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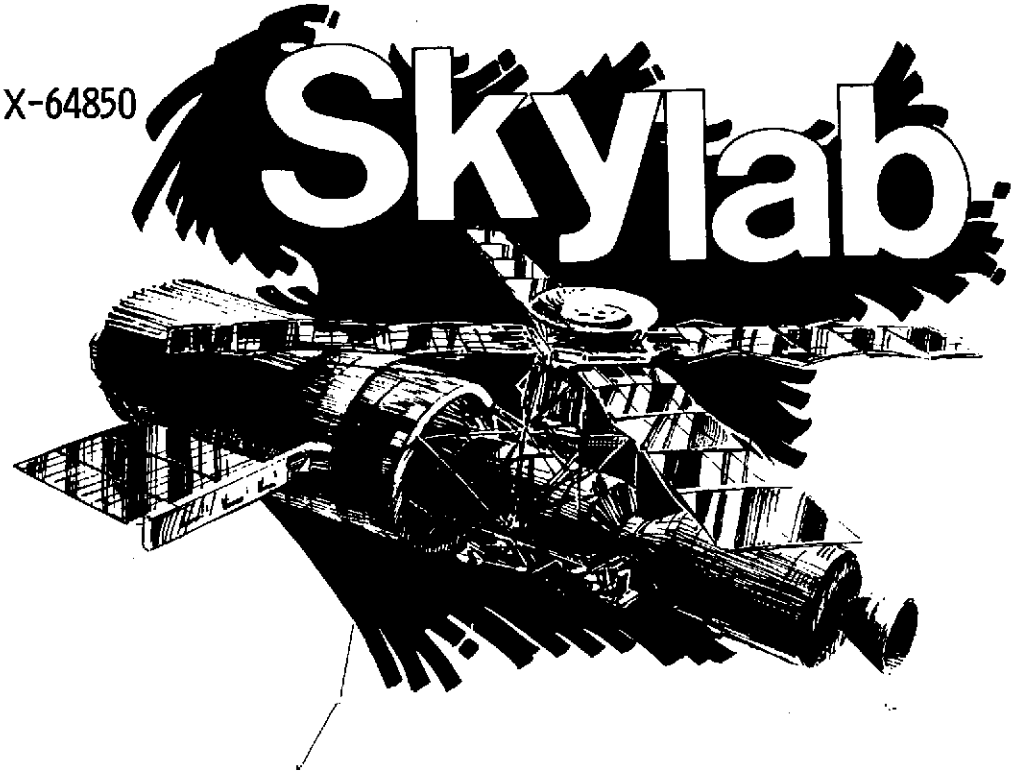

SYSTEM SAFETY CHECKLIST
SKYLAB PROGRAM REPORT

Skylab Program Office

NASA

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama

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Prepared from technical documentation developed and implemented on the Skylab Program. This document was prepared at the direction of the Test, Reliability, Quality Assurance and Safety Office, Skylab Program Office, MSFC, by Earl M. McNail*.

16. ABSTRACT

This document contains over 500 design criteria statements applicable to a wide variety of flight systems, experiments and other payloads, associated ground support equipment and facility support systems. The document reflects a composite of experience gained throughout the aerospace industry prior to Skylab and additional experience gained during the Skylab Program. It has been prepared to provide current and future program organizations with a broad source of safety-related design criteria and to suggest methods for systematic and progressive application of the criteria beginning with preliminary development of design requirements and specifications. Recognizing the users obligation to shape the checklist to his particular needs, a summary of the historical background, rationale, objectives, development and implementation approach, and benefits based on Skylab experience has been included.

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SYSTEM SAFETY CHECKLIST

SUMMARY

This document provides current and future program organizations with a broad source of safety-related design criteria and suggests methods for systematic and progressive application of the criteria beginning with preliminary development of design requirements and specifications.

INTRODUCTION

This document has been prepared to introduce potential users to a system safety experience retention concept which was formalized on the Skylab Program through the means of system safety (design criteria) checklists. The document contains a composite of four design series checklists that were issued for Skylab and reflects updated criteria based on implementation of the Skylab System Safety Checklist Program. The criteria have been prepared and organized for application on any space program. The document contains over 500 design criteria statements which are applicable to a variety of flight systems, experiments and other payloads, and associated ground support equipment and facility support systems. All of the suggested criteria are not applicable to all space activities, if for no other reason than the fact that Skylab involved manned flight. However, the consideration of criteria that may be too stringent in some applications may provide helpful stimulus to the design thought process.

The checklist will not be fully exploited unless it is used at the working design level during the earliest phases of development. It can be effectively used at more mature stages of product development for purposes such as support to analytical efforts, as inspection criteria, and to aid in identifying potential hazards during the review of design changes, but obviously with less opportunity for influencing the design with minimal cost or schedule impact.

Recognizing the user's obligation to shape the checklist to his particular needs, a summary of the background, rationale, objectives, development and implementation approach, and benefits based on Skylab experience has been included.

HISTORICAL BACKGROUND

Handbooks, guideline documents, hazard catalogs, and accident-incident summaries which have been developed over the past ten to fifteen years are valuable indicators of past performance. However, according to a review of accident and incident experience from a wide variety of aerospace sources during the Skylab Program, it was clearly indicated that certain types of hazards have resulted in unsafe failures, accidents, and incidents again and again in each new program.

The cumulative effects of new technology creates a significant number of new hazards that must be identified and controlled. However, experience has shown that the application of new technology to the development of each new product represents only a small part of the safety problem. The majority of system safety deficiencies and resultant accidents or incidents are largely related to design and operational conditions in areas where we have ten or more years experience. During Skylab, even with increased emphasis on the performance of Failure Mode and Effect Analyses (FMEA), System Logic Analysis, Sneak Circuit Analysis and many other forms of hazard analysis, a remaining management concern existed in the area of recurrence control of proven accident causes. Thus, an improved technique for the effective application of safety-related experience from previous programs was sought.

Some of the factors considered during initial studies to develop such a technique, which were also based on prior program experiences, are as follows:

1. Corrective action implies that something was not done properly the first time. Finding this out after the accident or failure occurs can be far more costly than the early identification of conditions which can lead to unsafe failures, equipment damage or personnel injury and correct them before they cause losses or casualties. Furthermore, the earlier in time that hazardous conditions are identified, the less they will cost to eliminate or reduce to an acceptable level. The factors of cost and schedule have a greater influence on decisions once designs are released and manufacturing and testing have started. This results in the tendency to apply procedural controls or rely on individual knowledge or awareness to control potential hazards in order to minimize design changes.

2. The responsibility for hazard identification and control has historically been inherent in the role of design engineering, reliability, quality assurance, and other disciplines. Nevertheless, there has been a limited understanding of the system safety aspects of a program by the various engineering, production, and operations personnel at all organizational levels throughout the industry.

3. Cost constraints have limited the development of large safety organizations at the individual program level. Further, assigned safety personnel have had limited multidiscipline experience.

4. There has been a recognized limitation of safety personnel to influence product design. Some of the contributing factors identified were: late assignment to a program, late completion of hazard analyses for designs reaching a production phase, and a limited number of safety personnel in combination with safety engineering time spent in developing plans, procedures, and techniques required to implement specified program level safety requirements.

Because such factors, either singly or in combination, have varied with programs, contractors, and contracting organizations no universal solution was apparent. However, the need for a technique to increase the effectiveness of existing safety personnel through all organizations responsible for product development was evident. It was also recognized that to be effective such a technique would have to be relatively simple and compatible with established policies, procedures, and practices of many disciplines within a wide variety of product development organizations.

A. Basic Objectives

The basic objectives of the techniques developed for Skylab were:

1. Determine the actual status of Skylab design features or operational conditions that could result in systems failure, equipment damage, or personnel injury.

2. Establish a systematic hazard identification and assessment program to supplement existing analytical efforts such as FMEA's, sneak circuit analysis, hazard analyses, etc.

3. Establish an approach to assess existing Skylab designs and operational conditions, using a broad combination of the retained safety-related experience from the aerospace industry as criteria.

4. Provide a method to ensure effective implementation and visibility to management of results.

According to the previously mentioned reviews of accident and incident experiences, inadequacy of overpressure relief protection has historically been a factor in equipment loss or damage. Although relief devices have been installed to protect against overpressurization from such causes as regulator failure or human error, they have in many cases failed to do so. They have been found to be undersized with respect to the maximum flow capacity of an upstream failed-open regulator, improperly set with respect to protection for the end product being pressurized, and inhibited by caps, plugs, or valves. This single condition (improper sizing of relief devices) is an example of many conditions that were of concern to Skylab management.

Initially, techniques to improve analytical methods for hazard identification were considered. Cost, limited numbers and experience of analysts, complexity of techniques, differences in established management practices within government agencies and contractor organizations, and the most important factor of time would not permit development and implementation of additional analytical methods. It was recognized, however, that a logical tool that could be applied to all existing analytical methods to assist in the identification of hazards is a checklist—specifically, a checklist based on tests, field operating experience, and accident history. From this basic thought and in recognition of the first three stated objectives the Skylab System Safety Checklist Program evolved.

It was recognized that safety program performance based on conventional indicators such as accident frequency, severity, or lost time would not be sufficient to the achievement of the fourth objective. The primary concern on Skylab was accident prevention with emphasis on recurrence control. Therefore, it was decided that a method to determine effectiveness would be based on potential hazards identified and actions taken to eliminate or control known accident or incident causes.

B. Checklist Development and Implementation Approach

At the time of initial development of the Skylab checklist concept the Skylab Program was in the later stages of development. For this reason, a more progressive <u>total program</u> concept was modified for Skylab application. A safety review of the entire Skylab Cluster and an assessment of the adequacy of protection for flight systems from ground support equipment (GSE) was to be performed as part of a Systems/Operations Compatibility Review preparatory to the Design Certification Review (DCR).

Four system safety checklists were developed using a broad combination of documents such as those shown in Table 1.

Table 1. Typical Source Data for Checklist Development

SKYLAB SYSTEM SAFETY CHECKLIST PROGRAM	
MANNED SPACE PROGRAMS ACCIDENT/INCIDENT SUMMARIES	NASA, DIR OF SAFETY, MARCH 1970
SYSTEM SAFETY ACCIDENT/INCIDENT SUMMARY	NAR, SPACE DIV. JULY 1967
AIR FORCE EASTERN TEST RANGE SAFETY MANUAL, VOL. I	AFETRM 127-1, JANUARY 1, 1969
MINUTES, SYSTEM SAFETY NETWORK TECHNICAL INTERCHANGE MEETINGS	
SPACE FLIGHT HAZARDS CATALOG	MSC 00134, REV. A. JANUARY 1970
MANAGEMENT MANUAL TECHNICAL INFORMATION BULLETINS	MSC-M8081. JANUARY 1970
SPACE FLIGHT HARDWARE ACCIDENT EXPERIENCE REPORT	MSFC. OCTOBER 14, 1966
APOLLO 14 SAFETY ASSESSMENT	MSC-SN-1-174-10. DECEMBER 2, 1970
AIR FORCE SYSTEMS COMMAND DESIGN HANDBOOK, SERIES 1-0	DH 1-6. JULY 20, 1968 REV. JULY 20, 1970
REPORT OF APOLLO 204 REVIEW BOARD...ALL APPENDICES	APRIL 5, 1967
REPORT OF APOLLO 13 REVIEW BOARD...ALL APPENDICES	JUNE 16, 1970
MANNED SPACECRAFT CRITERIA AND STANDARDS	MSCM 8080, APRIL 26, 1971

The approach selected for checklist development was to convert accident and incident data into positive design criteria statements which were specifically tailored to assess the hardware systems and equipment indicated by the following general titles:

1. Ground Support Equipment Design (SA-003-001-2H, July 1971).

2. Flight Systems Design (SA-003-002-2H, November 1971).

3. Experiment Systems Design (SA-003-003-2H, November 1971).

4. Experiment Ground Support Equipment Design (SA-003-004-2H, November 1971).

The approach selected for checklist implementation was to allow Skylab design organizations to assess that hardware for which they were responsible at the time the checklist was issued. This approach permitted the most rapid and accurate safety assessment of the Skylab hardware by using the personnel most knowledgeable of the design details —the design engineers. In addition, a system for receipt, review, evaluation, follow-up with design organizations, statusing, and tracking of potential problems and actions taken was developed concurrently with checklist development and issuance.

Each Skylab system safety checklist document was issued with separate instructions for completion. The checklists were issued by MSFC, Skylab Program management ". . . to provide an independent assessment of Skylab hardware, to be doubly sure that crew safety and the accomplishment of primary mission objectives will not be compromised. The principle of 'experience retention' has been applied to the development of the checklists, which are based on the safety-related experiences from many sources in the aerospace community, in both industry and Government."

The checklist format, as shown in Figure 1, with sample criteria statements applicable to GSE design, was unique in both the manner in which it was written and the manner in which it was intended to be used. The intent was to provide actual status of design features. Therefore, such common terms as "critical," "high pressure," "low pressure," "high voltage," and "shall be avoided" were not used. Words of this type could have led to ambiguity and might have been subject to differences of opinion. The format was designed to accommodate a specific procedure for completion and standardized processing of the checklists at MSFC. The procedure was developed to attain the stated checklist program objectives. The basic procedure for completion and return is outlined as follows:

1. Checklists were intended for use by each design element having responsibility for an end item or subsystem.

2. Columns were to be marked based on actual conditions of design, regardless of what may have been required in the design specification.

3. "Noncompliance" or "Not Applicable" responses required a statement on a supplemental status form describing and justifying the existing conditions, or describing the alternate method by which the intent of the stated criterion had been met. The checklist statements were meant to be taken literally, i.e., compliance with the intent was not cause for marking the compliance column.

4. Completed checklists were to be signed and returned to the issuing organization for review, evaluation and statusing.

SYSTEM SAFETY CHECKLIST

ITEM NUMBER	TITLE: SECTION/TITLE: DATE: ORGANIZATION: SYSTEM/SUBSYSTEM:	COMPLIANCE	NON-COMPLIANCE	NOT APPLICABLE
•	Adjacent or incompatible system connectors or flanged connections shall be keyed or sized so it is physically impossible to connect an incompatible pressure unit, commodity or pressure level.			
•	Pressure relief valves and relief vent lines shall be sized to exceed the maximum flow capacity of the upstream pressure regulating device.			
•	Shutoff valves shall not be installed in series with relief valves unless a burst disc or other positive relief device is installed in parallel.			
•	All adjacent connectors shall be shaped or restrained so that they are physically impossible to mismate.			
•	Connectors with unkeyed symmetrical pin arrangements shall not be used.			
•	Overload protection devices shall be sized (or set) so that the combination of current and time at which the device operates will not cause the operation of upstream protective devices.			

Figure 1: TYPICAL FORMAT AND SAMPLE CRITERIA - GROUND SUPPORT EQUIPMENT DESIGN

C. Ground Rules for Checklist Program Implementation

Ground rules for contractual action control, approval cycles, release procedures, tracking of problem-action summaries, etc., were as follows:

1. Checklists would neither impose requirements on the designs nor, in themselves, authorize or recommend design changes.

2. Checklists would be released by appropriate MSFC project offices.

3. Upon receipt of returned checklists by project offices, copies would be submitted to the Skylab Test, Reliability, Quality Assurance and Safety Office (SL-TQ) for review, evaluation, and statusing.

4. Processing by SL-TQ would include the preparation of problem-action summaries which would be submitted to appropriate management for further investigation or corrective action. A special task team was established by the Skylab Program Office to assist in uniform problem verification, follow-up with design organizations, and to recommend or initiate corrective actions as appropriate.

5. Problem-action summaries would be tracked until closed by MSFC or contractor action. In other words, tracked until a design change was approved and incorporated or the disposition and rationale for risk acceptance was approved by program management.

6. Constraint inputs to plans, procedures, and operations (flight and ground, to include tests, handling, transportation and storage) would be developed based on hazards identified and residual risks which management deemed acceptable.

D. Benefits of Checklist Technique

This self-assessment checklist technique and the broad-based systematic application of checklists, in combination with the evaluation and corrective action system, resulted in the following:

1. Demonstration that if experience retention information is brought to the attention of the designer in a direct manner, he will apply it. Oversights in new designs and in converting equipment from

previous programs to new uses on Skylab were identified and corrected. Many of these actions were initiated by the responsible design groups during checklist completion prior to checklist return to MSFC. "Non-compliance" columns were marked and the actions that were in process to correct deficiencies were stated in the supplemental rationale.

2. Provided a method for coordinating the efforts of many government and contractor organizations from a systems safety point of view. Detailed reviews of management controls, processes, and operating procedures resulted from questions brought out by evaluation efforts. These reviews considered such factors as controls to prevent installation of components in reverse, controls to ensure application of proper torque values, verification of pressure regulator and flow control device settings, verification of cleanliness levels of GSE prior to use with flight hardware, and inspection of connectors for bent pins, foreign objects, or contamination prior to mating.

3. Extended the capability of a small group of system safety specialists to permit a program-wide safety assessment through engineering organizations responsible for hardware development. Names and department numbers of individual engineers who had completed each checklist section were submitted to MSFC with each checklist. Rapid response was provided by telephone to questions arising during the evaluation process. Copies of detailed drawings or procedures were submitted upon request as required to process potential problem-action summaries. The use of existing design groups minimized the development and continuous maintenance (changes) of detail design schematics at the component, subassembly, or subsystem level by the system safety evaluation group. Design changes occurring after initial checklist submittal were reviewed against checklist criteria by the design group responsible for the change. Supplemental status sheets were submitted to the safety evaluation group for changed items. This supplemental status was reviewed for impact against previously baselined safety checklist status for the equipment.

4. Provided management with visibility of results. Centralized processing of completed checklists and a coordinated corrective action system provided a focal point for overall checklist program status. Comparisons between checklists for flight and ground equipment used in combination resulted in the identification and resolution of potential hazards not recognized at the individual equipment level. Significant risks were immediately brought to the attention of the responsible design organization for confirmation and corrective action recommendations. Potential problems were resolved through Configuration Change (Review) Board action. Skylab system safety checklist program status reviews were included as part of periodic MSFC Skylab Program Management Reviews. In addition, checklist status was included as a special subject within Reliability and Safety portions of the DCR, both at the individual prime contractor level and at the overall Skylab level.

E. Conclusions Based on Skylab Experience

The basic concept for progressive total program application of system safety checklists can be effectively implemented on any program, subsystem, or product of any size of complexity. A master set of checklists can be developed from this initial baseline document and from which applicable sections or criteria statements can be selected to fit a given discipline, product, or program. This approach would minimize continual redevelopment efforts on each program or for each product. However, the need to select and tailor the criteria to the specific product, operation, or program is essential to the achievement of the stated objectives.

In addition to the benefits previously described, the disciplined approach provided by this checklist technique will provide the following:

1. Assists all disciplines in the application of safety-related experience.

2. Provides educational benefits to all disciplines and helps to prevent oversights by bringing attention to many of the conditions which have contributed to accidents, incidents, or failures in the past.

3. Provides a systematic method to identify hazards which can be used independently or in support of more sophisticated hazard analysis methods.

SUGGESTIONS FOR FUTURE PROGRAM APPLICATION

The composite system safety checklist (parts I and II contained herein) can be applied by the following methods.

1. Direct incorporation of criteria statements into design specifications. This approach would provide visibility of "noncompliance" items and alternate methods by which the intent has been met through a standard configuration management process (e.g., waiver or deviation requests and subsequent risk decisions).

2. The addition of two additional columns on a form similar to that used on Skylab (see Figure 1) could be used for programs in the very early phases of development (i.e., prior to the Preliminary Requirements Review or Preliminary Design Review). The additional columns could be used for "Design Will Comply" and "Design Will Not Comply."

In cases where the "Noncompliance" column is marked in addition to "Design Will Comply," no supplemental rationale would be required. At such time as the design is changed to meet the criteria, the status would be changed. If no additional visibility is provided during periods between milestone reviews or preferably a lesser but reasonable period of time, the item being <u>tracked</u> could be investigated further.

3. The approach used on Skylab could be effectively implemented for program phases such as during detail design prior to the Critical Design Review or Design Certification Review.

