Deep Space Mission System

Manufacturing Requirements DSN Cables and Harnesses

General Specification

DSMS No. **DOS-8913-GEN, Rev. E, --7**
Issue Date: June 18, 2003

Jet Propulsion Laboratory
California Institute of Technology

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General Specification

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Document Change Log

Revision	Issue Date	Affected Sections or Pages	Change Summary
DOS-8913-GEN, Rev. E	05/08/1973	All	Revision
DOS-8913-GEN, Rev. E, --1	04/16/1975	Page 43	
DOS-8913-GEN, Rev. E, --2	04/06/1976	Pages 10, 61	
DOS-8913-GEN, Rev. E, --3	09/10/1993	Pages 2, 51	
DOS-8913-GEN, Rev. E, --4	11/08/1993	Pages 2, 62	
DOS-8913-GEN, Rev. E, --5	06/15/1994	Pages 2, 63--70	
DOS-8913-GEN, Rev. E, --6	04/01/1995	Pages 2, 18, 35, 42, 43	
DOS-8913-GEN, Rev. E, --7	06/18/2003	Cover Signature Page Pages 2, 50, 51 DL-1 through DL-5	Redefined cable serial number labeling.

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1. SCOPE

1.1 Scope of specification. This specification provides the manufacturing and inspection requirements for the fabrication and labeling of cables and harnesses designed for use with, or as a part of, the Deep Space Network (DSN). The intent of this specification is to assure an end product of the highest possible quality and reliability.

1.2 Classification. DSN cable and harness assemblies shall be identified by the following classes as determined by the detailed engineering drawing.

Class 1 - Multiconductor, jacketed cables (refer to 3.2.1)
Class 2 - Multiconductor, nonjacketed harnesses (refer to 3.2.2)
Class 3 - Coaxial cables (refer to 3.2.3)

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on the date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

SPECIFICATIONS

Jet Propulsion Laboratory

GMO-50190-GEN	Inspection Standards for Workmanship, Operational Support Equipment, General Specification for
ES504049	Quality Control Requirements for Cabling and Harnesses, Ground Support Equipment, Detail Specification for
FS505117	Installation of Rayclad Thermofit Solder Sleeves for DSN Equipment

Federal

O-T-620	Trichloroethane-1, 1:1, Technical, Inhibited (Methyl Chloroform)
TT-I-735	Isopropyl Alcohol
QQ-W-343	Wire, Electrical and Non-Electrical, Copper (Uninsulated)
QQ-S-571	Solder, Tin Alloy, Lead-Tin Alloy and Lead Alloy

Military

MIL-C-17	Cables, Radio Frequency, Coaxial, Dual Coaxial, Twin Conductor, and Twin Lead
MIL-C-572	Cord, Yarns, and Monofilaments Organic Synthetic Fiber
MIL-I-631	Insulation, Electrical, Synthetic-Resin Composition, Nonrigid
MIL-W-5086	Wire, Electric Hook-Up and Interconnecting, Polyvinyl Chloride Insulated Copper or Copper Alloy Conductor
MIL-R-6855	Synthetic Rubber Sheets, Strips, Molded, or Extruded Shapes
MIL-C-7078	Cable, Electric, Aerospace Vehicle, General Specification for
MIL-F-14256	Flux, Soldering, Liquid (Rosin Base)
MIL-W-16878	Wire, Electrical, Insulated, High Temperature
MIL-I-19166	Insulation Tape, Electrical, High Temperature, Glass Fiber, Pressure-Sensitive
MIL-S-22473	Sealing, Locking, and Retaining Compounds, Single Component
MIL-I-23053	Insulation Sleeving, Electrical, Heat Shrinkable, General Specification for
MIL-C-39012	Connector, Coaxial, Radio Frequency, General Specification for
MIL-T-43435	Twine and Tape, Impregnated, Lacing, and Tying
MIL-W-5086/2A	Wire, Electric, Hookup and Interconnecting, Polyvinyl Chloride Insulation, PVC - Glass - Nylon, Tin-Coated Copper Conductor, 600-Volt, 105°C

MIL-W-5088/8160	Wiring, Aircraft, Installation of
MIL-W-8160	Wiring, Guided Missile, Installation of, General Specification for

STANDARDS

Military

MS21980	Ferrule, Outer, Uninsulated, Shield Terminating, Type I Two Piece, Class 1
MS21981	Ferrule, Inner, Uninsulated Shield Terminating, Type I Two Piece, Class 1

DRAWINGS

Jet Propulsion Laboratory

~~9450483~~	~~Label, Cable Identification~~ Deleted Amendment # 2 6 April 76
9450484	Label, Cable Identification
9454446	Label, Identification - DSN

PUBLICATIONS

Military

MIL-HDBK-216	RF Transmission Lines and Fittings

(Copies of specifications, standards, procedures, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by such activity.)

3. REQUIREMENTS

3.1 General requirements. Unless otherwise noted on the procurement document or the detailed engineering drawing, the following general manufacturing requirements shall apply to all classes of cable assemblies fabricated or labeled in accordance with this specification.

3.1.1 Materials.

3.1.1.1 Insulated wire. Conductors shall have basic construction in accordance with the specifications listed in Table I. Requirements for wire gauge, twisting, shielding, and other features shall be as specified on the detailed engineering drawing.

Table I. Insulated Wire Specification Requirements

Gauge	Specification	Type	Voltage Insulation
16, 18, 20, 22, 24	MIL-W-16878/1	B	600-volt/PVC (polyvinyl chloride) insulation (105°C)
14	MIL-W-16878/2	C	1000-volt/PVC insulation (105°C)
12	MIL-W-16878/3	D	3000-volt/PVC insulation (105°C)
10 and larger	MIL-W-5086/2A		600-volt/nylon jacketed glass braid over PVC insulation (105°C)

3.1.1.2 Fillers. Wires of the same American Wire Gauge (AWG) size and type as the majority comprising the completed cable may be used as fillers if such wires are continuous, i. e., no splices. Conductive filler ends shall be insulated using sleeving as specified in 3.1.1.3 when wires are not used as fillers, nonconductive fillers may be used provided that such fillers are not hygroscopic.

3.1.1.3 Sleeving. Heat-shrinkable sleeving in accordance with MIL-I-23053/5, class 2 (flexible, transparent, irradiated polyolefin) shall be used to insulate all splices, shield terminations, and conductive filler ends, and to provide increased termination isolation at connectors.

3.1.1.4 Solder sleeves. Solder sleeves used for splicing and terminating shields shall be in accordance with JPL Specification FS505117.

3.1.1.5 Shielding, braided. Unless otherwise specified on the detailed engineering drawing, shields for single conductors, conductor complexes, and overall shields shall be of braided construction. Shielding of MIL-W-5086 wire shall be in accordance with MIL-C-7078. Overall shields and shielding of MIL-W-16878 wire shall be in accordance with 3.2.5.3 of MIL-W-16878. Braided shields over a wire complex of five or more conductors shall have a spiral wrap of polyester tape over the last lay of wires under the shield. The tape and wrap shall be in accordance with 3.1.1.8.

3.1.1.6 Shielding, aluminized polyester. Techniques for using aluminized polyester as a shield for single conductors and conductor complexes shall be as follows:

a. Conductors to be shielded shall be combined with a stranded, tinned-copper drain wire in a manner consistent with 3.2.1.2 herein. Drain wires shall be in accordance with Federal Specification QQ-W-343, type C, class C tin coated and shall be size AWG 24 or larger.

b. The conductor complex shall be spiral wrapped using aluminized polyester tape with aluminized surface contacting the drain wire and using a pitch which will provide a 50% overlap.

3.1.1.7 Inner shield coverings. Unless otherwise specified on the detailed engineering drawing, cable assemblies with internal braided shields shall have the shields covered with a nonconductive covering, for isolation, as specified below.

a. Cable assemblies consisting of four or fewer shielded complexes and wires in any combination shall have the individual shields covered with a polyvinyl chloride jacket in accordance with 3.2.5.2 of MIL-W-16878.

b. Cable assemblies consisting of five or more shielded complexes and wires in any combination shall have the individual shields covered with a spiral wrap of polyester tape. The tape and wrap shall be in accordance with 3.1.1.8.

3.1.1.8 Polyester tape. Polyester tape used under and over braided shields shall meet or exceed the requirements of MIL-I-631, type G, class 1. The tape used shall not be less than 0.0005-inch thick. The tape shall be spiral wrapped to provide a 50% overlap.

3.1.1.9 Jacket and tape materials. All jacket and tape materials used in the construction of cables in accordance with this specification shall be certified new material. Any material which has been previously processed in any manner not essential to its manufacture shall not be considered as new material and its use shall be cause for rejection of the finished cable assembly.

3.1.1.10 Connectors. The connector and size shall be as specified on the applicable engineering drawing. Any modifications to connectors shall be performed only upon written authorization from JPL cognizant engineering personnel prior to start of any modification of the assembly or part. If this modification removes any surface process, treatment, or plating, the modified surface shall be treated with the correct process in accordance with the applicable connector or material specification. All contacts shall be installed in connectors even though they may not be wired.

3.1.1.11 Termination of unused wires. All ends of unused conductors shall be turned back and secured individually with shrink tubing. The secured end shall be left long enough for termination at a later date.

3.1.1.12 Connector sealing compounds. Connector sealing compounds (potting and molding compounds) shall be in accordance with 3.3.5.1 and 3.3.6.1 of this specification.

3.1.1.13 Strain relief devices. The requirements for use of a strain relief device shall depend on the cable type (refer to 3.2.1.1 and 3.2.2.1). Where engineering drawings do not specify the type of strain relief device to be used, prior approval of the type selected for use shall be obtained from JPL engineering. The cable manufacturer shall install a protective cable clamp bushing on all connector assemblies utilizing a strain relief device to protect the wires and/or to insure proper fit between cable and clamp.

3.1.1.14 Cable identification. Cable identification shall be accomplished by labels in accordance with 3.3.7.1.

3.1.1.15 Additional requirements, class E cable assemblies (PC boards). In addition to the requirements specified herein, the following requirements shall apply to all type E cable assembly cables terminated with PC boards.

a. At no time shall the cable clamp or wiring components mounted on the PC board exceed the height of the handle attached to the PC board.
b. The outside diameter of the cable under the strain relief clamp, as supplied with Printed Wiring Board Connector Module 9449988, shall be 0.30-inch minimum and 0.50-inch maximum.
c. Conductors shall be spot tied between the strain relief clamp and the termination point, as necessary, to insure that the requirement of (a.) above is adhered to.
d. Only 22 and 24 gauge wire can be used on PC boards. In cases where the cable conductor is larger than 22 gauge, the conductor shall be spliced with a 22-gauge wire for termination on the PC board. In cases where the cable conductor is smaller than 24 gauge, it shall be spliced with a 24-gauge wire for termination on the PC board. Splices shall be in accordance with 3.3.4.

3.1.2 Workmanship. Inspection and workmanship shall be in conformance with JPL Specification GMO-50190-GEN and as specified herein.

3.1.2.1 Connector cleaning. Connectors shall be cleaned in accordance with 3.3.5.2.

3.1.2.2 Ferrule cleaning. Ferrules shall be cleaned in accordance with 3.3.1.2.a and 3.3.4.4.a.

3.1.2.3 Wire tension. Connectors shall be wired in a manner which will assure an even distribution of wire tension and will minimize wire crossovers. All wires entering a connector shall equally support the cable mass.

3.1.2.4 Connector termination isolation. Where connector or connector compounds do not provide adequate conductor termination isolation, and where this is not accomplished by connector sealing (potting or molding), sleeving in accordance with 3.1.1.3 shall be used.

3.1.2.5 Connector molding and potting. Connector molding and potting shall be uniform in hardness and shall not exhibit any excessive build-up or uneven areas, voids, chips, flakes, bubbles, punctures, or holes.

3.1.2.6 Connector clamps. Connector clamps or retaining devices shall not be tightened to a point of distorting the cable bundle or causing a possible cold-flow condition.

3.1.2.7 Label legibility. All label markings shall be legible. Markings shall be placed so they read toward the connector.

3.2 Detailed manufacturing requirements, class 1, 2, and 3 cable assemblies.

3.2.1 Class 1 cables, multiconductor, jacketed.

3.2.1.1 Types. Class 1 cables will be of five types based on the connector backshell requirements. Specific type requirements will be determined by notes on the detailed engineering drawing.

Type A	Cable clamp or strain relief (nonmolded/ nonpotted). Drawing note will be: "Fabricate and identify per JPL Specification DOS-8913-GEN, class 1, type A."
Type B	Potted connector backshell (refer to 3.3.5). Drawing note will be: "Fabricate and identify per JPL Specification DOS-8913-GEN, class 1, type B."
Type C	Molded connector backshell (refer to 3.3.6). Drawing note will be: "Fabricate and identify per JPL Specification DOS-8913-GEN, class 1, type C."
Type D	Nonmolded, nonpotted, nonclamped bulkhead-type connector. Drawing note will be: "Fabricate and identify per JPL Specification DOS-8913-GEN, class 1, type D."
Type E	Printed circuit board. Drawing note will be: "Fabricate and identify per JPL Specification DOS-8913-GEN, class 1, type E."

3.2.1.2 Basic cable construction. Cable assemblies shall be manufactured using a planetary or equivalent technique which lays wires in helical layers concentric with a central core, but prevents any twist from being introduced into the individual wires. The pitch/diameter ratio for any given layer of wiring components shall be not less than 8 to 1 nor greater than 12 to 1. Each successive layer shall be laid in the opposite rotation to the preceding layer. Lay patterns shall be designed and controlled to provide minimum cable diameter while maintaining flexibility. Cable lay pattern shall be designed to provide a circular cross-section to the finished cable assembly.

