FIBER OPTIC CABLE, SINGLE FIBER, MULTIMODE, SPACE QUALITY

SPECIFICATION CUSTODIAN:

THE BOEING COMPANY
SPACE AND COMMUNICATIONS DIVISION
2100 SPACE PARK DRIVE
HOUSTON TEXAS, 77058
CAGE CODE: 2B945

INTERNATIONAL SPACE STATION PROG

SSQ 21657 Revision N/C

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REV LTR	DESCRIPTION OF CHANGE	Author and Date	Approval Signature
NEW			
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PREFACE

SSQ 21654 Space Station Program, Cable, Single Fiber, Multimode, Space Quality, General Specification, details the requirements and characteristics for a single fiber cable with a glass optical fiber and the appropriate processes, procedures and tools.

_____ _____

Program Manager (or delegated authority) Date
Space Station Program

SPACE STATION PROGRAM OFFICE
CABLE, SINGLE FIBER, MULTIMODE, SPACE QUALITY
GENERAL SPECIFICATION
CONCURRENCE

PREPARED BY: _____ PRINT NAME

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SUPERVISED BY: _____

_____ _____

DQA
PRINT NAME ORGANIZATION

SIGNATURE DATE

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1.0 SCOPE

1.1 Purpose

The purpose of this specification is to detail the requirements and characteristics for a single fiber cable for use on the International Space Station. This document specifies the requirements for interior, exterior or both interior and exterior service in a manned, zero gravity, low earth orbit with a minimum life expectancy of 15 years (5 years in orbit prior to service and 10 of service). Additionally, the cable may have 5 years of terrestrial exposure prior to the 15 years of orbit. Where performance characteristics cannot be verified using industry standard test methods, the user must ultimately determine the suitability of these items for use on a case-by-case basis.

1.1 Intent

The SSQ 21654 cable specified herein is intended for use with the size 16 optical termini specified in SSQ 21635, SSQ 21636, and SSQ 21637 type connectors and in environments that includes a space vacuum and a normally pressurized habitat. This document is intended to serve as the procurement specification. Cables construction to meet this specification can have an internal configuration, an internal configuration and/or a configuration that meets both the internal and external requirements. The different configurations are delineated by dash number to the cable part number as defined by Section 6.

Additional Environmental, Mechanical and Material Concerns

There are aspects of the internal and external environment known to degrade fiber optic cables. The user should be aware of the information in this section and should assess these concerns on a case-by-case basis while considering its application.

1.2 Interconnect system

The fiber optic cable is part of an interconnect system that includes fiber optic termini, connectors, accessories, wire and cable, tools, assembly processes and procedures and, as such, are commonality color coded to aid in their proper match in an effort to eliminate errors in ground based factory or on-orbit installation, assembly and repair.

The specific color assignments are usually found in the appendix which contains the drawings of contacts, or in a table listing color assignments by wire size or listed as a requirement with other detail characteristics (fiber optic cable). For example, the fiber optic cable defined in this SSQ is color coded violet and the fiber optic termini used with this cable will have a violet stripe on the barrel to indicate it is used with this cable. The contact will also have strips designating the contact size and connector type. Anyone familiar with the system can tell at a glance it is a correct combination.

1.2.1 Tools, processes, and procedures

Appendices are included within this specification providing tools and fiber/cable stripping processes and procedures. Users with certified tools and applicable processes and procedures in

place need only demonstrate that those tools, processes and procedures meet the requirements applicable to the subject at hand.

Users without adequate tools and applicable processes and procedures are provided with a list of tools and applicable processes and procedures which will assure compliance to the requirements specified herein.

1.3 Classification

Cable configured to this specification and bearing the appropriate part number shall be considered as Class S – Space Qualified.

1.4 Document generation

This specification, revision, text and graphics, is computer generated. The text software is Microsoft® Word. This software contains conversion capability for many major word processor programs. See the Microsoft® Word user's reference.

1.5 Configuration management

This NASA specification is under configuration management by the NASA Space Station program, Johnson Space Center, Houston, Texas. Parts defined by and manufactured to this specification are configuration controlled by base line control documentation, **NOT** by specification revision letter.

1.5.1 Specification changes

Changes to this specification shall be reviewed and approved by the NASA International Space Station Program Office, or their designee, prior to official release of the revision containing those changes.

1.5.2 Specification distribution

Released copies of this specification are available from the specification custodian and/or the NASA International Space Station Program Office, Parts Control Board, Johnson Space Center, Houston, Texas.

1.5.3 Procuring activity

The procuring activity is responsible for supplier negotiations dealing with their procurement effort. This includes any development associated with product not developed and tooled as part of the initial release of this specification.

The procuring activity is responsible for the coordination of all specification related issues with the specification custodian such that development status and any related changes may be incorporated.

A development status data base shall be maintained by the specification custodian and/or the NASA International Space Station Program Office with the intent of incorporation in a program wide data base (EPIMS) when available.

1.6 Specification custodian

The supplier(s) shown on the title page of this specification have been designated by the NASA International Space Station Program Office, Johnson Space Center, Houston Texas as the specification custodian and is tasked to generate this specification and provide related custodial activities on behalf of NASA.

The specification custodian, in conjunction with the NASA Space Station Program Office, Johnson Space Center, Houston Texas, or their designee, is responsible for program coordination, supplier coordination, technical evaluation and incorporation of comments, and final preparation of revisions to this specification.

The specification custodian, with approval of the NASA Space Station Program Office or their designee, may assign any portion, or all, of these duties to any active participant in the Space Station program.

The specification custodian shall act in concert with the joint work package connector board and the procuring activity, or as directed by the NASA International Space Station Program Office or their designee, in all issues regarding this specification.

1.7 Approved sources

Approved suppliers shall allow user review of any and all listed materials, processes, procedures, drawings, or any other item of interest related to this specification, at the supplier's facility or mutually agreed to location. Should disagreement arise, direction from the NASA International Space Station Program Office via the specification custodian shall be requested. The decision of the NASA International Space Station Program Office shall be final.

It is intended that data deemed "proprietary" by the supplier shall be protected to the best of the user's ability.

Approved Sources are documented in 6.0.

2.0 Applicable Documents

2.1 Government documents

The following documents, of the exact issue shown, or if no issue is specified, the issue in effect at the date of invitation to bid, form a part of this specification to the extent specified herein. In the event of conflict between documents referenced here and the contents of 3.0, 4.0, 5.0, 10.0, and the associated Appendices, the requirements detailed by this specification are considered the superseding requirements. (See 1.0 Scope.)

2.1.1 Specifications

2.1.1.1 Federal

2.1.1.2 Military

JSC-SPEC-SP-R-0022	General Specification Vacuum Stability Requirements of Polymeric Material for Spacecraft Applications
NHB 5300.4 (3G)	Inspection System Provisions for Suppliers of Space Materials, Parts, Components and Services
NASA-STD-6001	Flammability, Odor and Offgassing Requirement Test Procedures for Materials in Environments that Support Combustion
SSP 30233	Space Station Requirements for Materials and Processes, General Specification for
STP 30253	
MSFC-HDBK-527/ JSC 09604	Materials Selection For Space Hardware Systems
NSFC-SPEC-164	

2.1.2 Standards

2.1.2.1 Federal

FED-STD-228	Cable and Wire, Insulated; Methods of Testing.

2.1.2.2 Military

DOD-STD-1678	Fiber Optic Test Methods and Instrumentation
MIL-C-12000	Cable, Cord, and Wire, Electric, Packaging of
MIL-B-81705	Barrier Materials, Flexible, Electrostatic-Free, Heat Sealable
MIL-STD-104	Limits for Electrical Insulation Color
MIL-STD-129	Marking for Shipment and Storage.
MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-810	Environmental Test Methods and Engineering Guidelines
MIL-STD-45662	Calibration Systems Requirements.
MS90376	

(Copies of specifications and standards required by suppliers in connection with a specific acquisition should be obtained from the contracting activity or as directed by the contracting activity.)

2.1.3 Other publications

The following documents form a part of this specification to the extent specified herein.

Electronic Industries Association (EIA)

ASTM E595	Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment.
EIA/TIA-455-13	Visual and Mechanical Inspections of Fibers, Cables, Connectors and Other Fiber Optic Devices.(DOD Adopted)
EIA/TIA-455-20	Measurement of Change in Optical Transmittance.
EIA/TIA-455-30	Frequency Domain Measurement of Multimode Optical Fiber Information Transmission Capacity
EIA/TIA-455-31B	Fiber Tensile Proof Test Method
EIA/TIA-455-37A	Low or High Temperature Bend Test for Fiber Optic Cables
EIA/TIA-455-41A	Compressive Load Resistance of Fiber Optic
EIA/TIA-455-45B	Method for Measuring Optical Fiber Geometry Using a Laboratory Microscope
EIA/TIA-455-46	Spectral Attenuation Measurement for Long-Length, Graded Index Optical Fibers
EIA/TIA-455-47B	Output Far-Field Radiation Pattern Measurements. (DOD Adopted)
EIA/TIA-455-60	Measurement of fiber or Cable Length Using an OTDR
EIA/TIA-455-61	Measurement of Fiber or Cable Attenuation Using an OTDR
EIA/TIA-455-171	Attenuation by Substitution Measurement—for Short-Length Multimode Graded-Index and Single-Mode Optical Fiber Cable Assemblies.
EIA/TIA-455-177A	Numerical Aperture Measurement of Graded-Index Optical Fibers
EIA/TIA-455-189	Ozone Exposure Test for Fiber Optic Components
BELCORE GR326-CORE	Generic Requirements for Single-Mode Optical Connectors and Jumper Assemblies

2.2 Interpretation

Should the requirements of this specification and/or any associated documents become subject to conflicting interpretation, clarification shall be formally requested.

In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

2.3 Communications

All written communications shall be through the NASA International Space Station Program Office, Johnson Space Center, Houston, Texas, the specification custodian or the procuring activity. The procuring activity shall be responsible for assuring program coordination (see 1.7).

3.0 Requirements

3.1 Item description

The design, construction, and physical dimensions of the complete cable and cable elements shall be as specified herein and in Appendix A. This specification defines a simplex or singe fiber construction. Some requirements are identified specifically for internal use cables, external use cables and both internal and external use cables. They are specified by dash number per section 6.0. All cable constructions and designs shall be of a circular cross-section and generally concentric geometry.

3.2 General requirements

3.2.1 Identification of Design

Prospective suppliers shall submit one reproducible copy of the following:

3.2.1.1 Drawings and MSDS Information

Drawings shall be submitted which show the internal cross-sectional drawing shall show all internal and external dimensions and their tolerances; identification of all materials and coatings (by chemical composition or by original manufacture's part number) used in the construction of the cable; the location and size of marking; the maximum guaranteed weight. The drawing may be exaggerated dimensionally. Material Safety Data Sheets shall be provided for all raw materials used.

3.2.1.2 Exceptions and deviations

Prospective suppliers shall submit a list of exceptions to or deviations from the conditions or requirements of the specification detailing by paragraph number the specifics of exceptions or deviations and the rationale or reasons thereof. The schedule and/or cost impact of not allowing each exception or deviation shall be identified.

3.2.2 Data required for final design approval

3.2.2.1 Test procedures

Detailed qualification and acceptance test procedures shall be submitted to and approved by the specification custodian prior to the start of testing.

3.2.2.1.1 Qualification test procedures

Detailed qualification test procedures shall be submitted for approval by the specification custodian four weeks minimum prior to scheduled start of qualification testing.

3.2.2.1.1.1 Qualification test lengths

The test sample length is specified in Table I. 200 meters shall be retained by the supplier for qualification tests and 25 meters shall be supplied to specification custodian to be forwarded to NASA for materials testing.

