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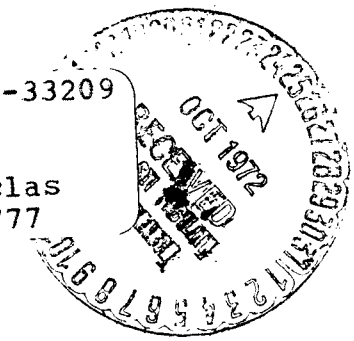
Volume IV of IV

MANUFACTURE AND QUALITY CONTROL OF INTERCONNECTING WIRE HARNESSES

September 1, 1972



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16. ABSTRACT This document has been prepared for use as a standard for manufacture, installation, and quality control of eight types of interconnecting wire harnesses. It is made up of four volumes under one reference number to simplify control and referral on contracts. Each volume can be independently employed should only harnesses within one volume be of interest. The processes, process controls, and inspection and test requirements reflected are based on (a) acknowledgment of harness design requirements defined in MSFC document 40M39582, "Harness, Electrical Design Standard," (b) acknowledgment of harness installation requirements defined in MSFC-SPEC-494, "General Specification for Installation of Harness Assembly (Electrical Wiring), Space Vehicle," (c) identification of the various parts, materials, etc, utilized in harness manufacture, and (d) formulation of a typical manufacturing flow diagram for identification of each manufacturing and quality control process, operation, inspection, and test.

The document covers interconnecting wire harnesses defined in the design standard. Volume I covers type I, enclosed in fluorocarbon elastomer convolute, tubing; type II, enclosed in TFE convolute tubing lined with fiberglass braid; type III, enclosed in TFE convolute tubing; type V, combination of types III and IV: Volume II covers type IV, open bundle (not enclosed): Volume III covers type VI, enclosed in TFE heat shrink tubing; type VII, flexible armored: and Volume IV covers type VIII, flat conductor cable. Volume breadth covers installations of groups of harnesses in a major assembly and the associated post installation inspections and electrical tests. All vol's are TM X-64685.

Knowledge gained through experience on the Saturn V Program coupled with recent advances in techniques, materials, and processes have been incorporated into this document.

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PREFACE

Throughout the Saturn Program, refinements in interconnecting wire hanress designs, manufacturing and installation techniques, and inspection and testing requirements were implemented to achieve optimum reliability in space vehicle and payload electrical systems. The preparation of this document was undertaken to assure such learning as was afforded by the Saturn Program is made available for future programs. This information was further supplemented with inclusion of recent advancements made in harness designs, manufacturing techniques, etc.

Under the direction of Mr. Richard G. Smith, MSFC Saturn Program Manager, the responsibility for providing overall direction was assigned to the Quality and Reliability Assurance Laboratory, MSFC with the task of preparing the document assigned to North American Rockwell Corporation, Space Division. The task was formally defined as three subtasks:

(a) Update of harness design Standard 40M39582,

(b) Update of harness installations design Specification MSFC-SPEC-494, and

(c) Derivation of the manufacturing and quality control processes volumes.

Formation of an AD HOC committee, comprised of representatives of MSFC Science and Engineering Laboratories (Astrionics, Astronautics, Process Engineering, and Quality and Reliability Assurance)for technical guidance, assured unity of input and compatibility between documents.

The task, as defined in Task Authorization 15 (TA 15) dated April 13, 1972 and amended by TA 15 C1, dated January 11, 1972, issued to North American Rockwell Corporation, Space Division, pursuant to NASA contract NAS7-200, was completed with delivery of report SA72-SA-0060 on July 31, 1972. The North American Rockwell Corporation Study Manager was Mr. W. L. Malohn, directly assisted by Messrs. J. Vandergriff, R. H. Parker, and E. J. Stringer.

FOREWORD

This document is one of a series of four volumes prepared for use as a standard for manufacturing and quality control of interconnecting wire harnesses for space vehicle and payload applications.

The procedures reflected herein are based on the following four key elements:

1. Formulation of a typical manufacturing flow diagram for identification of each manufacturing and quality control process, operation, inspection and test point.
2. Identification of the various parts, materials, tools, and components, utilized in harness manufacture.
3. Acknowledgement of design standards as defined in MSFC document 40M39582, "Harness, Electrical Design Standard".
4. Acknowledgement of harness assembly installation standards defined in MSFC-SPEC-494, "General Specification for Installation of Harness Assembly (Electrical Wiring), Space Vehicle".

The complete series of documents covers the following harness types:

Volume I

Type I	Enclosed in fluorocarbon elastomer convolute tubing
Type II	Enclosed in TFE convolute tubing lined with fiberglass braid
Type III	Enclosed in TFE convolute tubing
Type V	Combination of Type III and Type IV

Volume II

Type IV	Open bundle (not enclosed)

Volume III

Type VI	**Enclosed in TFE heat shrink tubing**
Type VII	**Flexible armored**

Volume IV

Type VIII	**Flat conductor cable**

VOLUME IV

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ILLUSTRATIONS

SECTION 1
INTRODUCTION

1.1 SCOPE

The intent of this document is to establish uniform criteria to be used for acquisition, fabrication, and installation of flat-conductor cable (FCC) harnesses, used for interconnecting wiring. This document shall be used as the basis for contractors and their suppliers to establish standard manufacturing and quality control techniques.

1.2 APPLICABILITY

This document identifies and describes the manufacturing process/controls, quality control inspection criteria, and test requirements that shall be used for the following major categories:

a. Flat-Conductor Cable Preparation
b. Harness Fabrication
c. Harness Installation

1.2.1 APPLICABLE DOCUMENTS

The following documents form a part of this document to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or requests for proposals shall apply. This document shall take precedence over all other contractually imposed fabrication or inspection criteria and/or requirements relative to Type VIII - Flat-conductor cable harnesses. In case of conflict between this document and the design documents 40M39582 and MSFC-SPEC-494, the design documents will take precedence:

40M39582 - Harness, Electrical Design Standard
MSFC-SPEC-494 - Installation of Harness Assembly (Electrical Wiring), Space Vehicle, General Specification for

1.3 DEFINITIONS

For the purpose of this document, the following definitions shall apply.

1.3.1 Type VIII - Flat-conductor cable harness - shall consist of one or more flat-conductor cables; with or without breakouts; assembled with two or more electrical termination devices and so arranged that as a unit, can be assembled and handled as one assembly.

1.3.2 Flat-Conductor Cable - An electrical cable consisting of three or more solid, rectangular, nickel plated copper conductors. The conductors are embedded in high-performance insulating material in a flat and parallel configuration.

SECTION 2
MANUFACTURING FLOW DIAGRAMS

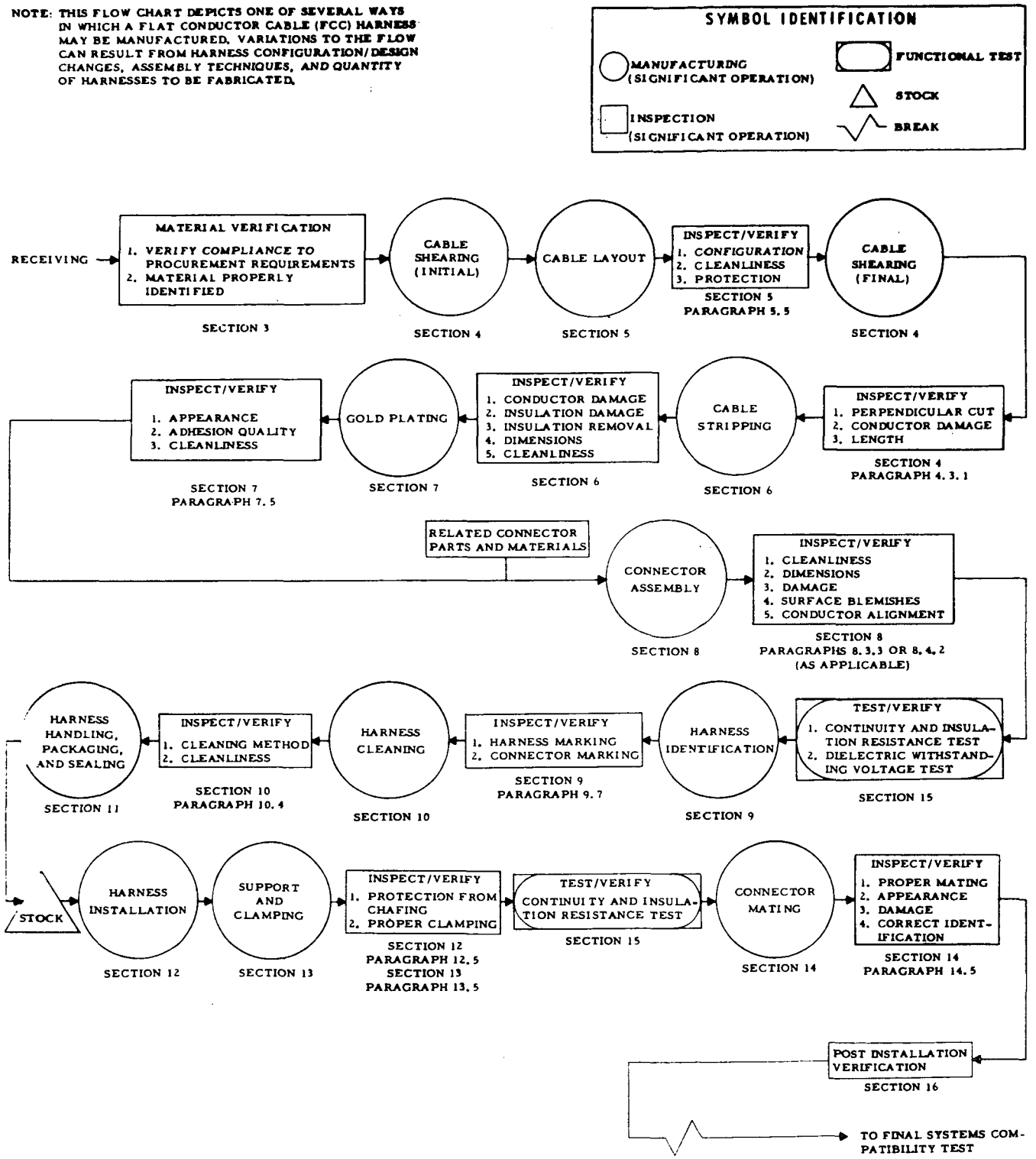
2.1 SCOPE

The flow diagram contained in this section depicts one of several ways in which a flat-conductor cable harness may be manufactured. Variations to the suggested flow can result from harness configuration/design changes, assembly techniques, quantity of harnesses to be fabricated, and numerous other criteria. The enclosed diagram shall be used in conjunction with the manufacturing process control and test criteria contained in this document, as a guideline for manufacture of the applicable harnesses.

2.2 APPLICABILITY

The diagram is a sequential flow chart identifying the manufacturing operations, process control points, and test requirements, that shall be used for Type VIII - flat-conductor cable, interconnecting wire harnesses.

NOTE: THIS FLOW CHART DEPICTS ONE OF SEVERAL WAYS IN WHICH A FLAT CONDUCTOR CABLE (FCC) HARNESS MAY BE MANUFACTURED. VARIATIONS TO THE FLOW CAN RESULT FROM HARNESS CONFIGURATION/DESIGN CHANGES, ASSEMBLY TECHNIQUES, AND QUANTITY OF HARNESSES TO BE FABRICATED.



FLOW CHART (TYPE VIII-FLAT CONDUCTOR CABLE HARNESS)

SECTION 3
RECEIVING INSPECTION

3.1 GENERAL

This section defines the minimum requirements for inspection verification of electrical materials acceptance, prior to issuance for manufacturing operations.

3.2 SCOPE

Electrical materials are those articles employed in fabrication and installation of interconnecting electrical cable harnesses and consist of, but are not limited to, flat conductor cable, clamps, supports, potting compounds, premolded connector plugs, connector plug components, such as seals, retaining keys, and any other parts used for assembly of premolded connectors.

3.3 PURPOSE

The purpose of acceptance inspection is to assure that suppliers of production materials have adequately performed the required inspections and tests necessary to assure a quality product which meets procurement specification requirements. Acceptance inspection tests may be conducted by 100 percent inspection or on a random sample, selected from each lot, batch, or group of materials submitted for acceptance at one time. Acceptance inspection tests shall not alleviate the supplier of his responsibility for performing all inspection and test requirements as specified in the procurement documents.

3.4 REQUIREMENTS

The materials and associated articles procured for fabrication and installation of interconnecting space vehicle electrical harnesses shall meet the following requirements and any additional requirements specified by the procurement documentation.

3.4.1 CERTIFICATION REPORTS

When specified, certification prescribed by the procurement specification shall be reviewed for conformance to requirements.

3.4.2 SAMPLING FOR ACCEPTANCE

Sampling shall be defined as a length, group, or individual units randomly selected from a lot, batch, or group submitted for acceptance inspection and test at one time. Sampling shall be planned in accordance with NHB 5300.4 (1B), paragraph 1200, which provides direction for establishing and maintaining sampling plans.

3.4.3 EXAMINATION OF MATERIALS

Each inspection lot and type of material submitted for acceptance shall be given a careful visual and dimensional examination to determine compliance with the applicable procurement specification requirements. Dimensional inspection shall be made using calibrated precision measuring instruments to determine product dimensional compliance. Materials shall be subjected to those tests as required to assure complete compliance to procurement specification acceptance and/or to validate conformance to paragraph 3.4.1. Examination of materials shall be performed in facilities as directed in paragraph 3.4.4.

3.4.4 FACILITIES

Facilities utilized for materials inspection and testing shall, as a minimum, satisfy the environmental and cleanliness levels directed by the procurement specification for the materials to be processed. Environmental and cleanliness controls shall be invoked to assure continued maintenance of prescribed levels.

3.5 RECEIVING INSPECTION AND TEST OF FLAT CONDUCTOR CABLE

Flat-conductor cable shall be subjected to visual inspection to assure compliance with the detail procurement specification requirements (i.e., identification, certification, dimensions, etc.). Samples, as defined in paragraph 3.4.2, shall be subjected to the following inspection and tests, as prescribed in the detail procurement specification.

3.5.1 IDENTIFICATION

The cable, as received, shall be identified in accordance with MIL-C-55543. Each cable roll shall be inspected for proper identification, and information shall be recorded in a receiving log for a permanent record as follows:

DATE RECEIVED	PART NUMBER LOT NUMBER	MANUFACTURE CODE	DATE OF MANUFACTURE

A sample of a convenient length, 6 or 8 inches from each lot received, should be extracted and filed with the receiving and inspection record.

3.5.2 CERTIFICATION OF CONDUCTOR MATERIAL

With each shipment of cable, certification of conductor material should be provided by the manufacturer. This information should be filed with the receiving and inspection record.

3.5.3 PACKAGING AND PACKING INSPECTION

Cables should be received in a condition in accordance with MIL-C-12000. Minimum acceptable lengths for various cable widths shall conform with the requirements outlined in MIL-C-55543.

3.5.4 CABLE DIMENSIONS

Inspection of cable dimensions on the receiving level should be divided into three inspection areas. Any variance from the dimensions specified in MIL-C-55543 should be considered a major defect and cause for rejection:

a. Cable width - The entire cable shall be checked for width dimensions and adherence to the requirements of MIL-C-55543.

b. Conductor spacing and alignment - Checking for spacing and alignment shall be accomplished to a tolerance stated in specification MIL-C-55543.

c. Conductor cross section - A sample shall be checked for conductor cross section dimensions to tolerances of specification MIL-C-55543.

3.5.5 WORKMANSHIP

The workmanship of the received cable shall be examined on a sampling or 100% basis as specified by the procurement specification. The workmanship shall reflect the use of current high grade production techniques and controls which produce a uniform and consistent product free from defects which would adversely affect the serviceability of the cable. The workmanship shall exhibit a sufficient contamination control which precludes interlaminar inclusions, conductor discoloration and moisture entrapment. The cable shall not be creased, abraded, scraped, scratched or peeled indicative of handling damage. Evidence of poor workmanship shall be cause for rejection.

3.5.6 RECEIVING INSPECTION (ELECTRICAL TEST)

The following electrical tests of cables shall be performed at receiving level:

a. Cable Electrical Continuity. Both ends of the cable length should be stripped, and a continuity check should be made on each conductor.

b. Insulation Resistance. A sample should be cut from the end of the cable roll and tested per MIL-C-55543.

c. Conductor Resistance. The dc resistance of the individual conductors should be taken on a sample basis and tested in accordance with Federal Test Method Standard No. 228, Method No. 6021.

d. Dielectric Withstanding Voltage. A sample from each inspection lot should be subjected to the dielectric withstanding voltage test per MIL-C-55543.

3.6 RECEIVING INSPECTION PREMOLDED PLUGS

Each premolded plug shall be subjected to a comprehensive visual examination for compliance with the detail procurement requirements, correct identification, and to assure that the plugs are free of contamination and/or damage. Plugs shall be packaged to provide protection against mishandling, contamination, and accelerated aging during storage.

3.6.1 IDENTIFICATION

The shipping containers of plugs as received should be identified properly in accordance with MIL-STD-129. The plugs as received should be identified

3.6.1 IDENTIFICATION (Continued)

properly in accordance with MIL-STD-130. Each shipment should be inspected for proper identification, and information should be recorded in a receiving log for a permanent record as follows:

DATE RECEIVED	PART NO. LOT NO.	MANUFACTURING CODE	DATE OF MANUFACTURE

3.6.2 MATERIAL CERTIFICATION

Certification of plug material should be provided by the manufacturer with each shipment of plugs and filed with each receiving and inspection record.

3.6.3 PACKAGING AND PACKING INSPECTION

Connector plugs should be received in a condition in accordance with MIL-P-116. Preservation and packing should be as the contract or purchase order requires. Specifics may be found in MIL-C-55544.

3.6.4 PLUG DIMENSIONS

An appropriate sampling plan should be initiated to check critical plug dimensions. All dimensions should comply with MIL-C-55544; any variance from these dimensions should be considered a major defect. The sampling plan initiated should include sectioning of the plug to inspect critical internal dimensions.

3.6.5 WORKMANSHIP

Overall quality of the plug should be checked in the following areas:

a. Flash. Flash, or excessive material on the plug, can be particularly critical if it exists in the plug window area. An appropriate sampling plan to identify this defect cannot be overstressed.

b. General Damage. The received plug should be inspected, on a sample basis, for general damage (cracks, nicks, etc.).

c. Porosity. A sample should be taken from each inspection lot and sectioned for porosity inspection. The cut section should be viewed for porosity under 3X magnification. The complete procedure for

3.6.5 WORKMANSHIP (Continued)

porosity identification is defined in Federal Test Method Standard No. 406, Method No. 5021.

d. Plug Material Testing. Specific parameters to ensure consistent material quality should be checked on an inspection-lot basis until a reasonable confidence level has been reached. The tests are as follows:

1. Insulation Resistance. For procedure, see Federal Test Method Standard No. 406, Method No. 4041.
2. Dielectric Withstanding Voltage. See Federal Test Method Standard No. 406, Method No. 4031.
3. Brittleness. See Federal Test Method Standard No. 406, Method No. 2051.

3.7 RECEIVING INSPECTION OF PLUG COMPONENTS

Each plug component shall be subjected to a comprehensive visual examination for compliance with detail procurement requirements, correct identification, and to assure that the components are free of contamination and/or damage. Plug components shall be packaged to provide protection from mishandling, contamination, and accelerated aging during storage.

3.7.1 BACK-SHELL/PREMOLDED PLUG CONFIGURATION

Overall quality of the back shell/premolded plug components shall be checked in the following areas:

a. Plating Consistency. A sample should be extracted from each inspection lot and checked for plating consistency. The plate should be even and free of blisters, nodules, pits, and porosity when viewed under a magnification of 3X. Finish requirements should be per MIL-C-55544.

b. Dimensions. A sample should be extracted from each inspection lot and measured for critical dimensions. Dimensional requirements are found in MIL-C-55544.

3.7.2 PREMOLDED PLUG WEDGE AND RETAINER

Overall quality of the premolded plug wedge and retainer components shall be checked in the following areas:

3.7.2 PREMOLDED PLUG WEDGE AND RETAINER (Continued)

a. Dimensions. Initiate a sampling plan to check critical dimensions. Dimensions are found in MIL-C-55544.

b. Material Testing. Specific parameters to ensure consistent material quality should be checked on an inspection lot basis until a reasonable confidence level has been reached. The tests are as follows:

1. Insulation Resistance. For procedure, see Federal Test Method Standard No. 406, Method No. 4041.

2. Dielectric Withstanding Voltage. See Federal Test Method Standard No. 406, Method No. 4031.

3. Brittleness. See Federal Test Method Standard No. 406, Method No. 2051.

3.7.3 SEAL

Overall quality of the seal shall be checked in the following areas:

a. Dimensions. Initiate sampling plan to check overall dimensions.

b. Hardness. Check the seal for hardness using durometer shore (a). Hardness should be Shore A78±3.

c. Age Control and Storage. The age and storage control of gasket material should be in accordance with MSFC-STD-105.

3.8 MOLDING COMPOUNDS, POTTING COMPOUNDS, AND ADHESIVES CONTROL

The general requirements for storage and in-plant control of the plating compounds and adhesives are specified herein.