3.2.1.3 Breakouts. At points where a cable assembly subdivides into two or more smaller cables, a primer and polyurethane compound in accordance with Table VI shall be molded around the points of convergence. Cable jacks shall be prepared in accordance with applicable portions of 3.3.6.4. The separate cables shall be bound together prior to their point of emergence from the molded mass. The mold configuration shall provide adequate encapsulation of junctions without introducing an excessively large mass into the assembly (refer to 3.3.6.3). Individual cable jackets shall be overlapped a minimum of 1/2 inch by the molded mass to provide mechanical support, and shall be completely bonded to the molded mass. The cables branching out shall have the same helically stranded construction and flexibility as the main cable.

CAUTION

Where coaxial cable elements are required in a class 1 cable assembly, accelerated curing temperatures for molded or potting cabling, if used, shall be chosen which will not destroy the basic physical and electrical properties of the coaxial cable(s).

3.2.1.4 Tapes. A spiral wrap of tape providing a minimum of 50% overlap shall be provided over the outer layer of wiring in accordance with the following:

3.2.1.4.1 Nonoverall shielded cable assemblies. Nonoverall shielded cable assemblies shall contain tape that meets or exceeds the requirements of MIL-I-631, type F, form T, class 1, category 1, grade A. Where it is necessary to facilitate the lay-up of a cable, yarn defined in MIL-C-572 (type P, form 4, three ends of 210 denier nylon), may be applied as a binder over any wiring group (not overall shielded) which constitutes a complex of the total cable wiring.

3.2.1.4.2 Overall shielded cable assemblies. Cable assemblies which have an overall braided shield and which consist of five or more shielded

complexes or wires or both, shall have a spiral wrap of polyester tape under the shield and over the shield prior to application of the outer jacket. The tape and wrap shall be in accordance with 3.1.1.8. Cable assemblies with an overall shield and consisting of four or fewer conductors do not require a spiral wrap of polyester tape prior to application of the outer jacket.

3.2.1.5 Jacketing. Outer jackets of the complete cables shall be to two types. The bill of material on the detailed engineering drawing shall specify the type to be used. The cable jacketing material shall extend under the connector cable clamp, mold, or other strain relief device to ensure that the jacketing and cable body will remain securely clamped or contained during normal flexing or stressing of the cable in the clamping area. (The minimum cable bend radius shall be 10 times the outside diameter of the finished cable for purposes of defining "normal" flexing.)

Type I Neoprene compound (synthetic rubber) conforming to MIL-R-6855, class II grade 60. Material shall not cause deterioration of finished surfaces of wood, metal, or fabric, with which the cable may come into contact. The jacket shall not become tacky when exposed to severe climatic conditions. Natural rubber, reclaimed rubber, or fabric shall not be included in the jacket material. Type I tubing wall thickness shall be in accordance with Table II. The size of the jacketing material shall be selected to provide a snug fit between the inner wall of the jacketing and the outer surface of the cable bundle. The installed jacketing inside diameter (ID) shall not exceed the preinstalled jacketing ID by more than 10%. Type I jacketing material "cure dates,", as described in MIL-R-6855, shall be less than 6 calendar quarters prior to the date of the JPL cable assembly in-process inspection.

Type II Plenum rated jacketing. When type II jacketing is specified, the cable and jacket shall conform to the requirements of UL 910. The jacket shall be applied by extrusion to the cable assembly. The insulation shall be applied concentrically about the cable bundle and so cured, processed, or maintained as to provide for accurate centering of the cable bundle and retention of a circular cross-section. The insulation wall thickness for type MPP and CMP shall comply with UL 444; type CL3P and CL2P shall comply with UL13: type FPLP shall comply with UL 1424; type OFMP and OFCP shall comply with UL 1651. The plenum cable manufacturer, part number, plenum type, gauge, temperature rating, and UL listing shall be stamped at a maximum of every 24 inches on the cable. Substitutions permitted (NEC 760-53) are as follows: MMP, CMP, and FPLP for CL3P, MMP, CMP, FPLP, and CL3P for CL2P.

Definitions:

MMP=	Multipurpose Plenum Cable
CMP=	Communication Plenum Cable
CL3P=	Class 3 Remote-Control, Signaling and Power Limited Plenum Cable
CL2P=	Class 2 Remote-Control, Signaling and Power Limited Plenum Cable

OFNP=Nonconductive Optical Fiber Plenum Cable
OFCP=Conductive Optical Fiber Plenum Cables

Note: Type II jacket may be used in place of Type 1 or Type III jacket without prior approval of JPL.

Type III — Polyvinyl chloride (PVC) extruded jacketing. When type III jacketing is specified, it shall be black in color and applied by extrusion to the cable assembly. The insulation shall be applied concentrically about the cable bundle and so cured, processed, or maintained as to provide for accurate centering of the cable bundle and retention of a circular cross-section. At any cross-section along the length of the completed cable, the insulation wall thickness shall be in accordance with Table III.

Note: Type I jacket may be used in place of Type III jacket without prior approval of JPL.

3.2.2 Class 2 cables, multiconductor, nonjacketed.

3.2.2.1 Types. Class 2 cables shall be of five types based on connector backshell requirements. Specific type requirements will be determined by notes on the detailed engineering drawing.

Type A — Cable clamp or strain relief (nonmolded/nonpotted). Drawing note will be: "Fabricate and identify per JPL Specification DOS-8913-GEN, class 2, type A."

Type B — Potted connector (refer to 3.3.5). Drawing note will be: "Fabricate and identify per JPL Specification DOS-8913-GEN, class 2, type B."

Type C — Molded connector (refer to 3.3.6). Drawing note will be: "Fabricate and identify per JPL Specification DOS-8913-GEN, class 2, type C."

Type D — Nonmolded, nonpotted, nonclamped bulkhead type connector. Drawing note will be: "Fabricate and identify per JPL Specification DOS-8913-GEN, class 2, type D."

Type E Printed circuit board. Drawing note will be: "Fabricate and identify per JPL Specification DOS-8913-GEN, class 2, type E."

Table II. Type I Tubing Sizes and Tolerances*

Inside Diameter (in. ±1/64)	Wall Thickness		
	Light (in.)	Heavy (in.)	Extra Heavy (in. ±1/32)
1/8	3/64 + 1/64, -0	1/16 + 1/64, -0	3/16
5/32	3/64 + 1/64, -0	1/16 + 1/64, -0	3/16
3/16	3/64 ± 1/64	1/16 + 1/64, -0	3/16
1/4	1/16 ± 1/64	3/32 ± 1/64	3/16
5/16	1/16 ± 1/64	3/32 ± 1/64	3/16
3/8	1/16 ± 1/64	3/32 ± 1/64	1/4
7/16	1/16 ± 1/64	3/32 ± 1/64	1/4
1/2	1/16 ± 1/64	1/8 ± 1/64	1/4
9/16	1/16 ± 1/64	1/8 ± 1/64	1/4
5/8	1/16 ± 1/64	1/8 ± 1/64	--
3/4	3/32 ± 1/64	1/8 ± 1/64	--
7/8	3/32 ± 1/64	1/8 ± 1/64	--
1	3/32 ± 1/64	1/8 ± 1/64	--

*The figures in this table contain intentional deviations from MIL-S-6855, but are in compliance with tubing sizes and tolerances recommended for use in DSIF equipment cabling.

3.2.2.2 Basic cable construction. All class 2 cables shall be compact and neatly formed with a minimum of crossovers. The lay pattern shall be determined by the number of connectors on the cable assembly.

Table III. Type III Wall Thickness Versus Cable Outside Diameter (all dimensions are in inches)

Cable OD Less Jacket	Jacket Wall (nominal)	Jacket Wall (minimum)	Jacket Wall (maximum)
0.0 - 0.30	0.035	0.030	0.040
0.30 - 0.50	0.045	0.040	0.050
0.50 - 0.75	0.050	0.045	0.055
0.75 - 1.00	0.060	0.055	0.065
1.00 - 1.50	0.090	0.085	0.100
1.50 and above	0.125	0.110	0.135

3.2.2.2.1 Assemblies with four or fewer connectors. Class 2 cable assemblies with four or fewer connectors shall utilize the same method of manufacture described in 3.2.1.2 for class 1 cable assemblies.

3.2.2.2.2 Assemblies with five or more connectors. Class 2 cable assemblies with five or more connectors may have the conductors twisted or grouped into a nontwisted lay pattern, and formed as required by the detailed engineering drawing.

3.2.2.3 Wire grouping. Wire grouping at breakouts and connector entries shall be performed as follows:

a. Wire groups or bundles within a cable, approaching branch points, shall be positioned to accept the minimum amount of harness distortion.
b. Connectors shall be wired in an orderly fashion to obtain an even distribution of wire tension. All wires in a connector shall equally support the cable mass.
c. Wires shall be properly positioned prior to approaching the branch points in order to minimize crossovers.

d. Splices, when required, shall be located in the backshell area if possible, provided enough antiflexing support is obtainable.

3.2.2.4 Spot ties. Conductors of class 2 cables shall be secured with spot ties consisting of a clove hitch and a square knot. Groups of wires having an overall diameter of 1/2 inch or less shall have spot ties spaced at 3/4-inch intervals. Groups of wires with 1/2-inch to 3/4-inch overall diameters shall have the spot ties spaced at 1-inch intervals. Groups of wires having overall diameters greater than 3/4 inch shall have spot ties spaced at 1-1/2-inch intervals.

3.2.2.5 Spot tie material. Spot tie material shall be flat, braided, nylon yarn impregnated with microcrystalline fungicidal wax, in accordance with MIL-T-43435, type 1.

3.2.3 Class 3 cables, coaxial type. Coaxial cables shall be in accordance with Specification MIL-C-17. Class 3 cable assemblies will be of the types specified below. Specific type requirements will be determined by notes on the detailed engineering drawing.

Note: When more than one coaxial conductor is required in a cable assembly, the class 1 or class 2 manufacturing requirements are applicable (as specified in the detailed engineering drawing), in addition to the class 3 requirements.

Type A Nonpotted backnut. Drawing note will be: "Fabricate and identify per JPL Specification DOS-8913-GEN, class 3, type A."

Type B Potted backnut (refer to 3.3.5.4). Drawing note will be: "Fabricate and identify per JPL Specification DOS-8913-GEN, class 3, type B."

Type C Crimped connector. Drawing note will be: "Fabricate and identify per JPL Specification DOS-8913-GEN, class 3, type C."

Type D — Bulkhead type connector. Drawing note will be: "Fabricate and identify per JPL Specification DOS-8913-GEN, class 3, type D."

Type E — Printed circuit board. Drawing note will be: "Fabricate and identify per JPL Specification DOS-8913-GEN, class 3, type E."

3.2.3.1 Basic cable construction. Assembly procedures for coaxial connectors shall be in accordance with MIL-HDBK-216 for MIL-C-39012 connectors and in accordance with the connector manufacturer's specifications for special connectors. All coaxial connectors shall be of captivated contact type. In addition, the following requirements shall apply:

a. The contact depth shall be maintained within ±0.015 inch of the specified dimension or to the tolerance established by the connector manufacturer on connectors where contact depth is preset. In areas of conflict between JPL and connector manufacturer's requirements, the conflict shall be referred to cognizant JPL personnel for resolution.
b. The cable shall be free of distortion, cracks, burns, or other damage.
c. There shall be no nicks or cuts on shield braid.
d. The center conductor shall be free of nicks.
e. The dielectric shall be cut 90 degrees to center conductor.
f. The center conductor length shall be such that upon insertion, the dielectric touches the contact and the conductor is visible through the inspection hole.
g. The completed termination shall withstand the connector manufacturer's written recommended pull-test requirements.

3.2.3.1.1 Additional requirements, type A and type B cables. In addition to the requirements specified above, the following requirements shall apply for type A and type B cable assemblies:

a. There shall be no buildup of solder on the exterior of the center contact.
b. There shall be no flux on the contact.
c. The dielectric shall not be burned, distorted, frayed, or contaminated.
d. All cable braid shall be "combed" so that the strand crossover does not exceed 5%.
e. The backnut shall be torqued as specified in Table IV.

Table IV. Coaxial Connector Backnut Torque Limits

Connector Backnut Thread OD (inch)	Torque (inch-pounds)
Less than 1/4	15 to 20
1/4 to 1/2	25 to 30
Greater than 1/2	35 to 40

3.2.3.1.2 Additional requirements, type B cables. In addition to the requirements specified above (3.2.3.2 and 3.2.3.2.1) type B cables shall have been assembled completely, including torquing of the backnut prior to potting. Potting shall be accomplished in accordance with the procedure of 3.3.5.4.

3.3 Detailed manufacturing requirements, processes, and procedures.

3.3.1 Shield terminations. The following requirements and procedures shall apply to the termination of shields of conductors and conductor complexes having overall diameters less than 0.370 inch. Unless otherwise specified on the detailed engineering drawing, and subject to prior approval by

cognizant JPL engineering, the method used to terminate shields of cables having larger diameters will be at the option of the contractor. Methods selected by the contractor shall provide adequate isolation of all portions of the termination and maximum electrical reliability.

3.3.1.1 Materials. Unless otherwise specified, the following materials and equipment shall be used for all shield terminations.

a. Ferrules. Inner ferrules shall be tin-plated brass alloy and shall conform to Military Standard MS21981. Outer ferrules shall be uninsulated, tin-plated copper or brass alloy and shall conform to Military Standard MS21980.

b. Sleeving. Heat shrinkable sleeving shall be in accordance with 3.1.1.3.

c. Solder sleeves. Solder sleeves in accordance with 3.1.1.4 may be used to terminate braided shielding. Installation of solder sleeves shall be in accordance with JPL Specification FS505117.

d. Crimping tool. Crimping tools shall be in accordance with manufacturer's recommendations for the particular outer ferrule used.

e. Heating device. The heating device used for shrinking sleeving shall be capable of delivering an accurately aimed stream of air heated to temperatures of 200° to 300°C (392° to 572°F).

f. Cleaning solvent. Technical inhibited -1, 1:1 trichloroethane conforming to Federal Standard O-T-620.