4. The checklist technique described could also be used as a supplement to the review of all design changes. Overall system safety status could then be maintained throughout the program. This status could be reviewed as part of major milestone reviews and provide a continuous source of information for the progressive development of hazard summaries or catalogs. This information could also become input data to (or be combined with) a critical items list. Thus, increased confidence could be obtained in the late phases of a program, such as during a Design Certification Review or Flight Readiness Review, as to the residual risks associated with the product and its intended use.

Recognizing the users obligation to shape the checklist application technique to his particular needs, it is important to note that a criteria statement marked "noncompliance" would not in all cases indicate a hazardous condition. Alternate methods within the design may accomplish the same intent. The evaluation of completed checklists for independent hardware end items should consider equipment used in combination to accomplish a specific operation. Interfacing systems or equipment may complement each other or create systems-level hazards. The visibility afforded by completed checklists could allow these determinations to be made. The evaluation of criteria statements in combination within a single checklist could be used to produce a <u>safety profile</u> of the product or equipment being assessed. Similarly, the evaluation of multiple checklists for equipment used in combination to accomplish a test or similar function can be used to produce a <u>system</u> safety profile.

Amplifying a previous example, a pressurization console may not incorporate built-in relief protection but the interfacing system in an upstream facility may provide adequate console protection. A flight pressure vessel which is to become a component part of a larger system, on the other hand, may not have built-in relief protection and may be vulnerable to loss during component level test. Multipurpose test facilities and consoles may incorporate adequate self-protection as a system but may not protect the equipment under test. This can happen where various organizations or contractors are involved in designing equipment and subsystems. System safety checklists can be used as an aid in assessing the safety aspects of an integrated system for all planned operational configurations.

SYSTEM SAFETY CHECKLIST - PART I

FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN

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SYSTEM SAFETY CHECKLIST - PART I

FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN

SECTION: 1.0 SYSTEMS CRITERIA

1.1 ELECTRICAL POWER SYSTEMS

1. DC RETURNS SHALL NOT BE DISCONNECTED OR ISOLATED FROM THE SINGLE POINT GROUND CONNECTION TO THE SPACECRAFT STRUCTURE DURING ANY MODE OF SYSTEM, EXPERIMENT OR OTHER PAYLOAD OPERATION.

2. MODULE, EXPERIMENT AND OTHER PAYLOAD MATING SURFACES SHALL BE ELECTRICALLY BONDED SO THAT A FAULT CURRENT (BASED ON MAXIMUM SHORT CIRCUIT CURRENT THAT MAY RESULT FROM AVAILABLE POWER WITHIN INDIVIDUAL EQUIPMENT) MAY BE SAFELY RETURNED FROM ANY POINT ON THE STRUCTURE OF THE MODULE, EXPERIMENT OR OTHER PAYLOAD TO THE SPACECRAFT SINGLE POINT GROUND.

3. THE ELECTRICAL POWER SYSTEM SHALL INCLUDE THE CAPABILITY TO ISOLATE EACH LOAD INDEPENDENTLY FROM THE POWER SOURCE TO PERMIT LOAD SELECTION DURING EMERGENCY CONDITIONS.

4. REDUNDANT POWER DISTRIBUTION BUSES SHALL NOT BE ROUTED THROUGH THE SAME CONNECTOR.

1.2 ENVIRONMENTAL AND THERMAL CONTROL SYSTEMS

5. MEANS SHALL BE PROVIDED FOR THE CREW AND BY GROUND COMMAND TO OVERRIDE THE AUTOMATIC ENVIRONMENTAL CONTROL SYSTEM.

6. MEANS SHALL BE PROVIDED FOR THE CREW AND BY GROUND COMMAND TO OVERRIDE THE AUTOMATIC ACTIVE THERMAL CONTROL SYSTEM.

7. REDUNDANT OXYGEN AND COOLANT WATER SUPPLY CONNECTIONS SHALL BE PROVIDED AT EVA STATIONS.

8. THE OXYGEN SYSTEM SHALL HAVE REDUNDANT LINES AND ISOLATION VALVES TO CONNECT OXYGEN STORAGE BOTTLES TO THE OXYGEN PRESSURE REGULATION SUBSYSTEM (COMPONENTS) TO ENSURE THAT A LEAK IN A SINGLE OXYGEN LINE WOULD NOT RESULT IN A LOSS OF THE TOTAL OXYGEN SUPPLY.

9. THE NITROGEN SYSTEM SHALL HAVE REDUNDANT LINES AND ISOLATION VALVES TO CONNECT NITROGEN STORAGE BOTTLES TO THE NITROGEN PRESSURE REGULATION SUBSYSTEM (COMPONENTS) TO ENSURE THAT A LEAK IN A SINGLE NITROGEN LINE WOULD NOT RESULT IN A LOSS OF THE TOTAL NITROGEN SUPPLY.

SYSTEM SAFETY CHECKLIST - PART I	
FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN	
SECTION: 1.0 SYSTEMS CRITERIA	
10.	THE SPACECRAFT HABITABLE ENVIRONMENT (E.G., CABIN, LABORATORY, ETC.) VENTING SYSTEM SHALL NOT VENT THROUGH OUTLETS THAT ARE USED TO VENT OTHER LIQUIDS OR GASES.
11.	THE SPACECRAFT HABITABLE ENVIRONMENT RELIEF VALVE(S) AND OTHER VENTING DEVICES SHALL PROVIDE AN AUDIBLE AND VISUAL INDICATION WHEN NOT FULLY SEATED.
12.	DEVICES WITH REPLACEABLE OR CLEANABLE ELEMENTS SHALL BE PROVIDED TO REMOVE PARTICULATE MATTER FROM THE HABITABLE ENVIRONMENT.
	1.3 <u>CAUTION AND WARNING (C&W) TYPE SYSTEMS (E.G., HAZARD OR EMERGENCY DETECTION SYSTEMS)</u>
13.	EACH PARAMETER MONITORED BY THE CAUTION AND WARNING SYSTEM SHALL BE TELEMETERED TO THE GROUND UPON SENSING AN OUT-OF-TOLERANCE CONDITION.
14.	ALL C&W SYSTEM SENSORS SHALL FAIL IN SUCH A MANNER THAT A SIGNAL INPUT WILL BE INITIATED TO THE C&W SYSTEM, RESULTING IN AN ALARM.
15.	ALL SENSORS FOR ALL PARAMETERS MONITORED BY THE C&W SYSTEM SHALL BE INDEPENDENTLY POWERED BY THE C&W SYSTEM TO PREVENT LOSS OF HAZARD INDICATION DUE TO POWER FAILURE OF A MONITORED SYSTEM.
16.	END-TO-END IN-FLIGHT CHECKOUT CAPABILITY SHALL BE PROVIDED FOR EACH SUBSYSTEM SECTION OF THE C&W SYSTEM INCLUDING THE CAPABILITY TO TEST EACH SENSOR OPERATION.
17.	THE C&W SYSTEM SHALL MONITOR ITS OWN PERFORMANCE AND ALERT THE CREW TO OUT-OF-LIMIT CONDITIONS, INCLUDING LOSS OF PRIMARY POWER.
18.	THE C&W SYSTEM AUDIO TONES SHALL NOT BE ROUTED TO EVA CREWMEN, IF A CREW MEMBER IS ON WATCH INSIDE THE SPACECRAFT.
19.	ALL C&W SYSTEM AUDIO TONE (LEVEL) CONTROLS SHALL BE DESIGNED SUCH THAT THE TONE IS STILL AUDIBLE AT THE MINIMUM CONTROL SETTING.

SYSTEM SAFETY CHECKLIST - PART I	
FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN	
SECTION: 1.0 SYSTEMS CRITERIA	
	1.3 CAUTION AND WARNING (C&W) TYPE SYSTEMS (Cont.)
20.	THE OPERATION OF ANY SWITCH THAT WOULD DISABLE AN EMERGENCY OR WARNING SUBSYSTEM TONE GENERATOR OR SPEAKER BOX(ES) SHALL GENERATE A TELEMETRY SIGNAL TO THE GROUND IN ORDER TO PROTECT AGAINST INADVERTENT OPERATION OR FAILURE OF THE SWITCH FROM DEGRADING THE C&W SYSTEM CAPABILITY TO SOUND AN AUDIBLE ALARM.
21.	AN INHIBIT SWITCH SHALL BE PROVIDED IN EACH SENSOR CIRCUIT TO ALLOW ISOLATION OF A SINGLE MALFUNCTIONING SENSOR AND PERMIT NORMAL OPERATION OF ALL OTHER REMAINING SENSING UNITS.
22.	THE CAPABILITY SHALL BE PROVIDED TO TRANSMIT A "CREW ALERT" FROM A GROUND COMMAND IN ORDER TO INITIATE A WARNING THROUGH THE C&W SYSTEM.
23.	ALL SENSORS USED FOR INPUTS TO SYSTEMS OTHER THAN C&W, WHICH ARE ALSO USED BY THE C&W SYSTEM, SHALL BE ISOLATED SUCH THAT A FAILURE IN THE OTHER SYSTEM WILL NOT AFFECT THE CAUTION AND WARNING SYSTEM.
24.	FIRE SENSORS (DETECTORS) SHALL BE LOCATED TO PROVIDE COVERAGE OF ALL HABITABLE AREAS OF THE SPACECRAFT.
	1.4 ATTITUDE AND POINTING CONTROL TYPE SYSTEMS (APCS) (E.G., GUIDANCE, NAVIGATION, FLIGHT CONTROLS)
25.	GYROSCOPE INSTALLATIONS USED FOR GUIDANCE, STABILIZATION AND CONTROL OR SIMILAR APPLICATIONS SHALL INCLUDE PROVISIONS FOR VERIFICATION BY GROUND CONTROL AND THE FLIGHT CREW THAT GYRO ROTATIONAL SPEED IS WITHIN LIMITS.
26.	ALL ATTITUDE AND POINTING CONTROL GYROS SHALL ACTUATE ALARMS WHEN THE GYROS ARE IN OPERATIONAL USE BUT NOT OPERATING WITHIN THE SPECIFIED RANGE OF ROTATIONAL SPEED.
	1.4.1 THRUSTER TYPE ATTITUDE CONTROL SYSTEMS (ACS)
27.	THE ACS SHALL BE CAPABLE OF ISOLATING OR INTERRUPTING THE COMMAND TO EACH THRUSTER CONTROL VALVE IN ORDER TO PROTECT AGAINST INADVERTENT COMMANDS OR A STUCK OPEN THRUSTER.
28.	AN INTERLOCK SHALL BE PROVIDED TO PRECLUDE OPERATION OF THE ACS THRUSTERS DURING EVA.

SYSTEM SAFETY CHECKLIST - PART I

FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN

SECTION: 1.0 SYSTEMS CRITERIA

1.4.1 THRUSTER TYPE ATTITUDE CONTROL SYSTEMS (ACS)

29. THERE SHALL BE GROUND COMMAND CAPABILITY TO INHIBIT THE IMPULSE OF THE ACS THRUSTERS.

1.5 CREW ACCOMMODATIONS

30. A SELF-CONTAINED, PORTABLE BREATHING OXYGEN SYSTEM SHALL BE PROVIDED FOR EACH ASTRONAUT FOR USE DURING EMERGENCY CONDITIONS.

31. A FIRE EXTINGUISHER(S) SHALL BE PROVIDED IN EACH MODULE AND CREW COMPARTMENT.

32. CREW ACCOMMODATIONS, INCLUDING SLEEPING ACCOMMODATIONS, SHALL BE DESIGNED AND LOCATED SUCH THAT INVOLUNTARY MOVEMENTS OF CREWMEN SHALL NOT ACTUATE EQUIPMENT.

33. EAR PROTECTIVE DEVICES SHALL BE PROVIDED WHICH ARE DESIGNED SOLELY TO PREVENT INJURY TO THE EAR FROM EXCESSIVE NOISE LEVELS AND SHALL BE IN ADDITION TO DEVICES WHICH ARE USED FOR ANOTHER PURPOSE, SUCH AS A COMMUNICATIONS HEADSET.

34. ALL RESTRAINING DEVICES, CABLE OR WIRING HARNESSES AND UMBILICALS WHICH MAY RESTRAIN A HUMAN OPERATOR OR TEST SUBJECT SHALL INCLUDE QUICK DISCONNECT OR RAPID RELEASE DEVICES TO FREE THE OPERATOR OR SUBJECT UNDER ADVERSE CONDITIONS.

35. ALL QUICK DISCONNECT OR RAPID RELEASE MECHANISMS USED TO FREE A HUMAN OPERATOR OR TEST SUBJECT FROM ANY RESTRAINING DEVICE, CABLE, WIRING HARNESS OR UMBILICAL SHALL AUTOMATICALLY REMOVE POWER OR RENDER INOPERATIVE ALL EQUIPMENT ACTING UPON OR USED BY THE TEST SUBJECT OR OPERATOR FOR ALL MODES OF EQUIPMENT OPERATION.

1.6 EXPERIMENT AND OTHER PAYLOAD HARDWARE ACCOMMODATIONS

1.6.1 GENERAL

36. ROTATIONAL EQUIPMENT WITHIN ENCLOSURES REQUIRING PERIODIC ACCESS, SUCH AS MOTOR DRIVEN CANISTERS CONTAINING PHOTOGRAPHIC EQUIPMENT OR TELESCOPES, SHALL BE PROVIDED WITH A POSITIVE MANUAL LOCKING DEVICE, ACCESS DOOR INTERLOCK WITH DRIVE MECHANISMS OR SIMILAR CREW PROTECTION IN ORDER TO PREVENT EQUIPMENT ROTATION DURING PERIODS REQUIRING CREW ACCESS, SUCH AS DURING FILM RETRIEVAL AND REPLACEMENT ACTIVITIES.

1.6.1 GENERAL (Cont.)

37. CAPABILITY SHALL BE PROVIDED TO REMOVE ELECTRICAL POWER FROM EACH EXPERIMENT INTERFACE WITHOUT AFFECTING THE OPERATION OF OTHER EXPERIMENTS OR SYSTEMS.

38. VIEWFINDERS AND SIMILAR CREW OPERATED SIGHTING EQUIPMENT SHALL INCORPORATE FILTERS OR AUTOMATIC APERTURE CONTROLS THAT WILL LIMIT THE AMOUNT AND TYPE OF LIGHT SEEN BY A CREWMAN.

39. THERE SHALL BE A DISPLAY DEVICE TO INDICATE TO THE CREW THE OPEN POSITION OF ANY EXTERNAL DOOR OVER A WINDOW IN THE SPACECRAFT STRUCTURE WHICH IS USED BY AN EXPERIMENT AND WHICH MAY BE OBSTRUCTED FROM VIEW BY THE INSTALLED EXPERIMENT (DIRECT MECHANICAL LINKAGE WITH NO ELECTRICAL INTERFACE PREFERRED).

40. ALL EQUIPMENT USING A SINGLE PANE WINDOW IN THE SPACECRAFT STRUCTURE SHALL BE SEALED AGAINST THE SPACECRAFT STRUCTURE AND SHALL BE CAPABLE OF WITHSTANDING 4.0 TIMES THE DIFFERENTIAL PRESSURE ACROSS THE SPACECRAFT SHELL IN ORDER TO PROTECT AGAINST RAPID DEPRESSURIZATION OF THE SPACECRAFT IN THE EVENT OF LOSS OF SPACECRAFT WINDOW INTEGRITY.

1.6.2 MEDICAL EQUIPMENT AND EXPERIMENTS

41. ELECTRICAL SHOCK PROTECTION CIRCUITS IN ALL EQUIPMENT INCORPORATING PROBES, SENSORS AND SIMILAR DEVICES THAT ARE ATTACHED TO A CREWMAN OR TEST SUBJECT SHALL BE DESIGNED TO REMOVE THE INPUT POWER TO THE EQUIPMENT WHEN A CURRENT LEVEL OF 100 MICROAMPERES IS SENSED.

42. ELECTRICAL SHOCK PROTECTION CIRCUITS SHALL BE TOTALLY REDUNDANT TO INSURE CREW PROTECTION IN THE EVENT OF PRIMARY SHOCK PROTECTION CIRCUIT FAILURE.

43. VALVES OR SIMILAR COMPONENTS THAT COULD BE OPERATED OUT-OF-SEQUENCE SO THAT FLAMMABLE OR TOXIC FLUIDS COULD BE INTRODUCED INTO THE HABITABLE AREAS OF THE SPACECRAFT SHALL BE PROVIDED WITH INTERLOCKS TO PREVENT SUCH OPERATION.

44. ANY EQUIPMENT WHICH SUPPLIES A GAS TO BE INHALED BY A CREWMAN SHALL INCLUDE A FILTER AS THE LAST COMPONENT BEFORE THE POINT OF INHALATION.

SYSTEM SAFETY CHECKLIST - PART I	
FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN	
SECTION: 1.0 SYSTEMS CRITERIA	
	1.6.2 MEDICAL EQUIPMENT AND EXPERIMENTS (Cont.)
45.	ASTRONAUT RESTRAINTS, SHOES, SEAT AND HANDLEBARS USED ON ERGOMETERS AND COMPONENTS OF SIMILAR EQUIPMENT THAT MAY BE USED IN CONJUNCTION WITH ELECTRONIC SENSING DEVICES, SUCH AS A VECTORCARDIOGRAPH (VCG), SHALL BE ELECTRICALLY INSULATED TO PREVENT A PARALLEL ELECTRICAL PATH WHICH COULD AFFECT THE INSTRUMENTATION.
46.	ALL ELECTRODES AND FLEXIBLE TUBING UTILIZED IN MEDICAL EXPERIMENTS SHALL BE STRUCTURALLY CAPABLE OF WITHSTANDING DECOMPRESSION AND RECOMPRESSION OF THE SPACECRAFT WITHOUT DAMAGE.
47.	ALL MEDICAL EQUIPMENT TO BE PLACED AT THE ENTRANCE TO OR WITHIN A BODY OPENING OF A SUBJECT DURING FLIGHT SHALL BE STERILIZED AND INDIVIDUALLY PACKAGED.
	1.6.3 SCIENTIFIC AIRLOCK (SAL) AND EVA TYPE EQUIPMENT
48.	BASE SUPPORTS, BRACES, BUMPERS OR SIMILAR PROVISIONS SHALL BE DESIGNED TO LIMIT THE MOVEMENT OF ANY CANTILEVERED SAL MOUNTED EQUIPMENT SO THAT THE DESIGN LOAD LIMITS OF THE SAL ATTACH POINTS WILL NOT BE EXCEEDED DUE TO INADVERTENT IMPACT.
49.	ALL HANDLES USED FOR JETTISON OF EQUIPMENT EXTENDED THROUGH A SCIENTIFIC AIRLOCK (SAL) SHALL HAVE GUARDS, COVERS OR SIMILAR PROTECTION AGAINST INADVERTENT ACTUATION.
50.	THERE SHALL BE A VISUAL INDICATING DEVICE TO SHOW THAT A MECHANISM USED TO EXTEND EQUIPMENT EXTERNAL TO THE HABITABLE SPACECRAFT AREA IS FULLY EXTENDED OR RETRACTED.
51.	BOOMS REQUIRING EXTENSION BY THE USE OF EXTENSION ROD SEGMENTS SHALL HAVE SAFETY LATCHES WHICH AT ALL TIMES PREVENT INADVERTENT EJECTION OF EQUIPMENT DURING ASSEMBLY OF THE BOOM EXTENSION ROD.
52.	BOOMS PROVIDING EXTENSION THROUGH AN AIRLOCK SHALL HAVE JETTISON CAPABILITY WHEN THE BOOM OR EXTENSION ROD IS STUCK AT ANY POSITION OR THE EXPERIMENT ON THE BOOM IS STUCK AT ANY POSITION PREVENTING RETRACTION.
53.	BOOM EXTENSION ROD CONNECTION POINTS SHALL HAVE POSITIVE LATCHING MECHANISMS TO PREVENT INADVERTENT DISCONNECTION OF THE EXTENSION ROD.

1.6.3 SCIENTIFIC AIRLOCK (SAL) AND EVA TYPE EQUIPMENT (Cont.)

54. BOOMS EXTENDED IN ORBITAL PAYLOADS SHALL BE STRUCTURALLY CAPABLE OF WITHSTANDING ALL VEHICLE MOVEMENTS INCLUDING DOCKING MANEUVERS.

