelectric cell(s). A two pen single recorder (or its equivalent) may be used as an alternate. The parameters mentioned in Paragraph 4.5 shall be written on the recorder paper near the plot.

5.7 Photoelectric Cells - A photoelectric cell(s) capable of sensing light over the entire visible spectrum shall be provided and focused on the sample. This photoelectric cell(s) shall be cooled by a water jacket to reduce any effects of heat from the sample chamber on the photocell.

5.8 Thermocouple - Chromel-Alumel, Type K or an equivalent, (e.g., Platinum/Platinum Rhodium) thermocouple shall be provided for insertion in the thermocouple well of the TGA. Another thermocouple of the same composition shall be mounted in the interior of the sample cavity within one inch of the sample.

5.9 Specimen Holder - A material sample shall be placed in either an open glass grid, a metal platform, or a shallow crucible.

6.0 SAMPLE PREPARATION

6.1 Bulk materials may be in the form of circular discs. Any other configuration shall be described in detail.

6.2 A liquid sample shall be placed in a crucible. The weight of the crucible shall be tared so that it shall not be a recorded weight.

6.3 Powders shall be measured in their "as received" form.

6.4 Electrical wire insulation shall be stripped from the metal core. The form of sample will be coiled insulation.

6.5 Weight - The sample weight shall be 250 mg ± 10 but shall not exceed the greatest weight usable on the instrument (TGA) being used in the test. Varying weights may be used for different TGA equipment.

6.6 Materials not suited to testing in the forms described above shall be tested in special forms. In any event, the specimen configuration shall be recorded.

6.7 Two TGA analyses as here detailed shall be run on each material tested.

7.0 PRETEST PROCEDURE

7.1 Verify that all test equipment is in current calibration.

7.2 The sample chamber shall be thoroughly cleaned before each test.

7.3 Verify gas certification per applicable specification.

7.4 Verify material identification by one of the following:

7.4.1 Manufacturer's Certification

7.4.2 NASA Certification

7.4.3 Contractor Certification

7.4.4 Definite identification not available

7.5 Prepare samples per paragraphs 5.1, 5.2, 5.3, 5.4, or 5.6.

7.6 If irregularly shaped samples are tested describe the shapes.

7.7 Clean samples by brushing or by flowing an inert gas over them to remove loose surface contamination.

7.8 Weigh samples and record weight to the nearest ten-thousandth of a gram by means of a calibrated analytical balance.

7.9 Record the volume of the test chamber in liters.

7.10 Plug into AC outlets all electronic equipment and apparatus if applicable to equipment being used.

7.11 Turn on power to weight transducer. Set recorders to standby. Allow 1 hour warmup unless instrument has been in previous use if applicable to equipment being used.

7.12 Check temperature of water in water bottle around spring to ensure temperature is 45 degrees C ± 1 degree C if applicable to equipment being used.

7.13 Turn on sparker power supply (not the sparker itself).

7.14 Calibration of weight transducer if applicable to equipment being used.

7.14.1 Place an empty crucible in the stirrup.

7.14.2 Zero the pen at any desirable point on the X-axis. Normally this is near the bottom of the graph.

7.14.3 Set the scale and multiplier switches to a scale that will accommodate maximum sample weight loss. (Normally 250 mg). Record the scale and multiplier switches selected.

7.14.4 Place a calibrating weight of approximately the same weight as the sample on the calibration weight pan.

7.14.5 Set the weight XY plotter to "on".

7.14.6 Release the "calibration" know lock and, if necessary, increase or decrease the setting to allow the desired change of scale.

7.14.7 Remove the weights and rezero the Y-axis pen.

7.14.8 Repeat 6 and 7 until desired weight change scale length is achieved.
NOTE: If the pointer stays off scale, move the transducer along the vertical axis of the column to bring the pointer in range.

7.14.9 Remove weights.

7.14.10 Lock calibration knob.

7.15 If a change of ± 10mg in the magnitude of either the weight or weight loss is recorded, the weight transducer should be calibrated. No changes to the zero point of the weight transducer are allowed after calibration.

7.16 Mount specimen in holder and place in TGA. Record type of holder.

7.17 Measure spark gap and distance between electrodes per paragraph 4.2.3. Place the electrodes above the sample per paragraph 4.2.3.

7.18 Thermocouple Calibration. Instructions apply to specific equipment. These steps may vary with another type of equipment so long as the intent of the test procedure is not changed.

7.18.1 Place ice in ice reference "Thermos" junction. An alternate method may be employed to insure 0° C reference junction.

7.18.2 Set carriage scale and multipliers on both XY recorders to a value which will yield the desired scale length. Record both scale and multiplier selections used.

7.18.3 Mark temperature values on graph paper at 10 div marks.

7.18.4 Short the two "carriage" terminals on the TGA.

7.18.5 Zero both units.

7.18.6 Remove the shorting wire.

7.19 Photocell calibration (if applicable). Instructions apply to specific equipment. These steps may vary with another type of equipment so long as the intent of the test procedure is not changed.

7.19.1 Place all shields and other equipment in test configuration. Raise the sample chamber.

7.19.2 Plug the photocell into the recorder plug.

7.19.3 Adjust the zero on the photocell XY plotter to the desired point and set the scale to an appropriate value. Record both scale and multiplier selection used.

7.19.4 Test the set up by flashing and shining a flashlight up the furnace tube, or near the photocell.

7.20 This calibration holds only for the physical surroundings present at test time. If lights or shields are changed, recalibration is necessary. Note whether recalibration was necessary.

8.0 TEST PROCEDURE

8.1 Purge the TGA sample chamber with a 40 cc/min ± 2cc/min gas flow for at least 5 minutes prior to the test. Record the gas or gas mixture designated by Test Preparation Sheet (TPS) as the test atmosphere.

8.2 Pressurize the TGA chamber to the pressure called out in the TPS. Record the pressure. This will normally be 6.2 psia or 16.5 psia.

8.3 Make two runs. On the first run, do no sparking. Make first run a weight loss/heat rise recording on graph.

8.4 Heat TGA chamber at fixed rate. Record the rate at which the temperature is increased. Recommended rate is 9°C per minute.

8.5 Record the temperature at which the start of weight loss occurred, as measured on the weight recorder by a discernible drop from the baseline.

8.6 Record the peak TGA chamber pressure.

8.7 Record the temperature at the completion of the test.

8.8 Record weight at end of test.

8.9 Make the second run. It shall be performed identically in all respects with the first run except that the weighing mechanism (weight transducer) shall be anchored or fixed. The second run is madeto obtain flash and fire points.

8.10 Discharge the spark mechanism every minute beginning at ambient temperatures. Repeat until flash point (para. 3.1) is reached or until 300° C has been reached. Record flash point temperature or 300° C, whichever is lesser.

8.11 Continue the discharge of spark mechanism once each minute until the fire point is determined or 300° C is reached. Record fire point temperature at 300°C, whichever is lesser.

8.12 Superimpose the flash and fire point on the weight loss graph. These points may be ascertained by other valid means such as DTA and DCS data. In any case, the flash and fire point shall be related to the weight loss and reported as a function of such loss. The preceding test procedure is based on a specific Thermogravimetric Analytical instrument. It may be modified to achieve the same results using any TGA equipment so long as the intent of the test is not changed. Where test procedure is not applicable to a certain instrument it shall be disregarded and replaced with the appropriate operational procedure.

9.0 POST TEST PROCEDURE

9.1 Test shutdown. These instructions apply to specific test equipment. These steps may vary with another type of equipment so long as the intent of the test procedure is not changed.

9.1.1 As soon as visible flame appears as shown by the photocell or by visual determinations shut down the gas supply and sparking mechanism. Shut off the photocells.