3.3.1.2 Shield termination requirements. The following general requirements are applicable to all shielded wire terminated in accordance with this specification.

a. All ferrules shall be cleaned in an ultrasonic cleaning tank prior to JPL in-process inspection using the

solvent specified in 3.3.1.1.f. The immersion time shall be 2 (±0.5) minutes. After an initial cleaning, the process is to be repeated with clean solvent.

b. Shields shall be terminated at a minimum of 1/2 inch and a maximum of 3 inches from the center conductor termination.

WARNING

Shields shall never be terminated under a clamping device or strain relief device.

c. Where metal backshells and cable clamps are required, all shields shall be terminated where possible within a backshell, but shall not exceed 3 inches from back of connector.

d. Where more than one shielded conductor is included within the cable assembly, adjacent shield terminations shall be staggered.

e. Shield jumper wires shall be AWG 22, stranded, insulated wire and shall have a length of approximately 3 inches.

f. Shield jumper wires shall be positioned within the cable bundle to minimize crossovers.

g. The wire from the final shield termination to the connector contact shall have the same gauge as the nominal contact size ±1 gauge.

h. The shield return wire, a wire from the connector contact, and a shield jumper wire may be combined in the final shield termination as shown in Figure 1.

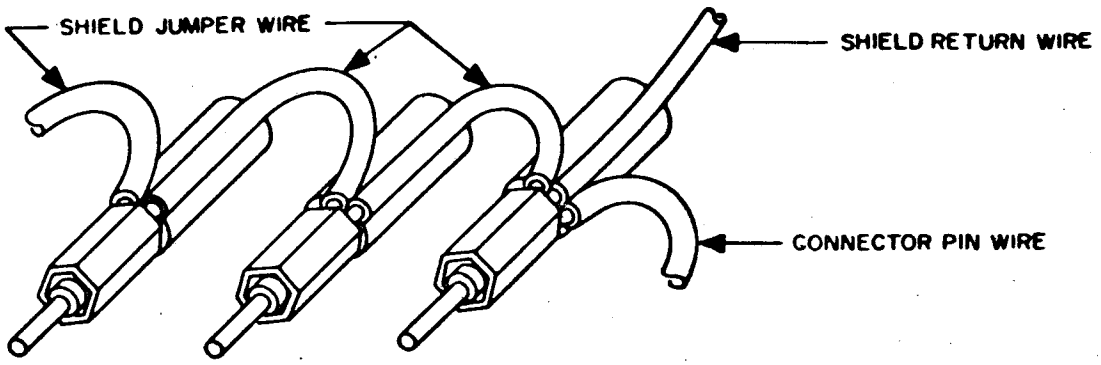

Figure 1. Shield Termination Jumpers

3.3.1.3 Termination of braided shields.

3.3.1.3.1 Nonfloating end. The following procedure shall be used to terminate the nonfloating ends of braided shielding.

a. Remove insulation jacket from shielding using thermal strippers. Splay shield out to accept the inner ferrule (see Figure 2).

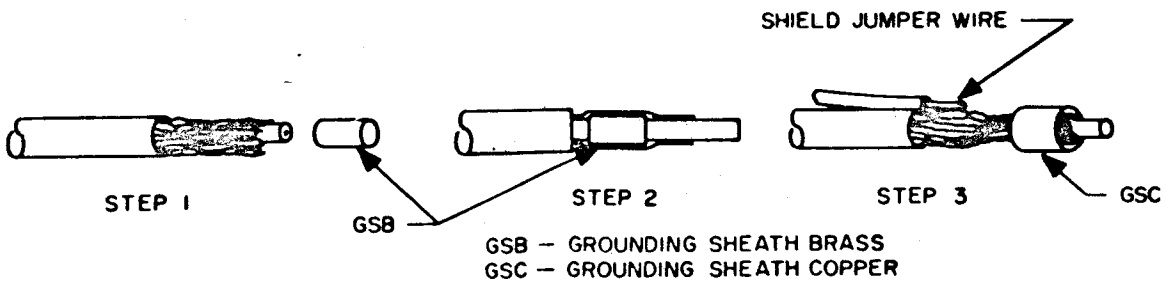

Figure 2. Braided Shield Terminations, Nonfloated

b. Select an inner ferrule which slips over the inner conductor(s) without binding. The inside diameter of the ferrule should not exceed the diameter of the conductor(s) by more than 0.025 inch. The ferrule should be slipped between the inner conductor(s) and the shield and butted against the shield jacket.

c. Prepare any wires to be crimped with the shield in accordance with 3.3.1.2. Sufficient insulation shall be removed to allow these wires to extend the full length of the ferrule.

d. Select an outer ferrule and install over the shielding and wires to be crimped with the shield. Butt the outer ferrule to the shield jacket. The inner ferrule shall protrude beyond the outside edge of the outer ferrule 1/16 inch (+1/32, -0 inch). The insulation on wires to be crimped with the shield shall not extend under the outer ferrule, and the insulation gap shall not exceed 1/32 inch.

e. Crimp the assembled termination with the crimping tool recommended for the outer ferrule selected.

f. Trim the excess shield and wire strands from the crimped termination using a very sharp cutting tool. The inner ferrule should be used as a cutting mandrel as shown in step 2 of Figure 3.

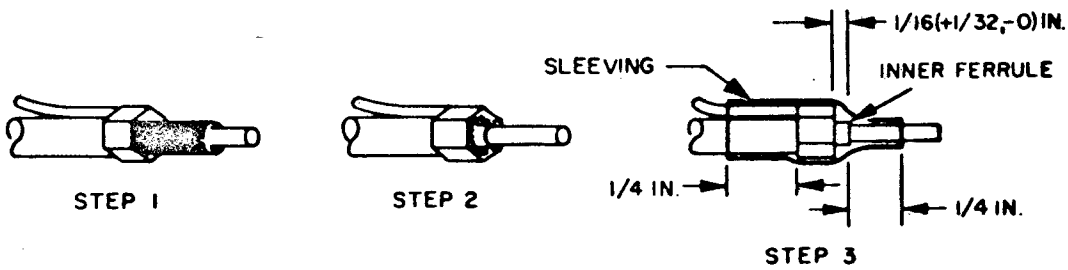

Figure 3. Crimping Procedure, Nonfloated Terminations

g. Heat shrinkable sleeving shall be applied over each completed termination. The sleeving shall overlap the termination at each end by 1/4 inch (+1/16, -0 inch) as shown in step 3 of Figure 3.

h. The completed termination shall be capable of withstanding a pull test of 10 pounds.

3.3.1.3.2 Floating end. The following procedure shall be used to terminate the floating ends of braided shielding.

a. Remove insulating jacket from shielding using thermal strippers.

b. Roll shield back over the shield jacket 3/16 inch (+1/32, -0 inch) as shown in step 2 of Figure 4.

c. Heat shrinkable sleeving shall be applied over each completed termination. The sleeving shall overlap the termination at each end by 1/4 inch (+1/16, -0 inch) as shown in step 3 of Figure 4.

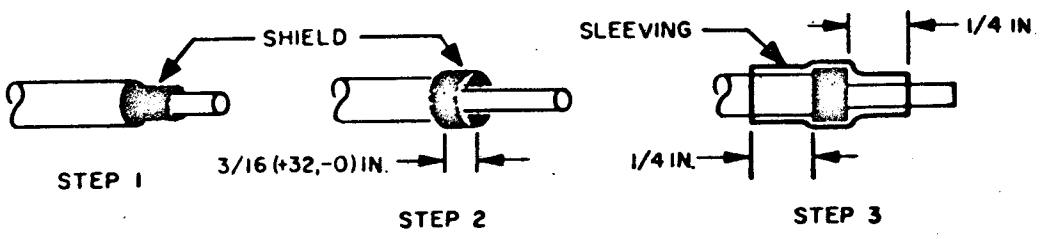

Figure 4. Shield Termination, Floated End

3.3.1.4 Termination of aluminized polyester shields.

3.3.1.4.1 Nonfloating end. The following procedures shall be used to terminate the nonfloating ends of aluminized polyester shielding.

a. Strip back aluminized polyester shield to uncover desired length of the inner conductor(s) and cut off using scissors.
b. Shrink a length of heat shrinkable sleeving over the drain wire. The sleeving shall extend a minimum of 1/4 inch under the end of the shield as shown in Figure 5.

3.3.1.4.2 Floating end. The following procedures shall be used to terminate the floating ends of aluminized polyester shielding.

a. Strip back aluminized polyester shield to uncover desired length of the inner conductor(s) and cut off using scissors.
b. Cut drain wire 1/4 inch from end of shield.
c. Shrink a length of sleeving over the drain wire. The sleeving shall extend a minimum of 1/4 inch under the end of the shield and a minimum of 1/4 inch past the end of the drain wire.
d. Secure the shield and drain wire by shrinking a 1-inch length of sleeving over the three wires and the end of the shield.

3.3.1.5 Shield terminations of type E cables (PC boards). All shield terminations for type E cable PC boards, except coaxial as noted below in 3.3.1.5.3, shall be a maximum of 4 inches or a minimum of 1 inch from point where cable crosses edge of PC board as shown in Figure 6.

3.3.1.5.1 Shielded and jacketed conductors. Each shield shall be terminated in accordance with 3.3.1.3.1 and 3.3.1.4 and staggered within the area described in 3.3.1.5.

