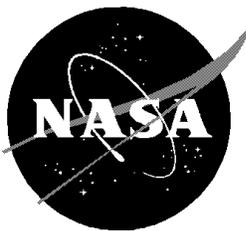


Safety Policy and Requirements

For Payloads Using the International
Space Station

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National Aeronautics and
Space Administration

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DESCRIPTION OF CHANGES TO
SAFETY POLICY AND REQUIREMENTS FOR PAYLOADS
USING THE INTERNATIONAL SPACE STATION

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--	Basic issue/AO96058	12/08/95	All
1	Update sections 213.1 and 220.10/R21700-ISS-0002	09/01/00	14,16,16A
2	Update section 102.2 / R21700-ISS-003	05/18/01	2

Note: Dates reflect latest signature date of CR's received by PILS.

ADDENDUM SCOPE

This addendum to NSTS 1700.7B has been prepared to expand and modify the existing NSTS 1700.7B requirements such that International Space Station (ISS) payload safety requirements are identified to the ISS payload development organizations.

The addendum is structured such that when it is used in conjunction with a unique Payload Integration Plan (PIP), the payload organization can provide a safe design for both the STS transportation phases and the ISS on-orbit operations. ISS payload which have a direct physical or functional interface with the orbiter or a Space Shuttle carrier in addition to a direct physical/functional interface with ISS carriers or elements must comply with the applicable requirements of the basic NSTS 1700.7B as well as the applicable requirements of this addendum.

ADDENDUM STRUCTURE

This addendum has been structured to take maximum advantage of the familiarity most payload organizations have with safety requirements defined in NSTS 1700.7B, and the safety process defined in NSTS 13830. These documents have been in use for many years with hundreds of major and minor payloads developed and flown on the Space Shuttle. The addendum approach was selected to relate Space Station requirements to the user's in a form that maintains continuity between the Shuttle and Space Station programs.

This addendum addresses each paragraph of NSTS 1700.7B and defines its applicability. Existing NSTS 1700.7B paragraphs have been identified as 1) Applicable, 2) Applicable with change, 3) Not applicable, or 4) Applicable only when specifically identified in the PIP. Paragraphs in this addendum have been identified as "added" when there is no existing counterpart in NSTS 1700.7B.

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CHAPTER 1: GENERAL

100 PURPOSE

This document establishes the safety policy and requirements applicable to **International Space Station (ISS)** payloads and their ground support equipment (GSE).

101 SCOPE

These requirements are intended to protect the general public, flight and ground personnel, **the STS and the ISS**, other payloads, GSE public-private property, and the environment from payload-related hazards. This document contains technical and system safety requirements applicable to **STS/ISS** payloads (including payload-provided ground and flight support systems) during ground and flight operations.

101.1 GSE Design and Ground Operations. For additional safety requirements which are unique to ground operations and GSE design, one shall refer to the joint Space and Missile Test Organization (SAMTO)/Kennedy Space Center (KSC) Handbook, SAMTO HB S-100/KHB 1700.7.

101.2 Flight Rules. Flight rules will be prepared for each **ISS increment** that outline preplanned decisions designed to minimize the amount of real-time rationalization required when anomalous situations occur. These flight rules are not additional safety requirements, but do define actions for completion of the **ISS objectives** consistent with crew safety. Compliance with minimum safety requirements of this document will not insure the mission success of a payload. For example, if an **ISS user** only monitors two of three inhibits to a catastrophic hazardous function (this is the minimum requirement specified in paragraph 201.3), a flight rule related to the loss of a monitored inhibit may be imposed which is not favorable to the mission success of the payload.

102 RESPONSIBILITY

102.1 Payload Organization. It is the responsibility of each payload organization to assure the safety of its payload and to implement the requirements of this document. Where a payload integration or mission management organization is identified, that

organization interfaces with the ISS on behalf of the group of individual payload elements or experiments under its control. That organization has the responsibility to assure that the individual payload elements are safe and meet the requirements of this document. That organization also has the responsibility to assure that interaction among its payload elements does not create a hazard.

102.2 Payload Safety Review Panel (PSRP) and Ground Safety Review Panel (GSRP), and ISS Program. The Payload Safety Review Panel (PSRP) and the Ground Safety Review Panel (GSRP) have been assigned the responsibility for conducting safety reviews for ISS payloads. The PSRP will review payloads for safety for all phases of flight operations. The GSRP will review payloads for safety for prelaunch and postlanding operations. The panels will be augmented by ISS representatives and International Partners as required.

It is the responsibility of the ISS Program to assure that interaction among mixed payloads, and between payloads and the ISS, does not create a hazard.

103 IMPLEMENTATION

This document identifies the safety policy and requirements which are to be implemented by the payload organization. The implementation of safety requirements by the payload organization will be assessed by the PSRP during the safety review process and must be consistent with hazard potential. The PSRP assessment of safety compliance will include a complete review of the safety assessment reports (paragraph 301) and may include audits and safety inspections of flight hardware. The detailed interpretations of these safety requirements will be by the PSRP, and will be determined on a case-by-case basis consistent with the payload's hazard potential. The following supplementary documents have been issued to assist payload organization in complying with the requirements of this document.

103.1 Implementation Procedure. NSTS/ISS 13830, a jointly issued Johnson Space Center (JSC) and Kennedy Space Center (KSC) document, has been published to assist the payload organization in implementing the system safety requirements and to define further the safety analyses, data submittals, and safety assessment review meetings. NSTS/ISS 13830 identifies the respective roles of the NSTS/ISS flight operator and the NSTS/ISS launch/landing site operator. It reflects a basic policy of commonality, compatibility, and coordination between the NSTS/ISS flight and ground elements in the implementation effort.

103.2 Interpretations of Requirements. NSTS/ISS 18798 is a collection of interpretations of requirements relative to specific payload designs. These interpretations shall be applied to payloads that utilize similar design solutions. Addenda to NSTS/ISS 18798 are distributed to payload organizations as additional interpretations are generated. Each additional addenda to NSTS 18798 will include an update table of contents which will also reflect the applicability of each letter to STS and/or ISS payloads.

104 GLOSSARY OF TERMS

For definitions applicable to this document, see Appendix A.

105 APPLICABLE DOCUMENTS

A list of documents which are referenced in this document is in Appendix B.

106 FIGURES

Figures referred to in the text are contained in Appendix C.

CHAPTER 2: TECHNICAL REQUIREMENTS

200 GENERAL

The following requirements are applicable to all payloads. When a requirement cannot be met, a noncompliance report must be submitted in accordance with NSTS/ISS 13830 for resolution.

- 200.1 Design to Tolerate Failures.** Failure tolerance is the basic safety requirement that shall be used to control most payload hazards. The payload must tolerate a minimum number of credible failures and/or operator errors determined by the hazard level. This criterion applies when the loss of a function or the inadvertent occurrence of a function results in a hazardous event.
- 200.1a Critical Hazards.** Critical hazards shall be controlled such that no single failure or operator error can result in damage to STS/ISS equipment, a nondisabling personnel injury, or the use of unscheduled safing procedures that affect operations of the Orbiter/ISS or another payload.
- 200.1b Catastrophic Hazards.** Catastrophic hazards shall be controlled such that no combination of two failures or operator errors can result in the potential for a disabling or fatal personnel injury or loss of the Orbiter/ISS, ground facilities or STS/ISS equipment.
- 200.2 Design for Minimum Risk.** Payload hazards which are controlled by compliance with specific requirements of this document other than failure tolerance are called "Design for Minimum Risk" areas of design. Examples are structures, pressure vessels, pressurized line and fittings, functional pyrotechnic devices, mechanisms in critical applications, material compatibility, flammability, etc. Hazard controls related to these areas are extremely critical and warrant careful attention to the details of verification of compliance on the part of the payload organization and the NSTS/ISS. Minimum supporting data requirements for these areas of design have been identified in NSTS/ISS 13830.
- 200.3 Environmental Compatibility.** A payload shall be certified safe in the applicable worst case natural and induced environments defined in the payload integration plan (PIP) and/or interface control document (ICD).

200.4 **ISS Services**

200.4a **Safe Without Services.** Payloads shall be designed to maintain fault tolerance or safety margins consistent with the hazard potential, without ground or flight crew intervention, in the event of sudden loss or temporary interruption of Space Station provided services. The payload must remain in a safe state until returned to operation by the ground or flight crew. Monitoring is to be continued after service loss when feasible.

200.4b **ISS Critical Services.** When Space Station services are to be utilized to assist in controlling payload hazards, the integrated system must meet the failure tolerance requirements of paragraph 200.1. The payload organization must provide a summary of the hazards being controlled by the Space Station services in the Safety Compliance Data Package, and the individual hazard reports must identify those space station interfaces used to control and/or monitor those hazards. In addition, the payload organization shall identify, in the payload/SS Interface Control Document (ICD), those space station interfaces used to control and/or monitor the hazards. Those payloads having hazards controlled by ISS-provided services and utilities shall perform post-mate interface verification prior to payload operations having hazard potential.

201 CONTROL OF HAZARDOUS FUNCTIONS

201.1 **General.** Hazardous functions are operational events (e.g., motor firings, appendage deployments, stage separations, and active thermal control) whose inadvertent operations or loss may result in a hazard.

201.1a **Inhibits.** An inhibit is a design feature that provides a physical interruption between an energy source and a function (a relay or transistor between a battery and a pyrotechnic initiator, a latch valve in the plumbing line between a propellant tank and a thruster, etc.). Two or more inhibits are independent if no single credible failure, event, or environment can eliminate more than one inhibit.

201.1b Controls. A device or function that operates an inhibit is referred to as a control for an inhibit. Controls do not satisfy the inhibit or failure tolerance requirements for hazardous functions. The "electrical inhibits" in a liquid propellant propulsion system ([paragraph 202.2a(3)]) are exceptions in that these devices operate the flow control devices (i.e., mechanical inhibits to propellant flow), but are referred to as inhibits and not as controls.