3.8.1 IDENTIFICATION AND STORAGE

The identification and storage requirements are as follows:

a. Issuance of materials should be on a first-in, first-out basis.

b. Materials should be stored per manufacturer's instructions.

c. All bulk materials should be labelled and identified, and stored and handled per manufacturer's instructions. Label as follows:

Perishable Item

Batch No. (Vendor's batch or lot numbers)

Stored At (Storage temperature)

Issue Date (Date material issued from storage)

Void After (Expiration date after testing and storage)

3.8.2 STORAGE SURVEILLANCE

The storage surveillance requirements are as follows:

a. Materials which have aged beyond the void date should be impounded and retested.

b. Materials should be reidentified with a new expiration date, if tested and found acceptable.

c. Records of periodic storage surveillance should be maintained.

3.9 RECEIVING AND INSPECTION OF CLAMPS AND SUPPORTS

Cable support clamps shall be submitted to a detail physical examination to determine compliance with criteria contained in the following paragraphs.

3.9.1 IDENTIFICATION

The clamps received should be identified per MIL-STD-129. Each shipment should be inspected for proper identification and recorded in a receiving log.

3.9.2 PACKAGING AND PACKING INSPECTION

FCC clamps received should be in accordance with MIL-P-116. Preservation and packing received should conform to the contract or purchase order requirements.

3.9.3 DIMENSIONS

A sample plan should be initiated for inspecting clamp dimensions per applicable drawing.

3.9.4 WORKMANSHIP

The clamping device should be inspected for the following:

a. General damage.

b. Plating consistency (if required).

c. Spring tension (if incorporated).

d. Cushion hardness - The rubber used on the clamp should be subjected to a durometer Shore inspection to determine if the cushion hardness is within tolerance.

SECTION 4

CABLE SHEARING

4.1 GENERAL

All flat-conductor cable shall be sheared to approximate length prior to the layout process, and then sheared to exact length (including additional length needed for stripping) after completion of layout. Cable shearing equipment of either automatic or manual operation may be utilized. In addition, it is sometimes necessary to shear cable using acceptable hand cutting tools. Regardless of the method used (automatic, manual, or hand), it is essential that the cut cable meet the requirements contained in the following paragraphs.

4.2 PROCESS CONTROL REQUIREMENTS

Prior to shearing of the cable, verify correct type in accordance with applicable drawings, including size, type plating, and insulation. Make sure cable has undergone receiving inspection criteria established in Section 3 of this document, and record lot number of cable on In-Process Control Documentation. Close visual examination shall be performed on the cable, and as a minimum, the following conditions shall be inspected for:

a. Air bubbles below the insulation surface.
b. Separation of insulation material from the conductors.
c. Damaged or broken conductors.
d. General damage, such as kinks, abrasions, cracks, or dents.

4.2.1 CLEANLINESS

The work area used for shearing cable shall exhibit a clean and orderly appearance. All dirt, grease, oil, chips, and other foreign material shall be removed from tools, equipment, and work areas.

4.2.2 EQUIPMENT/TOOL REQUIREMENTS

Hand or machine shearing equipment and tools shall be periodically certified per NHB5300.4(1B). A sticker or other device shall be attached to each tool or piece of equipment indicating certification and the next recertification due date. The work produced shall be checked to assure

4.2.2 EQUIPMENT/TOOL REQUIREMENTS (Continued)

that the insulation has not been punctured, crushed, or otherwise damaged, and that the cable ends are cut square. Cutting efficiency shall be maintained by replacing blades and calibrating when necessary.

4.3 CABLE SHEARING OPERATIONS

The shearing operations shall be performed in such a manner that the conductors and insulation are not damaged adjacent to the cut end. Wire shearing equipment or tools shall not cut, extrude, or otherwise damage adjacent insulation. Repetitive occurrences of improper shearing of the cable shall be cause for maintenance and/or re-calibration of the equipment.

4.3.1 SHEARING VERIFICATION REQUIREMENTS

Cable shearing should be performed using precision shears of either the hand operated, manual, or automatic type. Regardless of the type of tool/equipment used, there are three basic requirements to be met in the shearing operation:

a. The cut must be perpendicular to the conductors.

b. The conductor ends must not be deformed.

c. The linear dimensions should be accurate.

NOTE: The cut length shall include the mockup cable length plus proper allowance for strip dimensions.

SECTION 5
CABLE LAYOUT

5.1 GENERAL

This section establishes the fabrication criteria that pertains to grouping, layout, folding, splitting, and bundling of flat-conductor cables into the desired harness configuration. Several other elements relative to harness fabrication (shearing, stripping, etc.) are covered elsewhere in this document and should be referred to where applicable.

5.2 PROCESS CONTROL REQUIREMENTS

Prior to performing cable layout operations, verify correct type cable and that shearing operation has been properly performed. Make sure the cables have not been damaged and necessary process control verification has been performed. In addition to the preceding process control requirements, the control and handling precautions described in the following paragraphs shall be applied.

5.2.1 CONTROL AND CLEANLINESS OF MOCKUP AREAS

All mockup of flat-conductor cable shall be performed in a controlled area. The general working area and benches shall be maintained in a clean and orderly condition at all times. Only tools, fixtures, equipment, etc., which are required to perform the task shall be allowed in the area. Supply cabinets or shelves used to store cable, components, hardware, etc., shall be set aside from the immediate work area, and shall be maintained in a clean and orderly condition to avoid contamination of the cable and associated materials being assembled.

5.2.2 CABLE PROTECTION

All mockup boards or fixtures shall be inspected for sharp edges, protrusions, and any other conditions that may damage the flat-conductor cable insulation. All metallic guides and supports shall be covered with protective sleeving or coating.

5.3 FABRICATION AND HANDLING PRECAUTIONS

The fabrication and handling of flat-conductor cables and cable harness assemblies requires reasonable care to prevent damage and to assure cleanliness. In addition to the handling and packaging procedures described in Section 11, the following precautions shall be observed:

a. Cables and cable assemblies shall be fully supported at all times. They shall not be allowed to hang over the edges of work surfaces or to lay on protrusions that may cause damage to conductors or insulation. In no instance will they be placed on a surface, such as a floor, where they may be stepped on or damaged by vehicular traffic. Tools or other foreign objects shall not be layed on cables during fabrication or stowage.

b. During handling, care shall be exercised to prevent cables from being dragged over any surface. They shall be fully supported and lifted when moved.

5.3.1 CLEANLINESS PRECAUTIONS

Incomplete cable harness assemblies not in work (on benches or jig boards) shall be completely covered with polyethylene film or equivalent that will not degrade the intent of the completed harness. Work areas shall be clean at all times. Only tools in use shall be allowed on the working surfaces of benches and jig boards.

5.4 LAYOUT

To facilitate installation and maintenance, cable harness configurations should be developed utilizing mockups or jig boards. When performing harness layout operations, particular attention must be paid to cable conductor registration in the plugs and cable segment registration in the harness runs. The cable identification provided by the cable manufacturer, along one edge of the flat-conductor cable, identifies the index edge for each cable segment.

5.4.1 CABLE FOLDING

Variations in harness direction or harness branch breakouts can be performed by folding the flat-conductor cable over on itself. Various cable folding techniques are used, as illustrated in Figure 1, to provide the direction changes and cable registration required. Nonshielded flat-conductor cable can be folded flat on itself with no bend radius required. In

5.4.1 CABLE FOLDING (Continued)

those areas where cables branch out of major runs, or where the major run changes its direction by folding, there are two methods to be considered, as shown in Figure 2. Folding by group provides neater bundles and additional support, with fewer exposed edges. Folding by cable makes it much easier to install, remove, and replace individual cable assemblies. It is recommended that a maximum of ten cables be folded in a bundle. If there are more than ten cables in one run, a new run should be started along side the first. Cable folding operations shall be performed with an appropriate flat-conductor cable folding tool, as illustrated in Figure 3.

5.5 PROCESS VERIFICATION REQUIREMENTS

Flat-conductor cable harness layouts shall be inspected for compatibility of the harness configuration with the applicable mockup, fixture, jigboard, and/or engineering design drawing. Check for the proper bend-angle after folding and for damage around the fold area; delamination, conductor breakage, damaged insulation, etc.

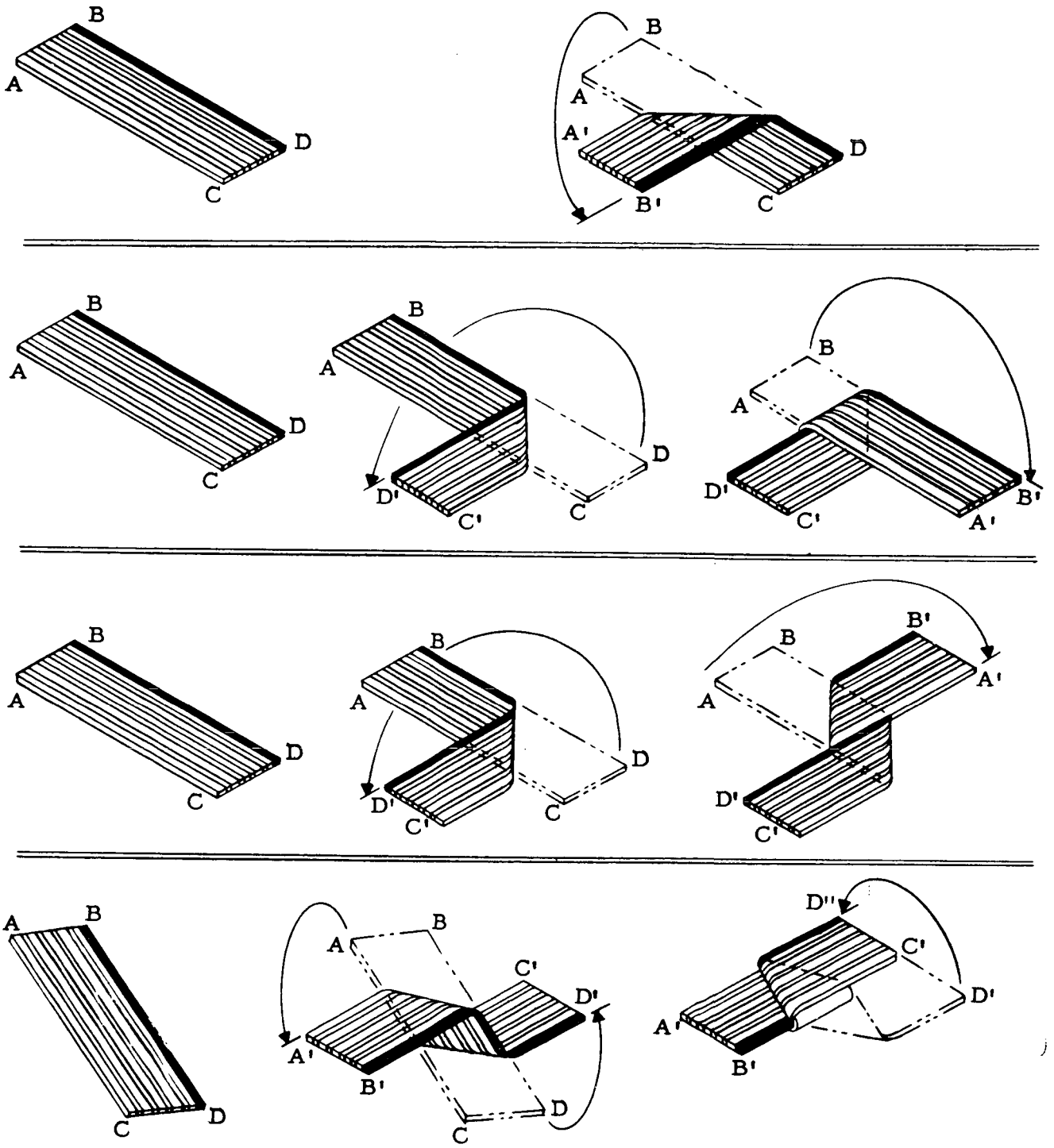
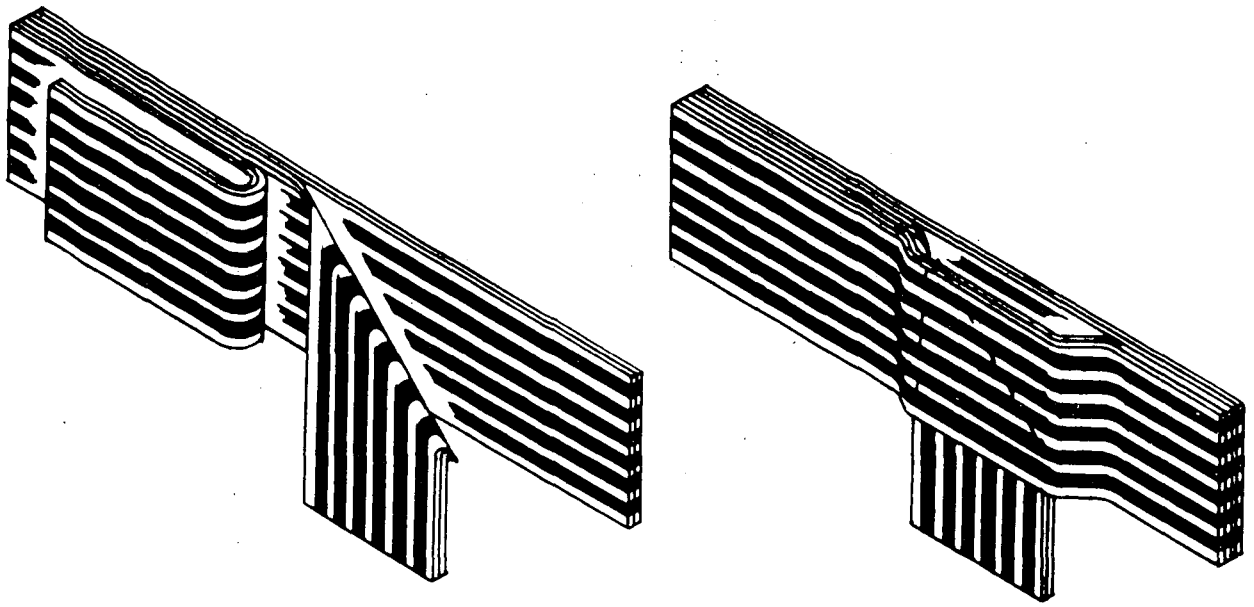
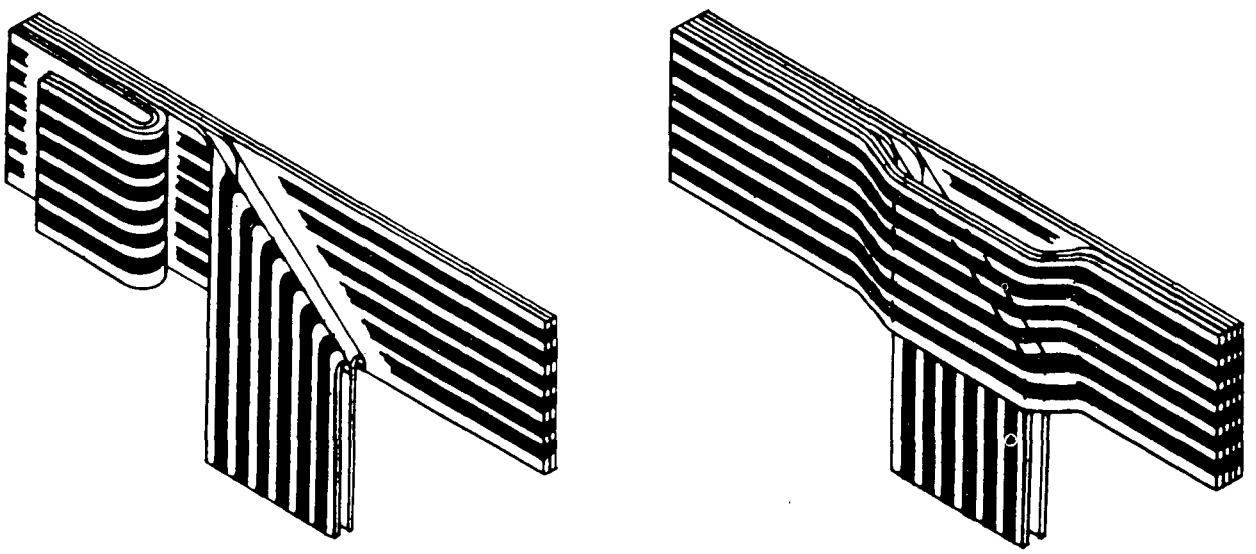


FIGURE 5-1 FCC FOLDING TECHNIQUES

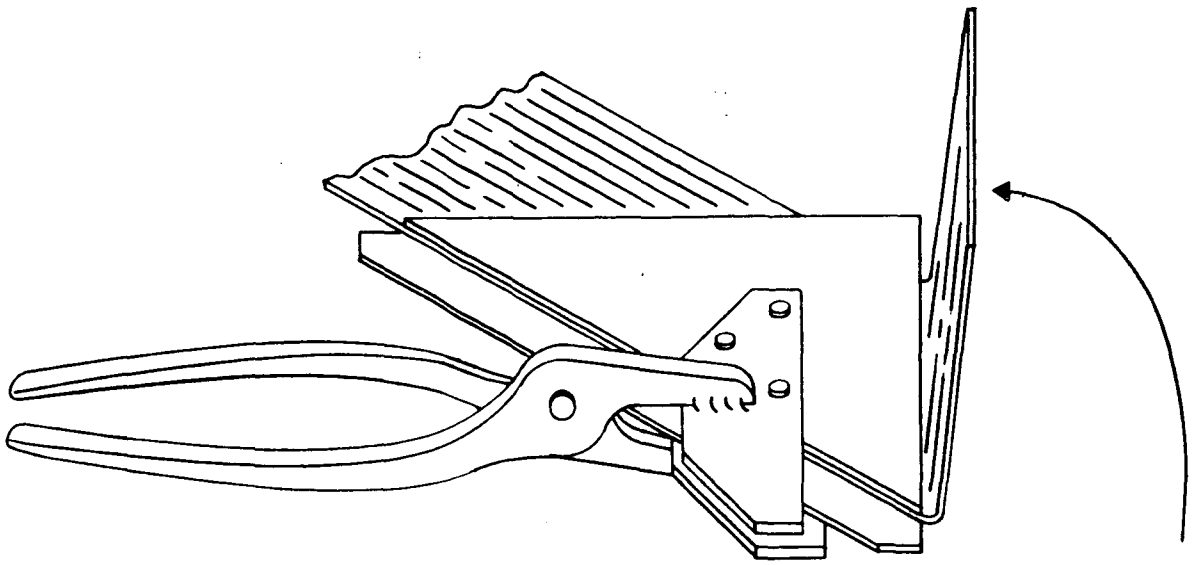


FOLDING BY GROUPS



FOLDING BY CABLE

FIGURE 5-2 FCC BRANCH BREAKOUT FOLDS



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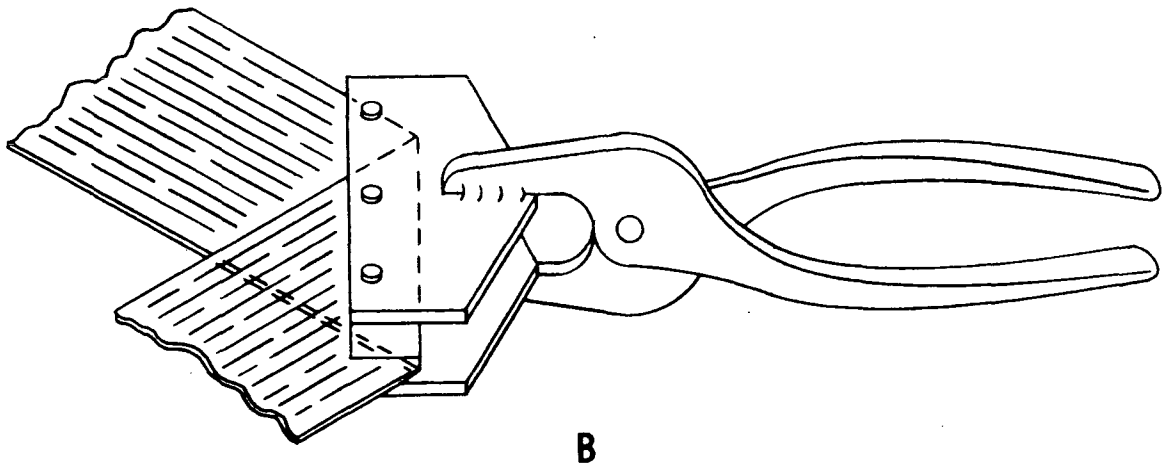

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FIGURE 5-3 FCC FOLDING TOOLS

SECTION 6
CABLE STRIPPING

6.1 GENERAL

The intent of this section is to establish techniques for the removal of insulation from flat-conductor cable. Several methods of removing insulation have been developed, but only those methods acceptable for removal of polyimide fluorinated ethylene propylene (FEP) insulations shall be covered in this section.

6.2 PROCESS CONTROL REQUIREMENTS

Prior to stripping flat-conductor cable, verify that the cable has been cut to the required length, including proper allowance for strip dimensions, and that the cable insulation is free of nicks, cuts, or abrasions. Assure that the harness layout is in the correct configuration and the cable has been sheared perpendicular to the conductor lay.