Table I - Test Lengths

Requirement Paragraph	Exposure Condition	Exposed Sample Length (meters)	Total Sample Length (meters)
3.4.1	Numerical Aperture	2 (Fiber)	
3.4.2	Optical Bandwidth	1000 (Fiber)	
3.5.1	Fungus	7 (Cable)	
3.5.2	Toxic Hazard	Part of above	
3.5.3	Odor	Part of above	
3.5.4	Flammablity	Part of above	
3.5.5	Vacuum Stability/Offgassing	Part of above	
3.5.10.1	Ionizing Radiation	100 (Cable)	130 (Cable)
3.5.10.2	Deep Dielectric Charging		
3.5.10.4	Static-ESD Environment	1 (Fiber)	1 (Fiber)
3.5.11	Vacuum	100 (Cable)	130 (Cable)
3.5.12	Survival Temperature	100 (Cable)	
3.5.13	Thermal Shock	100 (Cable)	110 (Cable)
3.5.14	Reactivity in Fluids	5 (Cable)	5 (Cable)
3.5.15	Humidity	100 (Cable)	110 (Cable)
3.5.16	Ambient Light Susceptibility	30 (cable)	40 (Cable)
3.6.1.1	Cable Jacket Strippability	1 (Cable)	1 (Cable)
3.6.1.2	Cable Buffer Strippability	Part of above	
3.6.1.3	Fiber Buffer Strippability	Part of above	
3.6.2	Cable Fiber Life	100%	100%
3.6.2.1	Intrinsic Fiber Strength	100%	100%
3.6.2.2	Dynamic Strength	80 (Cable)	80 (Cable)
3.6.3	Crush Resistance	5 (Cable)	5 (Cable)
3.6.4	Cable Bend	5 (Cable)	10 (Cable)
3.6.5	Cyclic Flexing	5 (Cable)	5 (Cable)
3.6.7	Cable Weight	1 (cable)	1 (Cable)
3.7.1	Fiber Core	1 (fiber)	1 (Fiber)
3.7.2	Fiber Cladding	Part of above	
3.7.3	Hermetic Coating	Part of above	

3.7.4	Fiber Coating	Part of above	
3.7.5.1	Cable Color	1 (Cable)	1 (Cable)
3.7.5.2	Cable Jacket	1 (Cable)	1 (Cable)
3.7.5.3	Cable Jacket Stability	2 (Cable)	2 (Cable)
3.7.5.4	Identification Marking	1 (Cable)	1 (Cable)
3.7.5.4.1	Legibility	1 (Cable)	1 (Cable)
3.7.5.4.2	Marking Durability	1 (Cable)	1 (Cable)
3.5.7.4.3	Printing Group	1 (Cable)	1 (Cable)
3.7.5.5	Cable Buffer	1 (Cable)	1 (Cable)
3.7.5.6	Cable Strength Member	1 (Cable)	1 (Cable)

3.2.2.1.1.2 Qualification inspection routine

The sample shall be subjected to the qualification inspection specified in Table XII, however the order may change from that shown. Fiber dimensional measurements must be performed prior to cabling and sample lengths shall be as required for the individual measurement. Qualification inspection shall be performed on sample units produced with equipment and procedures normally used in production at a laboratory acceptable to the government and the specification custodian.

3.2.2.1.1.3 Qualification test discrepancy

Any discrepancy that occurs during testing shall be reported to the specification custodian within 24 hours. Testing shall not continue unless otherwise advised by the specification custodian. The supplier shall prepare a description of the discrepancy, an analysis of the cause, corrective action proposed, and the extent of retest if applicable.

3.2.2.1.1.4 Qualification test failure

If a failure occurs during qualification tests, testing shall cease, the supplier shall notify the specification custodian at once verbally and shall follow-up with a written notification describing the cause of failure and the proposed corrective action. Written specification custodian approval of such action must be given prior to resumption of testing.

3.2.2.1.1.5 Qualification reports

A detailed qualification test report shall be submitted for approval by the specification custodian within four weeks following completion of testing to provide a record that the articles tested comply with the qualification test requirements of the specification. The report shall be certified by an authorized representative of the company, and shall contain the following information for which approval is requested:

a. Certification of the fact that the test samples were in conformance with and tested to the latest approved revision of the specification with respect tot he design, construction,

materials, workmanship, marking, manufacturing processes and controls, test procedures, etc.

b. Dated and signed examination and test results verifying that the samples complied with all the qualification test requirements of this drawing including:

1. Measured or observed test conditions at the time of test or examination as required.
2. All pertinent qualitative observations and quantitative values obtained by measurement, including oscillographs, recordings, charts, photographs, etc.
3. Calculated values and sample calculations.
4. References to applicable drawings or documents (design drawing, test procedure, Q.C. procedure, etc.) cross-correlated to the specific requirements and test method paragraph of this specification for each of the examination and test parameters itemized in Table VIII.

3.2.2.1.1.6 Qualification by similarity

If a cable, which is similar in materials and construction to what is specified herein, has previously been subjected to, and successfully passed, tests which are the equivalent of those required herein, it may be possible to utilize the previous tests in lieu of part or all of the testing required by this specification. In such a case, the supplier may submit a statement which identifies the similarities and differences between the previously tested cable and the cable specified herein. The statement should cover design features, construction and materials of the cable to permit a competent evaluation of the similarity of the cables and the validity of the comparison. The statement, together with certified copies of the earlier tests reports, shall be submitted for the qualifying activity approval in advance of the start of qualification testing. If approved, they shall also be included as part of the qualification test report.

3.2.2.1.1.6.1 Qualification by analysis

Should any of the requirements be qualifiable by analytical processes the supplier shall submit that analysis to the specification custodian for approval in advance of the start of qualification testing. If approved the analyses shall be included as part of the qualification test report.

3.2.2.1.1.6.2 Qualification test sample disposition

All test samples, or the remains thereof, shall be clearly identified as qualification test samples, along with their appropriate part number. The test samples shall then be protectively packaged and, unless otherwise specified in the purchase contract, shipped to the specification custodian in a container marked “Qualification Samples - Do Not Use”. The cable samples shall be conspicuously marked with at least two red “X’s” in a manner which does not obscure other markings.

3.2.2.1.1.7 Qualification Maintenance

Qualification status will be considered valid as long as the cable design, the manufaturing processes and raw materials used remain unchanged from thee used to produce the qualification test product. And design, process or raw material change must be approved by the specification

custodian prior to implementation so they can determine the product will meet the specification requirements. This analysis may show that additional testing is required to validate the product still meets the specification requirements or that the product will be sufficiently different such that a full re-qualification is necessary. Marking unqualified cable with the part numbers specified herein is considered fraudulent and may be grounds for prosecution.

3.2.2.1.2 Acceptance test procedures (4.6.1, 7.0)

Detailed acceptance test procedures shall be submitted for approval by the specification custodian six weeks minimum prior to scheduled start of acceptance testing. Acceptance tests shall be performed on every lot of cable produced and marked with the part numbers defined herein. Some of the acceptance test apply to the fiber before it is cabled. Minimum yield requirements are specified in section 3.10. Lots which do not meet these minimum yield requirements shall not be shipped and shall be identified as non-conforming product.

3.2.2.1.3 Discrepancy/failure analysis

The supplier is responsible to provide complete failure analysis of all failures. The analysis shall consist of an analysis plan, a narrative of the analysis activity and full documentation of any anomalies found, and recommend action.

Discrepancies/failures reported from any source shall be brought to the attention of the specification custodian, or NASA designated technical representative, within 5 working days of receipt by the supplier. The supplier shall analyze each report and shall transmit their recommended disposition or corrective action to the specification custodian within 10 working days of receipt of the report. Review of the proposed recommendations or corrective actions and notification of acceptance status shall be provided to the supplier within 5 working days of receipt of the report.

3.2.2.2 Materials list

A complete list of materials, including material rating in accordance with MSFC-HDBK-527/JSC-09604, quantity and exposed surface area shall be submitted four weeks prior to start of production. For external use cables, the exposed surface area will be considered to determine if decomposing materials are sufficient to inhibit proper function of susceptible subassemblies (such as photo-voltaic panels and thermal radiators). Specifically, Table II shows environments that are known to cause degradation to typical cable jacket materials and for which the user of the cable specified herein must consider for use in the next assembly.

Table II - Typical Cable Jacket Corroding Environments

Environment	Level	Controlling Document
Atomic Oxygen	The cable shall not degrade when exposed to 5×10^{21} atoms/cm^{2}year for 15 years.	SSP 30233 Rev E
Solar UV Radiation	***TBD***	SSP 30233 Rev E

Solar Particles	***TBD***	SSP 30233 Rev E
Arc Tracking	It may be possible that the byproducts of combustion of the cable may support an arc tracking scenario. All the wire insulation used in ISS is compliant but the FO cable shall not interact with the wires, or by itself to produce combustion byproducts that support arc tracking or can pass electrical current	NASA-STD-6001 Test 18 Replace one of the 7 wires with the FO cable. Subject the harness to a ignition source per the flammability test requirements. Perform in a O2 rich environment per Table VII.
HF Etching Resistance	HF is produced during fluoropolyimer processing operations and in subsequent episodes of handling or ESD insults on fluoropolyimers.	TBD
Ozone	The exterior cables will be subjected to Ozone during transport to orbit. The sample shall be wrapped around a 1.25 cm mandrel, subjected to 40°C, RH = 50% min., exposed to 1 day to 1000 PPM dose.	EIA/TIA 455 FOTP 189
Plasma	***TBD***	SSP 30233 E

3.2.3 Baseline configuration control

Configuration control will be accomplished by baseline control documentation. The specification custodian shall approve the process baseline control documentation prior to initiating manufacturing or testing of products to be furnished under this specification.

3.2.3.1 Baseline control document

The baseline control document shall be submitted to the specification custodian for approval, four weeks maximum prior to the start of production. The baseline control document shall be updated after each requirement change. The baseline control documentation shall include dimensions, processes and relevant process controls.

3.2.3.2 Baseline control deviations

After final approval of the baseline control documentation, there shall be no deviations without written approval for the specification custodian (see 1.6 and 1.7). All requests for deviation from the requirements of this specification shall be submitted to the procuring activity procurement department in writing and accompanied by through technical rationale.

3.2.4 Traceability

All finished cable must be traceable by lot date code to the part number and lot date code of all constituent and raw materials used the cables construction. All constituent fiber lots must be traceable to documentation establishing that it has been exposed to adequate proof test levels on a 100% basis. It is the responsibility of the supplier to monitor the fiber production and to insure

that surviving fiber of low yield runs (more that 20% crapped during a draw session due to proof breaks, dimensional instability or coating defects) is not shipped as part of this cable.

3.3 Workmanship (4.5, 4.7)

All details of workmanship shall be in accordance with high grade optical fiber and cable manufacturing practice. No fiber splices are allowed.

3.4 Optical (4.8)

3.4.1 Numerical aperture

The numerical aperture of the fiber shall be in 0.30 ± 0.02. The fiber optic cable numerical aperture shall be verified in accordance with EIA/TIA RS 455 FOTP 47 Method A. The cable shall be 2 ± 0.2 meters and the test shall be run at 1300 ± 30 nm.

3.4.2 Information transmission capacity

The –3dB bandwidth of 1 Km of fiber shall be as specified in 600 MHz-Km measured at 1300 ± 30 nm. The cable shall be measured for information transmission capacity in accordance with EIA/TIA RS 455 FOTP 30. Report the operator, date, test sample identification, test sample length, source wavelength and results.

3.4.3 Attenuation rate

The attenuation rate of cable shall be 6 ± 3 dB/Km (6 ± 3 dB/3300 feet) under all or combinations conditions specified herein and at the end of life. The allowable attenuation shall be measured at 1300 ± 30 nm.

3.4.4 Induced attenuation (4.8.3)

Induced loss measurements are used to determine the optical performance of the test sample during the exposure to the test environment. Therefore, the test equipment must remain connected to the unit under test for the duration of the stress exposure. Induced loss measurements are as accurate as the optical equipment (± 0.03 dB) and are preferred when testing small lengths of cable. The induced attenuation measurement shall be normalized to dB/Km and shall not exceed the attenuation rate in paragraph 3.4.3.