201.1c Monitors. Monitors are used to ascertain the safe status of payload functions, devices, inhibits and parameters. Monitoring circuits should be designed such that the information obtained is as directly related to the status of the monitored device as possible. Monitor circuits shall be current limited or otherwise designed to prevent operation of the hazardous functions with credible failures. In addition, loss of input or failure of the monitor should cause a change in state of the indicator. Monitoring shall be available to the launch site when necessary to assure safe ground operations. Notification of changes in the status of safety monitoring shall be given to the flightcrew in either near-real-time or real-time.

201.1c(1) Near-Real-Time Monitoring. Near-real-time monitoring (NRTM) is defined as notification of changes in inhibit or safety status on a periodic basis (nominally once per orbit). NRTM may be accomplished via ground crew monitored telemetry data. **Local visual indicators shall not be used as the only source of safety monitoring unless the crew is actively engaged in payload operations at the visual indicator location.**

201.1c(2) Real-Time Monitoring. Real-time monitoring (RTM) is defined as immediate notification to the crew. RTM shall be accomplished via the use of the **ISS caution and warning system** or by ground crew monitored telemetry data. An exception to this would be where RTM is necessary only during payload operations. Under these conditions, **local visual indicators** monitoring is acceptable. Real-time monitoring of inhibits to a catastrophic hazardous function is required when changing the configuration of the applicable payload system or when the provisions of paragraph 204 are implemented for flightcrew control of the hazard. If ground monitoring is used to meet real-time monitoring, a continuous real-time data link

(containing the applicable safety parameters) must be assured by the payload and continuous communications between the flight and ground crews must be established and maintained during the required period.

201.1c(3) Unpowered Bus Exception. Monitoring and safing of inhibits for a catastrophic hazardous function will not be required if the function power is deenergized (i.e., an additional fourth inhibit is in place between the power source and the three required inhibits) and the control circuits for the three required inhibits are disabled (i.e., no single failure in the control circuitry will result in the removal of an inhibit) until the hazard potential no longer exists.

201.1d Use of Timers. When timers are used on deployable payloads to control inhibits to hazardous functions, complete separation of the payload from the ISS must be achieved prior to the initiation of the timer. If credible failure modes exist that could allow the timer to start prior to a complete separation, a safing capability must be provided. If this safing is via a radio frequency (RF) command, then the command capability must be provided to the flightcrew.

201.1e Computer-Based Control Systems.

201.1e(1) Active Processing to Prevent a Catastrophic Hazard. While a computer system is being used to actively process data to operate a payload system with catastrophic potential, the catastrophic hazard must be prevented in a two-failure tolerant manner. One of the methods to control the hazard must be independent of the computer system. A computer system shall be considered zero fault tolerant in controlling a hazardous system (i.e., a single failure will cause loss of control), unless the system utilizes independent computers, each executing uniquely developed instruction sequences to provide the remaining two hazard controls.

201.1e(2) Control of Inhibits. The inhibits to a hazardous function may be controlled by a computer-based system used as a timer, provided the system meets all the requirements for independent inhibits.

201.2 Functions Resulting in Critical Hazards. A function whose inadvertent operation could result in a critical hazard must be controlled by two independent inhibits, whenever the hazard potential exists. Requirements for monitoring (paragraph 201.1c) of these inhibits and for the capability to restore inhibits to a safe condition are normally not imposed, but may be imposed on a case-by-case basis. Where loss of a function could result in a critical hazard, no single credible failure shall cause loss of that function.

201.3 Functions Resulting in Catastrophic Hazards. A function whose inadvertent operation could result in a catastrophic hazard must be controlled by a minimum of three independent inhibits, whenever the hazard potential exists. One of these inhibits must preclude operation by an RF command or the RF link must be encrypted. In addition, the ground return for the function circuit must be interrupted by one of the independent inhibits. At least two of the three required inhibits shall be monitored (paragraph 201.1c). If loss of a function could cause a catastrophic hazard, no two credible failures shall cause loss of that function.

202 SPECIFIC CATASTROPHIC HAZARDOUS FUNCTIONS

In the following subparagraphs, specific requirements related to inhibits, monitoring, and operations are defined for several identified potentially catastrophic hazardous functions. **Note: paragraphs 202.1 through 202.2d are not applicable to Space Station payloads unless specifically applied by the PIP.**

202.1 Solid Propellant Rocket Motors. Premature firing of a solid propellant rocket motor, while the payload is closer to the Orbiter than the minimum safe distance, is a catastrophic hazard.

202.1a Safe Distance. The safe distance for firing a solid rocket motor is defined as the separation distance achieved 45 minutes after deployment with the payload coasting with a minimum separation velocity of 1 foot per second. Payloads with a positive separation velocity less than 1 foot per second either:

(1) Shall provide an RF command capability as a flight crew function to inhibit automatic sequencing until a safe distance is assured; or

(2) Shall initiate payload sequencing (such as, starting a timer that will remove inhibits to cause

engine firing) by a real-time RF command with prior NSTS coordination and approval and the RF command to start sequencing shall not be sent until a safe separation distance is assured. For payloads deployed with the Remote Manipulator System (RMS), sequencing shall be initiated by a real time RF command.

202.1b Safe and Arm (S&A) Device. All solid propellant rocket motors shall be equipped with an S&A device that provides a mechanical interrupt in the pyrotechnic train immediately downstream of the initiator. The S&A device shall be designed and tested in accordance with provisions of MIL-STD-1576. If the S&A device is to be rotated to the arm position prior to the payload achieving a safe distance from the Orbiter: rotation must be a flightcrew function and must be done as part of the final deployment activities of the payload; and the initiator must meet the requirements of paragraph 210. The S&A must be in the safe position during Orbiter boost and entry. There must be a capability to resafe the S&A device: if the S&A device is to be rotated to the arm position while the payload is attached to the Orbiter; or if the solid rocket motor propulsion subsystem does not qualify for the unpowered bus exception of paragraph 201.1c(3). In determining compliance with paragraph 201.1c(3), the S&A device in the "safe" position shall be counted as one of the required inhibits.

202.1c Electrical Inhibits. In addition to the S&A, there shall be at least two independent electrical inhibits, to prevent firing of the motor if the S&A device will be in the "safe" position until the payload reaches a safe distance from the Orbiter. There shall be at least three independent electrical inhibits, in addition to the S&A, if the S&A device will be rotated to the arm position prior to the payload reaching a safe distance from the Orbiter.

202.1d Monitoring. Monitoring requirements are a function of the design and operations as follows:

202.1d(1) No Rotation of the S&A Prior to a Safe Distance. The capability to monitor the status of the S&A device and one electrical inhibit in near real-time is required until final separation of the payload from the Orbiter. No monitoring is required if the payload qualifies for the unpowered bus exception of paragraph 201.1c(3).

202.1d(2) S&A Will be Rotated to Arm Prior to a Safe Distance.

Prior to rotation of the S&A and separation of the payload from the Orbiter, the flight or ground crew must have continuous real-time monitoring to determine the status of the S&A and to assure that two of the three electrical inhibits are in place (paragraph 201.1c(2)).

202.2 Liquid Propellant Propulsion Systems.

202.2a Premature Firing. The premature firing of a liquid propellant propulsion system before the payload reaches a safe distance from the Orbiter is a catastrophic hazard. Each propellant delivery system must contain a minimum of three mechanically independent flow control devices in series to prevent engine firing. A bipropellant system shall contain a minimum of three mechanically independent flow control devices in series both in the oxidizer and fuel sides of the delivery system. These devices must prevent contact between the fuel and oxidizer as well as prevent expulsion through the thrust chamber(s). Except during ground servicing and as defined in paragraph 202.2a(2)(a), these devices will remain closed during all ground and flight phases until the payload reaches a safe distance from the Orbiter. A minimum of one of the three devices will be fail-safe, i.e., return to the closed condition in the absence of an opening signal.

202.2a(1) Safe Distance Criteria. The hazard of engine firing close enough to inflict damage to the Orbiter due to heat flux, contamination, and/or perturbation of the Orbiter, is in proportion to the total thrust imparted by the payload in any axis and shall be controlled by establishing a safe distance for the event. The safe distance shall be determined using Figure 1 (see Appendix C). For large thruster systems with greater than 10 pounds total thrust, the collision hazard with the Orbiter must be controlled by considering the safe distance criteria in Figure 1, together with the correct attitude at time of firing. For small reaction control system (RCS) thrusters with less than 10 pounds total thrust, the collision hazard must be controlled by the safe distance criteria in Figure 1 with consideration of many variables such as deployment method, appendage orientation, and control authority.

202.2a(2) Isolation Valve. One of the flow control devices shall isolate the propellant tank(s) from the remainder of the distribution system.

202.2a(2)(a) Opening the Isolation Valve. If a payload with a large liquid propellant thruster system also uses a small reaction control thruster system for attitude control, the isolation valve in a common distribution system may be opened after the payload has reached a safe distance for firing the reaction control thrusters provided the applicable requirements of paragraphs 202.2a(3) and 202.2a(4) have been met and two mechanical flow control devices remain to prevent thrusting of the larger system.

202.2a(2)(b) Pyrotechnic Isolation Valves. If a normally closed, pyrotechnically initiated, parent metal valve is used, fluid flow or leakage past the barrier will be considered mechanically noncredible if:

- a. The valve has an internal flow barrier fabricated from a continuous unit of nonwelded parent metal.
- b. The valve integrity is established by rigorous qualification and acceptance testing.

When the valve is used as a flow control device, the number of inhibits to valve activation determines the failure tolerance against fluid flow.

202.2a(3) Electrical Inhibits. While the payload is closer to the Orbiter than the minimum safe distance for engine firing, there shall be at least three independent electrical inhibits that control the opening of the flow control devices. The electrical inhibits shall be arranged such that the failure of one of the electrical inhibits will not open more than one flow control device. If the isolation valve will be opened under the conditions of paragraph 202.2a(2)(a) prior to the payload achieving a safe distance for firing a large thruster, three independent electrical inhibits must control the opening of the remaining flow control devices for the large thruster system.