9.1.2 Shut off the furnace controls.

9.1.3 After the fire has gone out, turn both XY recorders to standby.

9.1.4 Roll back the blast sheild and other safety devices used.

9.1.5 Open the door on the bottom of the furnace and lower it over the blower; turn the blower on.

9.1.6 Allow 40 minutes for the furnace and furnace tube to cool down.

9.1.7 Remove the sample for further analysis if any sample remains after test.

9.1.8 Remove the furnace tube and clean with appropriate solvent.

9.1.9 Blow the furnace tube out with compressed air (solvent fumes are explosive).

9.1.10 Clean sparker electrode.

9.2 Calculations

9.2.1 Calculate weight loss to the 4th decimal point (minimum) (First run). In the event that due to some contingency this value can not be obtained the most exact weight obtainable shall be determined. Reasons shall be stated as to why weight requested cannot be obtained and precision of reported weight shall be given.

9.2.2 Calculate percentage weight loss. (First run)

9.2.3 Record percentage weight loss. (First run)

9.2.4 Record average flash point temperature in degrees C if obtainable.

9.2.5 Record average five point temperature in degrees C.

9.2.6 Record average temperature at the start of weight loss in degrees C.

9.3 Describe appearance of sample at end of test.

9.4 Observations and comments.

10.0 REPORTING

Unless otherwise specified the following test data and pertinent information concerning the materials shall be reported.

10.1 Name of material (generic)

10.2 Vendor designation and vendor

10.3 Percentage weight loss (a graph(s) of the weight loss as shown by the TGA shall be sent to the data bank with the test report)

10.4 Flash point temperature

10.5 Fire point temperature (a graph(s) of the weight loss and/or fire point shall be sent to data bank with test report)

10.6 Temperature at start of weight loss

10.7 Atmosphere

10.8 Rate of temperature increase

10.9 Name and number of test procedure

10.10 Date of test

10.11 Test number

10.12 Identity of the testing organization or agency

10.13 Name of test coordinator

10.14 Names and signature of Test Engineer

TEST NO. 4

ELECTRICAL WIRE INSULATION AND ACCESSORY FLAMMABILITY TEST

1.0 PURPOSE

The purpose of this test is to identify flammable wire insulation and electrical accessory materials which may be used in the habitable areas of manned spacecraft. Electrical accessory materials consist of wire bundle sleeving, heat shrinkable tubing, bundle ties, cable clamps, identification tags, and coating materials.

2.0 TEST CONDITIONS - PRESSURES

The pressurized test environment for each material shall be determined from the applicable usage category and vehicle effectivity. The following table relates environmental test conditions to category and module combinations:

Category	Module	PSIA Oxygen
A	CM *	16.5
A	LM	6.2
C	CM	20.0
C	LM	8.7
H	CM	14.7 PSIA AIR (Unless otherwise specified)

3.0 TEST DISCIPLINE

3.1 Each test shall be directed by the cognizant Test Engineer or his appointed alternate.

3.2 The cognizant Test Engineer shall affix his signature to all test data sheets.

* Electrical wire insulation and accessory configurations which do not meet the criteria of acceptability stated in Paragraph 4.0 shall be retested in an atmosphere containing 60 percent oxygen and 40 percent nitrogen at 16.5 psia. Compatibility with the pure oxygen environment is the design goal. Deviations will not be required for materials in assemblies which pass the mixed atmosphere test requirement.

4.0 CRITERIA OF ACCEPTABILITY

Electrical wire insulation and accessories shall not be capable of sustaining combustion in the designated pressurized oxygen test atmosphere following removal of the ignition source containing an electrical current overload up to the melting point of the electrical wire.

5.0 TEST EQUIPMENT

5.1 Test Chamber - Test Chamber shall have sufficient volume to insure complete combustion of the wire bundle specimen and shall be suitably constructed and protected to insure safe operation. A window or viewing port for visual observations shall be provided. The test chamber shall contain inlets for vacuum, air, and oxygen, and electrical power for wire overload. A horizontal sample holder shall be included and positioned within the test chamber.

5.2 Pressure Gauge - The pressure gauge shall be capable of measuring absolute pressure up to 30 psia (1550 Torr) with an accuracy of ±0.1 psia. A comparable pressure transducer may be used.

5.3 Oxygen Supply - The oxygen shall be commercially available oxygen conforming to specification MIL-0-27210, Type 1. Suitable equipment for transferring oxygen to the test chamber shall be provided.

5.4 Sample Holder - The sample holder shall consist of two horizontally mounted electrical connections, i.e., knurled bolts, spaced twelve inches apart. A non-flammable center support shall be provided to support the center of the sample wire bundle. The electrical terminals shall be connected to the ignition power source.

5.5 Ignition Source - An external electrical power supply shall be provided which is capable of providing a large steady current through one wire of the sample bundle so that a very high temperature will be achieved quickly. The power source must be capable of supplying a current 10 percent above the nominal fusion current for that gauge wire being tested.

Wire Gauge No.	Initial Test Current (AMPS)	Nominal Fusion Current (AMPS)
28	10	15
26	15	20
24	20	30
22	25	40
20	40	60
18	55	80
16	80	120
14	110	160
12	150	225

6.0 SAMPLE PREPARATION

6.1 Wire Insulation Samples

6.1.1 Insulated wire samples shall be free of cuts, abrasions, or other flaws as determined by close visual inspection.

6.1.2 A test bundle of seven insulated wires, six of which are twelve inches in length and the seventh wire thirteen inches in length, shall be tightly bound together using Bentley Harris STFE-30 lacing tape in four places three inches apart. The thirteen inch length of wire shall be positioned on the exterior of the bundle in intimate contact with adjacent wires and shall be stripped of one half inch of insulation on each end. The wires shall be laid up parallel to each other and one end of the bundle shall be twisted 180° relative of the other.

6.2 Electrical Wire Accessories

6.2.1 Accessory specimens shall be free of cuts, abrasions or other flaws as determined by close visual inspection.

6.2.2 Accessory specimens shall be installed over or adjacent to wire bundles, prepared per Paragraph 6.1.2, in the manner in which they are intended to be installed in the spacecraft.

7.0 PRETEST PROCEDURE

7.1 Verify that all test equipment is in current calibration.

7.2 Verify oxygen certification (MIL-O-27210, Type 1).

7.3 Verify material identification by one of the items below:

7.3.1 Manufacturer's Certification.

7.3.2 NASA Certification.

7.3.3 Contractor Certification.

7.3.4 Definite identification not available.

7.4 Visually inspect each sample. (There shall be no cuts, abrasions or other flaws.)

7.5 Prepare three samples per 6.1.2.

7.6 Prepare wire accessories per 6.2.2.

7.7 Record wire gauge number.

7.8 Record power supply current capability in amps. Power supply must meet the requirement of Para. 5.5 for the gauge wire being tested.

7.9 Record thickness of wire insulation in mils.

7.10 Record volume of chamber in liters.

7.11 The sample bundle shall be mounted in the horizontal sample holder and positioned within the test chamber by fastening one end of the stripped wire to each of the electrical connection posts. It shall be supported in the middle by a center support, constructed with the same wire used for the test. Where required by configuration requirement, the sample wire bundle may be mounted in a vertical position.

8.0 TEST PROCEDURE

8.1 Evacuate the chamber to less than five (5) Torr.

8.2 Repressurize the chamber to (854 Torr) with oxygen. Allow the chamber to remain pressurized for one minute. A leak is indicated if a decrease in test chamber pressure of greater than 0.1 psia is observed after the system is closed off. If leakage is noted, the chamber shall be brought to atmospheric pressure, leak corrected, and steps 8.1 and 8.2 repeated.

8.3 After the chamber has stabilized at 854 Torr psia soak the specimen for 30 minutes. Record soak time.

8.4 Verify chamber pressure is 854 Torr and isolate the chamber.

8.5 Apply a current of per "Initial Test Current" of Para 5.5 to the wire. If ignition is not obtained in one minute, the current shall be increased in 5 ampere steps at one minute intervals until the wire fails or ignition occurs. Record whether ignition occurs or wire failed. If the wire fails, voltage shall remain applied to the open wire until it is positively established that current does not flow by bridging the gap to adjacent conductors.