55. BOOM EXTENSION MECHANISMS SHALL NOT UTILIZE ANY MATERIALS THAT OUTGAS CONTAMINANTS WHICH CAN AFFECT CONTAMINATION MEASUREMENT EXPERIMENTS OR OTHER EXTERNAL CONTAMINATION-SENSITIVE ELEMENTS.

56. ANY LOCKING OR BRAKING SYSTEM ON A BOOM WHICH EXTENDS THROUGH A SAL SHALL NOT DISTORT THE BOOM, WHEN CLAMPING FORCE IS APPLIED, SUCH THAT THE BOOM CANNOT BE RETRACTED OR EJECTED.

57. ALL EXPERIMENTS AND EXPERIMENT COMPONENTS WHICH ARE DEPLOYED BY AN EXTENDIBLE BOOM SHALL BE SECURED TO THE BOOM BY A POSITIVE LOCKING MECHANISM.

SYSTEM SAFETY CHECKLIST - PART I

FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN

SECTION: 2.0 GENERAL CRITERIA

1. OPERATING RANGE AND PERFORMANCE LIMITS FOR ALL SYSTEMS AND EQUIPMENT SHALL BE SPECIFIED IN THE DESIGN.

2. CLEANLINESS LEVELS AND CONTAMINATION CONTROL REQUIREMENTS SHALL BE SPECIFIED IN THE DESIGN.

3. COMPONENTS CONTAINING MERCURY SHALL NOT BE USED.

4. BERYLLIUM, BERYLLIUM OXIDES, OR BERYLLIUM ALLOYS SHALL NOT BE USED INSIDE THE SPACECRAFT HABITABLE ENVIRONMENT.

5. COMPONENTS USED IN AREAS WITH FLAMMABLE VAPORS, LIQUIDS, OR OTHER COMBUSTIBLE MATERIALS SHALL BE INCAPABLE OF CAUSING UNINTENTIONAL IGNITION.

6. EQUIPMENT DESIGN SHALL PRECLUDE THE GENERATION OF SOUND PRESSURE LEVELS ABOVE 85 db.

7. FRICTION TYPE LOCKING PINS IN WHICH THE LOCKING CAPABILITY BECOMES DEGRADED AS A RESULT OF REPEATED USE SHALL NOT BE USED.

8. ALL CONNECTORS (E.G., ELECTRICAL, HYDRAULIC, PNEUMATIC) SHALL HAVE TETHERED CAPS, PLUGS OR COVERS IN ORDER TO PROTECT AGAINST CONTAMINATION OR DAMAGE WHEN UNMATED.

9. LOCKING PINS, KNOBS, HANDLES, LENS COVERS, ACCESS PLATES, AND SIMILAR DEVICES WHICH MAY REQUIRE TEMPORARY REMOVAL SHALL BE TETHERED OR OTHERWISE HELD CAPTIVE TO THE EQUIPMENT WITH WHICH THEY ARE USED.

10. CHAINS, BEADED LINKS OR SIMILAR SEGMENTED DEVICES SHALL NOT BE USED AS TETHERS OR RESTRAINTS.

11. SYSTEMS SHALL BE DESIGNED SO THAT IT IS PHYSICALLY IMPOSSIBLE TO INSTALL COMPONENTS IN REVERSE.

12. THE SETTING, POSITION OR ADJUSTMENT OF CONTROLS SHALL NOT BE AFFECTED BY SHOCK, VIBRATION, OR ACCELERATION RESULTING FROM LAUNCH, DOCKING, OR ON-ORBIT OPERATIONS.

13. ANTENNAS WHICH ARE DESIGNED WITH ELECTROMECHANICAL DRIVE MECHANISMS TO PERMIT SCANNING SHALL INCLUDE A POSITIVE LOCKING DEVICE TO HOLD THE ANTENNA IMMOBILE WHEN UNDER ALL OPERATIONAL LOADS.

SYSTEM SAFETY CHECKLIST - PART I	
FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN	
SECTION: 2.0 GENERAL CRITERIA	
14.	ANTENNAS WHICH ARE DESIGNED WITH ELECTROMECHANICAL DRIVE MECHANISMS TO PERMIT SCANNING SHALL BE DESIGNED TO PROVIDE CREW INDICATION OF ANTENNA POSITION AND LOCKING DEVICE OPERATION.
15.	EQUIPMENT PERMANENTLY MOUNTED OR TO BE DEPLOYED EXTERNAL TO THE SPACECRAFT HABITABLE ENVIRONMENT SHALL NOT CONTAIN MATERIALS WHICH OUTGAS CONTAMINANTS THAT COULD AFFECT EXTERNAL CONTAMINATION SENSITIVE ELEMENTS (E.G., WINDOWS, OPTICS).
16.	EQUIPMENT REQUIRING ADJUSTMENT DURING OPERATION SHALL HAVE EXTERNAL ADJUSTMENT PROVISIONS.
17.	ALL MECHANICAL ACTUATING DEVICES SHALL HAVE POSITIVE MECHANICAL STOPS FOR PROTECTION AGAINST FAILURES THAT COULD ALLOW THE DEVICE TO EXCEED ITS INTENDED LIMITS OF TRAVEL.
18.	ALL THREADED FASTENERS AND FITTINGS SHALL HAVE TORQUE SPECIFIED IN THE DESIGN, AND SHALL REQUIRE WRENCHING DEVICES FOR ASSEMBLY AS OPPOSED TO KNURLED KNOBS, WING NUTS, ETC.
19.	OPENINGS (SLOTTED OR OTHERWISE) IN CABINETS, COVERS, AND SIMILAR ENCLOSURES THROUGH WHICH LEVERS, SHAFTS, AND SIMILAR CONTROLS OPERATE SHALL BE PROVIDED WITH NONFLAMMABLE PROTECTIVE COVERS, BOOTS, OR SLIDING PLATES TO PREVENT PERSONNEL INJURY OR EQUIPMENT DAMAGE RESULTING FROM INADVERTENT INSERTION OR ENTRY OF FOREIGN OBJECTS.
20.	HANDLES AND CONTROLS FOR MECHANISMS SUCH AS HATCHES, AIRLOCKS, AND FOLDING PLATFORMS SHALL BE DESIGNED WITH SUFFICIENT CLEARANCES TO PREVENT INJURY TO FINGERS AND HANDS.
21.	ALL HANDHOLDS AND HANDRAILS SHALL PROVIDE A MINIMUM CLEARANCE OF 2.0 INCHES BETWEEN THE GRIPPING SURFACE AND ANY ADJACENT STRUCTURE, AND SHALL PROVIDE A MINIMUM OF 5.5 INCHES OF STRAIGHT GRASPING LONGITUDINAL SURFACE.
22.	ALL INTERNAL AND EXTERNAL EQUIPMENT AND STRUCTURAL SURFACES INCLUDING COVERS, DOORS, REMOVABLE PANELS AND CONTAINERS SHALL BE FREE OF SHARP EDGES AND CORNERS FOR THE PROTECTION OF PERSONNEL AND EQUIPMENT.
23.	ACCESS DOORS, COVERS OR HATCHES WHICH ARE NOT REMOVABLE SHALL REMAIN IN THE DESIRED OPEN POSITION BY USE OF FRICTION OR OTHER DEVICES.

SYSTEM SAFETY CHECKLIST - PART I	
FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN	
SECTION: 2.0 GENERAL CRITERIA	
24.	ANY DOOR OR HATCH WHICH IS REQUIRED TO ISOLATE THE HABITABLE AREAS OF THE SPACECRAFT (CABIN ATMOSPHERE) FROM SPACE VACUUM SHALL HAVE REDUNDANT SEALS.
25.	ALL HATCHES REQUIRED FOR ASTRONAUT INGRESS TO OR EGRESS FROM THE SPACECRAFT OR BETWEEN COMPARTMENTS SHALL BE DESIGNED TO PERMIT INFLIGHT REPLACEMENT OF HATCH SEALS.
26.	EXPERIMENT AIRLOCKS AND SIMILAR MECHANICAL DEVICES THAT PENETRATE THE PRESSURE SHELL OF THE HABITABLE AREA OF THE SPACECRAFT SHALL BE DESIGNED TO PERMIT INFLIGHT REPLACEMENT OF SEALS.
27.	ALL GLASS OR SIMILAR SHATTERABLE MATERIAL SHALL BE COVERED WITH A SOLID MATERIAL (TRANSPARENT IF REQUIRED) TO PROTECT AGAINST THE INTRODUCTION OF PARTICLES INTO THE SPACECRAFT HABITABLE ENVIRONMENT AS A RESULT OF BREAKAGE.
28.	CONTROLS WHICH COULD CAUSE EQUIPMENT DAMAGE OR PERSONNEL INJURY IF OPERATED DURING GROUND OPERATIONS SHALL BE IDENTIFIED IN THE DESIGN.
29.	WARNING PLACARDS OR LABELS SHALL BE PROVIDED ON ALL CONTROLS WHICH ARE NOT TO BE OPERATED DURING GROUND OPERATIONS.
30.	ALL PLATFORMS, HANDRAILS, BOOMS, BOOM EXTENSION DEVICES AND SIMILAR INSTALLATIONS THAT ARE NOT DESIGNED FOR USE IN A ONE-G ENVIRONMENT SHALL BE PLACARDED WITH LOAD LIMITS AND PROTECTED FROM INADVERTENT USAGE DURING GROUND OPERATIONS.
31.	EMERGENCY CONTROLS (ELECTRICAL OR MECHANICAL) USED FOR SHUTDOWN, SAFING, JETTISON, ALARM OR CORRECTIVE ACTION SHALL BE CLEARLY MARKED, (E.G., PLACARDS, RED BOARDERS, ETC.), VISIBLE AND READILY ACCESSIBLE TO OPERATING PERSONNEL.
32.	DESIGN SPECIFICATIONS FOR SUBSYSTEM EQUIPMENT (E.G., CONSOLES, PANELS, ETC.), EXPERIMENTS AND OTHER PAYLOAD HARDWARE, INCLUDING SHIPPING OR STORAGE CONTAINERS FOR SUCH EQUIPMENT SHALL SPECIFY THAT THE LOCATION OF LIFT POINTS, ATTACH POINTS, CENTER OF GRAVITY AND GROSS WEIGHT SHALL BE IDENTIFIED ON ALL SUCH EQUIPMENT FOR WHICH LIFTING, HOISTING OR HANDLING FIXTURES MAY BE REQUIRED (E.G., HANDLING, INSTALLATION OR REMOVAL PRIOR TO OR AFTER FLIGHT).

SYSTEM SAFETY CHECKLIST - PART I	
FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN	
SECTION: 2.0 GENERAL CRITERIA	
33.	ALL EQUIPMENT WHICH MAY BE REQUIRED TO BE LIFTED OR MOVED BY A HOIST, CRANE, FORKLIFT OR OTHER EQUIPMENT SHALL HAVE PROVISIONS FOR TEMPORARY OR PERMANENT INSTALLATION OF ATTACH POINTS, LIFTING EYES, TIE-DOWNS, AND SIMILAR HARDWARE FOR POSITIVE ATTACHMENT OF SLINGS, CABLE HOOKS AND SIMILAR DEVICES.
34.	WARNING PLACARDS, SAFETY TAPE, COLOR CODED LABELS AND SIMILAR HAZARD IDENTIFICATION MATERIAL SHALL BE PLACED IN A CLEARLY VISIBLE LOCATION.
35.	ALL HANDLES, KNOBS, LATCHES, HATCHES, AND SIMILAR MECHANICAL DEVICES THAT REQUIRE ALIGNMENT OR ADJUSTMENT SHALL HAVE ALIGNMENT INDICES OR VISIBLE MARKINGS TO ENSURE PROPER ALIGNMENT, ADJUSTMENT, AND OPERATION INCLUDING REALIGNMENT IN FLIGHT.
36.	LOCATION OF ALIGNMENT INDICES, DETENTS, RIGGING POINTS OR ALIGNMENT MARKS SHALL BE ACCESSIBLE FOR ALIGNMENT RECHECK WITHOUT REMOVAL OF ANY COMPONENT.
37.	ALL FAN BLADES, PUMP IMPELLERS AND SIMILAR ROTATING MECHANISMS SHALL HAVE PROTECTIVE DEVICES SUCH AS A SHEAR PIN, FRICTION CLUTCH, MAGNETIC CLUTCH OR SIMILAR DEVICE TO PROTECT THE DRIVE MECHANISM.
38.	MOVING PARTS SUCH AS FANS, BELT DRIVE ASSEMBLIES AND SIMILAR COMPONENTS THAT COULD CAUSE PERSONNEL INJURY OR EQUIPMENT DAMAGE DUE TO INADVERTENT CONTACT WITH SUCH EQUIPMENT SHALL BE PROVIDED WITH GUARDS OR SIMILAR PROTECTIVE DEVICES.
39.	EQUIPMENT UTILIZING ROTATING MECHANISMS SHALL INCORPORATE PROVISIONS FOR CONTAINMENT OF FAILED PARTS.
40.	LOCK OR LATCHING MECHANISMS SHALL BE OPERABLE BY A SINGLE CONTROL AND PROVIDE CLEAR VISUAL INDICATION OF LATCH POSITION.
41.	FOLD AWAY OR FOLD OVER TYPE LATCHING DEVICES THAT MUST BE IN THE FOLDED POSITION TO ASSURE POSITIVE LOCKING SHALL BE SPRING LOADED OR PINNED IN THE FOLDED POSITION TO PREVENT INADVERTENT OPENING DUE TO VIBRATION.
42.	ALL SPACECRAFT WINDOWS SHALL BE PROVIDED WITH INTERNAL COVERS TO PROTECT THE WINDOW WHEN NOT IN USE DURING FLIGHT AND GROUND OPERATIONS.

SYSTEM SAFETY CHECKLIST - PART I	
FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN	
SECTION: 2.0 GENERAL CRITERIA	
43.	ALL SPACECRAFT WINDOWS SHALL BE PROVIDED WITH EXTERNAL COVERS TO PROTECT THE WINDOW DURING GROUND OPERATIONS, AND DURING FLIGHT AS APPROPRIATE FOR UV-SENSITIVE GLASS, ETC.
44.	ALL SPACECRAFT INTERNAL WINDOW COVERS SHALL BE STRUCTURALLY CAPABLE OF WITHSTANDING A MINIMUM PRESSURE EQUAL TO 4.0 TIMES THE DIFFERENTIAL PRESSURE ACROSS THE SPACECRAFT PRESSURE SHELL DURING ON-ORBIT OPERATIONS.
45.	WINDOW COVERS, EXPERIMENT DOORS AND SIMILAR ASSEMBLIES DESIGNED FOR AUTOMATIC OR REMOTE CONTROL OPERATION SHALL BE CAPABLE OF BEING DISABLED AND MANUALLY OPERATED (E.G., DRIVE MECHANISM MECHANICAL OVERRIDE), IN THE EVENT OF FAILURE TO OPEN OR CLOSE.
46.	DEPLOYED EQUIPMENT CHILLED BELOW THE CABIN DEW POINT SHALL BE PROTECTED AGAINST CONDENSATION WHEN RE-INTRODUCED TO THE CABIN ENVIRONMENT.
47.	EQUIPMENT CONTAINING LENSES SUCH AS CAMERAS, VIEWFINDERS, TELESCOPES, ETC., SHALL BE PROVIDED WITH VIEWING ELEMENT COVERS.
48.	CLEANING AGENTS AND PROCESSES THAT ARE COMPATIBLE WITH THE SYSTEM (E.G., COMPONENT MATERIALS, METAL SURFACES, COATINGS AND COMMODITIES USED WITHIN THE SYSTEM) SHALL BE SPECIFIED IN THE DESIGN.
49.	ALL CONTAINERS SUCH AS FILM CONTAINERS WHICH MAY BE PRESSURIZED WITH AN INERT GAS SHALL HAVE A POSITIVE PRESSURE INDICATING DEVICE.
50.	ALL CONTAINERS THAT ARE PRESSURIZED WITH INERT GAS SHALL BE TESTED TO A MINIMUM PROOF PRESSURE EQUIVALENT TO 2.0 TIMES THE MAXIMUM PRESSURE TO WHICH THEY WILL BE EXPOSED.
51.	ALL CONTAINERS THAT ARE PRESSURIZED WITH INERT GAS SHALL HAVE A MINIMUM DESIGN BURST PRESSURE OF 4.0 TIMES THE MAXIMUM DIFFERENTIAL PRESSURE TO WHICH THEY WILL BE EXPOSED.
52.	ALL EQUIPMENT AND COMPONENT CONTAINERS AND ENCLOSURES WITHIN THE HABITABLE AREAS OF THE SPACECRAFT SHALL BE STRUCTURALLY CAPABLE OF WITHSTANDING DECOMPRESSION AND RECOMPRESSION OF THE SPACECRAFT WITHOUT DAMAGE.

SYSTEM SAFETY CHECKLIST - PART I	
FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN	
SECTION: 2.0 GENERAL CRITERIA	
53.	RADIOACTIVE MATERIALS SHALL NOT BE USED FOR ILLUMINATING PURPOSES WITHOUT POSITIVE MECHANICAL PROTECTION AGAINST ABRASION OR FLAKING UNDER ALL POTENTIAL CONDITIONS OF USE.
54.	RADIOACTIVE MATERIALS SHALL NOT BE USED FOR ANY PURPOSE UNLESS IT CAN BE PROVEN THAT A NON-RADIOACTIVE SUBSTITUTE MATERIAL CANNOT BE USED.
55.	RADIOACTIVE MATERIAL EMBODIED OR SUSPENDED BY CERAMIC MATERIAL, PAINT OR SIMILAR COATINGS SHALL NOT RELEASE RADIOACTIVE MATERIAL AT ALL INTERNAL OR EXTERNAL ENVIRONMENTAL EXTREMES ANTICIPATED DURING GROUND OR FLIGHT OPERATIONS.
56.	ALL TEMPERATURE GAGES, PRESSURE GAGES, ELECTRICAL METERS AND SIMILAR READOUT DEVICES SHALL BE COLOR BANDED TO INDICATE SYSTEM OPERATING, MARGINAL AND HAZARDOUS RANGE LIMITS.
57.	ALL TEMPERATURE GAGES, PRESSURE GAGES, ELECTRICAL METERS AND SIMILAR READOUT DEVICES SHALL INDICATE NORMAL SYSTEM OPERATING RANGE WITHIN THE CENTER 50 PERCENT OF THE TOTAL RANGE OF THE READOUT DEVICE.
58.	DEBRIS GUARDS, SCREENS, FILTERS AND SIMILAR DEVICES SHALL BE LOCATED AT THE INLET TO ROTATING MECHANISMS SUCH AS DUCT-MOUNTED FAN ASSEMBLIES, COOLANT PUMPS AND SIMILAR ASSEMBLIES.
59.	HANDLES AND KNOBS ON ALL ROTARY CONTROLS SHALL BE KEYED OR SHAPED SO THAT IT IS PHYSICALLY IMPOSSIBLE FOR THEM TO TURN ON THE SHAFT. FURTHERMORE, EACH ROTARY CONTROL ASSEMBLY SHALL BE POSITIVELY KEYED OR PINNED TO ITS MOUNTING SURFACE TO ENSURE PROTECTION AGAINST SIMULTANEOUS ROTATION OF THE HANDLE, SHAFT AND CONTROL ASSEMBLY.

SYSTEM SAFETY CHECKLIST - PART I

FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN

SECTION: 3.0 ELECTRICAL AND ELECTRONIC

3.1 GENERAL

1. ALL ELECTRICAL CONNECTORS AND CABLE INSTALLATIONS SHALL BE DESIGNED WITH SUFFICIENT FLEXIBILITY, LENGTH, AND ACCESSIBILITY TO PERMIT DISCONNECTION AND RECONNECTION WITHOUT DAMAGE TO WIRING OR CONNECTORS.

2. GUIDE PINS OR SLIDES SHALL BE LOCATED ON ALL PANEL, DRAWER AND CHASSIS SUBASSEMBLIES FOR PURPOSES OF ALIGNMENT DURING INSTALLATION AND TO PREVENT CONTACT OF THE PANEL, CHASSIS OR DRAWER WITH EXPOSED TERMINALS INTERNAL TO THE EQUIPMENT DURING INSTALLATION AND REMOVAL.