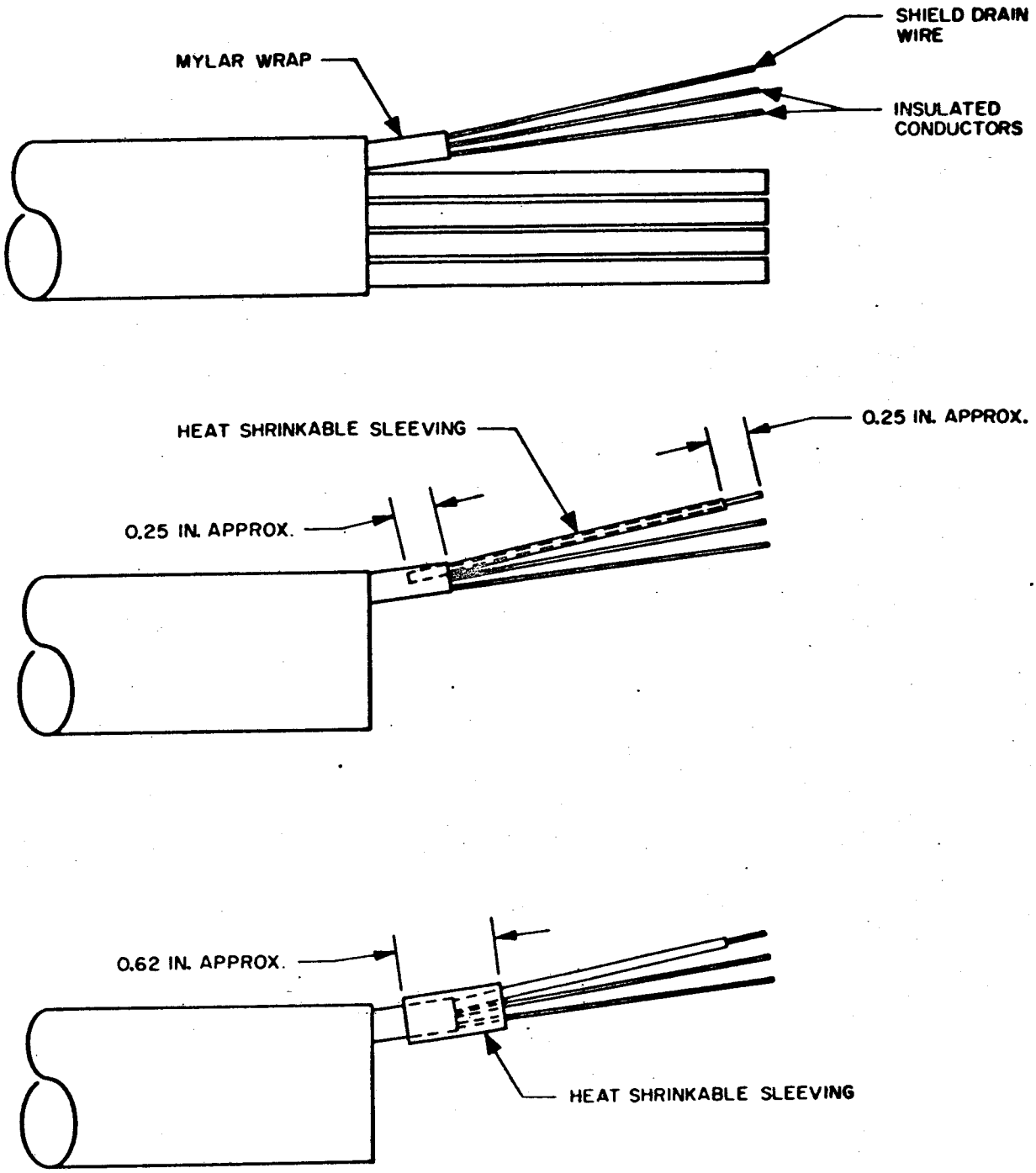

Figure 5. Method for Terminating Aluminized Polyester Shields

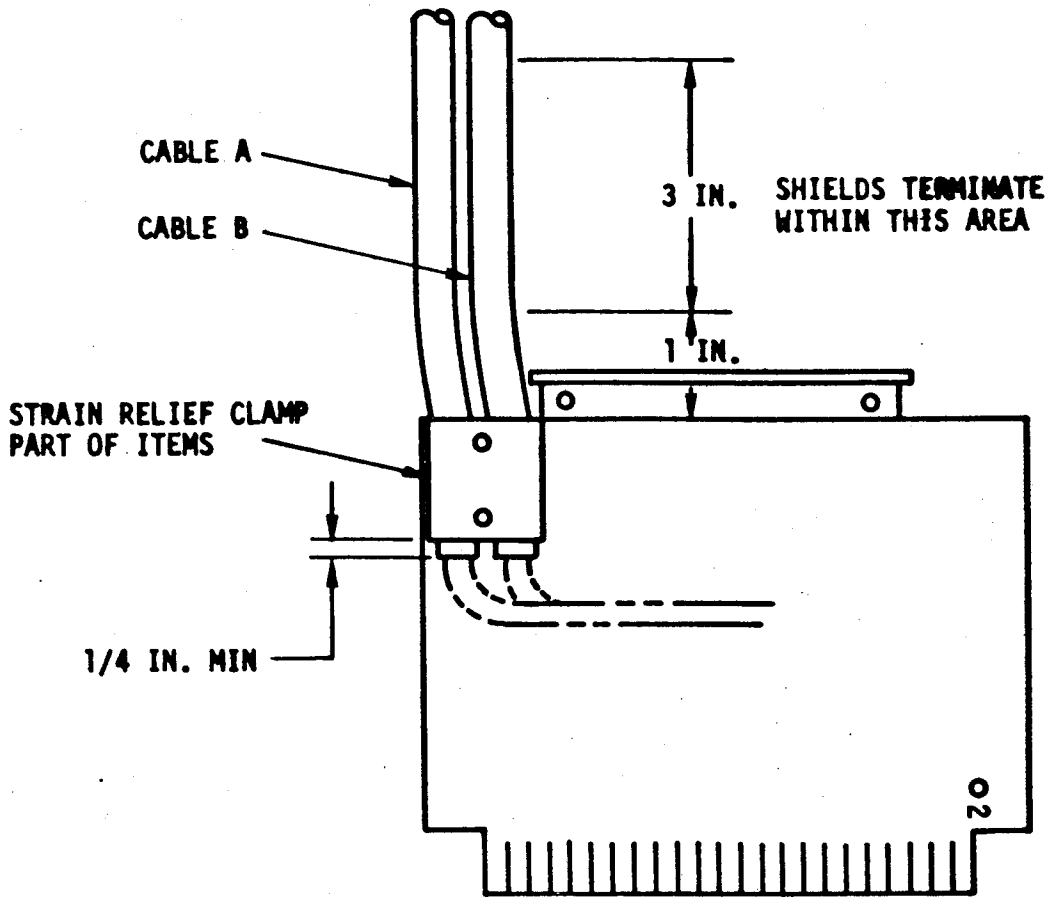

Figure 6. Shield Terminations, Type E Cables (PC Boards)

3.3.1.5.2 Shielded conductors (SCS and TPS). All shields shall be terminated at the same point within the area described in 3.3.1.5 and secured with 1 inch (±1/8 inch) of thermal fit tubing as shown in Figure 7.

3.3.1.5.3 Shielded coaxial conductors. Coaxial type shielding shall be terminated in accordance with 3.3.1 and shall be terminated on PC board as close to point of termination as possible.

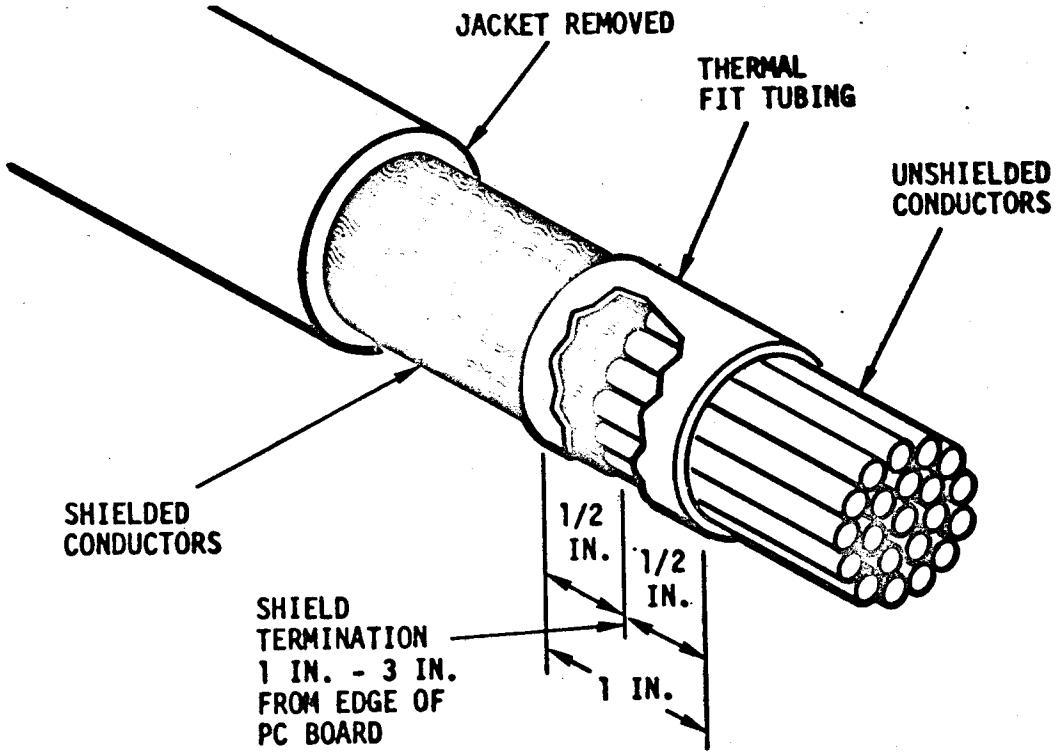

Figure 7. Termination of SCS and TPS Shields of Class I Cables

3.3.2 Crimped terminations. Unless otherwise specified and except as noted below, the hardware manufacturer's recommended crimping tools and procedures shall be used by the cable manufacturer. These written procedures shall be made available to JPL source inspectors.

3.3.2.1 Crimping requirements. The following requirements are necessary to ensure a good mechanical and electrical connection:

a. The conductor shall be visible when viewed from a direction perpendicular to the contact through the inspection hole.

b. There shall be no insulation gap between the conductor insulation and the point at which the conductor enters the terminal or contact.

c. When tested in accordance with 3.3.2.4 the mechanical connection of the wire and terminal shall be capable of withstanding the pull test values in Table V without noticeable separation from the contact.

3.3.2.2 Crimping preparation. All wire used shall be handled so as to prevent damage to the conductor and insulation. Wire strands shall remain in their original configuration. Insulation on wires shall be removed only by the use of thermal strippers. When the wire is covered with a glass composition braid, this braid shall be cut with a sharp knife causing a minimum of damage to the plastic insulation. The remaining plastic insulation shall then be removed using thermal strippers.

3.3.2.3 Crimp contact/wire gauge incompatibilities. Where incompatibilities exist between wire size and connector contact of terminal hardware the following procedures are applicable:

a. In all cases where the specified wire gauge is larger than the crimp termination, the wire shall be spliced to a wire of the same gauge as the contact utilizing splicing procedures specified in 3.3.4.

b. In all cases where the specified wire gauge is smaller than that recommended for a particular crimp contact size, terminations shall be accomplished by soldering in accordance with 3.3.3.

3.3.2.4 Pull test. The terminal of the connection to be tested shall be rigidly mounted and a force applied to the conductor in such a manner that the terminal and conductor will remain on a common central axis with the conductor unbent and untwisted. The force shall be gradually increased to the value specified in Table V and maintained at that value for a minimum of 5 seconds. At the conclusion of the test, the connection can meet the requirements of 3.3.2.1.

Table V. Pull Test Values for Connections of Wiring to Crimp Type Connector Contacts

AWG Wire Size (or cross-section circular mil equivalent)	Pull Test Value (pounds)
22	15
20	19
18	38
16	50
14	70
12	110

3.3.3 Soldered terminations. Soldered terminations shall be made as described herein. The essential features of a good solder joint are that each of the joined surfaces is wetted by a film of solder, the films of solder are continuous, and the solder fills the space between the surfaces uniformly. These films form only on a clean or oxide-free surface.

3.3.3.1 Soldering materials and equipment. Unless otherwise specified, the following materials and equipment shall be used for all soldered terminations:

a. Cleaning solvents. Cleaning solvent shall be Genesolv* 2000, methyl alcohol, or technical inhibited -1, 1:1 trichloroethane conforming to Federal Specification O-T-620.

b. Solder. Solder used for electrical and electronic connections shall conform to Federal Specification QQ-S-571, composition SN-63, form W, type R, core condition and size P3. Where use of SN-63 solder

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would delay completion of cable fabrication, solder conforming to QQ-S-571, composition SN-60, form W, type R, core condition, and size P3 may be substituted without prior approval of JPL.

c. Flux. Flux used on resoldered connections which cannot be disassembled and cleaned shall be liquid, nonactive, noncorrosive, nonconductive rosin flux conforming to MIL-F-14256, type W.

d. Soldering equipment. Temperature-controlled soldering irons shall be selected that satisfy the job requirements. Soldering guns or resistive soldering equipment shall not be used without prior JPL approval.

3.3.3.2 Soldering requirements. The following requirements are necessary to ensure a good mechanical and electrical condition:

a. When wires are terminated in connector solder cups, all strands shall be in the cup and the stranded bundle shall be inserted to the full depth of the cup.

b. The solder must fill the entire cup cavity at the rear of the connector contact without evidence of excessive solder.

c. Parts shall be held together during the soldering operation. The connection shall not be disturbed until the solder has completely solidified.

d. The areas to be connected shall be heated to the flow temperature of the solder. The heat shall be controlled during the soldering operation to prevent damage to the assembly.

e. The gap between the wire insulation and the soldered connection shall not exceed the diameter of the conductor; 1/32 inch is the recommended minimum gap for the smaller wire sizes.

f. Each completed solder connection shall have solder flow on all surfaces of contact between the connected parts, and be nonporous, free of voids, breaks, and similar imperfections. The general contour of each part shall be discernible at the completed connection. Heavy beads or fillets shall be cause for rejection.

g. There shall be no flux residues on surfaces of electrical contacts, or where residues interfere with operation or assembly of the component.

h. Swollen, distorted, scorched, or cracked insulating components shall be cause for rejection.

3.3.3.3 Preparation of surfaces. The surfaces of the parts to be joined shall be cleaned prior to the tinning or soldering operation using one of the solvents specified in 3.3.3.1.a.

a. Stripping of insulation. All wire used shall be handled so as to prevent damage to the conductor and its insulation. Wire strands shall remain in their original configuration. Insulation on wires shall be removed only by the use of thermal strippers. When the wire is covered with a glass composition braid, this braid shall be cut with a sharp knife, causing a minimum of damage to the plastic insulation. The remaining plastic insulation shall then be removed using thermal strippers.

b. Individual tinning of parts. All conductors shall be tinned prior to the soldering operation unless the size of the wire, where tinned, would make insertion of the wire into the cups difficult.

3.3.3.4 Connector/wire gauge incompatibilities. Where incompatibilities exist between sizes of wire and connector hardware, one of the

following splicing methods shall be used with wire of the nominal pin gauge ±1 gauge. See 3.1.1.15 for type E (PC board) cable termination compatibility requirements.

a. In-line splice to conform with the workmanship requirements of GMO-50190. (Solder sleeves may be used for in-line splices in accordance with JPL Specification FS505117.) (Refer to 3.3.4.3.)

b. Parallel splice, when used, shall be in accordance with paragraph 3.3.4.4.

3.3.3.5 Reworking soldered connections. Where a satisfactory solder joint is not obtained, the connection shall be disassembled, the parts cleaned, and the entire soldering operation repeated. Connections which cannot be disassembled and cleaned may be reheated with the addition of flux conforming to 3.3.3.1.c.

3.3.4 Splicing. Splicing of conductors shall be performed only when specified on the detailed engineering drawing or in this specification.

3.3.4.1 Splicing materials and equipment. Unless otherwise specified, the following materials and equipment shall be used for all splicing of conductors:

a. Shield termination ferrules. Ferrules shall be tin-plated copper or brass alloy and shall conform to Military Standard MS21980 or MS21981.

b. Sleeving. Heat-shrinkable sleeving shall be in accordance with 3.1.1.3.

c. Heating device. The heating device used for shrinking sleeving shall be capable of delivering an accurately aimed stream of air, heated to temperatures of 200° to 300°C (392° to 572°F).

d. Solder sleeves. Solder sleeves in accordance with 3.1.1.4. Installation shall be in accordance with this specification.

e. Cleaning solvent. Technical inhibited -1, 1:1 trichloroethane conforming to Federal Specification O-T-620.

3.3.4.2 Splicing requirements. The following general requirements are applicable to all splices made in accordance with this specification:

a. Splices shall be positioned as close as possible to the conductor termination. When practicable, splices shall be positioned within the backshell or mold area of the connector.

b. When twisted wires are spliced, the splices shall be separated by not more than 2 inches.

3.3.4.3 In-line splicing. The following requirements, in addition to those described in 3.3.4.2, shall be used for in-line splices. Figure 8 illustrates proper in-line splicing techniques.

a. Use appropriate solder sleeve.

b. Cover with shrink tubing extending approximately 1/4 inch over insulation.

3.3.4.4 Parallel splicing. The following requirements, in addition to those described in 3.3.4.2, shall be used for parallel splicing. Figure 9 illustrates proper parallel splicing techniques.

a. All ferrules shall be cleaned in an ultrasonic cleaning tank prior to JPL in-process inspection using the solvent specified in 3.3.4.1.e. The immersion time shall be 2 (±0.5) minutes. After an initial cleaning, the process is to be repeated with clean solvent.

