National Aeronautics and
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ES21

MULTIPROGRAM/PROJECT COMMON-USE DOCUMENT

INSTALLATION OF HARNESS ASSEMBLIES

(ELECTRICAL WIRING), SPACE VEHICLE,

GENERAL SPECIFICATION FOR

Approved for Public Release; Distribution is Unlimited

DOCUMENT HISTORY LOG

Status (Baseline/ Revision/ Canceled)	Document Revision	Effective Date	Description
Baseline	-	01/20/1971	
Revision	A	04/20/1973	-
Revision	B	05/01/2009	Updated figures and nomenclature to reflect existing cable harness standards.

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1. SCOPE

1.1 Scope. This specification establishes requirements for the design of installation and the actual installation of electrical harness assemblies in space vehicles and payloads.

1.2 Electromagnetic Compatibility (EMC) Classification. Harness assemblies used to interconnect electrical and/or electronic assemblies (excluding printed circuitry and internal black boxes) are classified as follows:

1.2.1 Class ML - Low-level analog or sensitive circuit designation

1.2.2 Class HO - Control and high-level discrete signal circuit Designation

1.2.3 Class EO - Power and high voltage (>40 V) circuit designation

1.2.4 Class RF - Radio Frequency

1.2.5 Class MO - Pyrotechnic Circuit designation

1.2.6 Class FO - Fiber Optic

1.3 Exceptions - This document does not apply to installation of fiber optic (Class FO) or rigid coax cable assemblies.

1.4 Ordnance Cabling. Routing and installation of ordnance harnesses shall meet the requirements of MIL-STD-1576, Electroexplosive Subsystem Safety Requirements and Test Methods for Space Systems.

2. APPLICABLE DOCUMENTS

2.1 Precedence - The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposals shall apply. When requirements of this specification and the requirements of any applicable document conflict, the requirements of this specification shall take precedence.

2.1.1 SPECIFICATIONS

2.1.1.1 Military

MIL-STD-889	Dissimilar Metals
MIL-STD-1576	Electroexplosive Subsystem Safety Requirements and Test Methods for Space Systems

2.1.1.2 George C. Marshall Space Flight Center

MSFC-SPEC-106	Testing Compatibility of Materials for Liquid Oxygen Systems
MSFC-SPEC-250	Protective Finishes for Space Vehicle Structures and Associated Flight Equipment, General Specifications for
MSFC-50M02442	Material Control for Contamination Due to Outgassing
MSFC-SPEC-522	Design Criteria for Controlling Stress Corrosion Cracking

2.1.1.3 NASA

NASA-STD-3000, Vol. 1	Man Systems Integration Standards
NASA-STD-6001	Flammability, Odor, Offgassing and Compatibility Requirements and Test Procedures For Materials in Environments that Support Combustion.
NASA-STD-8739.1	Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies.
NASA-STD-8739.4	Crimping, Interconnecting Cable Harness and Wiring
NASA-STD-4003	Electrical Bonding for NASA Launch Vehicles, Spacecraft, Payloads and Flight Equipment

2.1.1.4 Other Specifications

EOS / ESD S20.20. For the Development of an Electrostatic Discharge Control Program for- Protection of Electrical and Electronic Parts, Assemblies, and Equipment

3. REQUIREMENTS

3.1 Selection of Specifications and Standards. – Technical specifications required for installation and inspection not identified in this specification shall be selected in accordance with the order of precedence specified in NASA-STD-8739.4, except that approved and coordinated Government procuring activity specifications shall be first in the order of precedence.

3.1.1 Contractors Specifications. – Contractors' specifications may be used provided no higher precedence specification exists and provided the contractors' specification is approved by the procuring activity.

3.2 Harness Assemblies. – Unless otherwise specified or approved by the Government procuring activity, harness assemblies will conform to the requirements of NASA-STD-8739.4.

3.3 Installation Materials Selection.

3.3.1 Metallic. – Metallic materials shall be selected and used in accordance with MIL-STD-889 and MSFC-SPEC-522 to reduce corrosion and stress corrosion. Protective finishes shall conform to MSFC-SPEC-250 as modified by NASA-STD-6001 and MSFC-SPEC-106.

3.3.2 Nonmetallic. – Prior to installation, nonmetallic materials used in installation shall be approved for the predicted environments. Nonmetallic materials for use in inhabited or oxygen enriched areas shall be approved in accordance with NASA-STD-6001.

3.3.3 Compatibility. – Materials for subsequent installation within Liquid Oxygen (LOX) environments shall be LOX compatible in accordance with MSFC-SPEC-106. Materials for subsequent installation within liquid hydrogen, vacuum, radiation, and other extreme environments shall be qualified to requirements specified by the procuring activity and approved by the Government procuring activity.

3.3.4 Outgassing. – Materials used for installation of harness assemblies (wiring) shall be selected from the approved listing per MSFC-50M02442 or shall be approved in accordance with the outgassing requirements of NASA-STD-6001.

3.4 Reliability. – Electrical installation hardware shall be such that established vehicle or equipment reliability figures are not degraded.

3.5 Maintainability and Accessibility. – Maintainability and accessibility for servicing and repair of parts, components, and subsystems shall meet the requirements of NASA-STD-3000.

3.6 Bend Radius and Folding Techniques.

3.6.1 Optimum Bend Radius. – Bends in all cable harness classifications should approach 10 times the harness diameter. See Figure 1 for measurement of bend radius.

3.6.2 Minimum Bend Radius.

3.6.2.1 Coaxial Cable. – The minimum bend radius for coaxial radio frequency cable or harness assemblies containing such cable shall not be less than six (6) times the cable or harness diameter.

3.6.2.2 Wire Size Larger than 10. – The minimum bend radius for harness assemblies containing wire larger than size 10 shall not be less than six (6) times the harness diameter.

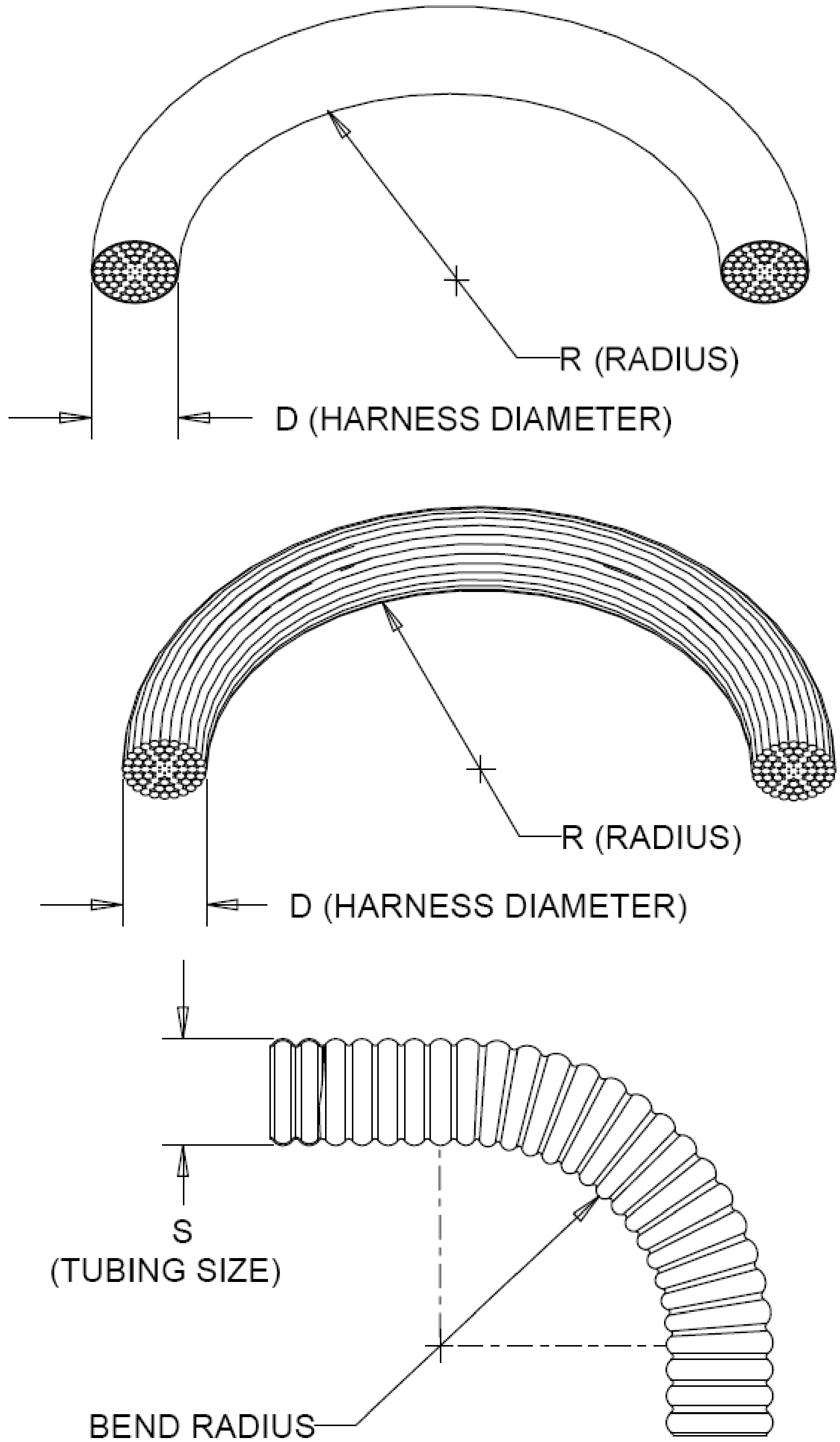


Figure 1. Harness Bend Radius

3.6.2.3 Wire Size 10 or Smaller. – The minimum bend radius for harness assemblies containing only wire size 10 or smaller shall not be less than three (3) times the harness diameter except that the minimum bend radius for a cable harness enclosed in fluorocarbon elastomer convolute tubing shall not be less than that specified in Table I.

TABLE I - Minimum Bend Radius for Fluorocarbon Elastomer Convolute Tubing

Fluorocarbon Elastomer ConvoluteTubing Size Nominal - Inches	Minimum Bend Radius Inches
06 – 3/16”	1/2
09 – 9/32”	1
12 – 3/8”	2
14 – 7/16”	2 5/8
16 – 1/2”	3 1/4
20 – 5/8”	4 1/4
24 – 3/4"	5
28 – 7/8”	6
36 – 1 3/32”	6 1/2

3.6.2.4 Flexible Flat Conductor Cable Harness. – Flexible flat conductor cable harnesses, unshielded, may be bent or folded flat to itself with no minimum bend radius required. Flexible flat conductor cable harnesses which contain individual layers of shielding which are not laminated or bonded to the cable layers shall be bent or folded with a 0.12 inch minimum bend radius. Bending and folding techniques for this type which provides for direction changes, branchouts and polarity changes are illustrated in Figures 2, 3 and 4.