3.4.5 Substitution loss (4.8.4)

Substitution loss measurements are used to determine the change in optical performance due to the exposure to the test environment. Since the substitution loss measurements quantify optical performance before and after the exposure the unit under test may be removed from the test equipment. Substitution loss measurement accuracy is limited to the connector remating repeatability (for ST connectors the accuracy is about 0.07 dB). Unless specified in the test requirement, the change in substitution loss measurements taken before and after the exposure to

the test shall not exceed 0.20 dB. The substitution loss measurement shall be normalized to dB/Km and shall not exceed the attenuation rate in paragraph 3.4.3.

3.5 Environmental

Selected materials shall comply with SSP 30233 and be of a type and quality to assure compliance with the requirements of this specification, and shall be physically and chemically compatible for their intended use and throughout their intended lifetime.

3.5.1 Fungus (4.9.1)

Materials shall be Grade 0 (fungus inert) as defined by MIL-STD-454, Requirement 4.

3.5.2 Toxic hazard (4.9.2)

3.5.2.1 Internal requirements

Toxic contamination levels must meet the requirements given in JSC 20584, “Spacecraft Maximum Allowable Concentrations for Airborne Contaminants”, or The Toxic Hazard Index shall be less than 0.5.

3.5.2.2 External requirements

None

3.5.3 Odor (4.9.3)

3.5.3.1 Interior

The materials used individually and combined shall have an odor rating of 2.5 or less.

3.5.3.2 Exterior

None

3.5.4 Flammability (4.9.4)

The materials used in the cable shall be non combustible or self-extinguishing and have an “A” flammability rating per MSFC-HDBK-527/JSC09604. Although the external cables are use in a environment that does not support ignition, they must meet the same flammability requires for to demonstrate that they will not support combustion while being transported in to orbit.

3.5.5 Vacuum Outgassing (4.9.5)

The polymeric materials used in the cable shall not exceed a maximum total mass loss (TML) of 1.0 percent mass and a maximum collected volatile condensable material (CVCM) content of 0.1 percent.

3.5.6 Radiation (4.9.6)

3.5.6.1 Ionizing radiation (4.9.6.1)

The external fiber optic cable shall survive a 15 year total dose and dose rates as follows:

Radiation Environments	**Dose Rate (rads/min)**	**15 year Total Dose**
Average Background Radiation	0.005 rad.min	37.8 rads
SAA, one daily in 60 minutes	0.115 rad/min	37.8Krads
Solar Flare, one year dose in 120 min., one time	21 rad/min	2.52 rads

A safety factor of 2 is required if every fiber lot is tested and is 4 if only the qualification lot is tested.

3.5.6.2 Deep dielectric charging (4.9.6.2)

The external cable shall be susceptible to discharge damage due to the potential differential charge of various cable components developed by ion and electron flux.

3.5.6.3 Static-ESD environment (4.9.6.2)

The fiber optic cable shall not be susceptible to discharging damage in minimum ESD potential of 15000 Volts.

3.5.7 Vacuum (4.9.7)

The fiber optic cable shall withstand 15 years in orbit without degradation.

3.5.8 Temperature survivability (4.9.8)

3.5.8.1 Internal requirements

The interior fiber optic cable shall withstand thermal excursions throughout its life from -35°C to 100°C.

3.5.8.2 External requirements

The exterior fiber optic cable shall withstand thermal excursions throughout its life from -121°C to 200°C.

3.5.9 Thermal cycle/shock (4.9.9)

3.5.9.1 Internal requirements

The interior fiber optic cable shall withstand thermal cycles throughout its life from -35°C to 100°C. Each cycle shall have a 90minute period.

3.5.9.2 External requirements

The exterior fiber optic cable shall withstand thermal excursions throughout its life from -121°C to 200°C. Each cycle shall have a 90 minute period.

3.5.10 Reactivity in fluids (4.9.10)

The fiber optic cable and its identification shall be impervious to the fluids for cleaning and that may exist in transport to orbit or while in service.

3.5.11 Humidity (4.9.11)

Both the internal and external cables shall be subjected to terrestrial humidity conditions (10% to 100% RH) for five years. Additionally they shall experience on orbit humidity levels as follows:

3.5.11.1 Internal cables

Interior fiber optic cable shall not degrade when exposed to 20% to 100% relative humidity for 15 years

3.5.11.2 External cables

Exterior fiber optic cables shall not degrade when exposed to 0% relative humidity for 15 years.

3.5.12 Ambient light susceptibility (4.9.12)

External cables shall not accept more than –57 dBm when exposed to 1500 W/m^2 of white light.

3.6 Mechanical (4.10)

3.6.1 Strippability (4.10.1)

The cable components (the jacket, strength member and cable buffer [if applicable]) shall be hand removable using standard wire mechanical strippers. The removal/preparation of any cable component shall not affect (damage, deform or stretch) any other cable component or stress the optical fiber in any way.

3.6.1.1 Cable jacket strippability (4.10.1.1)

A five centimeters length of cable jacket shall be removable by hand after it is circumferentially cut.

3.6.1.2 Cable buffer strippability (4.10.1.2)

The cable buffer shall be removable by hand without affecting the remaining buffer tube or the fiber and its coating.

3.6.1.3 Fiber buffer strippability (4.10.1.3)

The fiber buffer shall be capable of withstanding a pull or push force of 2.5 kilograms (5.5 pounds) over a length of 2.5 mm (0.1 inches) without delaminating or debonding from the glass fiber.

3.6.2 Cable fiber life

The fiber shall survive 15 years in orbit. The worst case cable bend radius is 1.25 cm. The fiber n value shall be derived by the strength tests per paragraph following in this section and the fiber life shall be calculated using the following equation:

$$\text{Time to Failure (Tf)} = B(\sigma a/\sigma p)^{-n}\ \sigma p^{-2}$$

$$B = 2[AY^2(n-2)KIC^{(n-2)}]^{-1}$$

Where:
σa = applied stress
σp = fiber proof stress
n = fiber n value which shall be measured for each fiber lot
Y = geometric constant for glass = 1.24
KIC = critical stress-intensity factor for fused silica = 0.789MPa m^{-2}
A = known from static fatigue data and cable be calculated as:
Log A = 3.289n – 10.05 (GPa-s)

(equations above are taken from Optical Fiber Telecommunications II, Miller and Kaminow, © 1988 AT&T and Bell Research, Inc and Academic Press, Inc.)

3.6.2.1 Intrinsic fiber strength

The intrinsic strength zone for fibershall be a minimum of 450 KPSI (11.0 lbs.) with a hermetic coating and 600 KPSI (14.4 lbs.) without a hermetic coating. One hundred percent of fiber manufactured to this specification shall be subjected to proof testing during the manufacturing process with a minimum test limit required to meet 3.6.2.

3.6.2.2 Dynamic strength (4.10.2)

Each lot of cabled fiber will be subjected to dynamic strength tests which be run on a minimum of 20 each 2 meter length samples taken from the beginning and end of the draw (40 samples total). When tested in accordance with the procedure in paragraph 4.10.2, a minimum of 70% of the samples will have breaking strengths in the intrinsic zone of the Weibull Distribution formed from the 40 samples and no sample shall break at less than the minimum proof test limit.

3.6.3 Crush resistance (4.10.3)

Cable shall withstand a minimum 50 pound compressive loading over 6.25 mm.

3.6.4 Cable bend

The cable shall withstand a 90 degree bend having a radius of 1.25 centimeter (0.5 inches) with less than 0.3 dB attenuation change. The cable shall also withstand 5 wraps around a 5 cm (2 inch) mandrel in accordance with EIA/TIA 455 FOTP 37 procedure at room temperature and –121°C while meeting the loss rate of paragraph 3.4.2.

3.6.5 Cyclic flexing (4.10.4)

The cable shall withstand 2000 cycles around a 12 mm diameter mandrel ± 90° at temperatures varying from room temperature to 200°C. The induced loss shall not increase more than 0.3 dB.

3.6.6 Cable weight (4.10.4)

The weight per unit length of the typical cable shall be in accordance with Appendix A but shall not exceed 8.2 kilograms per 1000 meters (5.5 lbs per 1000 feet).

3.6.7 Shock (4.10.6)

The fiber optic cable shall survive 3 shocks at 50G, 11 millisecond, half sine pulses in the axial direction and perpendicular to the axis (a total of 12 shocks).

3.6.8 Vibration (4.10.7)

The fiber optical cable shall survive 10 G peak vibration in the axial direction and perpendicular to the axis.

3.6.9 Acoustic (4.10.7)

External cables shall be subject to sound levels listing in Table III. This sound levels translate mostly to vibration. Verification shall be per 4.10.7 (Vibration)

Table III - Shuttle Payload Sound Spectrum During Launch

31.5 Hz	127 dB
40 Hz	129 dB
50 Hz	131.5 dB
63 Hz	135 dB
80 Hz	136 dB
100 Hz	136 dB
125 Hz	135 dB
160 Hz	134 dB
200 Hz	133 dB
250 Hz	132 dB
315 Hz	131 dB
400 Hz	129.5 dB

500 Hz	128 dB
630 Hz	124.5 dB
800 Hz	124.5 dB
1000 Hz	123 dB
1250 Hz	121.5 dB
1600 Hz	120 dB
2000 Hz	118.5 dB
2500 Hz	116.5 dB

3.7 Physical

3.7.1 Fiber core (4.11.3.2.1)

The fiber core shall be Germania doped silica or pure silica and have an active diameter of 100 ± 2 microns, and ovality not to exceed 5% and shall be verified. Every fiber lot shall have a Certificate of Conformance verify the correct dopent material and levels and index profile.

3.7.2 Fiber cladding (4.11.3.2.1)

The fiber cladding shall be doped silica and the outside diameter of 140 ± 2 microns, with ovality not to exceed 4% and core/cladding offset not to exceed 2%. If a removable coating is used, the fiber cladding shall be 170±2 microns with a maximum ovality of 4% and a maximum core/clad offset of 1.2%.

3.7.3 Hermetic coating (4.11.3.2.2)

3.7.3.1 Internal

A hermetic seal coating if be applied shall be as specified in Appendix A. The coating shall be uniformly applied and defect.

3.7.3.2 External

A hermetic seal coating is not required to be used on an exterior use only cable.

3.7.4 Fiber coating (4.11.3.2)

The fiber coating shall be of the materials and construction as specified in Appendix A. The outside diameter shall be 170 ± 2.0 microns with a wall thickness tolerance of 1 micron. The fiber core to fiber coating concentricity shall be 4 microns maximum. The fiber and fiber coating and coating shall be continuos and without defect when inspected at 400X magnification. Fiber coatings and cables shall be dimensionally uniform, free of lumps, kinks, splits, scraped or abraded surfaces and inclusions.

3.7.5 Cable jacket color

3.7.5.1 Translucent cable jacket (4.11.3.1)

A translucent cable jacket will be used when printed information on sub-surface layers are intended to show through the jacket for identification. When used with a transparent or translucent cable jacket, one or more of the strands of strength member will be colored violet in accordance with MIL-STD-104.

3.7.5.2 Opaque cable jacket

When an opaque or colored cable jacket is used, the color will be in accordance with MIL-STD-104. Although the jacket may be somewhat translucent, the coloration of the jacket is not intended to reveal any information contained on the inner layers of cable construction per Appendix A. The jacket color shall be uniform.

3.7.6 Cable jacket (4.11.3.2)

The cable jacket shall provide environment and physical protection to the cable elements. The cable jacket shall be applied concentrically to the cable core to maintain circularity in the completed cable. The cable shall be made of material as specified in Appendix A, with an outside diameter of 2.10 ± 0.05mm and a wall thickness of 0.25mm, minimum. The outer jacket shall be free of cuts, burnt areas, abrasions, holes, roughened areas, bulges, thin spots and discontinuities when inspected at 5X magnification.