3. ALL CONTROL SHAFTS, KNOBS, HANDLES OR LEVERS SHALL BE GROUNDED, INSULATED OR MADE OF NONCONDUCTIVE MATERIAL IN ORDER TO PRECLUDE PERSONNEL SHOCK OR BURN.

4. RECEPTACLES WHOSE MATING PLUGS HAVING LOCKING FEATURES REQUIRING A TWISTING MOTION (BAYONET OR THREADED TYPES) SHALL BE POSITIVELY KEYED OR PINNED TO THEIR MOUNTING SURFACE SO THAT IS IS PHYSICALLY IMPOSSIBLE FOR THE RECEPTACLE TO TURN DURING PLUG ATTACHMENT.

5. ALL EXTERNAL PARTS OF RF EQUIPMENT, EXCLUDING THE DRIVEN ELEMENTS OF THE ANTENNA AND TRANSMISSION LINES, SHALL BE AT GROUND POTENTIAL AT ALL TIMES.

6. RF EQUIPMENT SHALL BE SHIELDED TO PREVENT PERSONNEL EXPOSURE TO RF LEVELS GREATER THAN 10 mw/cm^2 EXCEPT IN FRONT OF THE ANTENNA.

7. CATHODE RAY TUBES SHALL BE COVERED IN FRONT WITH A SAFETY SHIELD TO PROTECT PERSONNEL FROM TUBE IMPLOSION.

8. CONFORMAL COATINGS WHICH MAY OVERSTRESS COMPONENTS SUCH AS GLASS DIODES SHALL NOT BE USED.

9. POLYURETHANE CONFORMAL COATINGS CONTAINING SOLVENTS WHICH DISSOLVE POLYSTYRENE SHALL NOT BE USED ON CIRCUIT BOARDS CONTAINING POLYSTYRENE COMPONENTS.

10. ULTRASONIC VIBRATION SHALL NOT BE SPECIFIED AS A METHOD FOR CLEANING ELECTRONIC ASSEMBLIES.

11. GASKETS, SEALS AND SIMILAR COMPONENTS CONTAINING SULPHUR SHALL NOT BE USED WITHIN OR IN CONTACT WITH ELECTRICAL COMPONENTS CONTAINING COPPER, ZINC, NICKEL, OR SILVER.

SYSTEM SAFETY CHECKLIST - PART I	
FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN	
SECTION: 3.0 ELECTRICAL AND ELECTRONIC	
	3.1 <u>GENERAL</u> (Cont.)
12.	THE DESIGN OF MOUNTING SURFACES AND ATTACHMENT HARDWARE FOR ALL ELECTRICAL CONTACTOR ASSEMBLIES (E.G., SWITCHES, RELAYS, ETC.), SHALL MAINTAIN THE CONTACTS IN A HERMETICALLY SEALED ENVIRONMENT.
13.	ALL CONNECTORS, CIRCUIT BOARDS, TERMINAL BOARDS, SWITCHES, RELAYS AND SIMILAR COMPONENTS SHALL BE POTTED, SEALED, OR OTHERWISE PROTECTED AGAINST SHORTING BY MATERIALS FLOATING IN A ZERO-G ENVIRONMENT.
14.	ALL CONNECTORS, CIRCUIT BOARDS, TERMINAL BOARDS, SWITCHES, RELAYS AND SIMILAR COMPONENTS SHALL BE POTTED, SEALED, OR OTHERWISE PROTECTED AGAINST THE EFFECTS OF LIQUID LEAKAGE OR CONDENSATION.
15.	GUARDS OR COVERS SHALL BE PROVIDED OVER ALL TERMINATION POINTS WHERE VOLTAGE POTENTIALS EXIST IF ACCESS IS POSSIBLE WITH VOLTAGE APPLIED.
16.	ALL GUARDS OR COVERS PROVIDED FOR PERSONNEL PROTECTION SHALL BE CLEARLY MARKED TO INDICATE THE VOLTAGE POTENTIAL OF THE COVERED TERMINAL.
17.	INSULATED GUIDES SHALL BE PROVIDED WHEREVER AN ADJUSTMENT TOOL COULD CONTACT ANY ADJACENT CIRCUIT COMPONENT HAVING A VOLTAGE POTENTIAL.
18.	ALL PORTABLE ELECTRICAL EQUIPMENT SHALL BE DESIGNED SO THAT AN INTERNAL SHORT WILL NOT RESULT IN A VOLTAGE POTENTIAL BEING APPLIED TO THE CASE OR ENCLOSURE.
19.	EQUIPMENT SHALL REVERT TO A SAFE CONFIGURATION WHEN AN INPUT POWER LOSS OCCURS.
20.	ALL HEATERS SHALL HAVE INDEPENDENT REDUNDANT CIRCUITS FOR TEMPERATURE SENSING AND CONTROL.
21.	HEATERS SHALL HAVE OVERTEMPERATURE SHUT-OFF DEVICES INDEPENDENT OF ANY THERMOSTAT) WHICH REQUIRE MANUAL RESET.
22.	ANY SYSTEM WHICH HAS A CAPABILITY OF LOCKING OUT GROUND COMMAND CONTROL SHALL PROVIDE AN INDICATION TO THE GROUND WHENEVER THE CONTROL(S) IS IN THE LOCKED-OUT POSITION.

SYSTEM SAFETY CHECKLIST - PART I	
FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN	
SECTION: 3.0 ELECTRICAL AND ELECTRONIC	
	3.2 <u>CABLING AND WIRING</u>
23.	ALL CABLES AND WIRING SHALL BE CLAMPED AND SUPPORTED TO REMAIN CLEAR OF SHARP EDGES AND MOVING PARTS.
24.	ALL CABLES AND WIRING SHALL BE CONFIGURED, CLAMPED AND SUPPORTED TO ELIMINATE MECHANICAL STRESS ON WIRES, TERMINATIONS AND CONNECTORS DURING GROUND AND FLIGHT ENVIRONMENTS (E.G., SHOCK, VIBRATIONS, ETC.).
25.	ALL CABLES AND WIRES SHALL BE MARKED TO CLEARLY INDICATE THE CORRECT MATING CONNECTION OR TERMINATION POINT IN ORDER TO PRECLUDE PHASE REVERSAL OR CROSS-CONNECTION.
26.	ALL WIRING SHALL BE LOCATED AND CLAMPED TO ELIMINATE ANY POSSIBILITY OF CONTACT WITH LIQUID LINES.
27.	THE DESIGN SHALL SPECIFY THAT WIRING SHALL NOT BE SPLICED.
28.	POWER AND SIGNAL (INCLUDING COMMAND) WIRING SHALL NOT BE ROUTED THROUGH THE SAME CABLE, CABLE BUNDLE, OR WIRING HARNESS IN ORDER TO MINIMIZE VOLTAGE INDUCTION INTO ADJACENT CIRCUITS.
29.	SHIELDS USED TO PROTECT AGAINST INDUCED VOLTAGE FOR FREQUENCIES UP TO 50 KHz SHALL BE CONTINUOUS THROUGH ALL CONNECTORS AND GROUNDED AT ONLY ONE END.
30.	SHIELDS USED TO PROTECT AGAINST INDUCED VOLTAGE FOR FREQUENCIES ABOVE 50 KHz SHALL BE CONTINUOUS THROUGH ALL CONNECTORS AND GROUNDED AT BOTH ENDS.
31.	POLYVINYL CHLORIDE SHALL NOT BE USED AS WIRE INSULATION.
32.	ELECTRICAL WIRE OR CABLE INSULATED OR COATED WITH POLYTETRAFLUOROETHYLENE (TFE) OR FLUORINATED ETHYLENE PROPYLENE (FEP) SHALL BE ETCHED PRIOR TO POTTING TO ASSURE POSITIVE BOND AND ENVIRONMENTAL SEAL.
33.	WHEN ETCHING OF INSULATION IS REQUIRED, THE DESIGN SHALL SPECIFY THAT THE OPEN END OF THE WIRE WILL NOT BE EXPOSED TO THE ETCHANT.

SYSTEM SAFETY CHECKLIST - PART I

FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN

SECTION: 3.0 ELECTRICAL AND ELECTRONIC

3.2 CABLING AND WIRING (Cont.)

34. CABLING OR WIRING LOCATED OUTSIDE THE HABITABLE AREA OF THE SPACECRAFT SHALL BE CAPABLE OF FLEXING WITHOUT DAMAGE TO THE WIRE OR INSULATION AT THE EXTREME TEMPERATURE ENVIRONMENT OF SPACE.

35. WIRES AND CABLES SHALL NOT BE IDENTIFIED OR MARKED BY HOT STAMPING ON THE INSULATION.

36. SOLID WIRE (SINGLE STRAND) SHALL NOT BE USED IN LOCATIONS WHERE IT MAY BE SUBJECTED TO FLEXING.

3.3 CONNECTORS

37. ALL MATING PLUGS AND RECEPTACLES SHALL BE MARKED OR CODED TO CLEARLY INDICATE THE CORRECT MATING CONNECTION.

38. ALL ADJACENT CONNECTORS SHALL BE SHAPED OR RESTRAINED SO THAT IT IS PHYSICALLY IMPOSSIBLE TO MISMATE.

39. CONNECTORS WITH UNKEYED SYMMETRICAL PIN ARRANGEMENTS SHALL NOT BE USED.

40. ONLY FEMALE CONNECTORS SHALL BE USED AS ACCESS TO SOURCES OF POWER.

41. ALL FLIGHT OR PROTOTYPE SYSTEM CONNECTORS WHICH INTERFACE WITH GROUND SUPPORT EQUIPMENT SHALL BE INDIVIDUALLY SHAPED OR RESTRAINED SO THAT IT IS PHYSICALLY IMPOSSIBLE TO MISMATE THE INTERFACING GROUND SUPPORT EQUIPMENT CONNECTORS.

42. POWER CIRCUITS AND SIGNAL CIRCUITS SHALL NOT BE ROUTED THROUGH THE SAME CONNECTOR IN ORDER TO MINIMIZE THE INTRODUCTION OF VOLTAGE TRANSIENTS INTO THE SIGNAL WIRING.

43. ELECTRICAL CONNECTORS USED WITHIN THE HABITABLE AREAS OF THE SPACECRAFT SHALL HAVE SELF-LOCKING DEVICES AND SHALL NOT REQUIRE THE USE OF SAFETY WIRE.

44. SHORTING DEVICES SUCH AS SPRINGS OR CLIPS SHALL NOT BE USED IN CONNECTORS.

SYSTEM SAFETY CHECKLIST - PART I	
FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN	
SECTION: 3.0 ELECTRICAL AND ELECTRONIC	
	3.4 <u>BATTERIES</u>
45.	BATTERIES SHALL HAVE DECALS OR MARKERS TO INDICATE THE TYPE OF ELECTROLYTE AND SPECIAL SAFETY PRECAUTIONS.
46.	ALL BATTERY VENTS AND RELIEF DEVICES SHALL BE DESIGNED TO PREVENT THE EJECTION OF ELECTROLYTE FROM THE BATTERY.
47.	ALL BATTERY VENTS AND RELIEF DEVICE OUTLETS SHALL BE LOCATED TO PRECLUDE DAMAGE TO ADJACENT EQUIPMENT OR INJURY TO OPERATING PERSONNEL.
48.	BATTERIES SHALL NOT BE VENTED INTO THE HABITABLE AREAS OF THE SPACECRAFT.
49.	ALL BATTERIES SHALL HAVE DECALS OR MARKERS TO CLEARLY INDICATE THE POSITIVE AND NEGATIVE TERMINALS.
50.	ALL BATTERY CASES SHALL BE DESIGNED TO CONTAIN ALL ELECTROLYTE DURING ALL OVERPRESSURE CONDITIONS SUCH AS THOSE WHICH COULD BE CAUSED BY OVERLOAD OR INTERNAL SHORTS.
51.	INSTALLED BATTERIES (SINGLE OR MULTIPLE CELLED) SHALL BE ENCLOSED WITHIN A CONTAINER WHICH WILL PREVENT ELECTROLYTE LEAKAGE INTO THE SURROUNDING AREA IN THE EVENT OF DAMAGE TO THE BATTERY CASE.
52.	THE DESIGN SHALL SPECIFY THAT ALL BATTERIES AND CHARGER ASSEMBLIES SHALL BE TESTED AT FULL OPERATIONAL LOADS PRIOR TO INSTALLATION INTO THE SPACECRAFT, EXPERIMENT OR OTHER PAYLOAD.
	3.5 <u>CONTROL FUNCTIONS AND COMPONENTS</u>
53.	ALL SWITCHES SHALL BE CLEARLY MARKED OR LABELED TO INDICATE THE SYSTEM FUNCTION FOR EACH SWITCH POSITION.
54.	NEGATIVE CONTROL OR SWITCHING IN THE POWER RETURN LEADS OF A COMPONENT SHALL NOT BE USED UNLESS THE POSITIVE LEAD IS SWITCHED SIMULTANEOUSLY.
55.	SELF-TEST CIRCUITS SHALL INDICATE THE ACTUAL SYSTEM RESPONSE, RATHER THAN INDICATE ONLY THE INITIATION OF A COMMAND OR TEST SIGNAL.

SYSTEM SAFETY CHECKLIST - PART I

FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN

SECTION: 3.0 ELECTRICAL AND ELECTRONIC

3.5 CONTROL FUNCTIONS AND COMPONENTS (Cont.)

56. SELF-LATCHING FUNCTION SWITCHES SUCH AS PUSHBUTTON SWITCH-INDICATORS WHICH MAY BE OPERATED WITHOUT INDICATING THE SWITCH POSITION DURING A POWER OFF PHASE SHALL NOT BE USED.

57. ALL CIRCUIT BREAKERS OR SWITCHES USED TO CONTROL EQUIPMENT OR CIRCUITRY INTENDED FOR EMERGENCY PURPOSES SHALL HAVE POSITIVE PROTECTION AGAINST INADVERTENT OPERATION.

58. ALL CIRCUIT BREAKERS OR SWITCHES USED TO CONTROL THE ARMING OF PYROTECHNIC DEVICES SHALL HAVE POSITIVE PROTECTION AGAINST INADVERTENT OPERATION.

59. REDUNDANT CONTROL CIRCUIT COMPONENTS SHALL BE INDEPENDENT OF THOSE COMPONENTS USED IN THE PRIMARY CONTROL CIRCUIT.

60. PRIMARY AND REDUNDANT CONTROL CIRCUIT WIRING SHALL NOT BE ROUTED THROUGH THE SAME CABLE OR CONNECTOR.

61. PRIMARY AND REDUNDANT CONTROL CIRCUITS SHALL INCLUDE AN INFLIGHT CHECKOUT CAPABILITY WHICH WILL VERIFY THE INDEPENDENT OPERATION OF EACH CIRCUIT.

62. PRIMARY AND REDUNDANT SYSTEM CIRCUITS SHALL NOT BE SUPPLIED FROM THE SAME BRANCH POWER BUS OR CIRCUIT BREAKER.

63. ALL CIRCUITS (INCLUDING LATCHING RELAY CIRCUITS) SHALL BE PROTECTED AGAINST INADVERTENT OPERATION DUE TO VOLTAGE TRANSIENTS.

64. ALL SYSTEM INDICATORS USED TO MONITOR SYSTEM STATUS SHALL INDICATE THE ACTUAL SYSTEM RESPONSE RATHER THAN INDICATE ONLY THE INITIATION OF A COMMAND OR APPLICATION OF POWER.

65. LOSS OF CONTROL CIRCUIT POWER SHALL NOT RESULT IN POWER LOSS TO DEVICES WHICH INDICATE RESPONSE OR CONFIGURATION STATUS OF CONTROLLED COMPONENTS, (I.E., POWER FOR INDICATORS OR INSTRUMENTATION USED TO MONITOR VALVE POSITION, PRESSURE LEVELS, ETC., SHALL BE INDEPENDENT AND ISOLATED FROM FAILURES IN CONTROL CIRCUITS FOR THOSE VALVES OR SENSORS).

SYSTEM SAFETY CHECKLIST - PART I	
FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN	
SECTION: 3.0 ELECTRICAL AND ELECTRONIC	
	3.5 <u>CONTROL FUNCTIONS AND COMPONENTS</u> (Cont.)
66.	TERMINAL LUGS AND INSULATED WASHERS USED WITH STUD-MOUNTED DIODES SHALL HAVE SUFFICIENT MATCHING SURFACE AREA TO ENSURE THAT THE TERMINAL LUG WILL REMAIN INSULATED FROM THE MOUNTING STRUCTURE.
67.	POSITIVE MECHANICAL MEANS SHALL BE SPECIFIED IN THE DESIGN TO ENSURE ADEQUATE CONTACT PRESSURE IS MAINTAINED AT STUD-MOUNTED DIODE CONNECTIONS.
68.	POSITIVE PROVISIONS SHALL BE SPECIFIED IN THE DESIGN TO PRECLUDE SEEPAGE OF CONFORMAL COATINGS INTO ELECTRICAL INTERFACES IN STUD-MOUNTED DIODE INSTALLATIONS.
69.	ALL POWER AND SIGNAL RETURNS FOR FLIGHT SYSTEMS, EXPERIMENTS OR OTHER PAYLOAD SHALL BE ISOLATED FROM THE CHASSIS AND SHALL BE ROUTED THROUGH CONNECTORS OR TERMINALS TO A SINGLE POINT GROUND TERMINATION FOR INTERFACE WITH THE SPACECRAFT SINGLE POINT GROUNDING SYSTEM.
70.	SPACECRAFT STRUCTURE SHALL NOT BE USED FOR THE RETURN OF CURRENT TO THE POWER SOURCE.
	3.6 <u>OVERLOAD PROTECTION</u>
71.	CIRCUIT BREAKERS SHALL PROVIDE A VISUAL INDICATION WHEN TRIPPED.
72.	CIRCUIT BREAKERS SHALL TRIP AND PROTECT THE CIRCUIT EVEN IF THE SWITCH LEVER IS PHYSICALLY HELD IN THE "ON" POSITION.
73.	OVERLOAD PROTECTION DEVICES SHALL BE INSTALLED IN EACH UN-GROUNDED CONDUCTOR IN THREE (3) PHASE POWER SYSTEMS AND SHALL BE DESIGNED SO THAT ALL THREE (3) DEVICES TRIP SIMULTANEOUSLY.
74.	ALL ADJUSTABLE TYPE CIRCUIT BREAKER SETTINGS SHALL BE SPECIFIED IN THE DESIGN.
75.	ALL CIRCUIT BREAKERS SHALL BE SIZED (OR SET) TO PROTECT THE SMALLEST WIRE WITHIN A CIRCUIT, INCLUDING ALL BRANCHES WHICH DO NOT HAVE INDEPENDENT CIRCUIT PROTECTION.
76.	OVERLOAD PROTECTION DEVICES SHALL BE SIZED (OR SET) SO THAT THE COMBINATION OF CURRENT AND TIME AT WHICH THE DEVICE OPERATES WILL NOT CAUSE THE OPERATION OF UPSTREAM PROTECTIVE DEVICES.

SYSTEM SAFETY CHECKLIST - PART I	
FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN	
SECTION: 3.0 ELECTRICAL AND ELECTRONIC	
	3.6 <u>OVERLOAD PROTECTION</u> (Cont.)
77.	A CIRCUIT BREAKER OR SIMILAR OVERLOAD PROTECTION SHALL BE PROVIDED IN EACH EXPERIMENT OR OTHER PAYLOAD IN ORDER TO PREVENT AN OVERLOAD IN ONE EXPERIMENT OR PAYLOAD FROM AFFECTING OTHER EXPERIMENTS OR INTERFACING EQUIPMENT.

SYSTEM SAFETY CHECKLIST - PART I

FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN

SECTION: 4.0 LIQUIDS AND GASES

4.1 GENERAL

1. SYSTEMS SHALL BE DESIGNED TO MINIMIZE THE EFFECTS OF SHOCK WAVES OR PRESSURE SURGES GENERATED BY SUDDEN CHANGES IN FLOW.

2. ALL PRESSURE REGULATOR, FLOW CONTROL, AND RELIEF DEVICE SETTINGS SHALL BE SPECIFIED IN THE DESIGN.

3. PROOF TEST REQUIREMENTS FOR ALL COMPONENTS SHALL BE A MINIMUM OF 1.5 TIMES THE MAXIMUM PRESSURE AT WHICH THEY WILL BE REQUIRED TO OPERATE WITHIN THE SYSTEM.

