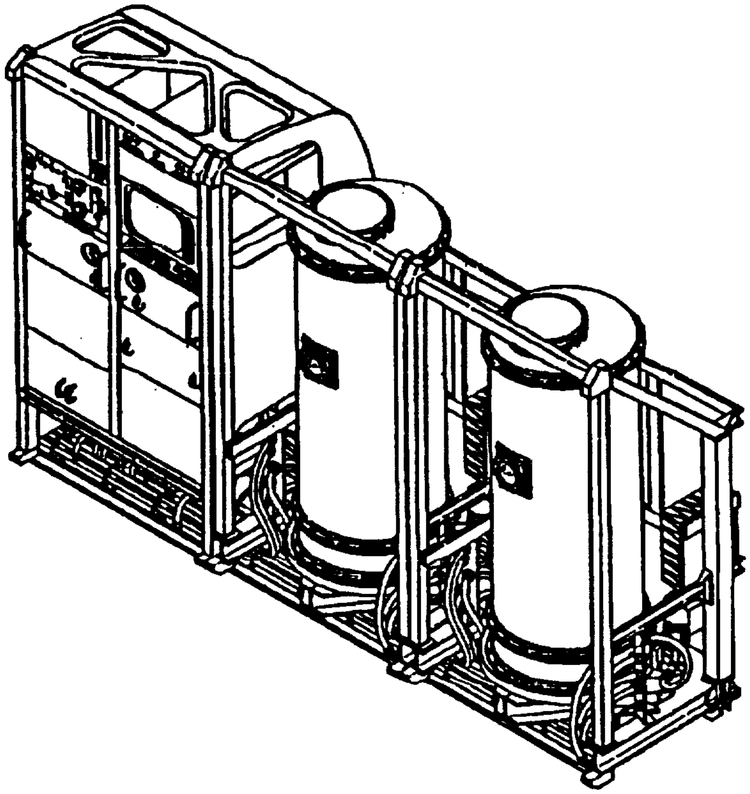
SPACE STATION FURNACE FACILITY
Contract End Item Specification (CEI), Part I



DR-7
May 1992

Volume II, Appendix 1
Final Study Report (DR-8) of
Space Station Furnace Facility
Contract No. NAS8-38077

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9 April 1992

CONTRACT END ITEM SPECIFICATION PART I

FOR

SPACE STATION FURNACE FACILITY CORE

(DRAFT)

National Aeronautics & Space Administration
Marshall Space Flight Center
Huntsville, AL 35812

(NASA-CR-192473) SPACE STATION FURNACE FACILITY. VOLUME 2: APPENDIX 1: CONTRACT END ITEM SPECIFICATION (CEI), PART 1 Final Report (Teledyne Brown Engineering) 117 p

N93-23083

Unclas

G3/35 0157532

This was prepared by Teledyne Brown Engineering under contract to NASA. It was developed for the Payload Projects Office at the Marshall Space Flight Center.

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ACKNOWLEDGEMENT

This document is the Preliminary Contract End Item (CEI) Specification developed for the Space Station Furnace Facility. The initial document was developed and revised by Teledyne Brown Engineering (TBE) under contract to George Marshall Space Flight Center. This document was delivered to the Contracting Technical Office Representative (COTR) in April of 1992. The document was subsequently submitted for internal review by MSFC and updated. This document was baselined and released with a draft Request for Proposals and the initiation of the procurement process for the Phase C/D development. To avoid confusion during the procurement process, the CEI Specification included in this report is the baselined version released for the draft RFP.

CONTRACT END ITEM SPECIFICATION PART 1

FOR

SPACE STATION FURNACE FACILITY CORE

(DRAFT)

ABBREVIATIONS AND ACRONYMS

A	amperes
ASTM	American Society for Testing and Materials
atm	atmospheres
AWG	American Wire Gage
CCB	Configuration Control Board
CDR	Critical Design Review
CEI	Contract End Item
cfm	cubic feet per minute
CRD	Capabilities Requirements Document
dB	decibels
dc	Direct Current
DMS	Data Management System
EDU	Engineering Design Unit
EEE	Electrical, Electronic, and Electromechanical
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Isolation
EPS	Electrical Power System
ERD	Experiment Requirements Document
ESF	Experiment Specific Function
EVA	Extravehicular Activity
FDDI	Fiber Distributed Data Interface
FDS	Fire Detection System
FMEA	Failure Modes and Effects Analysis
FO	Functional Objective
FSE	Flight Support Equipment
GBytes	Gigabytes
GDS	Gas Distribution System
GFE	Government Furnished Equipment
GIDEP	Government/Industry Data Exchange Program
GN_2	Gaseous Nitrogen
GSE	Ground Support Equipment
HOL	high order language
hr	hour
HRDL	High Rate Data Link
Hz	Hertz
IC1	Integrated Configuration 1
IC2	Integrated Configuration 2
ICD	Interface Control Document
ISPR	International Standard Payload Rack
JSC	Johnson Space Center
kbits	kilobits
Kg	kilogram
kPa	kilopascals
KSC	Kennedy Space Center
kW	kilowatts
LNS	Liquid Nitrogen System
MPE	Mission Peculiar Equipment
MPLM	Mini-Pressurized Logistics Module
ms	milliseconds
MSAD	Microgravity Science Application Division
MSFC	Marshall Space Flight Center
MTBF	Mean Time Between Failures

ABBREVIATIONS AND ACRONYMS (Continued)

MTC	Man Tended Configuration
MUA	Materials Usage Agreement
N	newtons
NASA	National Aeronautics and Space Administration
NDE	Nondestructive Evaluation
NSPAR	Nonstandard Part Approval Request
NTSC	National Television Standard Code
ORU	Orbital Replacement Unit
OSSA	Office of Space Science and Applications
PDR	Preliminary Design Review
PES	Payload Executive Software
PIND	Particle Impact Noise Detection
POCC	Payload Operations Control Center
psia	pounds per square inch absolute
psid	pounds per square inch differential
PW	Printed Wire
QC	Quality Control
CRD	Capabilities Requirements Document
SSF	Space Station Freedom
SSFF	Space Station Furnace Facility
SSP	Space Station Program
STS	Space Transportation System
TBD	To Be Determined
TCS	Thermal Control System
UF	Utilization Flight
USL	U.S. Laboratory
V	volts
VC	Visibly Clean
VDC, Vdc	Volts DC
VES	Vacuum Exhaust System
W	watts

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

1. SCOPE

1.1 Scope

This specification establishes the performance, design, development, and verification requirements for the Space Station Furnace Facility (SSFF) Core.

1.2 Specification Overview

This specification presents the definition of the SSFF Core and its interfaces, specifies requirements for the SSFF Core performance, specifies requirements for the SSFF Core design and construction, and establishes the verification requirements.

1.3 CEI Specification Basis

This specification was formulated using the SSFF Capabilities Requirements Document (CRD), JA55-032. The CRD is the basis for the design requirements for both the SSFF Core and the selected furnace modules.

2. APPLICABLE DOCUMENTS

The following documents, latest revision unless otherwise specified, are a part of this specification to the extent specified herein. In the event of conflict between documents referenced herein and the contents of this specification, this specification shall apply.

2.1 Space Station Program Documents

Document Number	Title
SSP 30219	Space Station Reference Coordinate System
SSP 30482	SSF Electrical Power Specification and Standard Vol. I EPS Electrical Verification Specification
SSP 30482	SSF Electrical Power Specification and Standard Vol II Consumer Restraints
SSP 41002	International Standard Payload Rack NASA/ESA/NASDA Modules Interface Control Document
SS-HDBK-0001	WP01 Elements Accommodation Handbook
SS-RQMT-0009	MSFC Space Station Documentation Preparation Requirements
SS-SPEC-0003	Logistics Elements Contract End Item Specification
SS-SRD-0001B	Space Station Freedom Program Definition and Requirements, System Requirements

2.2 MSFC Documents

Document Number	Title
JA-418	Payload Flight Equipment Requirements for Safety Critical Structures
MM 8040.12	Standard Contractor Configuration Management Requirements, MSFC Programs
MM 8075.1	MSFC Software Management and Development Requirements 91 Manual
MMI 1710.6	MSFC Program for Personnel Certification
MMI 5320.1	Implementation of the NASA Standards Parts Program
MMI 6400.2	Management Instruction-Packaging, Handling, and Moving Program Criteria Hardware
MSFC-HDBK-505	Structural Strength Program Requirements
MSFC-HDBK-527	Materials Selection List for Space Hardware Systems

MSFC-HDBK-668	Model Data Procurement Document for Spacelab Payload (Instrument or Facility) Phase C/D Contracts
MSFC-HDBK-1453	Fracture Control Program Requirements
MSFC-PROC-1301	Guidelines for Implementation of Materials Control Procedures
MSFC-SPEC-222	Resin Compounds, Electrical and Environment Insulation, Epoxy
MSFC-SPEC-250	Protective Finishes for Space Vehicles Structures and Associated Flight Equipment, General Specification for
MSFC-SPEC-266	Plates, Identification, Metal Foil, Adhesive Backed
MSFC-SPEC-494	NASA Installation of Wiring Assembly (Electrical Wiring), Space Vehicle, General Specification for
MSFC-SPEC-504	Welding, Aluminum Alloys
MSFC-SPEC-522	Design Criteria for Controlling Stress Corrosion Cracking
MSFC-SPEC-548	Vacuum Baking of Electrical Connectors
MSFC-SPEC-560	Specification, Welding, Steel, Corrosion and Heat Resistant Alloys
MSFC-SPEC-684	Vacuum Baking of Electrical Cables
MSFC-SPEC-708	Harness Identification Marker
MSFC-SPEC-1198	Screening Requirements for Non-Standard Electrical, Electronics, and Electromechanical Parts
MSFC-STD-156	Riveting, Fabrication and Inspection, Standard for
MSFC-STD-275A	Marking of Electrical Ground Support Equipment, Front Panels, and Rack Title Plates
MSFC-STD-349	Standard Electrical and Electronic Reference Designations
MSFC-STD-355	Radiographic Inspection of Electronic Parts
MSFC-STD-481	Radiographic Inspection Procedures and Acceptance Standards for Fusion Welded Joints in Stainless and Heat Resistant Steel
MSFC-STD-486	Threaded Fasteners, Torque Limits for
MSFC-STD-506	Materials and Processes Control
MSFC-STD-509	Lubricant Selection
MSFC-STD-512	Man/System Requirements for Weightless Environments

MSFC-STD-513	Personnel Certification for Packaging, Handling, and Moving of Program Critical Hardware
MSFC-STD-531	High Voltage Design Criteria
MSFC-STD-555A	MSFC Engineering Documentation Standard (Supersedes MSFC-STD-555)
MSFC-STD-561	Threaded Fasteners, Securing of Safety Critical Flight Hardware Structure Used on Shuttle Payloads and Experiments
MSFC-STD-655	Weld Filler Metal, Control of
MSFC-STD-781	Standard for Electrical Contacts, Retention Criteria
MSFC-STD-1249	Standard, NDE Guidelines and Requirements for Fracture Control Programs
S&E 5310.2	Equipment Logs/Records

2.3 JSC Documents

Document Number	Title
JSC-20793	Manned Space Vehicle Battery Safety Handbook
JSC 30200	Documentation Format Requirements
JSC-SC-M-0003	Functional Design Requirements for Manned Spacecraft and Related Flight Crew Equipment, Markings, Labeling, and Color
JSC-SE-R-0006	General Specification Requirements for Materials and Processes
JSC-SL-E-0002	Electromagnetic Interference Characteristics, Requirements for Equipment
JSC-SN-C-0005	NASA Specification Contamination Control Requirements for the Space Shuttle Program
JSC-SPEC-M1	Specification, Marking and Identification
JSC-SP-R-0022	General Specification Vacuum Stability Requirements of Polymeric Material for Spacecraft Application
NSTS 1700.7	Safety Policy Requirements for Payloads using the Space Transportation System
NSTS 13830	Implementation Procedures for STS Payloads System Safety Requirements
NSTS 18798	Interpretations of STS Payload Safety Requirements

2.4 Other NASA Documents

Document Number	Title

CR 5320.9	Payload and Experiment Failure Mode and Effects Analysis and Critical Items List Groundrules (NASA)
FED-STD-209	Clean Room and Work Station Requirements, Controlled Environment
ICD-2-19001	Shuttle Orbiter/Cargo Standard Interfaces
KHB 1700.7	Space Transportation System Payload Ground Safety Handbook
NASA-RP-1024	Anthropometric Volume I
NASA-STD-3000	Volume IV: Space Station Man-Systems Integration Standards
NHB 5300.4 (1B)	Quality Program Provisions for Aeronautical and Space System Contractors
NHB 5300.4 (1D-2)	Safety, Reliability, Maintainability, and Quality Provisions for the Space Shuttle Program
NHB 5300.4 (3A-1)	Requirements for Soldered Electrical Connections
NHB 5300.4 (3G)	Requirements for Interconnecting Cables, Harnesses, and Wiring
NHB 5300.4 (3H)	Requirements for Crimping and Wire Wrap
NHB 5300.4 (3I)	Requirements For Printed Wiring Boards
NHB 5300.4 (3J)	Requirements for Conformal Coating and Staking of Printed Wiring Boards and Electronic Assemblies
NHB 5300.4 (3K)	Design Requirements for Rigid Printed Wiring Boards and Assemblies
NHB 6000.1	Requirements for Packaging, Handling, and Transportation for Aeronautical and Space Systems, Equipment, and Associated Components
NHB 8060.1	Flammability, Odor, and Offgassing Requirements and Test Procedures for Materials in Environments that Support Combustion
NHB 8071.1	Fracture Control Requirements for Payloads Using the National Space Transportation System

2.5 Military Documents

Document Number	Title
DOD-STD-100	Engineering Drawing Practices
MIL-B-5087	Bonding, Electrical, and Lightning Protection for Aerospace Systems
MIL-B-7883	Brazing of Steels, Copper Alloys, Nickel Alloys, Aluminum and Aluminum Alloys

MIL-C-17	Cables, Radio Frequency, Flexible and Semi-rigid, General Specification for
MIL-C-5015	Connectors, Electrical, Circular, Threaded, AN Type, General Specification for
MIL-C-5541	Chemical Conversion Coatings on Aluminum Alloys
MIL-C-27500	Cable, Electrical, Shielded and Unshielded, Aerospace
MIL-C-39012	Connectors, Coaxial, Radio Frequency, General Specifications for
MIL-E-45782	Electrical Wiring, Procedure for
MIL-HDBK-5	Metallic Materials and Elements for Aerospace Vehicle Structures
MIL-HDBK-17	Plastics for Aerospace Vehicles
MIL-HDBK-23	Structural Sandwich Composites
MIL-HDBK-216	R.F. Transmission Lines and Fittings
MIL-P-27401	Propellant Pressurizing Agent, Nitrogen
MIL-P-55110	Printed Wiring Boards, General Specification for
MIL-S-7742	Screw Threads, Standard Optimum Selected Series, General Specification for
MIL-S-83519	Shield Termination, Solder Style, Insulated, Heat-Shrinkable, Environment Resistant, General Specification for
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-130	Identification Marking of US Military Property
MIL-STD-453	Inspection, Radiographic
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462	Electromagnetic Interferences Characteristics, Measurement of
MIL-STD-750	Test Methods for Semiconductor Devices
MIL-STD-883	Test Methods and Procedures for Microelectronics
MIL-STD-889	Dissimilar Metals
MIL-STD-970	Standards and Specifications, Order of Preference for the Selection of

MIL-STD-975	NASA Standard Electrical, Electronic, and Electromechanical (EEE) Parts List
MIL-STD-981	Design, Manufacturing, and Quality Standards for Custom Electromagnetic Devices for Space Applications
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment & Facilities
MIL-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)
MIL-T-31000	Military Specification, Technical Data Packages, General Specification for
MIL-T-43435	Military Specification, Tape, Lacing and Typing
MIL-W-6858	Welding, Resistance; Aluminum, Magnesium, Non-Hardening Steels or Alloys, Nickel Alloys, Heat Resisting Alloys, and Titanium Alloys; Spot and Seam
MIL-W-22759/3	Wire, Electric, Fluoropolymer-Insulated, TFE-Glass-TFE, Nickel-Coated Copper Conductor, 600-Volt
MIL-W-22759/12	Wire, Electric, Fluoropolymer-Insulated, Extruded TFE, Nickel-Coated Copper Conductor, 600-Volt
MIL-W-22759/23	Wire, Electric, Fluoropolymer-Insulated, Extruded TFE, Nickel-Coated High Strength Copper Alloy Conductor, 600-Volt

2.6 Other Documents

Document Number	Title
320SPC0003	Critical Item Specification for Space Station Furnace Facility Rack Structures
D683-10577-1	Space Station Freedom Thermal Control System Coolant
JA55-032	Space Station Furnace Facility Capability Requirements Document
NAS 1746	Splice Shield Determination, Solder Style, Infrared Shrinkable, Insulated, Moisture Resistant
QQ-B-575	Braid, Wire, (Copper, Tin-Coated, or Silver Coated, Tubular or Flat)
QQ-R-566	Rod and Electrodes, Welding Aluminum and Aluminum Alloys
S683-29618	Prime Item Development Specification for Space Station Freedom United States Laboratory Vacuum System

3. REQUIREMENTS

3.1 Definition

The following paragraphs provide a general description of the SSFF, mission and operation concepts, systems engineering requirements and logistics component information.

3.1.1 General Description

The Space Station Furnace Facility (SSFF) is a multiple rack facility for materials research in the microgravity environment of the Space Station Freedom (SSF) United States Laboratory (USL). The SSFF will support materials research into the crystal growth and solidification processes of electronic and photonic materials, metals and alloys, glasses, and ceramics. To support this broad base of research requirements, the SSFF will operate, regulate, and support a variety of furnace modules.

The SSFF is an integrated facility that provides the functions, interfaces and equipment required to perform high temperature microgravity materials processing experiments aboard the SSF. This facility consists of two main parts: the SSFF Core and the experiment modules. The facility is designed to accommodate two experimenter-provided furnace modules housed within the two experiment racks, and is designed to operate these two furnace modules simultaneously.

Physically, the SSFF consists of three double-rack rack locations within the SSF. One rack, the Core rack, houses the central SSFF Core equipment. The other two racks, the experiment racks, house the distributed Core equipment and the furnace modules.

The SSFF Core equipment provides the functions of interfacing to the SSF services, conditioning and control of the services for furnace module use, providing the controlled services to the furnace modules, and interfacing to and acquiring data from the furnace modules.

3.1.1.1 Nomenclature - The designation SSFF includes the racks (Core Rack, Experiment Rack 1, and Experiment Rack 2), subsystems, SSF interface connections, and the furnace module interface connections. The term "Furnace Module(s)" includes the materials processing furnace(s) and associated equipment provided by the furnace experiment developer(s). Integrated Configuration One (IC1) includes the core and one experiment rack with an integrated furnace module. Integrated Configuration Two (IC2) includes the core rack and two experiment racks with integrated furnace modules.