8.6 Record current level at which ignition occurred or the wire failed. Record if combustion was sustained or halted upon removal of ignition source.

9.0 REPORTING

Unless otherwise specified the following test data and pertinent information concerning the materials shall be reported.

9.1 Name of material.

9.2 Vendor designation and vendor.

9.3 Results of test.

9.3.1 Combustion characteristics and phenomena - self extinguishing or burned.

9.3.2 Pressure rise in the chamber.

9.3.3 Current level at end of test.

9.4 Name and number of test procedure.

9.5 Date of test.

9.6 Test number.

9.7 Identity of the testing organization or agency.

9.8 Name of test coordinator.

9.9 Names and signature of Test Engineer.

TEST NO. 5
ELECTRICAL POTTING AND COATINGS
FLAMMABILITY TEST

1.0 PURPOSE

The purpose of this test is to determine the flammability characteristics of spacecraft pottings compounds in an oxygen atmosphere. The test is designed to simulate a short circuit or dielectric breakdown of current-carrying wires or of connector contacts within the potting used to seal electrical connectors.

2.0 TEST CONDITIONS - PRESSURES

The pressurized test environment for each material shall be determined from the applicable usage category and vehicle effectivity. The following table relates environmental test conditions to category and module combinations.

Category	Module	PSIA Oxygen
A	CM *	16.5
A	LM	6.2
B	CM *	16.5
B	LM	6.2
C	CM	20.0
C	LM	8.7
H	CM and LM	14.7 PSIA AIR (Unless otherwise specified)

3.0 TEST DISCIPLINE

3.1 Each test shall be directed by the cognizant Test Engineer or his appointed alternate.

3.2 The cognizant Test Engineer shall affix his signature to all test data sheets.

* Electrical potting and coatings configurations which do not meet the criteria of acceptability stated in Paragraph 4.0 shall be retested in an atmosphere containing 60 percent oxygen and 40 percent nitrogen at 16.5 psia. Compatibility with the pure oxygen environment is the design goal. Deviations will not be required for materials in assemblies which pass the mixed atmosphere test requirement.

4.0 CRITERIA OF ACCEPTABILITY

Connector potting material shall not sustain combustion in the pressurized oxygen test atmosphere following removal of the ignition source which contains electrical current overloads providing temperature up to the melting point of the conductor of the electrical wire.

5.0 TEST EQUIPMENT

5.1 Test Chamber - Test chamber shall have sufficient volume to ensure complete combustion of the wire bundle specimen and shall be suitably constructed and protected to ensure safe operation. A window or viewing port for visual observations shall be provided. The test chamber shall contain inlets for vacuum, electrical power for wire overload, air, and oxygen. A horizontal and vertical sample holder and a central connector mount shall be included and positioned within the test chamber. (See Figure 1)

5.2 Pressure Gauge - The pressure gauge shall be capable of measuring absolute pressure from 1 to 30 psia (1550 Torr) with an accuracy of ±0.1 psia.

5.3 Oxygen Supply - The oxygen shall be commercially available and conform to specification MIL-O-27210, Type 1.

5.4 Sample Holder and Connector Mount - The sample holder shall consist of two horizontally mounted electrical connections (bolt with knurled nuts) spaced 12 inches apart. The electrical terminals shall be connected to the ignition power source. A central connector mount consisting of a vertical panel drilled to receive a horizontal Jam Nut Type Receptacle shall be provided.

5.5 Ignition Source - An external power supply shall be provided which is capable of providing a large steady DC current so that a very high temperature will be achieved quickly. The power source must be capable of supplying 100 amperes of current through an 18 AWG fourteen inch long wire. A photocell to interrupt current at ignition shall be provided.

6.0 SAMPLE PREPARATION

6.1 Three (3) electrical connector samples shall be prepared for each candidate potting compound. The procedures for wiring and potting each of the electrical connectors shall be in accordance with Paragraphs 6.4 through 6.8. The procedure for preparing the wires shall be in accordance with Section 6.3

6.2 Verify material identification by one of the following:

6.2.1 Manufacturer's Certification

6.2.2 NASA Certification

6.2.3 Contractor Certification

6.2.4 Definite identification not available

6.3 A fourteen inch (14") length of AWG 18 white Teflon insulated wire (MIL-W-16878, Type E, or MIL-W-22759, Type MS21985) shall be prepared as follows:

6.3.1 Form a "U" bend in the middle of the wire and etch the center 4 inches. Neutralize in naptha solvent or ethyl alcohol.

6.3.2 Strip one half inch insulation from each end.

6.3.3 Cut the wire in half such that two inches of etched insulation remains on the unstripped end of each seven inch length.

6.4 Obtain a Straight Plug. Strip 1/4" from the etched end of each 7" wire prepared per 6.3. Crimp one 7" wire to contact K and the second 7" wire to adjacent contact L. See Figure 2. The etched ends of the wires are nearer to the contacts.

6.5 Crimp nine (9) etched (as in Para. 6.3.1) white AWG 20 Teflon insulated wires, each 3" long, to the remaining contacts.

6.6 Place the potting boot on the connector and fill with the candidate potting compound, per the manufacturer's instructions. Ensure that the potting compound is within recommended shelf life. Ensure that all steps are followed exactly as they would be on flight hardware, including cleaning and priming of connector rear insert for bondability, degassing potting compound, proper humidity control, etc.

6.7 Cure per applicable user's procedure or manufacturer's recommended time/temperature for optimum properties.

6.8 Remove potting boot.

7.0 CENTRAL CONNECTOR PREPARATION

7.1 Prepare three (3) Central Connectors per paragraphs 7.2 through 7.5 below.

7.2 Obtain a Jam Nut Receptacle. Crimp a short AWG 16 Teflon insulated jumper between contact K and contact L. See Figure 2.

7.3 Place the potting boot on the connector and fill with the candidate potting compound.

7.4 Cure per manufacturer's instruction.

7.5 Remove potting boot.

8.0 TEST PROCEDURE

The procedure shall be carried out in the following sequences:

8.1 The sample, prepared per Section 6.0 shall be mounted in the horizontal sample holder and positioned within the test chamber by fastening the stripped end of each 7" wire to an electrical connection. Mate and lock the specimen electrical connector to the Jam Nut Receptacle (prepared per 7.0) on the central connector mount. (See Figure 1.)

8.2 The test chamber shall be evacuated to a pressure of 1 Torr and repressurized to the test pressure with oxygen. Allow the chamber to remain pressurized for one minute. Leakage is indicated if a change in test chamber pressure is observed after the vacuum pump is closed off from the system. The system shall be brought to atmospheric pressure and the leakage eliminated before any additional tests are carried out. Repeat the above procedure.

8.3 After the test chamber has been stabilized at the test pressure, soak the specimens a minimum of ten minutes. Apply a current of 55 amperes to the wire. If ignition or considerable degradation is not obtained in one minute, the current shall be increased by 5 amperes (i.e., from 55 to 60 and 60 to 65, etc.) until such time as the wire fails or ignition occurs.

If ignition occurs prior to wire failing the photocell shall reduce current to zero amperes to evaluate self-extinguishing characteristics of potting compound.

8.4 Three samples of each potting compound shall be tested. The failure of any one sample to meet the criteria of Paragraph 4.0 shall be cause for rejection of that compound.