3.6.2.5 Wires with Polyimide Insulation. The minimum bend radius for harness assemblies containing polyimide insulated wires shall not be less than ten (10) times the harness diameter.

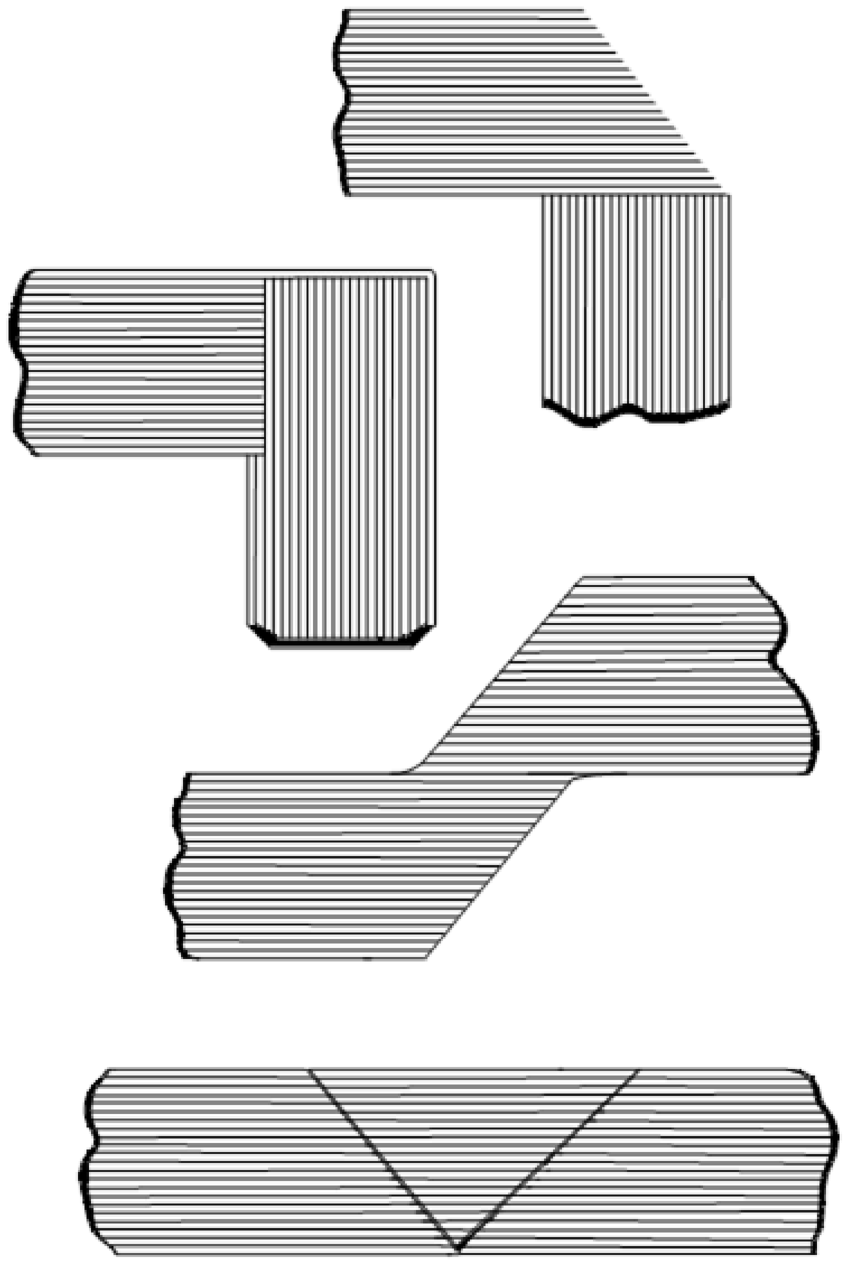


Figure 2. Bending and Folding Flexible Flat Conductor Cable Harnesses Direction and Polarity Change.

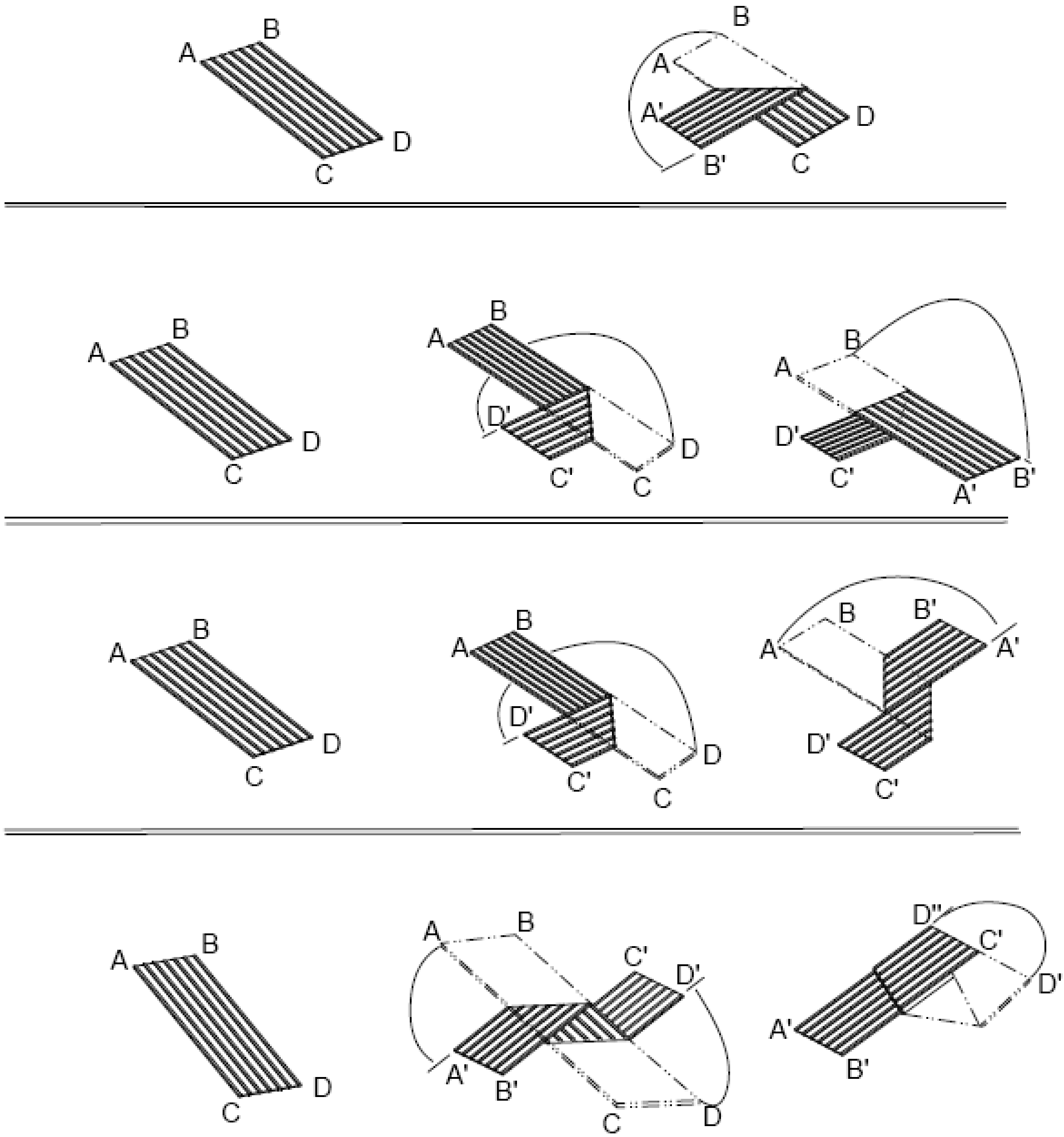


Figure 3. Bending and Folding Flexible Flat Conductor Cable Harnesses: Bending and Folding Sequence

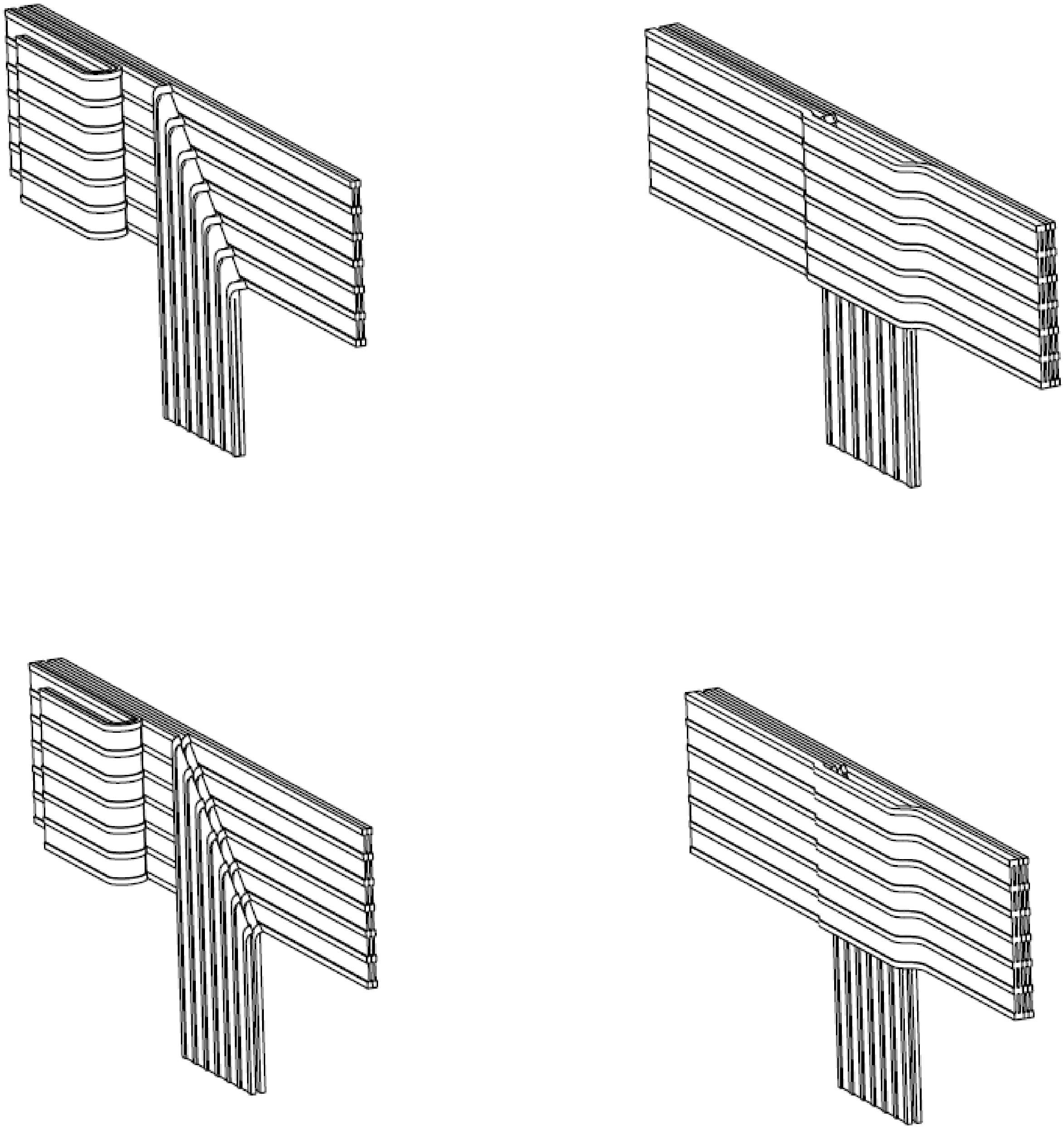


Figure 4. <u>Bending and Folding Flexible Flat Conductor Cable Harnesses Branch Outs and Direction Change</u>

3.7 Slack. – Slack (see Figures 5 and 6) shall be provided to avoid stress on the wires in the harness or connectors. Slack shall be minimized in order to achieve an orderly appearance of the installations.