3.1.1.2 Interface Definition - Interfaces between the SSF USL, GSE, and SSFF are shown in Figure 1.

3.1.2 Mission

The mission of the SSFF is to provide a SSF facility that can accommodate a wide range of microgravity materials processing experiments. To this end, the SSFF shall provide the capability of being reconfigured to meet the operational and performance requirements of these experiments, including the accommodation of a number of different materials processing furnace types. The range of performance requirements for these furnace types is defined in JA55-032. The SSFF shall occupy up to three adjacent rack locations in U.S. Laboratory Module-A of the SSF. Initial on-orbit operation is scheduled to begin in 1997 with two of the three rack structures and one furnace module, the Integrated Configuration One (IC1). The full SSFF three rack configuration (Integrated Configuration Two (IC2)) will be completed following the launch and on-orbit integration of the second experiment rack and furnace module in 1999.

3.1.2.1 Flights - Planned life for the SSFF is 30 years with components designed for 10 years. Design shall permit processing and integration into the Logistics Module at the Kennedy Space Center (KSC) and processing and integration into the SSF-USL Module on-orbit. The SSFF rack containing the core systems is to remain on orbit with in-flight replacement and repair of components as required to maintain operations during the life of the SSF. The Core and experiment rack assemblies will be of modular construction to allow component maintenance, component replacement, or experiment rack replacement as dictated by the mission manifest and the need for periodic refurbishment of the furnace modules.

3.1.2.2 Orbital Conditions - The SSFF is designed for use in the USL Module in the SSF standard orbit to utilize the microgravity environment.

3.1.3 Operational Concepts

The SSFF will be built up in two stages to reach the final flight configuration. The first stage is the launch and on-orbit operation of the core system rack and one experiment rack with an integrated furnace module, SSFF IC1. The second stage will be the launch and integration of the second experiment rack with an integrated furnace module, SSFF IC2. The initial SSFF launches and follow-on launches will be aboard the Mini Pressurized Logistics Module (MPLM) Utilization Flights (UF's).

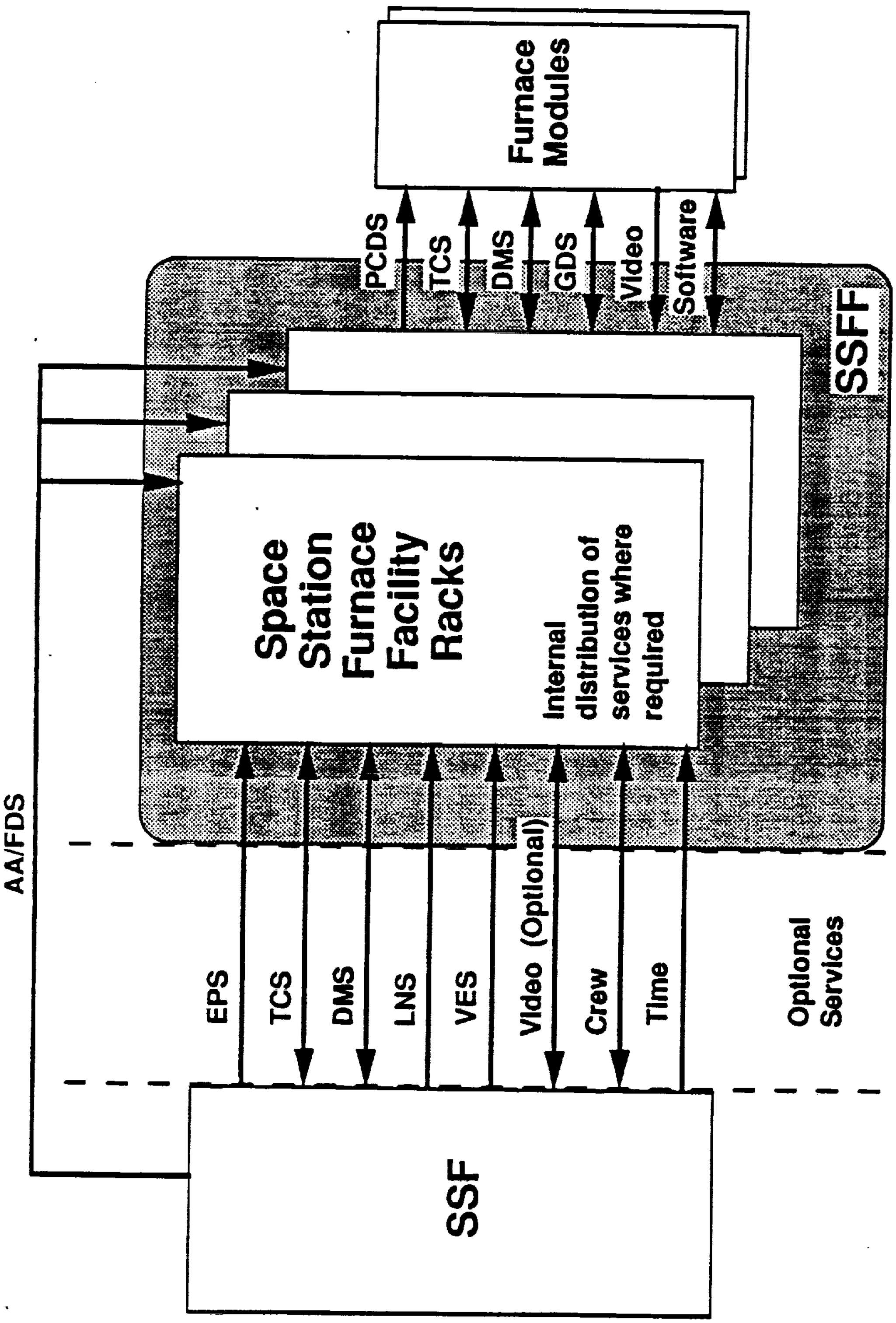


Figure 1. Space Station Furnace Facility Resource Interfaces

3.1.3.1 Ground Operations Concepts and Constraints - An Operations and Maintenance Processing Flow will be developed to define the ground operations concepts and constraints. Existing Ground Support Equipment (GSE) will be used to the maximum extent possible for ground integration and testing of the SSFF. GSE and ground operations shall comply with the safety constraints identified in KHB 1700.7A. The SSFF hardware will be designed to minimize the complexity of on-orbit integration.

3.1.3.1.1 Preflight Processing - Preflight processing will consist of integration and checkout of the furnace module, individual racks, the integrated furnace module and rack, and the SSFF as an integrated system (IC1). Interfaces shall be progressively verified, using interface simulators before each integration as the build of the SSFF is performed. The interface simulators will be of high fidelity to assure interface compatibility before integration or mating of the racks, furnace module and SSFF.

The Core rack assembly tests will be performed using a GSE test set, SSF and experiment rack interface simulators. Checkout will include the verification of the core rack subassemblies and software in addition to the verification of the SSF and experiment rack interfaces. The experiment racks will be checked out using a GSE test set and a core rack and furnace module simulator.

The Furnace Module interface to the experiment rack will be verified using the appropriate test set and experiment rack interface simulator. Following checkout and verification of the experiment rack and experiment rack interfaces, the furnace module will be integrated into the experiment rack and an integrated rack checkout performed. Testing of the integrated furnace module in the experiment rack will not include a retest of the system other than that required to verify the interface between the furnace module and the experiment rack.

3.1.3.1.2 Integrated System Testing - Integrated testing will consist of testing the SSFF two-rack configuration for IC1 and the three-rack configuration for IC2. The GSE will consist of a SSFF test set and a SSF interface simulator. The Core contractor shall be responsible for verifying, and maintaining overall SSFF system function and performance.

3.1.3.1.3 Preflight Access - The SSFF hardware will not require preflight access following integration testing in the Logistics Module.

3.1.3.1.4 Launch - The SSFF shall be passive during launch and return phases.

3.1.3.1.5 Post-Mission Processing - Processed samples shall be removed on-orbit and returned to ground between missions. When furnace modules are returned, they will be returned to the furnace developer. If integrated experiment racks are returned, the furnace module will be removed from the experiment rack and returned to the payload developer. The experiment rack will be refurbished and made ready for retest and integration of another furnace module.

3.1.3.1.6 Ground Support Equipment - GSE shall be the equipment required to support SSFF during the fabrication, test, storage, handling, and transport of the SSFF. The GSE shall be in two general categories: equipment used only at the contractor's facility, and equipment that must be carried to an out-of-plant test site or to the launch site. The GSE will include high fidelity interface simulators of the SSF to core rack, furnace module to experiment rack, experiment rack to core rack, and core rack to the experiment rack.

3.1.3.2 On-Orbit Integration - On-orbit integration will be at the rack level except for ORU replacement and/or furnace module changeout. Reverification of interfaces and system functionality will be performed following each rack change out and ORU replacement.

3.1.3.3 Flight Operations Concepts - In orbit, the SSFF will be dependent on the SSF resources for its operation. The operation of the system will not require continuous interaction by the crew, except for the critical tasks necessary for pre-activation, activation, and manual sample change out. Periodic monitoring and control will be performed by the on-board SSFF Data Management System and Payload Executive Software (PES) in conjunction with the Payload Operations Control Center (POCC) at MSFC.

3.1.4 Organizational and Management Relationships

SSFF is sponsored by NASA/OSSA (Code SN), Microgravity Science Applications Division (MSAD). Project and technical management responsibilities are assigned to MSFC. This specification is prepared in accordance with MM8040.12A. All changes to this specification, after it is baselined, must be approved by the Level III Configuration Control Board (CCB). This specification is prepared for and controlled by the MSFC SSFF Project Manager.

3.1.5 System Engineering Requirements

3.1.5.1 Specifications/Systems Analyses/Documentation - The SSFF capabilities shall be compatible with the requirements of the SSF and shall comply with the requirements of SS-

HDBK-0001, Vol. I. Specifications to which the SSFF must comply are delineated throughout this document. Systems analyses and trade studies shall be performed to support the SSFF design. Other analyses shall include: cost tradeoffs and human engineering, system-level documentation prepared and maintained, appropriate level schedules prepared and maintained, and documents prepared in accordance with SS-RQMT-0009, MSFC-STD-555A, and JSC 30200.

3.1.5.2 Drawings - Engineering drawings, parts and materials lists, and changes thereto, shall be in accordance with DOD-STD-100C, as supplemented by MIL-T-31000. The as-built hardware shall match the final released drawings, and verification of this shall be provided by the contractor's quality control.

3.1.5.3 Schematics - Schematics shall be prepared to show functional relationships with related items.

3.1.5.4 Plans, Procedures, and Log Books - Plans and procedures shall be prepared to develop and test the SSFF assembly in accordance with Data Requirements AV-01 through AV-05 of MSFC-HDBK-668. Log books shall be prepared and maintained in accordance with Science and Engineering Management Instruction S&E 5310.2.

3.1.6 Government-Furnished Equipment (GFE) List

Government-furnished property, if any, is TBD.

3.1.7 Critical Components

Components of the SSFF which meet the criteria specified herein shall be designated engineering or logistics critical components. Critical component detail specifications shall be prepared per MM 8040.12A for each component designated as a critical component. Criteria for critical component designation are as follows:

A component shall be designated a logistics-critical component when its repair or replacement lead time would impact the ability of the SSFF to be operationally available for the designated mission.

3.1.7.1 Engineering Critical Components List - The specification shall be amended as critical components are identified during the process of design and development.

3.1.7.2 Logistics Critical Components List - The specification shall be amended as critical components are identified during the process of design and development.

3.2 Characteristics

The SSFF shall be a facility that provides support to experiments in the electronic and photonic materials, metals and alloys, and glasses and ceramics in the material processing discipline.

3.2.1 Performance

3.2.1.1 SSFF General Performance

3.2.1.1.1 Experiment Support - The SSFF shall provide the capability to interface and support the operations of experiment modules identified in sections 5.1 through 5.11 of JA55-032.

3.2.1.1.2 Flexibility

a. The SSFF shall provide the capability to accommodate up to three experiment modules at the same time with the provision that no more than two experiment modules will be operated simultaneously.

b. The SSFF shall provide for the continuous operations of two experiment modules.

c. The SSFF shall be designed to support an adjacent three rack configuration with the racks in any arrangement.

3.2.1.1.3 Operations

a. The SSFF shall be designed to support experiment operation with a minimum of crew intervention, and shall provide completely automated operation during periods of crew absence at MTC.

b. The SSFF shall maintain a safe condition in the event of a failure.

c. The SSFF shall support on orbit maintenance as specified in Section 3.2.4 of this specification.

3.2.1.1.4 Environmental - The SSFF shall be designed to operate in the environment of the SSF-USL A.

3.2.1.1.5 Resupply - The SSFF shall support a ninety day experiment and resupply cycle.

3.2.1.1.6 SSFF Commonality - In those instances where significant financial, operational, or programmatic benefits will result, the SSFF Core shall employ SSF common hardware, software, and standard interfaces.

3.2.1.1.7 Interfaces

a. The SSFF shall interface with the SSF US Lab A for resources and communications with the ground.

b. The SSFF shall interface to the furnace module to provide resources control and to receive furnace module status.

c. The SSFF shall interface with the crew to provide an on-orbit command and display capability.

d. The SSFF shall interface with the SSFF Ground Support Equipment to support operations, test, and checkout of the SSFF.

3.2.1.2 Command and Data Management

3.2.1.2.1 Functional Requirements

3.2.1.2.1.1 - The SSFF shall control and manage power, water, gas, and vacuum resources provided to the furnace modules.

3.2.1.2.1.2 - The SSFF shall provide input/output channels and signal conditioning for sensors and effectors used in the control and management of the resources provided to the furnace modules.

3.2.1.2.1.3 - The SSFF shall provide non-volatile storage sufficient to record 90 days of status data, science data, and digitized video data.

3.2.1.2.1.4 - The SSFF shall support power-fail detection and recovery for power failures of less than TBD minutes in duration.

3.2.1.2.1.5 - The SSFF shall provide, for each SSFF processor, a bootstrap load capability for core and furnace specific application software and data which can be performed without breaking the SSFF flight configuration.

3.2.1.2.1.6 - The SSFF shall support real-time modification of SSFF and furnace module operational parameters, including science set points.

3.2.1.2.1.7 - The SSFF shall provide, for both furnace modules, independent control of power to each of the furnace module's heater elements.

3.2.1.2.1.8 - The SSFF shall provide the following input/output channels and signal conditioning for each of the two furnace module interfaces as specified in Table 1 below:

TABLE 1. Command and Data Management Furnace Module Interface Definition

Furnace Module Interface Signal Type	Number of Channels	Performance Specifications
Video Camera Interface	TBD	TBD
Discrete Input Module High-Level (TBD Vdc)	TBD	TBD
Discrete Input Low-Level (5 Vdc)	TBD	TBD
Discrete Output High-Level (TBD Vdc)	TBD	TBD
Discrete Output Low-Level (5 Vdc)	TBD	TBD
Contact Closure	TBD	TBD
Incremental Encoder Interface	TBD	TBD
Analog Input (±10 Vdc, +10 Vdc)	TBD	TBD
Analog Output (±10 Vdc, +10 Vdc)	TBD	TBD
Contamination Sensor Interface	TBD	TBD
Current Sensor Interface	TBD	TBD
LVDT/RVDT Interface	TBD	TBD
RTD Interface (100 or 1000 Ω)	TBD	TBD
Synchro/Resolver Interface	TBD	TBD
Thermocouple Interface (type S,K,or B)	TBD	TBD
Solenoid Valve Drive	TBD	TBD
DC Motor Drive	TBD	TBD
Peltier Pulsing	TBD	TBD
Sensor Bias/Excitation Interface	TBD	TBD
Stepper Motor Drive	TBD	TBD

3.2.1.2.1.9 - The SSFF shall support the integration and operation of I/O units and/or data processing units provided by the furnace module developer which meet the interface requirements specified in the TBD ICD.

3.2.1.2.1.10 - The SSFF shall support receipt of commands uplinked from the ground and transferred to SSFF via the SSF DMS FDDI.

3.2.1.2.1.11 - The SSF shall support downlink of data via the SSFF DMS FDDI.

3.2.1.2.1.12 - The SSFF shall support downlink of merged digitized video and non-video data via the SSF High Rate Data Link (HRDL).

3.2.1.2.1.13 - The SSFF shall support uplink and downlink data rates of up to 100 kbits per second on the FDDI.

3.2.1.2.1.14 - The SSFF shall support downlink data rates of up to 43 megabits per second on the HRDL.

3.2.1.2.2 Interface Requirements

3.2.1.2.2.1 - The SSFF shall interface with the SSF Data Management System (DMS) via the FDDI link in accordance with ISPR ICD SSP 41002.

3.2.1.2.2.2 - The SSFF shall interface with the SSF High Rate Data Link in accordance with ISPR ICD SSP 41002.

3.2.1.2.2.3 - The SSFF shall interface with the crew for command and data management functions via an SSFF provided graphics video display monitor and keyboard.

3.2.1.2.2.4 - The SSFF shall interface with the furnace modules for data management functions via the input/output channels, signal conditioning, and data interfaces specified in paragraphs 3.2.1.2.1.8 and 3.2.1.2.1.9 of this document.

3.2.1.3 Electrical Power

3.2.1.3.1 Functional Requirements

3.2.1.3.1.1 - The SSFF shall be capable of distributing a total maximum of 12 kW (peak) to SSFF electrical components and furnace modules.

3.2.1.3.1.2 - The SSFF shall be capable of providing a minimum of 6 kW total, continuously, to SSFF electrical components and accommodated furnaces.

3.2.1.3.1.3 - The SSFF shall be capable of utilizing both 6 kW SSF EPS feeds in parallel (12kW) while adhering to the SSF and SSFF electrical isolation, safing, fault propagation, and circuit protection requirements.

3.2.1.3.1.4 - The SSFF shall be capable of utilizing each of the 6 kW SSF EPS feeds as a primary power source while utilizing the remaining 6 kW feed as a safing feed.

3.2.1.3.1.5 - The SSFF shall provide isolation of SSF EPS port and starboard sources within the SSFF to a minimum of 1 mega ohm such that no single failure within the SSFF would cause port and starboard power sources to be electrically tied together.

3.2.1.3.1.6 - The SSFF shall be designed to utilize SSF EPS power of the quality specified below:

TBD

3.2.1.3.1.7 - The SSFF shall be designed to withstand the drop-out limits specified below while meeting SSF safing requirements:

TBD

3.2.1.3.1.8 - The SSFF shall not produce a damaging or unsafe condition under any operating condition of the SSF EPS.

3.2.1.3.1.9 - The SSFF shall not sustain loss of function or permanent damage as a result of normal operating transients and steady state tolerances specified in SSP 30482 Volume I.

3.2.1.3.1.10 - The SSFF shall be protected against damage as a result of normal operating voltage transients and steady state tolerances specified in SSP 30482 Volume I.

3.2.1.3.1.11 - The SSFF shall be restored to its specified performance when the SSF DC power is restored to normal operating conditions.

3.2.1.3.1.12 - The SSFF shall provide current pulsing to furnace modules meeting the following specifications:

Pulse Amplitude	5 to 60 A
Accuracy	+-5.0 % of setting at 5 A linearly decreasing to +-2.5 % at 60 A
Stability	+-0.5 % of setting at 5 A linearly decreasing to +-0.25% of setting at 60 A
Resolution	1 A
Pulse Width	10-100 ms
Accuracy	+-5.0 % of setting
Resolution	1 ms
Transition Time	≤5% of pulse width

Overshoot-Settling Time Product ≤TBD % of Pulse Width Setting-Pulse Amplitude Setting Product

Minimum Time Between Pulse	250 ms
Accuracy	TBD
Resolution	TBD
Pulse Power (Dissipated on module side of module/core interface)	
Peak	400 W
Time Averaged	40 W
Pulse Voltage	≤60 V at module/core interface
Pulse Polarity	Provisions shall be made for reversal of polarity in any sample

3.2.1.3.1.13 - The SSFF shall have the capability to record applied current and voltage during current pulsing, and provisions shall exist to time stamp data at the beginning of a current pulse period.