9.0 REPORT

The following test data and pertinent information concerning the materials shall be reported:

9.1 Name of the material (generic).

9.2 Vendor designation and vendor.

9.3 Results of each test including combustion phenomena if ignition occurs.

9.4 Date of test.

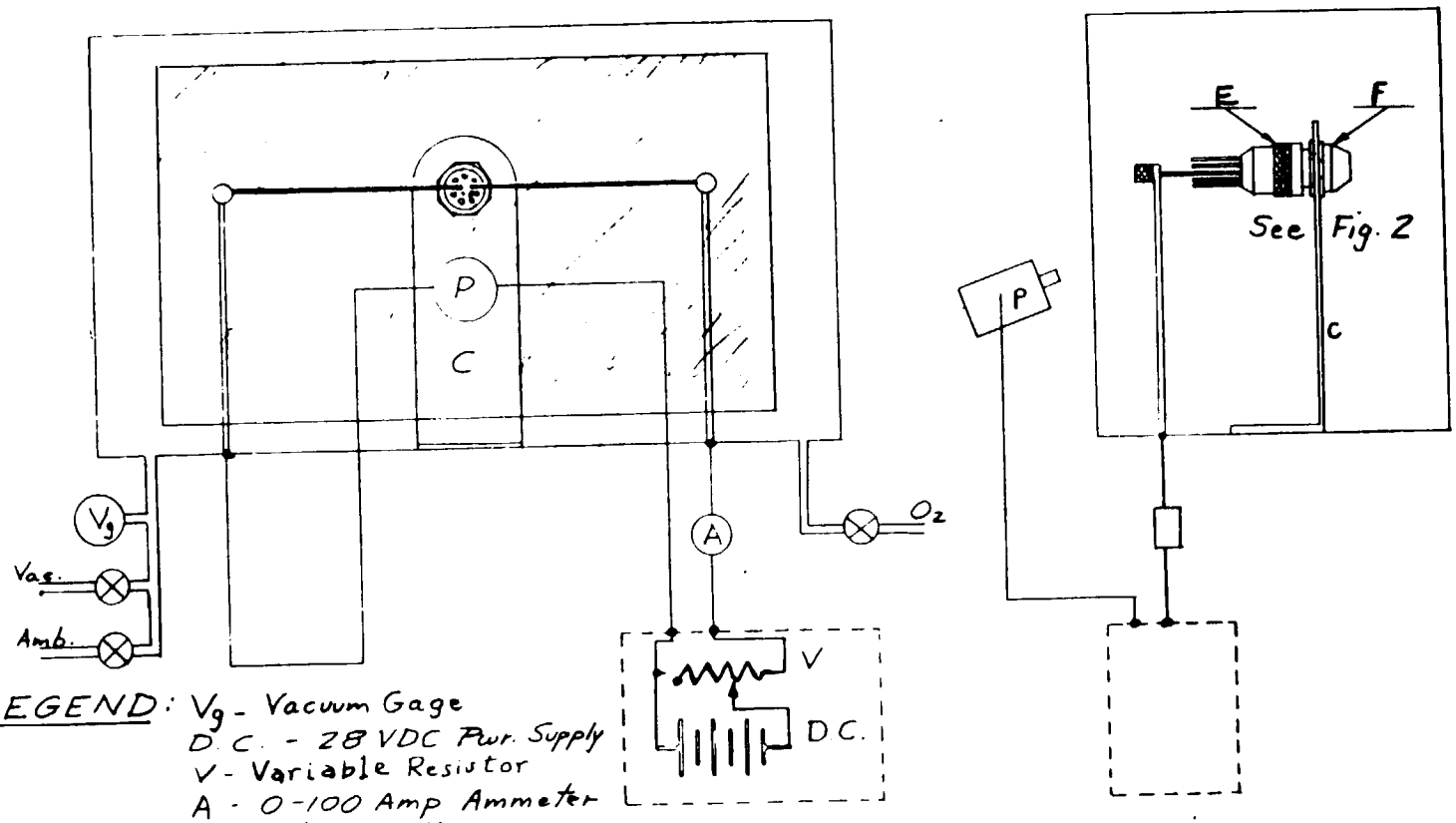
9.5 Test number.

9.6 Identity of the testing organization or agency.

9.7 Name of the test coordinator.

9.8 Names and signatures of Test Engineer.

FIG. 1 POTTING FLAMMABILITY TEST EQUIPMENT SCHEMATIC



LEGEND: V_g - Vacuum Gage
D.C. - 28 VDC Pwr. Supply
V - Variable Resistor
A - 0-100 Amp Ammeter
P - Photocell
C - Central Connector Mount
E - STRAIGHT PLUG
F - JAM NUT RECEPTACLE

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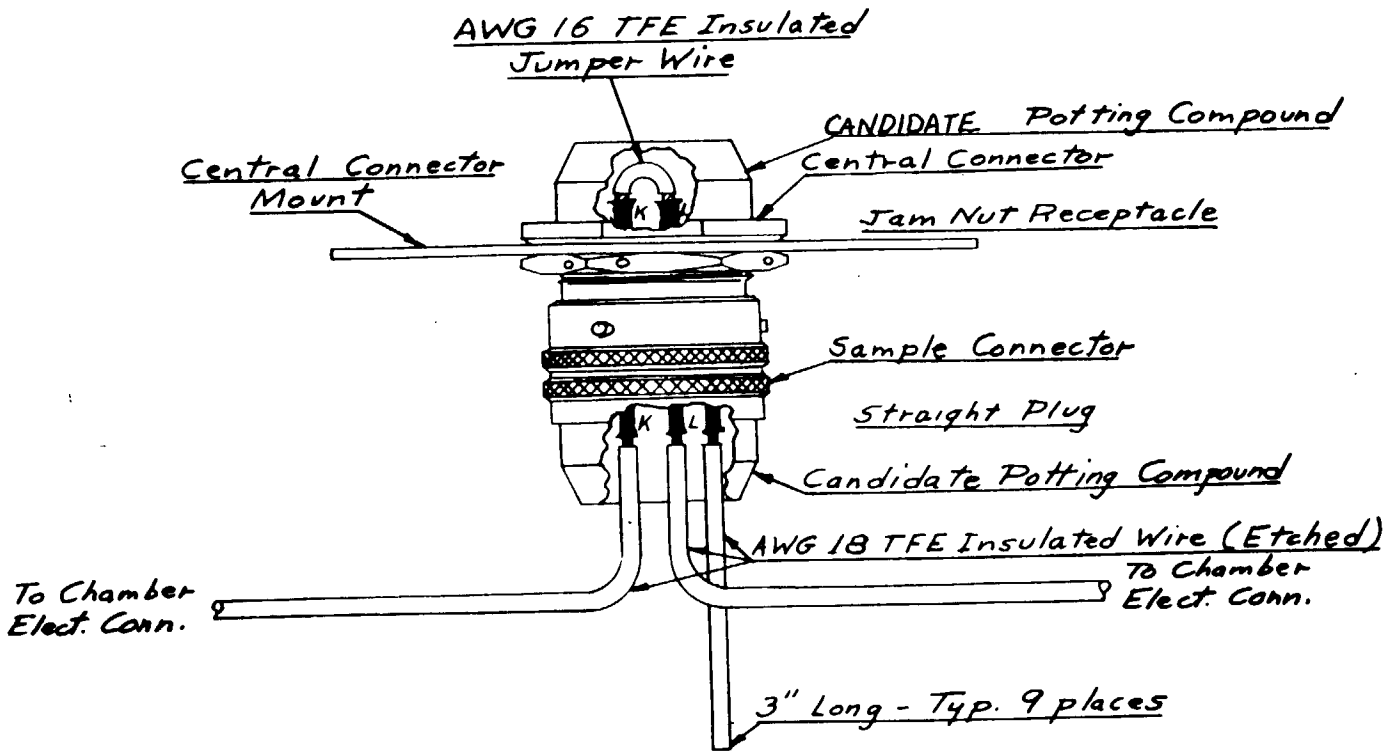
FIG. 2 SAMPLE CONFIGURATION



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TEST NO. 6

ODOR TEST

1.0 PURPOSE

The purpose of this test is to identify materials that are undesirable to the olfactory senses. A material that fails this test shall not be used in the habitable areas of the spacecraft.