6.2.1 GENERAL PROCESS ACCEPTANCE CRITERIA

All methods that are used in stripping cable shall be in accordance with applicable standards and specifications. The stripping operations shall be performed in such a manner that the conductors are not severed, scratched, or nicked. Minor longitudinal scratches and nicks on conductors shall be acceptable on non-plated conductors, but such scratches and nicks shall not penetrate through the plating on nickel plated conductors. The stripline should be even, and clean and free of all residual insulation or bonding agents, and no insulation should be left between the conductors.

6.2.2 OPERATOR QUALIFICATIONS

Personnel involved in insulation stripping operations shall be trained in the specific stripping process and meet the following minimum requirements:

a. Be familiar with the requirements of this document and associated documentation.

6.2.2 OPERATOR QUALIFICATIONS (Continued)

b. Receive instructions explaining the process requirements pertaining to stripping the specific insulation material.

c. Be skilled in the identification and use of tools/equipment required for stripping the cable insulation.

6.2.3 CLEANLINESS AND PROTECTION

The work area used for stripping of cable shall exhibit a clean and orderly appearance. All dirt, grease, oil, chips, and other foreign material shall be removed from the tools, equipment, and work area. After completion of the stripping process, the exposed conductors should be protected during handling by a device similar to the modified heavy duty paper clip illustrated in Figure 1.

6.3 MECHANICAL STRIPPING

Flat-conductor cable insulation material may be removed with a number of different mechanical techniques. The insulation material utilized, amount of insulation to be removed, and equipment availability must be considered when selecting the technique to be used. The preferred method for removing polyimide/fluorinated ethylene propylene (FEP) insulations is by one of the mechanical-cold blade processes. The following paragraphs describe the preferred mechanical stripping techniques, along with applicable precautions and process control criteria.

6.3.1 EQUIPMENT REQUIREMENTS

Mechanical stripping equipment shall be periodically certified per NHB 5300.4 (1B). A sticker or other method shall be attached to each piece of equipment indicating certification and the next recertification due date. The work produced shall be checked to assure that the insulation has been properly removed without conductor damage or damage to adjacent insulation. Stripping efficiency shall be maintained by replacing blades and calibrating when necessary.

6.3.2 MECHANICAL-COLD BLADE STRIPPING

Flat-conductor cables with FEP-bonded polyimide insulation can be stripped easily and quickly with a sharp blade stripper, without applying heat. The success of the cold blade stripper is dependent upon the bond of FEP conductors. The principle of this method is the use of a sharp blade that fractures the thin polyimide film and into the FEP layer, but does not contact the cable conductors. Figures 2 and 3 illustrate two types of stripping operations which may be utilized for insulation removal. Cold blade stripping shall be performed using manufacturer's instructions for the specific type equipment, in conjunction with the following procedures:

a. Verify that blade clearance gages are adjusted to cut through the cable insulation, but do not touch the conductors.
b. Position the cable in the desired position to obtain the correct strip length and clamp in place.
c. Strip the cable insulation.
d. Remove the cable and protect stripped conductors using a device similar to that illustrated in Figure 1.

6.3.3 MECHANICAL STRIPPING PROCESS VERIFICATION

Mechanical stripping process verification shall consist of the following general inspection criteria:

a. Conductor Damage - Particular attention must be given to conductor damage that may be caused by the knife blade. The conductors, under an ample magnification, should be observed for nicks, scratches, abrasions, bends, plating defects.
b. Complete insulation Removal - The stripline should be even, clean and free of all residual insulation and bonding agents. No insulation shall be left between the conductors. Each conductor should be checked under magnification for residual insulation and bonding agents. If the insulation is not properly removed, samples should be run on the particular stripping device being used to determine the appropriate stripping pressure to effectively strip the cable. The bond strength from cable to cable may vary; therefore it will be necessary at times to perform the task just described

6.3.3 MECHANICAL STRIPPING PROCESS VERIFICATION (Continued)

c. Conductor and Insulation Cleanliness - Each conductor should be inspected for cleanliness after stripping.

d. Dimension of Strip - Each stripped cable should be measured for proper strip length.

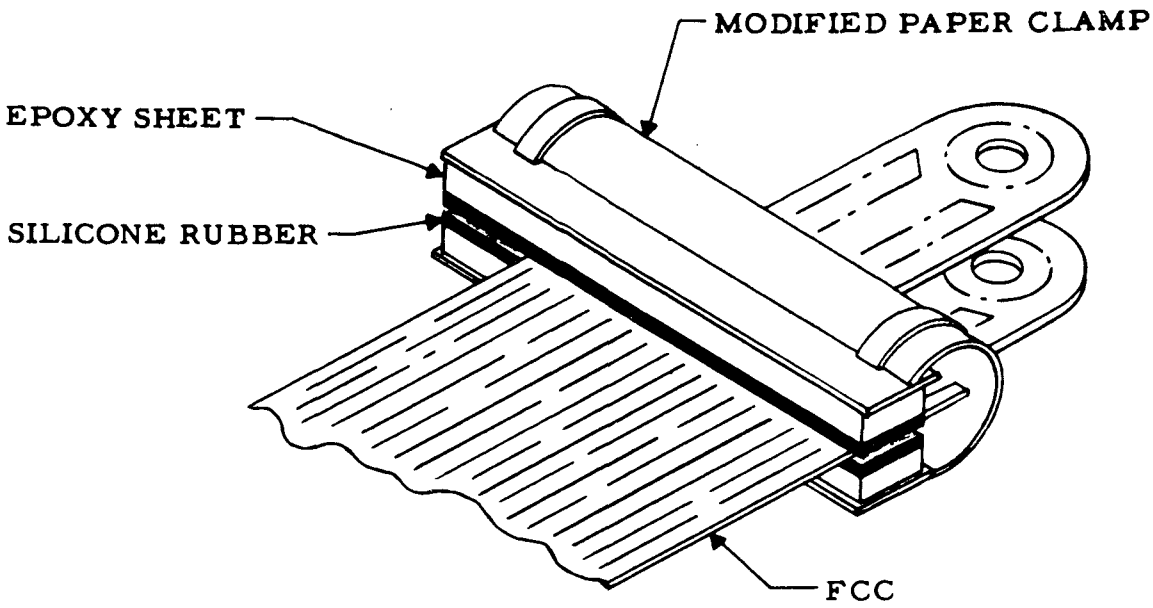


FIGURE 6-1 CONDUCTOR PROTECTING CLIP

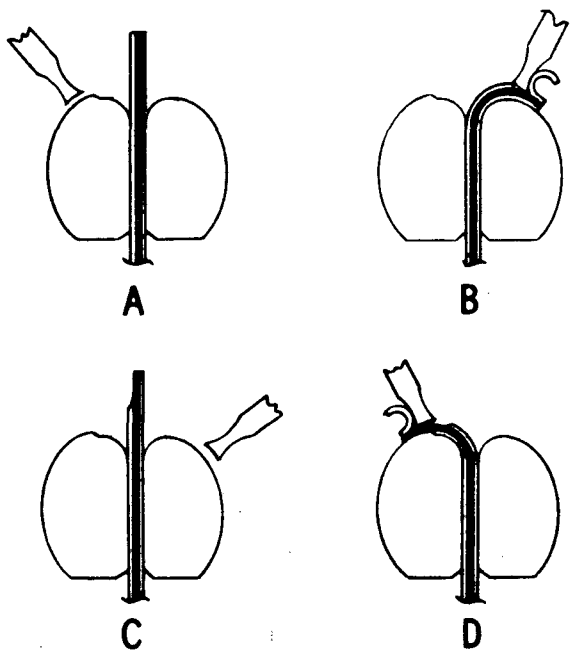


FIGURE 6-2 STRIPPING OPERATIONS-NASA MECHANICAL STRIPPER

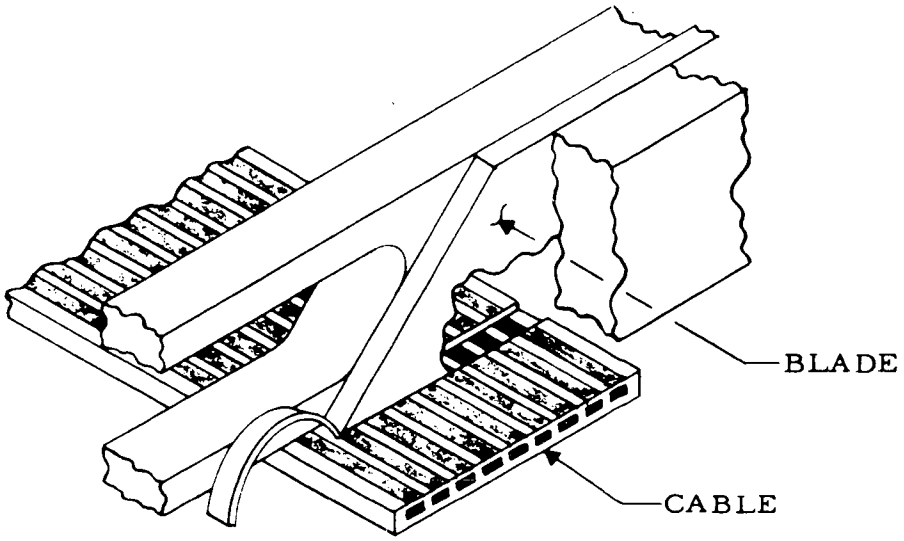


FIGURE 6-3 BLADE ACTION OF THE HOBEL STRIPPER

SECTION 7
CONDUCTOR PLATING

7.1 GENERAL

This section establishes the requirements for gold plating of flat-conductor cable conductors.

7.2 PURPOSE

The procedures contained in the following paragraphs apply to the gold plating of the nickel-plated conductors, used in the flat-conductor cable, conductor-contact plug system. The gold plating serves two purposes: (1) excellent surface conductivity, and (2) resistance to contact wear.

7.3 PROCESS CONTROL REQUIREMENTS

Prior to performing the gold plating process, examine the conductors in the area where the insulation has been removed. Remove any visible particles of insulation, adhesive or adhesive smear. Picks, tweezers, tissues and approved solvents may be used, but care must be taken to prevent damage to the nickel-plated conductors and/or cable insulation. During the cleaning and preparation processes exercise sufficient caution to prevent damage to the conductors such as cuts, nicks, scratches and excessive distortion.

7.4 GOLD PLATING

Gold plating shall be applied to the stripped, nickel-plated conductors of flat-conductor cable for improved surface conductance and corrosion resistance. Plating of the conductor contact areas with gold shall be performed as described in the following paragraphs and as sequenced in Figure 1. In addition, the gold plated surfaces shall meet the requirements established in Military Specification MIL-G-45204, Gold Plating (Electro-deposited), Type II, Class 1.

7.4.1 PREPARATION FOR GOLD PLATING

After verification that the stripped cable conductors have been properly nickel plated, the conductors shall be prepared for gold plating as described in the following procedure:

7.4.1 PREPARATION FOR GOLD PLATING (Continued)

NOTE: To minimize wicking of the plating solution, do not submerge cable into cleaning solution beyond the stripped portion of the conductors.

a. Electrically connect the FCC conductors to the plating cathode rod. Connection may be made with conductive electrical tape or spring type clamps.

CAUTION: The connection method shall produce no damage, bending, or excessive distortion to the conductors.

b. While applying 6-volts to the cable conductors, dip the exposed conductors into the alkaline solution. Dip time shall be held to a minimum which will produce a water break free surface. Dip time shall not exceed 20 seconds.

c. Immediately upon removal from the alkaline cleaning solution, spray rinse with deionized water for 30 to 45 seconds. Examine for a water break free surface. To achieve a water break free surface, step b may be repeated but not to exceed a 20 second exposure to the alkaline solution.

d. While applying 6-volts to the cable conductors, dip the exposed conductors into a 10% (ACS) sulphuric acid solution. Dip time shall be held for 60 to 90 seconds.

e. Immediately upon removal from the 10% sulphuric acid solution, spray rinse with deionized water for 10 to 15 seconds.

7.4.2 GOLD-STRIKE-PLATING PROCEDURE

It is necessary to gold-strike the surface of the nickel-plated conductors before gold plating to enable the surface to better receive the final gold plating. The procedure for gold-strike plating is as follows:

a. While applying 6-volts to the cable conductors, dip the exposed conductors into the gold strike solution. The gold strike solution shall be 0.03 to 0.05 troy oz./gal. of gold, citric acid to a baume 10, with a pH 3.5. Dip time for the gold strike shall be for 30 to 60 seconds.

b. Immediately upon removal from the gold strike solution, spray rinse with deionized water for 10 to 15 seconds.

7.4.3 GOLD-PLATING PROCEDURE

The gold plating equipment and process used shall be at the option of the manufacturer, but the plated conductors shall meet the requirements established in specification MIL-G-45204. The following procedure shall be utilized in conjunction with Figure 1 to ensure proper bonding of the gold to the nickel-plated conductor:

a. Immediately upon removal from the deionized water rinse, dip the exposed conductors into the gold plating solution. Autronex "C". Apply current to the cable conductors calculated at 10 amps/ft.^{2}. Plate for approximately 10 minutes to achieve class 1, minimum thickness, of 50 micro inches.

b. Upon removal from the gold plating solution, spray rinse in deionized water for 30 to 45 seconds.

c. Dry the exposed plated conductors and the cable end with dry, filtered compressed air.

d. Place the cable in an air circulated oven for a minimum of 30 minutes. The oven temperature shall be 50°C plus or minus 5°C.

7.5 PROCESS VERIFICATION

The gold plating shall be smooth, adherent, and free from blisters, laminations, nodules, pits, discontinuities, and porosity. Inspection under a magnification of 5X power should be used to identify these defects. The line of demarcation between gold-plating and nickel-plated areas shall be even and smooth.

7.5.1 SAMPLING AND TEST

Test specimens of the stripped cable (taken from a production inspection lot) shall be plated to a minimum thickness of 0.000050 inch and evaluated for thickness, adhesion, and corrosion resistance tests, as described in the following:

a. Thickness of the gold plate shall be a minimum of 0.000050 inch, unless otherwise specified. A section taken on a sample basis should be micro-photographed for measurement purposes.

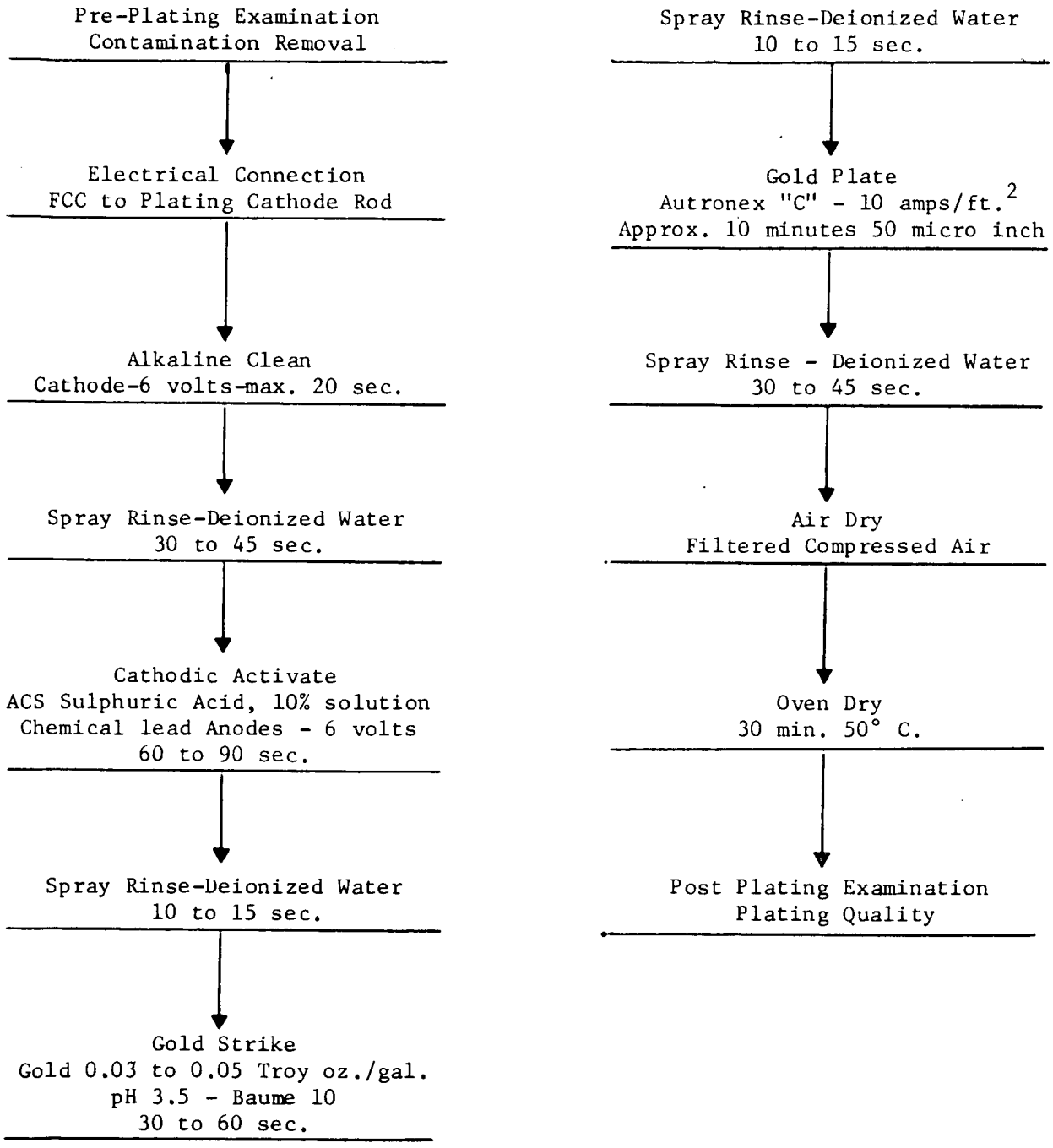
b. A plated sample shall show no evidence of gold plate separation from conductor, after bending 180 degrees around a 1/8 inch rod. Each time the plating solution is renewed or re-charged, a sample shall be plated before actual production begins, checking for

.1 SAMPLING AND TEST (Continued)

adhesion quality.

c. A gold-plated conductor sample shall evidence no corrosion of base metal after 2 hours of salt spray, in accordance with Federal Test Method Standard No. 151, Method No. 811.1.

FIGURE 1. PROCESS FLOW SEQUENCE FOR GOLD PLATING
FCC NICKEL COATED CONDUCTORS



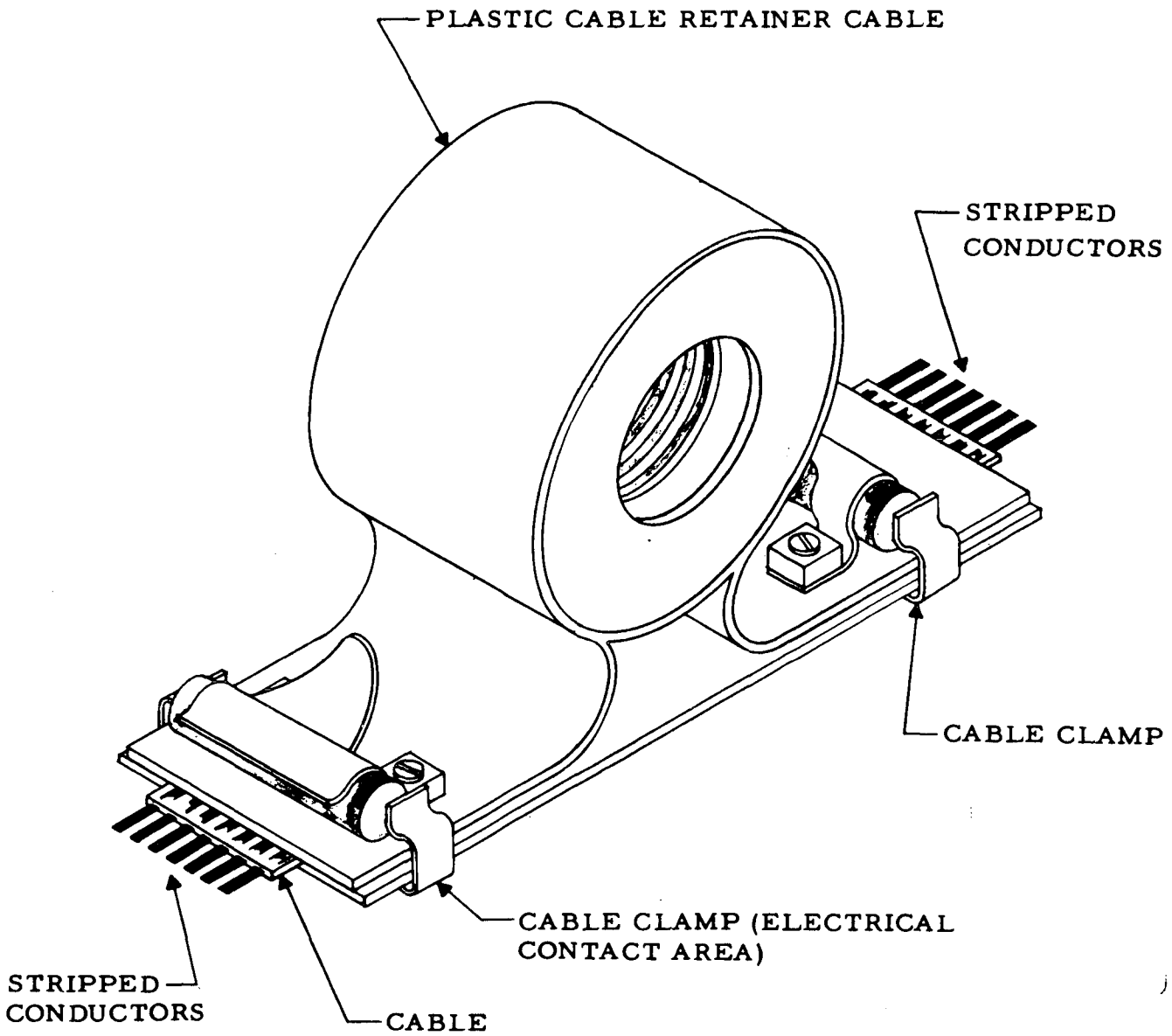


FIGURE 7-2 NASA/MSFC PLATING RACK WITH CABLE

SECTION 8
CONNECTOR ASSEMBLY

8.1 GENERAL

This section describes the procedures and process controls relative to assembly of both premolded rectangular plugs and molded-on cylindrical plug assemblies. Elements relative to cable stripping and conductor plating are contained in Sections 6 and 7 of this document, and should be referred to, prior to connector assembly operations.