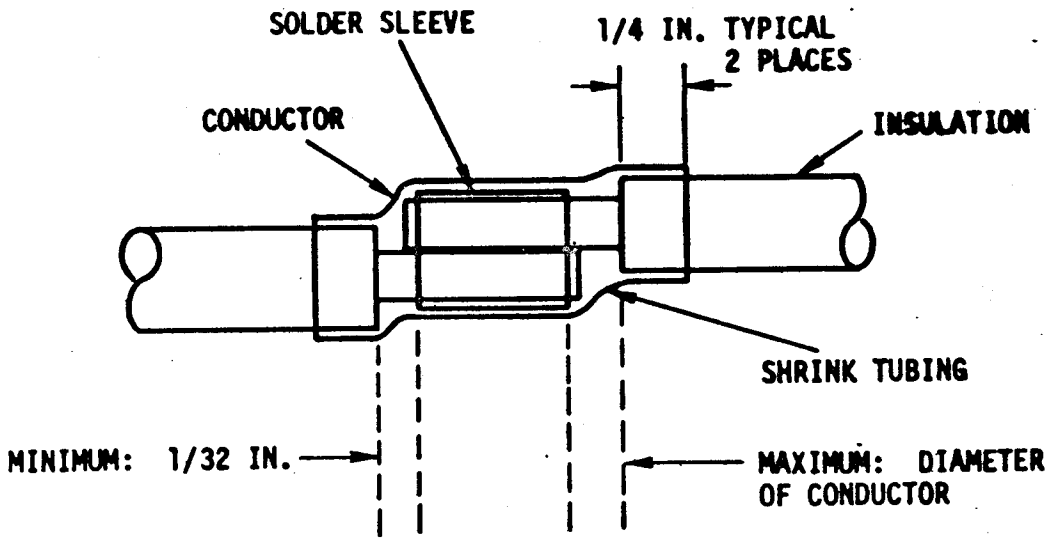

Figure 8. In-Line Splice

b. Surfaces of the parts to be joined shall be prepared in accordance with 3.3.3.3. Sufficient insulation shall be removed to allow the conductors to extend the full length of the ferrule and allow a gap between the insulation on the wires being spliced and the splice of 1/32 inch minimum or the diameter of the conductor.

c. Soldering procedure shall be in accordance with 3.3.3.

d. A complete solder fillet shall be visible at each end of the ferrule without evidence of excessive solder buildup on the outside of the ferrule.

e. Heat shrinkable sleeving shall be applied over each completed splice. Sleeving shall overlap the splice 1/2 inch (+1/16, -0 inch). When splices are positioned within the backshell mold area of a connector, the sleeving shall overlap the splice 3/16 inch (+1/16, -0 inch).

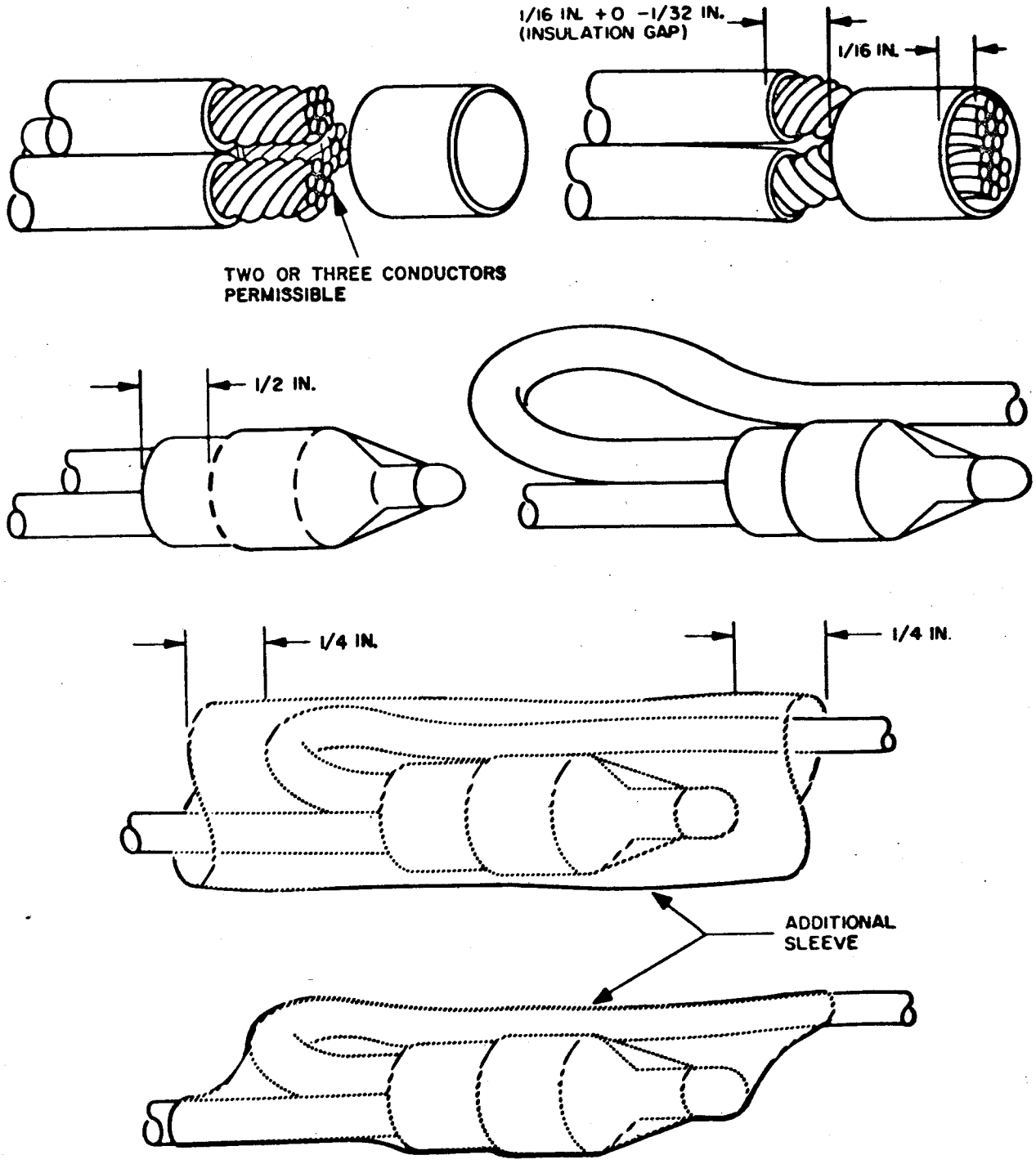

Figure 9. Parallel Splicing Sequence for Cables

f. A second piece of heat shrinkable sleeving shall be applied over each completed splice (see Figure 9). This sleeve shall extend a minimum of 1/4 inch beyond the end of the primary sleeve.

3.3.5 Connector potting. When connector potting (type B cable assemblies) is specified, the following requirements and procedures shall apply. Connector potting provides an environmental seal at the rear of the connector and a rigid support for the connector terminations.

3.3.5.1 Materials Unless otherwise specified, the following materials shall be used in the potting operation. Where more than one material is listed for a specific function, the particular material chosen will be at the contractor's option.

a. Cleaning solvent. Cleaning solvent shall be Genesolv* 2000, methyl alcohol, or technical inhibited -1, 1:1 trichloroethane conforming to Federal Specification O-T-620.

b. Potting/molding compounds and primers. Potting/molding compounds and their primers are listed in Table VI.

3.3.5.2 Connector cleaning. All connectors shall be cleaned in an ultrasonic cleaning tank, prior to JPL in-process inspection, using a solvent in accordance with 3.3.5.1.a. The immersion time shall not exceed 60 seconds nor be less than 30 seconds. The connectors shall be blown dry using filtered, dry, low-pressure air. Connectors shall be kept free of contamination during final assembly. Connector plating shall be slightly roughened using a medium grade of emery cloth before priming.

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Table VI. Potting/Molding Compounds and Primers

Compound or Primer	Description	Supplier	Usage
PR-1592	Polyurethane Compound	Courtaulds Aerospace	Potting/molding compound for class 1 & 2 cables
PR-1592	Polyurethane Compound	Courtaulds Aerospace	Prepotting/molding material
PR-420	Primer	Courtaulds Aerospace	Priming metals prior to application of PR-1552
PR-1523-M	Primer	Courtaulds Aerospace	Priming nylon prior to application of PR-1592
PR-1523-M	Primer	Courtaulds Aerospace	Priming neoprene prior to application of PR-1592
Tetra-Etch	Primer	W. L. Gore & Assoc	Priming PVC prior to application of PR-1592
PR-380-M	Polysulfide Compound	Courtaulds Aerospace	Potting Compound for class 3 cables
Tetra-Etch	Etchant	W. L. Gore & Assoc.	Etchant for Teflon prior to application of PR-420

Note: PR-1590 is an acceptable substitute for PR-1592.

3.3.5.3 Potting procedure for class 1 and class 2 cable assemblies. Potting procedures shall be in accordance with the potting compound manufacturer's recommended procedure as modified by the additional requirements and exceptions listed below:

a. Prior to the potting operation, the connections shall have been cleaned in accordance with 3.3.5.2 and received an in-process inspection in accordance with 4.3.2.

b. Connectors shall be prepotted to the level of conductor insulation using the compound recommended in Table VI. To prevent splaying of contacts it is recommended that a mating connector be installed prior to this operation. Prepotting compound shall be allowed to cure prior to application of final potting compound.

c. Apply potting compound recommended in Table VI by pouring or injection. It is recommended that the connectors be subjected to mild vibration during this process to settle the compound in the potting boot or backshell, to eliminate air bubbles, and to ensure even distribution of the potting compound.

CAUTION

Where coaxial cable elements are required in a class 1 or class 2 cable assembly, accelerated curing temperatures for potted connectors, if used, shall be chosen which will not destroy the basic physical and electrical properties of the coaxial cable.

d. The completed assembly shall not contain any surface cracks, voids, chips, bubbles, punctures, or holes which would prevent the potting compound from accomplishing the purpose for which it is intended.

3.3.5.4 Potting procedures for class 3 cable assemblies. The potting procedure shall be in accordance with the potting compound manufacturer's recommended procedure as modified by the additional requirements and exceptions listed below:

a. Prior to the potting operation, the connectors shall have been assembled in accordance with 3.2.3.2 through 3.2.3.2.2.

b. After receiving an in-process inspection as described in 4.3.2, the connector shall be assembled and the backnut tightened until the gasket is sheared.

c. Loosen the backnut and pull back from the connector.

d. Utilizing one of the solvents specified in 3.3.5.1.a, remove any deposits of grease, oil, wax, or other foreign material from the metal portions of the connector.

CAUTION

Do not allow solvents to come in contact with the jacket of neoprene jacketed cables.

e. Clean cable jackets by abrasion prior to application of potting compound. Remove resulting dust particles using a clean, dry brush. To obtain good adhesion to TFE or FEP fluorocarbon, the surface must be etched or treated to obtain a bondable surface.

f. Prepare potting compound in accordance with the potting compound manufacturer's instructions.

g. Apply sufficient potting compound to the rear of the connector to ensure that the fillet of potting compound shown in Figure 10 will exist when the backnut is reinstalled.

Note: To obtain good adhesion to polyvinyl jacketing, the surface should be made tacky with methyl ethyl ketone immediately prior to the application of the potting compound.

h. Reinstall connector backnut and tighten to the torque specified in Table IV.

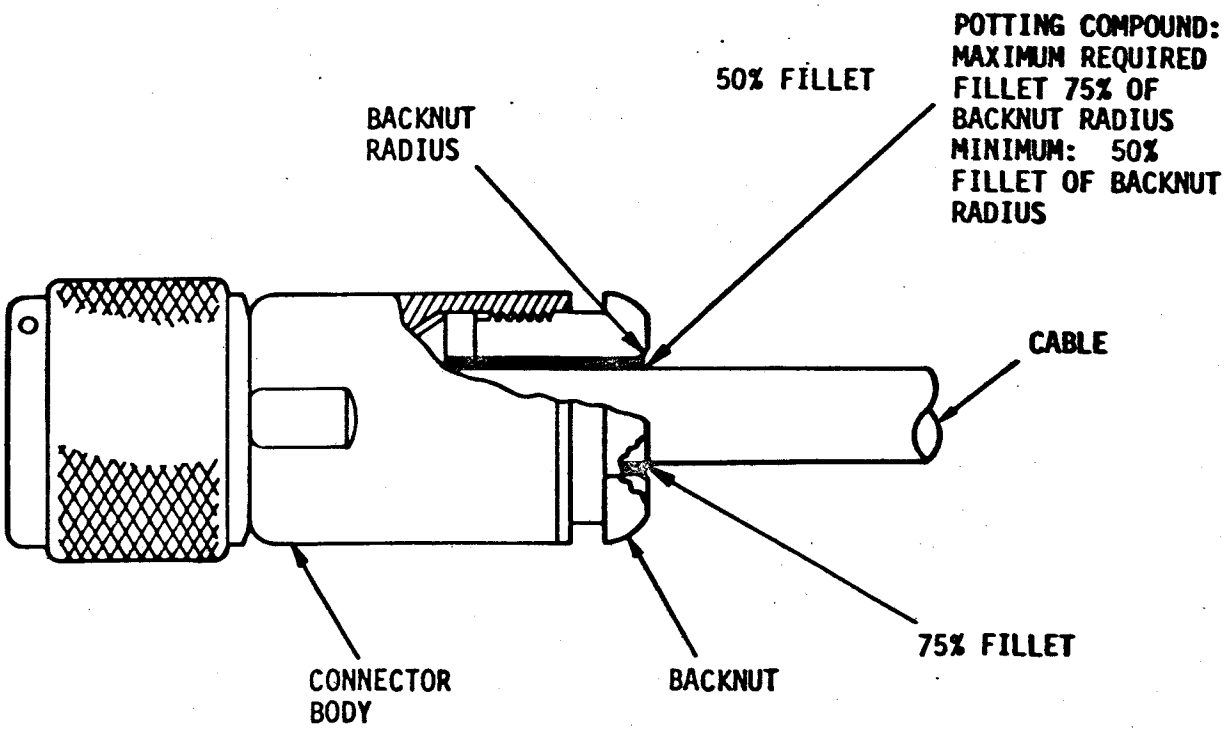


Figure 10. Connector Potting Compound Fillet, Dimensional Requirements

i. Allow potting compound to cure for 48 hours.