2.0 ODOR CRITERIA

2.1 Selection of Test Panel for Odor Evaluation - The test conductor shall establish a pool of qualified personnel. The Test Panel shall have a minimum of five members and a maximum of ten members.

2.1.1 Members of the pool shall be capable of detecting seven basic odors from the following solutions:

Primary Odor	Standard Compound	Amount Dilution in Water
Ethereal	1, 2 - dichloroethane	0.4 ml in 500 ml (4 ml in 5 l)
Camphoraceous	1, 8 - cineole	5 ml in 500 ml (1 ml in 100 l)
Musky	15 - hydroxypentadecanoic acid lactone	1 mg in 1,000 ml
Floral	1 - methyl-1-ethyl-2-phenyl propanol-1	0.075 ml in 500 ml (7.5 ml in 50 l)
Minty	menthone (dl)	2 ml in 333 ml (2 ml in 333 l)
Pungent	formic acid	25 ml of 90 percent solution in 500 ml
Putrid	methyl dithiomethane (methyl disulphide)	1 ml in 10,000 ml (1 ml in 10,000 l)

2.1.2 Members of the pool shall be given three odorless solutions along with the seven primary standards for the detection of odor.

2.1.3 The solutions shall be freshly prepared once a month or as needed.

2.1.4 The established pool for odor evaluation shall be requalified every three months.

2.1.5 Odor panel members should receive a nose and throat examination by medical staff prior to and after each odor test session.

2.1.6 Members of the pool shall not participate on the panel if their sense of smell is affected in any manner.

2.1.7 One of the seven basic odors shall be presented to the panel members as a standard for sensing odor prior to evaluation of odors from any sample material.

2.1.8 Panel members shall not be permitted to see or know the sample material being evaluated for odor.

2.1.9 Odor evaluations on sample materials shall be performed in a suitable room, free from extraneous odors.

2.1.10 Odor evaluations shall be performed on every new bottle of oxygen used for the tests.

2.2 Odor Evaluation and Acceptance Criteria - Each panel member shall evaluate the odor of a sample according to the following scale:

Members Rating	Test Conductor's Rating
Undetectable	0
Barely detectable	1
Easily detectable	2
Objectionable	3
Irritating	4

2.2.1 An average rating of 2.5 or lower of any sample material by the panel members, signifies the material passes the odor test.

3.0 TEST DISCIPLINE

3.1 All materials shall have been tested for carbon monoxide content and total organics before being subjected to the odor test. If a material yields over 25 micrograms of carbon monoxide/gram of material, or over 100 micrograms of total organics/gram of material, no odor test shall be performed. The material shall be rejected for odor and T.O.

3.2 Each test shall be directed by the cognizant Test Engineer or his appointed alternate.

3.3 The cognizant Test Engineer shall affix his signature to all test data sheets and verify that sample identification is adequate.

4.0 TEST EQUIPMENT

4.1 Test Chamber - The test chamber shall be made of pyrex glass and its internal volume shall be two liters minimum. The test chamber shall have the following:

4.1.1 A gas tight removable cover.

4.1.2 A sampling valve.

4.1.3 A sampling port capable of being sealed with a septum.

A laboratory vacuum dessicator may be utilized as a test chamber.

4.2 Oven - The oven shall be capable of providing a constant temperature of 200° F.

4.3 Oxygen Supply - The oxygen shall conform to MIL -0-27210, Type 1. Suitable equipment for transferring oxygen to test chamber shall be used.

4.4 Sample Transfer Equipment - Glass syringes shall be used for measuring and transferring the gas samples from the test chambers to panel members face mask.

4.5 Pressure Gauge - the pressure gauge shall be capable of measuring absolute pressures to within ±1 Torr accuracy.

4.6 Olfactometer - The olfactometer shall consist of a mask made of odorless flexible material which can be applied to a panel member's face.

4.7 All odor testing equipment shall be nonproducers of odor and carbon monoxide, under test conditions set forth under Section 6.0.

5.0 TEST SPECIMENS PREPARATION

5.1 Verify material identification by one of the following:

5.1.1 Manufacturer's Certification

5.1.2 NASA Certification

5.1.3 Contractor Certification

5.1.4 Definite identification not available

5.2 All materials tested shall be classified into four categories; samples based on surface, volume, or weight, or specialized items.

5.3 Samples based on Surface

This classification encompasses all those materials that are essentially two-dimensional. This would include films, fabrics, coatings, finishes, primers, adhesives, solid film lubricants, tapes, and electrical insulating material (spaghetti wire.)

The sample tested shall have a surface area of 300 ±15 square centimeters per liter of test container. Coatings, finishings, etc. shall be coated on clean aluminum substrate of 0.020 ±0.01 inch thickness. Material thickness, curing process, and method of application shall be in accordance with the manufacturer's recommendations. Material may be applied to both sides of the aluminum panel.

Tapes and other similar materials with an adhesive surface shall be fastened to a similar aluminum panel. In all cases, only the outer surface of a material on the aluminum panel is counted in the surface area determinations. Films, fabrics, and similar materials shall be cut to give 300 ±15 square centimeters surface area per liter of test container. Since these materials have both surfaces exposed when in use, both the top and bottom surface shall be counted in determining total surface area.

5.4 Samples Based on Volume

This classification encompasses all those materials having a definite volume but also having a large real surface area due to surface convolutions or matting. This classification shall include foams and other blown or foamed materials and matted materials such as rubberized horse-hair.

Samples of these materials shall be cut to a thickness of 1.25 centimeter ±0.25 centimeter unless the existing thickness is less than 1.0 centimeter. In this case, the existing thickness shall be used. The material shall be cut to such a size as to give 50 ±5 square centimeters of total surface per liter of test container volume. All surfaces (top, bottom, and sides) shall be used to compute total surface area. In cases where the natural thickness is such that the material cut would be too large to be placed into the container, two or more pieces may be cut so long as the total surface area requirement is met.

5.5 Samples based on Weight

This classification encompasses all those materials having a definite bulk and not falling into the volume classification. This shall include potting compounds, molding compounds, cast or formed objects, solid wires, and thick plastics. Liquids that are not used or applied as coatings on thin films shall be included.

The samples shall be used as much as possible in the supplied configuration and cut to give 5.0 ±0.25 grams per liter of test container. Potted or molded materials shall be prepared and cured per manufacturer's directions and cut to weight. Liquids shall be placed in an aluminum dish 2.25 ±0.25 inches in diameter. Sample weight shall be 5.0 ±0.25 grams per liter of test container.

5.6 Specialized Items

It must be recognized that some materials will not meet the above classifications and must be specially handled. This will most often occur with non-homogeneous materials. These cases will be tested in the manner designated by the chemist in charge with QA notification. The manner of testing and sample preparation shall be fully reported.

6.0 TEST CONDITIONS

6.1 The atmosphere in the test chamber at the start of the test exposure shall be MIL-0-27210, Type 1, oxygen at 260 ±5 Torr.

6.2 The sample materials shall be heated at a temperature of 155° F for a test duration of at least 72 hours.

6.3 Leak Check - The test system shall not increase in pressure more than one Torr while remaining at a reduced pressure of one Torr for a time period of one hour.

6.4 Each sample material shall be tested in a separate test chamber.

6.5 Odor evaluations shall be carried out within three hours of the conclusion of the thermal treatment.

6.6 All measuring equipment shall have the proper calibration stickers.

7.0 TEST PROCEDURE

The procedure shall be conducted in the following order.

7.1 Sample materials shall be prepared according to the conditions outlined under sample preparation in Section 5.0.

7.2 After placing sample materials in separate test chambers, the test chamber shall be evacuated to one Torr or less. The test chambers shall then be pressurized to 260 ±5 Torr with MIL 0-27210, Type 1, oxygen.