8.2 PROCESS CONTROL REQUIREMENTS

Prior to performing the assembly of any connector, verify that all cable has been sheared, stripped, and plated in accordance with the previous process requirements. Visually examine each connector and associated hardware to assure that the contacts (when applicable), finish, seal, conductor spacer, insert, keys, wedge, and insulators are not damaged, and are free of foreign material, grease, dirt, etc. Check the seal insertion area for imperfections such as mold flash, cuts, gouges, or obvious damage to the sealing area of the connector.

8.2.1 CONNECTOR PROTECTION

All connectors shall have caps or other protective devices installed throughout all stages of fabrication and testing, except when connected with mating connectors, or during individual connector testing. When caps are removed for testing, cleaning, etc., the caps shall be replaced promptly after the operation is completed.

8.2.2 CONNECTOR CLEANING

Prior to assembly of a connector, all components and the inside surface of the connector shall be kept free of oil, dirt, grease, and other foreign material. If present, these substances shall be removed by wiping with a clean lint free cloth, dampened with a suitable cleaning solvent, followed by wiping with a clean dry cloth. Also, a clean soft brush may be used to remove loose contaminate on seals.

8.3 PREMOLDED RECTANGULAR PLUGS

Premolded rectangular plugs are utilized for 1.0, 1.5, 2.0, 2.5, and 3.0-inch wide cables, and are composed of parts that require no additional molding. Figures 1 and 2 illustrate a typical cross-section of the premolded rectangular plug assembly, together with details which define the parts required. The rectangular plugs are tabulated for cable conductor widths of 0.040-inch, with conductors spaced on 0.075-inch centers. Premolded rectangular plugs may be modified to accept cable conductor widths of 0.115-inch and conductors spaced on 0.150-inch centers. Modification of the plugs, to accept the larger conductors, shall be performed as described in paragraph 8.3.1, prior to plug assembly per the standard procedures described in paragraph 8.3.2.

8.3.1 PREMOLDED PLUG MODIFICATION

Modification of standard premolded rectangular plugs may be performed to accept cable conductor widths of 0.115-inch and conductors spaced on 0.150-inch centers. The modification is performed by removing the insulation barriers, as required, on the conductor spacer, wedge, and housing components of the plug (Reference Figure 1). Upon completion of the modification process, the plug and flat-conductor cable may be assembled as described in the following paragraph.

8.3.2 PREMOLDED PLUG ASSEMBLY

Preparatory to plug assembly, the operator shall assure that the cable conductors have been stripped to a 0.500 $\pm$ 0.005-inch length using the appropriate procedure described in Section 6, and that the conductors have been properly plated as described in Section 7 of this document. After the stripping and plating procedures have been verified, the selected plug assemblies shall be fabricated using Figures 1 and 2, and the following procedure.

a. Thread stripped conductors (both cables) through central opening of base plate. Move base plate back on cabling far enough to give liberty in working with each strip.

8.3.2 PREMOLDED PLUG ASSEMBLY (Continued)

b. Position conductors of both cables into slots of conductor spacer, moving the stripped margin of insulation against the base of the conductor spacer ribs. Apply a small amount of adhesive (MSFC 222, Type V) to the wedge prior to insertion.

c. Clamp conductor spacer and cable in folding tool and bend conductors at a 90 degree angle across the wedge groove.

d. Fold the conductors into the conductor spacer groove utilizing the folding tool.

e. Thread conductor spacer through housing, making sure that it is seated well into the housing.

f. Move base plate into position in the housing.

g. Insert locking keys and twist ears of each key as illustrated in Figure 2.

h. Pot base of plug with potting compound per procedures described in paragraph 8.5.

i. Apply a thin film of silicone primer (GE-554004 or equivalent) into the seal groove of plug housing, and allow to cure.

j. Apply a thin film of adhesive (GE-RTV118 or equivalent) into the seal groove of the plug housing.

k. Install the silicone rubber seal into the groove. Make sure that the seal is seated properly.

8.3.3 PREMOLDED PLUG PROCESS VERIFICATION

Examine the completed plug to assure that all provisions of this document and applicable engineering documents are complied with. Particular care shall be exercised during the assembly operation to insure reliability. The following precautions are provided for specifying those inspection points necessary in the assembly of a premolded plug-flat cable assembly:

a. The operation of threading the conductors into the plug is particularly critical. Care must be taken not to damage the conductors during the insertion process. Any bends, kinks, or scratches should be cause for rejection if they affect proper seating of the conductors in the grooves of the plug.

8.3.3 PREMOLDED PLUG PROCESS VERIFICATION (Continued)

b. Check to assure that the cable stripline aligns with the inside edge of the plug.

c. Inspect the conductors, after folding, for separation of plating around the area of the fold.

d. Before potting verify plug keys are secured properly.

e. The potting compound in the base of the plug should be checked for quality as described in paragraph 8.5.8.

f. Inspect for excessive adhesive around or on the seal and for proper cure.

8.4 MOLDED-ON CYLINDRICAL PLUGS

Molded-on cylindrical plugs are utilized for 0.25 and 0.5-inch-wide cable. The plug assembly consists of coupling ring, window piece, conductor spacer, insulator, shell, and insert, which are assembled and molded together to form an integrated assembly. In addition, the assembled plug is potted and a seal is cemented into a groove on the plug face to seal the junction between plug and receptacle. Figures 3 and 4 illustrate a typical cross-section of the complete plug assembly, together with details which define the parts required.

8.4.1 MOLDED-ON PLUG ASSEMBLY

Preparatory to plug assembly, the operator shall assure that the cable conductors have been stripped to 0.470 $\pm$ 0.005-inch length using the appropriate procedure described in Section 6, and that the conductors have been properly plated as described in Section 7 of this document. After the stripping and plating procedures have been verified, the selected plug assembly shall be fabricated using Figures 3 and 4, and the following procedure:

a. Insert the conductors through their respective openings (beveled side) of the window piece.

b. Separate conductors of one cable from those of the other cable, and insert the conductor spacer into the window piece.

c. Clamp the conductor spacer and cable in folding tool and bend conductors at a 90 degree angle across the wedge groove.

8.4.1 MOLDED-ON PLUG ASSEMBLY (Continued)

d. Fold the conductors into the conductor spacer groove utilizing the folding tool.

e. Remove spacer and folded cables from folding tool.

f. Press insulator into the conductor spacer groove and trim the insulator flush with the sides of the conductor spacer.

g. Mold the insert around the assembled parts. The suggested molding procedure is given below. Molding temperatures and pressure shall be applicable to manufacturer's instructions:

1. Install proper mold halves into the molding machines and heat the mold.
2. Load hopper with dry molding material, and heat the material.
3. Purge machine, and charge cylinder with approximately 20 percent more material than is required for the part.
4. Insert cable spacer, and place the assembled parts properly in the lower mold half.
5. Close the mold-halves and apply pressure. Hold the pressure for 15 to 20 seconds.
6. Release pressure and recharge cylinder.
7. Allow 40 to 50 seconds cooling time between pressure release and opening of the mold halves. (Cycle requires approximately 1 minute.)
8. Open mold halves about 0.5 inch and pull bottom insert out. Open mold halves more to eject the molded part, and remove molded part from machine.

h. Remove cable spacer from between cables and trim sprues from molded plug body.

i. Dimple shell with a spring-loaded punch to keep shell on molded body. Dimples must be 120 degrees apart and 0.09-inch from front rim of shell.

j. Pot base of plug with potting compound per procedures described in paragraph 8.5.

k. Apply a thin film of silicone primer (GE-554004 or equivalent) into the seal groove of plug housing, and allow to cure.

8.4.1 MOLDED-ON PLUG ASSEMBLY (Continued)

l. Apply a thin film of adhesive (GE-RTV118 or equivalent) into the seal groove of the plug housing.

m. Install the silicone rubber seal into the groove. Make sure that the seal is seated properly.

8.4.2 MOLDED-ON CYLINDRICAL PLUG PROCESS VERIFICATION

Examine the completed plug to assure that all provisions of this document and applicable engineering documents are complied with. Particular care shall be exercised during the assembly operation to ensure reliability. The following precautions are provided for specifying those inspection points necessary in the assembly of a molded-on cylindrical plug-flat cable assembly:

a. The operation of threading the conductors into the plug is particularly critical. Care must be taken not to damage the conductors during the insertion process. Any bends, kinks, or scratches should be cause for rejection if they affect proper seating of the conductors in the windows.

b. Inspect the conductors, after folding, for separation of plating around the area of the fold after each operation.

c. Verify that molding operation has been properly performed as described in steps g-1 through g-8 of paragraph 8.4.1.

d. The potting compound in the base of the plug should be checked for quality as described in paragraph 8.5.8.

e. Inspect for excessive adhesive around or on the seal and for proper cure.

8.5 POTTING ENCAPSULATION

The procedures described in the following paragraphs are to be used in potting plug assemblies with elastomeric compounds. The criteria conforms to, and shall be used in conjunction with all requirements of procedures MSFC-SPEC-222 and MSFC-PROC-196, for using epoxy resin compounds.

8.5.1 PROCESS CONTROL REQUIREMENTS

Prior to the potting operation, verify that the plug assembly bears evidence of inspection acceptance for compliance to design requirements and

8.5.1 PROCESS CONTROL REQUIREMENTS (Continued)

workmanship. Care shall be taken to assure that all foreign material, such as dirt, oil, or grease, has been removed from the plug and cable areas to be potted. If contaminants are present, they shall be removed by wiping with a clean lint-free cloth, dampened with a suitable cleaning solvent, followed by wiping with a clean dry cloth.

8.5.2 CONTROL AND CLEANLINESS OF POTTING FACILITY

The potting facility shall be isolated from such contaminants as dust, metallic particles, water, oil, and grease. Bench tops shall be protected from spillage by disposable coverings, and floors shall be cleaned frequently with an acceptable cleanser. The temperature of the potting facility shall be maintained at 24 $\pm$ 2 degrees Celsius; and the relative humidity shall not exceed 55 percent. Adequate ventilation shall be provided to accommodate the volume of compounds, solvents, and primers being used. Forced-draft ventilation, where toxic fumes are generated, is necessary and fumes shall be drawn away from the operator and vented to the outside.

8.5.3 EQUIPMENT

The potting area should be equipped with air pressurization equipment capable of delivering moisture-free air (maximum 90 psig), and a vacuum system capable of producing a differential pressure for removing trapped air from the potting compound. Accurate weighing equipment shall be provided for measuring the potting constituents. The injection gun shall be either a manual or air-operated calking gun equipped with a disposable plunger, liner, and nozzle. In addition, holding racks should be available to hold the harness components rigid and in proper alignment.

8.5.4 HANDLING PRECAUTIONS

All personnel that are engaged in potting encapsulation shall demonstrate proficiency in producing high quality end items, and be trained in proper handling procedures. In general, the chemicals involved are safe when properly handled by trained and qualified personnel, but when carelessly handled, the materials utilized for potting may cause severe physiological reactions. The

8.5.4 HANDLING PRECAUTIONS (Continued)

following criteria shall be implemented, in conjunction with manufacturer's instructions, to insure safe handling procedures:

a. Avoid contact with solvents, primers, and compounds with the skin. Protective clothing shall be changed when soiled by potting materials, and shall be laundered prior to reuse. Special care shall be taken to prevent contact with open breaks on the skin.

b. Avoid ingestion and inhalation of vapors.

c. If the eyes are accidentally contaminated, flush with water and obtain medical attention immediately.

d. Areas of the skin exposed to solvents, primers, and compounds shall be cleaned with an approved cleaner and then with a nonabrasive soap and clean water. Personnel shall not smoke or eat until after thorough cleansing of exposed skin areas.

e. No smoking or open flames shall be allowed within 25 feet of an operation where compounds, primers, and solvents are being used. "NO SMOKING" signs shall be displayed in conspicuous places.

f. Cosmetics and hand creams shall not be used by the operators.

8.5.5 PLUG AND CABLE PREPARATION

To insure proper adhesion of the potting compound to all components, the plug, cable, and all other materials that will contact the compound must be clean and free from any trace of contaminants. Caution must be exercised during cleaning to insure that cable insulation and plug components are not exposed to cleaning solvent to the extent that swelling or other indications of damage occur. Upon completion of cleaning, primer shall be applied to the cable insulation 0.125 $\pm$ 0.06-inch above the area to be covered with the potting compound and to all surfaces of the plug coming into contact with the potting compound. The primer shall be cured in accordance with manufacturer's instructions.

8.5.6 POTTING COMPOUND PREPARATION

Prior to preparing the potting compound, verify that the resin and activator have been successfully acceptance tested and that the shelf life has not expired. The following procedures should be followed in preparing the compound for application:

8.5.6 POTTING COMPOUND PREPARATION (Continued)

a. Place the resin and activator (in the proper proportional ratios) in a clean, dry, nonporous container having at least four times the capacity as the volume of the combined parts. Blend the resin and activator thoroughly by mechanical agitation or by stirring with a clean spatula. Avoid fast stirring that may entrap excessive air.

b. Place the container in a vacuum chamber and apply a vacuum. Maintain the vacuum until foaming subsides, but not more than 10 minutes.

8.5.7 POTTING REQUIREMENTS

The potting process shall conform to all requirements of MSFC-PROC-196; facilities, equipment, safety precautions, personnel proficiency, and process controls shall be fully complied with. Upon verification of the preceding requirements the potting process shall be performed as described in the following procedure:

a. Transfer the mixed compound from the mixing container to the injection gun cartridge by carefully and slowly pouring the compound down the side of the cartridge, using care not to entrap air, until the desired level in the cartridge is reached. Put the plastic plunger in place and insert the cartridge into the gun. Attach the correct size nozzle for the applicable potting job and adjust the air pressure supply to approximately 15 psig.

b. Test the injection gun for free and even flow of compound from the nozzle.

c. Prepare a hardness test sample from each mixed batch by using a small container to make a "button" of the compound (approximately 1 inch in diameter by 0.750 inch thick). Cure according to the same schedule assigned to the job it is taken from. The button shall accompany the connector throughout the remainder of the cure cycle.

d. Position the nozzle at the center of the plug and start the flow of the compound.

e. Start the flow of the compound, assuring an even flow.

f. Keep the nozzle tip at the swell level and continue the injection until the required level is attained. Let the compound settle a minimum of 5 minutes and replenish to the required level.

g. Cure the potting compound as recommended by the manufacturer.

8.5.8 EXAMINATION OF POTTING

The potted plug assembly shall be examined for general appearance and quality of workmanship. The surfaces of the potted area shall be free from voids, blisters, tackiness, soft spots, cracks, discoloration, lumps, non-adherence, or any defect indicative of low quality resin or poor workmanship. The hardness of the resin shall be determined by three readings, using the D scale of a Shore Durometer, or equivalent. The readings shall be made on a flat surfaced sample "coupon" prepared and processed per MSFC-PROC-196.

CAUTION: Care shall be used in handling and examination of assemblies potted with epoxy resins. The rigid, sharp edges of the cured resins may cut, mar, or mutilate the cable assembly if the cable is forcefully handled.

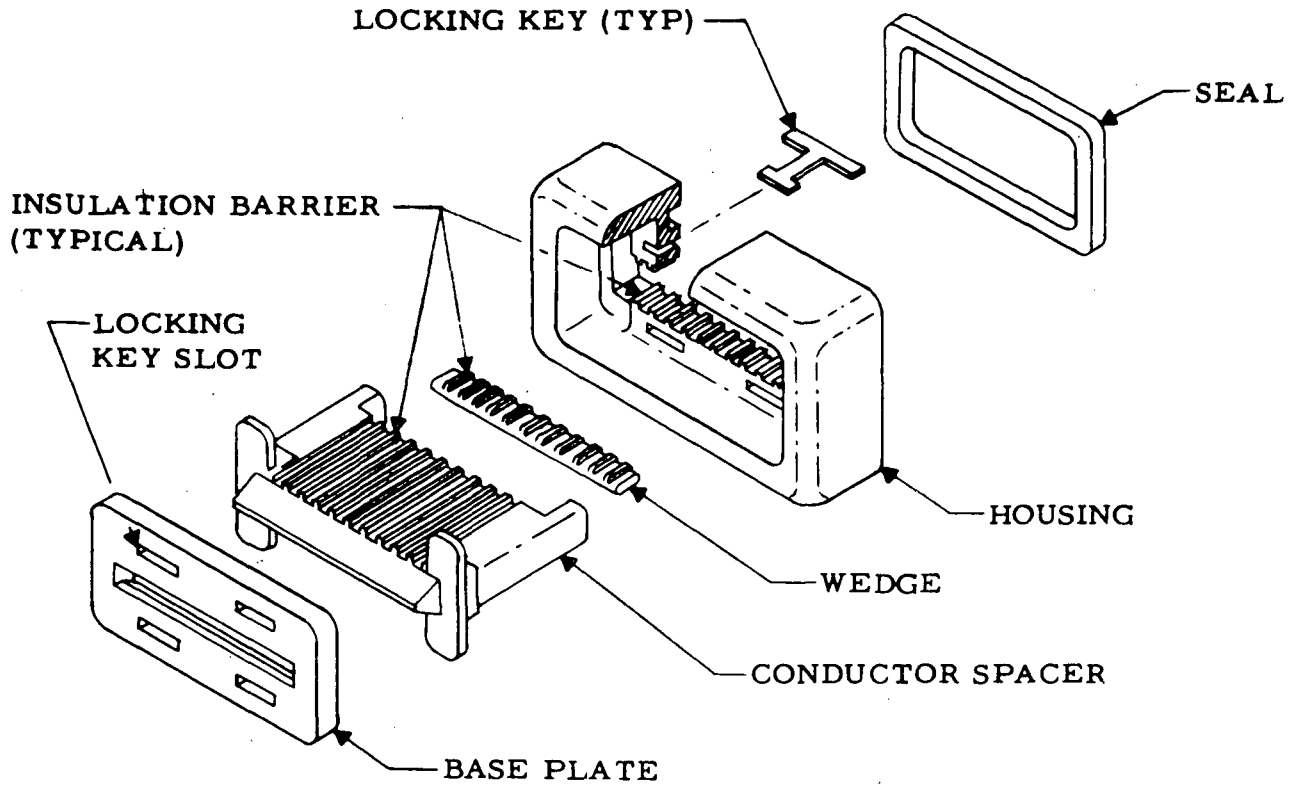


FIGURE 8-1 TYPICAL PREMOLDED RECTANGULAR PLUG PARTS

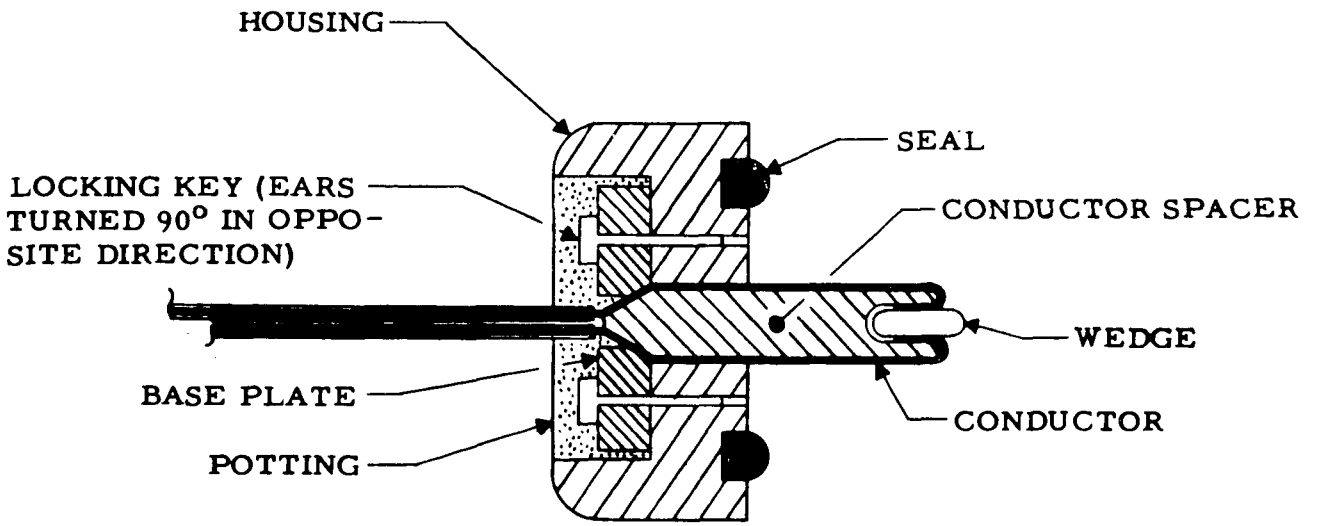


FIGURE 8-2 PREMOLDED RECTANGULAR PLUG (SECTION)