3.2.1.3.1.14 - The SSFF shall be capable of supporting magnetic damping with magnetic fields of up to 3 kGauss.

3.2.1.3.1.15 - The SSFF electrical performance shall be in accordance with SSP 30482 Vol II 8.1.

3.2.1.3.1.16 - The SSFF electrical components design shall be in accordance with JSC-SE-R-0006 and SSP 30482 Vol II 8.2.

3.2.1.3.1.17 - The SSFF shall be bonded in accordance with MIL-B-5087.

3.2.1.3.1.18 - The SSFF shall be grounded/isolated in accordance with SSP 41002.

3.2.1.3.1.19 - The voltage of de-energized SSFF electrical power connectors during mating and demating shall not exceed a maximum of TBD VDC.

3.2.1.3.2 Interface Requirements

3.2.1.3.2.1 - The SSFF shall receive 120 VDC electrical power from the SSF at the ISPR.

3.2.1.3.2.2 - The SSFF shall be capable of distributing 120 VDC power to the SSFF components and to the accommodated furnaces.

3.2.1.3.2.3 - The SSFF shall supply 28 VDC power to the SSFF subsystem and/or furnace modules.

3.2.1.3.2.4 - The SSFF shall interface with the SSF EPS via the electrical power connectors mounted on the ISPR utility interface panel.

3.2.1.3.2.5 - The SSFF shall interface with the SSF EPS 120 VDC, 10 amp safing connector mounted on the right hand inboard section of the utility interface plate.

3.2.1.3.2.6 - The EPS shall be capable of interfacing with two SSF EPS power feeds to supply SSFF electrical power.

3.2.1.3.2.7 - The interface voltage of each SSF EPS feeder shall be 120 VDC.

3.2.1.3.2.8 - The SSFF shall interface with one 6kW nominal continuous primary power feed and one secondary 6kW nominal continuous power feed.

3.2.1.3.2.9 - The SSFF shall interface with the SSFF subsystems electrical components and furnace modules.

3.2.1.4 Thermal Control

3.2.1.4.1 Functional Requirements

3.2.1.4.1.1 - The SSFF shall provide cooling for components in the SSFF as required to dissipate consumed power.

3.2.1.4.1.2 - The SSFF cooling loop shall have the capability to collect, transport and reject all thermal energy produced up to 12 kW.

3.2.1.4.1.3 - The SSFF cooling medium shall be water and air.

3.2.1.4.1.4 - The SSFF water shall be single phase in accordance with D683-10577-1.

3.2.1.4.1.5 - The SSFF shall provide simultaneous water cooling to the Core subsystems and furnace modules.

3.2.1.4.1.6 - The SSFF shall be capable of operating with maximum heat loads from the Core and two experiment rack assemblies.

3.2.1.4.1.7 - The SSFF shall provide redundant pumps in the event of a pump failure.

3.2.1.4.1.8 - The SSFF shall provide temperature sensing capability in the water cooling loop in the range of TBD for each SSFF rack.

3.2.1.4.1.9 - The SSFF coolant temperature shall be maintained in the range of 18.3 °C to TBD °C.

3.2.1.4.1.10 - Exposed surfaces within the SSFF racks should not exceed a maximum temperature of 45°C. Surfaces exceeding these limits shall be protected from crew interaction.

3.2.1.4.1.11 - The SSFF shall maintain the coldplate surface temperature for SSFF avionics boxes operating under peak power conditions at a temperature of not greater than 50°C.

3.2.1.4.1.12 - The TCS shall provide pressure sensing capability in the range of 0 bar absolute to 6.90 bar absolute for each SSFF rack.

3.2.1.4.1.13 - The SSFF coolant pressure shall be maintained in the range of 1.0 to 3.45 bar absolute.

3.2.1.4.1.14 - The total system pressure loss shall not exceed 1.72 bar in normal operations.

3.2.1.4.1.15 - The SSFF shall provide separate, parallel flow for each experiment rack.

3.2.1.4.1.16 - The SSFF shall have the capability to maintain flow balancing.

3.2.1.4.1.17 - The SSFF shall provide flow sensing capability in the range of 0 kg/hr to 272.2 kg/hr for each SSFF rack.

3.2.1.4.1.18 - The SSFF shall be capable of delivering a flow rate of 0 kg/hr to 272.2 kg/hr of water.

3.2.1.4.1.19 - The SSFF shall provide the capability to control flowrate to each furnace rack in the range of 0 kg/hr to 90.7 kg/hr.

3.2.1.4.1.20 - The SSFF coolant loop leakage shall not exceed TBD.

3.2.1.4.1.21 - The external leakage for the SSFF fluid disconnects shall not exceed 0.001 cm^3/hr at 21.1 °C and 6.21 bar differential pressure.

3.2.1.4.1.22 - Air inclusion for one SSFF fluid disconnect shall not exceed TBD.

3.2.1.4.1.23 - The SSFF valves and associated electronics shall accommodate 120 VDC power.

3.2.1.4.1.24 - Heat rejected to Avionics Air shall not exceed 1.2 kW per rack.

3.2.1.4.1.25 - The SSFF shall accommodate a minimum avionics air flow rate of 5 cfm for fire detection and suppression.

3.2.1.4.1.26 - The SSFF avionics air pressure differential at design flow rate shall not exceed 0.5 kPa per rack, as stated in SSP 41002.

3.2.1.4.1.27 - The SSFF shall provide the capability to detect loss of avionics air cooling in each rack.

3.2.1.4.1.28 - The SSFF cooling loop shall be isolated from the SSF TCS cooling loop.

3.2.1.4.1.29 - The SSFF shall provide the capability to isolate either or both furnace racks from the SSFF cooling loop.

3.2.1.4.1.30 - The SSFF shall have the capability of equipment removal and installation without filling and draining the fluid loop.

3.2.1.4.1.31 - Isolation valves shall be provided in the SSFF to permit maintenance and isolation of individual components or groups of components from the system for maintenance and to aid in leak detection and isolation.

3.2.1.4.1.32 - Components of the SSFF which require maintenance shall be installed with self-sealing, quick disconnect devices.

3.2.1.4.2 Interface Requirements

3.2.1.4.2.1 - The SSFF shall interface with the SSF TCS moderate temperature loop per ISPR ICD.

3.2.1.4.2.2 - The SSFF shall provide a cooling water interface to each SSFF furnace module as shown in Table 2 below:

TABLE 2. Thermal Control Furnace Module Interface Definition

Maximum volume subjected to LOC	TBD
Maximum continuous heat dissipation	TBD
Maximum energy storage	TBD
Inlet water temperature (to furnace)	TBD
Outlet water temperature	TBD
Water flow rate (to furnace)	TBD
Pressure drop at max flow rate	TBD
Maximum heated water volume	TBD

3.2.1.4.2.3 - The SSFF Core equipment shall interface with the SSF avionics air at each rack location.

3.2.1.5 Gas Distribution System

3.2.1.5.1 Functional Requirements

3.2.1.5.1.1 - The SSFF shall be capable of supplying each experiment with inert gas for operation of furnace modules.

3.2.1.5.1.2 - The SSFF shall distribute GN_2 from the SSF LNS to the furnace modules.

3.2.1.5.1.3 - The SSFF shall be capable of distributing up to 11.4 kg of GN_2 from SSF LNS for a 90 day service cycle.

3.2.1.5.1.4 - The SSFF shall be capable of supplying up to 8.2 kg of Argon in one ORU module for a 90 day service cycle.

3.2.1.5.1.5 - The SSFF shall provide valves where necessary to permit leak detection, maintenance, and/or isolation of individual components or groups of components.

3.2.1.5.1.6 - Components of the SSFF which may require rapid disconnection or modular assembly /disassembly shall be installed with self-sealing, quick disconnect devices.

3.2.1.5.1.7 - Pressure vessel and component design shall use the appropriate proof factors as specified in MSFC-HDBK-505.

3.2.1.5.1.8 - Pressure vessels shall be designed to leak-before rupture as specified by MSFC-HDBK-505, MSFC-HDBK-1453, and NSTS 1700.7.

3.2.1.5.1.9 - The gases shall be monitored and controlled such that the furnace cavity pressure is maintained in accordance with the following specifications:

Range	0.1 - 1.0 atm
Absolute Accuracy	± 0.05 atm
Resolution	0.02 atm

3.2.1.5.1.10 - The SSFF shall monitor and characterize effluent gases from the furnace modules.

3.2.1.5.1.11 - The SSFF shall have the capability to isolate and contain those effluent gases deemed unacceptable per S683-29618.

3.2.1.5.1.12 - The SSFF shall provide the necessary levels of containment for contaminated gases as specified by NSTS 1700.7B.

3.2.1.5.1.13 - The SSFF flight GDS shall include equipment in the Core rack and experiment racks that can be assembled/connected on orbit.

3.2.1.5.2 Interface Requirements

3.2.1.5.2.1 - The SSFF shall interface with the SSF LNS for GN2.

3.2.1.5.2.2 - The SSFF shall interface with one (1) gas line at the core rack as provided by the USL-A module.

3.2.1.5.2.3 - The SSFF shall be capable of interfacing with the USL-A module LNS at an interface pressure of 620-758 kPa (90-110 psia).

3.2.1.5.2.4 - The SSFF shall provide GN2 to the furnace modules at pressures up to 2.41 bar absolute.

3.2.1.5.2.5 - The SSFF shall provide argon to the furnace modules at pressures up to 2.41 bar absolute.

3.2.1.5.2.6 - The SSFF shall be capable of providing the total mass of gas per 90 days to the experiment racks of :

Argon	8.2 kg
GN2	11.4 kg

3.2.1.5.2.7 - The GN_2 supplied to the facility by SSF and distributed to the furnace modules shall be Type I, Grade C as per MIL-P-27401C.

3.2.1.5.2.8 - The argon supply shall be research grade purity (99.9995%) as per Table 3.

TABLE 3. Gas System Argon Supply Contaminant Limits

CO_2 < 0.5 ppm
CO < 1.0 ppm
H_2 < 1.0 ppm
CH_4 < 0.5 ppm
N_2 < 3.0 ppm
N_2O < 0.1 ppm
O_2 < 1.0 ppm
THC < 0.5 ppm
H_2O < 0.5 ppm
Dew Point = -112°F

3.2.1.5.2.9 - The gas system shall not degrade the GN_2 supplied by the SSF LNS.

3.2.1.6 Vacuum Exhaust

3.2.1.6.1 Functional Requirements

3.2.1.6.1.1 - The SSFF shall be capable of supporting 10^{-3} torr from SSF VES.

3.2.1.6.1.2 - The SSFF shall be capable of controlling access to the Space Station 10^{-3} torr VES to each experiment for operation of the furnace modules.

3.2.1.6.1.3 - The SSFF shall provide valves where necessary to permit leak detection, maintenance, and/or isolation of individual components or groups of components.

3.2.1.6.1.4 - Components of the SSFF which may require rapid disconnection or modular assembly/disassembly shall be installed with self-sealing, quick disconnect devices or quick acting flanges.

3.2.1.6.1.5 - Pressure vessel design shall use the appropriate proof factors as specified in MSFC-HDBK-505.

3.2.1.6.1.6 - The SSFF shall contain the necessary safety interlocks to prevent inadvertent disconnection (closure) of the relief path.

3.2.1.6.1.7 - The SSFF shall provide pressure relief for the furnace modules.

3.2.1.6.2 Interface Requirements

3.2.1.6.2.1 - The SSFF shall be capable of interfacing with the one (1) USL-A module vacuum exhaust interface at the core rack ISPR location via the utility interface panel.

3.2.1.6.2.2 - The SSFF shall supply the experimenter with an SSF-supplied vacuum source of 1×10^{-3} torr at the SSF interface.

3.2.1.6.2.3 - The SSFF shall provide to the experimenter a minimum pumping rate of TBD.

3.2.1.7 Video

3.2.1.7.1 Functional Requirements

3.2.1.7.1.1 - The SSFF shall provide the capability for acquiring and processing standard analog color video (NTSC).

3.2.1.7.1.2 - The SSFF design shall support future growth, technical advances, and the use of high resolution.

3.2.1.7.1.3 - The SSFF shall be capable of supporting the on-board video generation as described below:

Frame Rate (frames per sec):	30
Camera Resolution:	768x494
Digital Image Resolution:	768x494, 8 bits per pixel, red, green, and blue
Analog Image Resolution:	360 TV Lines Horizontal 525 TV Lines Vertical

3.2.1.7.1.4 - The SSFF shall provide for on-board process monitoring of:

- processing for frame rate conversions and frame grabbing
- image enhancement (if necessary for crew participation)
- video data compression

3.2.1.7.1.5 - The SSFF shall provide for archiving or transmittal for an average of one (1) frame per 5 minutes of video data.

3.2.1.7.1.6 - The SSFF shall provide the capability to store up to 2.3 GBytes of data over a seven day period.

3.2.1.7.1.7 - The SSFF shall support up to 13 GBytes downlink per day of video data.

3.2.1.7.2 Interfaces

3.2.1.7.2.1 - The SSFF shall interface to the SSF video connection at the ISPR for one video input.

3.2.1.7.2.2 - The SSFF shall interface to the SSF video connection at the ISPR for one video output.

3.2.1.7.2.3 - The SSFF shall interface to the SSF video connection at the ISPR for synchronization and control.

3.2.1.7.2.4 - The SSFF interface to the SSF video connection at the ISPR interface shall be in accordance with TBD.

3.2.1.7.2.5 - The SSFF shall interface to the furnace module cameras for image data.

3.2.1.7.2.6 - The SSFF shall support crew interface via video display.

3.2.1.8 Software

3.2.1.8.1 Functional Requirements

The software requirements specified herein cover only those requirements that are not specified in the other sections of Paragraph 3.2.1 of this document. The extent of allocation of the other requirements to software will depend on the SSFF design (i.e. number and location of computers).

3.2.1.8.1.1 - The SSFF software shall be developed in accordance with the guidelines specified in MM8075.1 as tailored by the software management and development plans submitted by the selected phase C/D contractor.

3.2.1.8.1.2 - The SSFF shall provide the software functions common to all furnace modules identified for use in the SSFF.

3.2.1.8.1.3 - The SSFF shall facilitate on-orbit configuration control, installation, and verification of revisions of the SSFF software and data.

3.2.1.8.1.4 - The SSFF shall perform initialization of the SSFF hardware and software.

3.2.1.8.1.5 - The SSFF shall validate and execute valid commands/requests received from the ground, crew, and furnace modules.

3.2.1.8.1.6 - The SSFF shall format non-video and video data for transfer to the ground via the SSF HRDL.

3.2.1.8.1.7 - The SSFF shall format non-video data for transfer to the ground via the SSF FDDI.

3.2.1.8.1.8 - The SSFF shall perform fault detection, isolation, and recovery functions for the SSFF software and hardware.

3.2.1.8.1.9 - The SSFF shall track and report usage of expendables and equipment with a life-cycle of less than one year.

3.2.1.8.1.10 - The SSFF shall support electrical and mechanical calibrations of SSFF equipment.

3.2.1.8.1.11 - The SSFF shall execute SSF Payload Executive Software (PES) commands and shall provide data to the SSF PES.

3.2.1.8.1.12 - The SSFF shall support integration and operation of Experiment Specific Functions (ESF) for those functions that are unique to a specific furnace.

3.2.1.8.1.13 - The SSFF shall provide a real-time, multi-tasking operating system with a high order language (HOL) interface.

3.2.1.8.1.14 - The SSFF shall provide a HOL interface to the command uplink and data downlink functions.

3.2.1.8.1.15 - The SSFF shall provide a HOL interface to the on-orbit display functions for display of science.

3.2.1.8.1.16 - The SSFF shall provide a HOL interface to the data storage and retrieval functions.

3.2.1.8.1.17 - The SSFF shall provide a HOL interface to the fault detection, isolation and recovery functions.

3.2.1.8.1.18 - The SSFF shall provide a HOL interface to the I/O and data channels provided by the SSFF for the furnace module.

3.2.1.8.1.19 - The SSFF shall provide a HOL interface to the core service request functions related to control and management of power, water, gas, and vacuum.

3.2.1.8.1.20 - The SSFF shall provide a HOL interface to the furnace heating control functions.

3.2.1.8.1.21 - The SSFF shall provide a HOL interface to the current pulsing control functions.

3.2.1.8.1.22 - The SSFF shall provide on-orbit displays of SSFF status and health.

3.2.1.8.2 Interface Requirements

3.2.1.8.2.1 - The SSFF shall interface with the SSF DMS Payload Executive Software (PES) in accordance with the protocol defined in TBD ICD.

3.2.1.8.2.2 - The SSFF shall interface with the SSF HRDL in accordance with the protocol defined in TBD ICD.

3.2.1.8.2.3 - The SSFF shall provide an interactive, graphics interface with the crew.

3.2.1.8.2.4 - The SSFF shall interface with the ESF software as specified in paragraphs 3.2.1.8.1.12 through 3.2.1.8.1.21 of this document.

3.2.1.9 Mechanical Structures

3.2.1.9.1 Functional Requirements

3.2.1.9.1.1 - The SSFF shall provide the structural components required for subsystem rack integration and operational support.

3.2.1.9.1.2 - Design and analysis of the subsystem specific components of the SSFF shall satisfy the stress and life criteria given in this specification.

3.2.1.9.1.3 - Safety and fracture critical structures shall be defined in the SSFF and tracked per this specification and JA-418.

3.2.1.9.2 - Interface Requirements

3.2.1.9.2.1 - The mechanical structures shall interface with the SSFF subsystem components and furnace modules.

3.2.2 Physical Characteristics

3.2.2.1 Mass and Volume Allowance

3.2.2.1.1 - The mass of the fully assembled SSFF facility flight configuration shall not exceed 2400 kg.

3.2.2.1.2 - A mass properties status reporting program shall be established to track the SSFF up through final integration and on-orbit reconfiguration.

3.2.2.1.3 - The mass allowance of each of the outfitted SSFF racks shall not exceed 800 kgs.

3.2.2.1.4 - The mass allowance of each of the SSFF racks not outfitted shall not exceed 100 kgs.

3.2.2.1.5 - The SSFF shall allocate a minimum of TBD kgs for furnace modules.

3.2.2.1.6 - The mass distribution of the integrated rack location shall fall within the envelope given in Figure 2.

3.2.2.1.7 - Each furnace module shall be allocated a minimum of 0.65 cubic meters of volume within its respective rack assembly. This furnace module volume allocation shall include a cylindrical volume of 67.0 cm in diameter and 166.0 cm in length.

3.2.2.2 Toxic Waste and Hazard Control

TBD

3.2.2.3 Structural and Mechanical

3.2.2.3.1 Functional Requirements

3.2.2.3.1.1 - The SSFF facility subsystems shall be integrated as much as possible by discrete system specific modules.

3.2.2.3.1.2 - The SSFF packaging shall maximize ease of maintenance, ORU replacement, and facility upgrade or modification.

3.2.2.3.1.3 - Separate storage facilities shall be provided for the FSE, spares and ORUs utilized by the SSFF.