7.3 The test chambers shall be exposed to a temperature of 155° F inside an oven for a time period of at least 72 hours, allowing time for initial warm-up.

7.4 Following the required exposure of the test chambers to the oven temperature, the test chambers shall be removed.

7.5 The pressure in the test chambers shall be measured and recorded.

7.6 Observation of distillable residues on interior chamber walls shall be made and recorded. A material that deposits a residue on the chamber walls may be cause for rejection subject to the rating per Sec. 2.3.

7.7 The test chambers shall be pressurized to one atmosphere with oxygen and a sampling septum installed.

7.8 Sampling for Odor Test - A known volume of atmosphere from each sample shall be extracted from the test chamber by means of a clean syringe and diluted with fresh oxygen in the proportion of one part of sample atmosphere to 29 parts of oxygen (by volume). If the odor evaluation is acceptable, another extraction shall be made in similar fashion and diluted with fresh oxygen in the proportion of one part of sample atmosphere to 9 parts of oxygen (by volume). If the odor evaluation is acceptable, a third extraction shall be made and evaluated without dilution. An unacceptable evaluation at any dilution unequivocally rejects the material and suspends further odor evaluation.

8.0 REPORTING

Unless otherwise specified, the following test data and pertinent information concerning the materials shall be reported.

8.1 Name of material.

8.2 Vendor designation and vendor.

8.3 Rating numbers determined by the panel members.

8.4 Definition of the odor as interpreted by each panel member.

8.5 Status of the material as a result of the test.

8.6 Name and number of the test procedure.

8.7 Date of test.

8.8 Identity of the testing a organization.

8.9 Name of test coordin

8.10 Names and signature t Engineer.

TEST NO. 7

DETERMINATION OF CARBON MONOXIDE AND TOTAL ORGANICS

1.0 PURPOSE

The purpose of this test is to quantify the evolution of potentially toxic or objectionable volatiles from non-metallic material candidates for use in space vehicle crew compartments. The volatiles to be determined by this test are limited to two categories: 1) Carbon Monoxide, and 2) Total Organics.

2.0 SIGNIFICANCE

Test No. 7 is designed to eliminate from manned space vehicle usage those materials which out-gas significant amounts of toxic or objectionable volatiles.

3.0 CRITERIA OF ACCEPTABILITY

The concentration of out-gassed material (total organics) in the spacecraft will be function of the individual materials in use therein, and also of the effective spacecraft crew bay volume.

3.1 The maximum allowable level of total organics in the tested configuration shall not exceed 100 micrograms of total organics per gram of sample.

3.2 The maximum allowable level of carbon monoxide from the sample in the tested configuration shall not exceed 25 micrograms per gram.

4.0 TESTED DISCIPLINE

4.1 Each test shall be directed by the cognizant Test Engineer or his appointed alternate.

4.2 The cognizant Test Engineer shall affix his signature to all test data sheets and verify that identification of material is adequate.

5.0 TEST EQUIPMENT

5.1 Test Chamber - The test chamber shall have a main chamber volume of two liters minimum. It shall be fabricated of materials and designed to allow ready cleaning. The chamber and gas handling system shall be lined with stainless steel. All other non-metallic materials used to fabricate the chamber or gas handling system shall be certified as non-volatile under test conditions. The chamber shall be designed to prevent condensation or trapping of gaseous products except in the room temperature condenser. The test chamber shall be provided with a thermometer or thermocouple and pressure gauge for temperature and pressure determinations respectively. The chamber shall be connected to a series of traps and inlet tubes to permit evacuation, pressure readings, oxygen introduction, helium flow for trapping purposes, and sample withdrawal for quantification of volatile out-gassed products. An alternate procedure involved the connection of the test chamber directly to a gas chromatograph and/or mass spectrometer for the gas analyses.

5.2 Heating Source - The oven shall maintain constant temperature control over the test chamber to ± 5°F. The temperature during sample exposures shall be recorded.

5.3 Vacuum Pump - The vacuum pump shall be capable of producing a vacuum less than one Torr with little or no system contaminants.

5.4 Analytical Equipment - The analytical equipment shall consist of the following and any other instruments which the tester desires to use to completely and efficiently analyze offgassing products. These equipment items shall be identified.

5.4.1 Gas Chromatograph System - Recorder, thermal conductivity and hydrogen flame ionization and electron capture detectors.

5.4.2 Gas Sampling System suitable for transfer of measured volumes of gas samples from the test chamber to the gas chromatograph.

5.4.3 Calibration Gas Samples as required to quantify detector sensitivity and readout. These may be bought from a manufacturer or made up in the laboratory.

6.0 PREPARATION OF TEST EQUIPMENT

6.1 Prior to loading of sample into a container, the container shall be loaded to 5.0 psi with oxygen, heated at 200° F for 24 hours, and the oxygen analyzed for total organics and carbon monoxide. The container shall be certified clean for use if the total organics value is 10 ppm by volume or less. After use, the container shall be reused without cleaning if the sample values are equal to or less than the above. If not, the container shall be heated and purged with air or nitrogen by some convenient method, such as a heat gun with blower, loaded to 5.0 psia with oxygen, and tested to the above specifications.

6.2 Leak Check - The test system shall not increase in pressure more than one Torr while remaining at a reduced pressure of one Torr for a time period of one hour.

7.0 TEST SPECIMENS

7.1 Verify material identification by one of the following:

7.1.1 Manufacturer's Certification

7.1.2 NASA Certification

7.1.3 Contractor Certification

7.1.4 Definite identification not available

7.2 All the materials tested in the program shall be classified into four categories: samples based on surface, volume, or weight, or specialized items.

7.3 Samples based on Surface

This classification encompasses all those materials that are essentially two-dimensional. This would include films, fabrics, coatings, finishes, primers, adhesives, solid film lubricants, tapes, and electrical insulating material (spaghetti wire).

The sample tested shall have a surface area of 300 ±15 square centimeters per liter of test container. Coatings, finishings, etc. shall be applied to clean aluminum substrate of 0.020 ± 0.01 inch thickness. Material thickness, curing process, and method of application shall be in accordance with the manufacturer's recommendations. Material may be applied to both sides of the aluminum panel. Tapes and other similar materials with an adhesive surface shall be fastened to a similar aluminum panel. In all cases, only the outer surface of a material on the aluminum panel is counted in the surface area determinations. Films, fabrics, and similar materials shall be cut to give 300 ± 15 square centimeters surface area per liter of test container. Since these materials have both surfaces exposed when in use, both the top and bottom surface shall be counted in determining total surface area.

7.4 Samples based on Volume

This classification encompasses all those materials having a definite volume but also having a large real surface area due to surface convolutions or matting. This classification shall include foams and other blown or foamed materials and matted materials such as rubberized horse-hair.

Samples of these materials shall be cut to a thickness of 1.25 centimeter ± 0.25 centimeter unless the existing thickness is less than 1.0 centimeter. In this case, the existing thickness shall be used. The material shall be cut to such a size as to give 50 ± 5 square centimeters of total surface per liter of test container volume. All surfaces (tops, bottoms, and sides) shall be used to compute total surface area. In cases where the natural thickness is such that the material cut would be too large to be placed into the container, two or more pieces may be cut so long as the total surface area requirement is met.

7.5 Samples Based on Weight

This classification encompasses all those materials having a definite bulk and not falling into the volume classification. This shall include potting compounds, molding compounds, cast or formed objects, solid wires, and thick plastics. Liquids that are not used or applied as coatings or thin films shall be included.

The samples shall be used as much as possible in the supplied configuration and cut to give 5.0 ± 0.25 grams per liter of test container. Potted or molded materials shall be prepared and cured per manufacturer's directions and cut to weight. Liquids shall be placed in an aluminum dish 2.25 ± 0.25 inches in diameter. Sample weight shall be 5.0 ± 0.25 grams per liter of test container.