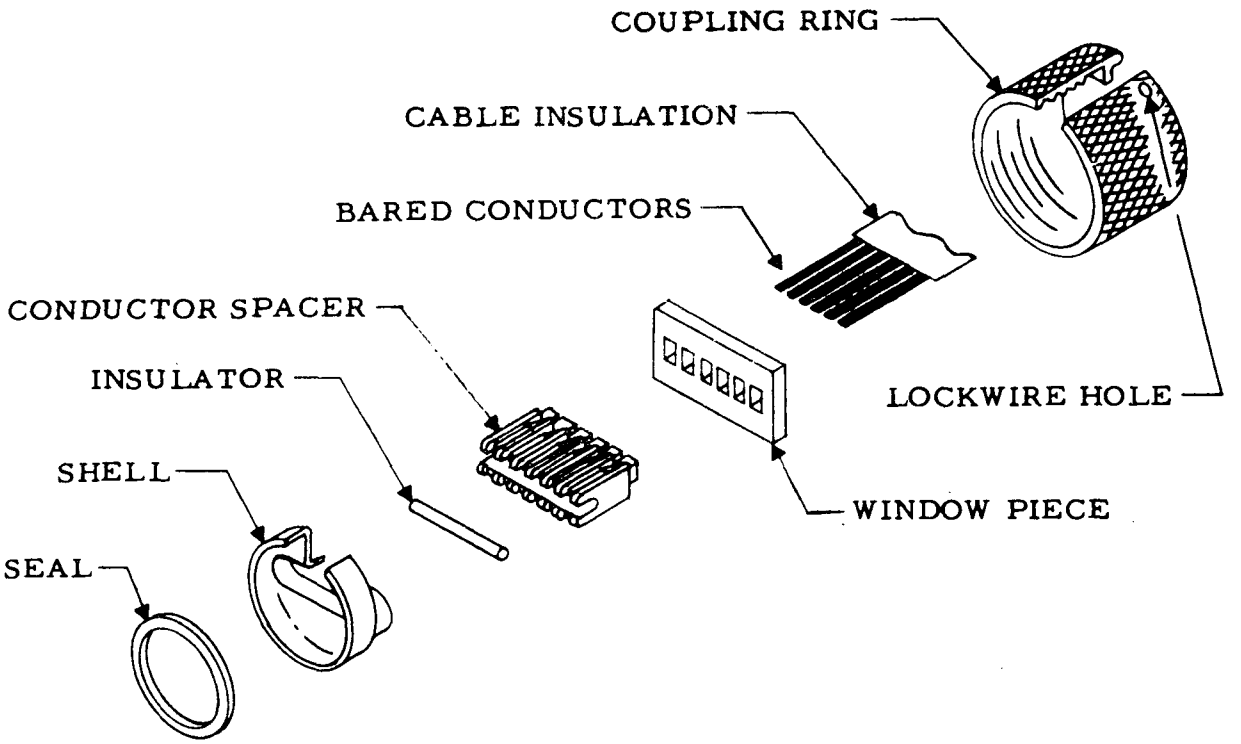


FIGURE 8-3 CYLINDRICAL PLUG PARTS

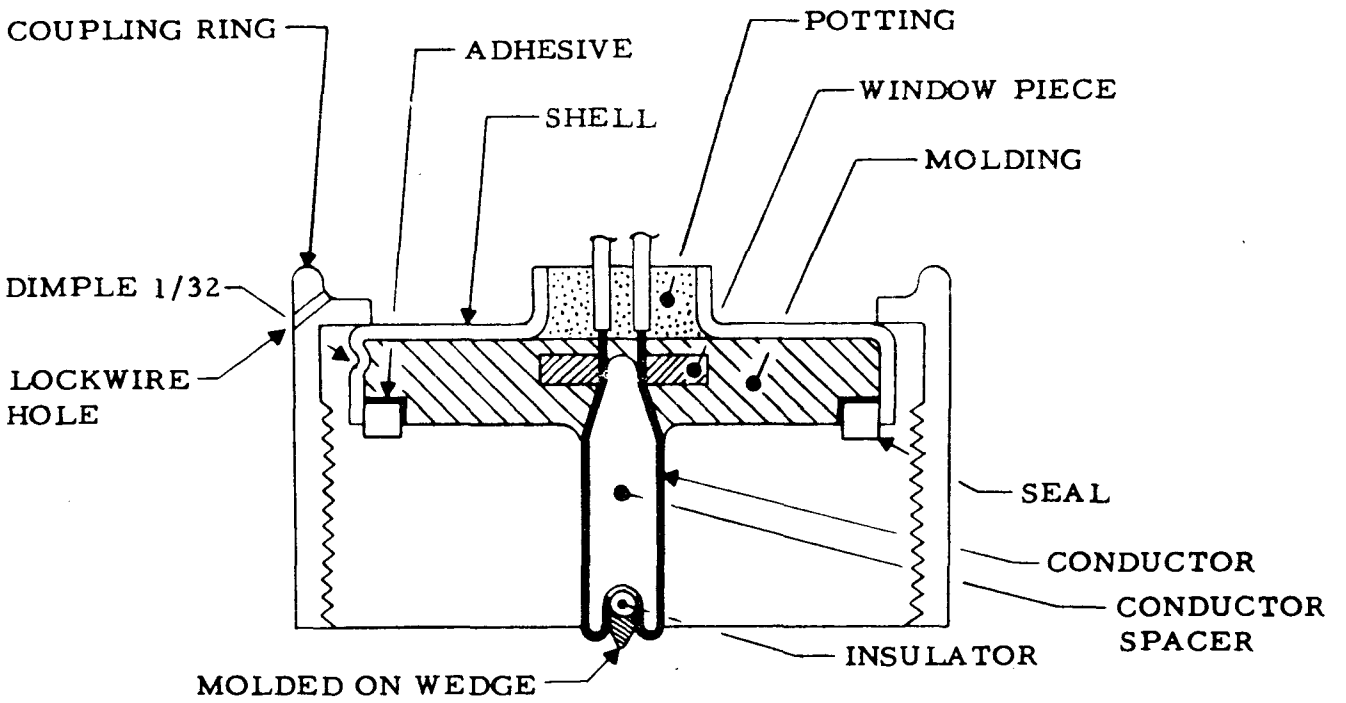


FIGURE 8-4 CYLINDRICAL PLUG (DIMPLED)

SECTION 9
HARNESS IDENTIFICATION

9.1 GENERAL

This section defines the requirements for both temporary and permanent identification of flat-conductor cable harness assemblies and connectors, including the criteria for temporary markings that are necessary to facilitate harness installation.

9.2 TEMPORARY HARNESS IDENTIFICATION

Temporary identification for scheduling and process control which is not required for the finished assembly is permissible. Such identification markers shall not adversely affect the assembly, and shall not appear on the completed harness.

9.2.1 TEMPORARY IDENTIFICATION METHODS

Tagging may be used to temporarily identify harnesses, although identification-marking-by-packaging shall be used in preference to tagging for harnesses which can be placed in a package conveniently. When used, tags shall be of cloth or pressed fiber, and shall be legibly marked by impression stamping or other permanent method using characters at least 3/32 inch high. Tags shall be securely attached to the harness with cord, or by wrap around in a manner that will not damage the assembly in processing, shipment, or storage. Application of adhesive tags is not recommended due to the possibility of harness contamination.

9.3 PROCESS CONTROL

Before application of the permanent harness and connector identification markings, verify that the narness assembly complies with the applicable sections of this document, and design engineering requirements. Verify that the harness configuration and temporary harness identification agree with the design engineering drawings, and connector "P" (plug) numbers are correct. After removal of the temporary identification markers, verify that harness surface is not contaminated or damaged such as cuts, nicks, or abraded areas.

9.4 IDENTIFICATION CRITERIA

The combination of letters and numbers which constitute the identification code shall be in accordance with design engineering drawings. Unless otherwise specified on the applicable drawings, identification shall be applied directly to a piece of insulated sleeving or a band marker, as applicable. Application of identification shall not cause damage to the sleeve or marker, and the identification shall be applied so that it cannot be readily rubbed off. Identification markers shall withstand the same temperatures and other environmental conditions to which the harnesses are subjected.

9.4.1 HARNESS ASSEMBLY IDENTIFICATION

The harness reference designation and part number shall be stamped on a band marker or insulated sleeve as described in the applicable procedures and as illustrated in Figure 1. The marker or sleeve shall be placed as close as possible to the lowest alpha numbered connector (i.e., "P1") on the harness, but not more than 12 inches from the connector.

9.4.2 CONNECTOR IDENTIFICATION

A band marker or insulated sleeve marked with the applicable connector reference designation and mating part reference designation, shall be located adjacent to each connector as illustrated in Figure 2.

9.4.3 ACCESSIBILITY

The identification shall be installed so that it is readable from the normal point of observation. Specifically, if there is a choice of installing the identification "upside down" or "right side up" from the normal point of observation, the identification should be installed "right side up". The numbers may read either toward or away from the terminated end of the harness. An objective shall be to position all identification markers on the harnesses so as to provide maximum visibility after installation. Every effort shall be made to locate identification so that clamps, support devices, etc., do not have to be removed, or the harness twisted, in order to read the identification.

9.4.4 LEGIBILITY

All identification characters shall be legible, permanent, and colored (where applicable) to contrast with the surface on which the identification

9.4.4 LEGIBILITY (Continued)

is placed. The characters shall be of sufficient size and color to provide ease of identification through fabrication, checkout, and mission duration.

9.5 IDENTIFICATION OF HARNESSES

All harness assembly identification criteria shall be marked by direct application on band markers or by means of a stamped piece of sleeving. Regardless of the method selected, an attempt shall be made to use the same method for all identification purposes so that uniformity can be maintained. All identification markers shall be firmly secured to the harness so as to prevent loss of markers from shock, vibration, etc.

9.5.1 MARKING EQUIPMENT

Band marker and sleeve identification marking shall be accomplished with calibrated marking machines as specified in the applicable process specification or manufacturer's instructions for detailed calibration and operation of the machine. Marking shall be performed utilizing a marking machine with automatic foil and work feeds (optional), adjustable pressure and dwell time. Marking materials (such as foils, inked ribbons, etc.) shall be selected to correspond with the base material being identified.

9.5.2 MARKING PROCESS CONTROL

Prior to hot impression marking of the identification bands and sleeves, assure that:

1. Band marker or sleeving is free of dust, grease, or other foreign matter.
2. The correct size of type is selected per the manufacturer's instructions. Flat faced type shall be used for marking identification plates, bands, and sleeving not supported by a mandrel.
3. Marking machine has received periodic inspection and maintenance at intervals that will assure that the machine and accessories are in good operating condition. Marking foil is the correct type required for the type sleeving or band material to be marked.

9.5.3 APPLICATION

Identification shall be imprinted on band markers or sleeves using an approved method which will not impair the quality of the marker or sleeve.

9.5.3 APPLICATION (Continued)

When the direct stamping process is used for band markers or sleeve identification, the following procedure shall be used:

a. Regulate the pressure, indicated type temperature, and dwell time for each material to provide maximum transfer of pigment from foil to the material being imprinted, and for best legibility. Use the lowest pressure and shortest dwell time that will produce a legible and permanent imprint, to prevent penetration of the type through the material.

b. Use characters of sufficient size and machine adjustments necessary to provide markings for best legibility.

c. To prevent uneven depth marking, make sure that type faces are clean and that all characters are set in the same plane. Plated and unplated type may be of different depths and should not be used together.

9.5.4 STAMPED INSULATION SLEEVE IDENTIFICATIQN METHOD

Harness identification criteria may be applied by affixing marked, nonmetallic sleeves imprinted with the applicable identification data. Sleeving material shall withstand the same temperatures and other environmental conditions to which the wire harness is subjected. When the harness identification criteria is applied utilizing sleeves, the following procedure shall be used:

a. Select the correct size sleeve to fit over the harness. Where possible, the sleeve should be snug enough so that subsequent string ties are unnecessary.

b. Apply the identification markings to the sleeve using the direct stamping application procedure described in paragraph 9.5.3.

c. Cut the sleeving so that each length includes a complete identification. The sleeve shall be no longer than necessary to include all identification information plus a margin for clarity.

d. Locate the identification sleeves on the wire harness as described for the applicable identification requirement.

9.5.5 BAND MARKER IDENTIFICATION METHOD

Identification of harnesses may be accomplished by affixing marked, nonmetallic band markers or identification plates imprinted with the applicable

9.5.5 BAND MARKER IDENTIFICATION METHOD (Continued)

identification data. All band markers, identification plates, and adjustable cable straps used for identification purposes shall meet design standard 40M39582. When harness identification criteria is applied utilizing band markers, the following procedure shall be used:

a. Select the desired size identification plate and strap (if required) to fit over the harness.

b. Apply the identification markings to the plate using the direct stamping application procedure described in paragraph 9.5.3. Flat-face type and foil must be used. More than one number, or row of numbers may be stamped on a single band marker.

c. Place the plate and strap(s) around the wire bundle and run strap tip through the hub. The ribs must be placed against the wire bundle. Pull the strap(s) tightly around the wire bundle by hand.

d. Tighten strap(s) using manufacturer's recommended tool and procedure, taking care not to damage the wire harness, and cut excessive strap length.

9.6 LOCATION MARKER IDENTIFICATION

Non-metallic identification markers may be installed on the harness assemblies to reference and identify specific locations during harness installation. Band markers or insulated sleeves shall be stamped with applicable stringer, station, frame, aximuth, grid, or plane location markings, and located on the harness to aid in installation and configuration control.

9.7 IDENTIFICATION PROCESS VERIFICATION

Visually examine the final harness and connector identification markings to assure that:

a. The identification marker material is of the correct type and style.

b. The identification marking agrees with applicable engineering drawing.

c. Lettering or numbering is legible.

d. Identification markers are located properly.

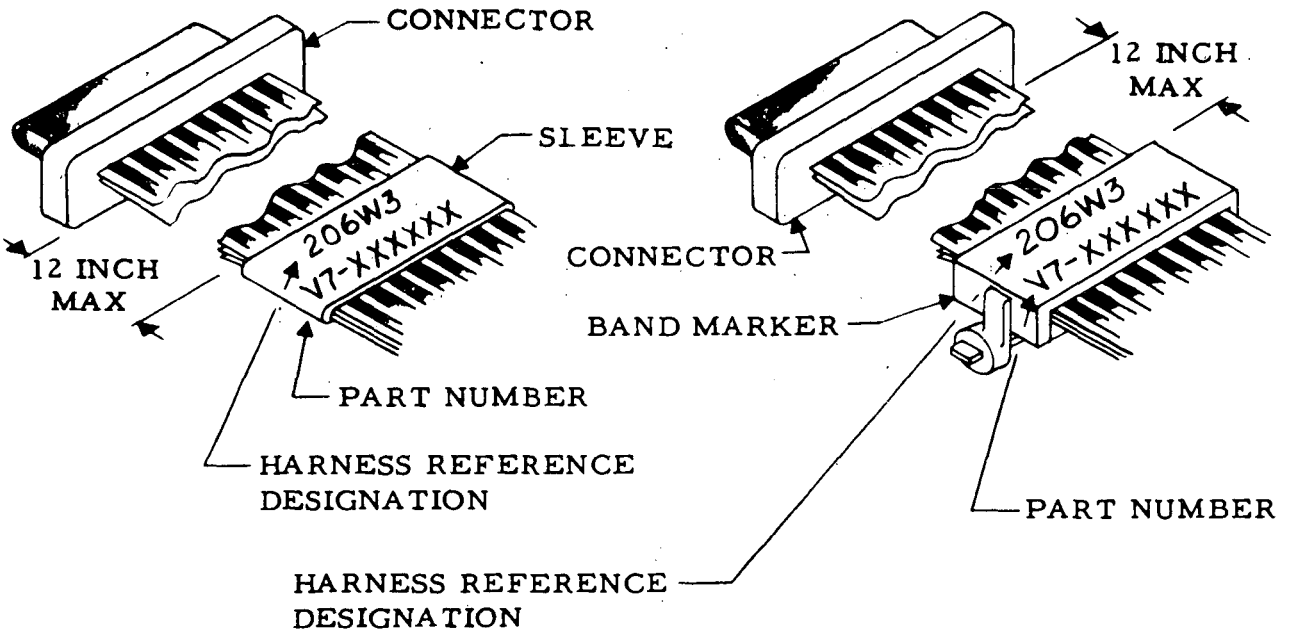


FIGURE 9-1 IDENTIFICATION OF HARNESS ASSEMBLY

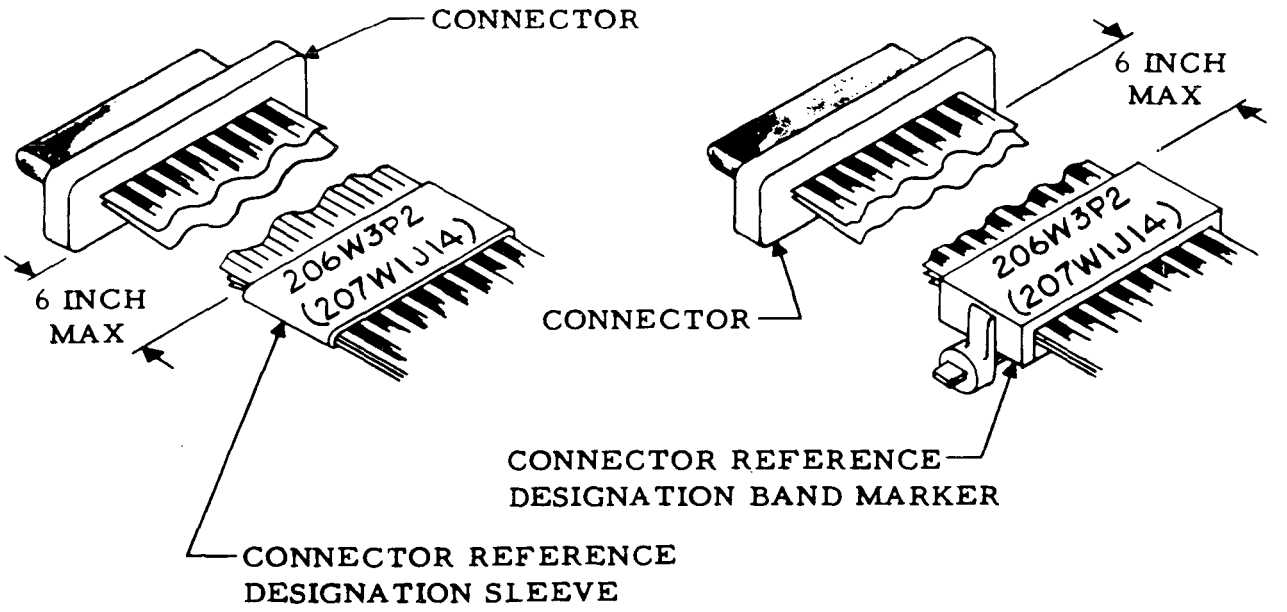


FIGURE 9-2 IDENTIFICATION OF CONNECTOR PLUGS

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SECTION 10
HARNESS CLEANING

10.1 GENERAL

This section establishes the procedure for cleaning flat conductor cable harness assemblies, after completion of final fabrication and test. The cleaning procedures outlined in the following paragraphs shall be used in conjunction with the handling and packaging criteria contained in Section 11.

10.2 PROCESS CONTROL REQUIREMENTS

Prior to cleaning, assure that the harness assembly has successfully met all previous quality and design requirements. Visually examine the assembly to assure that flat conductor cable and connectors are free of damage, and that the harness is properly identified. In addition, verify that the facility environmental controls are within requirements stated in the following paragraphs, prior to start of cleaning.

10.2.1 FACILITY REQUIREMENTS

Final harness cleaning and sealing shall be accomplished in a class 100,000 level clean room that complies with the intent of MSFC-STD-246A. The temperature shall be +68°F to +78°F, and relative humidity shall be 60%, or less, if necessary to preclude condensate forming. The garment requirements shall be coveralls, caps, and shoe covers, and the handling of the harness during cleaning operations shall be performed with clean, lint-free gloves. Records shall be maintained of the facilities environmental levels, with daily checks of temperature and humidity, and a minimum of three times a week for airborne particulate. Daily checks shall be performed to assure positive pressure differential and air flow of at least 40 FPM.