202.2a(4) Monitoring. At least two of the three required independent electrical inhibits shall be monitored by the flight or ground crew until final separation of the payload from the Orbiter. The position of a mechanical flow control device may be monitored in lieu of its

electrical inhibit, provided the two monitors used to meet the above requirement are independent. Either near real-time or real-time monitoring will be required as defined in paragraphs 201.1c(1) and 201.1c(2). One of the monitors must be the electrical inhibit or mechanical position of the isolation valve. Monitoring will not be required if the payload qualifies for the unpowered bus exception of paragraph 201.1c(3). If the isolation valve will be opened prior to the payload achieving a safe distance from the Orbiter, all three of the electrical inhibits that will remain after the opening of the isolation valve must be verified safe during final predeployment activities by the flight or ground crew.

202.2b Adiabatic/Rapid Compression Detonation. While the payload is inside the Orbiter cargo bay, the inadvertent opening of isolation valves in a hydrazine (N₂H₄) propellant system shall be controlled as a catastrophic hazard unless the outlet lines are completely filled with hydrazine or the system is shown to be insensitive to adiabatic or rapid compression detonation. Hydrazine systems will be considered sensitive to compression detonation unless insensitivity is verified by testing on flight hardware or on a high fidelity flight type system that is constructed and cleaned to flight specifications. Test plans must be submitted to the NSTS as part of the appropriate hazard report. If the design solution is to fly wet downstream of the isolation valve, the hazard analysis must consider other issues such as hydrazine freezing or overheating, leakage, single barrier failures, and back pressure relief.

202.2c Propellant Overheating. Raising the temperature of a propellant above the fluid compatibility limit for the materials of the system is a catastrophic hazard. Components in propellant systems that are capable of heating the system (e.g., heaters, valve coils, etc.) shall be two-failure tolerant to heating the propellant above the material/fluid compatibility limits of the system. These limits shall be based on test data derived from NASA-STD-6001 test methods or on data furnished by the payload supplier and approved by the NSTS. Propellant temperatures less than the material/fluid compatibility limit, but greater than 200 degrees Fahrenheit must be approved by the NSTS.

The use of inhibits, cutoff devices, and/or crew safing actions may be used to make the system two failure tolerant to overheating. Monitoring of inhibits (paragraphs 201.1c and 201.3) or of propellant temperature will be required.

- 202.2d Propellant Leakage.** A payload shall be two failure tolerant to prevent leakage of propellant into the Orbiter cargo bay past seals, seats, etc., if the leak has a flow path to the storage vessel. If the leak is in an isolated segment of the distribution system, failure tolerance to prevent the leak will depend on the type and quantity of propellant that could be released. As a minimum such a leak will be one failure tolerant.
- 202.3 Inadvertent Deployment, Separation, and Jettison Functions.** Inadvertent deployment, separation or jettison of a payload, payload element or appendage is a catastrophic hazard unless it is shown otherwise. The general inhibit and monitoring requirements of paragraph 201 shall apply.
- 202.4 Planned Deployment/Extension Functions.**
- 202.4a Preventing Payload Bay Door Closure.** If during planned payload operations an element of the payload or any payload airborne support equipment (ASE) violates the payload bay door envelope, the hazard of preventing door closure must be controlled by independent primary and backup methods. The combination of these methods must be two-fault tolerant. Two methods are considered independent if no single event or environment can eliminate both methods (i.e., the methods have no common cause failure mode).
- 202.4b Cannot Withstand Subsequent Loads.** If during planned operations an element of a payload or its ASE is deployed, extended, or otherwise unstowed to a condition where it cannot withstand subsequent STS/ISS induced loads, there shall be design provisions to safe the payload with redundancy appropriate to the hazard level.
- 202.4c Payload Reconfiguration.** Payload equipment shall not be reconfigured, erected, or operated upon in a manner which could present a hazard to the crew, ISS/Orbiter, or which would make it unsuitable for safe return if the item is planned for return.

202.5 RF Energy Radiation. Allowable levels of radiation from ISS payload transmitter systems in their operating locations shall be limited as follows:

- a. The Orbiter, Orbiter RMS, EMU, and Orbiter payload limits are defined in NSTS-21000-IDD-ISS, Shuttle Orbiter/International Space Station Cargo Standard Interfaces, paragraph 10.7.3.2.2.
- b. Personnel limits are defined in paragraph 5.7.3.2.1 of SSP 50005.
- c. The Space Station equipment limit is defined by the test limit RS03 of SSP 30237.
- d. No radiation is permitted during transport or assembly of transmitting equipment.

Radiation levels which would exceed the above limits are considered to be catastrophic and the system design must comply with the requirements of paragraph 200.1b if the equipment is connected to a power source.

202.6 Fluid Release from a Pressurized System Inside of a Closed Volume. Release of any fluid from pressurized systems shall not compromise the structural integrity of any closed volume in which hardware is contained, such as the Shuttle cargo bay or crew habitable volumes. In accordance with NSTS 07700 (Volume XIV, Attachment 1, ICD-2-19001, Section 10.6.2.3), pressurized systems that are two fault tolerant to release of fluid through controlled release devices do not require analysis. Also, pressurized systems that are two fault tolerant or designed for minimum risk, as applicable, to prevent leakage, do not require analysis. Systems which do not meet the above shall be reviewed and assessed for safety on a case-by-case basis, and approval must be given by the SSP.

203 RETRIEVAL OF PAYLOADS

203.1 Safing. Deployable and/or free flying payloads that are designed to be retrieved or revisited shall have the capability to return systems which are hazardous to a safe condition (i.e., meet all the applicable requirements of this document).

- 203.2 Substantiating Failure Tolerance.** Payloads must be designed so as to allow substantiation of safing by the **Orbiter/ISS** flightcrew or ground crew prior to retrieval and while the payload is still a safe distance from the **Orbiter/ISS**. By direct or indirect means, it must be substantiated that catastrophic hazardous functions are at least two-failure tolerant. Specific plans to be used to determine the safe status of a retrievable payload must be approved by the **PSRP**.
- 203.3 Monitoring.** After retrieval, the monitoring requirements of paragraphs 201.1c and 201.3 will apply.

203.4 Certification. Prior to the **NSTS/ISSP** retrieval or revisit mission, the payload organization must certify the safety of the payload. This certification must be based upon a hazard analysis that considers the effect of the current condition of the payload (including the impact of all anomalies) during all subsequent flight and ground operations with the **STS/ISS**.

204 HAZARD DETECTION AND SAFING

The need for hazard detection and safing by the flightcrew to control time-critical hazards will be minimized and implemented only when an alternate means of reduction or control of hazardous conditions is not available. When implemented, these functions will be capable of being tested for proper operations during both ground and flight phases and shall use existing **ISS** systems for fault detection and annunciation. Likewise, payload designs should be such that real-time monitoring is not required to maintain control of hazardous functions. With **PSRP** approval, real-time monitoring and hazard detection and safing may be utilized to support control of hazardous functions provided that adequate crew response time is available and acceptable safing procedures are developed. **Flight or ground crew hazard detection and safing actions are not available for ascent and descent flight phases.**

205 CONTINGENCY RETURN AND RAPID SAFING

The payload design shall not impede emergency IVA egress to the remaining contiguous pressurized volumes. Crew egress time from experiment apparatus shall be less than 30 seconds.

206 FAILURE PROPAGATION

The design shall preclude propagation of failures from the payload to the environment outside the payload.

207 REDUNDANCY SEPARATION

Safety-critical redundant subsystems shall be separated by the maximum practical distance, or otherwise protected, to ensure that an unexpected event that damages one is not likely to prevent the others from performing the function. All redundant functions that are required to prevent a catastrophic hazard must not be routed through a single connector.

208 STRUCTURES

- 208.1 Structural Design.** The structural design shall provide ultimate factors of safety equal to or greater than 1.5 for the on-orbit mission phase for ISS payloads and 1.4 for all other mission phases except emergency landing. This includes loads incurred during payload and Orbiter operations for all payload configurations or while changing configuration as specified in the PIP. Verification of design compliance shall be in accordance with NSTS 14046 and SSP 52005. When failure of structure can result in a catastrophic event, the design shall be based on fracture control procedures to prevent structural failure because of the initiation or propagation of flaws or crack-like defects during fabrication, testing, and service life. Requirements for fracture control are specified in NASA-STD-5003.
- 208.2 Emergency Landing Loads.** The structural design shall comply with the ultimate design load factors for emergency landing loads that are specified in the ICD's between the Orbiter and the payload. Structural verification for these loads may be certified by analysis only.
- 208.3 Stress Corrosion.** Materials used in the design of payload structures, support bracketry, and mounting hardware shall be rated for resistance to stress corrosion cracking (SCC) in accordance with the tables in MSFC-HDBK-527/JSC 09604 and MSFC-SPEC-522. Alloys with high resistance to SCC shall be used whenever possible and do not require approval. When failure of a part made from a moderate or low resistance alloy could result in a critical or catastrophic hazard, a Material Usage Agreement that includes a Stress Corrosion Evaluation Form from MSFC-HDBK-527/JSC 09604 must be attached to the applicable stress corrosion hazard report contained in the safety assessment report (see paragraph 301). When failure of a part made from a moderate or low resistance alloy would not result in a hazard, rationale to support the nonhazard assessment must be included in the stress corrosion hazard report. Approval of the hazard report shall constitute approval for the use of the alloy in the documented applications. Controls that are required to prevent SCC of components after manufacturing shall be identified in the hazard report and closure shall be documented in the verification log (see paragraph 214.2) prior to flight.

