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DEPARTMENT OF DEFENSE HANDBOOK

GENERAL HANDBOOK FOR SPACE VEHICLE WIRING HARNESS DESIGN AND TESTING

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1. SCOPE

1.1 Purpose.

This handbook sets forth the general design and testing requirements for electrical wiring harnesses (see 6.2.5) and cable assemblies (see 6.2.4) that are to be installed in space vehicles.

1.2 Application

The wiring requirements covered by this handbook are applicable to wiring harnesses and accessories for use in the interconnection of electrical and electronic equipment in space vehicles. This handbook may also be used to specify requirements for interconnect wiring on launch vehicles, intercontinental ballistic missiles, or other vehicles (see 6.1). For those applications the term "space vehicle” is to be interpreted as the applicable vehicle.

2. APPLICABLE DOCUMENTS

2.1 Issues of documents.

The following documents form a part of this handbook to the extent described herein.

Military Specifications.

MIL-C-17	Cables, Radio Frequency; Flexible and Semi-rigid, General Specification for
MIL-W-5088	Wiring, Aerospace Vehicle
MIL-W-5846	Wire, Electrical, Chromel and/or Alumel, Thermocouple
MIL-C-24308	Connectors,, Electric, Rectangular, Miniature PolarizedShell, Rack and Panel, General Specification for

MIL-C-38999	Connectors, Electric, Circular Miniature, High Density,Quick Disconnect, Environment Resistant, Removable Crimp Contacts, General Specification for
MIL-C-39012	Connector, Coaxial, Radio Frequency, General Specification for
MIL-C-55544	Connectors, Electric, Environment Resistant, for Use with Flexible Flat Conductor Cable and Round Wire, General Specification for
MIL-W-81044	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy
MIL-W-81381	Wire, Electric, Polyimide-Insulated, Copper or Copper Alloy
MIL-C-83723	Connectors, Electric, Circular, (Environment Resisting), Receptacles and Plugs, General Specification for
MIL-C-83733	Connectors, Electrical, Miniature, Rectangular Type, Rack to Panel, Environment Resisting, 200 degrees Total Continuous operating Temperature, General Specification for

<u>Military Standards</u>

MIL-STD-863 Wiring Data, Preparation of

<u>Military Handbooks</u>

MIL-HDBK-216 R-F Transmission Lines and Fittings

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions be obtained from the contracting office or as directed by the contracting officer.)

2.2 Other publications.
The following documents form a part of this handbook to the extent described herein.

THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS

IEEE 200-1975 Reference Designations for Electrical and Electronics Parts and Equipments (with ANSI Y32.16-1975)

(Application for copies be addressed to the Institute of Electrical and Electronics Engineers. Inc., 345 East 47th street, New York, New York 10017)

3. REQUIREMENTS

3.1 Order of precedence.

In the event of conflicts between any of the documents referenced herein and the contents of this handbook, the contents of this handbook should be considered the superseding requirements.

3.2 Supplementary specifications and standards.

When this handbook and the documents referenced herein fail to provide a suitable reference, other appropriate documents may be used. If the documents referenced in this handbook do not provide the contractually required reliability, quality level, or technical performance, they be interpreted as being referenced to limit the variety of the physical and functional parameters to the extent practicable. In those cases, the referenced specifications be the basis of contractor specifications that would add, delete, or change specific requirements. When a detail or general military specification exists for the class of material required, the contractor's specification should reference the existing military specification and set forth only the needed new requirements and deviations. If required by the contract, the supplementary specifications that are prepared by the contractor should be submitted to the contracting officer for review or approval prior to their use. When required by the contracting officer, the contractor should provide data substantiating the supplementary requirements and should provide samples for testing. The use of contractor's specifications should not constitute waiver of Government inspection requirements.

3.3 Selection of parts, materials, and processes.

Unless otherwise specified in the contract, the parts, materials, and processes should be selected and controlled in accordance with contractor established and documented procedures to satisfy the specified wiring harness requirements. The selection and control procedures should emphasize quality and reliability, as required, to minimize total life cycle costs for the applicable vehicles. An additional objective in the selection of parts should be to maximize commonality and minimize the variety of wiring components and related servicing tools required in the fabrication, installation, and maintenance of the vehicle electrical wiring system.

3.4 General design requirements

3.4.1 Circuit categories.

The electrical characteristics required for interconnecting wiring are the first consideration to be established in designing electrical wiring harnesses for space vehicles. In particular, the wire types (see 6.2.1) required depend upon the voltage, current capacity, and frequency of the circuits. The five major categories and the various subcatagories of circuits are defined in the following subparagraphs and summarized in Table I. Each circuit in each wiring harness or cable assembly should be categorized in accordance with these definitions.

3.4.1.1 Category I (power and control).

Includes (a) dc circuits over 10 volts (V), (b) dc circuits below 10 V and over 5 amperes (A), (c) ac circuits below 0.1 megahertz (MHz) with voltages above 25 V rms, and (d) pulse circuits with maximum voltages above 25 V with rise and fall times greater than 1 microsecond.

3.4.1.2 Category II (high-level signals).

Includes (a) digital circuits with voltage levels from 5 to 25 V maximum and rise and fall times greater than 1 microsecond, (b) digital circuits with maximum voltage levels from 1 to 10 V and rise or fall times less than 1 microsecond, (c) ac circuits below 0.1 MHz with voltages between 5 V and 25 V, and (d) ac circuits between 0.1 MHz and 1.0 MHz with voltage levels between 1 V and 10 V.