3.2.2.3.1.4 - Each fully integrated SSFF rack assembly shall be self supporting in a 1g environment when held at the SSF interface points, as defined in SSP 41002.

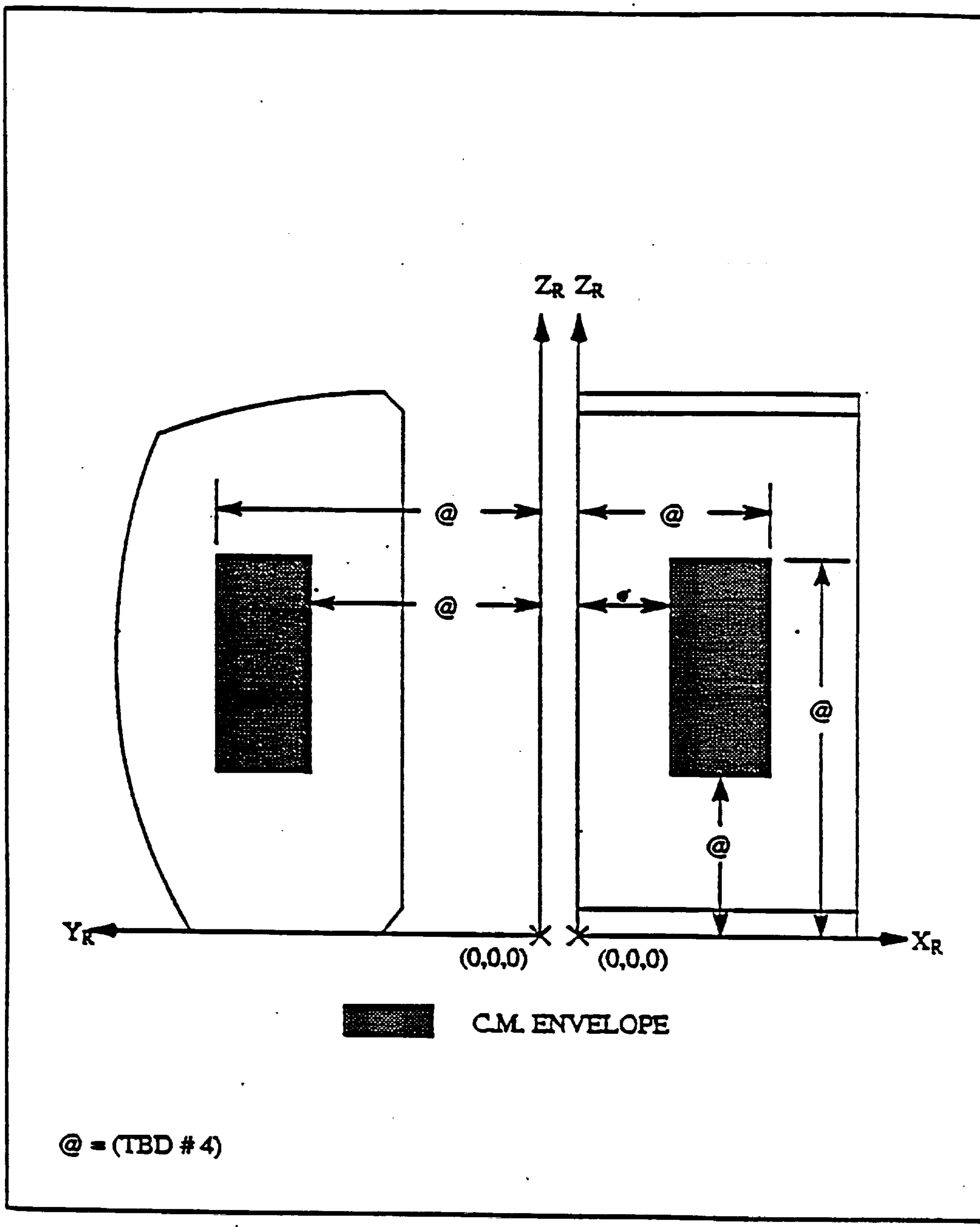


FIGURE 2. CENTER OF GRAVITY ENVELOPE

3.2.2.3.1.5 - When configured for the launch and landing conditions, SSFF rack replacement structures shall have a minimum natural frequency of 25 Hz.

3.2.2.3.1.6 - Subsystem components shall have a minimum hard-mounted natural frequency of 35 Hz.

3.2.2.3.1.7 - The SSFF rack subsystem arrangement and structural integration equipment shall not block or prevent maintenance access.

3.2.2.3.1.8 - The SSFF rack subsystem arrangement and structural integration equipment shall not prevent removal of items designated as ORUs.

3.2.2.3.1.9 - Any integrated SSFF rack assembly shall have the capability to be unlatched and safely rotated from the normal operational position within 60 seconds by a single crewmember.

3.2.2.3.1.10 - The SSFF utility panel interface plate and interconnect lines shall allow EVA gloved hand disconnect/connect per NASA STD-3000, Vol. IV.

3.2.2.3.2 <u>Interface Requirements</u>

3.2.2.3.2.1 - Packaging of SSFF FSE, spares and ORUs shall be compatible with the SSF Logistics requirements per SSP 41002.

3.2.2.3.2.2 - The SSFF packaging shall be compatible with SSF per SSP 41002.

3.2.2.3.2.3 - The SSFF shall interface with the SSF FDS per SSP 41002.

3.2.2.3.2.4 - The SSFF shall interface with the SSF Avionics Air per SSP 41002.

3.2.2.3.2.5 - The SSFF structural interface loads applied to the logistic carrier and to the US Lab interface attachment points shall not exceed TBD load limits.

3.2.2.3.2.6 - No features of the integrated SSFF equipment shall extend beyond the face of the rack (Crew hand and foot restraints are an exception).

3.2.2.3.2.7 - Equipment exposed on the face of the racks shall be able to withstand the crew imposed forces given in Table 4.

3.2.2.3.2.8 - The SSFF facility shall be able to tolerate depressurization of the US Lab and return to service on repressurization per the depressurization/repressurization profiles specified in TBD.

3.2.2.3.2.9 - The SSFF rack enclosures shall be able to withstand a 0.5 psi internal pressure differential.

3.2.2.3.3 Rack Replacement Structure Requirements

3.2.2.3.3.1 - The SSFF rack replacement structures shall be designed to meet the requirements specified in Contract End Item Specification 320SPC0003.

3.2.3 Reliability

Equipment reliability shall be achieved through the application of valid engineering practices and procedures. Internal single failure points shall not propagate to affect the USL or crew. Consideration should be given to designing redundancy in critical systems to maximize experiment reliability. Further, redundant element failures also shall not propagate. A failure modes and effects analysis shall be performed which will be in compliance with CR 5320.9. The SSFF shall have a mean time between failures (MTBF) of TBD days.

3.2.4 Maintainability

The SSFF shall be designed and built to allow isolation, detection, and correction of faults. Self-test/diagnostic capabilities shall be included. Modular construction shall be used to facilitate ease of removal and replacement, with minimum repair-in-place required. Equipment that will require servicing or maintenance shall be designed to be accessible per the following requirements:

3.2.4.1 Accessibility - Design requirements which facilitate access to the equipment for maintenance are as follows:

a. The ORUs shall be designed to provide access to all points, units, components, and installations which require maintenance based upon anthropometric data of 3.2.4.3.f.

b. The ORUs shall have the capability to permit inspection while in their installed positions without requiring removal of other ORUs.

c. ORUs shall be limited in size in order to permit passage through the USL airlock, hatches, and internal passages.

d. Each access port, door, lid, opening, and cover shall be uniquely identified and labeled.

e. Access to replace an ORU shall not require removal of more than one access panel. (Rack front access doors are not considered access panels.)

f. Accesses and covers shall be devoid of sharp corners and be equipped with grasp areas per NASA-STD-3000, Volume IV.

g. Access covers that are not completely removeable shall be self-supporting in the open position and shall be designed for normal crew-induced loads.

h. Sliding, rotating, or hinged units to which rear access is required shall be free to open or rotate their full distance and remain in the open position without being supported by hand.

i. ORUs which are partially pulled out of their installed positions for maintenance shall be self-supporting in that position.

j. Design shall permit the safe operation of applicable ORUs with maintenance access covers removed or opened.

k. Any access door, lid or cover, behind which a potentially hazardous condition may exist as identified in the hazard analyses, shall be labeled with appropriate warnings.

l. If a hazardous condition, defined by the hazards analyses, exists behind an access panel, a safety indicator shall be provided.

m. Accessibility to ORU attaching hardware, electrical connectors, electrical breakers/fuses and plumbing shall be provided.

n. Fuses shall be accessible for removal and replacement.

o. Terminal points on junction boxes shall be located so that maintenance access is provided for removal and installation.

p. Maintenance points for fluid systems, including those for filling, draining, purging or bleeding, shall be in accessible locations as defined by the reach envelopes of 3.2.4.3.f.

q. Isolation valves shall be provided in liquid and gas systems to permit maintenance and isolation of individual components or groups of components from the system for maintenance and to aid in manual leak detection and isolation.

r. Clearance shall be provided for the removal and replacement of equipment undergoing maintenance to preclude any interference with critical SSF USL equipment functions and to prevent the creation of any safety hazards.

s. Stowage and stowed gear shall not preclude access to installed ORUs.

t. Design of element structure and equipment, including interfaces, shall be such that all portions of the pressure shell, bulkheads and seals shall be accessible for maintenance as specified in NASA-STD-3000, Volume IV.

u. Covers, control panels, doors, and drawers which open for maintenance shall not be obstructed from opening completely. Bulkheads, brackets, and other units shall not interfere.

v. If energy must be OFF during maintenance, reset shall be made manually.

w. When manually resetting of circuit breakers is required, the breakers shall be located within reach of the crewmembers as specified in 3.2.4.3.f.

x. Protective features as defined in hazards analyses, shall be employed to preclude personnel injury during all maintenance activities.

y. Shut-off valves and electrical power breakers used for emergency equipment shutdown shall not require removal of any access panel to operate and they shall be able to be operated by hand without the use of foot restraints.

z. As a goal, items most critical to SSFF operations and which require rapid maintenance, shall be most accessible. As a goal, when criticality is not a factor, items requiring the most access shall be most accessible.

aa. As a goal, blind access for maintenance shall be avoided.

ab. As a goal, operational uniformity shall be the practice in the design of all doors, covers, and lids which provide access to equipment in accordance with NASA-STD-3000, Volume IV.

3.2.4.2 Installation/Removal - Design requirements which facilitate installation/ removal of ORUs that require on-orbit maintenance are as follows:

a. Manual push and pull forces required shall not exceed the applicable fifth percentile mean force values called out in 3.2.4.3.f.

b. ORUs shall be designed to preclude incorrect installation.

c. Limit stops shall be provided on racks and drawers which are required to be pulled out of their installed positions for maintenance. The limit stop design shall permit overriding of stops for unit removal.

d. Self-aligning features (e.g., guide pins or rails) shall be provided for installation, alignment, and positioning of ORUs.

e. Liquid and gas connectors shall be located and configured to enable maintenance and leak detection.

f. Provisions shall be made to capture and contain any hazardous fluid released during maintenance.

g. ORUs that contain hazardous gases shall be installed with self-sealing, quick disconnect devices for maintenance.

h. ORUs which are connected to piping or tubing shall be replaceable without removing adjacent piping/tubing.

i. No maintenance installation or operational interface shall be lockwired or staked.

j. ORUs shall be designed with restraining and handling devices for temporary storage by the crew in a micro-g environment.

k. The design of access covers, caps, and other structural parts that may be removed on-orbit for maintenance or other planned activities must provide a means (hinges, tethers, etc.) to retain the removed part in a safe position, accessible for replacement.

l. Element thermal design criteria shall provide for ORU replacement or maintenance in a manner which will preclude degradation or damage to any other ORU, subsystem, or component.

m. Personnel and equipment mobility aids and restraints shall be provided to support on-orbit maintenance. Location of mobility aids and restraints shall be per 3.2.4.3.f.

n. Latches, handles, and operating mechanisms shall be designed to be latched or unlatched and opened or closed with one hand by the entire crewmember population without having to use any operating instructions.

o. As a goal, interconnecting plumbing and wire/cable access between ORUs shall have sufficient attachment length and mounting characteristics to facilitate removal/replacement.

p. As a goal, all liquid and gas systems shall be designed to minimize the amount of fluid released during maintenance.

q. As a goal, the quantity of fasteners required to secure/release an ORU from its installed position shall be minimized.

3.2.4.3 Human Factors for Maintainability - The applicable sections of NASA-STD-3000, Volume IV apply to the following items:

a. Items of the same or similar form which have different functional properties shall be identifiable and distinguishable.

b. Calibration or adjustment points on applicable ORUs shall be located or guarded so that adjustments will not be inadvertently disturbed.

c. The proper orientation for an ORU to be placed in its transportation/storage case shall be obvious by its design or marking.

d. The capacities shall be plainly marked on components requiring fluid replacement.

e. Valve positions (open, closed) shall be readily distinguishable.

f. Reach envelopes, crew load, crew forces, and general work constraints for the SSFF maintenance tasks, shall be as specified in NASA-STD-3000 Volume IV, Figures 8, 9, and 10, Number 67, 5th percentile.

g. Handles and grasp areas shall be placed on the accessible surface of a rack integrated ORU consistent with the removal direction.

h. Items requiring handling shall be provided with a minimum of two handles, or one handle and one grasp area. Items less than 1 cubic-foot in volume whose form factor permits them to be handled easily shall be exempt from this requirement.

i. Clearances shall be provided between handles and obstructions consistent with anthropometric requirements.

3.2.4.4 Tools - The hardware shall be designed for removal, replacement, service, and repair using the tools provided by SSFF. Special tools required for on-orbit maintenance, if required, shall also be provided with the item. When hand tools are required to perform adjustments, protective features shall be provided to prevent maintenance-induced failures.

3.2.4.5 ORU Labeling - ORUs shall be labeled for automatic reading by an automated reader type device.

3.2.4.6 Test Equipment - Test equipment used for performing maintenance of the SSFF shall adhere to the following requirements:

a. It shall be functionally verifiable.

b. Its use shall not introduce a safety hazard.

c. It shall not overstress or damage components being tested.

d. It shall have built-in safety features or safety interlocks which shall give an indication when activated.

e. As a goal, specialized maintenance equipment shall be kept to a minimum.

3.2.5 Operational Availability

The SSFF shall have a useful life of no less than TBD hours under any natural combination of environmental conditions specified in section 3.2.7 of this specification. This operational life applies to all operations during ground bench tests, prelaunch checkout at KSC, and missions, and may accrue over a TBD years period from delivery.

3.2.6 Safety

The SSFF shall be designed to comply with the safety requirements specified in NSTS 1700.7B for transportation to and from orbit by the STS, SSP 30XXX (NSTS 1700.7B, Addendum 1) for on-orbit SSFF operation, and KHB 1700.7A for GSE and ground operations. To assure that the SSFF design and operations do not pose an unacceptable risk to the SSF, the Orbiter, other payloads, or ground processing facilities and equipment, the SSFF must comply with the requirements for successfully completing the shared Safety Review process defined in SSFP 30XXX for the SSF and NSTS 13830 for the NSTS.

3.2.6.1 Hazard Reduction Precedence Sequence - Actions for the elimination or control of hazards shall be conducted in the following order of precedence.

3.2.6.1.1 Design for Minimum Hazard - Damage control, containment and isolation of potential hazards shall be included in design considerations.

3.2.6.1.2 Safety Device - Hazards which cannot be eliminated through design selection shall be controlled through the use of automatic safety devices (e.g., pressure relief valves).

3.2.6.1.3 Warning Device - When hazards cannot be eliminated by design or controlled through use of automatic safety devices, the timely detection of hazardous conditions and generation of a warning signal shall be employed, coupled with emergency safing or shutdown controls.

3.2.6.2 Design to Failure Tolerance - When the loss of a function or the inadvertent occurrence of a function results in a hazard, the SSFF must tolerate a minimum number of credible failures and/or operator errors as determined by the hazard level (i.e., critical or catastrophic as defined in paragraph 200.1 of NSTS 1700.7).

3.2.6.3 Design for Minimum Risk - SSFF hazards which are controlled by specific design requirements other than failure tolerance are called "design for minimum risk" designs. Examples are structures, pressure vessels, material compatibility, etc.. Minimum supporting data for these areas of design are specified in SSFP 30XXX for the SSF and NSTS 13830 for the STS.

3.2.7 Environmental Conditions

The SSFF shall be capable of meeting the requirements of this specification after being exposed to any of the environments in this section. Table 5 identifies the environment which is applicable to each mission stage. The Orbiter Static Coordinate System is shown in Figure 3.

3.2.7.1 Prelaunch/Post Flight - The SSFF shall be capable of meeting the applicable requirements specified in Section 3.2.1 of this specification after exposure to any of the following conditions during prelaunch and post-flight periods:

- Pressure — Minimum: 0.852 bar absolute
  Maximum: 1.050 bar absolute
- Humidity — 0 to 100% relative humidity
- Sand and Dust — As encountered in desert and ocean areas, equivalent to 240-mesh silica flour with particle velocity up to 9.15 km/hr and a particle density of 0.25 g/ft^3.

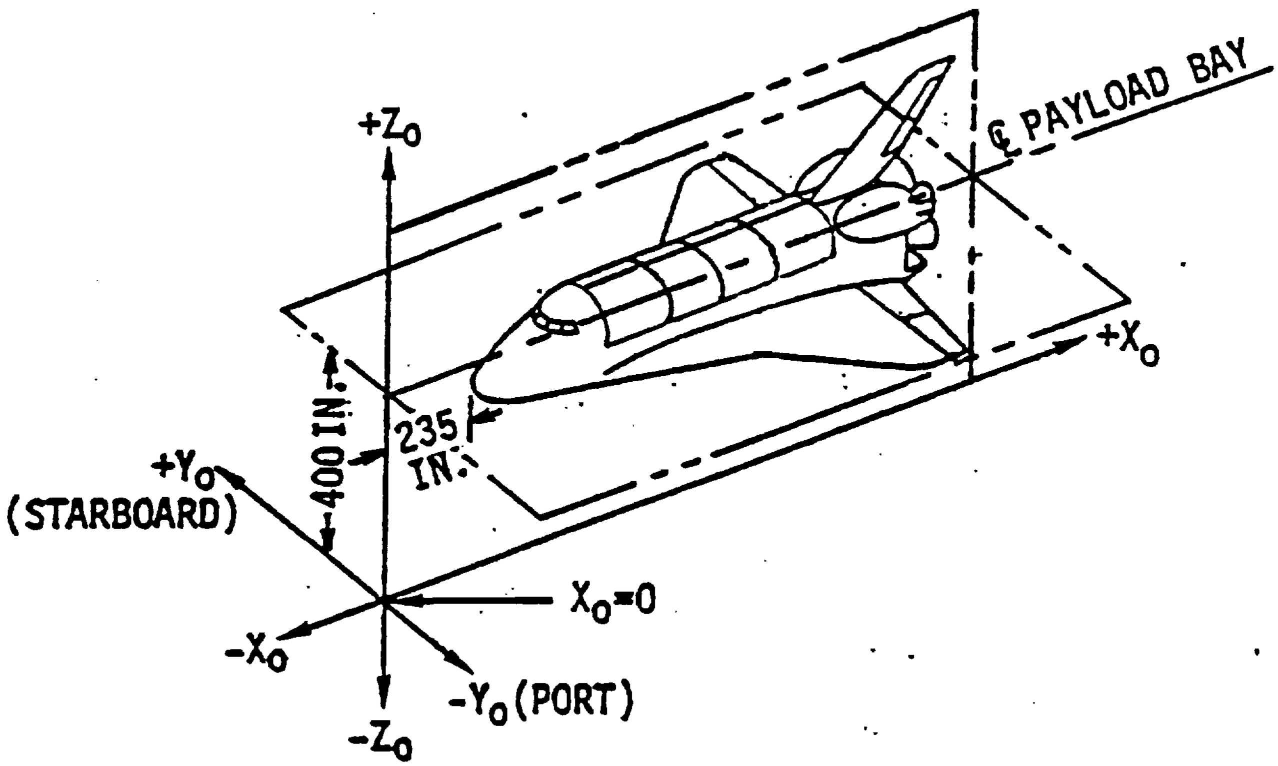
3.2.7.2 Ascent/Descent - The SSFF shall be capable of meeting the applicable requirements specified in Section 3.2.1 of this specification after exposure to the following conditions:

- Pressure — Minimum: 0.690 ± 0.014 bar absolute
  Maximum: 1.050 bar absolute
- Humidity — Minimum: 0% relative
  Maximum: 100% relative
- Acceleration — See Tables 6 and 7
- Vibration — Per Paragraphs 3.2.7.2.1, 3.2.7.2.2, and 3.2.7.2.3.