208.4 Pressure Systems. The maximum design pressure (MDP) for a pressurized system shall be the highest pressure defined by maximum relief pressure, maximum regulator pressure or maximum temperature. Transient pressures shall be considered. Design factors of safety shall apply to MDP. Where pressure regulators, relief devices, and/or a thermal control system (e.g., heaters) are used to control pressure, collectively they must be two-fault tolerant from causing the pressure to exceed the MDP of the system. Pressure integrity shall be verified at the system level.

208.4a Pressure Vessels. Pressure vessels shall comply with the pressure vessel requirements of MIL-STD-1522A (including revisions as of December 1984) as modified by the paragraphs (1), (2), (3), (4) and (5) below. Particular attention shall be given to insure compatibility of vessel materials with fluids used in cleaning, test, and operation. Data requirements for pressure vessels are listed in NSTS/ISS 13830.

- (1) Approach "B" of figure 2 is not acceptable.
- (2) In addition to other required analyses, composite pressure vessels shall be assessed for adequate stress rupture life.
- (3) Nondestructive evaluation (NDE) of pressure vessels shall include inspection of welds after proof testing.
- (4) MDP as defined above (see paragraph 208.4) shall be substituted for all references to maximum expected operating pressure (MEOP).
- (5) A proof test of each flight pressure vessel to a minimum of 1.5 x MDP and a fatigue analysis showing a minimum of 10 design lifetimes may be used in lieu of testing a certification vessel to qualify a vessel design that in all other respects meets the requirements of this document and MIL-STD-1522A, Approach A.
- (6) The minimum factor of safety for ISS pressure vessels is 2.0 x MDP unless the PSRP specifically authorizes a lower factor. In no case shall the factor be less than 1.5 x MDP and the vessel design and test program must certify the vessel for all environments and service life.

208.4b

Dewars. Dewar/cryostat systems are a special category of pressurized vessels because of unique structural design and performance requirements. Pressure containers in such systems shall be subject to the requirements for pressure vessels specified in paragraphs 208.4 and 208.4a as supplemented by the requirements of this section.

(1) Pressure containers shall be leak-before-burst (LBB) designs where possible as determined by a fracture mechanics analysis. Containers of hazardous fluids and all non-LBB designs must employ a fracture mechanics safe-life approach to assure safety of operation.

(2) MDP of the pressure container shall be as determined in paragraph 208.4 or the pressure achieved under maximum venting conditions whichever is higher. Relief devices must be sized for full flow at MDP.

(3) Outer shells (i.e., vacuum jackets) shall have pressure relief capability to preclude rupture in the event of pressure container leakage. If pressure containers do not vent external to the dewar but instead vent into the volume contained by the outer shell, the outer shell relief devices must be capable of venting at a rate to release full flow without outer shell rupture. Relief devices must be redundant and individually capable of full flow.

(4) Pressure relief devices which limit maximum design pressure must be certified to operate at the required conditions of use. Certification shall include testing of the same part number from the flight lot under the expected use conditions.

(5) Nonhazardous fluids may be vented into the cargo bay if analysis shows that a worst case credible volume release will not affect the structural integrity or thermal capability of the Orbiter. ISS payloads may vent non-hazardous gas into the waste gas system in accordance with the SSP 52000, Payload Interface Definition Documents (IDD's). Payloads using the waste gas system and external payloads shall identify venting requirements in the payload unique Interface Control Document (ICD).

(6) The proof test factor for each flight pressure container shall be a minimum of 1.1 times MDP. Qualification burst and pressure cycle testing is not required if all the requirements of paragraphs 208.4, 208.4a and 208.4b are met. The structural integrity for external load environments must be demonstrated in accordance with NSTS 14046.

208.4c Pressurized Lines, Fittings, and Components.

(1) Pressurized lines and fittings with less than a 1.5-inch outside diameter and all flex-hoses shall have an ultimate factor of safety equal to or greater than 4.0. Lines and fittings with a 1.5-inch or greater outside diameter shall have an ultimate factor of safety equal to or greater than 2.0 for ISS payloads.

(2) All line-installed bellows and all heat pipes shall have an ultimate safety factor equal to or greater than 2.5.

(3) Other components (e.g., valves, filters, regulators, sensors, etc.) and their internal parts (e.g., bellows, diaphragms, etc.) which are exposed to system pressure shall have an ultimate factor of safety equal to or greater than 2.5.

(4) Secondary compartments or volumes that are integral or attached by design to the above parts and which can become pressurized as a result of a credible single barrier failure must be designed for safety consistent with structural requirements. These compartments shall have a minimum safety factor of 1.5 based on MDP. If external leakage would not present a catastrophic hazard to the Orbiter/ISS, the secondary volume must either be vented or equipped with a relief provision in lieu of designing for system pressure.

208.4d Flow Induced Vibration. Flexible hoses and bellows shall be designed to exclude flow induced vibrations which could result in a catastrophic hazard.

208.4e Meteoroid and Debris Protection. An external payload with pressure vessels, cryogenic carrier, or other hardware that would create a hazard if impacted by meteoroid/debris shall provide meteoroid/debris shielding sufficient to be equal or better than the probability of 0.9999 of experiencing no penetration of the critical hardware over a 1 year period. The Payload exposure to M/OD environment shall not endanger the crew or module survivability. This includes initial failure of the payload and secondary effects of

the failure including creation of secondary ejecta.

Sections 8.1 and 8.2 of NASA SSP 30425 specify a summary of the meteoroid environments and the associated shielding/de-focusing factors and space debris environment.

- 208.5 **Sealed or Vented Compartments.** Payload sealed compartments shall be designed to withstand the maximum pressure differential created by ascent, descent, or on-orbit emergency ISS depressurization or repressurization activity. Vented compartments must size vent flow areas such that structural integrity is maintained at the maximum rate of change of pressure.

209 MATERIALS

MSFC-HDBK-527/JSC 09604 contains a listing of materials (both metals and nonmetals) with a "rating" indicating acceptability for each material's characteristic. For materials which create potential hazardous situations as described in the paragraphs below and for which no prior NASA test data or rating exists, the payload organization shall present other test results for NSTS/ISSP review or request assistance from the NSTS/ISSP in conducting applicable tests. The payload material requirements for hazardous materials, flammability, and offgassing are as follows:

- 209.1 **Hazardous Materials.** Hazardous materials shall not be released or ejected in or near the Orbiter. During exposure to all STS environments, hazardous fluid systems must contain the fluids unless the use of the Orbiter vent/dump provisions has been negotiated with the NSTS. Payload organizations shall submit material data for toxicological assessments per JSC 27472. Hazardous materials shall not be released or ejected in or near the ISS, unless such release/ejection has been negotiated with the ISSP.
- 209.1a **Fluid Systems.** Particular attention shall be given to materials used in systems containing hazardous fluids. These hazardous fluids include gaseous oxygen, liquid oxygen, fuels, oxidizers, and other fluids that could chemically or physically degrade the system or cause an exothermic reaction. Those materials within the system exposed to oxygen (liquid and gaseous), both directly and by a credible single barrier failure, must meet the requirements of NASA-STD-6001 at MDP and temperature. Materials within the system exposed to other hazardous fluids, both directly and by a credible single barrier failure, must pass the fluid compatibility requirements

of NASA-STD-6001 at MDP and temperature. The payload supplier's compatibility data on hazardous fluids may be used to accept materials in this category if approved by the PSRP.

- 209.1b Chemical Releases.** The use of chemicals which would create a toxicity problem (including irritation to skin or eyes) or cause a hazard to STS/ISS hardware if released should be avoided. If use of such chemicals cannot be avoided, adequate containment shall be provided by the use of an approved pressure vessel as defined in paragraph 208.4 or the use of two or three redundantly sealed containers, depending on the toxicological hazard for a chemical with a vapor pressure below 15 psia. The payload organization must assure that each level of containment will not leak under the maximum use conditions (i.e., vibration, temperature, pressure, etc.). Mercury is an example of such a chemical, since it produces toxic vapors and can amalgamate with metals or metal alloys used in spacecraft hardware. Documentation of chemical usage, along with the containment methods, will be supplied for review and approval.
- 209.2 Flammable Materials.** A payload must not constitute an uncontrolled fire hazard to the STS/ISS or other payloads. The minimum use of flammable materials shall be the preferred means of hazard reduction. The determination of flammability shall be in accordance with NASA-STD-6001. Guidelines for the conduct of flammability assessments are provided in NSTS 22648. A flammability assessment shall be documented in accordance with NSTS/ISS 13830.
- 209.2a Orbiter Cabin** *(Note: Not applicable unless the payload is transported or operated in the Orbiter cabin).* Materials used in the Orbiter cabin must be tested in accordance with NASA-STD-6001 at the use condition of 10.2 psi total pressure and 30 percent oxygen concentration (worst case Orbiter cabin condition). When flammable materials are used in quantities where the weight or surface area is greater than 0.1 pounds or 10 square inches respectively, the methods of control of flame propagation must be described in the flammability assessment report.
- 209.2b Other Habitable Areas.** Materials used in habitable areas other than the Orbiter cabin shall be tested in accordance with NASA-STD-6001 in the worst case atmosphere (i.e., oxygen concentration). Propagation path considerations of paragraph 209.2a apply.

The ISS worst case operating environment is 15.2 psia with 24.1 percent oxygen for all locations except airlocks. Airlock worst case environment is 10.2 psia with 30 percent oxygen. Payloads are only required to test materials in the worst case airlock environment if they intend to operate in the airlock during EVA preparations.

When flammable materials are used in quantities where the weight or surface area is greater than 0.1 pounds or 10 square inches, respectively, the methods of control of flame propagation must be described in the "flammability assessment report," prepared in accordance with NSTS 22648.

209.2c Outside Habitable Areas. Materials used outside the pressurized areas shall be evaluated for flammability in an air environment at 14.7 psi. Propagation path considerations of NSTS 22648 apply for material usages of greater than 1 pound and/or dimensions exceeding 12 inches.