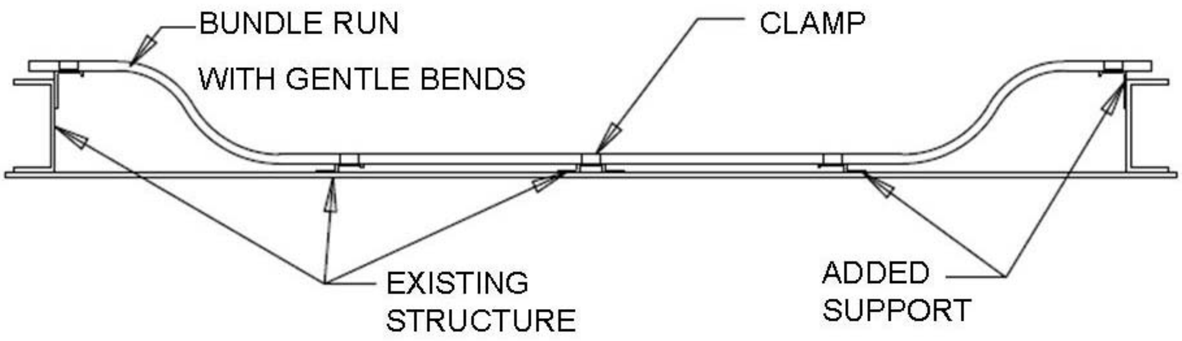


Figure 5. Harness Slack Between Supports

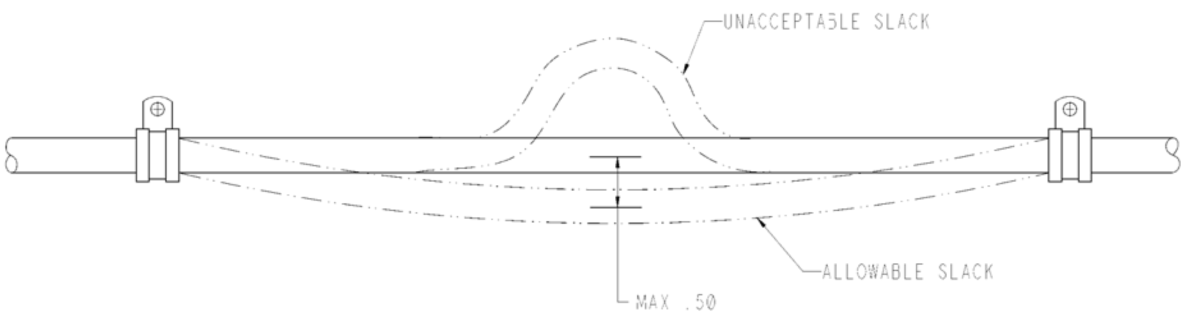


Figure 6. Typical Direct Routing with Gentle Bends

3.7.1 Sharp or Rough Object Protection - If the slack permits the harness to come within 1/4 inch of any sharp or rough object which could cause damage, one or more of the following shall be accomplished: Reduce slack. Increase the distance from the object, add additional support and/or add adequate protection to the wiring and to the sharp or rough object to adequately protect the harness from damage.

3.7.2 Slack Between Supports. – Slack between supports shall be as follows:

3.7.2.1 Enclosed Harnesses - Harnesses that are enclosed in fluorocarbon elastomer or Tetrafluoroethylene (TFE) convolute tubing (with or without fiberglass braid) shall have no more slack than necessary to permit ease of installation and maintenance and to prevent mechanical stress on couplings and clamps.

3.7.2.2 Other Harnesses - Slack shall be in accordance as follows for open bundle harnesses, those enclosed in TFE heat shrink tubing and all flexible armored harnesses:

a. For assemblies containing 0 through 4 American Wire Gage (AWG) wire, slack shall be provided between clamps to avoid stress on harness, but shall not be greater than 1 inch between support points.

b. For assemblies containing all other size wire, slack shall be provided between clamps to avoid stress on harness but it shall not be greater than 1/2 inch between support points.

c. To permit connector replacement, there shall be additional length in the harness at the initial installation. The additional length shall be distributed throughout the length of the harness assembly not to exceed slack requirements of (a) or (b) above.

d. Where there is relative motion between support points, the slack in the harness assembly span between those points shall be sufficient to prevent stress on the wiring or connector.

3.7.2.3 Flexible Flat Harnesses - Flexible Flat Conductor Cable Harnesses shall have no slack other than necessary to permit direct routing with gentle bends, when required, and which prevents mechanical stress on the harness, support clamps and harness terminations. When there is relative motion between support clamps or between support clamps and harness terminations, the installation design shall specify the required slack, which will assure no damage to the harness by the movement. See Figure 6 for example of direct routing and gentle bends.

3.8 Excess length. – Harness 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 3.7. Excess length for Flexible flat conductor cable harnesses shall be resolved by fold-back methods.

3.9 Modifications. – All modifications made to a harness assembly after installation will meet the requirements of approved design change documentation. After modification the harness installation shall be re-verified to comply with installation criteria established herein.

3.10 Protection. – Harness assemblies shall be protected against damage from abrasion, flexing, contact with sharp edges or protrusions, and environments.

Note: Slack Requirements are covered in 3.7.

3.10.1 Moving Parts. – Harness assemblies, wires, or cables, attached to moving parts shall be designed and installed to minimize stress to the electrical conductors. The harness shall also be protected to prevent damage.

3.10.2 Cushions and Grommets. – Harness assemblies routed over protrusions or sharp edges or through structural holes shall be protected with cushions or grommets meeting the requirements of 3.3. See Figure 7 for examples of grommet configurations.

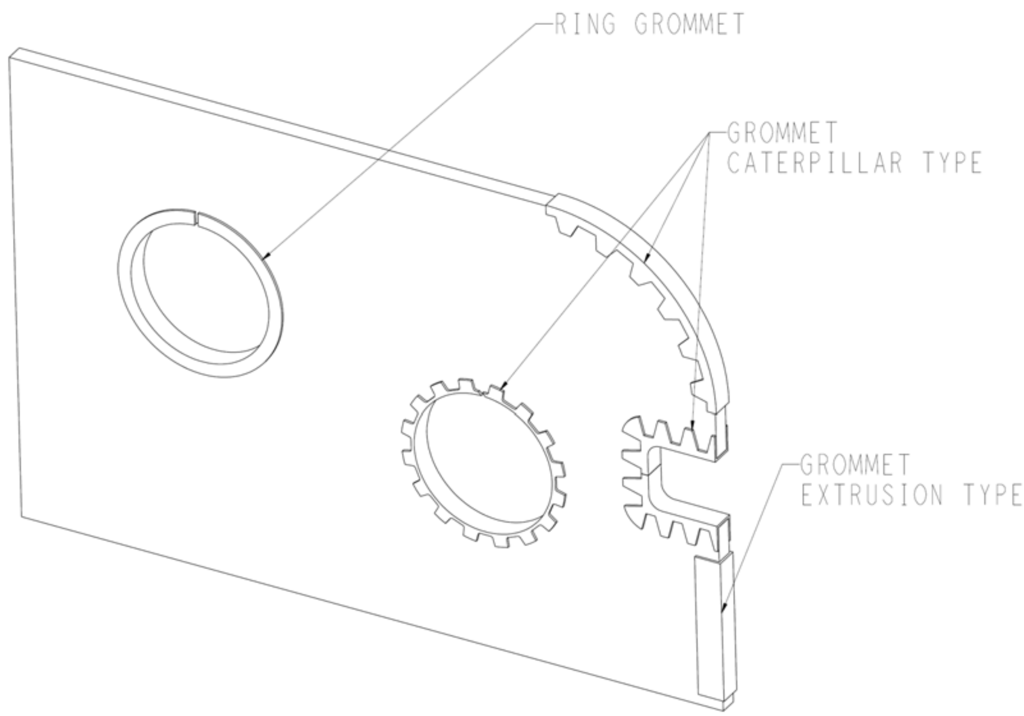


Figure 7 – Examples of Grommets.

3.10.3 Protective Covering. Except when connected with mating connectors, or during individual connector testing, all connectors shall be covered by caps which provide environmental protection.

3.10.4 Tape, Heat Shrinkable Boots, and Sleeving.

3.10.4.1 Harness Overwrap – Sleeving may be used as a protective over-wrap for harnesses. Spot ties or tape, as required by engineering drawings, shall be used to prevent slippage of the overwrap.

Note: Tape should not be used as a primary means of protection against abrasion or damage to harnesses.

3.10.5 Harness Damage Prevention – If the routing designer determines that the possibility of damage to wiring / harnesses exists due to routing / location constraints and cannot be corrected by re-routing or other methods performed at installation, then the routing designer shall coordinate with the harness designer to mitigate the risk of damage in the harness design.

3.11 Stowage. – Harnesses that are partially installed shall be affectively stowed to prevent damage to the installed and uninstalled portions. The supplier shall submit, as part of the quality control plan, detailed procedures to be followed in assuring that stowed harnesses will be protected from damage and that permanent installation is accomplished. This requirement is not applicable to those harnesses or portions of harnesses that are prescribed by flight configuration design to be unmated or stowed.

3.12 Prevention of Inadvertent Connector De-mate - After final mating, electrical connectors shall be secured using safety wire, epoxy staking, or other approved positive locking method to prevent inadvertent de-mating of the mated connector pair. Connectors having self-locking coupling rings do not require additional locking provisions.

3.13 Cleanliness. – All materials used during installation of electrical systems shall be maintained in a clean condition commensurate with the cleanliness requirements of the installation environment. Cleaning of electrical systems shall be in accordance with requirements of the item drawings and specifications, or in absence of drawing or specification callout, maintenance of cleanliness level shall be in accordance with a procuring activity approved plan (including materials and processes). Levels of controlled environmental work areas shall be in accordance with MSFC-STD-246.