10.3 CLEANING OF HARNESS ASSEMBLIES

Completed harness assemblies shall be cleaned with either isoprophyl alcohol (FED-SPEC-TT-I-735, Grade A) or ethyl alcohol (FED-SPEC-O-EO-760) to remove all contamination and foreign matter. Harnesses subjected to the outlined method of cleaning shall not be immersed in the approved cleaning solvent, and will not require any form of heat drying. Complex surfaces shall

10.3 CLEANING OF HARNESS ASSEMBLIES (Continued)

be blown clean with nitrogen per MIL-P-27401, Type I, or dry air that has been cleaned and dried in accordance with the procedures specified in MSFC-PROC-404, except hydrocarbon content shall not exceed 15 ppm by volume.

CAUTION: Use of other than the above cleaning agents and methods may result in degradation to the connector materials and possible damage to the cable insulation.

10.4 CLEANLINESS VERIFICATION

The cleaning procedure employed shall remove traces of oil, wax, gum, dust, dirt, fingerprints, organic soils, scale, corrosion, and other foreign materials as determined by visual examination using black and/or white light inspection. Scale-free discoloration and specific surface treatments shall not be considered visual contamination. During final cleaning, particles of dust which are observed under black light, but are not visible under white light, shall be removed by the use of a vacuum; any other foreign matter on the harness shall be cause for recleaning. Upon verification of cleanliness, the harness shall be tagged, sealed, and packaged, as described in Section 11 of this document.

SECTION 11

HARNESS HANDLING, PACKAGING AND SEALING

11.1 GENERAL

This section establishes and defines the methods and requirements for handling, packaging, and sealing of flat-conductor cable harness assemblies.

11.2 PROTECTION LEVEL CRITERIA

Flat-conductor cable harness assemblies require varying degrees of protection at all times. The performance and/or reliability of the assembly can be directly affected by the lack of adequate packaging or protection during in-process handling, storage, and shipment. Harness assembly protection shall be considered as the application of protective measures to prevent damage from physical and climatic environments during intra/inter facility handling, in-process, transportation, and storage operations.

11.3 APPLICATION

The appropriate level of harness protection shall be implemented by the manufacturing planning documents, and shall provide the necessary information required to assure adequate protection from the initial processing of the flat-conductor cable, through shipment of the finished harness assembly.

11.4 IN-PROCESS HARNESS ASSEMBLY HANDLING PROTECTION

Harness handling shall be done carefully and held to a minimum to reduce the possibility of connector damage and work-hardening, or fatigue of the cable. All connectors shall be protected with suitable snug-fitting plastic dust caps as illustrated in Figure 1, except when it is necessary to work directly upon them, or when mated. Conductor ends shall be protected as illustrated in Figure 2. Care is required in handling completed harness assemblies which have been cleaned and packaged to prevent damage or rupture of the outer wrap or packaging.

11.4.1 INTRA-INTER PLANT PROTECTION

Whenever harnesses are required to be transported to a service or repair area, they shall be packaged for shipment so that the harness does not become damaged. Connectors shall be individually wrapped with nylon bags and cushion material to prevent damage to themselves or other parts of the harness.

11.5 FINAL HARNESS ASSEMBLY SEALING AND PACKAGING

Prior to the sealing of the completed and cleaned harness assembly, assure that all design criteria and cleaning requirements have been performed and are acceptable. Verify that each connector is protected with a plastic cap and over-wrapped with a nylon bag.

11.5.1 HARNESS ASSEMBLY SEALING

Completed flat-conductor cable harness assemblies shall be coiled to form a loop of sufficient diameter whereby the cable will not be creased or permanently deformed. It is advisable to package harness lengths longer than 5 feet in a handling device similar to that shown in Figure 3. Assure that connectors are adequately protected and cannot damage the flat-conductor cable insulation. Additional cushion material may be installed at this time. Place the harness into a clean nylon bag, purge with dry nitrogen, and immediately heat seal; then overbag with antistatic polyethylene film, 6 mils thick and heat seal. Identify the sealed harness per paragraph 11.5.4.

11.5.2 HARNESS ASSEMBLY PACKAGING

Prior to packaging, assure that the sealed harness assembly wrapping is free of pin holes, tears, or cuts, loose or damaged closures, or broken cleanliness certification decals.

11.5.3 PROTECTIVE CONTAINERS

Select a suitable size cushioned container to place the harness into. The container construction and material shall be on such integrity to provide positive protection from physical and climatic environments during storage and transportation. The container size shall be selected so that the harness, or handling device containing the harness, generally fills the container, but does not interfere with closing of the container. Additional cushion material may be added to firmly hold the harness and prevent excessive movement.

11.5.4 IDENTIFICATION

Each cleaned and bagged harness assembly and container shall have an identification label or tag attached to the sealed harness (may be inserted between the nylon and polyethylene bag) and attached to the outside of the container, or inserted in the container, if the label or tag can be viewed from the outside. The tag or card shall carry the following information:

DRAWING/PART NUMBER_____

E.O._____

SERIAL NUMBER_____

INSPECTED BY:_____

CONTRACT NUMBER_____

"THIS HARNESS ASSEMBLY HAS BEEN CLEANED IN ACCORDANCE WITH_____."

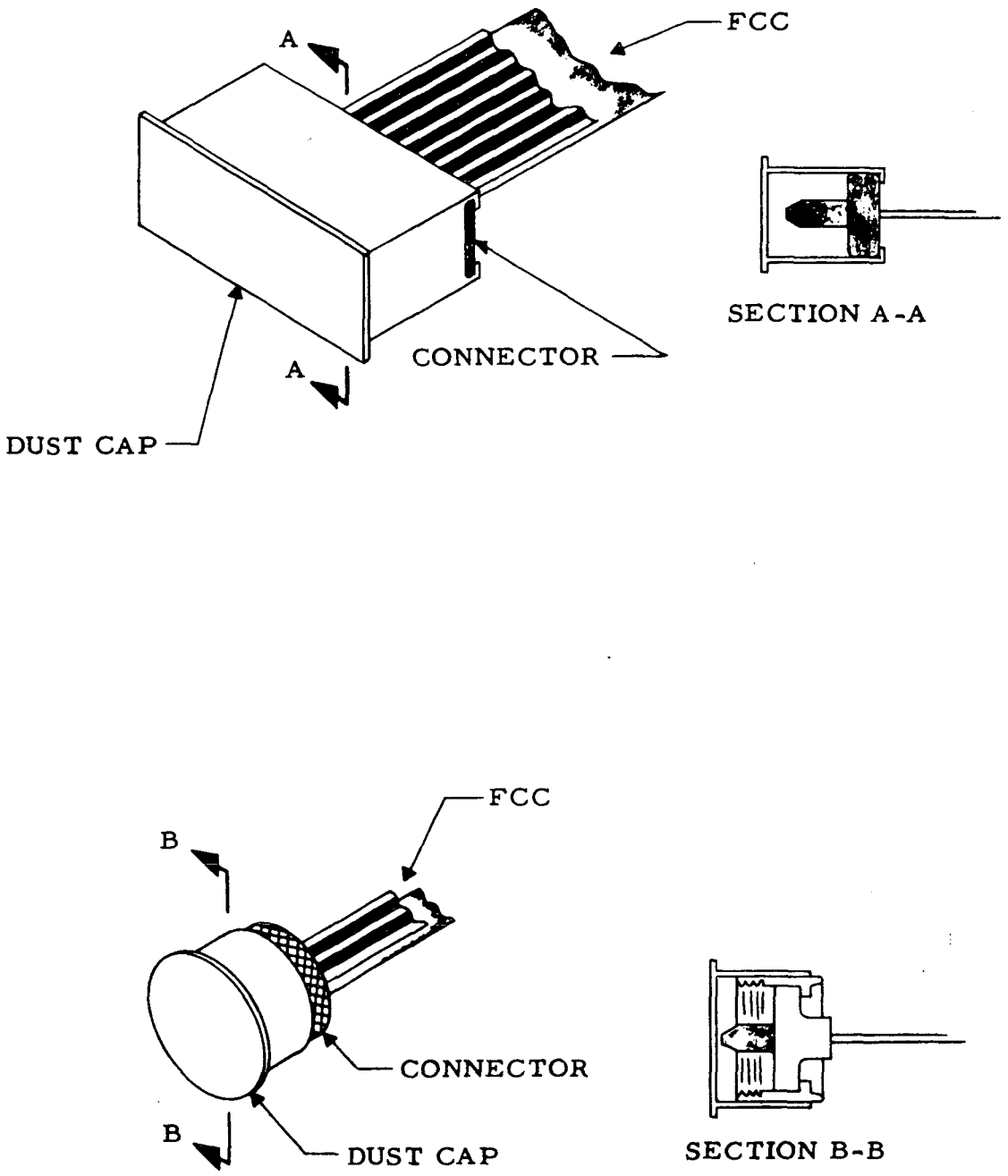


FIGURE 11-1 TYPICAL CONNECTOR DUST CAPS

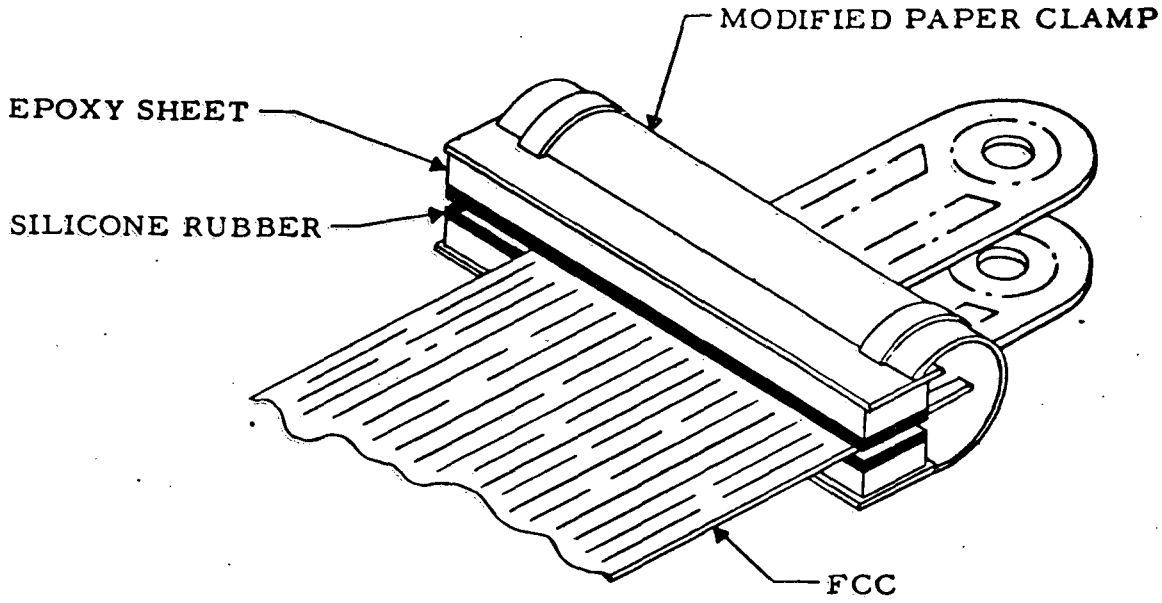
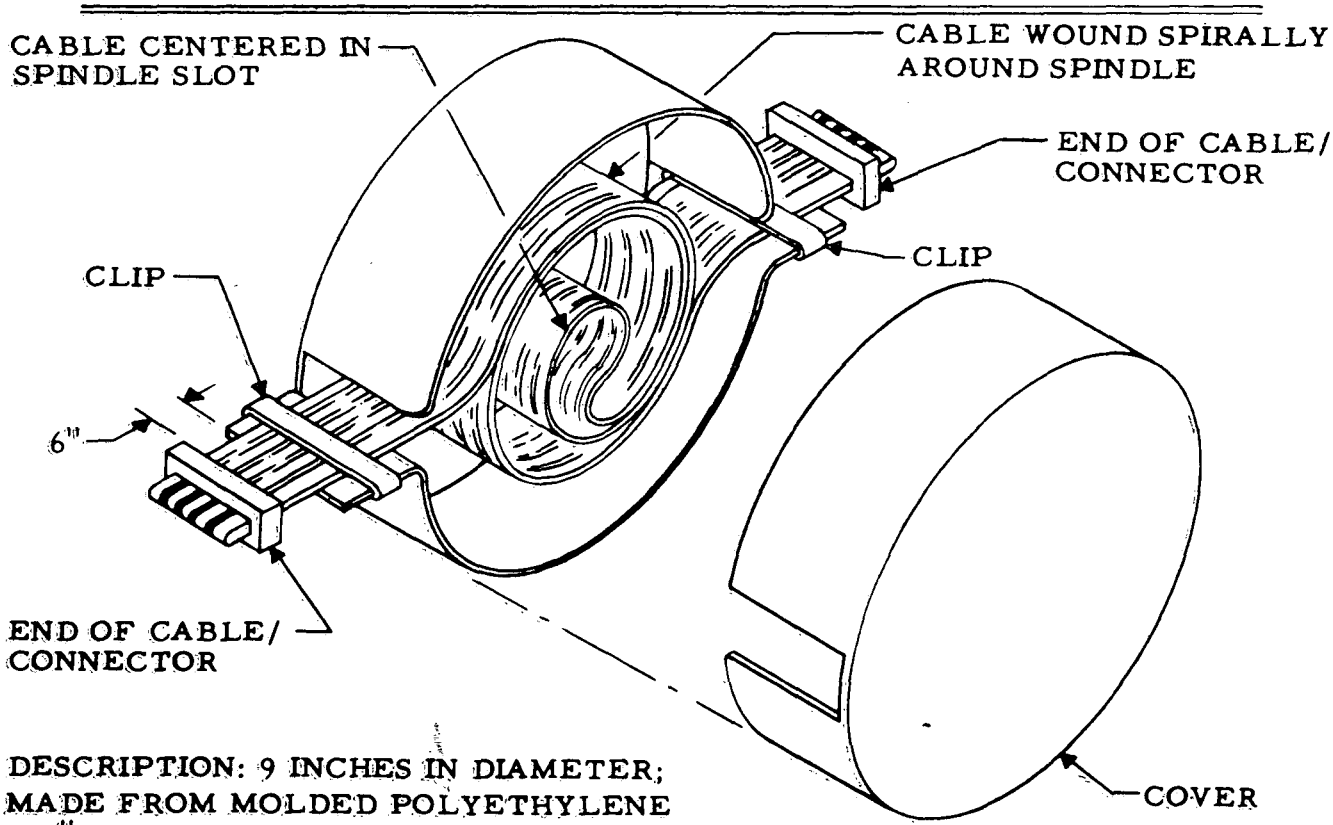


FIGURE 11-2 CONDUCTOR PROTECTING CLIP



DESCRIPTION: 9 INCHES IN DIAMETER; MADE FROM MOLDED POLYETHYLENE 1/8" THICK, WITH MOLDED COVER.

FIGURE 11-3 FCC HANDLING DEVICE

SECTION 12

HARNESS INSTALLATION

12.1 GENERAL

This section establishes the installation criteria that pertains to flat-conductor cable interconnecting harnesses. The intended application of Type VIII harnesses is for general use in areas outside the crew compartment.

12.2 PROCESS CONTROL REQUIREMENTS

Prior to installation of the completed harness assembly, verify that the harness has satisfactorily complied with all applicable processes, controls, and requirements of this document and applicable engineering design drawings. Assure that the harness has successfully passed functional testing and has been cleaned in accordance with Section 10 of this document. Special care shall be taken to assure that the harness packaging is free of physical or environmental damage, and identified in accordance with Section 9 of this document. Verify that the harness assembly is adequately protected from physical damage or contamination at all times, during and after installation, by application of temporary protective outer coverings. Before routing the harness assembly, verify that the area is ready for the harness, and that all sharp edges, protrusions, or structural members are covered with protective material as specified in the following paragraphs.

12.2.1 SAFETY

The application of safety measures and the required scope of compliance shall be determined by the Safety Representative. Care shall be exercised during the performance of the installation requirements of this document. Good workmanship practices are essential to the safety of the personnel installing the finished product, and to the equipment in which the harness may be an integral part.

12.2.2 FACILITIES

All harnesses shall be unpackaged and installed in a clean area. The general working area shall be maintained in a clean and orderly condition

12.2.2 FACILITIES (Continued)

at all times. Only tools, fixtures, test equipment, etc., which are required to perform the task shall be allowed in the area.

12.3 HARNESS PROTECTION

Where harnesses pass near sharp or abrasive surfaces and may come in contact with such surfaces due to stresses during handling or flight, the harness shall be suitably protected to avoid any damage. The following paragraphs establish criteria for determining harness protection requirements, and provide techniques for eliminating potential damage conditions.

12.3.1 PROTECTIVE DEVICE REQUIREMENTS

A complete visual inspection shall be made of all surfaces coming into contact with harnesses to verify that no sharp or rough edges exist. Protective devices shall be installed to provide permanent harness protection from abrasion or other damage. Protection shall be installed where harnesses are routed across protruding or sharp edges of structures; through or across unprotected holes or cutouts; where cables can contact protruding rivets or other fasteners; and at any location where the danger of chafing the harness exists. Particular attention shall be given to harness slack in this respect.

12.3.2 CHAFING

Harnesses must be protected against damage that may result from rubbing against a surface or edge, or against any other object. Locations of possible abrasion damage (chafing) to the harnesses are as follows:

a. Where a harness passes around a corner of a shelf, bracket, equipment or structure.
b. Where a harness passes through a hole, and a clamp or grommet along is not adequate.
c. Where a harness is exposed to excessive contact by personnel or equipment.
d. Where harnesses pass near sharp edges of bolts, nuts, or rivets.

12.3.3 HARNESSES ON OR NEAR MOVING PARTS

Harnesses that are attached to assemblies where relative movement occurs, or near rotating parts, shall be installed and protected in such a manner as to prevent damage caused by movement. This deterioration includes abrasion

12.3.3 HARNESSES ON OR NEAR MOVING PARTS (Continued)
caused by one harness rubbing against another or by twisting and bending. Harnesses should be rerouted or protective devices shall be installed to provide permanent protection from abrasion and/or other damage.

12.3.4 PROTECTIVE GROMMETS

Where harnesses are routed over, or may contact any protrusions or sharp edges, protection of the harnesses will be provided by covering the protrusion or sharp edge with Teflon cushion or equivalent material. Where harnesses are routed over or through structural members that have Teflon caterpillar-type grommets, rigid grommets, or any protrusions and sharp edges, the harness should be supported by clamping to prevent the possibility of chafing. Figures 1 and 2 illustrate typical installations where grommet protection would be applied. When necessary to trim grommets to obtain proper fit, the gap after installation shall not exceed 1/10th inch. The angle of the cut shall be 45 degrees to the axis of the wire harness.

12.3.5 PROTECTIVE CLAMPING

Approved clamps shall be used to maintain the separation between any surface and the harness assembly. Harnesses shall be prevented from moving inside the clamp by selecting the proper clamp size and installing it with adequate tightness (see Section 13, "Support and Clamping"). Clamps used to support and separate harnesses from adjacent surfaces shall be attached to structure for support whenever possible. If supporting structure is not available, the clamps may be attached to lines carrying inert fluids such as water, helium, or nitrogen. (For lines carrying flammable fluids, see paragraph 12.4.2.) If the clamps are attached to the lines carrying inert fluids, the clamps shall be located close to those clamps which support the line itself. Cables shall not depend on insulating tubing to maintain a separation from any adjacent surface; except that insulating tubing shall enclose the cables when they lie on the inner surface of metallic conduit.

12.4 HARNESS INSTALLATION

Where possible, all harnesses shall be installed in the form of quickly removable and replaceable harnesses, attachable to and detachable from the the adjacent harnesses, regardless of function, location, or form of electrical

connection. All harnesses shall be installed so that installation or removal of equipment is permitted. Harnesses shall not be pulled to facilitate installation, nor to secure additional slack. Any visible evidence of damage to the harness is cause for rejection.

12.4.1 ROUTING

All flat-conductor cable harnesses shall be routed to avoid abrasion, cutting, or piercing of the outer insulation by contact with rough surfaces, sharp edges, or shockmounted equipment. Harness assemblies clamped to the structure shall be routed as directly as possible (insofar as practical harness assemblies shall be mounted parallel and/or perpendicular) and shall be protected along traffic lanes and near entrance areas where the harness is susceptible to use as handholds, steps, or other misuse. Harnesses may contact other harnesses provided they are suitably attached and routed to:

a. Provide accessibility for inspection and maintenance.
b. Prevent harness deterioration from high temperature or cold temperature extremes.
c. Minimize possibility of damage.
d. Minimize the need for protective material.

12.4.2 ROUTING NEAR FLAMMABLE FLUID LINES

Cables and cable bundles should be separated and supported away from lines containing flammable liquids, gases and oxygen, and associated equipment. Cables and cable bundles shall not normally be attached to lines and equipment containing flammable liquid gases, unless flammable lines and equipment require electrical connections. When clearance is less than 2 inches, separation shall be maintained by attaching a cable clamp to a fitting on the equipment or a clamp on the line, and no less than 1/2 inch separation shall be maintained. Reference Figure 3.

12.4.3 ROUTING NEAR NON-FLAMMABLE FLUID LINES

Where necessary due to structural characteristics, harness assemblies may be clamped to a non-flammable fluid line for separation. Installations shall be separated from non-flammable fluid lines by a minimum of 1/2 inch. Reference Figure 3.