TABLE 5. APPLICABLE ENVIRONMENTS FOR EACH MISSION PHASE

PHASE \ ENVIRONMENT	QUASI-STATIC	RANDOM	ACOUSTIC	CREW INDUCED	THERMAL (PAYLOAD BAY ONLY)	PRESSURE	SHOCK
Transportation	X*						X
Launch/Ascent	X	X	X			X	
On-Orbit				X	X	X	
Descent					X	X	
Landing (Nominal)	X				X		
Landing (Emergency)	X				X		

*Must be included if equipment has $f_n < 50$ Hz or weighs ≥ 300 lb.



<u>Origin</u>: In the Orbiter plane of symmetry, 400 in. below the center line of the payload bay and at Orbiter X station = 0.

<u>Orientation</u>: The X_o axis is in the vehicle plane of symmetry, parallel to and 400 in. below the payload bay centerline. Positive sense is from the nose of the vehicle toward the tail.

The Z_o axis is in the vehicle plane of symmetry, perpendicular to the X_o axis positive upward in landing attitude. The Y_o axis completes a right-handed system.

<u>Characteristics</u>: Rotating right-handed cartesian. The standard subscript is o (e.g., X_o).

FIGURE 3. ORBITER STATIC COORDINATE SYSTEM

TABLE 6. QUASI-STATIC DESIGN LOAD FACTORS FOR MODULE-MOUNTED EQUIPMENT DURING LIFT-OFF AND LANDING (LIMIT LOAD CONDITIONS)

COMPONENT LOCATION \ CONDITION	X (g)	Y (g)	Z (g)	Qx rad/sec2	Qy rad/sec2	Qz rad/sec2
	LIFT-OFF					
Rack-mounted component	±13.6	±11.0	±8.3			
Rack or rack-replacement structure	±9.0	±7.6	±8.0	±53.4	±42.0	±31.5
	LANDING					
Rack-mounted component	±12.2	±12.9	±8.7			
Rack or rack-replacement structure	±5.8	±5.5	±4.6	±29.6	±24.9	±35.9

TABLE 7. QUASI-STATIC LOAD FACTORS FOR EMERGENCY LANDING: SPACELAB MODULE-MOUNTED EQUIPMENT (ULTIMATE LOAD CONDITIONS)

COMPONENT \ CONDITION	ULTIMATE EMERGENCY LANDING		
	X (g)	Y (g)	Z (g)
Module-Mounted Equipment	+4.5 -1.5	±1.5	-4.5 +2.0

TABLE 7 IS SUPPLIED FOR INFORMATION ONLY. THESE CRITERIA ARE NOT CURRENTLY PUBLISHED IN SS-HDBK-0001.

Logistics module air temperature during ascent/descent (based on Spacelab):

OPERATIONAL PHASE	T MIN. (°C)	T MAX. (°C)
Launch/Ascent	5	50
Reentry	10	50
Post Landing	10	50

Design criteria shall include the pressure range of 0.0 to 1.050 bar absolute cabin pressure.

3.2.7.2.1 Sinusoidal Vibration - This environment covers low frequency transient vibrations induced by such phenomena as gust loadings, engine ignition and cut-off, separation, and docking. All SSFF equipment and hardware must withstand the relevant sinusoidal vibration environment specified in Table 8.

3.2.7.2.2 Acoustic Noise - This environment results from the reverberant sound field set up within the Orbiter cargo bay during launch and ascent. All SSFF equipment and hardware must withstand the relevant acoustic environment specified in Table 9.

3.2.7.2.3 Random Vibration - This environment occurs during lift-off and results from the vehicle vibrations induced by the propulsion system and the acoustic noise level within the cargo bay. All SSFF equipment and hardware must withstand the relevant random vibration environment specified in Table 10. Random vibration accelerations should be established for each axis using the environment presented in Table 10, combined with the lift-off low frequency accelerations presented in Table 8, to establish the total lift-off accelerations in each axis. Random vibration should be established using the procedure shown in JA-418, Section 2.2.5.

3.2.7.3 On-Orbit - The SSFF shall be capable of meeting the applicable requirements specified in Section 3.2.1 of this specification while being exposed and after exposure to the following conditions (based on Spacelab):

On-orbit cabin air temperature: 18 to 27°C

Avionics loop temperature:

Air Cooling	Maximum inlet temperature:	35°C
	Minimum inlet temperature:	10°C
Surface Cooling	Maximum temperature:	35°C
	Minimum temperature:	10°C

TABLE 8. SINUSOIDAL VIBRATION CRITERIA FOR SPACELAB MODULE-MOUNTED EQUIPMENT

LOCATION IN MODULE	FREQUENCY (Hz)	INPUT LEVEL g (0-TO-PEAK)		
		X	Y	Z
Overhead Stowage Containers	5-12 12-35 35-50	1 4.3 1	1 5.4 1	1 4.1 1
Center Floor Racks	5-13 13-35 35-50	1 2.6 1	1 1.6 1	1 5.6 1
Racks	5-12 12-35 35-50	1 4.7 1	1 5.1 1	1 5.9 1
		Sweep Rate at 3 oct/min		
Assuming 1-10 flights		1 sweep up and down for each axis		
Assuming 10-50 flights		Repeat the sweep for each additional increment of 10 flights/or portions thereof		

NOTE: The response in each axis of the component CG shall not exceed the highest input level of that axis by more than 40%.

THIS TABLE IS SUPPLIED FOR INFORMATION ONLY. THESE CRITERIA ARE NOT CURRENTLY PUBLISHED IN SS-HDBK-0001.

TABLE 9. SPACE STATION FREEDOM ELEMENT INTERNAL ACOUSTIC SPECTRUM

1/3 OCTAVE BAND CENTER FREQUENCY (Hz)	SOUND PRESSURE LEVEL (dB) ref. 2 x 10^{-5} N/m^2 LIST-OFF	AERONOISE
31.5	106.0	96.0
40.0	109.0	99.5
50.0	111.5	102.0
63.0	114.0	105.0
80.0	116.0	108.0
100.0	117.5	110.0
125.0	118.5	112.0
160.0	119.0	113.5
200.0	119.0	115.0
250.0	118.0	116.0
315.0	117.5	116.5
400.0	115.5	114.5
500.0	112.5	111.0
630.0	109.5	107.5
800.0	107.0	104.5
1000.0	103.0	101.5
1250.0	99.5	97.5
1600.0	95.5	94.0
2000.0	91.5	90.0
2500.0	88.0	86.5
3150.0	83.0	82.0
4000.0	79.0	77.0
5000.0	74.5	73.0
6300.0	70.0	68.0
8000.0	66.0	63.0
10000.0	60.0	57.5
Overall	127.5	123.5

Duration: 60 seconds + 30 seconds per mission

TABLE 10. RANDOM VIBRATION ENVIRONMENTS FOR EQUIPMENT DESIGN

LOCATION	FREQUENCY	LEVEL
Input to endcone-secondary-structure-mounted equipment	20 Hz 20 - 70 Hz 70 - 200 Hz 200 - 2000 Hz 2000 Hz Composite	0.005 g^2/Hz +3.3 dB/oct 0.02 g^2/Hz -4.0 dB/oct 0.00093 g^2/Hz 3.1 g_{rms}
Input to standoff-mounted equipment	20 Hz 20 - 100 Hz 100 - 1000 Hz 1000 - 2000 Hz 2000 Hz Composite	0.035 g^2/Hz +6.0 dB/oct 0.010 g^2/Hz -15.0 dB/oct 0.0031 g^2/Hz 10.8 g_{rms}
Input to rack-mounted equipment	20 Hz 20 - 70 Hz 70 - 200 Hz 200 - 2000 Hz 2000 Hz Composite	0.005 g^2/Hz +3.3 dB/oct 0.02 g^2/Hz -4.0 dB/oct 0.00093 g^2/Hz 3.1 g_{rms}
Input to cylinder-wall-mounted equipment Radial axis (normal to skin)	20 Hz 20 - 100 Hz 100 - 1000 Hz 1000 - 2000 Hz 2000 Hz Composite	0.028 g^2/Hz +6.0 dB/oct 0.7 g^2/Hz -15.0 dB/oct 0.022 g^2/Hz 28.6 g_{rms}
Input to cylinder-wall-mounted equipment Longitudinal and tangential axes	20 Hz 20 - 90 Hz 90 - 350 Hz 350 - 2000 Hz 2000 Hz Composite	0.015 g^2/Hz +6.0 dB/oct 0.3 g^2/Hz -4.0 dB/oct 0.029 g^2/Hz 15.0 g_{rms}
Input to endcone-mounted equipment Radial axis (normal to skin)	20 Hz 20 - 100 Hz 100 - 300 Hz 300 - 2000 Hz 2000 Hz Composite	0.008 g^2/Hz +6.0 dB/oct 0.20 g^2/Hz -9.0 dB/oct 0.00068 g^2/Hz 8.7 g_{rms}
Input to endcone-wall-mounted equipment Tangential to skin	20 Hz 20 - 80 Hz 80 - 200 Hz 200 - 2000 Hz 2000 Hz Composite	0.002 g^2/Hz +5.0 dB/oct 0.02 g^2/Hz -9.0 dB/oct 0.00002 g^2/Hz 2.2 g_{rms}

Surface temperature:

Module interior ≤30°C

Touch temperature ≤45°C

Pressure: 0.690 bar absolute minimum

1.050 bar absolute maximum

Humidity: 25-75%.

3.2.7.4 Ground Handling/Transportation/Storage - The SSFF shall be capable of meeting the applicable requirements specified in this specification after exposure to the following conditions, if properly prepared for shipment/storage before exposure:

• Pressure	Minimum:	0.850 bar absolute
	Maximum:	1.050 bar absolute
• Temperature	Minimum:	-5°C
	Maximum:	65°C
• Humidity	Minimum:	5% relative
	Maximum:	100% relative.

3.2.7.5 Thermal Design - The data and guidelines required to develop a thermal control plan for the SSFF are listed in SSFF XXXX.

3.2.7.6 Shock Criteria - During ground handling, the maximum shock environments experienced by SSFF equipment and items are represented by 20-G sawtooth shock pulses having a 10-msec duration along both directions of each of the three orthogonal axes. Equipment shall either be designed to withstand this basic shock or be protected during handling via equipment container design.

3.2.8 Transportability/Transportation

Packaging and containers shall be provided to protect the Core system during transportation in the environment described in section 3.2.7 of this specification. Modes of transportation shall be by air or road. Ground handling and ground transportation loads shall not exceed 80% of the design loads for unpackaged equipment.

The handling and transport of the Core system shall meet the requirements of MMI 6400.2 and NHB 6000.1.

3.2.9 Storage

Protection shall be provided to the SSFF equipment to prevent damage from the environmental storage conditions described in section 3.2.7 of this specification.

3.3 DESIGN AND CONSTRUCTION

3.3.1 Selection of Specifications and Standards

Specifications and standards for design of the SSFF are called out in this document. The selection of specifications and standards used in design and fabrication of the SSFF when not specifically identified in this document, shall be selected in accordance with MIL-STD-970. Parts, unless otherwise specified, shall be per MMI 5320.1. If contractor or other specifications or standards normally used in the design and fabrication of such equipment meet or exceed the requirements levied in this document, then the use of those specifications or standards is permitted. Rationale for the selection of contractor specifications and standards over existing higher order or precedence specifications and standards shall be compiled and maintained for historical record and shall be made available to the procuring agency upon request. This rationale shall include identification of each higher order or precedence specification or standard examined and state why each was unacceptable. For purposes of this order or precedence, commercial materials, parts, and processes shall be considered equivalent to contractor standards.

3.3.2 General Electrical Design Requirements

Electrical design and construction of the SSFF shall be in accordance with the requirements of the following paragraphs.

Fuses or circuit breakers shall be provided to protect against current overload. Trip times of protection devices downstream shall be less than that of upstream devices (i.e. downstream trip's first). Fuses or circuit protection devices shall meet the requirements of SS-HDBK-0001, Vol. I. Wiring shall be sized to be compatible with upstream fusing. Circuit breakers shall be used wherever possible in place of fuses. Attention should be paid to the blow curves of protection devices versus those of upstream devices.

If batteries are used, they shall be designed to prevent explosion, spillage of electrolytes, and release of hazardous materials per JSC-20793. All switches and circuit breakers shall be protected against accidental actuation.

3.3.2.1 Electrical, Electronic, and Electromechanical (EEE) Parts - The contractor shall prepare, implement, and maintain an approved EEE Parts Control Plan to describe in detail the EEE parts program. The program shall comply with the requirements stated herein, and may be included in the Quality Control Plan.

3.3.2.1.1 EEE Parts Selection - Maximum use shall be made of NASA standard parts, Grade Two minimum, in the design, modification, and fabrication of the SSFF except for applications deemed critical. The parts selection shall conform to the requirements and guidelines contained in MIL-STD-975H, and screening shall conform to the requirements and guidelines contained in MSFC-SPEC-1198. The program objective shall be to minimize part types, utilize standard part types to the maximum extent feasible, and to assure that appropriate quality levels are maintained.

3.3.2.1.2 Nonstandard Parts Selection Criteria - Nonstandard EEE parts may be used when there is no standard part with a performance capability to satisfy the application requirements, or a standard part is not available. The minimum screening requirements shall be as specified in MSFC-SPEC-1198C. Nonstandard parts shall be selected with first consideration given to the inherent capability of the parts to withstand the space, terrestrial, and mission environments to which the parts will be subjected. When making nonstandard parts selections, previous parts experience and known failure mechanisms which have been documented in Government/Industry Data Exchange Program (GIDEP) "Failure Experience Data Bank Summary", shall be reviewed to assure that the selected parts do not have the same or similar design deficiencies or failure mechanisms. A Nonstandard Part Approval Request (NSPAR) (Form EC-43-11) shall be submitted for each nonstandard Grade 1 part. The rationale for use shall be included. The design, manufacturing, and quality standards for custom electromagnetic devices shall be in accordance with MIL-STD-981.

3.3.2.1.3 Particle Impact Noise Detection (PIND) - All integrated circuits and semiconductors that are cavity devices to be used in flight hardware only shall be PIND tested per Method 2020 of MIL-STD-883C (Microcircuits) or Method 2052 of MIL-STD-750C (Semiconductors).

3.3.2.1.4 Radiographic Inspection - All integrated circuits and semiconductors that are cavity devices to be used in flight hardware only shall undergo radiographic inspection per Method 2012 of MIL-STD-883C (Microcircuits) or Method 2076 of MIL-STD-750C (Semiconductors).

All thermistors for space flight application shall undergo radiographic inspection per Appendix J of MSFC-STD-355C(1).

3.3.2.1.5 Parts Qualification - All EEE parts shall be qualified for the application and only procured from manufacturers who are qualified or their authorized distributors. Parts shall be qualified by one of the following methods:

- Qualification based on existing data that are applicable to the part design and manufacturer to be used in this project.
- Qualification based on similarity, provided the design is similar, manufactured by the same manufacturer and process, and the design differences are not great enough to invalidate the data.
- Qualification through higher level of assembly testing.
- Parts of unusual design, materials, or construction techniques shall be qualified by complete part level qualification test.

3.3.2.1.6 As-Designed Engineering Parts List - An As-Designed EEE Engineering Parts List shall be maintained. This list shall include all NASA standard parts and all approved nonstandard parts that are used in the equipment. This list shall be divided into flight and non-flight component sections, and shall include the following information:

- Part name (resistor, capacitor, etc.).
- Common/similar part number.
- Procurement specification number.
- Quantity used per component.
- Manufacturer's name

3.3.2.1.7 EEE Parts Derating Criteria - The EEE parts derating shall comply with the derating criteria of MIL-STD-975.

3.3.2.1.8 EEE Parts Traceability - A traceability record which provides the following as-built information for each EEE part installed, shall be prepared for each flight component:

- Name of component(s) used in.
- Component part number.
- Serial number.

- Part number and circuit location (R_1,C_2,Q_2).
- Manufacturer.
- Date code or lot number.
- Serial number, when so marked.

MSFC Form 456 or its equivalent may be used to meet this requirement.

3.3.2.2 Harness, Cable, and Wire Characteristics - Cables and wires shall meet the requirements of NHB 5300.4(3G) and MIL-C-27500. Electrical connectors and harness installations shall be designed with sufficient flexibility, length, and protection to permit disconnection and reconnection without damage to wiring or connectors. Service loops shall be provided to ease interface connection efforts.

Electrical harnesses and connectors shall be designed so that individual harnesses can be removed without disrupting the integrity of adjacent harnesses or lines and to facilitate replacement of electrical subsystem units.

Harness, cable, and wire installation and routing shall be designed to minimize potential damage and shall be protected by proper supporting devices. Wires passing through or adjacent to metal structures shall be adequately protected from chafing, abrasion, and cold flow compression.

3.3.2.3 Cable and Wire Specification - All wire bundles, harnesses, and cables shall conform to the requirements of MIL-C-17F, MIL-W-22759/3D, /12F, and /23, MIL-C-27500G, MSFC-DWG-40M39513/5C, MSFC-DWG-40M39526/5C, and MIL-HDBK-216 as appropriate. Internal wire bundles shall be finished in accordance with MIL-E-45782B(1), Method A. Installation shall be per MSFC-SPEC-494A. Internal wiring within the SSFF shall not use silver-plated wire. Wire smaller than 24 AWG shall not be used for point-to-point connections.

3.3.2.4 Connector Specification - Connectors shall be in general accordance with MSFC-DWG-40M38277 and MSFC-DWG-40M39569, MIL-C-39012C, and MIL-C-5015G Series 2 where appropriate. Connectors shall have normal clocking unless interface requirements dictate otherwise. Connectors shall be selected such to prevent improper mating if cross connection can damage hardware or adversely affect the mission. All unmated connectors shall be protected by tethered caps.