CAUTION

Any flexing of the potted area during the cure period may cause separation of the potting material from the cable jacket.

j. After application, a strong fillet of compound shall exist between the connector backnut and the cable jacket, extending onto the backnut radius a minimum

of 50% to a maximum of 75% of the total shoulder surface and an equal amount onto the cable jacket around 360 degrees of the junction formed by the connector and the cable. The compound shall not have any voids or bubbles visible to the unaided eye and shall have a maximum surface adhesion to both elements without separation under normal flexure. (Normal flexure is defined as a bend radius not less than 10 times the outside diameter of the finished cable.)

3.3.6 Connector molding. When connector molding is specified (type C cable assemblies), the following requirements and procedures shall apply. Connector molding provides a nonrepairable, environmentally sealed cable assembly of maximum reliability.

3.3.6.1 Materials. The following materials are required in addition to the connector potting materials listed in Table VI for preparation of molded cable assemblies:

a. Primer. Primer conforming to MIL-S-22473, grade T, form R shall be used on surfaces prior to application of sealing compound specified below.

b. Sealing compound. Sealing compound conforming to MIL-S-22473, grade AA shall be used to prevent rotation of threaded connector components after assembly.

3.3.6.2 Connector cleaning. Connectors shall be cleaned in accordance with 3.3.5.2.

3.3.6.3 Mold configuration. The mold configuration shall provide adequate encapsulation of the termination area without introducing any

excessively large mass into the assembly. Mold configuration shall not exceed the following limits:

a. Mold length - The length of the mold shall not exceed 2-1/2 times the diameter of the cable, with jacket, as measured adjacent to the area to be molded, or 5 inches from face of connector, whichever is less.

b. Mold diameter

1) Cable plug - The thickness of mold around the back of the connector, A follower, or adapter shall be a minimum of 1/8 inch and a maximum of 1/4 inch. Mold diameter shall not be greater than the coupling ring diameter.

2) Cable receptacles and bulkhead connectors - The mold diameter shall not exceed the diameter of the connector barrel.

c. Breakouts - The diameter of the largest cable segment may be used to determine the mold length as in (a.).

3.3.6.4 Molding procedure. Molding procedures shall be in accordance with the manufacturer's recommended procedure, as modified by the additional requirements and exceptions listed below:

a. Prior to the molding operation, the connectors shall have been cleaned (refer to 3.3.5.2) and shall have received an in-process inspection in accordance with 4.3.2.

b. Cable jackets shall be cleaned by abrasion or by use of a solvent compatible with the cable jacket material. Use of solvents other than those specified in 3.3.5.1.a shall require prior approval of cognizant JPL engineering personnel.

c. Connectors shall be prepotted to the level of conductor insulation prior to positioning in the mold cavity. The prepotting compound shall be selected from Table VI.

d. All surfaces of connector and jacket material which will receive molding compound shall be primed using material conforming to 3.3.6.1.a.

e. The connector breakout shall be positioned in the mold cavity and molded using compound conforming to Table VI.

f. The molding compound, when cured, shall be of uniform hardness and shall be free of bubbles, voids, and foreign matter. The molding compound shall be confined to the mold area. Wicking of the molding compound shall not be allowed beyond the mold area.

3.3.6.5 Pygmy connector modification. When the cable diameter or shield termination and/or splice bundle exceeds the connector opening, the connector may be modified as shown in Figure 11.

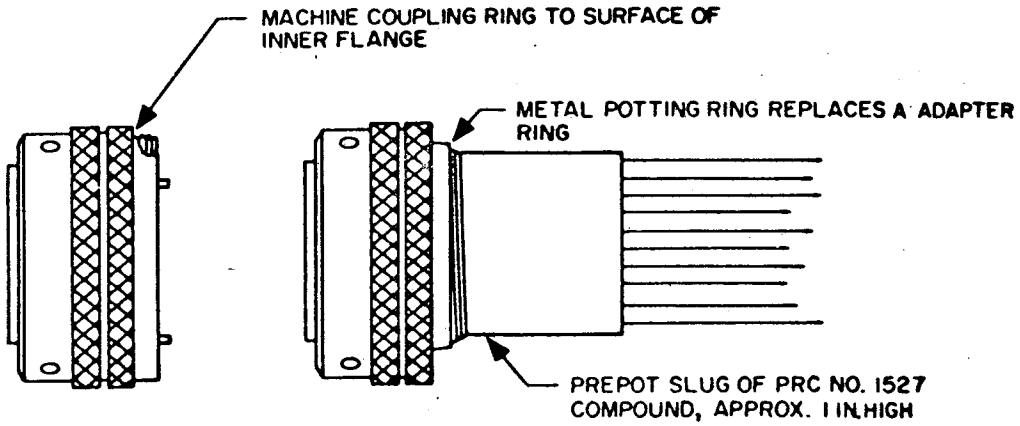


Figure 11. Pygmy Connector Modification

3.3.7 Cable Identification

Cable identification shall be accomplished by means of labels. Except as noted on the detailed engineering drawings, the requirements listed below are applicable to all labels.

3.3.7.1 Label Information, Positioning, and Number

The required number of labels, their positions, and the label information is a function of the length of the completed cable as described above.

Note A: The cable serial number (S/N) shall consist of a cable manufacturer's identity (10 alpha numeric characters maximum), and a six-digit date code (mm-yyyy) indicating the month and year of manufacture. The label serial number information shall be generated by the cable manufacturer. The label shall be provided by the cable manufacturer and shall be affixed to the cable prior to delivery to JPL.

3.3.7.1.1 Cables Less Than 24 inches Long

Cables less than 24 inches long shall have one label centered showing part number, serial number, and connector reference designators (abbreviated) as shown in Figure 12. The cable number shall be marked if required by the detailed engineering drawing. Cables that are too short for the one label, shall be tagged with the required information.

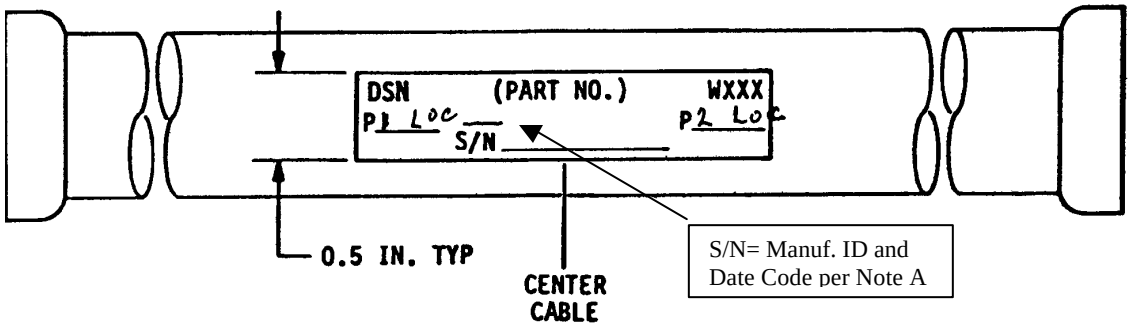


Figure-12 Labeling, Cables Less Than 24 Inches Long

3.3.7.1.2 Cables Between 24 inches and 72 inches Long

(Paragraph deleted)

Figure-13 Cables 24 to 72 Inches Long (Figure deleted)

3.3.7.1.3 Cables Longer Than 24 Inches

Cables longer than 24 inches **shall** have four labels, depending on detailed drawing requirements. One label showing part number, serial number (Per Note A above), and connector reference designator (abbreviated) **shall** be affixed at each end of the cable, approximately 1 inch from the connector or mold line, as shown in Fig. 14. If required by the detailed engineering drawing, labels showing cable reference designator and location code information (refer to Fig. 14) **shall** be affixed approximately 1 inch from each part number label.

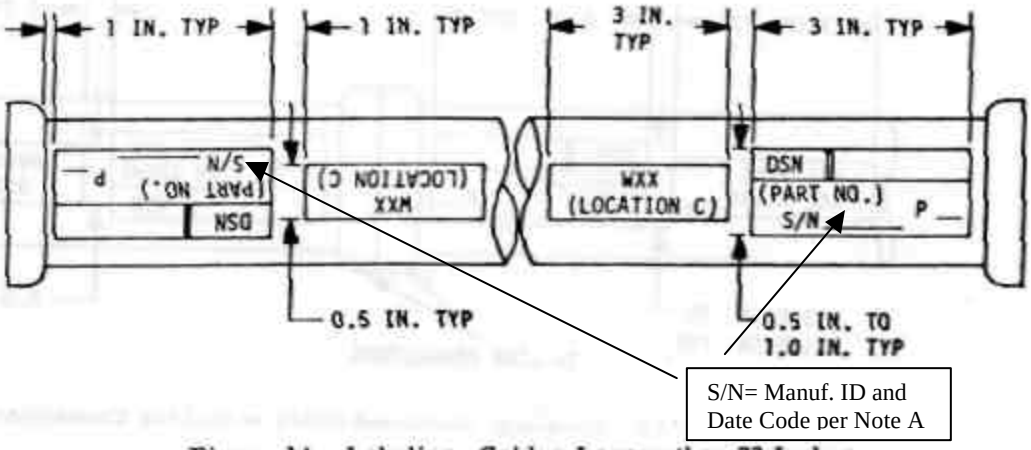


Figure 14. Labeling, Cables Longer than 72 Inches

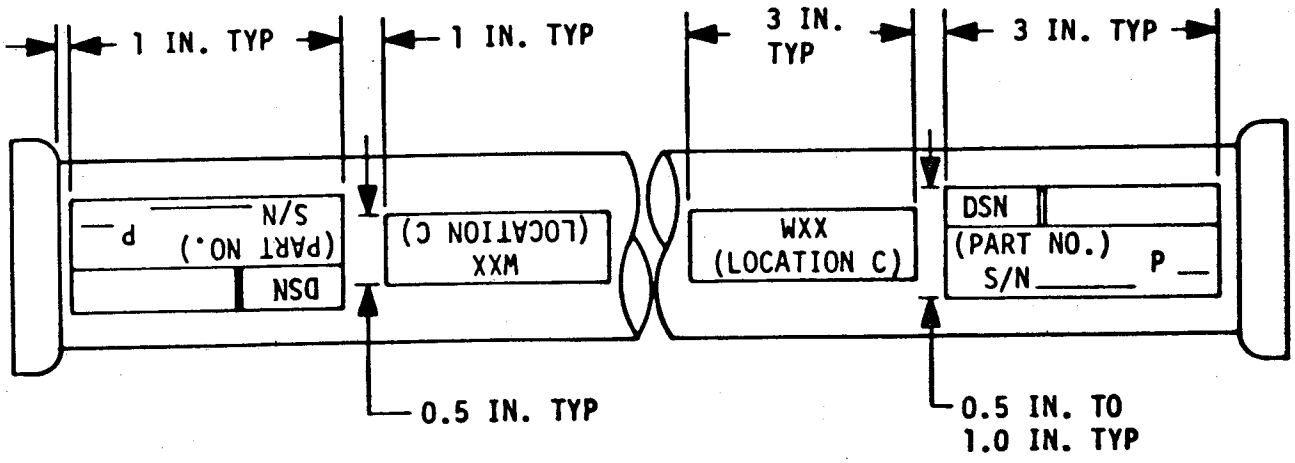


Figure 14. Labeling, Cables Longer than 72 Inches

3.3.7.1.4 Labeling of sectioned cables. Sectioned cables shall receive the same labeling as in 3.3.7.1.3 except that at the in-line connector, the location label shall show that the cable connects to another cable (refer to 3.3.7.2). Sectioned cables between two subsystems shall have a subsystem designator for each subsystem. Sectioned cables within a single subsystem shall have only one subsystem designator. Figure 15 illustrates proper labeling procedure for in-line cables.

3.3.7.1.5 Labeling of type E cables (PC board). Figure 16 illustrates the label that is to be applied to type E cable assemblies (PC board). This label shall be applied to the outside of the PC board handle. The other end of the cable shall be identified in accordance with 3.3.7.3 if it is not terminated with a PC board. See 3.3.7.2 and Figure 17 for explanation of code C.

3.3.7.2 Location codes. Location codes are used to locate and define the connector to which the cable connects. Location information shall consist of station number, subsystem reference designator, subsystem name, subsystem number, module level, cable number, and connector number. The appropriate way in which to utilize this information is shown in Figure 17.

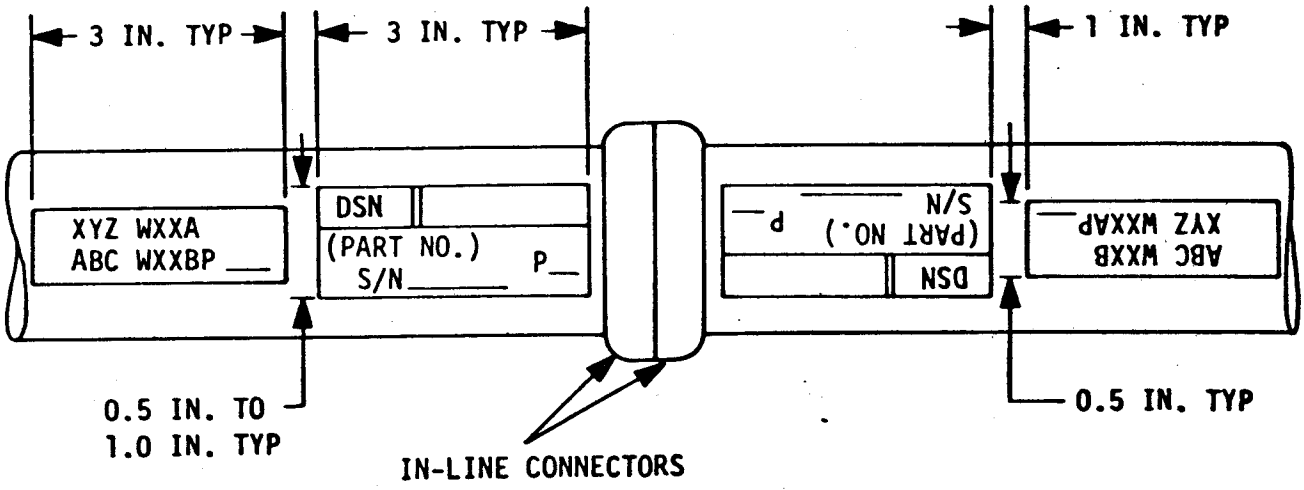


Figure 15. Labeling, Sectioned Cable at In-Line Connectors

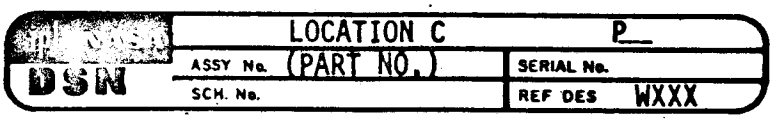
3.3.7.3 Character size. Character size shall be large enough to permit legible marking of the required information. In no case shall the character height be less than 0.09 inch.