209.3 Material Offgassing in Habitable Areas. Usage of materials which produce toxic levels of offgassing products shall be avoided in habitable areas. Payload elements going into such areas are required to be subjected to offgassing tests (black-box levels) for safety validation prior to integration with STS/ISS elements. Rigorous material control to insure that all selected materials have acceptable offgassing characteristics is a negotiable alternative to black-box level testing. The offgassing test specified in NASA-STD-6001 or an ISSP approved equivalent shall be used for the black-box level offgassing test. The document MSFC-HDBK-527/JSC 09604 contains a listing of materials and black boxes that have been subjected to offgassing tests.

210 PYROTECHNICS

If premature firing or failure to fire will cause a hazard, the pyrotechnic subsystem and devices shall meet the design and test requirements of MIL-STD-1576.

210.1 Initiators. NASA Standard Initiators (NSI's) are the preferred initiators for all safety critical pyrotechnic functions. Extensive qualification and acceptance test programs are required if other initiators are used.

210.2 Pyrotechnic Operated Devices.

210.2a Debris Protection. Pyrotechnic devices that are to be operated in or near the ISS/Orbiter or that do not meet the criteria of this document to prevent inadvertent operation, shall be designed to preclude hazards due to effects of shock, debris, and hot gasses resulting from operation. Such devices shall be subjected to a "locked-shut" safety demonstration test (i.e., a test to demonstrate the capability of the devices to safely withstand internal pressures generated in operation with the moveable part restrained in its initial position).

210.2b Must Function Safety Critical Devices. Where failure to operate will cause a catastrophic hazard, pyrotechnic operated devices shall be designed, controlled, inspected, and certified to criteria equivalent to those specified in NSTS 08060. The data required for PSRP review are identified in NSTS/ISS 13830. If the device is used in a redundant application where the hazard is being controlled by the use of multiple independent methods, then in lieu of demonstrating compliance with criteria equivalent to NSTS 08060, sufficient margin to assure operation must be demonstrated. When required, pyrotechnic operated devices shall demonstrate performance margin using a single charge or cartridge loaded with 85 percent (by weight) of the minimum allowable charge or other equivalent margin demonstrations.

210.2c Electrical Connection. Payloads with pyrotechnic devices which if prematurely fired may cause injury to people or damage to property shall be designed such that these devices can be electrically connected after all payload/Space Station electrical interface verification tests have been completed. Ordnance circuitry must be verified safe prior to connection of pyrotechnic devices.

210.3 Traceability. The payload organization shall furnish the PSRP a list of all safety critical pyrotechnic initiators installed or to be installed on the payload, giving the function to be performed, the part number, the lot number, and the serial number.

211 DESTRICT SYSTEMS

Destruct systems will be used only when approved by the PSRP and must comply with the requirements of paragraphs 200, 201, 202, 204, and 210.

212 RADIATION

212.1 Ionizing Radiation. Payloads containing or using radioactive materials or that generate ionizing radiation shall be identified and approval obtained for their use. Descriptive data shall be provided in accordance with NSTS/ISS 13830. Major radioactive sources require approval by the Interagency Nuclear Safety Review Panel through the NASA coordinator for the panel. DOD payloads involving radioactive materials will be processed through their own established procedures. Radioactive materials shall comply with appropriate license requirements at the planned launch and landing sites.

212.2 Electromagnetic Emissions and Susceptibility. Payload unintentional emissions shall be limited to those levels identified in SSP 30237 by the test limits of RE02, CE01, and CE03. The payload must demonstrate that safety critical electrical equipment is not susceptible to the Electromagnetic environment in its operating location(s).

212.3 Lasers. Lasers used on ISS payloads shall be designed and operated in accordance with American National Standard for Safe Use of Lasers, ANSI-Z-136.1.

212.4 Optical Requirements. Optical instruments shall prevent harmful light intensities and wavelengths from being viewed by operating personnel. Quartz windows, apertures or beam stops and enclosures shall be used for hazardous wavelengths and intensities. Light intensities and spectral wavelengths at the eyepiece of direct viewing optical systems shall be below the Threshold Limit Values for physical agents defined in the American Conference of Governmental Industrial Hygienists.

213 ELECTRICAL SYSTEMS

- 213.1 General.** Electrical power distribution circuitry shall be designed to include circuit protection devices to protect against circuit damage normally associated with an electrical fault when such a fault could result in damage to the **Orbiter/ISS** or present a hazard to the crew by direct or propagated effects. **Circuit protective devices and wire sizes shall conform to the requirements of SSP 57000, Pressurized Payload Interface Requirements Document (IRD) or ISS approved International Partner equivalent, at the payload power distribution interface with ISS.** For payload power distribution within the payload, circuit protective devices shall be sized such that steady state currents in excess of those allowed by TM 102179 are precluded. Bent pins or conductive contamination in an electrical connector will not be considered a credible failure mode if a postmate functional verification is performed to assure that shorts between adjacent connector pins or from pins to connector shell do not exist. If this test cannot be performed, then the electrical design must insure that any pin if bent prior to or during connector mating cannot invalidate more than one inhibit and that conductive contamination is precluded by proper inspection procedures.
- 213.2 Batteries.** Batteries used on **ISS** payloads shall be designed to control applicable hazards caused by buildup or venting of flammable, corrosive or toxic gasses and reaction products; the expulsion of electrolyte; and by failure modes of overtemperature, shorts, reverse current, cell reversal, leakage, cell grounds, and overpressure. Safety guidelines for **ISS** payload batteries are contained in JSC 20793. Since lithium batteries have uniquely hazardous failure modes, their use is discouraged where the use of other types of cells is feasible. When lithium batteries are used, the **PSRP** will require extensive testing and analyses to demonstrate their safety under all applicable failure modes.
- 213.3 Lightning.** Payload electrical circuits may be subjected to the electromagnetic fields described in **Shuttle Orbiter/International Space Station Cargo Standard Interfaces (NSTS 21000-IDD-ISS)** due to a lightning strike to the launch pad. If circuit upset could result in a catastrophic hazard to the STS, the circuit design shall be hardened against the environment or insensitive devices (relays) shall be added to control the hazard.

214 VERIFICATION

Test, analysis, and inspection are common techniques for verification of design features used to control potential hazards. The successful completion of the safety process will require positive feedback of completion results for all verification items associated with a given hazard. Reporting of results by procedure/report number and date is required.

214.1 Mandatory Inspection Points (MIP's). When procedures and/or processes are critical steps in controlling a hazard and the procedure and/or process results will not be independently verified by subsequent test or inspection, it will be necessary to insure the procedure/process is independently verified in real-time. Critical procedure/process steps must be identified in the appropriate hazard report as MIP's requiring independent observation.

214.2 Verification Tracking Log. A payload safety verification tracking log (see NSTS/ISS 13830) is required to properly status the completion steps associated with hazard report verification items.

215 HAZARDOUS OPERATIONS

215.1 Hazard Identification. The payload organization shall assess all payload flight and ground operations and determine their hazard potential to the STS/ISS. The hazardous operations identified shall be assessed in the applicable flight or ground safety assessment report.

215.2 Exposure to Risk. STS/ISS exposure to increased risk as a result of ground or flight operations shall be minimized. Those ground operations (e.g., armplug installation in a payload pyrotechnic system, final ordnance connection, radioisotope thermoelectric generator (RTG) installation, etc.) which place the payload in a configuration of increased hazard potential shall be accomplished as late as practicable during the payload processing flow at the launch site.

215.3 Access. Payloads shall be designed such that any required access to hardware during flight or ground operations can be accomplished with minimum risk to personnel.

216 SERIES PAYLOADS AND REFLOWN HARDWARE

"Reflown hardware" are payloads or elements of payloads which are made up of hardware items that have already physically flown on the STS/ISS and are being manifested for reflight. "Series payloads" are payloads or elements of payloads which are of the same or similar design to previously flown STS/ISS payloads.

- 216.1 **Recertification of Safety.** Series payloads and reflown hardware must be recertified safe and must meet all the safety requirements of this document. Caution should be exercised in the use of previous safety verification data for the new usage.
- 216.2 **Previous Mission Safety Deficiencies.** All anomalies during the previous payload missions must be assessed for safety impact. Those anomalies affecting safety critical systems must be reported and corrected. Rationale supporting continued use of the affected design, operations or hardware must be provided for PSRP approval.
- 216.3 **Limited Life Items.** All safety critical age sensitive equipment must be refurbished or replaced to meet the requirements of the new ISS mission.
- 216.4 **Refurbishment.** Safety impact of any changes, maintenance or refurbishment made to the hardware or operating procedures must be assessed and reported in the safety assessment reviews (paragraph 304). Hardware changes include changes in the design of the payload, changes of the materials of construction, changes in sample materials that may be processed by the payload, etc.
- 216.5 **Safety Waivers and Deviations.** The acceptance rationale for all deviations from the previous flight must be revalidated by the payload organization. Waivered conditions from the previous missions must be corrected.

217 EXTRAVEHICULAR ACTIVITY (EVA)

All payload requirements for EVA must be defined and documented in the PIP. Any agreed to EVA task used to satisfy the failure tolerance criteria of this document can be used only as a third level of protection to safe a payload. Payload organizations which plan to use crew EVA for mission enhancement, mission success, or safety critical payload operations will comply with the requirements of NSTS 07700, Volume XIV, Appendix 7. Any payload outside the crew

habitable area within 24 inches of the SSP Orbiter sills or airlock hatch, and/or within any 48-inch worksite envelopes must meet EVA crewmember contact hazard requirements in NSTS 07700, Volume XIV, Appendix 7, for inadvertent contact, and the payload organization must document the associated hazards. Furthermore, all other payloads outside the crew habitable area must be assessed for compliance with EVA crewmember contact hazard requirements in NSTS 07700, Volume XIV, Appendix 7, for inadvertent contact, and the payload organization must document the associated hazards. All ISS external attached payloads must design to the sharp edge, protrusion and glove temperature requirements of NSTS 07700, Volume XIV, Appendix 7, even if EVA is not planned or anticipated.