3.7.7 Cable stability (4.11.5)

The cable jacket and buffer shall be dimensionally stable and shall not shrink more than 0.4 percent after being subjected to thermal shock cycles per section 4.10.13.

3.7.8 Identification marking (4.11.3.1)

The finished cable shall be identified by a printed marking. This printed marking may be applied either outside of the jacket (if it is opaque or colored) or on an internal cable member (if viewing information is intended to be viewed through the jacket.

3.7.9 Legibility (4.11.3.1)

Printed marking shall be sized and oriented on the finished cable to be legible normally corrected vision.

3.7.9.1 Opaque jacket

When finished cable is constructed in accordance with 3.11.2.5.1.a, printing shall be of sufficient contrast against background color to be discernable to the unaided eye at a distance of 0.5 meter.

3.7.9.2 Translucent jacket

When finished cable is constructed in accordance with 3.11.2.5.1.b, printing shall be of sufficient contrast against background color to be discernable to the unaided eye at a distance of 0.5 meter. Colored strands of the shall be visible through the jacket.

3.7.10 Marking durability (4.11.4)

The marking shall be permanent upon completion of the reactivity to fluids test per 3.5.14 as defined below:

3.7.10.1 Opaque jacket

When finished cable is constructed in accordance with 3.11.2.5.1.a, printed markings shall be of such a material and installed such that the printing withstands the solvent durability qualification test of Section 4.10.14. Within a marking group of 3.11.2.5.6, no more than three consecutive characters are allowed to be illegible if both adjacent marking groups of 3.11.2.5.6 are intact.

3.7.10.2 Translucent jacket

When finished cable is constructed in accordance with 3.11.2.5.1.b, printing shall be of such a material and installed such that installation of over-layers does not result in damage to the printing in excess of 3.11.2.5.9. b. Within a marking group of 3.11.2.5.6, 10% of the total characters of that group are allowed to be illegible if both adjacent marking groups of 3.11.2.5.6 are intact and paragraph a of this section is met.

3.7.11 Printing groups (4.11.3.1)

Printed marking groups of 3.11.2.5.6 shall be installed at .25 meter intervals. Printed marking groups shall include the following:

a. Full part number
b. Supplier's CAGE code
c. Unique lot/date code

3.7.12 Cable buffer (4.11.3.2.3)

The cable buffer shall be of the materials and construction specified in Appendix A, and has a maximum outside diameter of 785 microns. The buffer shall be free of cut, holes, bulges, thin spots and discontinuities when inspected at 10X magnificaiton.

3.7.13 Cable strength member (4.11.3.2.3)

The cable strength member shall be braided material in accordance with Appendix A, with an outside diameter of 1.6mm, maximum. The braid shall cover a minimum of 90 percent of the cable buffer. The strength members shall be uniform and laid with no discontinuities when inspected at 10X magnification.

3.7.14 Lengths and splices

Continuous cable lengths shall be no shorter than 100 meters (328 feet) unless otherwise specified by the purchase order. The fiber shall not be spliced within a given spool of cable. The splice free spool shall be verified in accordance with EIA/TIA-455-60 (length) and EIA/TIA-455-61 (splices).

4.0 QUALITY ASSURANCE PROVISIONS

4.1 General

This section establishes the requirements for verifying cable performance, operability, and physical characteristics by test, analysis, demonstration or examination. The test program shall assure that the cable and its documentation meet the requirements established in 3.0, 5.0, 6.0 and Appendix A.

The quality assurance provisions shall consist of the following classifications of inspections as follows:

a. Qualification

4.2 Responsibility for inspection

4.2.1 Supplier responsibilities

Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements and acceptance tests as specified herein and in Table XII. The specification custodian reserves the right to perform or witness any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to requirements.

All items must meet all requirements of 3.0 and 5.0 and Appendix A. The inspections set forth in this specification shall become part of the supplier's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the supplier of the responsibility of assuring that all products or supplies submitted to the government for acceptance, comply with all requirements of the contract.

4.2.2 Test equipment and inspection facilities

Provision for test and measuring equipment and inspection facilities of sufficient accuracy, quality, and quantity to permit performance of the required inspections shall be the responsibility of the supplier and approved by the specification custodian.

Unless otherwise specified, all examinations and tests shall be performed within the following ranges of ambient temperature, humidity and pressure.

a. Temperature: Room ambient (20^0C to 30^0C)
b. Relative humidity: Room ambient (10-80 %)
c. Barometric pressure: 24 to 31 inches of mercury

4.2.3 Test equipment error

Equipment used to measure parameters shall not introduce errors greater than 10 percent of the tolerance on the parameter, or in the case of a single limit tolerance, the test equipment error shall be applied to the specified parameter in a manner to assure the parameter is being met. Accuracy of less than one-tenth of the tolerance shall require approval of the specification custodian. Test equipment calibration shall comply with MIL-STD-45662 or as an alternative, the test equipment calibration shall be current and certified as defined in the domestics contracts paragraph of MIL-STD-45662.

4.3 Product assurance program

4.3.1 Quality and reliability assurance plan

The supplier shall prepare a quality and reliability assurance plan. The plan shall be submitted for review and approval as required by the purchase contract. Use NHB 5300.4 (3G) as a guideline for the inspection requirements in addition to the inspection required to insure part quality.

4.3.2 Critical hardware notation

The supplier shall establish procedures by which their purchase orders (PO's), purchase requests (PR's), request for proposals (RFP's), contracts, and subcontracts, and those of their subsuppliers and suppliers down to the lowest tier, shall include the following information. Additionally, each sheet of each drawing and the first sheet of each control document (i.e.; process, specification, procedure, etc.) shall also provide this information. The information shall be printed or stamped in bold face type.

FOR USE IN MANNED SPACE FLIGHT.
MATERIALS, MANUFACTURING, AND WORKMANSHIP
OF THE HIGHEST QUALITY STANDARD
ARE ESSENTIAL TO ASTRONAUT SAFETY.

4.3.3 Disposition and corrective action

The supplier shall recommend the disposition or corrective action for all analyzed discrepancies.

Implementation of the recommended disposition or corrective action shall be at the sole discretion of the specification custodian and shall not be implemented without written approval from the specification custodian.

4.4 Preparation of optical test samples

The termination method of the connectors/terminations joining the test cable to the test set shall be proven to be low loss and low variation in their environment throughout the duration of the

tests. The connectors shall be polished to achieve a Physical Contact (PC) interface geometry per BellCore GR 326.

4.5 Materials inspection (3.3)

Materials inspection shall consist of certification, supported by verifying data, that materials used in fabricating the delivered cable are in accordance with the requirements of section 3.3 and Appendix A.

4.6 Product acceptance test

4.6.1 Acceptance of product for delivery (3.2.2.1.2, 7.0)

Product Acceptance Tests shall consist of those inspections and tests listed in Table XII and shall be performed in accordance with the approved acceptance test plan in accordance with section 3.2.2.1.2.

4.6.2 Unit of manufacture

The unit of manufacture shall be defined by the purchase order.

4.6.3 Sample unit

Sample length shall be one (1) meter for dimensional and mechanical inspection, as required for numerical aperture (NA), attenuation and bandwidth tests.

4.7 Workmanship verification

Inspect for quality and workmanship per EIA/TIA 455 FOTP 13 at the required magnifications.

4.7.1 Inspection Equipment

Optical Magnifier, 10X power (maximum) for examination of the product for damage and defects such as cracks, splits in outer jacket, etc.

Optical microscope, 400X minimum, with video processing equipment for verification of fiber core, cladding and coating dimensions.

4.8 Optical Verification (3.4)

The following are the procedures required to make optical loss measurements for the International Space Station Program. The induced and substitution loss measurement procedures as well as the test equipment and SRD fabrication procedures are outlined below. Although the EIA/TIA Specifications are referenced, the following procedures take precedence in the case of conflict.

4.8.1 Optical test set

Below are the functional requirements of the optical test equipment. The RIFOCS CP-1107 and CP-1148 as well as other RIFOCS equipment built for Space Station meet these requirements.

4.8.1.1 Light source

The optical source shall be an optically and modally stabilized having a center wave length between 1330 ± 30 nanometers. The far field ½ sine angle output of the source shall conform to Table IV when measured per EIA/TIA 455 FOTP 47B. The source bandwidth shall be within 60 nanometers. The optical output power shall not be modulated.

Table IV - Far Field Output

NA	Power (Percent)
0.093 to 0.118	80
0.139 to 0.167	60
0.182 to 0.208	40
0.224 to 0.250	20
0.267 to 0.290	5

4.8.1.2 Source monitoring equipment (SME)

The source output power shall be capable of monitoring and recorded without disconnecting the test specimen. These measurements are used to allow corrections to compensate for source output variations.

Equipment that does not have continuous source monitoring capability, shall include a Certificate of Compliance that the optical source remains optically stable to ± 0.03 dB and modally stable within 1 percent of the measured optical power at each specified ½ sine ∠ for the duration of the testing sequence. The validation of the source shall be obtained before and after the testing and shall be submitted with the test data.

4.8.1.3 Detection equipment

The detector and associated electronics shall be capable of measuring all energy exiting from the fiber and have a linear active area at least 10 times larger than the fiber core. They shall be linear at the wavelengths used, and over the expected range of power. The resolution of the detection equipment shall be as follows in Table V:

Table V - Equipment Resolution Requirements

Interconnection Device Loss	Resolution
>.5 dB	.1 dB
<.5 dB	.05 dB

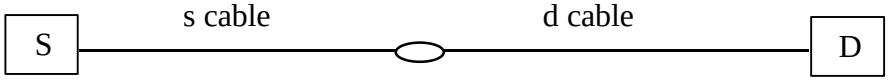
The detector shall be linear within 3 percent over the duration of the test and over a 23 ± 5^0C temperature range.

4.8.1.4 Reference cable set and fabrication

The reference cable 6 ± 0.6 meters of fiber optic cable specified herein or optically equivalent and terminated with ST connectors polished to attain a physical contact interface BellCore GR 326. The substitution loss of the reference cable shall not exceed 0.30 dB and the fiber core shall be free from surface defects when viewed at 100 power magnification.

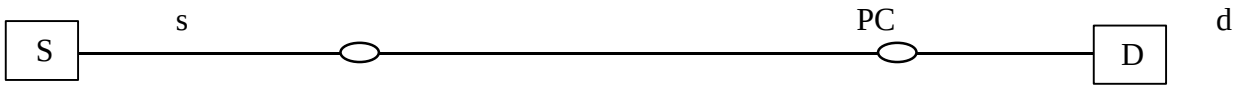
SRD Cable sets are high quality optical jumpers used for optical testing. Their performance is continually monitored and logged to insure consistent performance. Below are the detailed instructions for building the cable sets.

Step 1 - Connect a source (s) cable to a mode conditioned optical source and a detector (d) cable to an optical power meter. Connect the cables together and measure and record the optical power throughput as P_{sd}.