3.14 Harness Installation.

3.14.1 Routing of Similar Harnesses - All harnesses having the same EMC classification may be combined and routed together provided that the runs do not contain critically redundant circuits.

3.14.2 EMC Classification / Separation Requirements – Program-or project-specific requirements for cable separation have precedence over this specification. If no cable separation requirements are levied by the user's program or project, then Table II may be used as a guideline for reasonable mitigation of electromagnetic interference (EMI) from cable coupling.

TABLE II
WIRING CLASSIFICATION SEPARATION REQUIREMENTS

Routed Parallel to Bundle		Routed Parallel to Bundle		Separation Requirements (inches)			
NASA EMC Classification	83575 EMC Classification	NASA EMC Classification	83575 EMC Classification	L < 12”	12” < L < 36”	36” < L < 60”	60” < L
ML	I b, II a, II c, III a, III c, III e	HO	I a, I b, II a, II c, III a	0.0	1.25	2.40	4.75
		EO	I a	0.0	1.75	3.60	7.10
		MO	IV	1.25	2.40	4.75	9.5
		RF	I c, I d, II a, II b, II c, II d, III b, III c, III d, III e, V a, V b, V c	0.0	3.00	6.00	11.8
HO	I a, I b, II a, II c, III a	EO	I a	0.0	.60	1.25	2.40
		MO	IV	1.25	2.40	4.75	9.5
		RF	I c, I d, II a, II b, II c, II d, III b, III c, III d, III e, V a, V b, V c	0.0	1.75	3.60	7.10
EO	I a	MO	IV	1.25	2.40	4.75	9.5
		RF	I c, I d, II a, II b, II c, II d, III b, III c, III d, III e, V a, V b, V c	0.0	1.25	2.40	4.75
MO	IV	RF	I c, I d, II a, II b, II c, II d, III b, III c, III d, III e, V a, V b, V c	1.25	1.25	2.40	4.75

3.14.3 Cable Crossover- Crossover of cable harnesses of different classifications shall be made as close to right angles as possible.

3.14.4 Applicable Harness Installations Drawings. – Installation drawings shall be provided which detail the harness routing, securing, grouping, layer sequencing, locations, configurations, and special precautions and procedures. Requirements not covered by this specification shall be approved by the procuring activity prior to harness installations.

3.14.5 Harness Routing – Harness assemblies shall be routed as directly as possible and, where practical, shall be routed parallel and/or perpendicular to other components and to one another to facilitate right angle crossovers and branchouts. Harnesses shall be routed to avoid damage from abrasion, rough surfaces, sharp edges and shock-mounted equipment. Harnesses routed near entrance and access areas along traffic lanes and those which may be susceptible for use as handholds shall be protected. Harnesses may contact other harnesses providing the harnesses are routed to prevent interweaving of bundles and are protected from chafing. Routing of cable harnesses shall be accomplished in accordance with section 3.2.1 circuit classification and wiring classification separation requirements. Flexible flat conductor harnesses may be routed individually or collectively in layers and clamped or bonded as a group. To accomplish directions or polarity changes, harness branchouts and disposition of excessive slack in routing flexible flat conductor harnesses, the bending and folding techniques shown in Figures 2, 3 and 4 shall be used. Harness routing should provide protection from inadvertent mismating of connectors. Typical harness routing for flexible flat conductor harnesses is shown in Figures 13 through 16.

3.14.5.1 Routing Near Fluid and Gas Lines – Harness assemblies shall be separated from lines carrying flammable or nonflammable fluids and gasses. Harnesses shall not be secured to fluid or gas lines except as provided in 3.14.8.

a. Flammable Lines. – A minimum separation of 2.0 inches between unprotected harnesses and lines carrying flammable fluids should be maintained. When this separation cannot be maintained due to design constraints, the harness shall be covered with an approved flame retarding material and rigidly clamped to maintain a separation of not less than 0.5 inch. Where barriers exist which preclude contact between harnesses and flammable fluid lines, the requirements for separation, mounting and covering shall not apply.
b. Non-flammable Lines. – A minimum separation of 0.5 inch between un-protected harnesses and lines carrying non-flammable fluids shall be maintained.
c. Temporary Support - All wiring, connectors and terminal blocks shall be adequately supported during installation, rework, and ground operations to prevent damage due to excessive bending, kinking or strain using temporary supports.

3.14.6 Harness Support and Separation Clamps. – Support and separation clamps for harness assemblies shall be mounted to primary and secondary structures, except as provided in 3.14.8. The method of attachment shall not degrade the structural integrity of the basic structure. Support and separation clamps shall be the primary method for securing harness assemblies in vehicle applications and shall reduce or eliminate harness vibration, maintain clearances and relieve stress on harnesses and harness terminations. Wiring shall not be added / routed through closed cable clamps.

3.14.6.1 Clamp Types. – Clamp types used for the support and separation of harness assemblies shall be as follows:

a. Open bundle harnesses, those enclosed in TFE heat shrink tubing or flexible armored harnesses shall be supported by cushion type clamps.
b. Any combination of (a) and (e) shall be supported by cushion-type clamps except where harness sections are enclosed with TFE convolute tubing. Convolute tubing enclosed sections may be supported by non-cushion type clamps.
c. Flexible flat conductor harness may be supported by either cushion or non-cushion type clamps. Support clamps may be either bar strap, tubular or sheet metal and may be either commercial or custom design.
d. Loop type clamps may be used to support harness assemblies which do not exceed 2.0 inches in diameter. Harness assemblies greater than 2.0 inches in diameter shall be supported by saddle-type clamps. Typical support and separation clamp types are shown in Figures 9, 10, 11 and 12.
e. Harnesses enclosed in fluorocarbon elastomer or TFE convolute tubing (braided or unbraided) may be supported by non-cushion-type clamps.