12.4.4 IMPROPER CONNECTIONS

Where similar connectors are used in adjacent locations, harnesses should be so routed and supported that improper connections cannot be made. When this requirement cannot be accomplished by routing, special markings or identification shall be provided to preclude improper connections.

12.4.5 DIRECTION OF BREAKOUTS

When breakouts of harnesses are made at a support clamp, they will, where possible, be made in a direction away from the clamp-cushion wedge or clamp-mounting screw. If the harness must break out in both directions, care shall be taken to ensure that the harness covering will not be damaged by the metallic portions of the clamp.

12.4.6 SLACK

Slack in harnesses between clamp installations shall be provided to avoid strain on cables in the harness or connections. Slack shall not be so great that the harness, under its own weight, or under acceleration or vibration loads, contacts sharp or rough objects that might damage the harness. Movement of the harness by hand shall not cause the harness to touch any adjacent surface. Movement by hand is defined as applying sufficient forces to move the harness without visibly distorting or moving the mounting clamps, or causing the harness to slide within the clamps. A 1/4 inch distance shall be maintained between the harness and any adjoining structure. Slack shall be minimized in order to achieve a neat and orderly appearance of the installation, but sufficient slack shall be provided for the following purposes:

a. To permit ease of maintenance and one or two reterminations, except where space limitation exist. In such cases, slack may be eliminated, providing no strain is placed on the cable termination.
b. To permit free movement of shock-and-vibration mounted equipment.
c. To prevent mechanical strain on the cable, cable supports, and cable junctions.

12.4.7 EXCESS LENGTH

Harnesses shall not be routed solely for the purpose of removing excess length. All excess harness shall be distributed throughout the total harness length, but shall not exceed the slack requirements between supports as specified in paragraph 12.4.6.

12.5 INSPECTION REQUIREMENTS FOR HARNESS INSTALLATION

Harness installation integrity shall be in compliance with all provisions of this document. Particular care shall be exercised to ensure such compliance prior to closeout of areas or where subsequent installations make inspection difficult.

CAUTION: Any inspections performed to verify integrity of installation shall be accomplished by visual examination where possible. Handling or movement of harnesses shall be minimized to that necessary to verify compliance. Due care must be exercised to avoid possible damage to a critical installation.

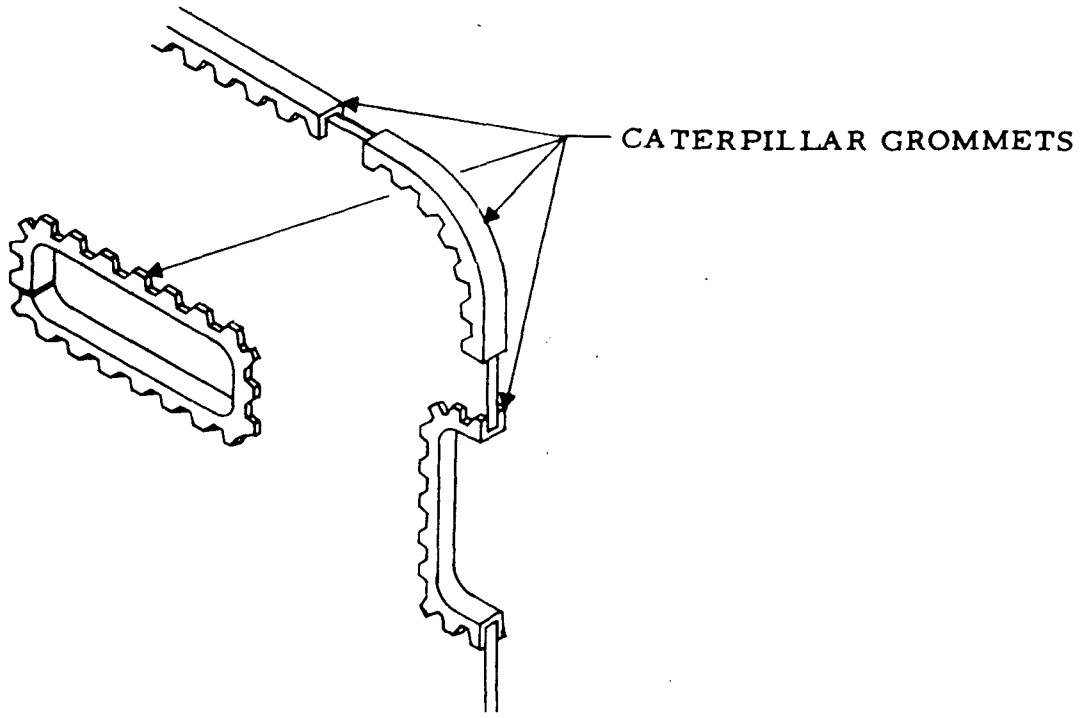


FIGURE 12-1 INSTALLATION OF CATERPILLAR GROMMETS

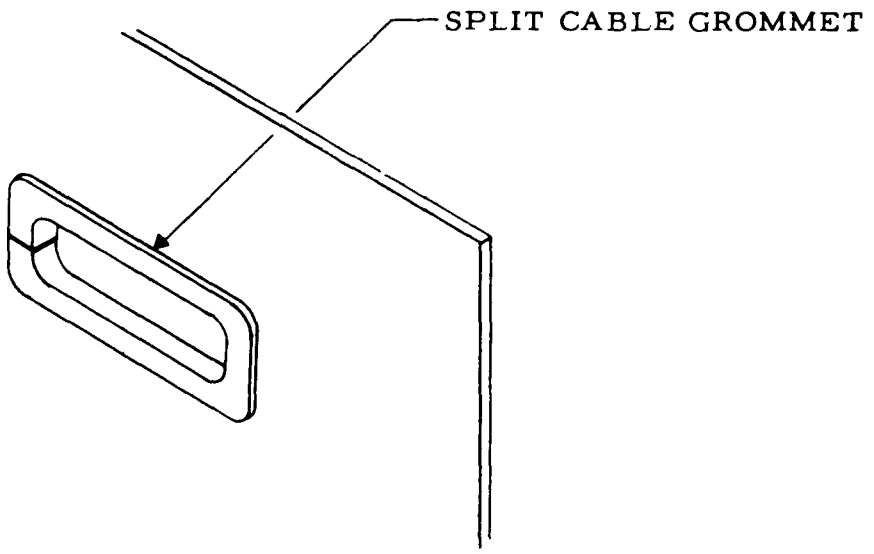


FIGURE 12-2 INSTALLATION OF SPLIT CABLE GROMMETS

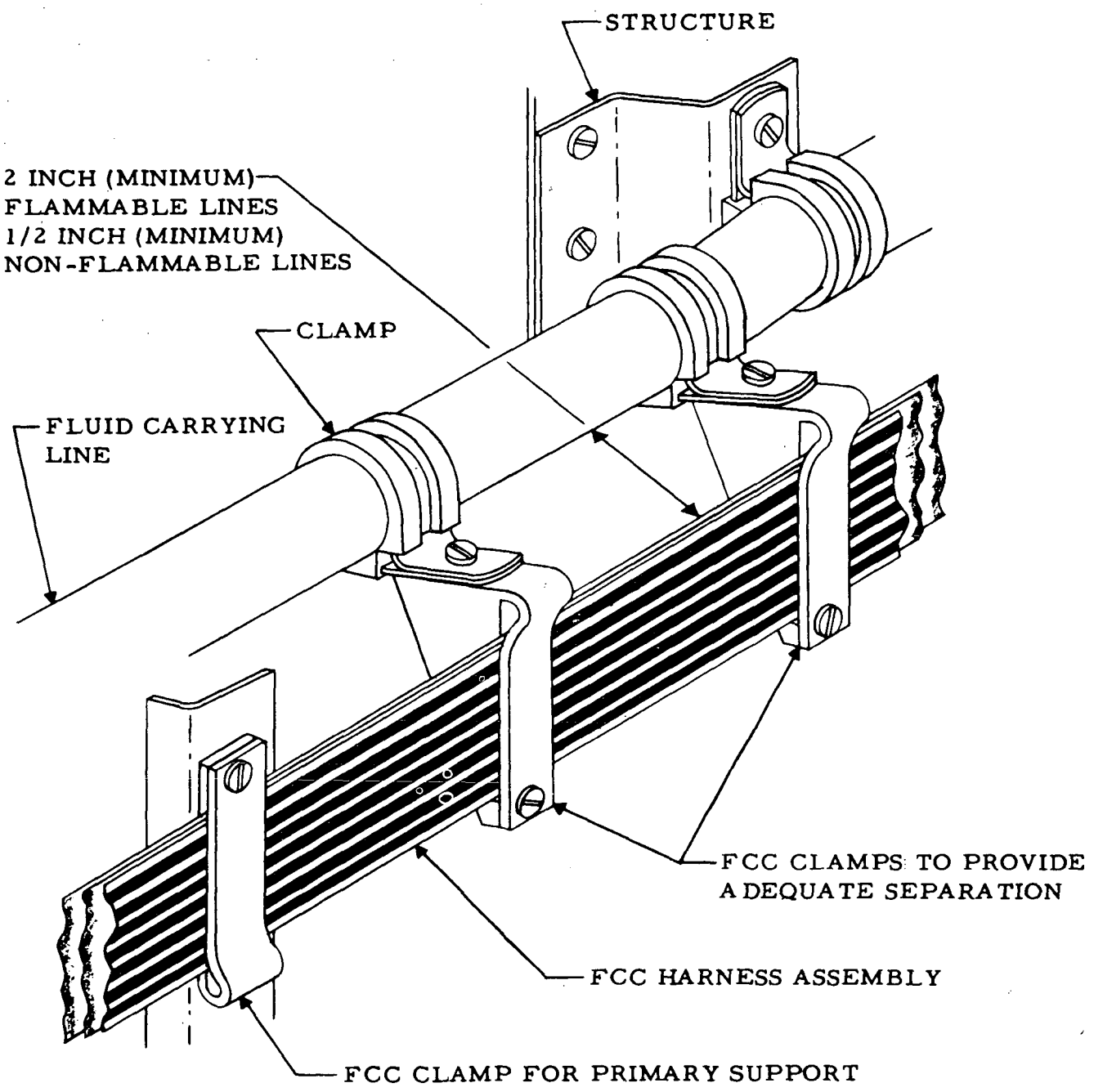


FIGURE 12-3 SEPARATION OF FCC HARNESSES FROM FLUID LINES

SECTION 13
SUPPORT AND CLAMPING

13.1 GENERAL

The primary purpose of the flat-conductor cable clamp is to secure and support the cable harnesses. These clamps are also utilized to reduce or eliminate vibration, to maintain clearance, and to relieve strain on cable terminating devices, shock/vibration mounts and other equipment. This section contains criteria relative to proper clamping techniques.

13.2 REQUIREMENTS

The standards, specifications, and engineering drawings that apply to installation of FCC harnesses shall include the clamping requirements for proper harness support. Installation of the supports and clamps for FCC is governed by the number of bundles, the distance between bundles, and the branches of each bundle. Cables are to be supported as required by engineering drawings, but the following criteria shall be considered during the installation process:

a. Prevention of chafing and migration within the support clamp.
b. Provision of clearance when harnesses are routed through or adjacent to bulkheads or structural members.
c. Maintenance of proper grouping during routing.
d. Prevention of mechanical strain that would break cables or connections.
e. Prevention of excessive movement under vibration.
f. Free movement of shock/vibration-mounted equipment.
g. Prevention of interference between harnesses and other equipment.

13.2.1 TEMPORARY SUPPORT PROVISIONS

All harnesses shall be adequately supported during installation to prevent damage due to excessive bending, kinking, or strain. Such supports shall be of a type which will not cause cold flow of the cable insulation. A simple hook, as illustrated in Figure 2, is sufficient for temporarily holding cables in place, and to allow additions or removal of cables without losing the position of the others. Regardless of the method selected, the support device must be capable of maintaining the harness(es) without

13.2.1 TEMPORARY SUPPORT PROVISIONS (Continued)

damage to the harness or adjacent structure or equipment.

13.3 CLAMPING DEVICES

In the fabrication and installation of harnesses, cushion-type clamps or non-cushion type clamps may be used for harness support. Clamping devices snall be of suitable size and type to hold the cables firmly without damage after fastening and without changing the shape of the bundle.

13.3.1 CLAMP SIZE SELECTION

Harnesses shall be supported by clamps as specified on the applicable installation drawing. To insure proper fit, it is recommended that provisions be made to allow deviation of clamp sizes larger or smaller that specified on the installation drawing. High temperature (200°C) cushioned, metal non-cushioned, or metal-cushioned, double grip clamps as illustrated in Figure 1, may be used on flat-conductor harnesses. In addition, the following criteria shall be used in selecting clamp sizes:

a. The size of the clamp shall permit the mounting tabs of the clamping device to be secured without deforming the cable harness.
b. Washers or other spacer devices shall not be installed on clamp mounting devices to obtain proper fit.
c. Deformation of the clamp or clamp cushion material shall be cause for rejection.
d. Clamps shall be of sufficient size that the harness is held firmly without the need of wrapped sleeving or tape, or the use of filler materials.
e. Clamp size shall be adequate to hold the harness securely in position without being pinched or damaged.
f. Clamping device shall have sufficient grip to prevent sliding of the harness inside the clamp after securing.

13.3.2 CABLE HARNESS INSTALLATION

Whenever a clamp is installed to support a harness, the entire harness must be contained within the clamp. The insulation material shall not be wedged between the mounting tabs of the clamp.

13.4 CLAMP AND SUPPORT INSTALLATION

Harness assemblies supported by clamps shall be secured to the vehicle structure with support sections as illustrated in Figure 3. The modular hole patterns on the clamp mounting surfaces permit the acceptance of the modular-width clamps selected. The various support sections may be bonded, riveted, or bolted to existing structure. When harnesses are routed over or through structural members that have grommets, or any other protrusions and sharp edges, the harness shall be supported by clamping to prevent the possibility of chafing.

13.4.1 LOCATION

Normal harness runs shall be supported by clamps at intervals of not more than fifteen inches. The location of clamp devices shall ensure harness support against vibration, chafing, or general harness damage, and shall be sufficient to maintain the desired harness installation configuration. The following criteria shall be used as a basis for nominal clamp spacing:

a. The distance between the first clamp and the back of the connector shall be no greater than 15 inches.
b. Harnesses shall be supported at intervals not to exceed 15 inches.
c. Where harnesses are routed through or over grommets, the harness shall be supported by clamping as close as practical to the grommet.

13.4.2 MOUNTING OF CLAMPS

Support clamps shall be firmly secured and installed at right angles to the harness to minimize the possibility of abrasion from edges of clamps. The installation of a typical high-temperature flat-conductor cable clamp is accomplished as follows:

a. The harness is aligned and positioned on the support.
b. The clamp is positioned on top of the harness.
c. The fasteners in each end of the clamp are aligned with the holes in the support.
d. Pressure is applied on the clamp until the spacers of the clamp come in contact with the support.
e. The fasteners are turned to secure the clamp to the support.

13.5 SUPPORT AND CLAMPING ACCEPTANCE CRITERIA

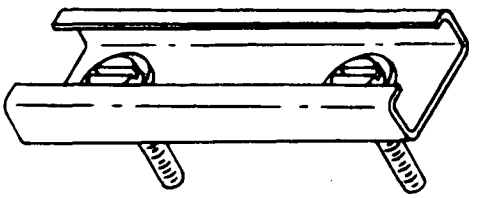
The installation of the supports and clamps for flat-conductor cable is governed by the number of bundles, the distance between bundles, and the branches of each bundle. Since the type of clamps and the exact method of installation will vary depending upon the particular application, a general inspection plan is presented. The installation of clamps and supports should consist of the following general inspection points and areas of concern:

a. Area of clamp or support attachment should be clean and free of all contamination and oxidation.

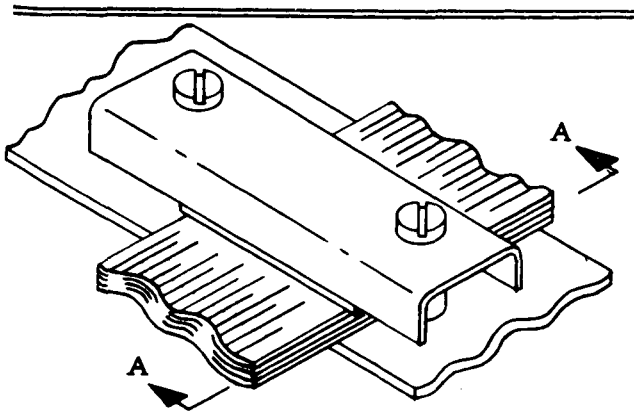
b. The clamps must be aligned properly to accommodate the number of cable bundles required.

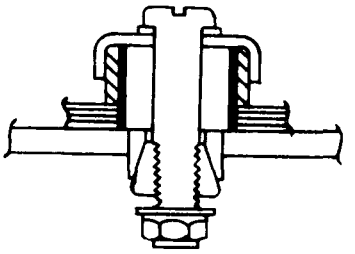
c. The clamps and supports should be placed at appropriate intervals to prevent excessive cable slack. Support should be placed at least every 15 inches.

d. Clamps should provide a snug grip on the cable bundles to prevent chafing and travel of the cable bundle.

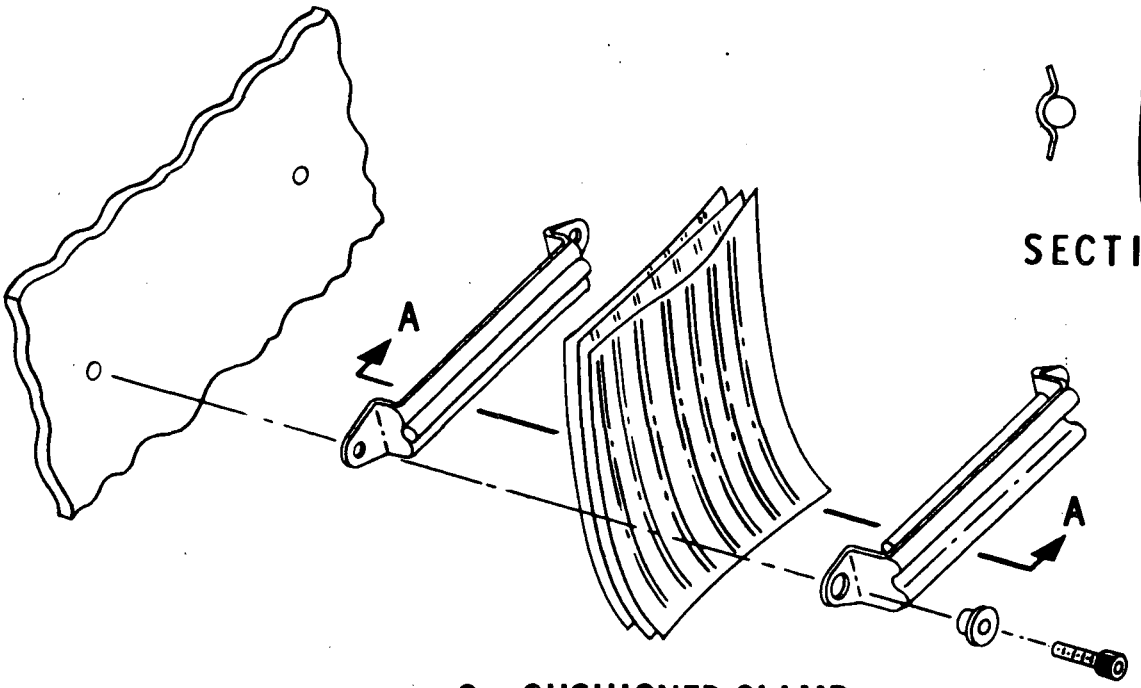


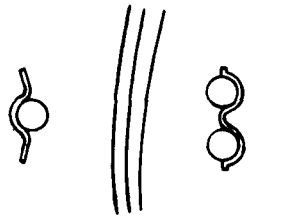
A. METAL NON-CUSHIONED CLAMP





B. DOUBLE GRIP CLAMP





C. CUSHIONED CLAMP

FIGURE 13-1 HIGH TEMPERATURE CABLE CLAMPS

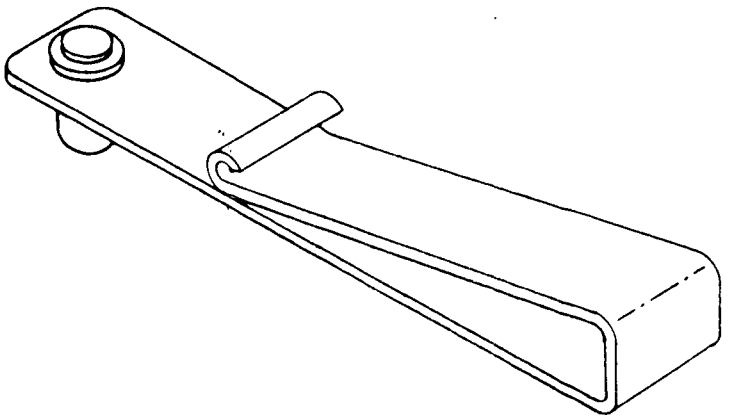


FIGURE 13-2 TEMPORARY FCC INSTALLATION SUPPORT HOOK

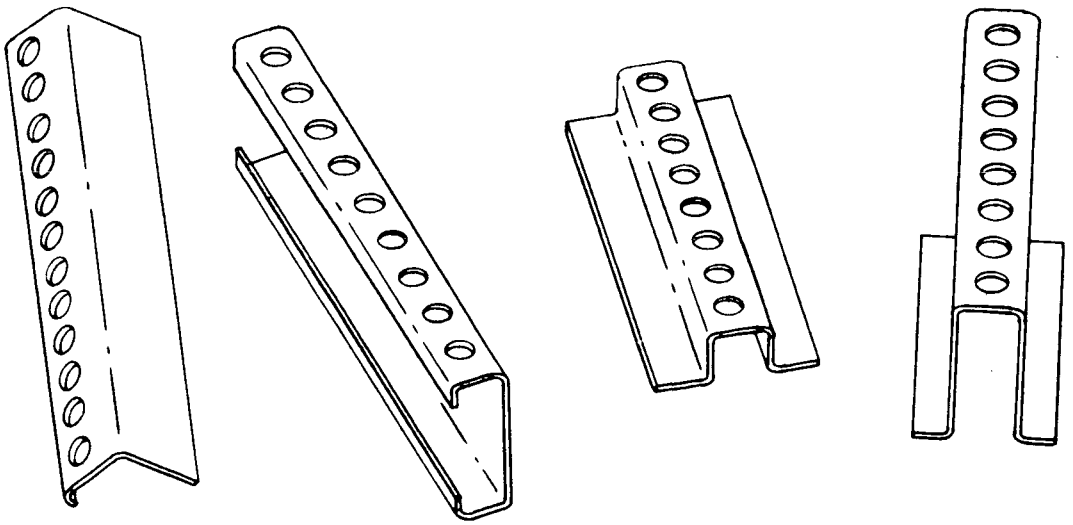


FIGURE 13-3 CLAMP SUPPORT SECTIONS

SECTION 14

CONNECTOR MATING

14.1 GENERAL

This section establishes the standard processes related to mating of premolded rectangular plugs and molded-on cylindrical plugs. The criteria contained in the following paragraphs shall apply to both type plugs, except where noted.