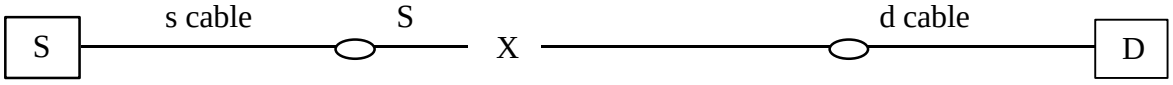
Measure: P_{sd} (from previously fabricated SRD cable set)

Step 2 - Terminate a 6 meter length of fiber optic cable with ST-PC connectors. The endface geometry of the finish connector shall be PC in accordance with BellCore GR 326. This cable will be called a PC cable. The cable can be of a suitable construction to facilitate the testing application however, the fiber must be the same fiber as used in the Units Under Test (UUT) are to be used. Connect the PC cable to the s and d cables and measure and record the optical throughput as P_{PC}. L_{PC} shall not exceed 0.4 dB. The cables shall not be disconnected from the source until the last step is completed. Calculate the loss of the PC cable as follows:



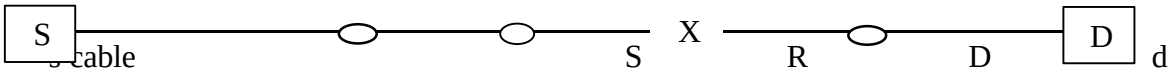
Measure: P_{PC}
Calculate: $L_{PC} = P_{sd} - P_{PC}$ </= 0.30 dB

Step 3 - Cut the cable approximately two meters from the source end of the fiber the cable and install an ST-PC connector one each side of the cut cable. The endface geometry of the finish connector shall be PC in accordance with BellCore GR 326. Measure and record the OPT as P_{I1}. Calculate the insertion loss (L_{I1}) as follows:



Measure: P_{I1}
Calculate: $L_{I1} = P_{PC} - P_{11}$ </= 0.30 dB

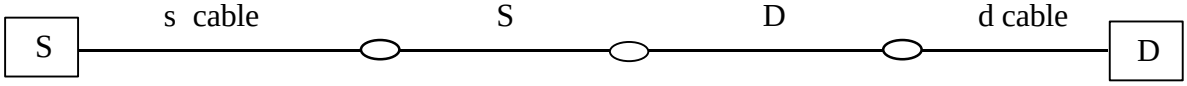
Step 4 - Cut the cable approximately two meters from the detector end of the fiber the cable and install an ST-PC connector one each side of the cut cable. The endface geometry of the finish connector shall be PC in accordance with BellCore GR 326. Measure and record the OPT as P_{I2}. Calculate the insertion loss (L_{I2}) as follows:



d cable

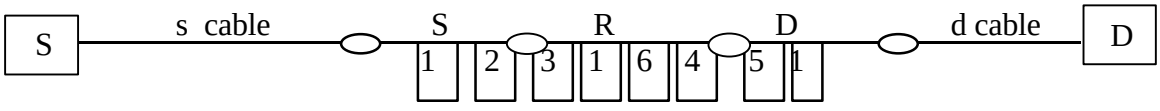
Measure: P_{I2}
Calculate: $L_{I2} = P_{I1} - P_{I2}$ </= 0.30 dB

Step 6 - Remove the new R cable and connect the new S and D cables together. Measure and record the OPT (P_{SD}). Calculate the R cable Loss as $L_R = P_{SD} - P_{SRD}$ where $P_{SRD} = P_{I2}$.



Calculate the Total Insertion Loss: LI = L1I + L2I [0.03dB

Step 5 – Calculate L_R and identify the cable as show below:



NOTES:

Label 1 - ID, month, year and serial number for the SRD cable set
Label 2 - SR
Label 3 - RS
Label 4 - RD
Label 5 - DR
Label 6 - Ref Cable Loss "Lref = X.XX dB" (X.XX = P_{SD} - P_{SRD} measured on the new SRD set)

4.8.1.5 MTC cable

An MTC cable shall 6.0 ± 0.6 meters of fiber optic cable which uses the fiber specified herein. It shall be terminated with ST connectors and polished to achieve a physical contact interface in accordance with BellCore GR326. The substitution loss shall not exceed 0.4 dB and the cable shall be free from surface defects when viewed at 100 power magnification. This cable shall be protected and stored in a safe and environmentally stable area when not used.

When using a RIFOCS test set, the MTC cable can be RIFOCS' P/N 333-110-03.

4.8.2 Optical test set calibration

The test set calibration consists of two processes; one for the source and detector and one for the S and D cables. The measurement procedure outlined below is very rigorous and is required to attain 0.10 dB measurement accuracy.

4.8.2.1 Meter and source calibration using the MTC cable

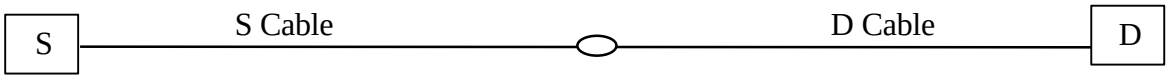
Clean each termini optical surface on the appropriate MTC cable using a clean lint free wipe wetted with N-Propyl alcohol (as required) followed by a clean lint free wipe (dry) (as required). Using clean, dry compressed air, blow the connector receptacle on the source and detector. If the mode conditioner is physically separatable from the source, connect the MTC cable to the configuration that is calibrated, usually the source with out the mode conditioner. Disconnect the source side of the MTC cable from the source and reclean the source receptacle and the mating optical terminus. Repeat the cleaning remating steps until three consecutive OPT measurements agree to within 0.03 dB. Repeat this process on the detector side of the MTC Cable interfaces. If this is the first use of the test set, MTC cable or after each calibration, record the final OPT in the equipment log. Verify that the recorded OPT is within 0.1 dB of the certified source output minus the MTC cable loss (the loss is labeled on the cable). If this is not the first use or not after calibration, record the final OPT into the equipment log as PMTC(date). The OPT shall not exceed 0.1 dB change from the other logged readings.

4.8.2.2 SRD cable set calibration

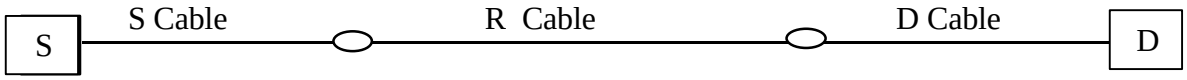
For optical test sets that have a mode conditioner that can be removed from the test set: Clean the connectors on a small jumper and the optical source port and the mode conditioner ports. Clean and connect one end of the jumper to the source and the other to the mode conditioner input. Clean and connect the MTC cable to the mode conditioner output and the other end of the optical power meter. Note the OPT. Disconnect and clean the small jumper to source interface

until three readings agree to within 0.03 dB. Repeat for the small jumper to the mode conditioner interconnect. Remove the MTC cable.

Clean each connector optical surface on the appropriate S cable and D cable using a clean lint free wipe. Wet with N-Propyl alcohol as required than follow by a clean lint free wipe (dry). Clean the connector receptacle on the source (or mode conditioner output port if it is a separate unit which hereafter will be referred to the "source") and detector. Install the S and D into the source and the detector and mate the S and D cables. Disconnect the S from the source and reclean the source receptacle and the mating optical terminus. Repeat the cleaning remating steps until three consecutive OPT measurements agree to within 0.03 dB. Repeat this process on the D to detector receptacle and then on the S to D interfaces. Record the final OPT as P_{SD} and the meter monitor power as P_{MSD} (if SEM is used).



Disconnect the S and D cables and install the R cable so that the source side of the R cable connects to the S cable and the D side of the R cable connects to the D cable. Note the OPT. Unmate clean and remate the S to R cable junction until three OPTs agree to within 0.03 dB. Repeat for the R to D cable junction. Record the final OPT as P_{SRD}. If P_{SRD} deviates greater than 0.2 dB for L_R list on the Reference cable label remove and discard this SRD cable set.



4.8.3 Induced loss (3.4.4)

The change in the attenuation of the fiber induced by exposure to environmental or physical test conditions shall be measured in accordance with EIA/TIA RS 455 FOTP 20 with the following parameters:

a. The source and detector shall comply with 4.8.1.1.
b. An optical power divider (per paragraph 2.2 of FOTP 20) shall not be used.
c. The test sample shall be terminated with ST-PC connectors on each end. The endface geometry shall be in accordance with BellCore GR 326 CORE.
d. A reference sample shall not be used and the reference power shall be the initial optical power through the test specimen.
e. The optical test setup shall not be disconnected between the time the baseline value is established and measurement of power throughput after completion of the primary test.

4.8.3.1 Optical measurements

The following Optical Power Throughput measurements shall be recorded:

P_{MSDD} = Meter Optical Power Throughput (OPT), SD - Cable, Induced Loss
P_{MDB} = Meter OPT, Before, Induced Loss
P_{MDX} = Meter OPT, After or Subsequent, Induced Loss

P_{SSD} = OPT, SD - Cable, Induced Loss
P_{DB} = OPT, Before, Induced Loss
P_{DX} = OPT, After or Subsequent, Induced Loss

4.8.3.2 Test set-up

The test equipment shall be in accordance with 4.8.1 and calibrated in accordance with 4.10.12.2. The test set shall remain connected to the test sample during the environmental exposure.

4.8.3.3 Test procedure

The test setup shall not be separated from source once testing has begun. Induced attenuation measurements shall be made immediately before, during and/or after tests as specified in the applicable mechanical or environmental test method. Replace the R Cable with the unit under test.

Clean the test sample to S Cable to UUT interconnection and record the OPT. Reclean the interconnection until three consecutive OPT measurements agree to within 0.03 dB. Repeat for the UUT to D cable interconnection. Record the final OPT measurement as P_{DB} and the meter monitor power as P_{MDX}. Run the environmental test. Measure and record the test sample OPT at the specified intervals as P_{DX} where x indicates the interval . After the environmental test is complete, measure the final OPT and record it as P_{DF} and the meter monitor power as P_{MDF}.

4.8.3.4 Induced loss calculations

Induced loss shall be calculated as follows when the power is measured in watts

$$\Delta L_D \text{ (dB)} = 10 \log\left(\frac{P_{DB}}{P_{DX}} \bullet \frac{P_{MDX}}{P_{MDB}}\right)$$

or when the power is measured in dB

$$\Delta L_D \text{ (dB)} = (P_{DB}-P_{DX}) - (P_{MDB} - P_{MDX})$$

4.8.4 Substitution loss (3.4.5)

(Reference EIA/TIA 455 FOTP-171, however these requirements supersede FOTP-171 when conflicting.)

4.8.4.1 Optical measurements

The following Optical Power Throughput measurements shall be recorded:
P_{MSD} = Meter Optical Power Throughput (OPT), SD - Cable, Substitution Loss
P_{MSI} = Meter OPT, Initial, Substitution Loss
P_{MSF} = Meter OPT, Final, Substitution Loss
P_{SD} = OPT, SD - Cable, Substitution Loss

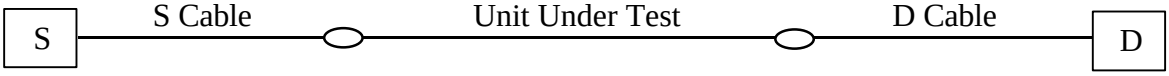
P_{SI} = OPT, Initial, Substitution Loss
P_{SF} = OPT, Final, Substitution Loss

4.8.4.2 Test equipment set up

The test equipment shall be per 4.8.1 and calibrated per paragraph 4.8.2. The test set may be disconnected from the test sample during the environmental exposure.

4.8.4.3 Test procedure

Replace the R Cable with the unit under test.



Clean the test sample to S Cable interconnection and record the OPT. Reclean the interconnection until three consecutive OPT measurement agree to within 0.03 dB. Repeat this process on the test sample to D Cable interconnection to test sample. Record the final OPT as P_s and the meter monitor power as P_{MS}.

4.8.4.4 Substitution loss calculations

The substitution loss shall be calculated as follows when the power is measured in watts

$$L_S \text{ (dB)} = 10 \log\left(\frac{P_{SD}}{P_S} \bullet \frac{P_{MS}}{P_{MSD}}\right)$$

or when the power is measured in dB
Substitution Loss (dB) = $(P_S - P_{SD}) - (P_{MS} - P_{MSD})$

4.8.4.5 OTDR loss measurements

TBD John White will supply verication

4.9 Environmental requirement verification

4.9.1 Fungus (3.5.1)

Test per MIL-STD-810, Method 508 and MIL-STD-454 Requirement 4. The test environment shall be per Table VI.

Table VI - Fungus Environmental Test Conditions

Test Condition	Test Limit
Humidity	90% to 100%
Temperature	23°C to 30°C
Duration	28 Days
Pass/Fail	Grade 0

4.9.2 Toxic hazard (3.5.2)

By test

The test shall be performed in accordance with NASA-STD-6001 Test 7 with the test conditions specified in Table VI. Ten samples that are at least 10 meters apart in a cable run length shall be tested.