4. ALL MATERIALS INCLUDING SEALS, GASKETS AND LUBRICANTS USED IN FLIGHT EQUIPMENT SHALL BE COMPATIBLE WITH THE SYSTEM COMMODITY AND SHALL MEET THE CLEANLINESS LEVELS AND CONTAMINATION CONTROL REQUIREMENTS OF THE INTERFACING FLIGHT SYSTEM, EXPERIMENT OR OTHER PAYLOAD HARDWARE FOR WHICH THE MOST STRINGENT REQUIREMENTS HAVE BEEN ESTABLISHED.

5. ALL PIPING AND COMPONENTS WITHIN EACH SYSTEM SHALL BE ELECTRICALLY BONDED ACROSS EACH CONNECTION (ALL PIPING SEGMENTS) AND SHALL BE GROUNDED TO REDUCE STATIC ELECTRICAL POTENTIAL.

6. ALL LIQUID AND GAS SYSTEMS SHALL BE DESIGNED TO PERMIT LEAK TESTING AFTER INSTALLATION.

7. ISOLATION VALVES SHALL BE PROVIDED AT THE FLIGHT SYSTEM INTERFACE FOR INDEPENDENTLY CONTROLLING LIQUIDS, GASES AND VACUUM BEING SUPPLIED TO EACH SUBSYSTEM, EXPERIMENT OR OTHER PAYLOAD.

8. AN ISOLATION SHUTOFF VALVE SHALL BE INSTALLED IN EACH SYSTEM, EXPERIMENT OR PAYLOAD SUPPLIED FROM A COMMON LIQUID OR GAS PRESSURE SOURCE.

9. ALL EQUIPMENT REQUIRING GAS FOR PURGING OR PRESSURIZATION SHALL INCLUDE A HAND VALVE AT THE INLET TO THE RECEIVING EQUIPMENT OR AS THE FIRST COMPONENT DOWNSTREAM OF THE RECEIVING EQUIPMENT INTERFACE WHENEVER THE SOURCE PRESSURE SHUTOFF VALVE IS NOT ACCESSIBLE TO THE OPERATOR AT THE WORK STATION OR EQUIPMENT RECEIVING THE GAS.

10. ELECTRICAL OR ELECTRONIC COMPONENTS SUCH AS MOTORS, SENSORS, OR SWITCHES USED IN LIQUID OR GAS SYSTEMS SHALL BE INSTALLED WITH THE COMPONENT HOUSING EXTERNAL TO THE VESSEL OR PIPING CONTAINING THE LIQUID OR GAS.

SYSTEM SAFETY CHECKLIST - PART I	
FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN	
SECTION: 4.0 LIQUIDS AND GASES	
	4.1 GENERAL (Cont.)
11.	TUBING CAPS, PLUGS, OR BLIND FLANGES (END PLATES) SHALL BE INSTALLED ON ALL TEST AND SERVICE PORTS WHICH ARE NOT REQUIRED TO FUNCTION IN FLIGHT.
12.	PUMPS AND COMPRESSORS SHALL BE PROTECTED AGAINST DAMAGE BY USE OF PROTECTIVE DEVICES SUCH AS THERMAL OVERLOADS, BY-PASS RELIEF DEVICES, VIBRATION SENSITIVE CUTOUT SWITCHES, PUMP SUCTION PRESSURE INTERLOCKS AND OVERSPEED CONTROLS.
13.	FILTERS SHALL BE INSTALLED IN PUMP AND COMPRESSOR INLET LINES WITH PRESSURE INDICATORS ON EACH SIDE OF THE FILTER OR A DIFFERENTIAL PRESSURE GAGE.
14.	FILTER HOUSINGS THAT ARE REQUIRED TO BE REMOVED FROM THE SYSTEM FOR ELEMENT REPLACEMENT SHALL NOT BE USED.
15.	DISSIMILAR METALS SHALL NOT BE USED IN COOLANT SYSTEM COMPONENTS IF A GALVANIC CIRCUIT IS THEREBY ESTABLISHED WITH THE COOLANT ACTING AS ELECTROLYTE.
16.	LIQUID LINE INSULATION SHALL BE MADE OF NONABSORBENT MATERIALS.
17.	TITANIUM OR ITS ALLOYS SHALL NOT BE USED IN OXYGEN SYSTEMS.
18.	TITANIUM OR ITS ALLOYS SHALL NOT BE USED WITH METHANOL.
	4.2 LINES
19.	ALL LINES AND FLEXIBLE HOSES SHALL HAVE A MINIMUM DESIGN BURST PRESSURE OF 4.0 TIMES THE MAXIMUM PRESSURE AT WHICH THEY WILL BE REQUIRED TO OPERATE WITHIN THE SYSTEM.
20.	ALL LINES SHALL BE FIRMLY SUPPORTED TO PROTECT AGAINST DAMAGE FROM MECHANICAL STRESS AND VIBRATION.
21.	ALL LINES SHALL BE INDEPENDENTLY CLAMPED.
22.	ALL LINES SHALL BE SUPPORTED AS CLOSE AS POSSIBLE TO LINE END FITTINGS AND CONNECTORS TO REDUCE MECHANICAL STRESS (INCLUDING SIDE LOADS) AND VIBRATION AT THE CONNECTION POINT.

SYSTEM SAFETY CHECKLIST - PART I	
FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN	
SECTION: 4.0 LIQUIDS AND GASES	
	4.2 LINES (Cont.)
23.	ALL RIGID LINES USED IN FIXED APPLICATIONS SHALL BE SUPPORTED AS CLOSE AS POSSIBLE AT EACH BEND IN THE LINE.
24.	SERVICE POINTS FOR FILLING, DRAINING, PURGING, OR BLEEDING SYSTEMS DURING GROUND OPERATIONS SHALL BE LOCATED EXTERNAL TO THE SPACECRAFT.
25.	ALL LINES IN ALL ANTICIPATED OPERATIONAL LOCATIONS OF THE SPACECRAFT (E.G., HABITABLE AREAS, EVA ROUTES AND EXPERIMENT WORK STATIONS) SHALL HAVE SLEEVES, BARRIERS, OR SIMILAR PROTECTION AGAINST INADVERTENT DAMAGE BY PERSONNEL.
26.	ALL LINES WHICH PASS THROUGH THE PRESSURIZED CABIN WALL INTO THE HABITABLE AREAS OF THE SPACECRAFT SHALL HAVE A SHUTOFF VALVE LOCATED IN THE LINE IMMEDIATELY AFTER IT ENTERS INSIDE THE CABIN WALL.
27.	ALL LINES WHICH DUMP OR VENT EXTERNAL TO THE HABITABLE AREAS OF THE SPACECRAFT SHALL HAVE THERMOSTATICALLY CONTROLLED HEATERS TO PROTECT AGAINST CLOGGING.
	4.3 FLEXIBLE HOSES
28.	FLEXIBLE HOSES SHALL HAVE A MINIMUM SLACK ALLOWANCE OF 5% OF THE TOTAL HOSE LENGTH.
29.	ALL FLEXIBLE HOSES SHALL BE CLAMPED AND SUPPORTED TO REMAIN CLEAR OF SHARP EDGES AND MOVING PARTS.
30.	FLEXIBLE HOSES SHALL HAVE HOSE RESTRAINTS CONNECTED ACROSS THE HOSE CONNECTIONS AND SECURED TO THE SPACECRAFT STRUCTURE.
31.	FLEXIBLE HOSE RESTRAINTS SHALL BE AT LEAST 50 PERCENT STRONGER THAN THE MAXIMUM CALCULATED IMPACT (FORCE) ON THE RESTRAINT DUE TO AN OPEN LINE (UNDER MAXIMUM OPERATING PRESSURE) MOVING THROUGH THE DISTANCE OF FLEXURE OF THE RESTRAINT.
32.	ALL FLEXIBLE HOSES SHALL BE CLEARLY MARKED TO INDICATE THE SYSTEM FUNCTION, CONTENT, AND MAXIMUM OPERATING PRESSURE.
33.	A PROTECTIVE COVERING SHALL BE PROVIDED AS AN INTEGRAL PART OF EACH FLEXIBLE HOSE TO PRECLUDE DAMAGE FROM ABRASION AND CHAFING.

SYSTEM SAFETY CHECKLIST - PART I

FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN

SECTION: 4.0 LIQUIDS AND GASES

4.4 FITTINGS, FLANGES AND CONNECTORS

34. SYSTEM CONNECTORS SHALL BE KEYED OR SIZED SO THAT IT IS PHYSICALLY IMPOSSIBLE TO CONNECT AN INCOMPATIBLE COMMODITY OR PRESSURE LEVEL.

35. ALL SYSTEM FITTINGS SHALL HAVE A MINIMUM DESIGN BURST PRESSURE OF 4.0 TIMES THE MAXIMUM PRESSURE AT WHICH THEY WILL BE REQUIRED TO OPERATE WITHIN THE SYSTEM.

36. ALL CONNECTORS AND FITTINGS REQUIRED TO BE DISCONNECTED DURING FLIGHT OPERATIONS SHALL HAVE TETHERED CAPS, PLUGS, OR COVERS TO PROTECT THE SYSTEM AGAINST CONTAMINATION OR DAMAGE WHEN DISCONNECTED.

4.5 PRESSURE AND LIQUID VESSELS

37. ALL PRESSURE VESSELS AND RESERVOIRS SHALL HAVE A MINIMUM DESIGN BURST PRESSURE OF 4.0 TIMES THE MAXIMUM DESIGN OPERATING PRESSURE UNLESS SPECIFICALLY DESIGNED IN ACCORDANCE WITH FRACTURE MECHANICS TECHNOLOGY AND SAFETY FACTORS SPECIFIED BY THE PROCURING AGENCY AND APPROVED FOR EACH VESSEL AND APPLICATION.

38. INITIAL OPENING OF ALL PRESSURE VESSEL PRIMARY RELIEF DEVICES SHALL BE NO HIGHER THAN 110 PERCENT OF THE MAXIMUM DESIGN OPERATING PRESSURE OF THE VESSEL.

39. ALL PRESSURE VESSELS AND RESERVOIRS SHALL HAVE AN ISOLATION SHUTOFF VALVE LOCATED AS THE FIRST COMPONENT DOWNSTREAM OF THE VESSEL AND AS CLOSE AS POSSIBLE TO THE VESSEL.

40. ALL PRESSURE VESSELS SHALL HAVE A VALVE TO PERMIT CONTROLLED REDUCTION OF PRESSURE AS DESIRED.

41. ALL PRESSURE VESSELS SHALL INCORPORATE PROVISIONS FOR MONITORING VESSEL PRESSURE.

42. ALL LIQUID VESSELS SHALL HAVE A LIQUID QUANTITY INDICATING DEVICE.

43. ALL LIQUID VESSELS SHALL HAVE A DRAIN VALVE LOCATED SUCH THAT ALL LIQUID MAY BE DRAINED FROM THE VESSEL DURING GROUND (HORIZONTAL OR VERTICAL) OPERATIONS.

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SECTION: 4.0 LIQUIDS AND GASES	
	4.5 <u>PRESSURE AND LIQUID VESSELS</u> (Cont.)
44.	ALL PRESSURE VESSELS SHALL BE CLEARLY MARKED OR LABELED TO IDENTIFY CONTENT AND OPERATING PRESSURE.
45.	ALL LIQUID VESSELS SHALL BE CLEARLY MARKED OR LABELED TO IDENTIFY COMMODITY AND CAPACITY.
	4.6 <u>PRESSURE RELIEF</u>
46.	A PRESSURE RELIEF DEVICE SHALL BE LOCATED DOWNSTREAM OF ANY PRESSURE REGULATING DEVICE WHERE INPUT PRESSURE TO THE REGULATING DEVICE CAN EXCEED THE PROOF PRESSURE OF ANY DOWNSTREAM SYSTEM COMPONENT.
47.	THE INITIAL OPENING OF SYSTEM RELIEF VALVES SHALL BE NO HIGHER THAN 110 PERCENT OF THE UPSTREAM REGULATOR SETTING.
48.	PRESSURE RELIEF VALVES AND RELIEF VENT LINES SHALL BE SIZED TO EXCEED THE MAXIMUM FLOW CAPACITY OF THE UPSTREAM PRESSURE REGULATING DEVICE UNDER FAILED OPEN CONDITIONS.
49.	INITIAL OPENING OF REDUNDANT RELIEF DEVICES, WHEN USED SHALL BE NO HIGHER THAN 125 PERCENT OF THE UPSTREAM REGULATOR SETTING.
50.	REDUNDANT RELIEF DEVICES SHALL BE LOCATED IN THE SYSTEM SO AS NOT TO RENDER THE PRIMARY RELIEF DEVICE INEFFECTIVE (E.G., SERIES INSTALLATION OF RELIEF VALVES).
51.	A RELIEF DEVICE SHALL BE LOCATED BETWEEN ANY RESTRICTOR ORIFICE INSTALLATION AND AN UPSTREAM PRESSURE REGULATING DEVICE, IF FAILURE OF THE REGULATOR WOULD RESULT IN OVERPRESSURE ABOVE PROOF LEVEL.
52.	ALL RELIEF PORTS AND VENT LINES SHALL BE DESIGNED (LOCATED) SO THAT ESCAPING LIQUID OR GASES WILL NOT BE HAZARDOUS TO PERSONNEL OR EQUIPMENT DURING FLIGHT OR GROUND OPERATIONS.
53.	ALL SYSTEM RELIEF AND VENT VALVES SHALL BE CLEARLY MARKED TO INDICATE COMPONENT NUMBER AND SYSTEM FUNCTION.
54.	ALL LIQUID AND GAS VENT OR RELIEF DEVICES SHALL VENT OUTSIDE THE SPACECRAFT HABITABLE AREAS.

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SECTION: 4.0 LIQUIDS AND GASES	
	4.6 PRESSURE RELIEF (Cont.)
55.	ALL SEALED PANELS, CONSOLES OR SIMILAR ENCLOSURES WHICH CONTAIN LIQUID OR GAS SYSTEM COMPONENTS SHALL HAVE AUTOMATIC (FAIL-SAFE) PRESSURE RELIEF DEVICES.
56.	INDEPENDENT (SEPARATE) LINES SHALL BE USED TO VENT OR RELIEVE (DISCHARGE) DIFFERENT COMMODITIES WHICH COULD DEFLAGRATE OR OTHERWISE REACT SUCH THAT ADVERSE PRESSURE, CONTAMINATION, CORROSION OR MATERIALS DEGRADATION COULD RESULT.
	4.7 VALVES, REGULATORS AND CONTROL DEVICES
57.	VENT OR BLEED VALVES SHALL BE LOCATED IN THE SYSTEM WHEREVER LIQUIDS OR PRESSURE COULD BE TRAPPED BETWEEN COMPONENTS.
58.	REGULATORS USED FOR STEP REGULATION SHALL OPERATE IN THE CENTER 50 PERCENT OF THEIR TOTAL RANGE.
59.	THE MAXIMUM OPERATING PRESSURE DELIVERED BY EACH REGULATOR SHALL NOT BE GREATER THAN 75 PERCENT OF THE MAXIMUM PRESSURE REGULATION CAPABILITY OF THE REGULATOR.
60.	MANUALLY OPERATED VALVES SHALL NOT BE USED TO BY-PASS PRESSURE REGULATOR OR FLOW CONTROL DEVICES.
61.	SHUTOFF VALVES SHALL NOT BE INSTALLED IN SERIES WITH RELIEF VALVES UNLESS ANOTHER INDEPENDENTLY OPERATED POSITIVE RELIEF DEVICE IS INSTALLED IN PARALLEL WITH THE SHUTOFF VALVE(S).
62.	CHECK VALVES SHALL BE LOCATED IN PRESSURE SYSTEMS TO MINIMIZE DOWNSTREAM PRESSURE LOSS RESULTING FROM LOSS OF SOURCE PRESSURE.
63.	CHECK VALVES SHALL BE USED TO ISOLATE PARALLEL SUPPLY SYSTEMS OR PRESSURE VESSELS WHICH CAN BE USED TO SERVICE A COMMON DOWNSTREAM SYSTEM.
64.	CHECK VALVES SHALL BE USED TO ISOLATE PARALLEL VENT LINES EACH OF WHICH VENTS INTO A COMMON MANIFOLD.
65.	LOCKING PINS OR SIMILAR DEVICES SHALL BE INCLUDED IN THE DESIGN OF ALL LIQUID AND GAS SYSTEMS TO PROVIDE POSITIVE PROTECTION AGAINST INADVERTENT OPERATION OF ALL MANUALLY OPERATED VALVES.

SYSTEM SAFETY CHECKLIST - PART I

FLIGHT SYSTEMS AND EXPERIMENT HARDWARE DESIGN

SECTION: 4.0 LIQUIDS AND GASES

4.7 VALVES, REGULATORS AND CONTROL DEVICES (Cont.)

66. ALL SYSTEM VALVES AND REGULATING DEVICES SHALL BE CLEARLY MARKED OR PLACARDED TO IDENTIFY COMPONENT NUMBER, SYSTEM FUNCTION AND DIRECTION OF OPERATION.

67. ALL ADJUSTABLE PRESSURE CONTROL DEVICES SHALL HAVE MARKINGS TO INDICATE THE DIRECTION OF PRESSURE INCREASE AND DECREASE ADJUSTMENT (COUNTER-CLOCKWISE INCREASE AND CLOCKWISE DECREASE ARE PREFERRED).

4.8 GAGES AND INDICATORS

68. VISUAL MONITORING CAPABILITY SHALL BE PROVIDED FOR EACH LEVEL OF SYSTEM PRESSURE.

69. DIRECT PRESSURE READOUT GAGES SHALL NOT BE USED.

70. ALL SEALED PANELS, CONSOLES, CONDUIT OR SIMILAR ENCLOSURES WHICH CONTAIN LIQUID OR GAS SYSTEM COMPONENTS SHALL HAVE PRESSURE INDICATING OR VAPOR DETECTION DEVICES TO MONITOR AND INITIATE AN ALARM IN THE EVENT OF SYSTEM LEAKAGE.

SYSTEM SAFETY CHECKLIST - PART II

GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN

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GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN

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GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN	
SECTION: 1.0 GENERAL CRITERIA	
1.	OPERATING RANGE AND PERFORMANCE LIMITS FOR ALL EQUIPMENT SHALL BE SPECIFIED IN THE DESIGN.
2.	TORQUE VALUES FOR ALL THREADED FASTENERS AND FITTINGS SHALL BE SPECIFIED IN THE DESIGN.
3.	ALL MECHANICAL ACTUATING DEVICES SHALL HAVE POSITIVE MECHANICAL STOPS FOR PROTECTION AGAINST FAILURES THAT COULD ALLOW THE DEVICE TO EXCEED ITS INTENDED LIMITS OF TRAVEL.
4.	OPENINGS (SLOTTED OR OTHERWISE) IN CABINETS, COVERS AND SIMILAR ENCLOSURES THROUGH WHICH LEVERS, SHAFTS AND SIMILAR CONTROLS OPERATE SHALL BE PROVIDED WITH NONFLAMMABLE PROTECTIVE COVERS, BOOTS, OR SLIDING PLATES TO PREVENT PERSONNEL INJURY OR EQUIPMENT DAMAGE RESULTING FROM INADVERTENT INSERTION OR ENTRY OF FOREIGN OBJECTS.
5.	MOVING PARTS SUCH AS FANS, BELT DRIVE ASSEMBLIES AND SIMILAR COMPONENTS THAT COULD CAUSE PERSONNEL INJURY OR EQUIPMENT DAMAGE DUE TO INADVERTENT CONTACT WITH SUCH EQUIPMENT SHALL BE PROVIDED WITH GUARDS OR SIMILAR PROTECTIVE DEVICES.
6.	LOCKING PINS, KNOBS, HANDLES, AND SIMILAR DEVICES WHICH MAY REQUIRE TEMPORARY REMOVAL SHALL BE TETHERED OR OTHERWISE HELD CAPTIVE TO THE EQUIPMENT WITH WHICH THEY ARE USED.
7.	BEADED LINK CHAINS SHALL NOT BE USED AS TETHERS OR RESTRAINTS.
8.	ALL CONTROLS AND INDICATORS SHALL BE CLEARLY MARKED OR LABELED TO INDICATE SYSTEM FUNCTION.
9.	EMERGENCY CONTROLS (ELECTRICAL OR MECHANICAL) USED FOR SHUTDOWN, SAFING, ALARM OR CORRECTIVE ACTION SHALL BE CLEARLY MARKED (E.G., PLACARDS, RED BOARDERS, ETC.), VISIBLE AND READILY ACCESSIBLE TO OPERATING PERSONNEL.
10.	MECHANICAL COMPONENTS OR MECHANISMS REQUIRING MANUAL OPERATION OR ADJUSTMENT SHALL BE DESIGNED FOR OPERATION WHILE WEARING PROTECTIVE CLOTHING SUCH AS GLOVES.
11.	ALL HANDLES AND CONTROLS INCLUDING THOSE FOR MECHANISMS SUCH AS FOLDING PLATFORMS SHALL BE DESIGNED WITH SUFFICIENT CLEARANCES TO ADJACENT STRUCTURES OR OTHER COMPONENTS TO PREVENT INJURY TO FINGERS AND HANDS.