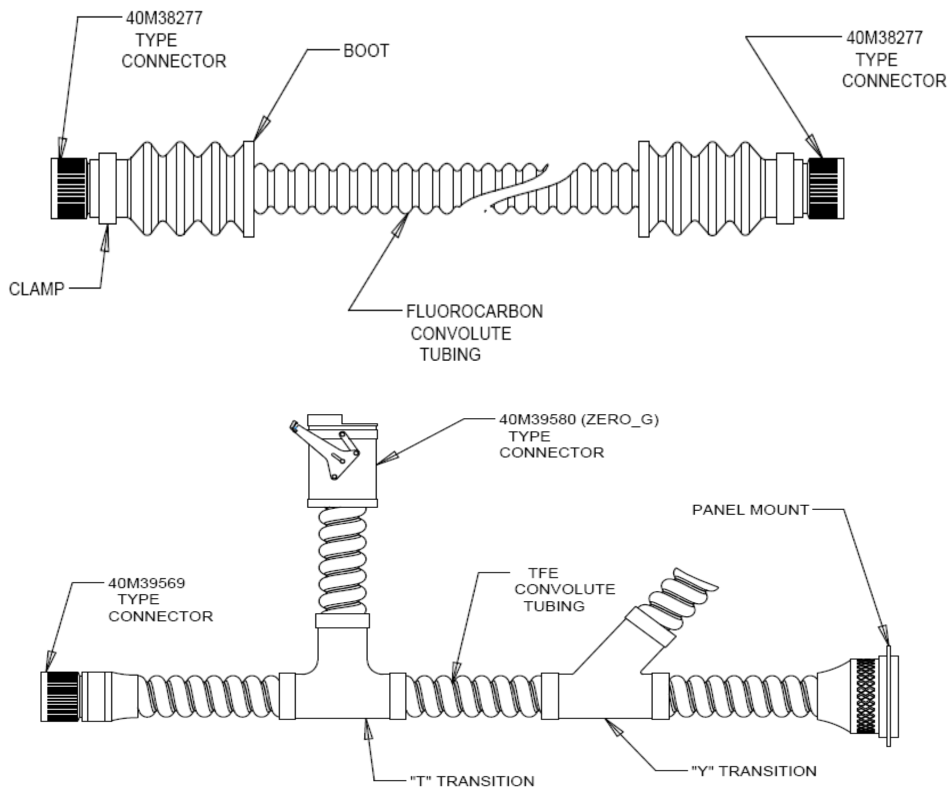


Figure 8 – Examples of Harness with TFE and Fluorocarbon Tubing

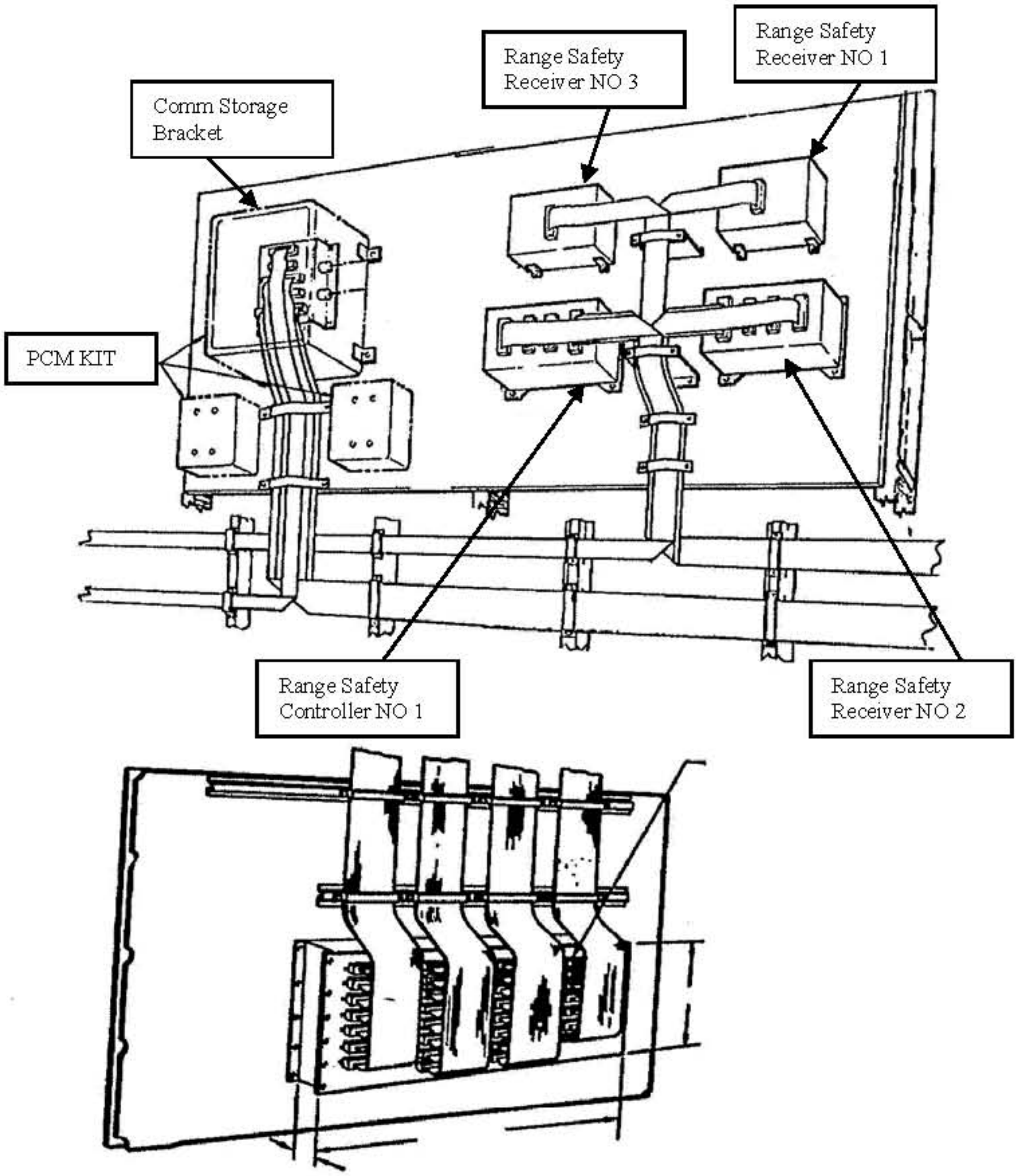
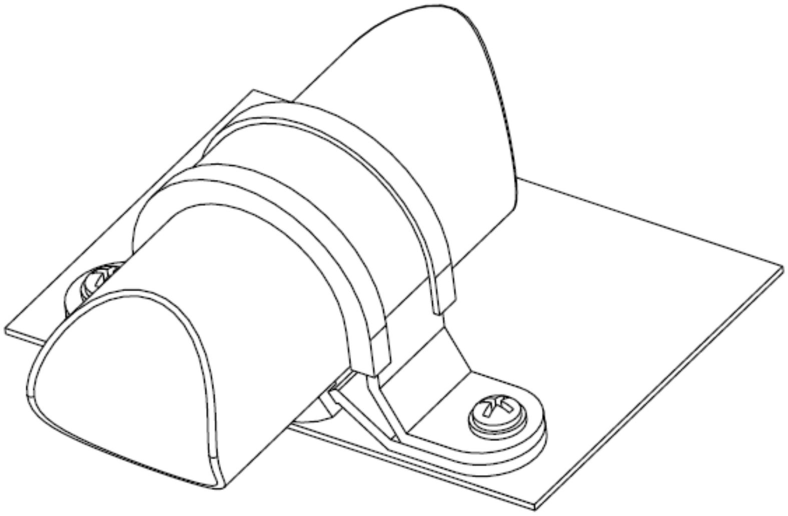
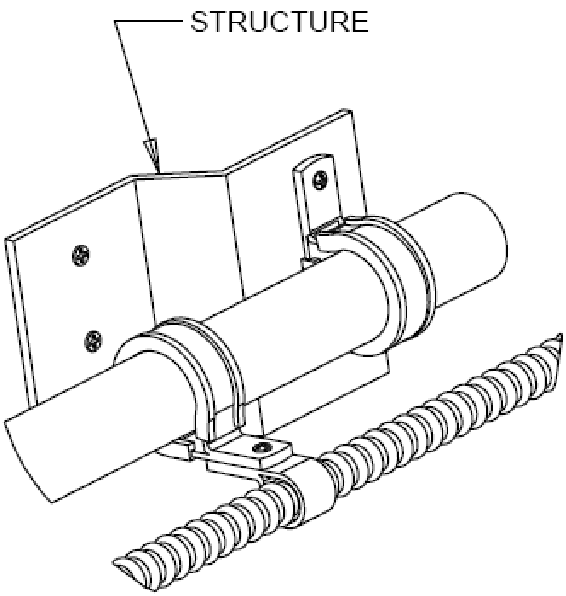
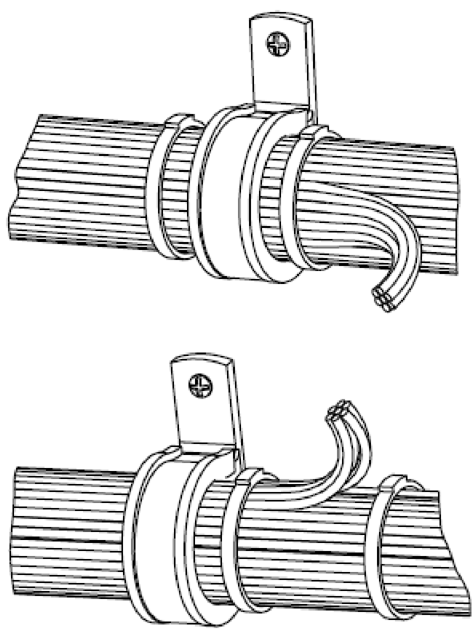


Figure 9. Typical Support and Separation Clamp Types



Saddle Clamp





Cushion and Non-Cushion

Loop Clamp

Figure10. Typical Support and Separation Clamp Types

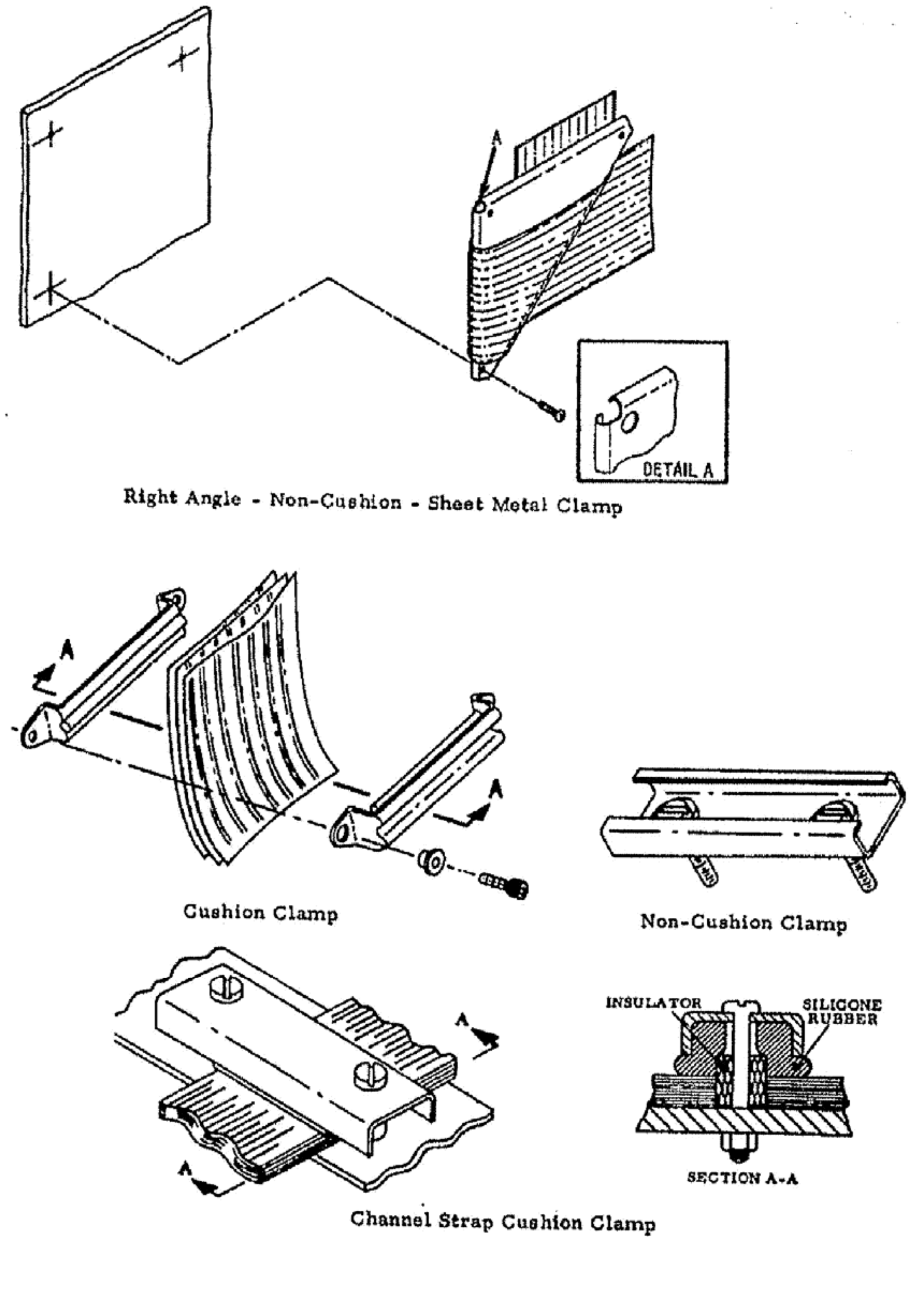
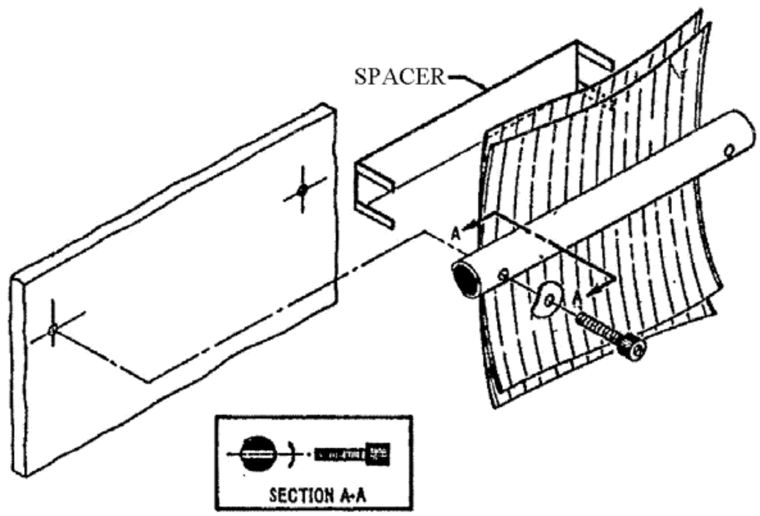
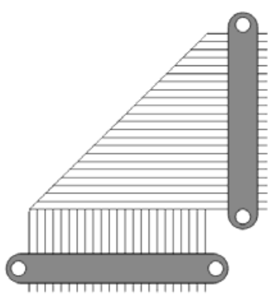


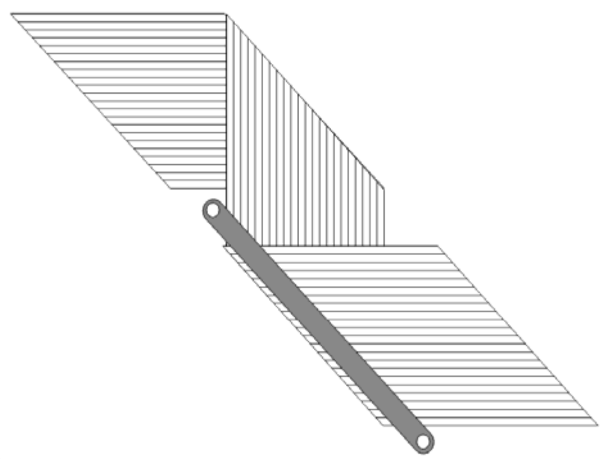
Figure 11. Typical Support and Separation Clamp Types



Tubular clamps with screw fasteners,



Metal noncushioned clamp, right-angle tubular,



Metal-Cushioned clamps for angle fold.