3.3.7.4 Color. Label marking shall be black unless material being marked is black. Label marking for black material shall be yellow.

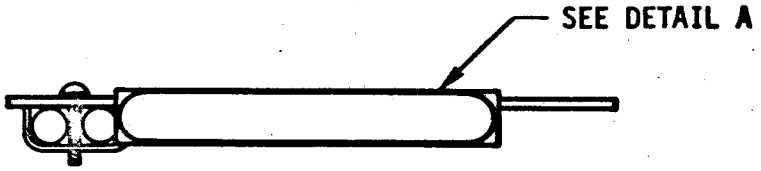
3.3.7.5 Legibility. All label markings shall be clearly legible. Markings shall be placed so they read toward the connector.

3.3.7.6 Label types. Labels shall be of seven types as listed below. The specific types shall be determined by the detailed engineering drawing.

Type I	Chemical bond film
Type II	Hot-stamped, heat-shrinkable sleeving
Type III	Nylon tie wraps
Type IV	Heat-shrinkable sleeving over glass tape
Type V	Hot-stamp
Type VI	Pressure sensitive film
Type VII	Pressure sensitive aluminized polyester



DETAIL A



VIEW A-A

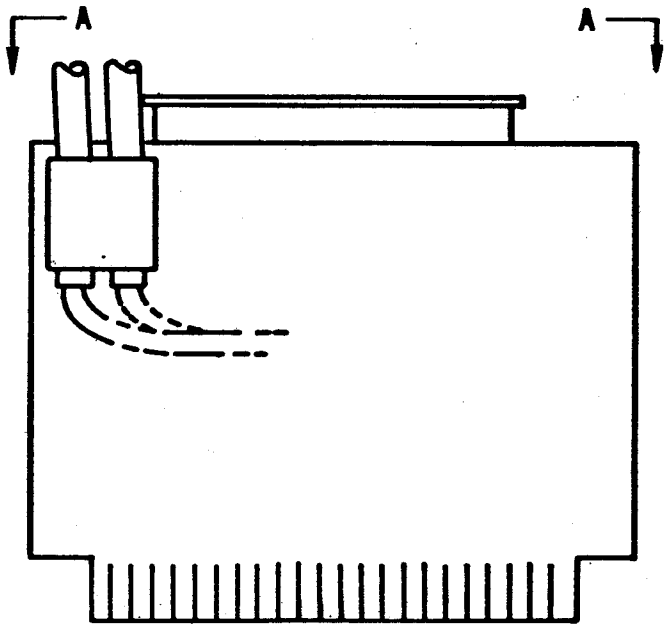


Figure 16. Type E Cable (PC Board) Label

3.3.7.7 Type I labels (chemical bond film).

3.3.7.7.1 Application. Unless otherwise specified by the detailed engineering drawing, type I labels shall be used on class 1 and class 3 cables with overall diameters of 0.37 inch or greater. Type I labels shall not be

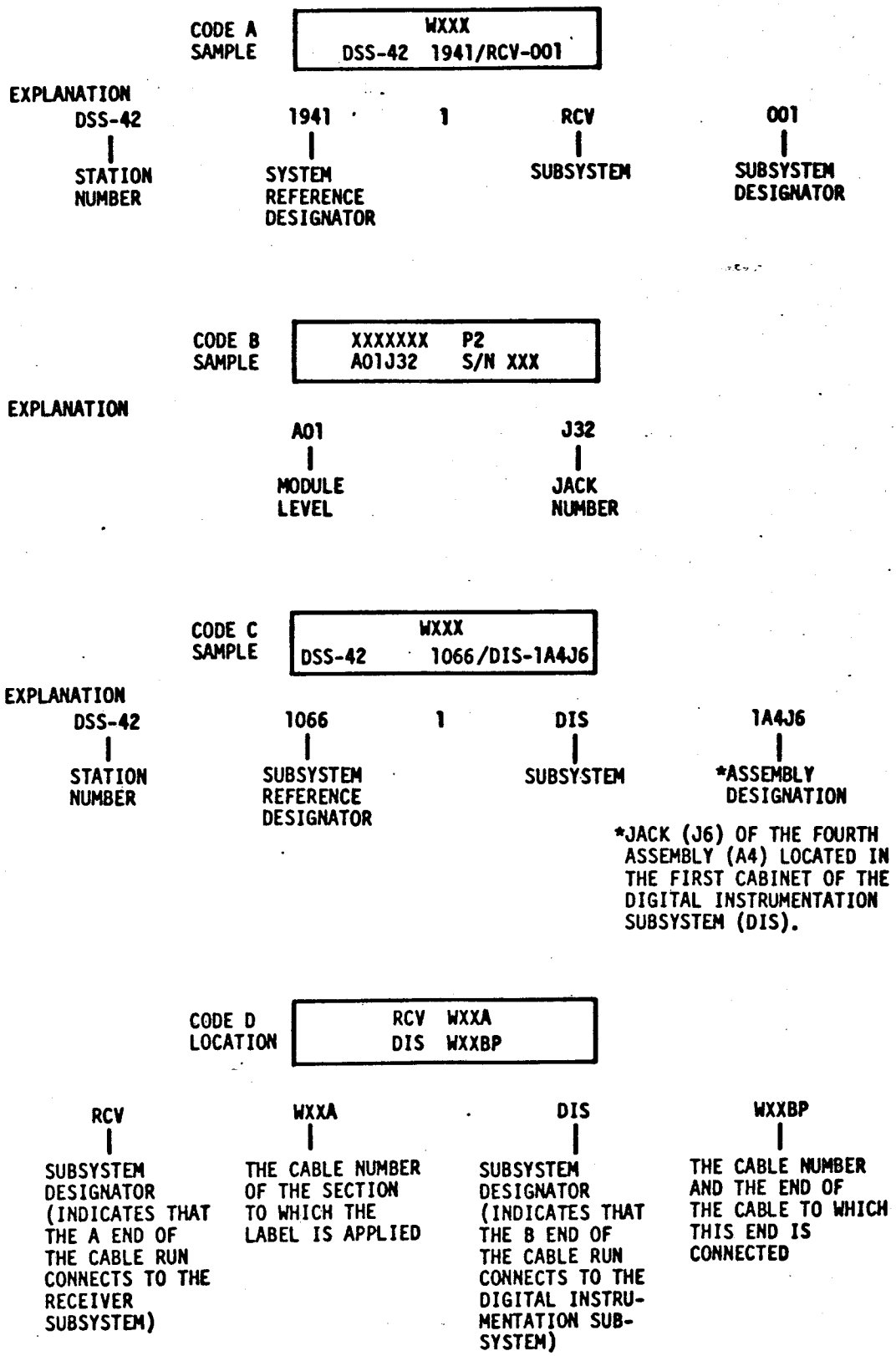


Figure 17. Samples and Explanations of Location Codes

used on cables which have jacket materials other than neoprene, polyurethane, acrylic, chlorobutyl, or polyvinyl chloride.

Note: Type VI label may be substituted for type 1 label with prior approval of JPL.

3.3.7.7.2 Materials and equipment. The following materials and equipment shall be used to apply type I labels:

a. Labels. Labels shall be type TPL-100/500-C manufactured by Cable Markers Co., 1128 East Elm, Fullerton, California 92631.

b. Base coating/finish coating. Protective base coating shall be type 373-mod manufactured by Cable Markers Co.

c. Protective letter seal. Protective finish coating shall be type 1102C manufactured by Cable Markers Co.

d. Cleaning solvent. Cleaning solvent shall be isopropyl alcohol conforming to Federal Specification TT-I-735.

e. Marking pens. The following marking pens are suitable for marking of type I labels:

1) "Ferber Neetline" (photocopy black) - fine or medium point; Ferber Pen Co.

2) "Blaze-Fine Repro" (black reproduction) - fine or medium point; Catalog No. 20, Blaze Pen Co.

3) "Linde Pen" (legal copy) - fine or medium point, black; Catalog No. 474-M, Linde Pen Co.

3.3.7.7.3 Application procedure. Labels shall be applied in accordance with manufacturer's instructions.

CAUTION

In the application of type I labels, the installer must be careful to prevent contamination of the cleaning solvent, base coating material, and finish coating material.

Note: Once the label has been properly contacted to cable, it will be impossible to remove the label without destroying it. When a label is damaged or spoiled in application, it shall be promptly removed and the cable section thoroughly cleaned. The complete application process shall then be repeated.

3.3.7.8 Type II labels (hot-stamped, heat-shrinkable sleeving).

3.3.7.8.1 Application. Unless otherwise specified on the detailed engineering drawing, type II labels shall be used on class 1 and class 3 cables with overall diameters of less than 0.37 inch, or when the outer jacket material is other than neoprene, polyurethane, acrylic, chlorobutyl, or polyvinyl chloride. Unless otherwise specified on the detailed engineering drawing, type II labels may be used, at the contractor's option, on class 2 cables.

Note: Type IV labels may be substituted for type II labels on class 1 and class 3 cable assemblies without prior approval of JPL.

3.3.7.8.2 Materials and equipment. The following materials and equipment shall be used to apply type II labels:

a. Sleeving. Heat-shrinkable sleeving shall be in accordance with MIL-I-23053/5, class 1, color black (flexible, black, irradiated polyolefin).

b. Lettering device. A hot impression stamp shall be used to mark the sleeving.

c. Heating device. The heating device used for shrinking sleeving shall be capable of delivering an accurately aimed stream of air heated to temperatures of 200° to 300°C (392° to 572°F).

3.3.7.8.3 Application procedure.

a. Select heat-shrinkable sleeving which, after shrinking, will remain firmly in place on the cable.

b. Mark the information required by the detailed engineering drawing on the sleeving using yellow foil and the hot-stamp lettering device. The marking shall be of a size such that after shrinking, the character height will not be less than 0.09 inch and the area occupied by the marking will not exceed 1/2 inch by 3 inches.

c. Install label (do not shrink) on cable before terminating the connector.

d. After the connector is terminated, position label in accordance with Figure 12, 13, 14, or 15 and shrink using heating device specified in 3.3.7.8.2.c.

CAUTION

Coaxial cables can be damaged by an excessive application of heat. To avoid this possibility, do not direct the air stream to the sleeving until it has reached the heated temperature, and remove as soon as the sleeving has shrunk.

3.3.7.9 Type III labels (nylon tie wraps).

3.3.7.9.1 Application. Type III labels shall be used when specified on the detailed engineering drawing and, subject to prior approval by cognizant JPL engineering, may be used on class 2 cable assemblies to replace type II or type IV labels.

3.3.7.9.2 Materials and equipment. The following materials and equipment shall be used to apply type III labels.

a. Nylon tie wraps. The type of tie wrap selected shall be at the option of the contractor. Sufficient space must exist to meet the requirements for character height and legibility specified herein.
b. Lettering device. A hot impression stamp shall be used to mark the tie wraps.

3.3.7.9.3 Application procedure.

a. Mark the information required by the detailed engineering drawing on the tie wrap using black foil and the hot-stamp lettering device.
b. Attach label to completed cable assembly in accordance with Figure 12, 13, 14, or 15.

3.3.7.10 Type IV labels (heat-shrinkable sleeving over glass tape).

3.3.7.10.1 Application. When specificed on the detailed engineering drawing, type IV labels shall be used on class 1 and class 3 cables with overall diameters of less than 0.37 inch, or when the outer jacket material is other than neoprene, polyurethane, acrylic, chlorobutyl, or polyvinyl chloride.

Note: Type II labels may be substituted for type IV labels on class 1 and class 3 cable assemblies without prior approval of JPL.

3.3.7.10.2 Materials and equipment. The following materials and equipment shall be used to apply type IV labels.

a. Glass tape. Pressure-sensitive glass tape shall conform to MIL-I-19166, 1/2 inch in width.

b. Sleeving. Heat-shrinkable sleeving shall be in accordance with MIL-I-23053/5, class 2 (flexible, transparent, irradiated polyolefin).

c. Heating device. The heating device used for shrinking sleeving shall be capable of delivering an accurately aimed stream of air heated to temperatures of 200° to 300°C (392° to 572°F).

3.3.7.10.3 Application procedure.

a. Select heat-shrinkable sleeving which, after shrinking, will remain firmly in place on the cable.

b. Place sleeving (do not shrink) on cable before terminating the connector.

c. Mark or type the information required by the detailed engineering drawing on the glass tape. The length of the completed label shall not exceed 3 inches.

d. After the connector is terminated, affix the marked glass tape to the cable, and position it in accordance with Figure 12, 13, 14, or 15. Position heat-shrinkable sleeving over label and shrink using heating device specified in 3.3.7.10.2.c.