SYSTEM SAFETY CHECKLIST - PART II	
GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN	
SECTION: 1.0 GENERAL CRITERIA	
12.	ALL HANDLES, KNOBS, LATCHES, HATCHES AND SIMILAR MECHANICAL DEVICES THAT REQUIRE ALIGNMENT OR ADJUSTMENT SHALL HAVE ALIGNMENT INDICES TO ENSURE PROPER ALIGNMENT, ADJUSTMENT AND OPERATION.
13.	ALIGNMENT INDICES, DETENTS, RIGGING POINTS OR ALIGNMENT MARKS SHALL BE VISIBLE FOR ALIGNMENT RECHECK WITHOUT REMOVAL OF ANY COMPONENT.
14.	SYSTEMS SHALL BE DESIGNED SO THAT IT IS PHYSICALLY IMPOSSIBLE TO INSTALL COMPONENTS IN REVERSE.
15.	ALL EQUIPMENT REQUIRED TO BE LIFTED OR MOVED BY HOIST OR CRANES SHALL HAVE LIFTING EYES OR SIMILAR PROVISIONS FOR POSITIVE ATTACHMENT OF SLINGS, CABLE HOOKS AND SIMILAR DEVICES.
16.	GROSS WEIGHT AND CENTER-OF-GRAVITY SHALL BE CONSPICUOUSLY IDENTIFIED ON ALL EQUIPMENT REQUIRED TO BE LIFTED OR MOVED BY HOISTS, CRANES, FORKLIFTS AND SIMILAR HANDLING EQUIPMENT.
17.	ATTACH POINTS FOR TIE-DOWNS SHALL BE CLEARLY MARKED OR LABELED ON ALL EQUIPMENT.
18.	SKID MOUNTED EQUIPMENT SHALL HAVE THE CENTER-OF-GRAVITY LOCATION AND GROSS WEIGHT CLEARLY IDENTIFIED ON EACH SIDE OF THE EQUIPMENT.
19.	SKID MOUNTED EQUIPMENT SHALL HAVE FORKLIFT INSERTS ON EACH SIDE.
20.	CASTERS ON MOBILE EQUIPMENT SHALL HAVE INDEPENDENT LOCKING DEVICES ON EACH CASTER.
21.	MOBILE EQUIPMENT SHALL HAVE SELF-CONTAINED WHEEL LOCKING DEVICES.
22.	ALL MOBILE OR PORTABLE EQUIPMENT SHALL HAVE STATIC GROUND PROVISIONS.
23.	COMPONENTS CONTAINING MERCURY SHALL NOT BE USED.
24.	CLEANLINESS LEVELS AND CONTAMINATION CONTROL REQUIREMENTS SHALL BE SPECIFIED IN THE DESIGN.

SYSTEM SAFETY CHECKLIST - PART II	
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SECTION: 1.0 GENERAL CRITERIA	
25.	CLEANLINESS LEVELS AND CONTAMINATION CONTROLS FOR ALL GROUND SUPPORT SYSTEMS OR EQUIPMENT WHICH EITHER DIRECTLY INTERFACE WITH, OR MAY BE REQUIRED FOR USE WITHIN FLIGHT HARDWARE SHALL HAVE REQUIREMENTS AT LEAST EQUAL TO THOSE OF THE FLIGHT SYSTEM, EXPERIMENT OR OTHER PAYLOAD HARDWARE THAT THEY ARE REQUIRED TO SUPPORT.
26.	CLEANING AGENTS AND PROCESSES THAT ARE COMPATIBLE WITH THE SYSTEM (E.G., COMPONENT MATERIALS, METAL SURFACES, COATINGS AND COMMODITIES USED WITHIN THE SYSTEM) SHALL BE SPECIFIED IN THE DESIGN.
27.	ALL CONNECTORS (E.G., ELECTRICAL, HYDRAULIC, PNEUMATIC) SHALL HAVE TETHERED CAPS, PLUGS OR COVERS TO PROTECT AGAINST CONTAMINATION OR DAMAGE WHEN UNMATED.
28.	NONFLAMMABLE PROTECTIVE COVERS (INCLUDING GRID FLOOR COVERINGS) SHALL BE PROVIDED FOR THE PROTECTION OF FLIGHT HARDWARE AND PERSONNEL AGAINST FALLING OBJECTS WHILE WORKING ON, OR ADJACENT TO, OR WITHIN THE FLIGHT MODULES WHEN MODULES ARE IN THE VERTICAL OR HORIZONTAL POSITION.
29.	GSE USED WITHIN THE SPACECRAFT SHALL NOT INCLUDE RADIOACTIVE MATERIAL.
30.	RADIOACTIVE MATERIAL SHALL NOT BE USED FOR ILLUMINATING PURPOSES WITHOUT POSITIVE MECHANICAL PROTECTION AGAINST ABRASION OR FLAKING UNDER ALL POTENTIAL CONDITIONS OF USE.
31.	RADIOACTIVE MATERIALS SHALL NOT BE USED FOR ANY PURPOSE UNLESS IT CAN BE PROVEN THAT A NON-RADIOACTIVE SUBSTITUTE MATERIAL CANNOT BE USED.
32.	RADIOACTIVE MATERIAL EMBODIED OR SUSPENDED BY CERAMIC MATERIAL, PAINT OR SIMILAR COATINGS SHALL NOT RELEASE RADIOACTIVE MATERIAL AT ALL INTERNAL OR EXTERNAL ENVIRONMENTAL EXTREMES ANTICIPATED DURING GROUND OPERATIONS.
33.	ALL EQUIPMENT, INCLUDING SHIPPING CONTAINERS AND VANS, SHALL HAVE WARNING PLACARDS TO IDENTIFY HAZARDOUS COMMODITIES AND RESTRICTIONS SUCH AS "NO SMOKING", "EXPLOSIVES", ETC.
34.	WARNING PLACARDS, SAFETY TAPE, COLOR CODED LABELS AND SIMILAR HAZARD IDENTIFICATION MATERIAL SHALL BE PLACED IN A CLEARLY VISIBLE LOCATION.

SYSTEM SAFETY CHECKLIST - PART II	
GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN	
SECTION: 1.0 GENERAL CRITERIA	
35.	EQUIPMENT DESIGN SHALL PRECLUDE THE GENERATION OF SOUND PRESSURE LEVELS ABOVE 90 db.
36.	ALL TEMPERATURE GAGES, PRESSURE GAGES, ELECTRICAL METERS AND SIMILAR READOUT DEVICES SHALL BE COLOR BANDED TO INDICATE SYSTEM OPERATING, MARGINAL AND HAZARDOUS RANGE LIMITS.
37.	ALL TEMPERATURE GAGES, PRESSURE GAGES, ELECTRICAL METERS AND SIMILAR READOUT DEVICES SHALL INDICATE NORMAL SYSTEM OPERATING RANGE WITHIN THE CENTER 50 PERCENT OF THE TOTAL RANGE OF THE READOUT DEVICE.
38.	ALL EQUIPMENT REQUIRING ADJUSTMENT DURING OPERATION SHALL HAVE EXTERNAL ADJUSTMENT PROVISIONS.
39.	ALL EQUIPMENT SHALL AUTOMATICALLY REVERT TO A SAFE CONFIGURATION WHEN AN INPUT POWER LOSS OCCURS.
40.	ALL OVENS, OR SIMILAR ENVIRONMENTAL CHAMBERS INCORPORATING HEATING ELEMENTS SHALL HAVE REDUNDANT AUTOMATIC HEATER SHUT-OFF DEVICES (INDEPENDENT OF PRIMARY TEMPERATURE CONTROLLING DEVICES) THAT REQUIRE MANUAL RESET.
41.	DRY AIR ONLY SHALL BE USED FOR GAS PURGES, TO PRECLUDE THE RISK OF ANOXIA ASSOCIATED WITH THE USE OF INERT GASES.

SYSTEM SAFETY CHECKLIST - PART II

GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN

SECTION: 2.0 ELECTRICAL AND ELECTRONIC

2.1 GENERAL

1. GUIDE PINS OR SLIDES SHALL BE LOCATED ON ALL PANEL, DRAWER AND CHASSIS SUBASSEMBLIES FOR ALIGNMENT DURING INSTALLATION AND TO PREVENT CONTACT WITH EXPOSED TERMINALS TO THE EQUIPMENT DURING INSTALLATION AND REMOVAL.

2. ALL ELECTRICAL AND ELECTRONIC EQUIPMENT SHALL HAVE AN EXTERNAL GROUNDING TERMINAL FOR CONNECTION TO FACILITY GROUND.

3. ALL CONTROL SHAFTS, KNOBS, HANDLES OR LEVERS SHALL BE GROUNDED, INSULATED OR MADE OF NONCONDUCTIVE MATERIAL IN ORDER TO PRECLUDE PERSONNEL SHOCK OR BURN.

4. ALL RACKS, CHASSIS AND COMPARTMENTS WHICH CONTAIN EXPOSED TERMINALS AND SIMILAR COMPONENTS SHALL BE CLEARLY MARKED OR PLACARDED TO INDICATE THE HIGHEST OPERATING VOLTAGE POTENTIAL PRESENT.

5. INSULATED GUIDES SHALL BE PROVIDED WHEREVER AN ADJUSTMENT TOOL COULD CONTACT ANY ADJACENT CIRCUIT COMPONENT HAVING A VOLTAGE POTENTIAL.

6. EQUIPMENT SHALL BE PROVIDED WITH A SINGLE MAIN POWER ON-OFF SWITCH WHICH WILL REMOVE ALL POWER (OTHER THAN INPUT POWER TO THE MAIN SWITCH) FROM THE EQUIPMENT WHEN THE SWITCH IS PLACED IN THE OFF POSITION.

7. ALL EXTERNAL PARTS OF RF EQUIPMENT, EXCLUDING THE DRIVEN ELEMENTS OF THE ANTENNA AND TRANSMISSION LINES SHALL BE AT GROUND POTENTIAL AT ALL TIMES.

8. RF EQUIPMENT SHALL BE SHIELDED TO PREVENT PERSONNEL EXPOSURE TO RF LEVELS GREATER THAN 10 mw/cm^2 EXCEPT IN FRONT OF THE ANTENNA.

9. CATHODE RAY TUBES SHALL BE COVERED IN FRONT WITH A SAFETY SHIELD TO PROTECT PERSONNEL FROM TUBE IMPLOSION.

10. CONFORMAL COATINGS WHICH MAY OVERSTRESS COMPONENTS SUCH AS GLASS DIODES SHALL NOT BE USED.

SYSTEM SAFETY CHECKLIST - PART II	
GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN	
SECTION: 2.0 ELECTRICAL AND ELECTRONIC	
	2.1 <u>GENERAL</u> (Cont.)
11.	ALL ELECTRICAL CONNECTORS AND CABLE INSTALLATIONS SHALL BE DESIGNED WITH SUFFICIENT FLEXIBILITY, LENGTH, AND ACCESSIBILITY TO PERMIT DISCONNECTION AND RECONNECTION WITHOUT DAMAGE TO WIRING OR CONNNECTORS.
12.	ALL CONNECTORS, CIRCUIT BOARDS, TERMINAL BOARDS, SWITCHES, RELAYS AND SIMILAR COMPONENTS IN EQUIPMENT WHICH MAY BE USED IN AN UNCONTROLLED ENVIRONMENT SHALL BE POTTED, SEALED, OR SIMILARLY PROTECTED AGAINST LIQUID LEAKAGE OR CONDENSATION.
13.	ELECTRICAL AND ELECTRONIC EQUIPMENT OR COMPONENTS WHICH HAVE NOT BEEN MOISTURE PROOFED, SHALL NOT BE LOCATED BELOW LIQUID LINES OR COLD SURFACES SUBJECT TO CONDENSATION.
14.	POLYURETHANE CONFORMAL COATINGS CONTAINING SOLVENTS WHICH DISSOLVE POLYSTYRENE SHALL NOT BE USED ON CIRCUIT BOARDS CONTAINING POLYSTYRENE COMPONENTS.
15.	SOLID WIRE (SINGLE STRAND) SHALL NOT BE USED IN LOCATIONS WHERE IT MAY BE SUBJECTED TO FLEXING.
16.	GASKETS, SEALS AND SIMILAR COMPONENTS CONTAINING SULPHUR SHALL NOT BE USED WITHIN OR IN CONTACT WITH ELECTRICAL COMPONENTS CONTAINING COPPER, ZINC, NICKEL, OR SILVER.
17.	ULTRASONIC VIBRATION SHALL NOT BE SPECIFIED AS A METHOD FOR CLEANING ELECTRONIC ASSEMBLIES.
	2.2 <u>CABLING AND WIRING</u>
18.	ALL ELECTRICAL CABLES AND WIRING SHALL BE CLAMPED AND SUPPORTED TO REMAIN CLEAR OF SHARP EDGES AND MOVING PARTS.
19.	ALL ELECTRICAL AND ELECTRONIC WIRING SHALL BE LOCATED AND CLAMPED TO ELIMINATE ANY POSSIBILITY OF CONTACT WITH LIQUID LINES.
20.	ALL ELECTRICAL CABLES AND WIRING SHALL BE CLAMPED AND SUPPORTED TO ELIMINATE MECHANICAL STRESS ON WIRES, TERMINATIONS AND CONNECTORS.

SYSTEM SAFETY CHECKLIST - PART II	
GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN	
SECTION: 2.0 ELECTRICAL AND ELECTRONIC	
	2.2 <u>CABLING AND WIRING</u> (Cont.)
21.	ALL ELECTRICAL CABLES AND WIRES SHALL BE MARKED TO CLEARLY INDICATE THE CORRECT MATING CONNECTION OR TERMINATION POINT TO PRECLUDE PHASE REVERSAL OR CROSS-CONNECTION.
22.	ALL ELECTRICAL POWER CABLES SUPPLIED FOR USE WITH GSE SHALL BE HEAVY DUTY TYPE WITH POSITIVE LOCKING DEVICES TO PREVENT INADVERTENT DISCONNECTION.
23.	ALL POWER CABLES SHALL HAVE AN INDEPENDENT NONCURRENT CARRYING GROUND CONDUCTOR.
24.	POWER AND SIGNAL WIRING SHALL NOT BE ROUTED THROUGH THE SAME CABLE BUNDLE OR WIRING HARNESS TO INSURE THAT VOLTAGE WILL NOT BE INDUCED INTO SIGNAL CIRCUITS.
25.	SHIELDS USED TO PROTECT AGAINST INDUCED VOLTAGE FOR FREQUENCIES UP TO 50 KHz SHALL BE CONTINUOUS THROUGH ALL CONNECTIONS AND GROUNDED AT ONLY ONE END.
26.	SHIELDS USED TO PROTECT AGAINST INDUCED VOLTAGE FOR FREQUENCIES ABOVE 50 KHz SHALL BE CONTINUOUS THROUGH ALL CONNECTIONS AND GROUNDED AT BOTH ENDS.
27.	WIRES AND CABLES SHALL NOT BE IDENTIFIED OR MARKED BY HOT STAMPING ON THE INSULATION.
	2.3 <u>CONNECTORS</u>
28.	ALL MATING PLUGS AND RECEPTACLES SHALL BE MARKED OR CODED TO CLEARLY INDICATE THE CORRECT MATING CONNECTION.
29.	ALL ADJACENT CONNECTORS SHALL BE SHAPED OR RESTRAINED SO THAT IT IS PHYSICALLY IMPOSSIBLE TO MISMATE.
30.	CONNECTORS WITH UNKEYED SYMMETRICAL PIN ARRANGEMENTS SHALL NOT BE USED.
31.	ONLY FEMALE CONNECTORS SHALL BE USED AS ACCESS TO SOURCES OF POWER.

SYSTEM SAFETY CHECKLIST - PART II	
GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN	
SECTION: 2.0 ELECTRICAL AND ELECTRONIC	
	2.3 CONNECTORS (Cont.)
32.	ALL GROUND SUPPORT EQUIPMENT CABLES WHICH CONNECT TO PROTOTYPE OR FLIGHT HARDWARE SHALL HAVE CONNECTORS WHICH ARE INDIVIDUALLY SHAPED OR RESTRAINED SO THAT IT IS PHYSICALLY IMPOSSIBLE TO MISMATE OR CROSS-CONNECT EITHER END OF THE CABLE.
33.	POWER CIRCUITS AND SIGNAL CIRCUITS SHALL NOT BE ROUTED THROUGH THE SAME CONNECTOR IN ORDER TO MINIMIZE THE INTRODUCTION OF VOLTAGE TRANSIENTS INTO SIGNAL WIRING.
34.	ALL POWER RECEPTACLES AND CONNECTORS LOCATED IN OR USED WITH EQUIPMENT CONTAINING FLAMMABLE VAPOR OR LIQUIDS SHALL BE EXPLOSION PROOF.
	2.4 BATTERIES
35.	ALL WET CELL BATTERIES SHALL HAVE POSITIVE VENTING CAPABILITY FOR EACH CELL.
36.	ALL HERMETICALLY SEALED BATTERIES SHALL HAVE BLOWOUT PLUGS FOR PRESSURE RELIEF.
37.	ALL BATTERY VENT, BLOWOUT PLUGS AND RELIEF OUTLETS SHALL BE DESIGNED SO THAT BATTERY ELECTROLYTE CANNOT BE EJECTED FROM THE BATTERY.
38.	ALL BATTERY VENTS, BLOWOUT PLUGS AND RELIEF OUTLETS SHALL BE LOCATED TO PRECLUDE DAMAGE TO ADJACENT EQUIPMENT OR INJURY TO OPERATING PERSONNEL.
39.	BATTERIES SHALL HAVE DECALS OR MARKERS WHICH INDICATE THE TYPE OF ELECTROLYTE AND SPECIAL SAFETY PRECAUTIONS.
	2.5 CONTROL COMPONENTS
40.	ALL ELECTRICAL AND ELECTRONIC COMPONENTS LOCATED WITHIN CONSOLES, PANELS OR SIMILAR EQUIPMENT ENCLOSURES CONTAINING OR EXPOSED TO FLAMMABLE VAPORS OR LIQUIDS SHALL BE EXPLOSION PROOF.
41.	ALL SWITCHES SHALL BE CLEARLY MARKED OR LABELED TO INDICATE THE SYSTEM FUNCTION FOR EACH SWITCH POSITION.

2.5 CONTROL COMPONENTS

42. ALL CIRCUIT BREAKERS OR SWITCHES USED TO CONTROL EQUIPMENT OR CIRCUITRY INTENDED FOR EMERGENCY PURPOSES SHALL HAVE POSITIVE PROTECTION AGAINST INADVERTENT OPERATION.

43. ALL CIRCUIT BREAKERS OR SWITCHES USED TO CONTROL THE ARMING OF PYROTECHNIC DEVICES SHALL HAVE POSITIVE PROTECTION AGAINST INADVERTENT OPERATION.

44. SELF-LATCHING FUNCTION SWITCHES SUCH AS PUSH-BUTTON SWITCH-INDICATORS WHICH MAY BE OPERATED WITHOUT INDICATING THE SWITCH POSITION DURING A POWER OFF PHASE SHALL NOT BE USED.

45. ALL CIRCUITS (INCLUDING LATCHING RELAY CIRCUITS) SHALL BE PROTECTED AGAINST INADVERTENT OPERATION DUE TO VOLTAGE TRANSIENTS.