Figure 12. Typical Support and Separation Clamp Types

Note: For permanent installations and when limited by design constraints, Flexible Flat Conductor harness may be adhesive bonded in lieu of being clamped. When bonding is used as the securing method, a systems compatible adhesive shall be specified on the design installation drawings and approved by the procuring activity prior to installations.

3.14.6.2 Clamp Size. – Clamps shall be adequate to hold harnesses securely in position without pinching, crushing or degrading the harness. Clamps shall provide a snug grip on the harness which prevents chafing and travel of the harness. Tape shall be used as a filler to obtain proper clamp fit only when a reduction in clamp size is insufficient. The size of the clamp shall permit the mounting tabs of the clamping device to meet without deformation.

a. Determining Bundle Size – Bundle diameters are the determining factor in clamp size. The number of wires and type of wire must be known in order to determine the bundle size. SAE AS50861/1 through AS50861/7 shall be used to define the wire diameter for a given gage and type of wire. Bundle diameters may be calculated as follows:

(1) Calculate the average wire Outer Diameter (OD) dimension (d_{av}).

Example: (MIL-W-5086 has been replaced with SAE AS50861)

(a) Gather bundle requirements for type of wire and number of wires:
5 wires of 12 AWG wire per AS50861/1
17 wires of 16 AWG wire per AS50861/1

OD of 12 AWG wire per AS50861/1	=	.137”
OD of 16 AWG wire per AS50861/1	=	.098

(b) Determine total number of wires, diameter of each type, and the sum of the wire type diameters:

5	x	.137”	=	.685”
17	x	.098”	=	1.666”
22 total wires				2.351”

(c) Determine average wire OD by dividing the sum of the wire type diameters by the total number of wires:

2.351	÷	22	=	.107”

(2) Calculate finished cable diameter (D)

(a) Multiply the average wire OD by the Bundle Size Factor β given in TABLE III for the total number of wires in the bundle:

D	=	*d_{av}	x	β
D	=	.107	x	5.8
Finished Cable D			=	.621”

Note: When the cable consists of the same gage wire, Step (1) is omitted and d_{av} is the diameter for that wire size per AS50861/1.

TABLE III – Bundle Size Factor

# of wires	β	# of wires	β	# of wires	β	# of wires	β
1	1.0	10	4.0	36	7.4	80	10.9
2	2.0	12	4.3	40	7.7	90	11.6
3	2.2	14	4.6	45	8.1	100	12.2
4	2.4	16	5.0	50	8.5	125	13.7
5	2.7	18	5.3	55	8.9	150	15.0
6	2.9	20	5.6	60	9.3	175	16.1
7	3.0	24	6.0	65	9.7	200	17.2
8	3.3	28	6.5	70	10.1	250	19.3
9	3.8	32	6.9	75	10.5	300	21.0

Note: β values not shown on TABLE III may be interpolated using existing values.

b. Determining Clamp Size. - The finished cable diameter D shall be used to select the appropriate clamp size. The clamp inner diameter (ID) shall be equal to or larger than the finished cable diameter D. For the example above, the clamp ID would be 0.625". If the cable bundle is required to be taped at the clamping location, the ID of the clamp shall be increased based on the number of layers and the thickness of the tape.

3.14.6.3 Clamp Interval and Location. – The interval and location of support clamps shall be as follows:

a. Connection to First Support Clamp. – The harness length between the rear of the connector and the first harness support clamp shall not exceed 15 inches.

b. Interval Between Support Clamps. – The distance between support clamps shall be adequate to support the size and weight of the harness or bundle and should not exceed 15 inches.

c. Ground Wire Clamps. – Ground wires should have cushion type clamps installed a maximum of 3 inches from the ground termination point.

d. Support at Grommets. – Where harnesses are routed through or over grommets, the harness shall be supported by clamps to eliminate chafing and abrasion.

3.14.7 General Harness Installation. – General harness routing, grouping and installation shall be as follows:

3.14.7.1 Harness Separation - Harnesses shall be separated from heated equipment and routed away from liquid drainage areas or locations where corrosive liquids may collect.

3.14.7.2 Vibration and Movement - Harness routing and installation shall preclude harness damage from vibration or movement of the harness with respect to adjacent components or structure.

3.14.7.3 Stress - Mechanical stress shall not be absorbed by harnesses or harness terminations but shall be absorbed by the harness support and separation clamps. Tightening of clamps shall not produce stress on harnesses and shall be relieved by slack.

3.14.7.4 Abrasion Protection - Harness routing and installation shall preclude abrasion, cutting or piercing damage of the harness from contact with rough surfaces or sharp edges.

3.14.7.5 Twisting Limits - Harness assemblies consisting of convolute tubing shall not be twisted during clamping and routing. All other harness assemblies shall not be twisted more than 1/4 turn between the connector and the first clamp to align connector keyways. Should additional twist be required, the required twist shall be made between the other support clamps

3.14.7.6 Acceptance Test - After a cable harness has been installed and prior to connection and final mating, the acceptance tests shall be repeated in the order specified in NASA-STD-8739.4 unless otherwise noted on applicable engineering drawings.

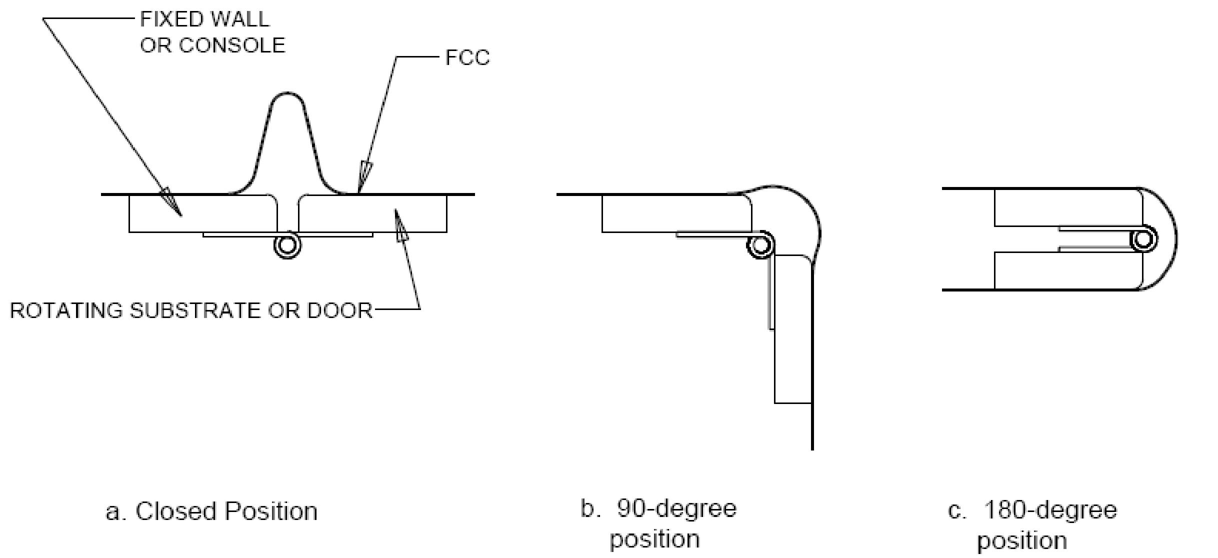
3.14.7.7 Unsupported Spans – Where spanning an unsupported gap between two structures which exceed the maximum allowable clamp spacing as determined by the installation documentation is unavoidable, the harness shall be provided a means of support which is structurally adequate to support the weight of the harness when exposed to any required vibration environments.

3.14.8 Installation – Engine Area. – Due to structural characteristics and design constraints in the engine area, harness assemblies may be installed and secured to other harnesses. Harness assemblies may also be secured to fluid lines. When harness assemblies are secured to other harnesses or fluid lines in the engine area, the installation design shall be supported by test and/or analysis and shall be approved by the procuring activity prior to installation.

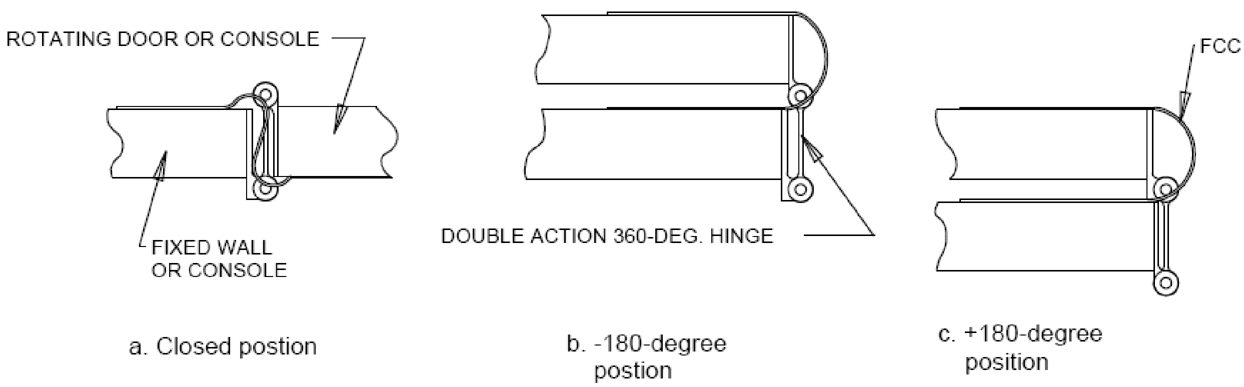
3.14.9 Installation – Fixed Components. – The harness and installation for systems having fixed position components shall be kept as simple as possible to provide a minimum of harness network. The harness installation shall permit placement or removal of system components. The installation shall permit free movement of shock and vibration mounted components.

3.14.10 Installation-Moving Components. – Harnesses which attach to components where relative motion such as hinge, rotate, gimbal, extend and retract occurs, shall be designed and installed in a manner which prevents damage to the harness by the movement. All harnesses shall be routed and installed to prevent the maximum movement from exceeding minimum bend radii and twist or bend constraints. Flexible Flat Conductor harnesses shall be designed and installed to either flex, fold, roll, extend or retract to accommodate the relative motion. See Figures 13, 14, 15, and 16 for typical installations.