7.6 Specialized Items

It must be recognized that some materials will not meet the above classifications and must be specially handled. This will most often occur with non-homogeneous materials. These cases will be tested in the manner designated by the chemist in charge with QA notification. The manner of testing and sample preparation shall be fully reported.

8.0 PROCEDURE

8.1 Purge the test chamber with MIL-O-27240, Type 1, oxygen until the minimum oxygen concentration is 95 percent to be determined with the gas chromatograph and begin heating. Bring the chamber to 155° ± 5°F and adjust the chamber pressure to 5.0 ± 0.1 psia. Allow the chamber to remain pressurized, and insure that it is free of leakage.

8.2 After twenty-four hours, check the oxygen for contaminants with the gas chromatograph. Proceed to 8.3 if the total contamination is less than 10.0 ppm by volume. If the contamination exceeds the above values, the test chamber shall be flushed and rechecked after an additional twenty-four hours. This procedure shall be continued until the contamination is below the specific level of ten ppm. If the acceptable contamination tolerance is not achieved after continuous flushing, the test chamber shall not be used.

8.3 Place a clean weighed specimen prepared per Section 7.0 in the test chamber.

8.3.1 The chamber shall be evacuated through a liquid nitrogen trap to below one Torr. The chamber shall then be closed off, heat applied, and oxygen filtered through a 5X Molecular Sieve bled into the chamber. The conditions of exposure shall be held at 5.0 ± 0.1 psia of 95 percent pure oxygen and 155° ± 5°F for a total period of 72 hours.

8.3.1.1 Following the designated exposure period, the chamber shall be brought to room temperature. The test specimen is removed from the chamber and weighed after the final gas samples are taken.

The gases shall then be analyzed for the following:

8.3.1.2 Total organics expressed as pentane equivalents.

8.3.1.3 Quantity of carbon monoxide evolved.

8.4 Determination of Total Organics - The gas chromatograph with the pertinent column and detectors, Beckman Total Hydrocarbon Analyzer or an equivalent instrument may be used for the determination. This gas chromatograph should be equipped with a flame ionization unit or its equivalent.

8.5 Determination of Carbon Monoxide - The carbon monoxide content of the evolved gases shall be determined under Sections 7.4 and 7.5 by utilizing an appropriate separation and analytical technique.

9.0 REPORTING DATA

9.1 The following test data and pertinent information concerning material tested shall be reported:

9.1.1 Name of the material (generic)

9.1.2 Vendor designation and vendor

9.1.3 Weight and size - length, width, and thickness of sample tested.

9.1.4 Results of tests

9.1.4.1 Carbon monoxide in micrograms per gram

9.1.4.2 Total organics in micrograms per gram

9.1.4.3 Weight loss, percent

9.1.4.4 Amount and type of any condensate

9.1.5 Name and number of test procedure

9.1.6 Date of test

9.1.7 Test Number

9.1.8 Identity of the testing organization or agency

9.1.9 Name of test coordinator

9.1.10 Names and signatures of Test Engineer.

SUPPLEMENTARY TEST NO. A

FRICTION AND IMPACT IGNITION TEST GUIDELINES

1.0 PURPOSE

The purpose of this test is to determine the sensitivity and compatibility of non-metallic materials with pure oxygen. The test is applicable to materials selected for use in the high pressure oxygen system (Category D).

2.0 TEST CONDITIONS

2.1 Only materials that have passed the other tests required of candidates for high pressure oxygen systems (Category D) shall be subjected to Supplementary Test No. A.

2.2 The materials shall be subjected to 3 successive tests at 1.5 kilogram meters using the test procedure described in Section 7.0 below.

2.3 The non-metallic materials specimen shall ungergo GOX impact sensitivity testing beginning at 1000 psia, or the highest operating pressure seen by the material in the GOX system. GOX impact test shall be conducted at subsequent increased pressure levels of 1000 psia until failure is observed.

3.0 TEST DISCIPLINE

3.1 Each test shall be directed by the cognizant Test Engineer or his appointed alternate.

3.2 The cognizant Test Engineer shall affix his signature to all test data sheets.

4.0 CRITERIA OF ACCEPTABILITY

4.1 When tested according to the procedure in Section 7.0 of this document, the material shall be tested at successively higher pressure until a reaction is observed by:

4.1.1 Discoloration

4.1.2 Evidence of combustion

4.1.3 Detonation

4.2 Material shall show no reaction at maximum use pressure plus 2000 psi.

5.0 SAMPLE PREPARATION

5.1 Sufficient material shall be available to permit the preparation and testing of at least 60 specimen samples prepared as follows:

5.1.1 Sheet materials up to 0.050 inch in thickness shall be tested as 0.250 inch diameter discs.

5.1.2 Materials normally used in thickness greater than 0.250 inch shall be cut and tested as 0.250 inch diameter discs of 0.050 ± .005" thickness.

5.1.3 Materials not readily available in sheet form, such as O-rings and the like, shall be tested in the available configuration, but the quantity used shall be limited to 0.5 ± 0.05 gram for each individual test.

5.1.4 Materials such as greases and fluids whose thicknesses are not dictated by conditions of use shall be tested as 0.050 ± .005 inch layers in test cups.

5.1.5 Coating materials such as dry-film lubricants shall be applied to 11/16 diameter stainless steel inserts in the same manner as to the same thickness that is intended for hardware application. After the samples have dried or cured, place in the regular specimen cups for test.

5.2 Sampling Cleaning

5.2.1. Solid materials, i.e., sheets, moldings, etc. shall be washed with a mild detergent solution, rinsed and dried by placing in a covered container in an air circulating oven at 212 to 239°F for one hour.

5.2.2 The test specimens shall be saoked in pure oxygen at room temperature for 24 hours in a separate pressure vessel.

6.0 PRETEST PROCEDURE

6.1 Verify that all the test equipment has been thoroughly cleaned according to the applicable method of the cleaning specification denoted in the procedure.

6.2 Verify that all test equipment is in current calibration.

6.3 Verify the material identification by one of the items below:

6.3.1 Manufacturer's Certification

6.3.2 NASA Certification

6.3.3 Contractor Certification

6.3.4 Definite identification not available.

6.4 Observe that the cleaned metallic components and GOX transfer lines are assembled.

6.5 Verify that the sample is contained in a specimen holder and cup assembly which will allow for the transfer of impact energy to the subject specimen in a repetitious manner.

7.0 TEST PROCEDURE

7.1 Place the sample in position within the sample retainer cavity.

7.2 Oxygen Generation - Moderate Pressure (20 psia to 2000 psia)

7.1.1 Pass gaseous oxygen from manifold K-bottles through molecular sieve filters to separate oil, a check valve and an additional residual water filter (Drierite type) before final pressurization of the test chamber.

7.1.2 Set the plummet, pestle, striker or suitable impact device in position.

7.1.3 Raise the chamber pressure to the desired level by passing the oxygen through a suitable, stainless steel particle filter and thence into the test bomb.

7.3 Maintain the pressures in the test chamber at ±10% of the pressure selected.

7.4 Maintain the temperature at 70 ± 2.0°F.

7.5 Activate the striker device.

7.6 Record the temperature and pressures in the chamber before, during and after the test.

7.7 At the conclusion of the test, release the residual GOX pressure in the assembly.

7.8 Disassemble the Apparatus.

7.9 Examine the sample specimen and cup specimen holder for visible signs of impact.

7.10 Record all observations.

8.0 REPORTING

The following test data and information shall be reported.

8.1 Name of material.

8.2 Vendor and vendor designation.

8.3 Results of test

8.3.1 Pressure change in the vessel.

8.3.2 Temperature change in the vessel.

8.3.3 Condition of sample after test.

8.3.4 Condition of vessel after test.

8.4 Name and number of test procedure.

8.5 Date of test.

8.6 Identity of testing organization or agency

8.7 Name of test coordinator

SUPPLEMENTARY TEST NO. B
FLASH POINT AND FIRE POINT TESTS

1.0 PURPOSE

The purpose of this test is to determine the spark ignition characteristics of non-metallic materials which are to be used in the areas of manned spacecraft exposed to the pure oxygen environments.