46. TERMINAL LUGS AND INSULATED WASHERS USED WITH STUD-MOUNTED DIODES SHALL HAVE SUFFICIENT MATCHING SURFACE AREA TO INSURE THAT THE TERMINAL LUG WILL REMAIN INSULATED FROM THE MOUNTING STRUCTURE.

47. POSITIVE MECHANICAL MEANS SHALL BE SPECIFIED IN THE DESIGN TO INSURE ADEQUATE CONTACT PRESSURE IS MAINTAINED AT STUD-MOUNTED DIODE CONNECTIONS.

48. POSITIVE PROVISIONS SHALL BE SPECIFIED IN THE DESIGN TO PRECLUDE SEEPAGE OF CONFORMAL COATINGS INTO ELECTRICAL INTERFACES IN STUD-MOUNTED DIODE INSTALLATIONS.

2.6 CONTROL FUNCTIONS

49. REDUNDANT CONTROL CIRCUIT COMPONENTS SHALL BE INDEPENDENT OF THOSE COMPONENTS USED IN THE PRIMARY CONTROL CIRCUIT.

50. PRIMARY AND REDUNDANT CONTROL CIRCUIT WIRING SHALL NOT BE ROUTED THROUGH THE SAME CABLE OR CONNECTOR.

51. REDUNDANT CONTROL CIRCUITS SHALL INCLUDE A SELF-TEST OR CHECK-OUT CAPABILITY.

SYSTEM SAFETY CHECKLIST - PART II	
GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN	
SECTION: 2.0 ELECTRICAL AND ELECTRONIC	
	2.6 <u>CONTROL FUNCTIONS</u> (Cont.)
52.	ALL CURRENT CARRYING CONDUCTORS (POWER, CONTROL, SIGNAL AND RETURNS) CONNECTED TO FLIGHT HARDWARE SHALL HAVE CURRENT OVERLOAD DEVICES FOR PROTECTION OF THE FLIGHT HARDWARE.
53.	NEGATIVE CONTROL OR SWITCHING IN THE POWER RETURN LEADS OF A COMPONENT SHALL NOT BE USED, UNLESS THE POSITIVE LEAD IS SWITCHED SIMULTANEOUSLY.
54.	SELF-TEST CIRCUITS SHALL INDICATE THE ACTUAL SYSTEM RESPONSE, RATHER THAN INDICATE ONLY THE INITIATION OF A COMMAND OR TEST SIGNAL.
55.	ALL SYSTEM INDICATORS USED TO MONITOR SYSTEM STATUS SHALL INDICATE THE ACTUAL SYSTEM RESPONSE RATHER THAN INDICATE ONLY THE INITIATION OF A COMMAND OR APPLICATION OF POWER.
56.	LOSS OF CONTROL CIRCUIT POWER SHALL NOT RESULT IN POWER LOSS TO DEVICES WHICH INDICATE RESPONSE OR CONFIGURATION STATUS OF CONTROLLED COMPONENTS (I.E., POWER FOR INDICATORS OR INSTRUMENTATION USED TO MONITOR VALVE POSITION, PRESSURE LEVELS, ETC., SHALL BE INDEPENDENT AND ISOLATED FROM FAILURES IN CONTROL CIRCUITS FOR THOSE VALVES OR SENSORS).
	2.7 <u>OVERLOAD PROTECTION</u>
57.	ALL CIRCUIT BREAKERS LOCATED IN OR USED WITH EQUIPMENT CONTAINING FLAMMABLE VAPORS OR LIQUIDS SHALL BE EXPLOSION PROOF.
58.	CIRCUIT BREAKERS SHALL PROVIDE A VISUAL INDICATION WHEN TRIPPED.
59.	CIRCUIT BREAKERS SHALL TRIP AND PROTECT THE CIRCUIT EVEN IF THE SWITCH LEVER IS PHYSICALLY HELD IN THE "ON" POSITION.
60.	OVERLOAD PROTECTION DEVICES SHALL BE INSTALLED IN EACH UNGROUNDED CONDUCTOR IN THREE (3) PHASE POWER SYSTEMS AND SHALL BE DESIGNED SO THAT ALL THREE (3) DEVICES TRIP SIMULTANEOUSLY.
61.	ALL ADJUSTABLE TYPE CIRCUIT BREAKER SETTINGS SHALL BE SPECIFIED IN THE DESIGN.

SYSTEM SAFETY CHECKLIST - PART II	
GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN	
SECTION: 2.0 ELECTRICAL AND ELECTRONIC	
	2.7 <u>OVERLOAD PROTECTION</u> (Cont.)
62.	ALL CIRCUIT BREAKERS SHALL BE SIZED (OR SET) TO PROTECT THE SMALLEST WIRE WITHIN A CIRCUIT, INCLUDING ALL BRANCHES, WHICH DO NOT HAVE INDEPENDENT CIRCUIT PROTECTION.
63.	OVERLOAD PROTECTION DEVICES SHALL BE SIZED (OR SET) SO THAT THE COMBINATION OF CURRENT AND TIME AT WHICH THE DEVICE OPERATES WILL NOT CAUSE THE OPERATION OF UPSTREAM PROTECTIVE DEVICES.
	2.8 <u>HAZARD DETECTION AND WARNING</u>
64.	HAZARD DETECTION AND WARNING SYSTEMS SHALL BE POWERED FROM AN INDEPENDENT EQUIPMENT OR FACILITY POWER BUS.
65.	POWER LOSS TO HAZARD DETECTION SYSTEMS SHALL RESULT IN THE GENERATION OF AN ALARM.
66.	POWER-OFF ALARMS SHALL BE ENERGIZED BY AN INDEPENDENT POWER SOURCE.
67.	HAZARD DETECTION AND WARNING CIRCUITRY SHALL INCLUDE A MASTER ALARM RESET CAPABILITY TO PERMIT CONTINUED MONITORING FOR ADDITIONAL OUT-OF-TOLERANCE CONDITIONS WHICH MAY OCCUR AFTER AN INITIAL ALARM.
68.	HAZARD DETECTION AND WARNING SYSTEMS SHALL INITIATE AN AUDIBLE ALARM AND VISUAL INDICATION FOR ANY OUT-OF-TOLERANCE CONDITION.
69.	HAZARD DETECTION AND WARNING SYSTEMS SHALL INCLUDE A SELF-TEST OR CHECKOUT CAPABILITY.

SYSTEM SAFETY CHECKLIST - PART II

GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN

SECTION: 3.0 LIQUIDS AND GASES

3.1 GENERAL

1. SYSTEMS SHALL BE DESIGNED TO MINIMIZE THE EFFECTS OF SHOCK WAVES OR PRESSURE SURGES GENERATED BY SUDDEN CHANGES IN FLOW.

2. ALL PRESSURE REGULATOR, FLOW CONTROL AND RELIEF DEVICE SETTINGS SHALL BE SPECIFIED IN THE DESIGN.

3. ALL LIQUID AND GAS SYSTEMS SHALL BE DESIGNED TO PERMIT LEAK TESTING AT MAXIMUM DESIGN OPERATING PRESSURE AFTER INSTALLATION.

4. PROOF TEST REQUIREMENTS FOR ALL COMPONENTS SHALL BE A MINIMUM OF 1.5 TIMES THE MAXIMUM PRESSURE AT WHICH THEY WILL BE REQUIRED TO OPERATE WITHIN THE SYSTEM.

5. ISOLATION VALVES SHALL BE PROVIDED FOR INDEPENDENTLY CONTROLLING LIQUIDS, GASES AND VACUUM BEING SUPPLIED TO EACH FLIGHT SUBSYSTEM, EXPERIMENT OR OTHER PAYLOAD DURING CHECKOUT OPERATIONS.

6. ALL SEALED PANELS, CONSOLES OR SIMILAR ENCLOSURES WHICH CONTAIN LIQUID OR GAS SYSTEM COMPONENTS SHALL HAVE AUTOMATIC (FAIL-SAFE) PRESSURE RELIEF DEVICES.

7. LINES SHALL BE PROVIDED FOR VENTING FLAMMABLE, TOXIC, ASPHYXIATING OR NOXIOUS WASTE TO THE EXTERIOR OF THE CHECKOUT ENVIRONMENT.

8. ALL VENT LINES AND RELIEF PORTS SHALL BE LOCATED SO ESCAPING LIQUID OR GASES WILL NOT BE HAZARDOUS TO PERSONNEL OR EQUIPMENT.

9. LIQUID LINE INSULATION SHALL BE MADE OF NON-ABSORBENT MATERIALS.

10. ALL PIPING AND COMPONENTS WITHIN EACH SYSTEM SHALL BE ELECTRICALLY CONTINUOUS OR BONDED ACROSS EACH CONNECTION (ALL PIPING SEGMENTS) AND SHALL BE GROUNDED TO REDUCE STATIC ELECTRICAL POTENTIAL.

11. ALL MATERIALS INCLUDING SEALS, GASKETS AND LUBRICANTS SHALL BE COMPATIBLE WITH THE SYSTEM COMMODITY AND SHALL MEET THE CLEANLINESS LEVELS AND CONTAMINATION CONTROL REQUIREMENTS OF THE INTERFACING FLIGHT SYSTEM, EXPERIMENT OR OTHER PAYLOAD HARDWARE FOR WHICH THE MOST STRINGENT REQUIREMENTS HAVE BEEN ESTABLISHED.

12. OXYGEN SYSTEMS OPERATING ABOVE 3000 PSI SHALL BE DESIGNED TO BE OPERATED REMOTELY.

SYSTEM SAFETY CHECKLIST - PART II

GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN

SECTION: 3.0 LIQUIDS AND GASES

3.1 GENERAL (Cont.)

13. TITANIUM OR ITS ALLOYS SHALL NOT BE USED IN OXYGEN SYSTEMS.

14. TITANIUM OR ITS ALLOYS SHALL NOT BE USED WITH METHANOL.

15. DISSIMILAR METALS SHALL NOT BE USED IN COOLANT SYSTEM IF A GALVANIC CIRCUIT IS THEREBY ESTABLISHED WITH THE COOLANT ACTING AS ELECTROLYTE.

16. ALL GROUND SUPPORT EQUIPMENT SUPPLYING LIQUIDS OR GASES TO FLIGHT SYSTEMS SHALL HAVE A FILTER INSTALLED AS THE LAST COMPONENT IN EACH SUPPLY LINE.

17. FILTER HOUSINGS THAT ARE REQUIRED TO BE REMOVED FROM THE SYSTEM FOR ELEMENT REPLACEMENT SHALL NOT BE USED.

18. FILTERS SHALL BE INSTALLED IN PUMP AND COMPRESSOR INLET LINES WITH PRESSURE INDICATORS ON EACH SIDE OF THE FILTER OR A DIFFERENTIAL PRESSURE GAGE.

19. PUMPS AND COMPRESSORS SHALL BE PROTECTED AGAINST DAMAGE BY USE OF PROTECTIVE DEVICES SUCH AS THERMAL OVERLOADS, BY-PASS RELIEF DEVICES, VIBRATION SENSITIVE CUT-OUT SWITCHES, PUMP SUCTION PRESSURE INTERLOCKS AND OVERSPEED CONTROLS.

20. PUMP AND COMPRESSOR ELECTRICAL CONNECTORS SHALL BE CLEARLY IDENTIFIED TO PREVENT PHASE REVERSAL.

21. ELECTRICAL OR ELECTRONIC COMPONENTS SUCH AS MOTORS, SENSORS, OR SWITCHES USED IN LIQUID OR GAS SYSTEMS SHALL BE INSTALLED WITH THE COMPONENT HOUSING EXTERNAL TO THE VESSEL OR PIPING CONTAINING THE LIQUID OR GAS.

3.2 LINES

22. ALL LINES AND FLEXIBLE HOSES SHALL HAVE A MINIMUM DESIGN BURST PRESSURE OF 4.0 TIMES THE MAXIMUM DESIGN OPERATING PRESSURE AT WHICH THEY WILL BE REQUIRED TO OPERATE WITHIN THE SYSTEM.

23. ALL LINES USED IN FIXED APPLICATIONS SHALL BE FIRMLY SUPPORTED TO PROTECT AGAINST DAMAGE FROM MECHANICAL STRESS AND VIBRATION.

24. ALL LINES USED IN FIXED APPLICATIONS SHALL BE INDEPENDENTLY CLAMPED.

SYSTEM SAFETY CHECKLIST - PART II	
GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN	
SECTION: 3.0 LIQUIDS AND GASES	
	3.2 LINES (Cont.)
25.	ALL LINES (FIXED OR FLEXIBLE) SHALL BE CLAMPED AND SUPPORTED AS CLOSE AS POSSIBLE TO LINE END FITTINGS AND CONNECTORS IN ORDER TO REDUCE MECHANICAL STRESS (INCLUDING SIDE LOADS) AND VIBRATION AT THE CONNECTION POINT.
26.	ALL RIGID LINES USED IN FIXED APPLICATIONS SHALL BE SUPPORTED AS CLOSE AS POSSIBLE AT EACH BEND IN THE LINE.
27.	ALL LINES INCLUDING FLEXIBLE HOSES USED IN FIXED APPLICATIONS SHALL BE CLEARLY MARKED TO INDICATE SYSTEM FUNCTION, CONTENT, MAXIMUM OPERATING PRESSURE AND DIRECTION OF FLOW.
28.	FLEXIBLE HOSE MATERIALS SHALL BE SELECTED FOR COMPATIBILITY WITH THE SERVICE COMMODITY.
29.	FLEXIBLE HOSES USED IN FIXED APPLICATIONS SHALL BE PROTECTED AGAINST ABRASION, CHAFING AND EXTREME TEMPERATURE CONDITIONS.
30.	FLEXIBLE HOSES SHALL HAVE A MINIMUM SLACK ALLOWANCE OF 5 PERCENT OF THE TOTAL HOSE LENGTH FOR ALL FIXED APPLICATIONS.
31.	ALL FLEXIBLE HOSES USED IN FIXED APPLICATIONS SHALL BE CLAMPED AND SUPPORTED TO REMAIN CLEAR OF SHARP EDGES AND MOVING PARTS.
32.	FLEXIBLE HOSES FOR USE IN TEMPORARY INSTALLATIONS SHALL HAVE PROVISIONS FOR ATTACHING HOSE RESTRAINTS ACROSS EACH CONNECTION.
33.	FLEXIBLE HOSES USED IN FIXED (PERMANENT) INSTALLATIONS SHALL INCORPORATE HOSE CONTAINMENT DEVICES TO RESTRAIN THE HOSE IN CASE OF RUPTURE.
34.	FLEXIBLE HOSE RESTRAINTS SHALL BE AT LEAST 50 PERCENT STRONGER THAN THE MAXIMUM CALCULATED IMPACT (FORCE) ON THE RESTRAINT DUE TO AN OPEN LINE (UNDER MAXIMUM OPERATING PRESSURE) MOVING THROUGH THE DISTANCE OF FLEXURE OF THE RESTRAINT.
35.	FLEXIBLE HOSES FOR USE IN TEMPORARY INSTALLATIONS SHALL HAVE ATTACHED TAGS OR PLACARDS TO INDICATE PROOF TEST PRESSURE, DATE OF LAST PROOF TEST AND REQUIRED RETEST INTERVALS.
36.	FLEXIBLE HOSES FOR USE IN TEMPORARY INSTALLATIONS SHALL BE CLEARLY MARKED TO INDICATE THE SYSTEM FUNCTION, CONTENT, AND MAXIMUM OPERATING PRESSURE.

SYSTEM SAFETY CHECKLIST - PART II

GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN

SECTION: 3.0 LIQUIDS AND GASES

3.2 LINES (Cont.)

37. ALL FLEXIBLE HOSES SHALL HAVE ATTACHED TAGS, PLACARDS, OR SIMILAR IDENTIFICATION PROVISIONS TO CLEARLY INDICATE THE CORRECT MATING CONNECTION.

3.3 FITTINGS, FLANGES AND CONNECTORS

38. ADJACENT OR INCOMPATIBLE SYSTEM CONNECTORS OR FLANGED CONNECTIONS SHALL BE KEYED OR SIZED SO IT IS PHYSICALLY IMPOSSIBLE TO CONNECT AN INCOMPATIBLE PRESSURE UNIT, COMMODITY OR PRESSURE LEVEL.

39. ALL SYSTEM FITTINGS SHALL HAVE A MINIMUM DESIGN BURST PRESSURE OF 4.0 TIMES THE MAXIMUM DESIGN OPERATING PRESSURE AT WHICH THEY WILL BE REQUIRED TO OPERATE WITHIN THE SYSTEM.

40. ALL FLANGED CONNECTIONS FOR FLEXIBLE HOSES TO BE USED IN TEMPORARY INSTALLATIONS SHALL BE PROVIDED WITH BLIND FLANGES (END PLATES) TO PROTECT AGAINST CONTAMINATION OR DAMAGE WHEN NOT IN USE.

41. ALL METALLIC FITTINGS, SLEEVES AND CONNECTORS SHALL BE RESISTANT TO STRESS CORROSION.

3.4 PRESSURE AND LIQUID VESSELS

42. ALL PRESSURE VESSELS AND RESERVOIRS SHALL HAVE A MINIMUM DESIGN BURST PRESSURE OF 4.0 TIMES THE MAXIMUM DESIGN OPERATING PRESSURE AT WHICH THEY WILL BE REQUIRED TO OPERATE WITHIN THE SYSTEM.

43. INITIAL OPENINGS OF ALL PRESSURE VESSEL PRIMARY RELIEF DEVICES SHALL BE NO HIGHER THAN 110 PERCENT OF THE MAXIMUM DESIGN OPERATING PRESSURE OF THE VESSEL.

44. ALL PRESSURE VESSELS AND RESERVOIRS SHALL HAVE AN ISOLATION SHUTOFF VALVE LOCATED AS THE FIRST COMPONENT DOWNSTREAM OF THE VESSEL AND AS CLOSE AS POSSIBLE TO THE VESSEL.

45. ALL PRESSURE VESSELS SHALL HAVE A VALVE TO PERMIT CONTROLLED REDUCTION OF PRESSURE AS DESIRED.

46. ALL PRESSURE VESSELS SHALL HAVE A POSITIVE PRESSURE INDICATING DEVICE.

SYSTEM SAFETY CHECKLIST - PART II

GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN

SECTION: 3.0 LIQUIDS AND GASES

3.4 PRESSURE AND LIQUID VESSELS (Cont.)

47. ALL LIQUID VESSELS SHALL HAVE A LIQUID QUANTITY INDICATING DEVICE.

48. ALL LIQUID VESSELS SHALL HAVE A DRAIN VALVE LOCATED AT THE LOWEST POINT SO THAT ALL LIQUID MAY BE DRAINED FROM THE VESSEL.

49. ALL PRESSURE VESSELS SHALL BE CLEARLY MARKED OR LABELED TO IDENTIFY CONTENT AND OPERATING PRESSURE.

50. ALL LIQUID VESSELS SHALL BE CLEARLY MARKED OR LABELED TO IDENTIFY COMMODITY AND CAPACITY.

51. PORTABLE PRESSURIZATION OR PURGE SUPPLIES SHALL INCLUDE RACKS, HOLDERS, OR CARTS TO SECURE AND PROTECT THE PRESSURE BOTTLES, HAND VALVES AND REGULATOR ASSEMBLIES AGAINST DAMAGE.

52. ALL CRYOGENIC LIQUID VESSELS SHALL BE THERMALLY INSULATED OR VACUUM JACKETED.

3.5 PRESSURE RELIEF

53. A PRESSURE RELIEF DEVICE SHALL BE LOCATED DOWNSTREAM OF ANY PRESSURE REGULATING DEVICE WHERE INPUT PRESSURE TO THE REGULATING DEVICE CAN EXCEED THE PROOF PRESSURE OF THE DOWNSTREAM SYSTEM (DOWNSTREAM SYSTEM INCLUDES COMPONENTS OR FLIGHT HARDWARE UNDER ALL TEST OR OTHER OPERATING CONDITIONS).

54. THE INITIAL OPENING OF SYSTEM RELIEF VALVES SHALL BE NO HIGHER THAN 110 PERCENT OF THE UPSTREAM REGULATOR SETTING.

55. PRESSURE RELIEF VALVES AND RELIEF VENT LINES SHALL BE SIZED TO EXCEED THE MAXIMUM FLOW CAPACITY OF THE UPSTREAM PRESSURE REGULATING DEVICE.