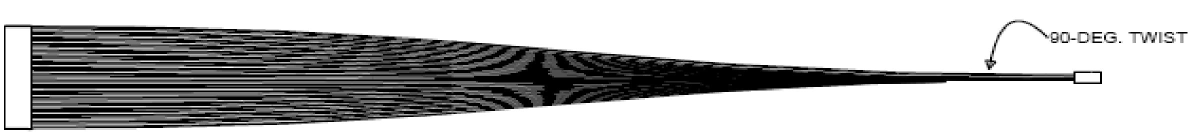
3.14.11 Connector Inspection Prior to Mating. – Before the connectors of the installed harness(es) are mated, both the plug and receptacle shall be inspected for cleanliness, damage of the threads, shells, seals or retaining clips; burrs, galling, or excessive thread lubricant; splayed, bent, retracted or extended contacts, sealing grommets and sealing plugs for unused contacts; and for the reference designation, (specified on applicable engineering drawings). Reference designations obscured by protective sleeving or other object shall be remarked on the protective cover or in a visible location.



Typical Single Action Hinge Installation



Typical Double Action Hinge Installation



Typical 90° Twist Installation

Figure 13. Typical Installation Methods for Flexible Flat Conductor Harnesses

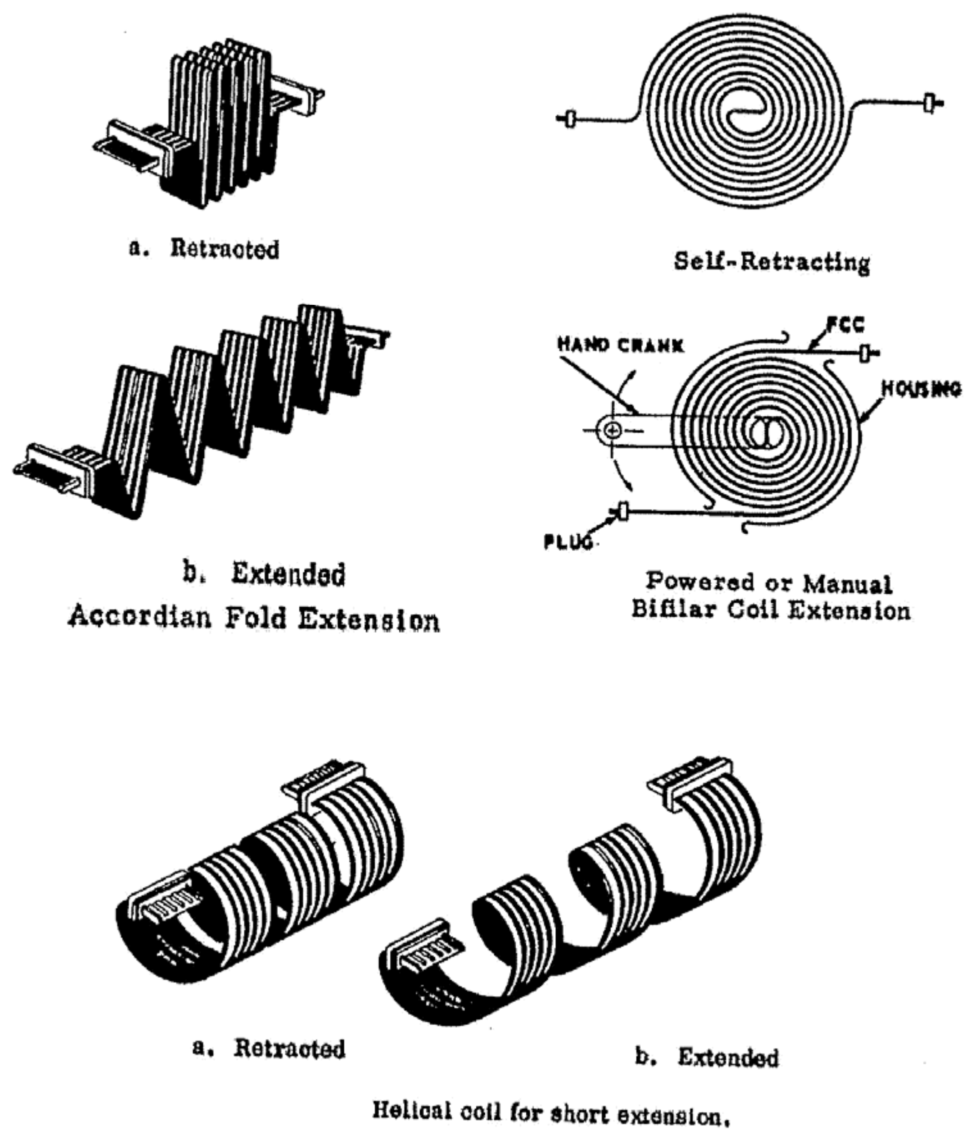


Figure 14. Typical Installation Methods for Flexible Flat Conductor Harnesses

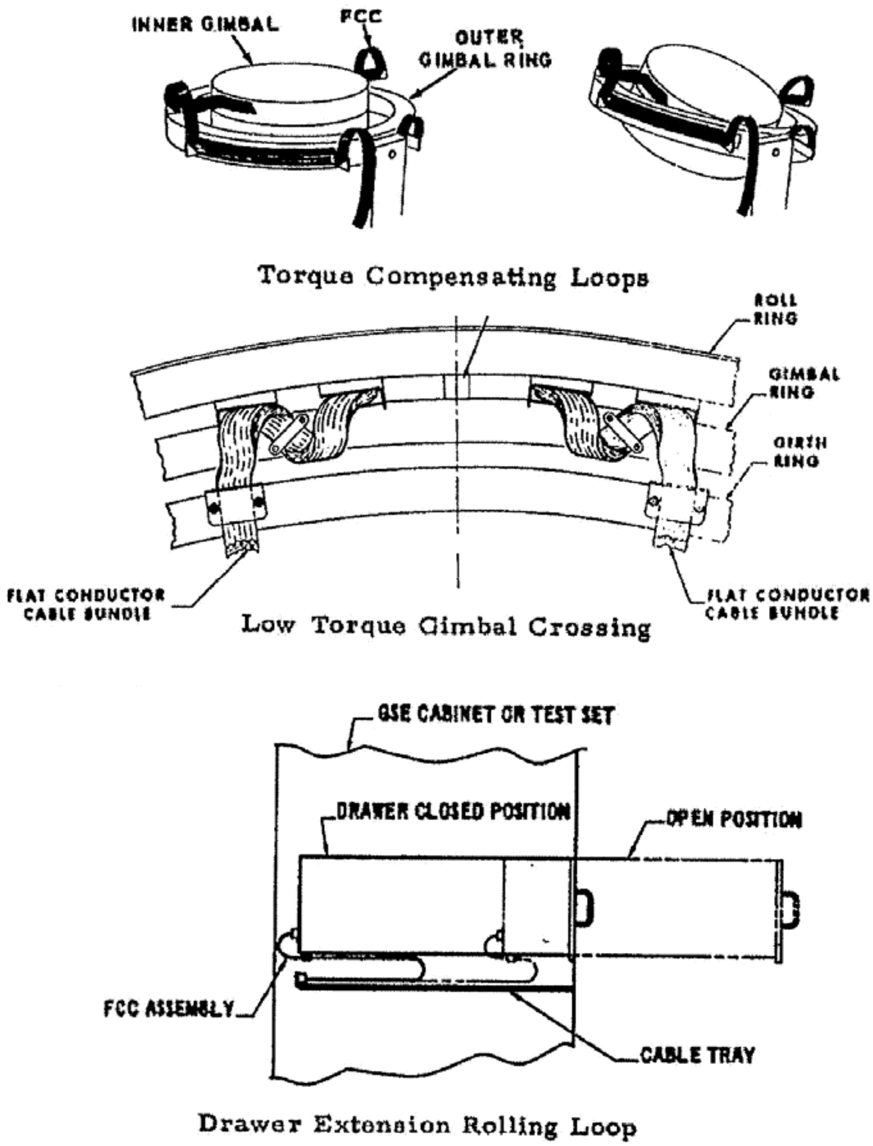


Figure 15. Typical Installation Methods for Flexible Flat Conductor Harnesses

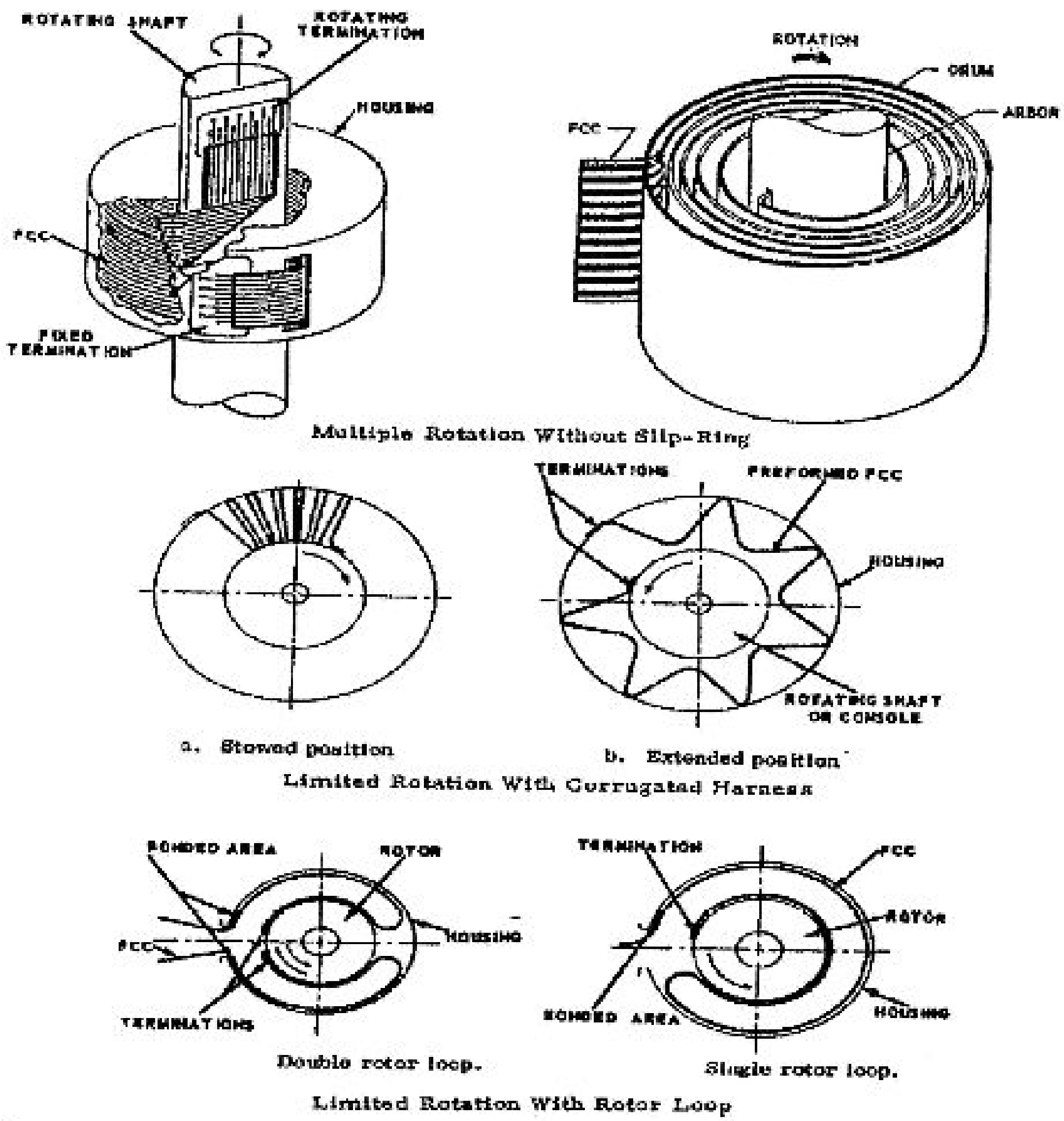


Figure 16. Typical Installation Methods for Flexible Flat Conductor Harnesses

3.14.11.1 Bent Connector Pins. – Where bent pins occur on connectors, disposition (repair, replacement or other) shall be in accordance with the requirements of NASA-STD-8739.4.