2.0 TEST CONDITIONS - PRESSURES

This test shall be performed for materials at the following pressures.

Categories	Module	PSIA (oxygen)
B, D, F	CM	16.5 and 6.2
B, D, F	LM	6.2

3.0 TEST DISCIPLINE

3.1 Each test shall be directed by the cognizant Test Engineer or his appointed alternate.

3.2 The cognizant Test Engineer shall affix his signature to all test data sheets and verify the adequacy of material identification.

4.0 DEFINITIONS

4.1 Flash Point - The flash point is the lowest temperature at which a material will give off, at or near its surface, flammable vapor which, when mixed with oxygen or air in the environment and exposed to an ignition source, will provide a non-self-sustaining flash or flame.

4.2 Fire Point - The fire point is the lowest temperature at which the mixture of vapors from the surface of a material and air or oxygen continue to burn after ignition. A self-sustaining, self-propagating glow shall be considered equivalent to flaming combustion.

5.0 CRITERIA OF ACCEPTABILITY

5.1 A material that evolves vapors which produce a visible flash at a temperature of less than 400° F when tested accordingly to Section 8.0 of this specification shall be considered unacceptable for use in the manned spacecraft crew bay areas. One or more of the three test specimens failing to meet the above requirements shall constitute the rejection of the materials being tested.

5.2 A material that shows evidence of charring, self-sustaining combustion, or other signs of pyrolysis at a temperature less than 450° F shall be considered unacceptable for use in the manned spacecraft crew bay areas.

6.0 TEST EQUIPMENT

6.1 Test Chamber

6.1.1 Construction

6.1.1.1 The test chamber shall be suitably constructed to ensure safe operation. A window or viewing port for visual observations shall be included. The chamber is to be fully protected against the possibility of operator injury in the event of explosive rupture.

6.1.1.2 Organic materials used in the construction of the chamber such as gaskets and seals shall be of types which contribute little or no outgassing products to the chamber or which can be pre-outgassed by vacuum cycling to a minimal amount of identifiable vapor, i.e., less than 10 ppm based on the chamber volume.

6.1.1.3 The chamber volume shall be large enough to accommodate a sample of a size specified in the appropriate paragraph of Section 7.

6.1.1.4 The test chamber may be heated by any externally applied method desired. However, the heating method must permit a temperature rise of at least 25° F per minute at 200° F and must maintain a temperature over the test chamber uniform within 10° F after a one minute hold at temperature of 600° F.

6.1.2 Thermocouple - All temperature measurements made in the interior atmosphere of the test chamber shall be made using suitable thermocouples. Temperatures shall be measured at one point on the test face of the specimen approximately one half inch from the sparking device.

6.1.3 Spark Ignition Equipment

6.1.3.1 Spark needles shall be made of platinum, platinum-rhodium alloy or platinum-iridium alloy wire shaped to a 0.004 inch radius point. The spark gap shall be adjusted to an electrode gap of one eighth inch at the beginning of any test.

6.1.3.2 Spark energy to be supplied by a high voltage capacitor. The capacitor shall be charged with a high voltage DC power supply to provide a spark energy of 40-100 milijoules to break down the dielectric gap between the electrodes. The sparking circuit shall be of minimum convenient capacitance, inductance, and resistance.

6.1.4 Oxygen Systems - The oxygen delivery system of the chamber shall consist of corrosion resistant steel tubing of suitable size inside the test chamber. The oxygen shall be brought into the chamber through this tube and exhausted directly from the chamber by the same type or any safe and efficient equipment.

6.1.5 Temperature Monitoring - Thermocouple readings may be monitored by multiple point recorders or any equally accurate method. Desired accuracy is $\pm 10^{\circ}$ F.

6.1.6 The flash and fire points shall be observed visually in a darkened room or with the aid of a photo cell.

7.0 TEST SAMPLE PREPARATION

7.1 Bulk materials shall be in the form of rectangular sheet stock 1 x 4 x 0.030 inches, unless otherwise specified.

7.2 Coatings and finishes shall be applied, in the form and thickness as used in the spacecraft, on one side of a 1 x 6 x 0.020 inch rectangular coupon of unclad aluminum. Pretreatment of aluminum and coating application technique shall conform to established practice for the coating test.

7.3 Film and fabric material shall be tested in their "as purchased" thickness with length and width dimensions of four inches and one inch, respectively.

7.4 Foams shall be in the form of rectangles 1 x 6 x 0.5 inches.

7.5 Electrical wire insulation specimens shall be in the form of insulated wire, six inches long. The insulation shall extend the full length of the wire.

7.6 Materials not suited to testing in the forms described above shall be tested in special form. In any event, the test specimen weight shall not exceed 5 grams per liter of chamber volume and the specimen configuration shall be recorded.

7.7 The specimens shall be cleaned by wiping with a solvent inert to the surface of the test material and drying by blowing with dry nitrogen or oxygen. No evidence of residue shall remain.

8.0 TEST PROCEDURE

8.1 The test specimens shall be conditioned by exposure to an atmosphere of 95 percent purity oxygen at (16.5 psia) 855±5 Torr for at least ten minutes for dense materials and thirty minutes for porous materials at room temperature.

8.2 The test chamber shall be thoroughly cleaned before each test. "Black Light" may be used to detect the presence of residue.

8.3 The specimen shall be mounted in the test chamber with its longest dimension vertical. The sparking point of the ignition needles shall be placed .031 ± .005 inches from the surface of the top of the specimen. The sample shall be contained in some sort of holder that will maintain its distance from the spark source during the entire temperature scan.

8.4 The test chamber shall be closed and evacuated, then filled with oxygen, 95 percent purity confirming to MIL-O-27210, Type I. Evacuating and filling shall be continued until a calculated 99.4 percent or higher oxygen concentration of the purity noted above exists in the system.

8.5 The chamber shall then be checked for leaks by checking the pressure gauge for an increase in pressure. A rise of 1 Torr after a one minute hold denotes a leak which must be corrected before proceeding to the next step.

8.6 At the conclusion of the leak test, chamber heating power, sufficient to cause the internal gas temperature to rise at the rate of $25^{o} \pm 2^{o}$ F per minute, shall be applied. The temperature shall be raised continuously at this rate with sparking at the end of each 25° rise.

8.7 The one minute sparking intervals shall be repeated and continued until the flash point has been observed or a maximum temperature of 600° F has been attained.

8.8 The test will be terminated when any indication of ignition of vapors of sample is observed.

8.9 The fire point tests shall be a continuation of the flash point test. Where flash does not precede fire, the flash point determination will not be considered void.

8.10 Testing of fire and flash points shall be stopped when the maximum temperature of 600° F has been reached.

8.11 If the behavior of the enclosed volume around the spark indicates by repeated strong flashes of igniting gases, that dangerous quantities of potentially explosive gases are being evolved, the test shall be discontinued.

8.12 Three samples of each material shall be tested.

9.0 REPORT

9.1 The temperature at which vapors ignite with a non-self-sustaining flame and no evidence of pyrolysis of the surface of the material shall be recorded as the flash point.

9.2 The temperature at which self-sustaining, self-propagating flame or glow is apparent on the surface of the material shall be recorded as the fire point.

9.3 The report shall include the following information:

9.3.1 Name of the material (generic).

9.3.2 Vendor designation and vendor.

9.3.3 Usage, quantity, and surface area in the spacecraft.

9.3.4 Flash and fire points, combustion characteristics.

9.3.5 Disposition or status, dimensions, and size of sample material.

9.3.6 Name and number of test procedure.

9.3.7 Date of test.

9.3.8 Test number.

9.3.9 Identity of the testing agency or component, and name of test coordinator.