56. REDUNDANT POSITIVE RELIEF CAPABILITY SHALL BE PROVIDED IN ALL GSE WHENEVER A GROUND SYSTEM PRIMARY RELIEF DEVICE MALFUNCTION COULD ALLOW FLIGHT SYSTEM PROOF PRESSURE LEVELS TO BE EXCEEDED.

57. INITIAL OPENING OF REDUNDANT RELIEF DEVICES SHALL BE NO HIGHER THAN 125 PERCENT OF THE UPSTREAM REGULATOR SETTING OR NO HIGHER THAN PROOF PRESSURE LEVEL OF THE DOWNSTREAM SYSTEM OR VESSEL UNDER TEST, WHICHEVER IS THE LESSER.

SYSTEM SAFETY CHECKLIST - PART II

GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN

SECTION: 3.0 LIQUIDS AND GASES

3.5 PRESSURE RELIEF (Cont.)

58. BREDUNDANT RELIEF DEVICES SHALL BE LOCATED IN THE SYSTEM SO AS NOT TO RENDER THE PRIMARY RELIEF DEVICE INEFFECTIVE (E.G., SERIES INSTALLATION OF RELIEF VALVES).

59. WHERE RELIEF VALVES AND BURST DISCS ARE USED IN COMBINATION, RELIEF VALVES SHALL BE LOCATED UPSTREAM OF BURST DISCS.

60. A RELIEF DEVICE SHALL BE LOCATED BETWEEN ANY RESTRICTOR ORIFICE INSTALLATION AND THE UPSTREAM PRESSURE REGULATING DEVICE, IF FAILURE OF THE REGULATOR WOULD RESULT IN OVERPRESSURE ABOVE PROOF LEVEL.

61. ONLY NONCHATTERING RELIEF DEVICES SHALL BE USED.

62. ALL SYSTEM VENT VALVES SHALL BE DESIGNED TO FAIL OPEN.

63. ALL SYSTEM RELIEF VALVES SHALL BE DESIGNED TO FAIL OPEN.

64. ALL SYSTEM VENT VALVES SHALL BE CLEARLY MARKED TO INDICATE COMPONENT NUMBER AND SYSTEM FUNCTION.

65. ALL SYSTEM RELIEF DEVICES SHALL BE CLEARLY MARKED TO INDICATE COMPONENT NUMBER, SYSTEM FUNCTION, OPERATING PRESSURE SETTING, LATEST TEST DATE AND RETEST INTERVAL.

3.6 VALVES, REGULATORS AND CONTROL DEVICES

66. REGULATORS USED FOR STEP REGULATION SHALL OPERATE WITHIN THE CENTER 50 PERCENT OF THEIR TOTAL RANGE.

67. MANUALLY OPERATED VALVES SHALL NOT BE USED TO BY-PASS PRESSURE REGULATORS OR FLOW CONTROL DEVICES.

68. PRESSURE REGULATORS SHALL HAVE INPUT AND OUTPUT GAGES LOCATED AS CLOSE AS POSSIBLE TO THE REGULATOR.

69. ONLY NONCHATTERING REGULATORS SHALL BE USED IN OXYGEN PRESSURIZATION SYSTEMS.

70. ALL SYSTEM VALVES AND REGULATING DEVICES SHALL BE IDENTIFIED BY COMPONENT NUMBER, SYSTEM FUNCTION AND DIRECTION OF OPERATION.

SYSTEM SAFETY CHECKLIST - PART II

GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN

SECTION: 3.0 LIQUIDS AND GASES

3.6 VALVES, REGULATORS AND CONTROL DEVICES (Cont.)

71. ALL ADJUSTABLE PRESSURE CONTROL DEVICES SHALL HAVE MARKINGS TO INDICATE THE DIRECTION OF PRESSURE INCREASE AND DECREASE ADJUSTMENT.

72. THE MAXIMUM SYSTEM OPERATING PRESSURE DELIVERED BY EACH REGULATOR SHALL NOT BE GREATER THAN 75 PERCENT OF THE MAXIMUM PRESSURE REGULATION CAPABILITY OF THE REGULATOR.

73. VENT OR BLEED VALVES SHALL BE LOCATED IN THE SYSTEM WHENEVER LIQUIDS OR PRESSURE COULD BE TRAPPED BETWEEN COMPONENTS.

74. SHUTOFF VALVES SHALL NOT BE INSTALLED IN SERIES WITH RELIEF VALVES UNLESS A BURST DISC OR OTHER POSITIVE RELIEF DEVICE IS INSTALLED IN PARALLEL.

75. ONLY SLOW OPENING AND CLOSING VALVES WITH NONROTATING POPPETS SHALL BE USED IN OXYGEN SYSTEMS.

76. CHECK VALVES SHALL BE LOCATED IN PRESSURE SYSTEMS TO MINIMIZE DOWNSTREAM PRESSURE LOSS RESULTING FROM LOSS OF SOURCE PRESSURE.

77. LOCKING PINS OR SIMILAR DEVICES SHALL BE INCLUDED IN THE DESIGN OF ALL LIQUID AND GAS SYSTEMS TO PROVIDE POSITIVE PROTECTION AGAINST INADVERTENT OPERATION OF ALL MANUAL LEVER OPERATED VALVES.

78. CHECK VALVES SHALL BE USED TO ISOLATE PARALLEL SUPPLY SYSTEMS OR PRESSURE VESSELS WHICH CAN BE USED TO SERVICE A COMMON DOWNSTREAM SYSTEM.

79. CHECK VALVES SHALL BE USED TO ISOLATE PARALLEL VENT LINES EACH OF WHICH VENTS INTO A COMMON MANIFOLD.

3.7 GAGES AND INDICATORS

80. PRESSURE GAGES SHALL BE INSTALLED IN THE SYSTEM TO PROVIDE VISUAL MONITORING CAPABILITY FOR EACH LEVEL OF SYSTEM PRESSURE.

81. ALL DIRECT PRESSURE READOUT GAGES SHALL BE EQUIPPED WITH SHATTERPROOF GLASS.

SYSTEM SAFETY CHECKLIST - PART II

GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN

SECTION: 3.0 LIQUIDS AND GASES

3.7 GAGES AND INDICATORS (Cont.)

82. ALL DIRECT PRESSURE READOUT GAGES SHALL HAVE BLOWOUT PLUGS WHICH ARE PROPERLY SIZED TO SAFELY RELIEVE THE GAGE AT MAXIMUM DESIGN OPERATING PRESSURE AND FLOW CAPACITY (BASED ON THE DIAMETER OF THE INLET TO THE GAGE) IN EVENT OF INTERNAL GAGE FAILURE.

83. ALL PANELS OR PLATES USED TO MOUNT PRESSURE GAGES SHALL INCORPORATE HOLES OF SUFFICIENT SIZE TO ELIMINATE IMPAIRMENT OF BLOW-OUT PLUG OPERATION.

84. THE INSTALLATION OF ALL DIRECT PRESSURE READOUT GAGES INCORPORATING BLOW-OUT PLUGS SHALL BE DESIGNED SO THAT THE DIRECTION OF DISCHARGE OF THE BLOW-OUT PLUG WILL NOT RESULT IN SUBSEQUENT DAMAGE TO ADJACENT EQUIPMENT OR INJURY TO PERSONNEL.

SYSTEM SAFETY CHECKLIST - PART II	
GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN	
SECTION: 4.0 HANDLING, TRANSPORTATION, STORAGE & PROTECTIVE EQUIPT.	
	4.1 <u>GENERAL</u>
1.	HANDLING AND TRANSPORTATION EQUIPMENT SHALL INCLUDE PROVISIONS FOR PROTECTING SHOCK SENSITIVE FLIGHT EQUIPMENT FROM SHOCK OR VIBRATION LOADS IN EXCESS OF FLIGHT LIMITS.
2.	HANDLING AND TRANSPORTATION EQUIPMENT SHALL INCLUDE PROVISIONS FOR PROTECTING SHOCK SENSITIVE GROUND EQUIPMENT WHICH DOES NOT HAVE SHOCK MOUNTING PROVISIONS.
3.	PROOF-LOAD DIAGRAMS SHALL BE INCORPORATED IN THE DESIGN OF ALL LIFTING AND HANDLING EQUIPMENT TO INDICATE TEST POINTS AND METHODS REQUIRED FOR PROOF TEST.
4.	LOAD TEST REQUIREMENTS SHALL BE SPECIFIED IN THE DESIGN FOR STANDS, LADDERS, HOISTS, SLINGS, AND HANDLING EQUIPMENT.
5.	TENSION AND TORQUE REQUIREMENTS SHALL BE SPECIFIED FOR TIE-DOWN DEVICES.
6.	WHEN NICOPRESS SLEEVES, CLAMPS OR SIMILAR COMPRESSION TYPE DEVICES ARE USED ON WIRE ROPE, AT LEAST TWO DEVICES SHALL BE USED TO ATTACH EACH HOOK, LINK, LOOP EYE, ETC.
7.	PROTECTIVE COVERS DESIGNED FOR THE PROTECTION OF FLIGHT AND GSE HARDWARE SHALL BE FLAME RESISTANT.
8.	SHIPPING CONTAINERS AND PROTECTIVE COVERS SHALL BE CONSPICUOUSLY MARKED TO IDENTIFY SPECIAL INSTRUCTIONS SUCH AS STEP, NO-STEP, HOISTING POINT, LIFTING POINT, CENTER OF GRAVITY, THIS SIDE UP, FOLD LINE, ETC.
9.	SHIPPING CONTAINERS AND PROTECTIVE COVERS DESIGNED FOR THE PROTECTION OF FLIGHT AND GSE HARDWARE SHALL DISSIPATE STATIC ELECTRICITY.
10.	TIEDOWNS SHALL HAVE POSITIVE LOCKING DEVICES.
	4.2 <u>TRANSPORTATION</u>
11.	TRANSPORTATION EQUIPMENT USED TO TRANSPORT EQUIPMENT SENSITIVE TO SHOCK OR ACCELERATION SHALL INCLUDE INSTRUMENTS THAT RECORD ACCELERATION ALONG THREE AXES WITH RESPECT TO TIME.

SYSTEM SAFETY CHECKLIST - PART II	
GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN	
SECTION: 4.0 HANDLING, TRANSPORTATION, STORAGE & PROTECTIVE EQUIPT.	
	4.2 <u>TRANSPORTATION</u> (Cont.)
12.	TOWED VEHICLES SHALL HAVE PERMANENTLY ATTACHED SAFETY CHAINS CAPABLE OF HOLDING THE VEHICLE IN EVENT OF TOWBAR OR HITCH FAILURE.
13.	HINGE TYPE TOWBARS SHALL HAVE A POSITIVE LOCKING DEVICE FOR STOWAGE IN THE RAISED POSITION WITH A STOP TO PREVENT CONTACT WITH THE LOAD ON THE VEHICLE.
14.	TRANSPORTING DEVICES SHALL HAVE TIEDOWN PROVISIONS FOR SECURING EQUIPMENT.
15.	BRAKING AND WHEEL LOCKING DEVICE CONTROLS ON TOWED MOBILE EQUIPMENT SHALL BE PROTECTED AGAINST INADVERTENT OPERATION.
16.	ALL TRANSPORT TRUCKS AND SUPPORT EQUIPMENT VANS SHALL BE PROVIDED WITH FIRE EXTINGUISHERS.
17.	ALL TRANSPORTATION EQUIPMENT SHALL DISPLAY A LOAD LIMIT PLACARD.
	4.3 <u>LIFTING EQUIPMENT</u>
18.	LIFTING EQUIPMENT INCLUDING INDIVIDUAL SLINGS, CABLES AND SIMILAR DEVICES SHALL EACH HAVE A METAL TAG OR PLACARD DISPLAYING THE LOAD LIMIT, PROOF LOAD, DATE OF LAST PROOF TEST AND RETEST INTERVAL.
19.	LIFTING DEVICES SHALL HAVE A POSITIVE MECHANICAL LOCKING DEVICE TO PREVENT INADVERTENT LOWERING OF THE LOAD IN THE EVENT OF LIFTING MECHANISM FAILURE.
20.	LIFTING EQUIPMENT SHALL HAVE PERMANENT MECHANICAL STOPS TO PRECLUDE EXCEEDING DESIGN LIMITATIONS SUCH AS BOOM ANGLE OR TRAVERSE LIMITS WHICH COULD OVERLOAD THE BOOM OR OVERTURN A MOBILE CRANE.
21.	ADJUSTABLE LIFTING FIXTURES OR OTHER DEVICES USED WITH LIFTING EQUIPMENT SHALL HAVE POSITIVE MECHANICAL STOPS WHICH ARE PERMANENTLY INSTALLED (E.G., RIVETED RATHER THAN FIXED BY SET SCREWS) TO PREVENT INADVERTENT DISASSEMBLY WHILE BEING ADJUSTED; THE DESIGN SHALL SPECIFY THAT INSTALLATION OF SUCH STOPS SHALL BE MANDATORY INSPECTION POINTS.

SYSTEM SAFETY CHECKLIST - PART II

GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN

SECTION: 4.0 HANDLING, TRANSPORTATION, STORAGE & PROTECTIVE EQUIPT.

4.3 LIFTING EQUIPMENT (Cont.)

22. AN AUTOMATIC BRAKING OR STOP FEATURE SHALL BE INCORPORATED ON ALL LIFTING MECHANISM CABLE DRUMS.

23. ELECTRICALLY POWERED LIFTING MECHANISMS SHALL HAVE INDEPENDENT MECHANICAL AND ELECTRICAL BRAKE SYSTEMS.

24. BRAKING SYSTEMS SHALL BE CAPABLE OF BRAKING AND SAFELY HOLDING A MINIMUM OF 150 PERCENT OF THE RATED LOAD.

25. CABLES ON LIFTING EQUIPMENT SHALL BE POSITIVELY SECURED TO THE TAKE-UP DRUM AND SHALL HAVE A MINIMUM OF FOUR FULL WRAPPINGS AROUND THE DRUM WHEN THE EQUIPMENT IS AT A MAXIMUM EXTENDED POSITION.

26. SLINGS SHALL BE DESIGNED FOR A SPECIFIC OPERATION.

27. HOOKS FOR LIFTING EQUIPMENT, INCLUDING HOOKS USED ON SLINGS AND CABLES, SHALL INCORPORATE POSITIVE SAFETY LATCHING DEVICES ACROSS THE HOOK OPENING.

28. SLING CABLES SHALL BE OF SUFFICIENT LENGTH SO THE ANGLE FORMED BY THE SLING CABLES AT THE POINT OF THE ATTACHMENT TO THE LIFTING DEVICE (E.G., CRANE CABLE HOOK) WILL NOT EXCEED 45°.

4.4 CRADLES, STANDS, AND SUPPORT DEVICES

29. CRADLES OR SUPPORT DEVICES SHALL CONFORM TO THE SHAPE, SIZE, WEIGHT, AND CONTOUR OF THE LOAD TO BE TRANSPORTED.

30. LOAD BEARING SURFACES ON CRADLE AND SUPPORT DEVICES SHALL HAVE SUFFICIENT BEARING AREA TO SUPPORT THE LOAD.

31. LOAD BEARING SURFACES ON CRADLES OR SUPPORT DEVICES SHALL HAVE PADDING TO PROTECT THE LOAD FROM DAMAGE.

32. THE EMPTY WEIGHT OF CRADLES AND SIMILAR SUPPORT DEVICES AND THEIR LOAD CAPACITY SHALL BE DISPLAYED ON THE DEVICE.

33. CRADLES AND SUPPORT DEVICES SHALL INCORPORATE PROVISIONS FOR ATTACHMENT OF TIEDOWNS (E.G., CABLES, STRAPS), FOR SECURING EQUIPMENT.

SYSTEM SAFETY CHECKLIST - PART II	
GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN	
SECTION: 4.0 HANDLING, TRANSPORTATION, STORAGE & PROTECTIVE EQUIPT.	
	4.4 CRADLES, STANDS, AND SUPPORT DEVICES (Cont.)
34.	TIEDOWN PROVISIONS SHALL BE INCLUDED FOR SECURING CRADLES OR SUPPORT DEVICES TO TRANSPORTATION EQUIPMENT.
35.	CRADLES AND SUPPORT DEVICES SHALL HAVE SLING EYES OR OTHER LIFTING PROVISIONS.
36.	GUIDELINES SHALL BE LOCATED ON CRADLES TO MATCH GUIDELINES ON SPECIAL LOADS, AND SHALL BE VISIBLE AFTER EQUIPMENT IS IN PLACE.
37.	ALL HOIST POINTS SHALL BE CONSPICUOUSLY IDENTIFIED ON ALL CRADLES.
38.	ALL PLATFORMS AND SUPPORT STANDS SHALL HAVE GUARDRAILS, GATES WITH LATCHES, AND TOE BOARDS.
39.	HANDRAILS SHALL BE CONTINUOUS AT CHANGES IN LEVEL AND AT ALL OTHER TRANSITION POINTS.
40.	LADDERS USED WITH SUPPORT STANDS OR PLATFORMS SHALL HAVE ATTACHED PINS OR OTHER LOCKING DEVICES FOR POSITIVE ATTACHMENT TO THE STANDS OR PLATFORM.
41.	ALL SUPPORT STANDS, PLATFORMS AND LADDERS SHALL DISPLAY A PLACARD TO IDENTIFY THE LOAD CAPACITY.
42.	ALL SUPPORT STANDS, LADDERS AND PLATFORMS USED WITHIN, ON OR ADJACENT TO FLIGHT HARDWARE (INCLUDING SUCH EQUIPMENT AS CONTOURED PLATFORMS USED ON TANK DOMES) SHALL BE PADDED TO PROTECT THE FLIGHT EQUIPMENT.
43.	ALL SUPPORT EQUIPMENT USED FOR INTERNAL ACCESS TO, OR WITH FLIGHT MODULES SHALL INCLUDE PROTECTION FOR MATING SURFACES, HATCH SEALING SURFACES AND SIMILAR PENETRATIONS OR OPENINGS ALONG THE ACCESS ROUTE.
44.	PROTECTIVE COVERS SHALL BE PROVIDED FOR ALL MATING SURFACES, HATCH SEALING SURFACES AND SIMILAR ACCESS OPENINGS TO PROTECT FLIGHT HARDWARE DURING GROUND OPERATIONS, INCLUDING THE INSTALLATION OF EQUIPMENT INTO FLIGHT MODULES AND MOVEMENT ALONG INTERNAL ACCESS ROUTES.
45.	COMBUSTIBLE MATERIALS SHALL NOT BE USED IN THE DESIGN OF STANDS, PLATFORMS, LADDERS, ETC.

SYSTEM SAFETY CHECKLIST - PART II

GROUND SUPPORT EQUIPMENT AND FACILITY SYSTEMS DESIGN

SECTION: 4.0 HANDLING, TRANSPORTATION, STORAGE & PROTECTIVE EQUIPT.

4.5 <u>SHIPPING AND STORAGE CONTAINERS</u>

46. ALL SKIDS, PALLETS AND SHIPPING CONTAINERS SHALL BE CLEARLY MARKED OR LABELED TO IDENTIFY HOISTING POINTS.

47. ALL CONTAINERS FOR SHOCK SENSITIVE EQUIPMENT SHALL HAVE NONRESETTING G-LOAD METERING DEVICES.

48. ALL METAL SHIPPING CONTAINERS SHALL HAVE GROUNDING PROVISIONS.

49. CENTER-OF-GRAVITY SHALL BE CONSPICUOUSLY IDENTIFIED ON ALL SHIPPING AND STORAGE CONTAINERS.

50. SHIPPING AND STORAGE CONTAINERS FOR PYROTECHNIC DEVICES SHALL MAINTAIN THE SAME MOISTURE TEMPERATURE, VIBRATION AND SHOCK ENVIRONMENT AS SPECIFIED FOR THE OPERATING ENVIRONMENT OF THE DEVICE.

51. SHIPPING AND STORAGE CONTAINERS FOR PYROTECHNIC DEVICES SHALL HAVE GROUNDING PROVISIONS WHICH ARE CLEARLY MARKED.

APPROVAL

SYSTEM SAFETY CHECKLIST

SKYLAB PROGRAM REPORT

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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