3.14.11.2 Connector Soft Mate - The harness installation drawing shall include a requirement that, after completing the connector examination but prior to the final connector mating, a "soft mate" procedure be performed for non-scoop-proof connectors as follows:

a. Mate the connector to the point of coupling nut contact with receptacle threads or bayonet pins.

b. Demate and visually inspect for bent pins or recessed pins or sockets.

c. If no recessing or bending is evident, perform the final mate of the connectors.

3.14.12. Mismating of Connectors. –Where mismating of connectors is not controlled by other means, the design of the cable routing shall ensure that connectors are separated and routed in such a way that it is not physically possible to accidentally mismate connector pair.

3.14.13. Torquing Connectors. – To assure proper alignment and prevent damage to threads, connectors having threaded couplings shall be tightened initially by hand. Final tightening of coupling nuts shall be performed in accordance with manufacturers' recommended values or as specified in the design documentation. Connectors having full mate indication shall be engaged to achieve full mate indication and do not require additional torquing of the coupling nut.

3.14.14. Jam Nut Torque – Connector jam-nuts shall be torqued to manufacturers' recommended values or as specified in design documentation. Please note that certain connectors such as hermetic types have unique values and applicable torques shall be determined for their application.

3.14.15 Electrical Bonding – Electrical bonding shall be performed in accordance NASA-STD-4003. Examples of ground wire termination are shown in Figure 17.

3.14.16 Staking and Potting – Where applicable, the staking and potting shall be in accordance with NASA-STD-8739.1.

3.14.17 Electrostatic Discharge Protection and Control – The handling and installation of cable harnesses shall meet the requirements of EOS / ESD S20.20.

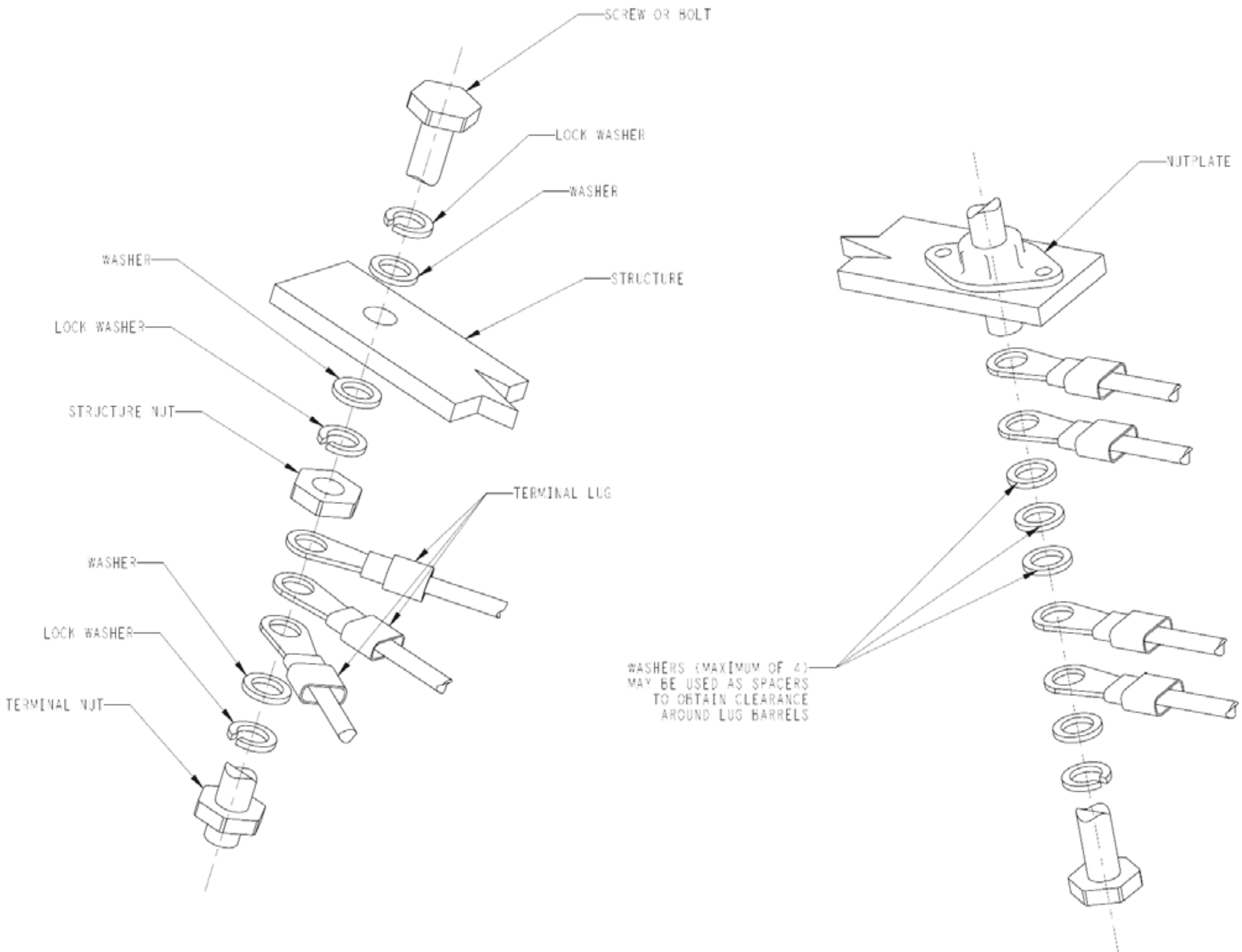


Figure 17 – Examples of Termination of Ground Wire to Structure.

4. QUALITY ASSURANCE

4.1 Supplier Inspection. – The supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own or any other inspection facilities and services acceptable to and approved by the procuring activity. Inspection and test records shall be kept complete and upon request made available to the procuring activity or its designated representative. The procuring activity or its designated representative, reserves the right to perform any or all the inspections set forth in this specification to ensure that the end item conforms to the prescribed requirements.

4.2 Tests. – Testing shall be performed to assure that individual wire continuity and insulation resistance has not been degraded by installation operations. The post installation test requirements shall be those continuity and insulation resistance test criteria previously employed for the fabrication and acceptance tests of each harness assembly and shall be performed with all connectors of the assembly disconnected.

4.2.1 Testing After Rework / Repair - After rework / repair of an installed harness, the subject harness shall undergo continuity, Dielectric Withstanding Voltage (DWV), and Insulation Resistance (IR) acceptance tests as originally required by the harness design documentation.

4.2.2 Test Equipment Interfaces - In order to prevent damage to flight connectors or contacts, connector savers or other approved connection devices shall be used to connect test probes and equipment to flight connectors.

4.3 Certification. – If no method exists for checking that a manufacturing process has been satisfactorily accomplished, then manufacturing and inspection personnel, equipment, and tools shall be certified by the supplier to perform specific, or all, operations. The certifying requirements shall be subject to review and disapproval by the procuring activity or its designated representative.

4.4 Visual Inspection - The installation drawing shall require that a visual inspection be performed in accordance with program / project quality inspection requirements to verify that each cable is free from damage or contamination.

5. NOTES

5.1 Intended Use. – This specification is intended to specify the requirements of the procuring activity in contract specifications.

5.2 Ordering Data. – Procurement documents, contracts, and program, project, system, or Component End Item (CEI) specifications should specify the title, number, and date of this specification.

6. DEFINITIONS – For the purpose of this specification, the following definitions apply:

6.1 Coaxial Cable. – A cable consisting of a conducting outer metal tube enclosing and insulated from a central conducting core, used for high-frequency signal transmissions. Two cylindrical conductors with a common axis, separated by a dielectric material.

6.2 Connector. – A mechanical device which provides electrical contact between wires and cables. It has the capability of being connected or disconnected. A complete connector assembly consists of a mated plug and receptacle. Either the plug or the receptacle may have pin or socket contacts.

6.3 Electrical Wire. – A single metallic electrical conductor of solid, stranded, or tinsel construction, designed to carry current. It may be bare or insulated, but does not have a metallic covering, sheath, or shield.

6.4 Electrical Harness Assembly. – One or more insulated wires or cables, with or without helical twist; with or without common covering, jacket or braid; 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.

6.5 Electrical Cable. – A pre-manufactured collection of two or more insulated wires, with or without a common covering (sheath, shield, or jacket), two or more insulated wires twisted or molded together without common covering.

6.6 Flammable Material. – Material with the capability of bursting into flame when a spark or open flame is passed sufficiently near, as with fumes and vapors from volatile combustible liquids and finely powdered combustible solids.

6.7 Flat Conductor Cable. – An electrical cable consisting of two or more solid, rectangular conductors. The conductors are embedded in high-performance insulating materials in a flat and parallel configuration.

7. Acronyms and Abbreviations

ANSI	American National Standards Institute
AWG	American Wire Gage
CEI	Component End Item
DWV	Dielectric Withstanding Voltage
ESD	Electrostatic Discharge
EMC	Electromagnetic Compatibility
ID	Inside Diameter
IEEE	Institute of Electrical and Electronic Engineers
IR	Insulation Resistance
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
OD	Outside Diameter
TFE	Tetrafluoroethylene

(Suggested changes together with suitable information should be directed to ES21 Structural and Mechanical Design, Marshall Space Flight Center, Alabama 35812)

Custodian: NASA, George C. Marshall Space Flight Center

Preparing Activity: George C. Marshall Space Flight Center