4.9.2.1 By analysis

The toxic hazard ratings for materials that have been previously tested are documented in MSFC-HDBK-527/JSC 09604 or the Material And Process Technical Information System (MAPTIS) electronic data base located at George C. Marshall Space Flight Center, Huntsville, Al.

4.9.3 Odor (3.5.3)

4.9.3.1 By test

The test shall be performed in accordance with NASA-STD-6001 Test 7 with the test conditions specified in Table V.

4.9.3.2 By analysis

The odor ratings for materials that have been previously tested are documented in MSFC-HDBK-527/JSC09604 or the Material And Process Technical Information System (MAPTIS) electronic data base located at George C. Marshall Space Flight Center, Huntsville, Al.

4.9.4 Flammability (3.5.4)

4.9.4.1 By test

The flammability test shall be conducted per NASA-STD-6001 Test 1 using the test details listed in Table VII.

Table VII - Flammability Test Requirement Details

4.1.1 Test Requirement	Test Detail
Environment	30% O_2 and 70% N_2 at 68.9 KPa (10psia)
Sample Orientation	60° per Figure 7 of NASA-STD-6001
Sample Length	Fourteen samples 40cm (16 inches) long
Ignition/Heat Duration	1100°C and a 6.4 cm high flame, 10 minute maximum burn time
Self Extinguishing	Within 30 seconds after the ignition source is removed.
Burn Events	No sparking No sputtering No flaming dripping No flame transfer by burning debris

4.9.4.2 By analysis

None. Although the materials that are used on the fiber optic cable are also used as insulators on electrical wire, the heat dissipation of the fiber optic cable sufficiently differs from the wire to warrant testing rather than verification by similarity to a wire product.

4.9.5 Vacuum Outgassing (3.5.5)

4.9.5.1 By test

The finished cable shall be conditioned at 125°C at a pressure 10^{-6} torr for 48 hours during the manufacturing or preshipment processing. The test shall be per ASTM E595 using the test parameters listed in Table VIII.

Table VIII - Outgassing Products/Vacuum Stability Test Conditions

Condition	Limits
Pressure	1.3 X 10^{-4} Pa max.
Temperature	124°C to 126°C
Condensable Plate Temperature	24°C to 26°C
Vacuum exposure time	24 hours

4.9.5.2 By analysis

The data for total maximum loss (TML) and maximum volatile condensable material (VCM) content of materials that have been previously tested is documented in MSFC-HDBK-527/JSC 09604 or the Materials And Process Technical Information System (MAPTIS) electronic data base located at George C. Marshall Space Flight Center, Huntsville, Al.

4.9.6 Radiation (3.5.6)

4.9.6.1 Ionizing radiation (3.5.6.1)

Total dose for verification 55.44 Krads using safety factor of 2 per ISS requirement.
Focus on only those exposures that will affect the fiber performance.
SAA, 13.8 rads/day over 60 min, dose rate = .23 rads/min, for up to a total dose of 50.4 krads
Solar Flare, 42 rads/min for upto 5040 rads.

Total dose performance testing shall be conducted in accordance with EIA/TIA 455 FOTP 64. Two 100 meter samples of cable from each end of each lot of fiber shall be. Additional length is needed run outside of the radiation test equipment. Optical power from source specified in 4.8.1.1 shall modified as required to have a maximum output of microwatt and shall be transmitting throughout the duration of the test. The optical power throughput shall be measured after the set up and before the initial exposure, every XX minutes during the exposure, and for 24 hours after the exposure. The dose rate test conditions shall be either option 1, or option 2 with

the thermal environment steady at -121°C +/- 4 °C. The temperature shall stay at -121°C for six days and then return to 25°C at no greater than 1°C/min, remaining at 25°C for the next 24 hours of exposure. At the completion of the seventh day, the cables shall be actively monitored for an additional 24 hours without radiation exposure at 25°C.

Option 1: Dose rate shall be 42 rads/min for two hours and then dose rate shall be decreased to 0.5 rad/min for six days or until saturation has been reached. The seventh day the temperature shall return to 25°C and the test shall be continued for an additional 48 hours. Upon reducing the dose rate, the time between the end of the high dose rate exposure and the beginning of the low dose rate exposure shall not exceed 30 minutes in which the cable under test is not being exposed to the gamma source.

Option 2: Two tests shall be conducted and the results of the test shall be used to determine the actual performance of the optical fiber at a low dose rate of .23 rads/min to a total dose of 50.4 krads. For the first test, the dose rate shall be 42 rads/min until a total dose of 55 Krads has been reached. For the second test the dose rate shall be less than 10 rads/min to a total dose of 55 Krads. If the lower dose rate test takes more than seven days then the following thermal environment shall be used. The temperature shall stay at -121 C for six days, return to 25°C on the seventh day with exposure continuing for 24 hours at 25°C.

4.9.6.2 Static-EMI environment (3.5.6.4)

The test shall be performed on cable assemblies that use electrically conductive coatings only. An ESD event meter shall be calibrated for the background events and then used to detect ESD event with the capacitor probe is brought near to the fiber. After the fiber has been subjected to the test, the fiber be inspected per 4.11.3.1 for defect and/or damage at 400 X magnification +/- 1 cm from the probe location and ground clamp location.

4.9.6.2.1 Human Body Model

These cables shall be subjected to a spark test per SSP 30253 except the fiber coating resistance over distance shall be considered as part of the 1500 resistor. For example, if the fiber coating has a resistivity of 500 ohms per 10 cm, than the test conducted with the capacitor probe at 10 cm shall use a 1000 ohm resistor in series with the fiber and ground clamp.

4.9.6.2.2 Machine Model

4.9.7 Vacuum (3.5.7)

Test per 4.10.12 – Temperature Survivability.

4.9.8 Temperature survivability (3.5.8)

100 meters of fiber optic cable shall be subjected to MIL-STD-202F Method 108A Test Condition C using the test conditions in Table IX. The cable shall be inspected to verify pysical conformance to Appendix A per 4.11.3.2.

Table IX - Temperature Survivability Test Conditions

	Internal	External
Pressure	1 X 10^{-6} max	1 X 10^{-6} max
Low Temperature	-46°C max	-135°C max
High Temperature	115°C min	215°C min
Duration	500 Hours	500 Hours

4.9.9 Thermal shock (3.5.9)

100 meters of fiber optic cable shall be exposed to thermal shock per MIL-STD-202F Method 107E using the test conditions in Table X. The temperature transition duration shall be less than 2 minutes.

Table X - Thermal Shock Test Conditions

	Internal	External
Low Temperature	-46°C max	-135°C max
Low Temperature Dwell Time	See Table 107-7 in MIL-STD-202F	See Table 107-7 in MIL-STD-202F
High Temperature	115°C min	215°C min
High Temperature Duration	See Table 107-7 in MIL-STD-202F	See Table 107-7 in MIL-STD-202F

4.9.10 Reactivity in fluids (3.5.10)

The samples shall be tested in the fluids listed in Table XI in accordance with NASA-STD-6001 Test 15 except the samples shall be 2 meters long and weighed to the nearest 0.01 gram. A virgin sample shall be used for each fluid. None of the cable components shall show signs of degradation when inspected per 4.11.3.1 for damage and dimensions.

Table XI - Test Fluids

Fluid	Test Temperature	Interior Duration	Exterior Duration
Alcohol	Room Temp.	45 minutes	45 minutes

4.9.11 Humidity (3.5.11)

Fiber optic cables samples shall be subjected to humidity per MIL-STD-202 Method 103B Test Condition C. The specimen shall be weighed before and within 15 minutes from the completion of the test to the nearest 0.01gram. The cables shall not increase in mass more than 0.2%. The samples shall be examined for degradation and the dimensions shall be verified per section 4.10.7 after the sample is allowed to dry at 21°C to 25°C and 20% to 60% RH. The dimensions shall meet the requirements in section 3.11 and the materials shall not visibly degrade.

4.9.12 Ambient light susceptibility (3.5.12)

A 4 meter length of fiber optic cable shall be tested per EIA/TIA RS 455 FOTP 22B. One end of the sample shall be terminated with a ST connector and the other end shall be folded over on itself such that the fiber breaks 15 cm from that end. The optical power meter shall be capable of reading to –65 dBm. An integrating sphere shall be used.

4.10 Mechanical requirement verification (3.6)

4.10.1 Strippability (3.6.1)

4.10.1.1 Cable jacket strippability (3.6.1.1)

Cut the cable jacket 5 cm from a end. The circumferential cut shall be preformed by an Ideal coax tool #45-162 with the cutting blade set to cut through at least 80% of the jacket but not entirely through. The cut shall be propagated by bending the cable around the cut. The 5 cm of cable jacket shall be removable by hand without the aid of tools.

4.10.1.2 Cable buffer strippability (3.6.1.2)

The cable buffer shall be cut using Clauss NO-NIK with a cut diameter of 254 microns (0.010 inches). After the tool is removed the cut end of the buffer tube shall be removable by hand without affecting the remaining buffer tube or the fiber and its coating. This is verified during the qualification sample preparation and during harness fabrication.

4.10.1.3 Fiber coating strippability (3.6.1.3)

Five fiber samples from random 30 centimeter lengths of cable shall be removed and one end cleaned using a low non-volatile residue wipe and alcohol. The fibers shall be installed into a connectors/ termini/ferrules measuring 172.7 microns to 175 microns. A drop of Epotec 353ND epoxy shall be placed on the tip of each ferrule. The fiber shall be moved a total of 2.5 millimeters in and out of the connector. The excess epoxy shall be removed and the remaining epoxy shall be cured at 100°C for 30 minutes. The excess fiber shall be cleaved and the remaining materials shall be ground off the tip using 30 micron lapping film. The termini shall be secured in a tensile test set and the fiber pulled until failure.

4.10.2 Dynamic tensile strength test (3.6.2.2)

Samples without the jacket, strength members, or buffers, shall be conditioned at room 72 +/- 5F with a relative humidity of 65 +/- 5% for 24 hours. After completion of the conditioning, the samples will be pulled to destruction with the strain rates specified in EIA/TIA 455 FOTP 28(C).

4.10.3 Crush resistance verification (3.6.3)

Crush resistance shall be verified in accordance with EIA/TIA 455 FOTP 41 using the following conditions:

a. The load shall be 22.6 Kilograms (50 lbs.) applied over a 6.25 mm (0.25 in) length (in place of the 102 mm [4 in] length specified in EIA/TIA-455-41).
b. The load shall be applied for 60 seconds
c. The load shall be applied and released in no less than 60 seconds and no greater than 120 seconds.
d. Visually inspect for damage at 10X magnification

The attenuation rate shall meet 3.4.3 when measured in accordance with paragraph 4.8.3 while load is applied.

1. Paragraph 4.3 4.8 and 5.1.6 of EIA/TIA-455-41 standard - The optical power shall be measured in accordance with 4.8.3 of this specification.

4.10.4 Cycling flexing (3.6.5)

Test in accordance with DOD-STD-1678 METHOD 2010, procedure 2 with the following specifications:

a. The test mandrel shall be 12 mm (0.5 inches) in diameter.
a. The test mass shall be 2.25 Kilograms (5 lbs.)
b. Sample length shall be five meters.

The following exceptions shall take precedence over DOD-STD-1678 procedure 2:

Step 2	The specimen shall be mounted in the test fixture and the optical power measured in accordance with 4.10.12.3.
Step 4	The test shall be conducted starting at room temperature, then ramp to a temperature of 120°C when 900 to 1100 cycles are completed, and then ramp down to room temperature when 1900 to 2000 cycles are completed.
Step 5	The optical power shall be measured at the completion of the 2000 cycles while the specimen is mounted in the fixture in accordance with 4.8.3.
Para. 5.4	Optical power shall be measured in accordance with 4.8.3. The number of transmitting fibers will not be counted.
Para. 5.6	The optical loss shall be calculated in accordance with 4.8.3.4.
Para. 5.8	Delete
Para. 5.9	Delete.
Para. 5.10	Visual inspection of the outer jacket shall be made under ten-power magnification per 4.11.3.1.