218 PAYLOAD COMMANDING

All hazardous commands that can be sent to the payload shall be identified. Hazardous commands are those that can remove an inhibit to a hazardous function or activate an unpowered hazardous payload system. Failure modes associated with payload flight and ground operations including hardware, software, and procedures used in commanding from payload operations control centers (POCC's) and other ground equipment must be considered in the safety assessment to determine compliance with the requirements of paragraphs 200.1, 201, and 202. NSTS 19943 treats the subject of hazardous commanding and presents the guidelines by which it will be assessed.

219 FLAMMABLE ATMOSPHERES *(Note: Applicable if not transported within a pressurized volume)*

During Orbiter entry, landing, and postlanding operations (whether planned or contingency), the normal payload functions shall not cause ignition of a flammable payload bay atmosphere that may result from leakage or ingestion of fluids into the payload bay.

*** Paragraphs deleted

220.10 Fire Protection. Fire protection requirements reflect the operating environment that is of extended duration with low personnel density in the habitable volumes. These requirements are intended to be consistent with the standard operational ISS crew responses where practical using standardized design and operations approaches.

220.10a Fire Prevention.

(1) Control of potential fuels, oxidizers and flame propagation shall be accomplished by compliance with the materials control requirements of paragraph 209 above.

(2) Friction, spontaneous combustion and other identifiable potential ignition sources shall be controlled to not create a fire event. Proper electrical power distribution design in accordance with paragraph 213 above shall be practiced for reduction of potential ignition sources.

220.10b Fire Event Detection. Fire event detection is required to provide timely notification to the crew of a fire event for all potential fire event locations within the payload.

(1) The preferred means of fire detection shall be by use of an approved ISS rack smoke detector. Implementation of ISS rack smoke detectors includes crew notification of a fire event by activation of a Class I alarm via the ISS C&W system and interruption of power to the affected rack. Subrack payload volumes must exchange air with the rack volume if they are to be considered part of the general rack fire event location covered by the rack smoke detector.

(2) For potential payload fire event locations not covered by a rack smoke detector, the payload must provide alternate means to assure an undetected fire event does not occur. When a fire event (or precursor condition) is detected by the alternate means, data shall be provided to the ISS C&W and PCS systems for annunciation of the occurrence of the event and to enable display of its location.

220.10c Fire Event Suppression. The Payload shall include provisions to enable prompt control of fire events, should one occur. Where fire extinguisher access ports are provided, they shall be consistent with the ISS Portable Fire Extinguishers. Provisions shall be included for removal of power and termination of forced airflow when a confirmed event is detected. Where power is removed by an automatic safing device, it shall not be automatically re-applied. Sealed containers which can be shown to preclude replenishment of oxygen and contain combustion effects and products during a fire event may rely on self-extinguishment in lieu of active-suppression.

221 ELECTRICAL CONNECTIONS

The design of electrical connectors shall make it impossible to inadvertently reverse a connection or mate the wrong connectors if a hazardous condition can be created. Payload and on-orbit support equipment wire harnesses and connectors shall be designed such that no blind connections or disconnections must be made during payload installation, operation, removal, or maintenance on-orbit unless the design includes scoop proof connectors or other protective features.

222 DESIGN FEATURES

222.1 Sharp Edges and Corner Protection. Payload design within a pressurized module shall protect crewmembers from sharp edges, protrusions, etc., during all crew operations. Translation paths and adjacent equipment shall be designed to minimize the possibility of entanglement or injury to crewmembers.

222.2 Touch Temperatures. Payloads within a pressurized module shall be designed such that the crew will not be exposed to excessive high or low surface touch temperatures.

CHAPTER 3: SYSTEM PROGRAM REQUIREMENTS

300 GENERAL

The following requirements are applicable to all payloads.

301 SAFETY ANALYSIS

A safety analysis shall be performed in a systematic manner on each payload, its GSE, related software, and ground and flight operations to identify hazardous subsystems and functions. The safety analysis shall be initiated early in the design phase and shall be kept current throughout the development phase. A safety assessment report which documents the results of this analysis, including hazard identification, classification, and resolution, and a record of all safety-related failures, shall be prepared, maintained, and submitted in support of the safety assessment reviews conducted by the PSRP in accordance with paragraph 304. Detailed instructions for the safety analysis and safety assessment reports are provided in NSTS/ISS 13830.

302 HAZARD LEVELS

Hazards are classified according to potential as follows:

- 302.1 **Critical Hazard.** Can result in damage to ISS equipment, a nondisabling personnel injury or the use of unscheduled safing procedures that affect operations of the ISS or another payload.
- 302.2 **Catastrophic Hazard.** Can result in the potential for a disabling or fatal personnel injury, loss of the ISS, ground facilities or ISS equipment.

303 HAZARD REDUCTION

Action for reducing hazards shall be conducted in the following order of precedence:

- 303.1 **Design for Minimum Hazard.** The major goal throughout the design phase shall be to insure inherent safety through the selection of appropriate design features. Damage control, containment, and isolation of potential hazards shall be included in design considerations.

- 303.2 Safety Devices.** Hazards which cannot be eliminated through design selection shall be reduced and made controllable through the use of automatic safety devices as part of the system, subsystem, or equipment.
- 303.3 Warning Devices.** When it is not practical to preclude the existence or occurrence of known hazards or to use automatic safety devices, devices shall be employed for the timely detection of the condition and the generation of an adequate warning signal, coupled with emergency controls of corrective action for operating personnel to safe or shut down the affected subsystem. Warning signals and their application shall be designed to minimize the probability of wrong signals or of improper reaction to the signal.
- 303.4 Special Procedures.** Where it is not possible to reduce the magnitude of an existing or potential hazard through design or the use of safety and warning devices, special procedures shall be developed to counter hazardous conditions for enhancement of personnel safety.

304 SAFETY ASSESSMENT REVIEWS AND SAFETY CERTIFICATION

Safety assessment reviews will be conducted by the flight operator and the launch/landing site operator to determine compliance with the requirements of this document. An initial contact meeting will be held at the earliest appropriate time and will be followed by formal review meetings spaced throughout the development of the payload and its GSE. The depth, number, and scheduling of reviews will be negotiated with the payload organization and will be dependent on complexity, technical maturity, and hazard potential. The KSC and JSC phase III safety reviews and ground safety certification must be completed 30 days prior to delivery of the payload, ASE, and GSE to the launch site except as noted in NSTS/ISS 13830. The ground safety certification shall include statements that the payload GSE and ground operations are safe and in compliance with ground safety requirements and that open safety verification from the JSC safety reviews for payload design and flight operations will not affect safe ground operations. Rationale for acceptance of open flight verification (see paragraph 214.2) during ground operations must be submitted by the payload organization with the ground safety certification statement and approved by the launch/landing site operator prior to the start of ground

processing. The flight safety certification shall be submitted at least 10 days prior to the Flight Readiness Review (FRR). The flight safety certification shall include statements that the payload design and flight operations are safe and are in compliance with the safety requirements of this document.

305 SAFETY COMPLIANCE DATA

Safety compliance data packages shall be prepared by the payload organization to support ground operations of the payload at the launch and landing sites and inflight operations of the payload with the STS and ISS. Integrated payload complement safety compliance data packages shall be prepared by the rack integration organization.

305.1 For GSE and Ground Operations. The data listed below shall be submitted to the launch/landing site operator as part of the data package for the phase III ground safety review.

- a. A payload safety verification tracking log.
- b. A safety assessment report for GSE design and ground operations. See paragraph 301.
- c. Approved waivers and deviations.
- d. A log book maintained on each pressure vessel/system showing pressurization history, fluid exposure, and other pertinent data.
- e. A summary and safety assessment of all safety-related failures or accidents applicable to payload processing, test, and checkout.

305.2 For Payload Design and Flight Operations. The data listed below shall be submitted to the PSRP as part of the data package for the phase III flight safety review.

- a. A safety assessment report for payload design and flight operations. See paragraph 301.
- b. A payload safety verification tracking log.
- c. Approved waivers and deviations.

d. A summary and safety assessment of all safety related failures and accidents applicable to payload processing, test, and checkout.

e. A list of all pyrotechnic initiators installed or to be installed on the payload, giving the function to be performed, the part number, the lot number, and the serial number. Submittal of this list may be delayed to be concurrent with the submittal of the flight safety certification statement.

305.3 Post-Phase III Compliance. When the flight certification statement of paragraph 304 is submitted, it shall be included with an updated payload safety verification tracking log that documents the closeout of all required safety verification. The verification tracking log and the certification statements must reflect the final configuration of the payload that includes all post phase III safety activity.

306 MISHAP/INCIDENT/MISSION FAILURES INVESTIGATION AND REPORTING

Mishap/incident/mission failures investigation and reporting for NASA equipment will be handled under the provisions of NASA Headquarters policy documents NPD 8621.1 and NPG 8621.1. NSTS 07700, Volume VIII, Appendix R contains additional provisions for payload mishaps/incidents that involve the Space Shuttle. For mishap/incident/mission failures involving non-DOD payloads occurring after delivery to NASA facilities, investigation and reporting will be in compliance with the above NASA documents. The payload organization and the individual payload element or experiment contractors will cooperate fully with the investigation and provide any records, data, and other administrative or technical support and services that may be deemed by the NSTS to be pertinent. For DOD payloads, the "Agreement Between the Department of Defense and the National Aeronautics and Space Administration for Joint Investigation of Aircraft or Space System Mishaps" will be the controlling document.

APPENDIX A: GLOSSARY OF TERMS

ADIABATIC COMPRESSION DETONATION. An observed phenomenon whereby the heat obtained by compressing the vapors from fluids (e.g., hydrazine) is sufficient to initiate a self-sustaining explosive decomposition. This compression may arise from advancing liquid columns in sealed spacecraft systems.

ASE. Airborne support equipment. The flight equipment and systems needed to support the payload such as data recording, control functions, instrumentation, and payload cradles.