14.2 PROCESS CONTROL REQUIREMENTS

Immediately prior to mating, visually examine each plug to ensure that:

a. The insert faces are clean and free of chips, dirt, mold flash, or any foreign materials that would cause damage, or that would prevent the plug from easily entering the receptacle.

b. The plug seals are clean, free of damage, and properly cemented in the plug face.

c. The sockets in the receptacle are not abnormally recessed or extended.

d. There are no nicks, fractures, or imperfections in the connector housing.

e. The conductor plating is free of flaking, porosity, roughness, or non-adhesion.

f. Plugs and receptacles are properly marked so that "P" and "J" match, and key configurations are compatible.

14.2.1 CONNECTOR PROTECTION

All connectors shall have protective caps installed throughout all stages of fabrication and installation, except when mated. The caps shall provide both environmental and physical protection.

NOTE: Protective caps on the connectors may be removed during the visual examination, but must be re-installed and remain in place until the connectors are ready to be coupled.

14.2.2 PRECAUTIONARY PROCEDURES

Caution shall be exercised when mating connectors to ensure that damage does not occur to plug or receptacle. Under no conditions shall connectors be

14.2.2 PRECAUTIONARY PROCEDURES (Continued)

subjected to undue manual force during the installation process. In addition, the following precautionary procedures shall be adhered to:

a. There should be adequate cable length for bundle flexing during connector coupling and uncoupling.

b. Cable bundles shall not be pulled to obtain the required length needed to complete the mating of connectors.

14.3 CONNECTOR MATING

Mating procedures for the two types of connectors are covered in the following paragraphs; (1) the rectangular pre-molded type which utilizes plug retainer clips; and (2) the molded-on cylindrical type which secures with a threaded coupling ring.

14.3.1 RECTANGULAR TYPE CONNECTOR INSTALLATION

When rectangular type plugs and receptacles are to be mated, align the mating keys on the plug with the key-ways on the receptacle, and engage by inserting plug into the receptacle until mated. Do not rock plug side-to-side during mating or unmating. After mating, secure the plug to the receptacle using the plug retainer clips located on the receptacle, and safety wire as described in paragraph 14.4. Mated connector is illustrated in Figure 1.

14.3.2 CYLINDRICAL TYPE CONNECTOR INSTALLATION

The cylindrical type connector employs key-slots in the receptacle and corresponding mating keys in the plug to ensure proper plug to receptacle orientation prior to engagement of the threaded coupling ring. Engagement is performed by aligning keys with keyways and inserting plug into the receptacle. Do not rock plug side-to-side during mating or unmating. Following mating, the connector shall be secured by tightening the threaded coupling ring as far as travel permits, by hand to permit proper alignment and prevent damage to threads. The connector shall be safety wired as described in paragraph 14.4, after securing. Mated connector is illustrated in Figure 2.

14.4 SAFETY WIRING

Safety wire shall be applied so that the connector will not loosen. The safety wire shall be installed with a double twist method and shall have 6-14 twists per lineal inch. The tag ends of the wire shall have 3 to 6 twists and

14.4 SAFETY WIRING (Continued)

shall be neatly trimmed to a length of approximately 1/2-inch. The tag ends shall be bent back against the connector to avoid snagging or scratching any object. The final installation of safety wire shall be correctly positioned with sufficient tension so that the wire cannot be moved or slid in any direction which could permit loosening. The wire shall have the shortest possible length. Acceptable methods for installing safety wire on both rectangular and cylindrical connectors are shown in Figures 1 and 2.

14.5 QUALITY CONTROL SEALING

Quality control seals shall be installed after the connector has been mated. Seals will be installed in such a manner that the retainer clips or threaded coupling ring, as applicable, cannot be disengaged without breaking the seal. The seals and the environment in which they are used shall be compatible. Connectors with broken seals shall be subjected to a thorough reinspection to assure connector integrity, and then resealed.

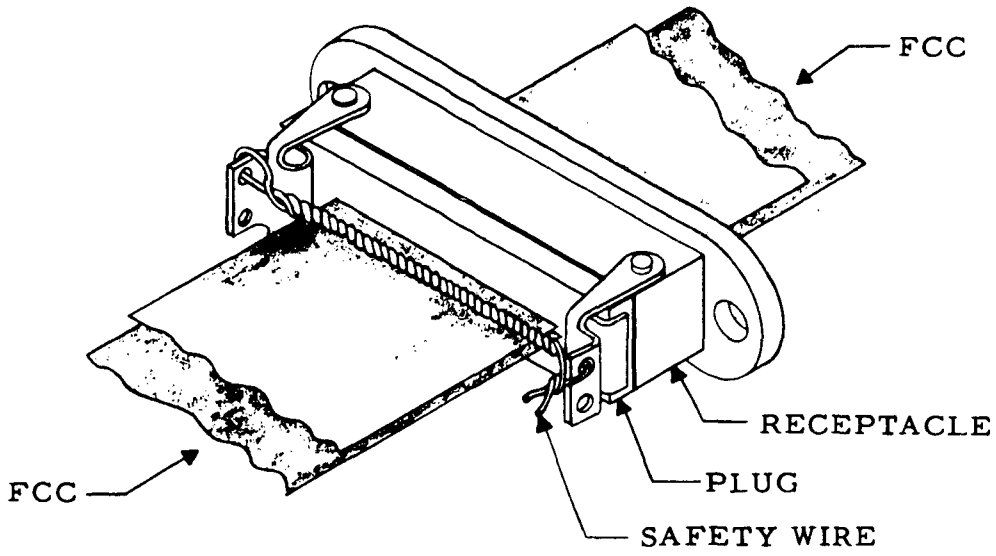


FIGURE 14-1 MATING AND SAFETY WIRING OF RECTANGULAR CONNECTORS

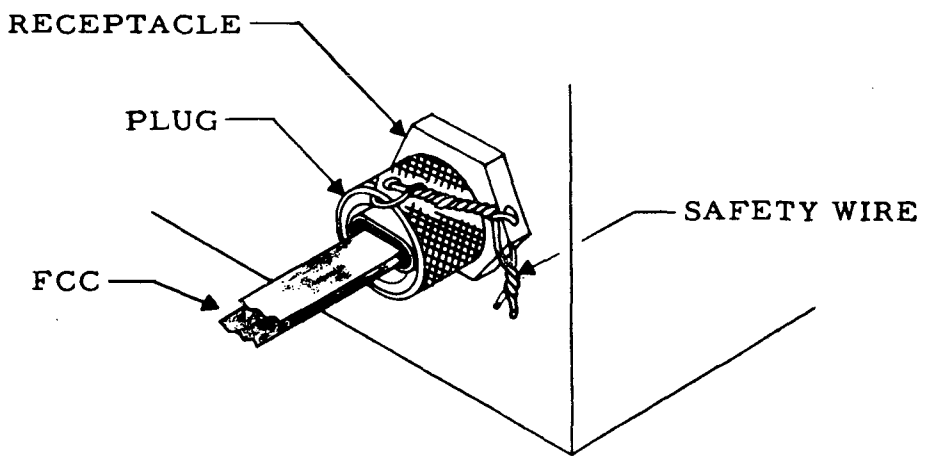


FIGURE 14-2 MATING AND SAFETY WIRING OF CYLINDRICAL CONNECTORS

SECTION 15

Test

15.1 GENERAL

This section establishes the requirements for performing continuity, insulation resistance, and dielectric withstanding voltage tests of electrical harness assemblies. Acceptable harness continuity will be assured by determining that the cable conductor resistance is less than the specified maximum value. Acceptable insulation resistance will be assured by determining that the cable insulation resistance is higher than the specified minimum value. Performance of the dielectric withstanding voltage test will assure that the cable insulation material and connector terminations have not been degraded during previous fabrication and handling operations. The continuity and insulation resistance tests may be performed, at the option of the harness fabricator, whenever it is deemed prudent to assure the status of electrical integrity prior to performing a manufacturing process, such as potting of connectors. The performance of these interim tests does not preclude performance of the mandatory final post-fabrication tests.

15.2 SAFETY REQUIREMENTS

Care shall be exercised during dielectric withstanding voltage and insulation resistance tests, which are performed at voltages hazardous to operating personnel. All test equipment used during the tests shall be thoroughly grounded and shall incorporate protective devices to guard personnel against electric shock. Personnel shall be kept away from output terminals of any test equipment, test cables, and harnesses while the tests are being performed.

15.3 TEST PREPARATION REQUIREMENTS

Preliminary preparation prior to electrical tests shall consist of verification that the harness assembly has satisfactorily completed the scheduled fabrication processes and is ready for test. Verify that all required test equipment is ready and is of the proper type, and has current

15.3 TEST PREPARATION REQUIREMENTS (Continued)

calibration certification. All personnel involved in the testing of harness assemblies shall be properly instructed and adequately trained to operate the test equipment per the test procedure.

15.3.1 SPECIAL PRECAUTIONS

Receptacles shall be mated to plug under test prior to attaching test leads. The type and size of mating test receptacle must match the connector undergoing test. Prior to connector mating and following connector demating verify that connectors are free of damage. Mating or demating of individual connectors must be done carefully to prevent damage to the connector shell and the connector contacts. A connector shall never be demated while a test voltage is being applied to the connector. Always verify that connector protective covers are installed or replaced on unmated connectors following testing.

WARNING: Under no circumstances shall insulation be probed with test lead probes or clips nor shall probes or clips be permitted to touch or be attached to the connector contacts.

15.3.2 PRE-POTTING PRE-TEST VERIFICATION

Prior to pre-potting electrical test, verify that all connectors are free of contamination. Examine connector for damage, recessed or bent contacts, and other damage that may occur during handling and previous processes.

15.3.3 HARNESS POST-FABRICATION PRE-TEST VERIFICATION

Prior to the post-fabrication test which follows completion of harness fabrication, assure that the completed harness assembly has complied with all applicable drawings, design criteria, fabrication requirements, and workmanship requirements, e.g., overall dimensions, harness identification, and handling damage (connector bent contacts and damaged, missing, or improper seals).

15.3.4 HARNESS POST-INSTALLATION PRE-TEST VERIFICATION

Prior to the post-installation tests verify that all connectors remain demated and that the harness assembly has been installed correctly and has protection from chafing, proper clamping and marking. Check all connectors

15.3.4 HARNESS POST-INSTALLATION PRE-TEST VERIFICATION (Continued)
for obvious handling damage prior to test.

15.4 HARNESS ASSEMBLY CONTINUITY TEST REQUIREMENTS

Each harness assembly shall be tested for point to point electrical continuity in accordance with the applicable wiring diagrams or engineering documentation. The circuit resistance shall be a maximum allowable of two (2) ohms, and the test voltage shall not exceed 50 Vdc. Any circuit having a resistance value greater than two (2) ohms, excluding the resistance in the test equipment and adapter cables, will be considered unacceptable.

15.5 HARNESS ASSEMBLY DIELECTRIC WITHSTANDING VOLTAGE (DWV) REQUIREMENTS

Whenever the dielectric withstanding voltage test is performed it shall be performed after the continuity test and be followed by the insulation resistance test. Since this (DWV) test is generally recognized as potentially accumulatively destructive to insulation, the test is performed once on the harness assembly, at the completion of harness fabrication. The harness assembly shall be capable of withstanding the application of 1000 volts (minimum) RMS, 60 CPS, or 1500 volts dc power for one minute maximum. Leakage current shall not exceed 0.5 millampheres. An appropriate current measuring device, capable of indicating leakage current of 0.5 millampheres or greater, and breakdown due to a sustained arc, shall be used during performance of this test. The voltage shall be applied at a rate of 500 volts per second, and shall be maintained for a maximum of one minute between:

a. Each conductor and all other connector contact terminated conductors in the same harness assembly.
b. Each conductor and each connector shell. (Not applicable to non-metallic shells.)
c. Each spare connector contact and all other contacts (wired or spare) and connector shell. (Not applicable to non-metallic shells.)

The test voltage shall be maintained for sufficient time, not exceeding one minute, to assure that the leakage current has reached a steady state condition. Test methods shall comply with method 301 of MIL-STD-202.

15.6 HARNESS ASSEMBLY INSULATION RESISTANCE TEST REQUIREMENTS

A test potential of 500 volts dc, plus or minus 25 volts dc, shall be applied for a minimum dwell time of 60 seconds. The measured insulation resistance shall be greater than 100 megohms.

15.6.1 POST-FABRICATION TEST

Harness assembly insulation resistance shall be measured between:

a. Each conductor and all other connector contact terminated conductors in the same harness assembly.

b. Each conductor and each connector shell. (Not applicable to non-metallic shells.)

c. Each spare connector contact and all other contacts (wired or spare) and connector shell. (Not applicable to non-metallic shells.)

15.6.3 POST-INSTALLATION TEST

Harness assembly insulation resistance shall be measured between:

a. Each conductor and all other connector contact terminated conductors in the same harness assembly.

b. Each conductor and each connector shell. (Not applicable to non-metallic shells.)

c. Space vehicle/payload structure and each conductor, and connector shell. (Not applicable to non-metallic shells.)

15.7 TEST OPERATIONS

Test operations shall assure that the test requirements are fulfilled.

15.7.1 POST-FABRICATION TESTING TECHNIQUE

Automatic or manual test equipment may be employed for post-fabrication continuity, dielectric withstanding voltage, and insulation resistance testing. When more complex harness configurations are involved, such as a harness having more than a nominal number of connectors or having a design such that a master connector, or two, is not evident, the automatic test equipment is highly desirable. Test adapter harnesses connected to each connector or junction device of the harness under test, and terminated in the automatic test equipment, will allow total test of all the parameters stated above as test requirements. An automatic test program can be prepared as a universal program, with resulting test anomalies being judged

15.7.1 POST-FABRICATION TESTING TECHNIQUE (Continued)

as either prescribed design or nonconformances. Automatic equipment with a universal program affords minimum test preparation and maximum repeatability. The test program may be further reduced during the dielectric withstanding voltage test and the insulation resistance test by "commoning" within the test equipment all conductors, connector shells (not applicable to non-metallic shells), that one conductor to be tested, and applying the test voltage between the conductor and the "commoned" conductors, etc. Evidenced anomalies will necessitate isolation of fault, while acceptable results simplify testing.

15.7.2 POST-INSTALLATION TESTING TECHNIQUE

Automatic or manual test equipment may also be employed for post-installation continuity and insulation resistance testing, as employed in the post-fabrication testing. However, due to the restrictions imposed by more complex space vehicle/payload structures, the accessability of installed harness connectors, weight limitations, etc., automatic equipment may not be advised. Manual continuity testing is achieved by identifying the appropriate harness assembly connectors and measuring the resistance between the terminal ends of each conductor; long test leads are generally required and may require consideration in measuring circuit resistance. Manual insulation resistance testing is accomplished by identifying those harness assembly connectors in which one end of each harness conductor is terminated and applying the test voltage between each conductor terminated in the connector under test and the balance of the conductors, connector shells (not applicable to non-metallic shells), and space vehicle/payload structure"commoned" via a test unit. To afford test between each conductor and all the connector shells during manual testing, all of the harness assembly connector shells not otherwise mounted to structure should be electrically connected to the space vehicle/payload structure, thus being "commoned" with the structure for test purposes (not applicable to non-metallic shells). This electrical connection is best achieved, with minimum chance of connector damage, by employing a special single conductor jumper equipped with a clip at one end for attachment to a structure "ground" stud and a soft metal nominal size coiled spring, looped end-to-end, at the other end of the jumper. The looped spring can be slipped over the connector shell and retain its position of electrical contact with the connector shell.

SECTION 16
POST INSTALLATION VERIFICATION

16.1 GENERAL

A post installation review shall be performed, upon the completion of installation of all harnesses and other manufacturing operations performed in the vicinity of harness installations. This review may be completed in appropriate increments if the installation areas are conveniently defined and completion of all manufacturing operations is so segmented. This section is provided as a basic guideline for performance of the post installation verification review and is intended for use in development of a complete and comprehensive installation review procedure.

16.2 PURPOSE

The objectives of the post installation verification review are (1) assessment of the installed wire harness routing, clamping, connector mating, and general lay to assure that the previously accepted installation of each harness has not been compromised by subsequent near-proximity manufacturing operations, harness installations, hardware modifications, etc; (2) general assessment of each installed harness, with emphasis on potentially susceptible areas, for damage or potential compromise of harness integrity; and (3) identification and formulation of design changes which (2) remove or reduce the potential of damage to networks harnesses during subsequent testing, handling, and mission performance, (b) provide improvement of crew and operator safety, and (c) improve the overall quality and reliability of the electrical networks.

16.3 POST INSTALLATION VERIFICATION

When it can be ascertained that all manufacturing operations have been completed within a distinct portion of an end assembly, a post installation verification review of all electrical networks harnesses comprising the completed area shall be performed. Special attention shall be given in

16.3 POST INSTALLATION VERIFICATION (Continued)

designating such areas to assure that such areas are not influenced by subsequent manufacturing operations, in adjacent areas, which would cause invalidation of an area verification review. Those harness installations which are enclosed in covered troughs or otherwise hidden from view by subsequent manufacturing operations shall be subjected to post installation verification review immediately prior to covering, thus precluding disassembly of hardware for performance of this review. However, special attention should be given to subsequent near-proximity manufacturing operations to assure that hidden damage is not incurred.

16.3.1 FIRST ITEM REVIEW

The post installation verification review of the first production item shall be attended by the responsible design engineering group so that resolution of problem areas (potential or real) which can be corrected by design change can be expedited. Possible design considerations may include re-routing or combining harness segments, adding separators or clamps, revising harness lengths, etc., and shall be freely advanced to assure that the production item displays clean, orderly appearing harness installations of the highest quality. The participation of the design engineering group in this first quality review will also allow a cross fertilization of problems recognized by the participating quality assurance group.

16.3.2 QUALITY VERIFICATION CRITERIA

The following checklist is provided as guidelines to inspection personnel. These guidelines are not to be construed as a complete list; inspecting personnel and persons compiling the inspection procedure are expected to employ their experience and knowledge of good harness installations practices and their initiative to insure the highest standard of quality:

a. Harness fabrication quality has not been degraded by assembly/installation operations or other activities.
    1. Identification
    2. Corrosion
    3. Deformed or broken connectors

.3.2 QUALITY VERIFICATION CRITERIA (Continued)

4. Fractured potting
5. Cleanliness (harnesses free from foreign matter)
6. Ruptured sleeving or sheathing
7. Disturbed shielding

b. Harness installation has not be degraded.

1. Support and clamping
2. Protective wrapping, convolute, sheath, etc.
3. Bend radius
4. Slack
5. Correct clamp (cushion not damaged)
6. Capping and stowage
7. Lacing and tying
8. Grounding/bonding
9. Spacing of harnesses

c. Connector mating has been properly performed or connectors stowed.

1. All harness connectors have been properly mated or stowed.
2. Torquing has been accomplished, as specified.
3. Safety wires are as prescribed, none broken, and no sharp strands.
4. Quality seals are in place and have not been broken.

TECHNICAL MEMORANDUM TM X-64685

APPROVAL

MANUFACTURE AND QUALITY CONTROL OF INTERCONNECTING WIRE HARNESSES

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

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

John M. Knadler, III

John M. Knadler, III, Technical Monitor
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