4.10.5 Cable weight (3.6.6)

Obtain a test sample that is 1 meter ± 1mm. Use a scale to determine the weight of the sample in grams. Measure and report the weight to the nearest 0.1 grams. That number will be the same as kilograms per kilometer. The weight shall be determined in accordance with FED-STD-228 Method 8311 except the length of the cable sample shall be 2 ± 10 % meters but measured to within 0.5 mm. The weight measurement shall be accurate to 0.20 grams.

4.10.6 Shock (3.6.7)

100 meters of fiber optic cable shall be coiled (approximate 30 cm (12 inches)) and securely mounted to the shock table using P clamps in four approximately equally spaced locations. The terminated ends of the cables shall be routed off the shock table and the optical test equipment shall be isolated from the shock environment. The cable shall be subjected to the shock pulses per MIL-STD-202 Method 213 Test Condition A.

4.10.7 Vibration (3.6.8)

100 meters of fiber optic cable shall be coiled (approximate 30 cm (12 inches)) and securely mounted to the vibration table using P clamps in four approximately equally spaced locations. The terminated ends of the cables shall be routed off the vibration table and the optical test equipment shall be isolated from the vibration environment. The cable shall be subjected to the shock pulses per MIL-STD-202 Method 204 Test Condition C except only one sweep in each directions shall be performed (a total of 2 sweeps) shall be performed and the resonance shall not be obtained (therefore the resonance instrumentation is not required).

4.11 Physical verifications

4.11.1 Test equipment

Dimensional and other measurement equipment (vernier calipers, rules, comparitors, scales, etc.) shall be of sufficient accuracy to verify dimensional and weight parameters specified in 3.0.

A microscope with a measuring video system capable of 400X, 200X and 50X magnification. Thermal shock chamber capable of operating over a temperature range of –135°C to +220°C with a worst case temperature error/variation of ±2.5°C and a maximum time of 2 minutes to transition the test sample between the high and low temperature set points.

4.11.2 Test specimen

The test specimen shall be a sample from the reel of the product lot being submitted for inspection. The length of the specimen for acceptance and receiving inspection shall be sufficient to perform all visual and mechanical examinations. Dimensional measurements shall be made on at least two (2) samples [minimum one (1) meter in length], one from the outside end of the product and one from the inside end of the reel of product.

4.11.3 Test procedures

4.11.3.1 Visual examination (3.7.5.1, 3.7.5.4, 3.7.5.4.1,3.7.5.4.3, 3.7.8)

The product shall be visually examined in accordance with the requirements in EIA/TIA RS 455 FOTP 13 to assure that it meets the specified requirements as to:

a. Materials used (Material certifications to establish conformance to material type requirements) and verification of data submitted relative to lot number, etc.

b. General design and construction
c. Workmanship
d. Finish
e. Identification of product (marking)
f. Damage
g. Color per MIL-STD-104

4.11.3.2 Dimensional examination (3.7.1, 3.7.2, 3.7.3, 3.7.4, 3.7.5.2, 3.7.7)

Data sheets shall be furnished, to the procuring quality organization, documenting the actual measurements of the dimensions specified in paragraphs 3.7.1, 3.7.2, 3.7.3, 3.7.4, 3.7.7 and Figure A-1 of Appendix A for each sample used for dimensional inspection for qualification and quality conformance (acceptance) inspections.

4.11.3.2.1 Fiber subassembly (3.7.1, 3.7.2, 3.7.3, 3.7.4)

The fiber core, cladding and coating dimensions shall be verified according to EIA/TIA RS 455 FOTP 45 with the following exceptions:

Para. 2.2	The microscope shall be equipped with video processing equipment allowing measurements to ± 2 microns at 400X magnification.
Para. 4.3	The fiber coating shall not be removed from the fiber.
Para. 4.4	The fiber and coating shall be terminated in a connector and polished to a flat surface which is within ± 2 degrees of perpendicular to the fiber axis.
Para. 4.6	The fiber rotation shall be aligned so that the largest measured diameter is horizontal. Use the video measurement system to measure the width and height of fiber in this orientation. Rotate the fiber to align smallest diameter horizontally and measure the width and height using the video measurement system.
Para. 4.7	The video system will impose a measurement image on the monitor and on the photographic image.

The following dimensions are to be verified:

a. Core diameter
b. Core ovality
c. Cladding diameter
d. Cladding ovality
e. Core/Cladding offset
f. Fiber coating diameter
g. Fiber coating ovality

4.11.3.2.2 Hermetic coating verification (3.11.1.3)

TBD – Sandia Lab Test

4.11.3.2.3 Cable buffer, strength member and jacket (3.7.5.5, 3.7.5.6)

The cable specimens shall be prepared for dimensional inspection by cross-sectioning the cable and viewing it at 50 X. using a video processor with a microscope in accordance with 4.9.13. The OD of each cable component may be measured by stripping off outer jacket, trimming strength member and stripping off buffer as required by the measurement method used.

4.11.4 Marking durability (3.7.10)

This test is to be performed only if markings are applied to the outer jacket of the cable

a. Immerse a 2 meter length of finished cable into a room temperature solution of isopropyl alcohol, ACS reagent grade.
b. Remove after 3 minutes of immersion.
c. Wipe full length of sample with clean cotton cloth
d. Repeat item c, for a total of three wipes
e. Inspect for printed marking integrity. Reject the cable if any symbolization has become illegible when viewed without magnification from a distance of approximately 0.5 meters.

4.11.5 Cable jacket stability verification. (3.7.7)

Obtain a test sample that is approximately 1 meters in length. Measure the actual length of the test sample to the nearest 0.025 millimeters. Subject the sample to five thermal shock cycles in accordance with the requirements in paragraph 4.9.13, then remove the sample from the chamber. Flex the sample holding the coiled cable with two hands on opposing sides of the cable and twisting one hand with respect to the other (the rotational axis is the line formed by both hands through the center of the coil). Then subject the sample to an additional five thermal shock samples per 4.9.13. Remeasure the length of the cable jacket to the nearest 0.025 millimeters Remove the cable jacket and strength member as required, then measure the buffer length. Calculate the percent of shrinkage.

5.0 PREPARATION FOR DELIVERY

5.1 Cleanliness

Extreme care shall be exercised during all packaging, packing, and marking procedures such that the cable cleanliness integrity and the packaging requirements of MSFC-SPEC-164 are not compromised.

5.2 Packaging requirements

Unless otherwise specified in the contract, the requirements for packaging of fiber optic cable shall be in accordance with MIL-C-12000.

5.2.1 Reels and spools

The cable shall be spooled on ESD reducing plastic reels.

The cable on each reel or spool shall have both ends readily available for testing without unwinding. A minimum of five meters of cable shall be exposed on the inside end of the cable to facilitate attenuation measurements and removal of the required mechanical and visual samples. The inner end shall be available at the outer surface of the reeled cable. Cable shall be spooled in such a way to minimize induced fiber losses and special care shall be exercised to prevent excess stress on the cable where it exits the reel on the inside end of spool. Both ends of the cable shall be secured to a flange. The reel or spool shall have an inner diameter greater than six (6) times the minimum bend radius of the cable.

5.3 Product and package marking

5.4 Marking of reels and spools

In addition to the marking specified in MIL-STD-129, each reel or spool shall be marked with the length of individual continuous lengths cable wound thereon. A warning label shall be applied to each reel to advise personnel to exercise caution in the handling of optical fibers. This label shall alert personnel to avoid skin puncture and contact with the eyes. It shall warn against staring at the output end of the fiber optic cables without eye protection (infrared viewer or equivalent) during testing when these cables are powered by high radiance light emitting diodes or lasers.

The identification marking label shall contain the following information:

SSQ Part number_____
Length _____ meters
Manufacturers P/N and Rev.# _____
Manufacture lot number _____
Date of manufacture _____
Supplier's name _____

5.4.1 Space Station critical hardware

Each reel and spool shall be identified with a removable tag. The tag shall be attached and removed in a manner such that the reel or spool will not be damaged or contaminated or otherwise rendered unsuitable for use. The tags shall be fluorescent international orange with black letters on both sides and shall read as follows.

CRITICAL SPACE STATION HARDWARE
DO NOT REMOVE UNTIL INSTALLATION

The tag size shall be commensurate with the unit size and the lettering size shall be legible to a person with normal sight at a distance of 3 feet.

5.4.2 Packaging labels

Each unit, intermediate, and final package/container shall be affixed with a self adhering label. The labels shall be fluorescent international orange with black letters and shall read as follows.

CRITICAL SPACE STATION HARDWARE
FOR USE IN MANNED SPACE FLIGHT.
MATERIALS, MANUFACTURING, AND WORKMANSHIP OF THE HIGHEST QUALITY STANDARDS ARE ESSENTIAL TO ASTRONAUT SAFETY.

The label size shall be commensurate with the package size and the lettering size shall be legible to a person with normal eyesight at a distance 3 feet and shall be logically applied to both sides of bags, top and bottom or top and two sides, depending on box geometry, of small boxes, and the top and at least 2 sides of the final container.

5.5 Unit protection and wrapping

Unless otherwise specified, each deliverable unit shall, as a minimum, be wrapped in an electrostatic free transportable polyethylene bag conforming to MIL-B-81705, Type II. Bags shall be heat sealed or sealed with a reusable sealing device manufactured from material conforming to MS90376, material B. The sealing method shall eliminate spillage and exclude particulate contaminates. Staples, tape or other static generating materials, shall not be used. The same information required by 5.4.1 for marking of reels and spools plus the date of packaging shall be permanently and legibly marked (1) on a low sulfur content card in and readable through the bag, (2) on the bag, or (3) a combination of marking on a card and the bag.

5.6 Unit packaging

Each bagged reel or spool unit shall be packaged in individual containers (paper product boxes are acceptable) to insure damage free delivery and storage. The information required by 5.4.1 and the date of packaging shall be permanently and legibly marked on the container.

5.7 Packing containers

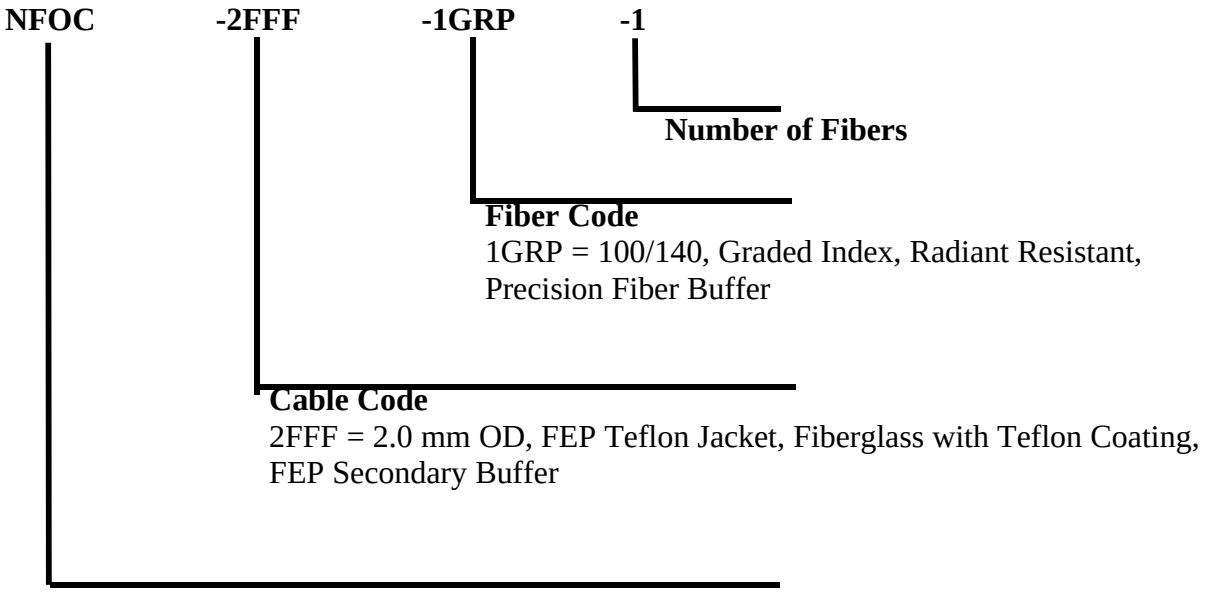
Each packaged unit (Reference paragraph 5.2) shall be packed in containers such that damage free delivery is assured. Containers shall comply with the Consolidated Freight Classification rules or other carrier regulations applicable to the mode of transportation. Each packed container shall be prominently marked with the same information required by 5.4.1 plus the quantity of reels or spools in the package and the date of packaging.