3.3.2.5 <u>Wire Braid Specification</u> - Wire braid shall be per QQ-B-575B. Only the tinned type shall be used. If wire braid is to be woven over a harness, then the wire shall be per ASTM B33.

3.3.2.6 <u>Lacing Tape Specification</u> - Lacing tape shall be per MIL-T-43435B, Type III, Finish A.

3.3.2.7 <u>Crimping of Electrical Connections</u> - Crimping of electrical connections shall be in accordance with the electrical and mechanical requirements of NHB 5300.4 (3H).

3.3.2.8 <u>Retention Testing of Electrical Connections</u> - Retention testing of electrical connections shall be in accordance with NHB 5300.4 (3G) and the following sections of MSFC-STD-781: 6.2.3 (items f, and h - j only), 6.2.4 (items i and j only), 6.3, 6.3.1, and 6.3.2.

3.3.2.9 <u>Vacuum Baking</u> - Connectors and backshells not certified to meet the requirements of MSFC-SPEC-522B and JSC-SP-R-0022A shall be vacuum baked in accordance with MSFC-SPEC-548B before being installed on harnesses or flight equipment. All completed harnesses, except harness assemblies that are within a sealed container, shall be vacuum baked in accordance with MSFC-SPEC-684.

3.3.2.10 <u>Shield Termination</u> - All wire bundles, harnesses, and cables external to the experiment equipment shall have provisions for grounding the shields through the harness connector backshell or through connector contacts. Individual shields shall be terminated with solder sleeves per MIL-S-83519 or NAS 1746. Overall shields not terminated by the connector backshell shall be terminated by shield rings per MSFC-DWG-40M38282 Type I or solder sleeves per MIL-S-83519 or NAS 1746.

3.3.2.11 <u>Harness, Cable, and Wire Current Ratings</u> - Wiring shall be sized to be compatible with upstream current limiting devices. The current carrying capacity of wires and multiwire cables or harnesses shall be determined per SS-HDBK-0001, Vol. I.

3.3.2.12 <u>Harness/Cable EMC Classification</u> - Experiment harnesses shall be divided into four classes to minimize EMI problems. Design criteria are specified in SS-HDBK-0001, Vol. I. MPE harnesses provided by MSFC will meet these specifications. As a minimum, the interface between the experiment and the MPE harnesses shall not mix Classes I and II with III and IV.

Harnesses within the experiment shall be separated into these classes to the extent possible and practical.

3.3.2.13 Wire Splices - Use of wire splices for initial design is not permitted except internal to transformers and chokes.

3.3.2.14 Identification Markers - All harnesses and connectors shall be clearly marked for identification per MSFC-SPEC-708.

3.3.2.15 External Electrical Networks - All harnesses, wire bundles, and cables shall conform to NHB 5300.4 (3G) and be installed per MSFC-SPEC-494A. The preferred method for overall protection is fabric braid. Individual cable shields shall be individually carried through connectors on separate contacts.

In order to minimize signal degradation of the analog output signals from the furnace assembly to the signal conditioning circuitry, the harnesses carrying these signals shall have overall shields which terminate to the connector backshell at each end. 360-degree termination and separate strain relief shall be provided. Also, the harness length and number of connections shall be minimized.

3.3.2.16 Internal Electrical Networks - Internal wiring and lacing shall be formed and secured to maintain the wire bundle during normal handling and installation in accordance with NHB 5300.4 (3G).

3.3.2.17 Electrical Bonding - Instrument case bonding requires compliance with MIL-B-5087. MIL-B-5087 covers, in general, all types of bonding between instruments and structure. The preferred method is metal-to-metal bonding of electrically active experiment equipment to the primary structure. Shields on wire harnesses external to experiment equipment shall have provision for grounding the shields through the harness connector backshell or through connector pins. Electrical bonding of payloads to the U.S. Lab is covered in SS-HDBK-0001, Vol. I.

3.3.2.18 Electromagnetic Compatibility (EMC) - The electrical subsystem shall be designed to comply with the requirements defined in MIL-STD-461 and JSC-SL-E-0002A, using the provisions of MIL-STD-462 where applicable.

3.3.2.19 Soldering and Brazing - Soldering of electrical connections shall be in accordance with NHB 5300.4 (3A-1) and brazing in accordance with MIL-B-7883C.

3.3.2.20 Grounding and Isolation - The grounding and isolation of circuit returns for dc, plus the handling of shield grounds in the electrical subsystem, shall comply with the requirements of SSP 41002.

3.3.2.21 Printed Circuit Assemblies - The design, documentation, and fabrication of printed wiring (PW) boards shall be in accordance with NHB 5300.4 (3K) and NHB 5300.4(3I). Materials for PW boards and requirements for conformal coating and staking of printed wiring boards and electronic assemblies shall be in accordance with NHB 5300.4 (3J). In addition, design and fabrication of printed wiring assemblies incorporating ribbon lead parts and requirements for soldered electrical connections shall be in accordance with NHB 5300.4 (3A-1).

3.3.2.22 Conformal Coating - Conformal coating (polyurethane) for printed circuit assemblies shall be in accordance with NHB 5300.4 (3J). The use of epoxy for conformal coating shall be in accordance with NHB 5300.4 (3J) and MSFC-SPEC-222C(1).

3.3.2.23 Multilayer Printed Wiring Boards - Multilayer printed wiring boards shall be designed and fabricated in accordance with NHB 5300.4 (3K) and MIL-P-55110D(3).

3.3.2.24 Procedure for Fracture Solder Joint Prevention - Under no circumstances shall the heat and solder be applied to both sides of the PTH. The solder connection on the heat and solder application side of the PTH shall meet all the requirements established by the soldering specification NHB 5300.4 (3A-1).

For the solder connection on the opposite side:

- On a functional pad the solder shall form a complete fillet between lead and solder pad and show evidence of solder wetting to both the lead and solder pad.
- On a non-function pad the solder shall show evidence of flow through and bonding of the lead to the solder pad.

3.3.2.25 Electrical Reference Designations - Reference designations shall be per MSFC-STD-349.

3.3.2.26 Inadvertent Electrical Shorts - The subsystem components shall be designed so that no electrically conducting surfaces are exposed to floating debris or foreign material in any gravity state from 0 to 4 g. Exposure may result in malfunctioning, shorting, or inadvertent actuation. Circuit wiring shall be properly sized to prevent any wiring in the circuit from becoming an ignition source if a short occurs.

3.3.2.27 Debris Protection - Flight hardware shall be designed so that malfunctions or inadvertent operations cannot be caused by exposure to conducting or nonconducting debris or foreign materials floating in a gravity-free state.

3.3.2.28 Protective Covers or Caps for Receptacles and Plugs - Captive protective metal covers or caps shall be provided for external electrical plugs and receptacles whenever they are not connected to the mating part.

3.3.2.29 Isolation of Test/Monitoring Points - Isolation between test/monitoring points and internal circuits shall be such that a test/monitor point short to ground shall not degrade equipment.

3.3.2.30 Protection of Electrical Devices and Assemblies - Electrical and electronic devices shall incorporate protection against reverse polarity and/or other improper electrical inputs during qualification, acceptance, and checkout test where such inputs could cause damage to the devices that would not be immediately and unmistakably apparent. If it is impractical to incorporate adequate protection as part of the flight device, protection shall be provided externally at the interface between the flight device and the ground test equipment. Handling of sensitive electronic parts and assemblies shall be in accordance with MIL-STD-1686A.

3.3.2.31 Power Supply Protection - Independent power sources may be tied together to a common load using series diodes in each source line, protected by a current limiting device at each point of application.

3.3.2.32 Improper and/or Cross Connection Prevention - Electrical connections shall be designed such that connector mating can be monitored visually, audibly, and by feel to ensure that proper mating has been accomplished. All connectors shall have the same clocking unless interface requirements dictate otherwise to reduce spares inventory requirements. All connector numbers/designators shall be clearly marked to prevent mis-mating.

3.3.2.33 Corona - The SSFF shall satisfactorily meet the requirements related to vacuum coronal prevention and electrical breakdown prevention to conform with MSFC-STD-531.

3.3.2.34 Lightning Protection - Lightning protection shall be in accordance with ICD-2-19001, Section 10.

3.3.2.35 Overload Protection - Power source lines will be protected by U.S. Lab or Space Station equipment. Power lines within SSFF shall be protected by suitable circuit breakers (or fusing, in special cases). See Section 3.2.1.3 for design requirements.

3.3.3 General Structural/Mechanical Design Requirements

The SSFF shall be designed to the load factors and factors of safety defined in this section and the requirements of MSFC-HDBK-505A for the application of factors of safety, stress analysis, and fatigue. The final version of all structural analyses must reflect the as-built configuration.

3.3.3.1 Equipment Integrity and Factors of Safety - The SSFF shall be designed to withstand the normal launch, operational, reentry, and landing environments defined in this specification, without failures, leaking fluids, or releasing equipment, loose debris, or particles which could damage the orbiter or cause injury to the crew. During qualification testing, a modal survey test will be performed to verify the dynamic math model. The SSFF equipment shall also be designed so that when subjected to the emergency loads environment of this specification there shall be no hazard to personnel or prevention of egress from the orbiter or the U.S. Lab. In addition, the SSFF equipment shall be able to withstand the environments resulting from ground handling and transportation defined in this specification.

Experiment equipment shall be designed such that the equipment integrity and load carrying capability of structural mounting provisions fulfill the following requirements.

- Factors of Safety - The minimum factors of safety to be used against limit load conditions to establish the design loads must be as defined in Table 11. The SSFF shall be designed to the factors of safety in MSFC-HDBK-505A for non-tested flight structures. Ground handling equipment shall be designed with factors of safety defined in KHB 1700.7A.
- Fracture Control - Experiment equipment must meet the fracture control requirements specified in this specification. To achieve this, the structure must be designed to either of two concepts:
  - Safe-life concept - The safe-life concept is to ensure that defects located in sensitive areas do not go undetected and cannot, under the expected loading conditions, grow sufficiently to cause catastrophic failure at limit load within service life. For reflyable structure elements, inspection intervals shall be set at a quarter of the crack growth life projection.

TABLE 11. MINIMUM DESIGN SAFETY FACTORS APPLICABLE TO EXPERIMENT EQUIPMENT

TBD

- Fail-safe concept - The fail-safe concept requires that, after failure of the primary load path, the alternate load path shall have limit load capability and fatigue life to the specified appropriate inspection interval.

General requirements that relate to equipment integrity can be found in two key documents:

- MSFC-HDBK-505A, Structural Strength Program Requirements, establishes general requirements for a structural strength program of analysis and testing. Factors of safety and service life to be used in hardware design are specified herein. Analyses covered in the document include stress, fracture mechanics, and fatigue. (Give special attention to paragraph 500.5).
- JA-418A is a compendium of requirements affecting the design, analysis, fabrication, test, and other verification requirements on STS payload flight equipment with safety-critical structural components. It supplements existing specifications and accommodating handbooks by summarizing and clarifying design load factors, design criteria, fabrication requirements, inspection requirements, analysis requirements, and reporting requirements for safety-critical flight structures.

3.3.3.2 Corrosion Prevention - Inasmuch as possible, corrosion resistant type metals shall be used, rather than putting total dependence on coatings for corrosion protection. Protective finishes, when required, shall conform to MSFC-SPEC-250A. Dissimilar metals, defined by MIL-STD-889B, shall not be used in combination unless they are suitably coated. Chemical conversion coatings shall be in accordance with MIL-C-5541D.

3.3.3.3 Stress Corrosion Cracking - MSFC-SPEC-522B shall be used for design and materials selection for controlling stress corrosion cracking. Metals susceptible to stress corrosion cracking in the environmental or service conditions defined herein shall not be used unless test data are furnished which indicate material suitability. As applicable, protective treatments shall conform to MSFC-SPEC-250A.

3.3.3.4 Load and Internal Pressure Combination - In circumstances where pressure loads have a relieving or stabilizing effect on structural load capability, the minimum expected value of such loads shall be used and shall not be multiplied by the factor of safety in calculating the design yield of ultimate load. For example, the ultimate compressive load in pressurized vehicle tankage shall be calculated as follows:

Ultimate Load = Safety Factor x Body Loads - Minimum Expected Pressure Load.

3.3.3.5 Misalignment and Tolerances - The effects of allowable structural misalignments, control misalignments, and other permissible and expected dimensional tolerances shall be considered in the analysis of all loads, load distributions, and structural adequacy.

3.3.3.6 Design Thickness - Stress calculations of structural members, critical for stability and compressive strength, may be performed using the mean drawing thickness as the maximum thickness. The thickness used in the stress calculations for pressure vessels and for tension-critical and shear-critical members shall be the minimum thickness shown on the drawing.

3.3.3.7 Vibration Frequency Constraints - To minimize the requirement for coupled loads analysis, the hard-mounted natural frequency of experiment equipment is required to be greater than 35 Hz when it is directly mounted to the SSF experiment mounting hardware or substitutes for that hardware, e. g., a rack replacement structure.

3.3.3.8 Materials Selection - Allowable mechanical properties of structural materials shall be obtained from authoritative sources, such as:

MIL-HDBK-5E	Metallic Materials and Elements for Aerospace Vehicle Structures
MIL-HDBK-17	Plastics for Flight Vehicles
MIL-HDBK-23A	Structural Sandwich Composites

Materials used in the design and fabrication of instruments shall be selected based on operational requirements as well as engineering properties.

3.3.3.9 Welding Requirements - Payload flight equipment welded structural components shall comply with the requirements for Class II or better welds in accordance with appropriate specifications for flight structures such as the following:

MIL-W-6858D	Welding, Resistance; Aluminum, Magnesium Non-Hardening Steels or Alloys, Nickel Alloys, Heat Resistant Alloys, and Titanium Alloys: Spot and Seam
MSFC-STD-481	Radiographic Inspection Procedures and Acceptance Standards for Fusion Welded Joints in Stainless and Heat Resistant Steel
MSFC-SPEC-504B	Welding, Aluminum Alloys
MSFC-SPEC-560A	Specification, Welded Steels, Corrosion and Heat Resistant Alloys
QQ-R-566B	Rod and Electrodes, Welding Aluminum and Aluminum Alloys
MSFC-STD-655	Weld Filler Metal, Control of

MIL-STD-453C Inspection, Radiographic

MSFC-SPEC-504B defines material and process requirements, inspection methods, and acceptance criteria applicable to gas-tungsten arc and gas-metal (shielded arc) welding of aluminum, where maximum strength welds are required and where weld strength is not specified. MSFC-SPEC-560A gives the same information for steels and corrosion and heat-resistant alloys.

The technique of welding a joint from opposite sides shall not be used on any joint unless approved by the procuring agency. Weldments on critical structures shall be avoided wherever possible, because of stringent requirements for space-qualified welds in terms of qualification of processes, weldment design, tests, and inspection.

3.3.3.10 Removable Installation - Threaded fasteners, for the attachment of payload equipment to the support structure that may require removal and reattachment, shall be designed in such a manner that lock wire and cotter pins can be installed to secure the nuts and bolts. A note will be put on the drawings stating which fasteners are to be lock wired or cotter pinned in accordance with MS33540J.

Where no tests, or only limited tests, are to be performed and a positive locking device cannot be incorporated into the design, analyses and rationale must be developed and a waiver obtained.

3.3.3.11 Corners, Edges, Protrusions, and Recesses - SSFF equipment shall be designed to minimize the likelihood of personnel injury from contact with sharp corners, edges, protrusions, or recesses. Exposed corners and edges of equipment items must conform to the requirements of MSFC-STD-512A.

Protrusions must have all sharp edges and exposed corners removed in accordance with the above specifications. Protrusions, which for operational reasons cannot be made safe, shall be covered with a protective device.

3.3.3.12 Surface Cleanliness - Equipment exterior surfaces shall meet the requirements for Visibly Clean (VC) level Highly Sensitive in accordance with JSC-SN-C-0005C, Specification Contamination Control Requirements for the Space Shuttle Program.

3.3.3.13 Fastener Requirements - MSFC policy for securing threaded fasteners on critical structure states that positive locking devices such as lock wire, cotter pins, or equivalent shall be used, or validation of design by vibration testing shall be required. Critical structure is defined as any structural member whose failure would create a safety hazard or jeopardize the success of the overall mission. It does not include the internal components of an instrument where the failure would be contained. Specific requirements are defined in:

MSFC-STD-561	Threaded Fasteners, Security of Safety-Critical Flight Hardware Structure Used on Shuttle Payloads and Experiments
MSFC-STD-486	Torque Limits for Threaded Fasteners
MS33540J	General Practices for Safety Wiring and Cotter Pinning
MIL-S-7742C	Screw Threads, Standard Optimum Selected Series, General Specification for
MSFC-STD-156(1)	Riveting, Fabrication and Inspection, Standard for

The principal concern is to assure that threaded fasteners, when exposed to the ground and flight environments (i.e., acoustic, thermal, and vibration-induced distortions), will not lose their preload by either the nut, bolt, or washer coming loose from the secured position after torquing.

The requirements to validate the securing of threaded fasteners can be satisfied by either vibration testing or designing the hardware with positive locking devices such as lock wire, cotter pin, or equivalent. Only safety-critical structures are subject to this requirement. Verification by vibration test requires prior approval by MSFC.

Good design practice shall be used in the selection of friction locking devices for threaded fasteners. The use of positive locking devices such as lock wire or cotter pins is required for flight equipment fluid fittings and for threaded fasteners used on critical structures.

Fastener allowable strength shall be in accordance with MIL-HDBK-5E. Threaded fasteners used for securing a single component, wherever possible, shall be the same type, size, and tensile strength. Use of blind fasteners shall be minimized. Self-locking nuts, if used, shall not be located where debris or contamination from disengagement of the fastener can harm or damage any electronic components. Assembly/subassembly installations shall be designed such that access to threaded fasteners may be accomplished without the use of universal joints, angular extensions, handle extensions, or combinations thereof. Captive fasteners shall be used on panels and components wherever possible.

3.3.3.14 Permanent Installation - Design of critical structures shall preclude inaccessible locations that interfere with installation of lock wire or cotter pins on threaded fasteners. Threaded fasteners on critical structures shall be safe, after having been properly torqued in accordance with MSFC-STD-486 or as specified on drawing, by utilizing a positive locking device such as lock wire, cotter pins, or equivalent in accordance with MS33540J.

3.3.3.15 Structural Containers - All containers shall be designed to allow easy access to the internal components for initial installation and for refurbishment and checkout. The container shall provide the load carrying capability and overall enclosure, hardware mounting provisions, and mechanical assembly provisions. The structural loads and dynamic criteria are specified in paragraph 3.2.

3.3.3.16 Fatigue - The SSFF shall be evaluated for its capability to sustain cyclic load conditions which are part of the design environment. For those components whose design is subjected to a cyclic or repeated load condition, or a randomly varying load condition, fatigue analysis shall be performed. Criteria for fatigue and fracture mechanics assessments of experiments/components is as follows: The maximum low frequency lift-off design load shall be applied at constant amplitude (but not to exceed 35 Hz) of the experiment/component to establish the number of cycles. Simultaneously, the maximum lift-off random vibration induced design load shall be applied at constant amplitude for 7.5 sec, again using the experiment/component fundamental frequency to establish the number of cycles. The lift-off low frequency and random vibration loadings must be applied simultaneously, with the low frequency loading applied in all three axes and the random vibration loading applied in one axis at a time.