CATASTROPHIC HAZARD. A hazard which can result in the potential for: a disabling or fatal personnel injury; or loss of the Orbiter, ground facilities or STS equipment.

CERTIFICATE OF SAFETY COMPLIANCE. (Appendix C, Figure 3). A formal written statement by the payload organization attesting that the payload is safe and that all safety requirements for this document have been met and, if not, what waivers and deviations are applicable.

CONTROL. A device or function that operates an inhibit is referred to as a control for an inhibit and does not satisfy inhibit requirements. The electrical devices that operate the flow control devices in a liquid propellant propulsion system are exceptions in that they are referred to as electrical inhibits.

CORRECTIVE ACTION. Action taken to preclude occurrence of an identified hazard or to prevent recurrence of a problem.

CREDIBLE. A condition that can occur and is reasonably likely to occur. For the purposes of this document, failures of structure, pressure vessels, and pressurized lines and fittings are not considered credible failure modes if those elements comply with the applicable requirements of this document.

CREDIBLE SINGLE BARRIER FAILURE. (Material/Fluid Compatibility). Potential leaks within a component that permit fluid to directly contact the materials behind the barrier or expose secondary compartments to system pressure conditions shall be considered in single barrier failure analysis (e.g., leaks from a fluid enclosure to an adjacent enclosure such as through mechanical joints, O-rings, gaskets, bladders, bellows, and diaphragms). Redundant seals in series which have been acceptance pressure tested individually prior to flight shall not be considered credible single barrier failures. Failures of structural parts

such as pressure lines and tanks, and properly designed and tested welded or brazed joints are not considered single barrier failures. Metallic bellows and diaphragms designed for and tested to demonstrate sufficiently high margins can be considered for exclusion from the category of credible single barrier failure. In order to be classified as a noncredible failure, the item must be designed for a safety factor 2.5 on the maximum design pressure, pass appropriate manufacturing inspections (such as dye penetrant, radiographic, and visual inspections) and leak checks, and be certified for all the operating environments including fatigue conditions.

CRITICAL HAZARD. A hazard which can result in damage to STS equipment, a nondisabling personnel injury, or the use of unscheduled safing procedures that affect operations of the Orbiter or another payload.

DEPLOYABLE PAYLOAD. A payload which is planned for release from the Orbiter.

DEVIATION. Granted use or acceptance for more than one mission of a payload aspect which does not meet the specified requirements. The intent of the requirement should be satisfied and a comparable or higher degree of safety should be achieved.

EMERGENCY. (Flight Personnel). Any condition which can result in flight personnel injury or threat to life and requires immediate corrective action, including predetermined flight personnel response.

EVA. Extravehicular activity by the flightcrew.

FACTOR OF SAFETY. The factor by which the limit load is multiplied to obtain the ultimate load. The limit load is the maximum anticipated load or combination of loads, which a structure may be expected to experience. Ultimate load is the load that a payload must be able to withstand without failure.

FAILURE. The inability of a system, subsystem component or part to perform its required function under specified conditions for a specified duration.

FAILURE TOLERANCE. The number of failures which can occur in a system or subsystem without the occurrence of a hazard. Single failure tolerance would require a minimum of two failures for the hazard to occur. Two-failure tolerance would require a minimum of three failures for a hazard to occur.

FINAL SEPARATION. Final separation from the Orbiter is achieved when the last physical connection between the payload and the Orbiter and/or payload ASE is severed and the payload becomes a free-flying payload.

FLIGHTCREW. Any personnel onboard the Space Shuttle engaged in flying the Space Shuttle and/or managing resources onboard, e.g., commander, pilot, and mission specialist.

GPC. Orbiter's General Purpose Computer.

GSE. Ground support equipment.

GROUND CREW. With respect to inflight monitoring, the term includes any personnel supporting the payload officer from a console in the Mission Control Center (MCC), remote POCC, or other support area.

HAZARD. The presence of a potential risk situation caused by an unsafe act or condition. A condition or changing set of circumstances that presents a potential for adverse or harmful consequences; or the inherent characteristics of an activity, condition, or circumstance which can produce adverse or harmful consequences.

HAZARD DETECTION. An alarm system used to alert the crew to an actual or impending hazardous situation for which the crew is required to take corrective or protective action.

INDEPENDENT INHIBIT. Two or more inhibits are independent if no single credible failure, event or environment can eliminate more than one inhibit.

INHIBIT. A design feature that provides a physical interruption between an energy source and a function (e.g., a relay or transistor between a battery and a pyrotechnic initiator, a latch valve between a propellant tank and a thruster, etc.).

JSC. Johnson Space Center, NASA, Houston, Texas.

KSC. Kennedy Space Center, NASA, Florida.

MANNED PRESSURIZED VOLUME. Any module in which a person can enter and perform activities in a shirt-sleeve environment.

MISHAP/INCIDENT. An unplanned event which results in personnel fatality or injury; damage to or loss of the STS, environment, public property or private property; or could result in an unsafe

situation or operational mode. A mishap refers to a major event, whereas an incident is a minor event or episode that could lead to a mishap.

MCC. Mission Control Center.

MONITOR. Ascertain the safety status of payload functions, devices, inhibits, or parameters.

NONCOMPLIANCE REPORT. A report documenting a condition in which a requirement cannot be met. It is the report used to request a waiver or deviation. See NSTS/ISS 13830 and Appendix C Figure 2.

NORMAL STS MISSION PHASES. All portions of the mission to be performed by the STS, excluding STS abort and emergency landing.

NSI. NASA standard initiator (pyrotechnic). The NSI is provided to the payload customer by NASA.

OFFGASSING. The emanation of volatile matter of any kind from materials into habitable areas.

OPERATOR ERROR. Any inadvertent payload operation by either flight personnel or the ground crew that affects either the Orbiter or a payload.

PAYLOAD. Any equipment or material carried by the STS that is not considered part of the basic STS itself. It, therefore, includes items such as free-flying automated spacecraft, individual experiments or instruments, and ASE. As used in this document, the term payload also includes payload-provided GSE and systems and flight and ground systems software.

PAYLOAD ELEMENTS. Experiments, instruments or other individual payload items which are subsets of an integrated, multipayload cargo complement on missions such as Spacelab, Long Duration Exposure Facility, etc.

PAYLOAD ORGANIZATION. The funding or sponsoring organization for the experiment, payload or mission. This does not mean the principal investigator, payload contractor, designer or developer except to the extent delegated by the sponsoring organization. For NASA payloads, a NASA Headquarters payload program office is the sponsoring organization and usually delegates to a NASA field installation the authority for formal interface with the NSTS in implementation of this document. Other payload organizations include, but are not limited to, the following: DOD, other U.S. Government agencies, non-U.S. Government public organizations, private persons or private organizations, international organizations, European Space Agency, and foreign governments.

PERSONNEL INJURY. With respect to catastrophic hazard levels for STS payloads, personnel injury will be limited to loss of life or major injury which can lead to either temporary or permanent incapacitation of the crew (e.g., bone fractures, second or third degree burns, severe lacerations, internal injury, severe (greater than 1Gy) radiation exposure, and unconsciousness). Other personnel injuries are related to a critical hazard level provided the injury does not impact the flightcrew's capability to accomplish safety critical tasks.

POCC. Payload Operations Control Center.

PRESSURE VESSEL. A container designed primarily for pressurized storage of gases or liquids and: (1) contains stored energy of 14,240 foot-pounds (0.01 pounds trinitrotoluene (TNT) equivalent) or greater based on adiabatic expansion of a perfect gas; or(2) will experience a design limit pressure greater than 100 pounds per square inch absolute (psia); or (3) contains a fluid in excess of 15 psia which will create a hazard if released.

RF. Radio frequency.

SAFE. A general term denoting an acceptable level of risk, relative freedom from, and low probability of: personal injury; fatality; damage to property; or loss of the function of critical equipment.

SAFETY ANALYSIS. The technique used to systematically identify, evaluate, and resolve hazards.

SAFETY CRITICAL. Containing an element of risk. Necessary to prevent a hazard.

SAFING. Actions which eliminate or control hazards.

SEALED CONTAINER. A housing or enclosure designed to retain its internal atmosphere and which does not meet the pressure vessel definition (e.g., an electronics housing).

SPACE SHUTTLE. The Orbiter, solid rocket boosters and external tank.

STRUCTURE. Any assemblage of materials which is intended to sustain mechanical loads.

STS ABORT. An abort of the STS mission wherein flight personnel, payload, and vehicle are returned to a landing site.

WAIVER. Granted use or acceptance of a payload aspect which does not meet the specified requirements; a waiver is given or authorized for one mission only. Safety waivers could include acceptance of increased risk.

APPENDIX B: APPLICABLE DOCUMENTS

Except as noted below the latest revision of the following documents form a part of this document to the extent specified herein. In the event of conflict between the reference documents and the contents of this document, the contents of this document will be considered superseding requirements. These documents can be accessed through the Johnson Space Center Payload Safety website: <http://jsc-web-pub.jsc.nasa.gov/psrp/>.