6.0 NOTES

6.1 Part numbers

The specification custodian part number consists of the part numbers shown in 6.2 and appendix A.

Part Number Identification Table



6.2 Approved source(s) of supply

Only the item described by this drawing when procured from the supplier or an approved distributor is approved for use. A substitute item shall not be used without the specification custodian's approval. Identification of approved supplier is not to be construed as a guarantee of present or continued availability as a source of supply.

Part Number	Approved Source of Supply	CAGE CODE
NFOC-2FFF-1GRP-1		
NFOC-2FFF-1GRP-1		

7.0 REQUIREMENTS VERIFICATION MATRIX

Table XII - Requirements Verification Matrix

VERIFICATION METHOD:			VERIFICATION PHASES:			
TBS = TO BE SUBMITTED BY SUPPLIER A = ANALYSIS S = SIMILARITY I = INSPECTION D = DEMONSTRATION T = OPERATIONAL TEST N/A = NOT APPLICABLE TBS = TO BE SUPPLIED BY CABLE SUPPLIER			D = DEVELOPMENT Q = QUALIFICATION A = ACCEPTANCE			
SECTION 3 PARAGRAPH	PARAGRAPH TITLE		D	Q	A	SECTION 4 PARAGRAPH
3.3.3	FUNGUS - DELETED	N/A				
3.3.3	OFFGASSING/TOXICITY - DELETED	N/A				
3.3.3.1	OUTGASSING/TOXICITY - DELETED	N/A				
3.3.3.2	ODOR - DELETED	N/A				
3.3.3.3	FLAMMABILITY - DELETED	N/A				
3.3.3.4	OUTGASSING (VACUUM STABILITY) - DELETED	N/A				
3.3.4	ATOMIC OXYGEN - DELETED	N/A				
3.4	DESIGN AND CONSTRUCTION - DELETED	N/A				
3.4.1	OPTICAL FIBER – DELETED	N/A				
3.4.1.1	OPTICAL FIBER BUFFER –DELETED	N/A				
3.4.2	CABLE – DELETED	N/A				
3.4.2.1	STRENGTH MEMBER – DELETED	N/A				
3.4.2.2	CABLE JACKET – DELETED	N/A				
3.4.2.3	COLOR – DELETED	N/A				
3.4.2.4	LENGTHS AND SLICES – DELETED	N/A				
3.4.2.5	CABLE WEIGHT – DELETED	N/A				
3.5	PHYSICAL – DELETED	N/A				
3.5.1	FIBER – DELETED	N/A				
3.5.1.1	NUMBERICAL APERTURE	N/A				
3.5.1.2	OPTICAL FIBER BANDWIDTH – DELETED	N/A				
3.5.2	CABLE	N/A				
3.5.2.1	ATTENUATION RATE – DELETED	N/A				
3.5.2.2	ATTENUATION MEASUREMENTS – DELETED	N/A				
3.5.2.2.1	INDUCED ATTENUATION – DELETED	N/A				
3.5.2.2.2	SUBSTITUTION LOSS – DELETED	N/A				

Table XII– Requirements Verification Matrix (continued)

3.5.3	RADIATION RESISTANCE – DELETED	N/A				
3.5.4	THERMAL SHOCK – DELETED	N/A				
3.5.5	SURVIVAL TEMPERATURE – DELETED	N/A				
3.5.6	CRUSH	N/A				
3.5.7	CABLE BEND	N/A				
3.5.8	JACKET SHRINKAGE	N/A				
3.5.9	VACUUM	N/A				
3.6	IDENTIFICATION MARKING	I	X	X	X	4.10.7
3.6.1	DURABILITY OF IDENTIFICATION – DELETED	N/A				
3.7	WORKMANSHIP	I	X	X	X	4.10.7
3.8	OPTICAL	N/A				
3.8.1	NUMERICAL APERTURE	TBS	X	X	X	EIA/TIA 455 FOTP 47
3.8.2	OPTICAL FIBER BANDWIDTH	TBS	X	X	X	EIA/TIA 455 FOTP 30
3.8.3	ATTENUATION	TBS	X	X	X	4.10.12
3.8.3.1	SUBSTITUTION LOSS	T	X	X		4.10.12.4
3.8.3.2	INDUCED LOSS	T	X	X		4.10.12.3
3.9	ENVIRONMENTAL					
3.9.1	FUNGUS	T	X	X		MIL-STD-810 Method 508
3.9.2	TOXICITY	T	X	X		MIL-STD-810 METHOD 508
3.9.3	ODOR	T	X	X		NHB 8060.1B
3.9.4	FLAMMABILITY	T	X	X		MSFC-HDBK-527
3.9.5	OUTGASSED PRODUCTS/ VACUUM STABILITY	T	X	X		JSC-SPEC-SP-R-0022
3.9.6	RADIATION RESISTANCE			X		
3.9.7	THEMAL SHOCK	D	X	X		MIL-STD-202 Method 107
3.9.8	SURVIVAL TEMPERATURE	D	X	X		
3.10	MECHANICAL					
3.10.1	STRIPPABILITY		X	X	X	VERIFIED DURING USE
3.10.1.1	CABLE BUFFER STRIPPABIILITY	D	X	X		VERIFIED DURING USE
3.10.1.2	FIBER BUFFER STRIPPIBILITY	D	X	X		
3.10.1.3	CABLE JACKET STRIPPABILITY	D	X	X		VERIFIED DURING USE

Table XII – Requirements Verification Matrix (continued)

3.10.2	FIBER PROOF TEST	TBS	X	X	X	
3.10.3	CYCLIC FLEXING	D	X	X		4.10.20
3.10.4	CRUSH	D	X	X		EIA/TIA-455 FOTP 41
3.10.5	CABLE BEND	D	X	X		
3.10.6	CABLE WEIGHT	TBS	X	X	X	
3.11	PHYSICAL					
3.11.1	FIBER AND FIBER BUFFER					4.10.7
3.11.1.1	FIBER CORE	TBS	X	X	X	4.10.7.4.3
3.11.1.2	FIBER CLAD	TBS	X	X	X	4.10.7.4.3
3.11.1.3	FIBER COATING DIAMTER	TBS	X	X	X	4.10.7.4.3
3.11.2	CABLE					
3.11.2.1	CABLE BUFFER	TBS	X	X	X	4.10.7
3.11.2.2	CABLE STRENGTH MEMBER	TBS	X	X	X	4.10.7
3.11.2.3	CABLE JACKET	TBS	X	X	X	4.10.7
3.11.2.3.1	CABLE JACKET OUTSIDE DIAMETER	TBS	X	X	X	4.10.7
3.11.2.3.2	CABLE JACKET STABILITY	D	X	X	X	
3.11.2.4	CABLE JACKET COLOR	D	X		X	MIL-STD-104
3.11.2.5	LENGTHS AND SPLICES	TBS			X	EIA/TIA-455 FOTP 60 & 61

APPENDIX A ITEM DETAIL SPECIFICATION

SPECIFICATION CUSTODIAN:

THE BOEING COMPANY
SPACE AND COMMUNICATIONS DIVISION
2100 SPACE PARK DRIVE
HOUSTON TEXAS, 77058
CAGE CODE: 2B945

INTERNATIONAL SPACE STATION PROGRAM OFFICE

SSQ 21657 Revision N/C

National Aeronautics and Space Administration
International Space Station Program
Johnson Space Center, Houston, Texas

10.0 SCOPE

This appendix defines the detail dimensional, material and performance requirements for a single element, multimode, fiber optic cable for use in near earth orbit and internal and external installations.

20.0 Applicable documents

None.

30.0 Requirements

30.1 Fiber characteristics

Attenuation (Cabled) -
Numerical Aperture
Bandwidth -
Proof Strength -
Core Ovality
Cladding Ovality
Core/Cladding Offset
Cable Weight -
Color -
Temperature: Operating
Storage

30.2 Physical dimensions and materials

The physical dimensions and materials for the cable are defined in Table A-I and Figure A-I. Dimensions are SI metric.

Table A-1, FIBER/CABLE DIMENSIONS

Find	Item	Dimension	Material	Construction
A B	Core Cladding	100±2um ±2um	Doped Silica	Drawn
C				
D	Fiber Coating Buffer	170±2um		Coat with Heat Cure
E	Cable Buffer	OD - 785 um max		Extruded
F	Strength Member			Braided
G	Cable Jacket	OD - 2.10±0.05mm		Extruded

40.0 Quality assurance provisions

The requirements of SSQ 21654 4.0 apply.

50.0 Packaging

Packaging of product produced to the requirements of this appendix shall be packaged in accordance with 5.0 of this specification.

60.0 Notes

The optical cable contains about 0.2% excess fiber when it is removed from the shipping reel. The excess fiber shall be removed prior to terminating the ends as follow:

Short Lengths (Less than 2 meters)

1. Cut the cable to the required length. Add the length required to terminate the ends.
2. After removing the cable jacket, strength member, and buffer tube, lay the length of cable so that it is straight and on a flat table.
3. Move the fiber in and out of the cable and verify that the fiber is free to move through the cable.
4. Clean the fiber and replace the fiber in its original position with respect to the optical cable jacket.

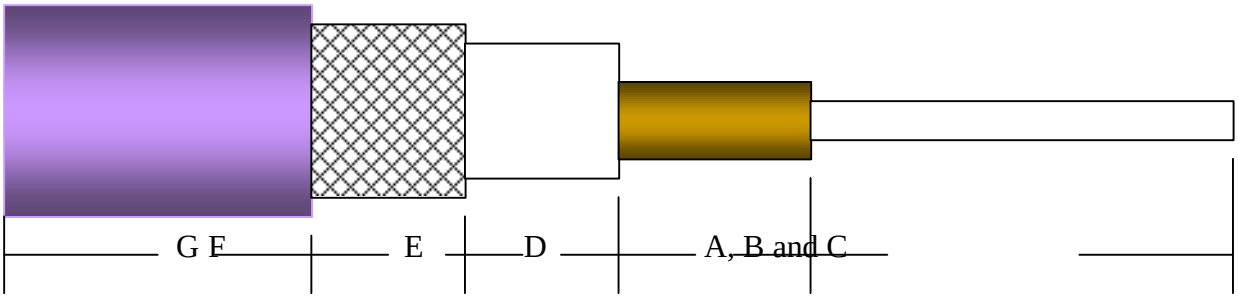


Figure A-1. Cable Configuration

Long Lengths (Greater than 2 meters)

1. Cut the cable 2 inches longer than required. Add the length required to terminate the ends.
2. Stretch the cable out on a table so that it lays straight and flat.
3. Remove one inch of cable jacket, strength member and cable buffer tube from each end.
4. Grab the fiber from one end and lift the fiber and approximately half the cable off the table.
5. If the fiber moves at the other end, set the cable down. If the fiber does not move, repeat the step above on the other cable end.
6. Cut off the excess fiber at each cable end.