A limit of 35 Hz for the experiment/component fundamental frequency for the low frequency assessment shall be applied, since no forcing functions are available to drive higher frequencies. The random vibration forcing function can, however, excite higher frequencies; therefore, the actual predicted or measured fundamental frequency must be used for the random vibration loading assessment.

Further, the maximum low frequency landing induced design loads shall be applied at constant amplitude for 10 sec, using the fundamental frequency (but again not to exceed 35 Hz) of the experiment/component to establish the total number of cycles. The landing loads must be applied in all three axes simultaneously.

The summation of the three loadings - the lift-off low frequency, the random vibration, and the landing low frequency induced loads - applied for the time durations listed above and at the experiment/component fundamental frequency, plus the maximum design loads for on-orbit operations, transportation, and ground handling applied for the total duration thereof, shall be adequate for a conservative fatigue/fracture mechanics assessment of experiments/components. Fatigue analysis shall demonstrate a minimum calculated life of 4.0 times the required service life of 10 years, plus testing, plus ground transportation. A minimum factor of 1.15 shall be used in the fatigue assessment, per MSFC-HDBK-505A, Section 700.

3.3.3.17 Fracture Control - Components with failure modes that could result in a hazard to the U.S. Lab, Space Station, Orbiter, or crew shall be considered fracture-critical candidates and undergo a fracture mechanics evaluation. The results of this evaluation will determine the parts to be placed under fracture control. The SSFF shall be examined to determine its fracture criticality and associated fracture control requirements as specified in MSFC-HDBK-1453 and NHB 8071.1. The fracture control program shall include fracture mechanics analysis and nondestructive evaluation (NDE) in accordance with MSFC-STD-1249 for all fracture sensitive parts.

3.3.4 Selection of Materials, Parts, and Processes

All metallic materials used in constructing the SSFF shall meet the requirements of MSFC-SPEC-522B. All nonmetallic materials used in constructing the SSFF shall meet the requirements of NHB 8060.1B for flammability and toxicity where applicable, and MSFC-HDBK-527F for overall materials selection, and shall be compatible with performance and environmental criteria for the equipment as specified herein. Selection of parts shall be made from existing qualified products lists, where possible. Commercial parts shall be selected in consideration of system design, functional, and reliability requirements. Lubricants shall be selected per MSFC-STD-509.

All materials and processes used in the construction of the SSFF shall meet the requirements of MSFC-STD-506C, JSC-SE-R-0006C, MSFC-PROC-1301, MIL-STD-454, and FED-STD-209B.

Only "A" rated materials shall be used where possible. Materials lists shall be provided as part of the PDR and CDR data packages and approved by the procuring agency prior to the start of flight hardware construction. Materials Usage Agreements (MUAs) shall be prepared for any material which is rated other than "A" in MSFC-HDBK-527F.

3.3.5 Contamination Control

Design, manufacturing, handling, and operational concepts shall minimize the probability of contamination. The SSFF shall be cleaned to the VC level Highly Sensitive of JSC-SN-C-0005C. During and after fabrication, parts and assemblies shall be visibly clean and free from processing or handling damage and imperfections. Cleanliness standards and practices shall be made an integral part of the fabrication, assembly, test, storage, and maintenance processes.

3.3.6 Coordinate System

The coordinate system of the assembly shall correspond to the standard Space Station reference coordinate system as specified in SSP 30219B.

3.3.7 Interchangeability and Replaceability

Mechanical and electrical interchangeability shall exist between like assemblies, sub-assemblies, and replaceable parts and components of operating subsystems, regardless of the manufacturer or supplier. All components which have the same part number, regardless of the source, shall be functionally and dimensionally interchangeable. However, readjustment or realignment of assemblies shall be permitted.

3.3.8 Identification and Marking

Identification and marking shall be in accordance with the requirements of MIL-STD-130F, JSC-SPEC-M1B, MSFC-SPEC-266A, and MSFC-STD-275A. All cable harnesses shall be identified with legible marking labels in accordance with MSFC-SPEC-708. Wires or jumpers that are too short to be marked shall be indicated on the detailed wiring diagrams. Each cable assembly shall be marked with a cable/connector, equipment/mating connector, and cable assembly designation. Markers shall be located as close to each connector as practical. Each separable or loose shipped structural/mechanical element shall be identified in the following manner: a. Manufacturer's Name, b. Part Number, c. Part Name, d. Serial Number, e. Contract Number, f. Weight, and g. CEI Number. Marking for shipment is specified in Section 5.3.

3.3.9 Workmanship

The SSFF shall be designed, constructed, and finished in a quality manner. Defective plating, painting, riveting, machine-screw assembly, welding, brazing, deburring, cleaning, or defective marking of parts and assemblies shall be cause for rejection. There shall be no burrs or sharp edges. Manufacturing practices that will produce equipment that is free of defects shall be followed. Workmanship standards shall be consistent with the requirements of MSFC-STD-512A and MIL-STD-454K, Requirement 9. An inspection system shall be maintained that satisfies the requirements of NHB 5300.4 (1B).

3.3.9.1 Quality - Quality planning and control of contractually fabricated (out-of-house) hardware shall be in accordance with NHB 5300.4 (1D-2).

3.3.9.2 Process Controls and Personnel Certification - Manufacturing and inspection processes and personnel shall be certified in accordance with NHB 5300.4 (3A-1), NHB 5300.4 (3J), NHB 5300.4 (3H), MMI 1710.6B, and MSFC-STD-513A.

3.3.10 Human Performance/Human Engineering

Human performance/human engineering shall be considered in the concept definition, design, development, testing/evaluation, and operational phases of the SSFF. All normal or contingency interfaces between the ground and/or flight crew shall be designed to meet the applicable requirements of NASA-STD-3000 Vol. IV, MIL-STD-1472C, JSC-SC-M-0003A, and NASA-RP-1024.

3.4 LOGISTICS

Logistics support for the SSFF shall be provided in accordance with the applicable specifications as provided in SS-SPEC-0003A. The logistics efforts shall include the following:

- Provisions for maintenance, repair, and servicing required on the payload system.
- Providing spares, special tools, and procedures; repair/replacement criteria.
- Identification of spares as to their long lead status.

The facilities required for the logistics support of SSFF include environmentally controlled storage and receiving areas, loading and shipping areas, and administrative offices. Equipment requirements for SSFF handling shall be provided by mechanical GSE and other common materials handling equipment.

3.5 PERSONNEL TRAINING

The SSFF contractor shall provide the equipment, data, documentation, and direct training instructions to support payload specialist training. Specific training tasks shall include training of the payload specialist to operate the SSFF system on-orbit and execute any contingency procedures, training of personnel to operate the Payload Operations Control Center (POCC) facilities, and training of personnel to operate the SSFF ground based equipment. A personnel training plan shall be provided in accordance with TBD.

The contractor shall provide one (1) Class I.A, one (1) Class II.B, and one (1) Class III.C Core simulators/trainers as defined by Table 12.

Table 12. Simulator/Trainer/Mockup Classification Matrix

Class / Functionally	F. FLIGHT-TYPE	A. FUNCTIONALLY ACTIVE	B. OPERABLE	C. STATIC
FLIGHT-TYPE	Flight Equipment Downgraded for Training	N/A	N/A	N/A
I. FLIGHT ASSY. TOLERANCE SIMILAR MATERIAL EXACT CONFIGURATION	N/A	I.A	I.B	I.C
II. RELAXED ASSY. TOLERANCE MIXED MATERIAL APPROXIMATE CONFIG.	N/A	II.A	II.B	II.C
III. APPROXIMATE DIMENSIONS OPTIONAL MATERIAL APPROPRIATE CONFIGURATION	N/A	III.A	III.B	III.C

3.6 INTERFACE REQUIREMENTS

The interface between the SSFF and furnace modules shall be controlled by interface control documents (ICDs). These ICDs shall contain all physical, functional, mechanical, electrical, and procedural requirements necessary to describe the interfaces. They shall also establish and obtain investigator agreement with the definition of all experiment interfaces and resource allocations.

4. VERIFICATION

The verification program shall assure that the SSFF hardware and software conforms to the design, construction, and performance requirements. Each requirement shall be verified by test or assessment as specified below. The Verification Cross Reference Index, Table 13, defines the verification requirements to be used for each of the Section 3 requirements of this specification.

4.1 Verification Method

Qualification and acceptance shall be accomplished by one or more of the following methods:

a. Test
- Functional test
- Environmental test

b. Assessment
- Similarity
- Analysis
- Inspection
- Demonstration
- Validation of records

4.1.1 Functional Tests

Functional testing is an individual or series of electrical or mechanical performance tests, conducted on flight or flight-configured hardware, at conditions equal to or less than design specifications. Its purpose is to establish that the system performs satisfactorily in accordance with design specifications.

4.1.2 Environmental Tests

Environmental testing is an individual or series of tests, conducted on flight or flight-configured hardware to assure the flight hardware will perform satisfactorily in its flight environment. Examples are vibration, acoustic, thermal vacuum, and EMC. Environmental testing may or may not be combined with functional testing, depending on the objectives of the test and planned operational usage.

TABLE 13. VERIFICATION CROSS REFERENCE INDEX

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 71

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.0	√								
3.1	√								
3.1.1		2							
3.1.1.1	√								
3.1.1.2		2	2,5	3	3,4	3,4	2,5		
3.1.2		2							
3.1.2.1		2,5			2,4				
3.1.2.2		2							
3.1.3	√								
3.1.3.1		2	2,5		4				
3.1.3.1.1		2	2,5	4	4	4			
3.1.3.1.2				4	3,4				
3.1.3.1.3	√			3,4					
3.1.3.1.4	√								
3.1.3.1.5							2,4	1,2	
3.1.3.1.6		2,5	2,5	4	5				
3.1.3.2		2	2,5	4			1		
3.1.3.3		2	2,5	4			1,4		
3.1.4	√								
3.1.5	√								
3.1.5.1		2		3					
3.1.5.2		2		3					
3.1.5.3		2		3					
3.1.5.4				3					
3.1.6		2	2,5	4					
3.1.7		2							
3.1.7.1		2							
3.1.7.2		2							

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 72

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2	√								
3.2.1	√								
3.2.1.1	√								
3.2.1.1.1		2,5	2,5	2,5	1		1		
3.2.1.1.2a		2,5	2,5	4	1				
3.2.1.1.2b		2,5	2,5	4	1				
3.2.1.1.2c		2,5	2,5	4	1				
3.2.1.1.3a		2,5	2,5	4	1		1,5		
3.2.1.1.3b		2	2,5	4	1		1,5		
3.2.1.1.3c		2	2,5	4	1		3,5		
3.2.1.1.4		2	2	2	1				
3.2.1.1.5		2	2	2	1				
3.2.1.1.6		2	2	2	1				
3.2.1.1.7a		2,5	2,5	1	1				
3.2.1.1.7b		2,5	2,5	1	1		1,5		
3.2.1.1.7c		2,5	2,5	1	1				
3.2.1.1.7d		2,5	2,5	4	1				

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 73

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.1.2	√								
3.2.1.2.1	√								
3.2.1.2.1.1			3,4	3,4	4	4	4		
		2,5	,5	,5					
3.2.1.2.1.2		2,5	3,4	3,4	4	4	4		
3.2.1.2.1.3		2,5	3,4	3,4	4	4	4		
		2,5	,5	,5					
3.2.1.2.1.4		2,5	4,5	4,5	4,5	4,5	5		
3.2.1.2.1.5		2	4,5	4,5	4,5	4,5	5		
3.2.1.2.1.6		2	3	3	3	3	5		
3.2.1.2.1.7		2	4,5	4,5	4,5	4,5	4		
3.2.1.2.1.8		2	3	3	3	3	3		
3.2.1.2.1.9		2	3	3	3	3			
3.2.1.2.1.10		2,5	3	3	3	3			
3.2.1.2.1.11		2,5	3	3	3	3			
3.2.1.2.1.12		2,5	3	3	3	3	5		
3.2.1.2.1.13		2,5	3	3	3	3	5		
3.2.1.2.1.14		2,5	3	3	3	3	5		
3.2.1.2.2	√								
3.2.1.2.2.1		2,5	3,4	3,4	3,4	3,4	4		
3.2.1.2.2.2			4,5	4,5	4,5	4,5	5		
3.2.1.2.2.3			4,5	4,5	4,5	4,5	5		
3.2.1.2.2.4			3,5	3,5	3,5	3,5	5		

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 74

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.1.3	√								
3.2.1.3.1	√								
3.2.1.3.1.1		2,5	2,5	2,5	1		1		
3.2.1.3.1.2		2,5	2,5	2,5	1		1		
3.2.1.3.1.3		2,5	2,5	2,5	1		1		
3.2.1.3.1.4		2,5	2,5	2,5	1		1		
3.2.1.3.1.5		2	2,5	2,5			1		
3.2.1.3.1.6		2	2,5	2,5			1		
3.2.1.3.1.7		2	2,5	2,5			1		
3.2.1.3.1.8		2	2,5	2,5			1		
3.2.1.3.1.9		2	2,5	2,5			1		
3.2.1.3.1.10		2	2,5	2,5			1		
3.2.1.3.1.11		2,5	2,5	2,5	5		1		
3.2.1.3.1.12		2,5	2,5	2,5			1		
3.2.1.3.1.13		2	2,5	2,5			1		
3.2.1.3.1.14		2	2,5	2,5			1		
3.2.1.3.1.15		2	2,5	2,5			1		
3.2.1.3.1.16		2	2,5	2,5			1		
3.2.1.3.1.17		2	3	3			1		
3.2.1.3.1.18		2	2,5	2,5			1		
3.2.1.3.1.19		2	2,5	2,5			1		

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 75

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.1.3.2		√							
3.2.1.3.2.1			2,5	2,5	2,5	5			
3.2.1.3.2.2			2,5	2,5	2,5				
3.2.1.3.2.3			2	2,5	2,5				
3.2.1.3.2.4			2	2,5	2,5	5			
3.2.1.3.2.5			2,5	2,5	2,5				
3.2.1.3.2.6			2	2,5	2,5				
3.2.1.3.2.7			2,5	2,5	2,5				
3.2.1.3.2.8			2,5	2,5	2,5				
3.2.1.3.2.9			2	2,5	2,5				

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 76

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.1.4	√								
3.2.1.4.1	√								
3.2.1.4.1.1	√	2	2,5	2,5			2,5		
3.2.1.4.1.2		2	2,5	2,5			1		
3.2.1.4.1.3		2	2	2			2,5		
3.2.1.4.1.4									
3.2.1.4.1.5		2	2	2			2,5		
3.2.1.4.1.6		2	2,5	2,5			1		
3.2.1.4.1.7		2	4	4			2,5		
3.2.1.4.1.8		2	2,5	2,5			2,5		
3.2.1.4.1.9		2	2,5	2,5			1		
3.2.1.4.1.10		2	2,5	2,5			1		
3.2.1.4.1.11		2	2,5	2,5			1		
3.2.1.4.1.12		2	4	4			1		
3.2.1.4.1.13		2	2,5	2,5			1		
3.2.1.4.1.14		2	2,5	2,5			1		
3.2.1.4.1.15		2	2,5	2,5			5		
3.2.1.4.1.16		2	4	4			2,5		
3.2.1.4.1.17		2	2,5	2,5			1		
3.2.1.4.1.18		2	2,5	2,5			1		
3.2.1.4.1.19		2	2,5	2,5			1		

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 77

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.1.4.1.20		2	5	5			5		
3.2.1.4.1.21		2	4	4			1		
3.2.1.4.1.22		2	5	5			1		
3.2.1.4.1.23		22	2,5	2,5			1		
3.2.1.4.1.24			2,5	2,5					
3.2.1.4.1.25		2	4	4			3		
3.2.1.4.1.26			5	5			3		
3.2.1.4.1.27		2	5	5					
3.2.1.4.1.28		2	5	5					
3.2.1.4.1.29		2	3,5	3,5					
3.2.1.4.1.30									
3.2.1.4.1.31									
3.2.1.4.1.32									
3.2.1.4.2	√								
3.2.1.4.2.1		2	3,5	3,5					
3.2.1.4.2.2		2							
3.2.1.4.2.3			4	4					

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 78

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.1.5	√								
3.2.1.5.1	√								
3.2.1.5.1.1		2	4	4			4		
3.2.1.5.1.2		2	4	4			4		
3.2.1.5.1.3		2	2,5	2,5			1		
3.2.1.5.1.4		2	2,5	2,5			1		
3.2.1.5.1.5		2	3,5	3,5			1		
3.2.1.5.1.6		2	3,5	3,5			1		
3.2.1.5.1.7		2	2,5	2,5			1		
3.2.1.5.1.8		2	2,5	2,5			1		
3.2.1.5.1.9		2	2,5	2,5			5		
3.2.1.5.1.10		2	2,5	2,5			1		
3.2.1.5.1.11		2	2,5	4			1		
3.2.1.5.1.12		2	4	4			1		
3.2.1.5.1.13		2	4	4			1		
3.2.1.5.2	√								
3.2.1.5.2.1		2	4	4			3		
3.2.1.5.2.2		2	4	4			3		
3.2.1.5.2.3		2	2,5	2,5			1		
3.2.1.5.2.4		2	2,5	2,5			5		
3.2.1.5.2.5		2	2,5	2,5			1		
3.2.1.5.2.6		2	2,5	1			1		
3.2.1.5.2.7		2	2,5	1			1		
3.2.1.5.2.8		2	2,5	1			1		
3.2.1.5.2.9		2	2,5	1			1		

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 79

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.1.6	√								
3.2.1.6.1	√								
3.2.1.6.1.1		2	2,5	2,5			1		
3.2.1.6.1.2		2	4	4			1		
3.2.1.6.1.3		2	3,5	3,5			1		
3.2.1.6.1.4		2	3,5	3,5			1		
3.2.1.6.1.5		2	2,5	2,5			1		
3.2.1.6.1.6		2	2,5	2,5			1		
3.2.1.6.1.7		2	4	4			1		
3.2.1.6.2	√								
3.2.1.6.2.1		2	4	4			3		
3.2.1.6.2.2		2	2,5	2,5			1		
3.2.1.6.2.3		2	2,5	2,5			1		

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 80

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods							Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.1.7	√								
3.2.1.7.1	√								
3.2.1.7.1.1					4,5	4,5			
3.2.1.7.1.2			4,5	4,5	3	3	4		
3.2.1.7.1.3			3	3	3,4	3,4	5		
3.2.1.7.1.4			3,4	3,4	4,5	4,5	5		
3.2.1.7.1.5			4,5	4,5	4,5	4,5	5		
3.2.1.7.1.6			4,5	4,5	4,5	4,5	5		
3.2.1.7.1.7			4,5	4,5	4,5	4,5	5		
3.2.1.7.2	√								
3.2.1.7.2.1			4,5	4,5	4,5	4,5	5		
3.2.1.7.2.2			4,5	4,5	4,5	4,5	5		
3.2.1.7.2.3			4,5	4,5	4,5	4,5	4		
3.2.1.7.2.4			4,5	4,5	4,5	4,5	4.		
3.2.1.7.2.5			4,5	4,5	3,4	3,4			
3.2.1.7.2.6			3,4 4	3,4 4	4	4	5		