DOCUMENT NUMBERS AND TITLES	REFERENCED IN PARAGRAPH
SAMTO HB S-100/KHB 1700.7 , Space Transportation System Payload Ground Safety Handbook.	101.1
NSTS/ISS 13830 , Payload Safety Review and Data Submittal Requirements	103.1, 200, 200.2, 208.4, 210.2, 212.1, 214.2, 301, 304
NSTS 18798 , Interpretations of NSTS/ISS Payload Safety Requirements.	103.2
NSTS 16979 , Part 1, Shuttle Orbiter Failure Modes and Fault Tolerances for Interface Services. Part 2, Failure Modes and Fault Tolerances for STS Payload Optional Service Kit Hardware.	200.4
MIL-STD-1576 , July 31, 1984, Electroexplosive Subsystem Safety Requirements and Test Methods for Space Systems.	202.1, 210, 210.1
Item deleted	
NASA-STD-6001 , Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion (formerly NHB 8060.1C)	202.2c, 209.1a, 209.2, 209.2a, 209.2b, 209.3, 220.1a(1)
NSTS 07700 , Volume XIV, Attachment 1, (ICD 2-19001), Shuttle Orbiter/Cargo Standard Interfaces.	202.5, 213.3, 220.1b, 220.2a
NSTS 14046 , Payload Verification Requirements.	208.1, 208.4, 220.9
NASA-STD-5003 , Fracture Control Requirements for Payloads Using the Space Shuttle.	208.1

DOCUMENT NUMBERS AND TITLES**REFERENCED IN PARAGRAPH**

MSFC-SPEC-522 , Revision B, Design Criteria for Controlling Stress Corrosion Cracking.	208.3
MSFC-HDBK-527/JSC 09604 , Materials Selection List for Space Hardware Systems.	208.3, 209, 209.3
MIL-STD-1522 , Revision A, including changes as of December 1984, Standard General Requirement for Safe Design and Operation of Pressurized Missile and Space Systems.	208.4
JSC 27472 , Requirements for Submission of Data Needed for Toxicological Assessment of Chemicals and Biologicals to be Flown on Manned Spacecraft.	209.1
NSTS 22648 , Flammability Configuration Analysis for Spacecraft Systems.	209.2
NSTS 08060 , Space Shuttle System Pyrotechnic Specification.	210.2
JSC 20793 , Manned Space Vehicle, Battery Safety Handbook.	212.2
ANSI-Z-136.1 , American National Standard for Safe Use of Lasers.	212.3
NSTS 07700 , Volume XIV, Appendix 7, System Description and Design Data - Extravehicular Activities.	217
NSTS 19943 , Command Guidelines for STS Customers.	218
JSC 20584 , Listing of Spacecraft Maximum Allowable Trace Gas Concentrations.	220.1a, 220.1c
NASA-STD-3000 , Volume 1, Man-Systems Integration Standards.	220.2, 220.2b
American Conference of Governmental Industrial Hygienists (ACGIH) , "Threshold Limit Values and Biological Exposure Indices for 1987-1988."	220.7b, 212.4
NPD 8621.1 , NASA Mishap Reporting and Investigating Policy.	306
NPG 8621.1 , NASA Procedures and Guidelines for Mishap Reporting, Investigating, and Record Keeping.	306

DOCUMENT NUMBERS AND TITLES**REFERENCED IN PARAGRAPH**

NSTS 07700 , Volume VIII, Appendix R, Space Shuttle Program Contingency Action Plan.	306
Agreement Between the Department of Defense and the National Aeronautics and Space Administration for Joint Investigation of Aircraft or Space System Mishaps.	306
SSP 30425 , Space Station Program Natural Environment Definition for Design.	
SSP 30237 , Space Station Electromagnetic Emission and Susceptibility Requirements for EMC	202.5, 212.2
SSP 50005 , International Space Station Crew Integration Standard (NASA Standard 3000)	202.5
SSP 52005 , ISS Payload Flight Equipment Requirements and Guidelines for Safety Critical Structures	208.1
TM 102179 , Selection of Wires and Circuit Protective Devices for Orbiter Vehicle Payload Electrical Circuits	213.1
Threshold Limit Values for Chemical Substances and Physical Agents published by the American Conference of Governmental Industrial Hygienists	212.4
NSTS 21000-IDD-ISS , Shuttle Orbiter/International Space Station Cargo Standard Interfaces	202.5, 213.3

APPENDIX C: FIGURES

SAFE DISTANCE FOR FIRING LIQUID PROPULSION THRUSTERS

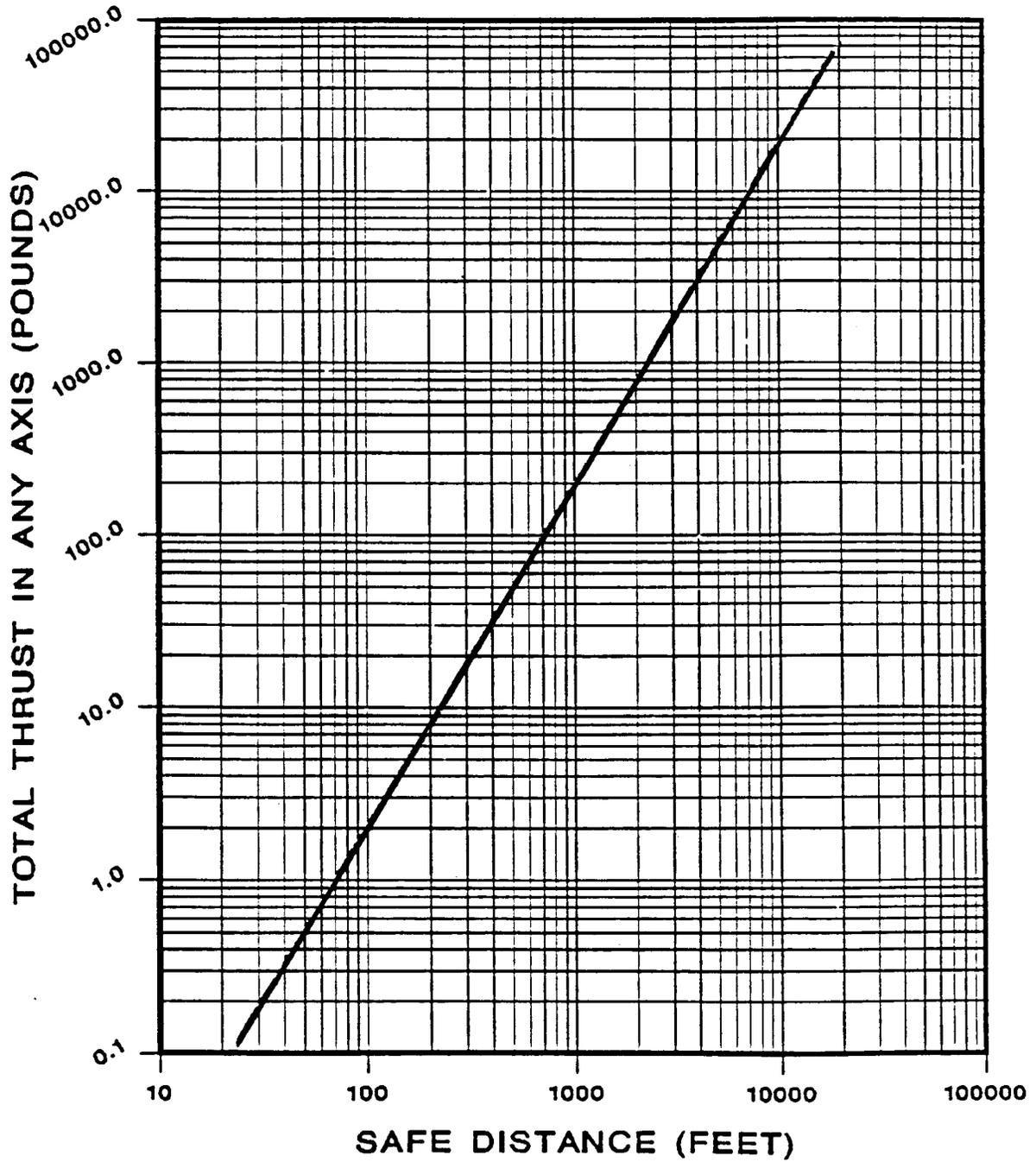


Figure 1.- Safe distance for firing liquid propulsion thrusters.

PAYLOAD SAFETY NONCOMPLIANCE REPORT		NO.	DATE
TITLE <i>(Brief reference to noncompliance)</i>			
PAYLOAD IDENTIFICATION <i>(Include reference to applicable payload element, subsystem, or component)</i>			
APPLICABLE REQUIREMENT			
DESCRIPTION OF NONCOMPLIANCE <i>(Specify how the design or operation does not meet the safety requirements)</i>			
HAZARD OR HAZARD CAUSE <i>(Include reference to Payload Hazard Report)</i>			
REASON REQUIREMENT CANNOT BE FULFILLED			
RATIONAL FOR ACCEPTANCE <i>(Define the design feature or procedure used to conclude that the noncompliance condition is safe. Attach applicable support data i.e. drawings, test reports, analyses, etc.)</i>			
APPROVAL SIGNATURES			
PAYLOAD ORGANIZATION			DATE
WAIVER APPROVAL		DEVIATION APPROVAL	
EFFECTIVITY		EFFECTIVITY	
NSTS/ISS PROGRAM	DATE	NSTS/ISS PROGRAM	DATE

JSC Form 542C (Rev Mar 83) (MS Word May 97)

Figure 2.- Payload Safety Noncompliance Report.

CERTIFICATE OF NSTS/ISS PAYLOAD SAFETY COMPLIANCE

FOR

a. PAYLOAD/MISSION/CARRIER: _____

b. Applicable to:

____ Payload Design and Flight Operations

____ Ground Support Equipment Design and Ground Operations

c. The Payload Organization Hereby Certifies that:

____ For STS, the Payload Complies with all Applicable Requirements of the NSTS 1700.7 (current issue), "Safety Policy and Requirements for Payloads Using the National Space Transportation System," and/or KHB 1700.7, "Space Shuttle Payload Ground Safety Handbook."

____ For ISS, the Payload Complies with all Applicable Requirements of the NSTS 1700.7 (current issue), "Safety Policy and Requirements for Payloads Using the National Space Transportation System," NSTS 1700.7 ISS Addendum (current issue), "Safety Policy and Requirements for Payloads Using the International Space Station," and/or KHB 1700.7, "Space Shuttle Payload Ground Safety Handbook"; and,

1) The Payload is Safe with Design Life of: _____

2) The Payload is Safe for an Operational Life of: _____

d. Approved Waivers/Deviations: _____

e. Approved (Payload Organization Manager):

f. Date: _____

JSC Form 1114A (Rev February 20, 2001) (MS Word September 1997)

Figure 3.- Certificate of NSTS Payload Safety Compliance.