CAUTION

Coaxial cables can be damaged by an excessive application of heat. To avoid this possibility, do not direct the air stream to the sleeving until it has reached the heated temperature, and remove as soon as the sleeving has shrunk.

3.3.7.11 Type V labels (hot-stamp).

3.3.7.11.1 Application. Type V labels shall be used when specified by the detailed engineering drawing. Type V labels shall be applied directly to the conductor or cable jacket using a hot impression stamp marking device. For small diameter wires, vertical reading type faces may be employed to improve legibility. Marking shall be in accordance with MIL-W-5088/8160.

3.3.7.12 Type VI labels (pressure-sensitive film).

3.3.7.12.1 Application. Type VI labels are intended for JPL use only to replace damaged labels, to reidentify an existing cable without extensive rework, for temporary cables, or other such applications. Unless specified by the detailed engineering drawing, type VI labels may be used on all cable assemblies ~~with an overall diameter of 0.37 inch or greater~~ with prior JPL approval. Deleted per Amendment #2 6 April 76

3.3.7.12.2 Materials. The following materials shall be used to apply type VI labels.

All print between brackets deleted per Amendment #2 6 April 76.

a. Labels. Labels [used for part number information (refer to 3.3.7.1) on cables with overall diameters of 0.37 inch or larger shall conform to JPL Drawing 9450483. Labels used for part number information on cables with overall diameters of less than 0.37 inch and labels used for reference designation and location code information (refer to 3.3.7.1)] shall conform to JPL Drawing 9450484.

b. Tape. Transparent vinyl tape shall be type 3669, 3-1/2 inches wide, manufactured by Reflective Products Division, Minnesota Mining & Manufacturing Co., St. Paul, Minnesota.

c. Cleaning solvent. Cleaning solvent shall be isopropyl alcohol conforming to Federal Specification TT-I-735.

3.3.7.12.3 Application procedure.

a. The cable shall be free of all foreign materials. Using the cleaning solvent specified in 3.3.7.12.2.c on any lintfree applicator, rub vigorously until all, or almost all, of the surface dirt and migratory "bloom" is removed from a 4-inch-wide band extending 360 degrees around the cable.

b. Type the information required by the detailed engineering drawing on the label.

c. On class 1 and 2 cable assemblies, a layer of vinyl tape conforming to 3.3.7.12.2.b shall be wrapped one complete turn around the cable and overlapped a minimum of 1/2 inch before the label is affixed.

d. Wrap one complete turn of the vinyl tape specified in 3.3.7.12.2.b around the cable over the label. The vinyl tape shall extend approximately 1/4 inch past each end of the label and overlap itself a minimum of 1/2 inch.

Note: Adhesion of the type VI label to the cable can be speeded by application of heated air to the completed label, being careful not to damage the label or cable.

3.3.7.13 Type VII labels (pressure-sensitive aluminized polyester).

3.3.7.13.1 Application. Type VII labels shall be used on the outside handles of PC boards when specified by the detailed engineering drawing (see Figure 16).

3.3.7.13.2 Materials

a. Labels. Labels shall be chrome polyester film pre-coated with pressure-sensitive adhesive. Part No. 530 as manufactured by Minnesota Mining and Manufacturing Co., St. Paul, Minnesota (see JPL Drawing 9454446).

b. Ink. Black stencil paste, Delux 23-793, manufactured by E. I. Dupont de Nemours and Co., Inc., Wilmington, Delaware.

c. Finish coat. Flat clear matte varnish, Part No. 32-18-KK, manufactured by Wornow Process Paint Co., Los Angeles, California.

3.3.7.13.3 Application procedure.

a. Mark the information required by the detailed engineering drawing on the label using a typewriter or rubber stamp. The character size shall not be less than 0.09-inch high.

b. After the marking has dried, peel the label from the backing and apply to PC board.

c. Apply a generous coating of clear varnish to the label and let it dry.

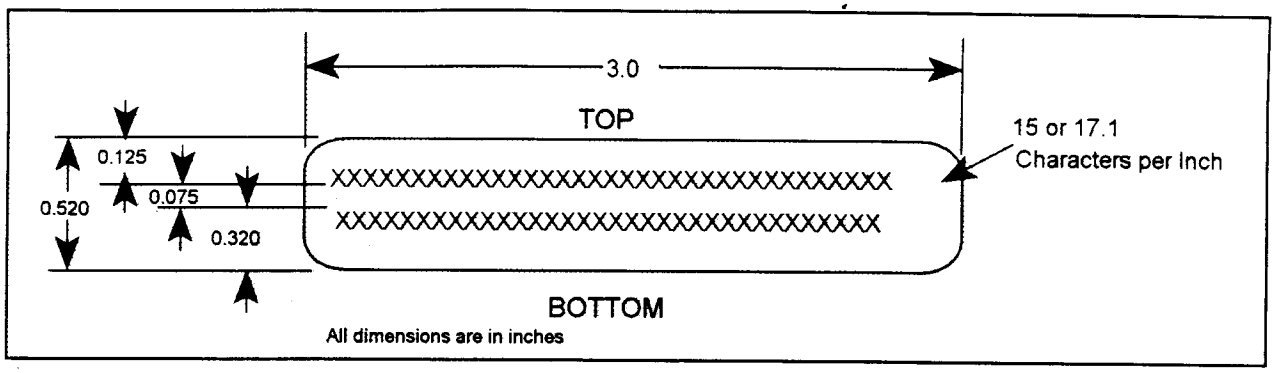
3.3.7.14 TYPE VIII Pressure Sensitive: Fiber Optic

3.3.7.14.1 Application. Type VIII labels shall be used on multimode and single mode fiber optic cable less than 4.953mm, (0.195") diameter.

3.3.7.14.2 Materials. The following materials shall be used to apply type VIII labels.

a. Labels. Labels used for part number information, serial number, reference designation and location code information shall conform to JPL drawing 9450484. Information on the label is to be per figure 3.3.7.14.2a.1

Figure 3.3.7.14.2a.1



b. Tape. Transparent vinyl tape shall be 88.92mm, (3-1/2"), +/-0 in width and the tape shall be indicated on the detail engineering drawing. Should the type not be indicated on the drawing or the supplier prefers to use a type other than indicated, this type shall require JPL approval.

c. Protective Coating. Krylon No. 1303 Crystal Clear Acrylic Coating or JPL Engineering equivalent.

d. Cleaning Solvent. Cleaning solvent shall be ethyl alcohol conforming to Federal Specification TT-I-735.

3.3.7.14.3 Application Procedure.

a. The cable shall be free of all foreign materials. Using the previously specified cleaning solvent on any lint free applicator, rub vigorously until all, or as much as possible, of the surface dirt and migratory, "bloom", is removed from a 101. 16mm, (4"),-wide band extending 360 degrees around the cable.

b. Type the information required by detail engineering drawing on the label.

c. Affix the label to the cable and position it as per the desired application.

d. Weather Exposed Environment. When cables are to be used outside, affix the label starting with the bottom edge of label first and wrap the label on the cable. Wrap one complete turn of the specified vinyl tape around the cable, over/on top of, the label. The vinyl tape shall extend approximately 6.35mm, (1/4"), past each end of the label and overlap

itself a minimum of 12.70mm, (1/2").

e. Enclosed Environment. When cables are to be used inside or in an enclosure, spray a protective coating on the label as described in 3.3.7.14.2c Affix the label starting with the bottom edge and wrap on cable.

4. QUALITY ASSURANCE PROVISIONS

4.1 General. The materials and processes covered by this specification shall be subject to inspection and electrical testing provisions contained herein. The finished product shall be subjected to JPL final inspection and acceptance. However, the contractor shall not rely on JPL source inspection to release him of his contractual obligation to control the quality and testing of his product, nor shall any statement made herein detract from or abrogate the terms and conditions of the procurement document.

4.1.1 Contractor's quality control program. The contractor's quality control program shall be in accordance with the requirements of JPL Specification ES504049.

4.2 Quality control. The contractor shall assure, to the satisfaction of JPL, that he has available comprehensive quality control procedures and equipment. Equipment, including all gauging, measuring, and test equipment, must be maintained for accuracy and calibration. The contractor shall perform scheduled calibrations of his inspection equipment, and records of each calibration shall be maintained that have traceability to the National Bureau of Standards. These records shall be available to JPL inspection. The contractor shall be responsible for performing all necessary quality control inspections on incoming materials, components and products, both contractor purchased and JPL furnished, to assure compliance with all requirements specified herein. The contractor shall make available to JPL sufficient test data and reports to verify that the completed product meets all requirements of this specification.

4.3 JPL inspection.

4.3.1 Sample inspection. The contractor will provide, upon request, samples of fabrication techniques previously defined in this specification and not evident in his own in-house fabrication, for inspection by JPL. All fabrication techniques questioned must be approved by JPL prior to usage.

4.3.2 In-process inspection. JPL will provide in-process inspections at the contractor's facility to adequately monitor the quality control effort. Monitoring of cable fabrication performed under the requirements of this specification shall be performed by JPL quality assurance personnel, during the period of manufacture, as deemed necessary or advisable by JPL.

4.3.3 Preliminary inspection. Unless otherwise specified by the procurement document, a preliminary inspection shall be made by JPL at the contractor's facility after completion of fabrication and testing prior to packaging and shipment, as noted below. Each item shall be visually inspected and be subject to electrical inspection. Packaging procedures shall be monitored by JPL quality assurance to assure compliance with Section 5.

4.3.4 Final acceptance inspection. Unless otherwise specified by the procurement document, final acceptance shall be made after completion of receiving inspection by the JPL quality assurance personnel and in conjunction with the JPL cognizant engineer.

4.4 Testing. All cable assemblies shall be tested as specified below prior to shipment to JPL. Tests shall be subject to JPL surveillance.

4.4.1 Continuity. Each conductor of the assembly shall be tested for proper continuity using JPL supplied drawings as a guide. This test shall be performed prior to closing of the connector (potting, molding) and again during preliminary inspection.

4.4.2 Insulation resistance (noncoaxial). The assembly shall be given an insulation resistance test. The test shall show a minimum resistance of 100 megohms at 500 ±25 V dc between each conductor, to every other conductor, shield, or connector shell where continuity should not exist. This test shall be performed prior to closing of the connector (potting, molding) and again during preliminary inspection.

4.4.3 High potential (coaxial elements, all classes). Coaxial elements shall be hi-pot tested at a voltage level up to, but not exceeding, the manufacturer's maximum voltage rating of either the cable or the connector, whichever is less.

4.4.4 Checking of off-clocked circular connectors (Positions W, X, Y, Z).

a. All off-clocked connectors shall be checked by using a JPL approved insert rotation gauge.
b. The vertical centerline of any insert arrangement and the main shell polarizing keyway shall be within ±0.005 inch of the manufacturer's indicated rotation.
c. In areas of conflict between JPL and the connector manufacturer's requirements, the conflict shall be referred to cognizant JPL personnel for resolution.

4.4.5 Checking of cables with connectors off-clocked.

a. All cables with connectors off-clocked shall be checked by using a JPL approved insert rotation gauge.
b. The vertical centerline of the insert with the main shell polarizing keyway shall be within ±1 degree to the vertical center line of the cable.

4.4.6 Additional test requirements. Additional tests, when required, shall be performed as specified by the engineering drawing or procurement document. All coaxial type cables shall be capable of passing Time Domain Reflectometer (TDR) test.

4.5 Test equipment. All test equipment shall be of sufficient accuracy and quality to permit performance of the required testing (refer to 4.2). All measurements and tests shall be made at ambient temperature, atmospheric pressure, and humidity.

4.6 Rejection and resubmittal. Assemblies that fail to meet requirements of this specification and all related documents shall be rejected and returned to the contractor. Prior to resubmittal, the contractor shall furnish the JPL quality assurance representative full written particulars regarding the cause of failure and the corrective action taken on the deficiencies. Each rejected assembly shall be identified by a JPL inspection report. This document will be cleared by JPL inspection only when the requirements of this specification have been complied with.

5. PREPARATION FOR DELIVERY

5.1 Cleaning cables prior to shipment. Cable assemblies shall be cleaned of all contaminants prior to shipment using a solvent compatible with the cable jacket and labels. Solvents other than those specified in 3.3.3.1 or 3.2.1.2 shall not be used without prior approval of cognizant JPL engineering personnel.

5.2 Packaging and packing. All materials and supplies furnished by the contractor shall be packaged, packed, boxed, or placed on reels by the contractor in such a manner as to insure safe delivery to the designated JPL acceptance point.

5.2.1 Cable lengths, 100 feet or less. Cable assembly lengths of 100 feet or less; or less than 50 pounds, may be coiled and secured with soft twine, or secured on a reel.

5.2.2 Cable lengths, 100 feet or more. Cable assembly lengths of more than 100 feet or more than 50 pounds shall be placed on a reel in the following manner. Reel size shall be such that the particular cable's minimum bend radius of 10 times the diameter will not be exceeded and the connectors are protected by the rim of the wheel.

a. Loop the cable and place the cable ends adjacent.
b. Roll the looped cable on the reel commencing with the looped end of the doubled cable. Make certain that the looped cable is placed horizontally on the reel hub.
c. Fasten the cable ends securely below and inside the rim of the reel.

5.3 Protection of connectors. Connectors shall be individually covered, packed, or packaged in such a manner as to insure adequate protection from dust, moisture, and physical damage.

6. NOTES

6.1 Fabrication techniques. Emphasis shall be placed on the use of JPL approved fabrication techniques. Unless specified by the detailed drawing, specification, or the procurement document, fabrication to commercial standards or military specifications is not an assurance of acceptance by JPL.

6.2 Warnings and cautions. Emergency medical treatment and personal hygiene requirements, as stated by the manufacturer of the applicable potting compound, primer, or solvent, shall be adhered to.

6.3 Ordering data. Procurement documents should specify in detail all of the required reference designation information for each specific cable ordered by this specification.

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