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 81

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
- A. Development
- B. Qualification
- C. Acceptance
- D. Integrated Systems
- E. Prelaunch Checkout
- F. Flight/Mission Operations
- G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.1.8	√								
3.2.1.8.1	√								
3.2.1.8.1.1			3,4	3,4	3,4	3,4			
3.2.1.8.1.2			3,4	3,4	3,4	3,4			
3.2.1.8.1.3			3,4	3,4	3,4	3,4			
3.2.1.8.1.4			3,4	3,4	3,4	3,4			
3.2.1.8.1.5			3,4	3,4	3,4	3,4			
3.2.1.8.1.6			3,4	3,4	3,4	3,4			
3.2.1.8.1.7			3,4	3,4	3,4	3,4			
3.2.1.8.1.8			3,4	3,4	3,4	3,4			
3.2.1.8.1.9			4,5	4,5	4,5	4,5			
3.2.1.8.1.10			4,5	4,5	4,5	4,5			
3.2.1.8.1.11			4,5	4,5	4,5	4,5			
3.2.1.8.1.12			4,5	4,5	4,5	4,5			
3.2.1.8.1.13			4,5	4,5	4,5	4,5			
3.2.1.8.1.14			4,5	4,5	4,5	4,5			
3.2.1.8.1.15			4,5	4,5	4,5	4,5			
3.2.1.8.1.16			4	4	4	4			
3.2.1.8.1.17			4	4	4	4			
3.2.1.8.1.18			5	5	5	5			
3.2.1.8.1.19			4	4	4	4			
3.2.1.8.1.20			4,5	4,5	4,5	4,5			
3.2.1.8.1.21			4,5	4,5	4,5	4,5			
3.2.1.8.1.22			5	5	5	5	4,5		

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 82

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.1.8.2	√								
3.2.1.8.2.1			5	5	5	5	5		
3.2.1.8.2.2			5	5	5	5	5		
3.2.1.8.2.3			5	5	5	5	5		
3.2.1.8.2.4			5	5	4	5			

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 83

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.1.9.1	√								
3.2.1.9.1.1		2							
3.2.1.9.1.2		2							
3.2.1.9.1.3		2		3					
3.2.1.9.2	√								
3.2.1.9.2.1		2							

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 84

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.2	√								
3.2.2.1	√								
3.2.2.1.1		2		3					
3.2.2.1.2		2		3		3			
3.2.2.1.3		2							
3.2.2.1.4		2							
3.2.2.1.5		2							
3.2.2.1.6		2		3,5					

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 85

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.2.2		2	2,5	4			1		
3.2.2.3	√								
3.2.2.3.1	√								
3.2.2.3.1.1		2							
3.2.2.3.1.2		2							
3.2.2.3.1.3	√								
3.2.2.3.1.4			5	5					
3.2.2.3.1.5		2	5	5					
3.2.2.3.1.6		2	5						
3.2.2.3.1.7		2		3					
3.2.2.3.1.8		2		3					
3.2.2.3.1.9		2	5						
3.2.2.3.1.10		2	4						
3.2.2.3.2	√								
3.2.2.3.2.1		2		3					
3.2.2.3.2.2		2		3					
3.2.2.3.2.3		2		3	4				
3.2.2.3.2.4		2		3	4				
3.2.2.3.2.5		2							
3.2.2.3.2.6		2		3					
3.2.2.3.2.7		2							
3.2.2.3.2.8		2	5						
3.2.2.3.2.9		2							

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 86

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.2.3.3	√								
3.2.2.3.3.1	√								

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 87

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.3		2	2,5						
3.2.4	√								
3.2.4.1	√								
3.2.4.1a		2	3,4						
3.2.4.1b		2							
3.2.4.1c		2							
3.2.4.1d		2		3					
3.2.4.1e		2	4						
3.2.4.1f		2		3					
3.2.4.1g		2	4						
3.2.4.1h		2	4						
3.2.4.1i		2	4						
3.2.4.1j		2							
3.2.4.1k		2		3					
3.2.4.1l		2		3					
3.2.4.1m		2							
3.2.4.1n		2	4						
3.2.4.1o		2	4						
3.2.4.1p		2	4						
3.2.4.1q		2							
3.2.4.1r		2							

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 88

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.4.1s		2							
3.2.4.1t		2							
3.2.4.1u		2	4						
3.2.4.1v		2							
3.2.4.1w		2	4						
3.2.4.1x		2							
3.2.4.1y		2	4						
3.2.4.1z		2							
3.2.4.1aa		2							
3.2.4.1ab		2							

C-2

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 89

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.4.2	√								
3.2.4.2a		2	4						
3.2.4.2b		2	4						
3.2.4.2c		2	4						
3.2.4.2d		2		3					
3.2.4.2e		2							
3.2.4.2f		2							
3.2.4.2g		2							
3.2.4.2h		2							
3.2.4.2i		2		3					
3.2.4.2j		2		3					
3.2.4.2k		2		3					
3.2.4.2l		2							
3.2.4.2m		2							
3.2.4.2n		2	4						
3.2.4.2o		2	4						
3.2.4.2p		2	5						
3.2.4.2q		2							

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 90

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.4.3	√								
3.2.4.3a		2		3					
3.2.4.3b		2		3					
3.2.4.3c		2							
3.2.4.3d		2		3					
3.2.4.3e		2		3					
3.2.4.3f		2							
3.2.4.3g		2		3					
3.2.4.3h		2		3					
3.2.4.3i		2							

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 91

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.4.4		2	2,5			5			
3.2.4.5				4					
3.2.4.6	√								
3.2.4.6a		2	2,5	4					
3.2.4.6b		2	2,5	4					
3.2.4.6c		2	2,5	4					
3.2.4.6d		2	2,5	4					
3.2.4.6e		2	2,5	4					
3.2.5		2	2,5						

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 92

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.6		2	2,5	4					
3.2.6.1	√								
3.2.6.1.1		2	2,5	4					
3.2.6.1.2		2	2,5	4					
3.2.6.1.3		2	2,5	4					
3.2.6.2		2	2,5	4					
3.2.6.3		2	2,5	4					

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 93

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.7		2	2,5						
3.2.7.1		2	2,5						
3.2.7.2		2	2,5						
3.2.7.2.1		2	2,5						
3.2.7.2.2		2	2,5						
3.2.7.2.3		2	2,5						
3.2.7.3		2	2,5						
3.2.7.4		2	2,5						
3.2.7.5		2	2,5						
3.2.7.6		2	2,5						
3.2.8		2	2,5						
3.2.9		2							

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 94

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.3	√								
3.3.2		2	2,5	4					
3.3.2.1		2							
3.3.2.1.1		2		3					
3.3.2.1.2		2		3					
3.3.2.1.3		2	2,5						
3.3.2.1.4		2		3					
3.3.2.1.5		2	1,5	1,5					
3.3.2.1.6		2	3						
3.3.2.1.7		2	2,5						
3.3.2.1.8		2		3					
3.3.2.2		2		3					
3.3.2.3		2		3					
3.3.2.4		2		3					
3.3.2.5		2		3					
3.3.2.6		2		3					
3.3.2.7		2		3					
3.3.2.8		2		3					
3.3.2.9		2		3					
3.3.2.10		2		3					
3.3.2.11		2		3					
3.3.2.12		2		3					
3.3.2.13		2		3					
3.3.2.14		2		3					
3.3.2.15		2		3					
3.3.2.16		2		3					
3.3.2.17		2	2,5	3					
3.3.2.18		2	2,5	3					

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 95

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.3.2.19		2		3					
3.3.2.20		2	2,5	3					
3.3.2.21				3					
3.3.2.22				3					
3.3.2.23				3					
3.3.2.24				3					
3.3.2.25				3					
3.3.2.26				3					
3.3.2.27				3					
3.3.2.28				3					
3.3.2.29		2	2,5	3					
3.3.2.30		2		3					
3.3.2.31		2	2,5	3					
3.3.2.32		2		3					
3.3.2.33		2	2,5	3					
3.3.2.34		2		3					
3.3.2.35		2		3					

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 96

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.3.3		2		3					
3.3.3.1		2	2,5	3					
3.3.3.2		2	2,5	3					
3.3.3.3		2	2,5	3					
3.3.3.4		2	2,5	3					
3.3.3.5		2							
3.3.3.6		2							
3.3.3.7		2		3					
3.3.3.8		2		3					
3.3.3.9		2,3		3					
3.3.3.10		3		3					
3.3.3.11		3		3					
3.3.3.12		3		3					
3.3.3.13		2	2,5	3					
3.3.3.14				3					
3.3.3.15		2,3		3					
3.3.3.16		2,3		3					
3.3.3.17		2,3							

TABLE 13. VERIFICATION CROSS REFERENCE INDEX (cont.)

CEI Nomenclature/Number	VERIFICATION CROSS REFERENCE INDEX	Spec No. 320SPC0001 Dated 9 April 1992 Page 97

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Similarity
2. Analysis
3. Inspection
4. Demonstration
5. Test

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

N/A - Not Applicable

Section 3.0 Performance / Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.3.4		2		2,3	2,3				
3.3.5		2							
3.3.6		2,3							
3.3.7		2		2,3	2,3				
3.3.8		2,3		3	3				
3.3.9				3	3				
3.3.9.1				3	3				
3.3.9.2				3	3				
3.3.10		2	2,4	3,4	3,4				
3.4		2							
3.5					3,4				
3.6					3				

4.1.3 Similarity Assessment

Verification by similarity is the process of assessing, by review of prior test data or hardware configuration and application, that the article is sufficiently similar or identical in design and manufacturing process to another article that has previously been qualified to equivalent or more stringent specifications.

4.1.4 Analysis Assessment

Verification by analysis is a process used in lieu of, or in addition to, testing to verify compliance to specification requirements. The selected techniques may include Table 13, systems engineering analysis, statistics and qualitative analysis, computer and hardware simulations, and analog modeling. The analysis of safety-critical structures shall conform to the requirements of JA-418A. Analysis may be used when it can be determined that:

a. Rigorous and accurate analysis is possible.

b. Test is not cost-effective/practicable.

c. Similarity is not applicable.

d. Verification by inspection is not adequate.

4.1.5 Inspection Assessment

Verification by inspection (e.g., physical verification of compliance with drawings, wire coating, workmanship, material compliance) is a process which may be used in lieu of, or in conjunction with, testing to verify design features.

4.1.6 Demonstration Assessment

Validation by demonstration is the process where demonstration techniques (e.g., service access, maintainability, transportability, crew hardware interfaces) are used in lieu of, or in conjunction with, the verification requirements.

4.1.7 Validation of Records Assessment

Verification by validation of records is the process where documentation and records are used at hardware acceptance to verify design, construction, testing, and processes.

4.2 Verification Levels

Verification levels are those used to identify discrete verification activities.

4.2.1 Component Level

The component level is the hardware level within each subsystem where end item verification is first applied. Both qualification and acceptance verifications may be performed on flight and flight-configured components

4.2.2 Subsystem/System Level

This verification level follows the component level, and consists of two or more components, including interconnecting cabling. This level of verification is performed prior to assembly into the flight module, and may include flight or flight-configured hardware separately or in combination.

4.2.3 SSFF End Item

The End Item hardware level consists of the SSFF and GSE. Verification includes interface checks, operation of individual subsystems, combined systems acceptance tests, and mission simulation tests.

4.3 Verification Types

Verification types are development, qualification, acceptance, and qualification/ acceptance.

4.3.1 Development Verification

Development verification is the process used to verify the feasibility of the design approach, and to provide confidence in the ability of the hardware to comply with performance criteria. Where a vendor is required to perform development verification, appropriate direction shall be included in the verification matrix.

4.3.2 Qualification Verification

Qualification verification is an individual or series of functional and environmental tests conducted on flight-configured hardware, at conditions normally more severe than acceptance test conditions, to establish that the hardware will perform satisfactorily in the flight environments with sufficient margins. Where a vendor is required to perform qualification verification, appropriate direction shall be included in the matrix Table 13. Tests shall be conducted per approved procedure and with Quality Control (QC) surveillance.

4.3.3 Acceptance Testing

Testing shall verify the design and operational requirements of Section 3 of this specification. All SSFF interfaces shall be verified. The main objective of the acceptance phase shall be to verify that the flight system meets the mission performance requirements as an integrated unit, and is physically and operationally compatible with mating hardware, systems, software, and GSE. The tests shall be performed under QC surveillance. The following general requirements apply to the acceptance tests:

a. Environmental tests (if conducted) shall be at reduced levels to check manufacturing processes, but to avoid hardware fatigue.

b. Calibration and alignment of equipment, as necessary, shall be accomplished prior to conducting acceptance verification.

c. The severity, number, and duration of acceptance tests shall not result in over-stressing or degradation of performance capability.

d. Records shall be kept, as required, to document the results of acceptance verification.

e. Acceptance verification shall be conducted in accordance with approved procedures/documentation

4.3.4 Integrated Systems (Pre-level IV)

The integrated system phase shall be conducted to verify intra/inter system interfaces, and to verify that system equipment will operate properly as part of the total U.S. Lab/SSFF system.

4.3.5 Prelaunch Checkout

Prelaunch checkout shall be performed to verify the physical and functional compatibility and flight readiness of the SSFF/U.S. Lab system.

4.3.6 Flight/Mission Operations

Flight operations shall perform the planned SSFF mission operations timeline, defined by the Functional Objectives (FOs) in the SSFF Experiment Requirements Document (ERD), with other mission functions. Flight operations shall also verify the SSFF design.

4.3.7 Post-Flight

Post-flight operations shall verify removal, handling, refurbishment, and checkout procedures, and determine the minimum turnaround time.

4.4 Test/Equipment Failures

Test articles that experience failure during test may be repaired and retested, provided analysis shows that no design change is necessary. If a design change is required to effect repair, the test item shall be considered to have failed the test, and normal change control procedures shall be followed.

4.5 Verification Facilities and Equipment

Existing facilities and equipment shall be used to the maximum extent practical. Maximum use of the same test equipment shall be made for testing at multiple locations to assure uniformity of test results. All test equipment shall be designed with a fail-safe goal in order that equipment failure will not degrade flight hardware. All test equipment shall be verified prior to interfacing with flight equipment to ensure that no damage or degradation to flight hardware will be induced.

4.6 Quality Assurance

A Quality Program shall be established in accordance with NHB 5300.4 (1B) and SS-SRD-0001B, Section 9.

5. PREPARATION FOR DELIVERY

A packaging, handling, and transportation form shall be prepared in accordance with NHB 6000.1C. Program Critical Hardware shall be packaged, handled, stored, and shipped in accordance with NHB 6000.1C and shall not be exposed to more severe handling environments than those defined in this specification.

5.1 Preservation and Packaging

5.1.1 Cleaning

Prior to packaging, all components shall be visibly clean to the VC level Highly Sensitive requirements of JSC-SN-C-0005C. Components will be assembled and the complete assembly prepared for shipment while maintaining the VC level Highly Sensitive status.

5.1.2 Attaching Parts

When parts accompany a component, such as attachment hardware etc., they shall be preserved, bagged, appropriately identified and attached to the component with which they are used.

5.1.3 Electrical Connectors

All electrical connectors shall be capped with electrostatic discharge proof protective dust caps. Caps shall be friction fitting or threaded type which do not require tape or an additional mechanical device to secure.

5.1.4 Critical Surfaces

Critical surfaces, such as interfaces, shall be protected using protective pads as appropriate. Material used for protective pads shall not cause component degradation.

5.1.5 Wrapping

All components shall be double bagged using anti-static "Kapran 980". The inner bag shall be dry nitrogen purged, evacuated and sealed.

5.1.6 Cushioning

When required for protection, components shall be cushioned using a suitable resilient foam cushioning material such as polyethylene, polyurethane or polystyrene. The component surfaces shall be wrapped to prevent direct contact with the cushioning material.

5.2 Packing

The SSFF shall be packed in a suitable shipping container(s) conforming to the requirements of NHB 6000.1C. The container(s) shall be closed and secured by fasteners. Special fixtures or shipping container design features shall be provided such that the SSFF is not damaged or thrown out of alignment during shipment. The container shall provide protection against the environments defined in this specification and shall comply with the applicable tariffs and regulations for the particular mode of transport when shipped.

5.3 Marking for Shipment

The shipping container shall be marked and labeled in accordance with MIL-STD-129J, including precautionary markings necessary to ensure safety of personnel and facilities and to ensure safe handling, transport, and storage. Modes of transportation shall be as stated in this specification. Identification information on the shipping container shall be in the following format and shall include:

MSFC CONTROL NUMBER_______________
ITEM NAME_______________
NSN/NATO STOCK NUMBER_______ (WHEN APPLICABLE)
MANUFACTURER'S TYPE OR PART NUMBER_______________
QUANTITY IN PACKAGE_______ TRACEABILITY INFORMATION
AGE CONTROL MARKING_______________
SERIAL NUMBER_______________
MANUFACTURER_______________
MSFC PURCHASE ORDER NUMBER_______________
DATE OF PACKAGING_______________
LEVELS OF PACKAGING_______________
LEVELS OF PACKAGING AND PACKING_______________
MANUFACTURER'S PACKAGE PART NUMBER_______________
(NOT REQUIRED FOR OFF-THE-SHELF CONTAINERS)

6. NOTES

6.1 Definitions

6.1.1 Acceptance Tests

Acceptance tests are functional tests to determine that the SSFF is capable of meeting performance requirements prescribed in this specification in a nominal operational environment. The acceptance test program shall be approved by the MSFC SSFF Project Manager.

6.1.2 Certification

Certification consists of qualification testing and analysis required to determine that the SSFF meets all requirements from component level through acceptance test level. The MSFC SSFF Project Manager shall review the planned certification criteria and approve whether qualification tests or certification by analysis are to be used.

a. Qualification Tests - Demonstration by test that the SSFF is capable of meeting design performance requirements, including design margin, under operating environmental conditions described in this specification.

b. Certification by Analysis - Certification by analysis allows the use of appropriate engineering analyses, including measurements by assessment and simulation to provide fulfillment of certification objectives. Certification by analyses will normally be performed because of one or more of the following factors:

   1. The inability to effectively simulate flight conditions in a ground test.

   2. Qualification testing would be impractical.

   3. Analysis may be used where it can be shown that the article is similar or identical in design, manufacturing processes, and quality control to another article that has been previously certified to equivalent or more stringent criteria.

6.1.3 Fail Safe

Fail safe is the ability of a system, component, or part to sustain a failure without causing a failure in any other system, component, or part of the experiment, its carrier, or the U.S. Lab module.

6.1.4 Failure

Failure is the inability of the SSFF to perform its required functions within specified limits, under operating conditions.

6.1.5 Operating Life

Operating life is the specified operation time (or number of operating cycles) that a SSFF can accrue before replacement or refurbishment, without risk of degradation of performance beyond acceptable limits.

6.1.6 Shelf Life

Shelf life is that period of time during which a SSFF may remain in storage without having its operability affected. Preventive maintenance, servicing, and replacement of age-sensitive material parts shall be permitted on a scheduled basis during the storage period.

6.1.7 Useful Life

Useful life is the total life span, including service and storage with normal preventive maintenance and servicing, before the SSFF is considered unacceptable for further usage.

6.1.8 Verification

Verification is the process of planning and implementing a program that determines that the SSFF meets all design, performance, and safety requirements. The verification process includes development testing, qualification testing, acceptance testing, and analysis necessary to support the total verification plan. Engineering Design Unit (EDU) test results will not be used as closure data for verification items.