3.4.1.3 Category III (low-level signals)·

Includes (a) dc circuits below 10 V and less than 5 A, (b) ac circuits between 0.1 MHz and 1.O MHz with voltage levels less than 1 V, (c) ac circuits below 0.1 MHz with voltages less than 5 V, (d) digital circuits with maximum voltages less than 1 V and with rise or fall times less than 1 microsecond, and (e) digital circuits with maximum voltages less than 5 V and with rise and fall times greater than 1 microsecond.

3.4.1.4 Category IV (electroexplosive device circuits).

Includes all electroexplosive device (EED) circuits.

3.4.1.5 Category V (high-frequency signals).

Includes (a) all ac circuits above 1 MHz and (b) high-level digital circuits with maximum voltages above 10 V and with rise or fall times less than 1 microsecond, and (c) ac circuits between 0.1 MHz and 1.0 MHz with voltage levels above 10 V.

3.4.2 Shielding requirements.

Shielding (see 6.2.2) should be provided as indicated in the following subparagraphs. All shielding should be insulated to prevent uncontrolled grounding.

3.4.2.1 Interconnect wiring for category I circuits.

Wiring for category I circuits should have the power or signal wire(s) twisted with the return wire. The wiring may be unshielded.

3.4.2.2 Interconnect wiring for category II circuits.

Wiring for category II circuits should have twisted signal and return wires with each pair, or circuit, shielded.

3.4.2.3 Interconnect wiring for category III circuits.

Wiring for category IIIa should have twisted signal and return wires. Category IIIa wiring should be shielded as a group from category IIIb and other categories. Wiring for category IIIb should have twisted signal and return wires with each pair, or circuit, shielded. Wiring for category IIIc should have twisted signal and return wires. Category IIIc wiring should be shielded as a group from category IIIa, IIIb, and other categories. Wiring for category IIId and category IIIe should have twisted signal and return wires with each pair, or circuit, shielded.

3.4.2.4 Interconnect wiring for category IV circuits.

Wiring should be twisted pairs, each pair shielded.

3.4.2.5 Interconnect wiring for category V circuits.

Wiring interconnections, other than waveguide, should be shielded coaxial cable, balanced shielded cable, or balanced cable with a characteristic impedance of 100 ohms or less.

3.4.2.6 Added shielding.

Shielding can be added over that specified for the category of each circuit to prevent excessive radiation from, or excessive pickup on, the circuit. Coax or balanced shielded cable may be used instead of twisted shielded pairs particularly in applications where the capacitance per meter is critical. Shielding should be added over that specified for the category of each circuit to the extent required when an electromagnetic pulse (EMP) environment is specified. Shielded circuits may be routed together in a bundle with a common secondary shield.

3.4.3 Shield termination and shield grounding.

Multiple point shield grounding should be used on high-frequency circuits (above 0.1 MHz), on digital circuits with rise or fall times less than 1 microsecond, and on all EED firing circuits (category IV). Single end shield grounding should be maintained on all other circuits, except that when multiple shields are used to prevent induced interference, the outer shield should be multipoint grounded. When single end shield grounding is used to protect a circuit against induced radiation, the ground should be at the receiver or high impedance end. When single end shield grounding is used to minimize radiation from a circuit, the ground should be at the signal source end.

3.4.3.1. Shield terminations for electromagnetic pulse (EMP) environment.

Wire shields in all categories of circuits that may be subjected to an EMP environment should be bonded around the circumference, and preferably within the backshell, of the connectors. Inner shields that are designed to be ungrounded at one end should be terminated within the connector shell and the ends secured against fraying. Ungrounded inner shield terminations should be insulated from the connector pins, the backshell of the connector, and from adjacent shields.

3.4.3.2 Shield ground terminations for category IV circuits.

Wire shields in category IV circuits (EEDs) should be bonded around the circumference, and preferably within the backshell of the connectors. Circuits such as pyrotechnic event instrumentation circuits that make a direct connection to the electroexplosive device circuit should employ shields which are bonded around the circumference and preferably with the backshell at the pyro junction or relay box connector. If an EMP environment is not specified, the shield ground at the other instrumentation circuit connector may be grounded through a pigtail to a pin in the connector or directly to structure.

Table 1 Summary Of Circuit Categories And Shielding Requirements

Circuit Character	Level Volts (V)or Amperes (A)	Category (see 3.4.1)	Shielding(see 3.4.2)
Direct current	Below 10 V and less than 5 A	IIIa	shielded as a group from other categories
	Below 10 V and above 5 A	Ib	none
	Above 10 V	Ia	none
Alternating current below 0.1 MHz	Below 5V RMS	IIIc	shielded as a group from other categories
	Between 5 V and 25 V RMS	IIc	each pair shielded
	Above 25 V RMS	Ic	none
Alternating current between 0.1 MHz and 1 MHz	Below 1 V RMS	IIIb	each pair shielded
	Between 1 V and 10 V RMS	IId	each pair shielded
	Above 10 V RMS	Vc	coax or balanced shielded cable
Alternating current above 1 MHz	all	Va	waveguide, coax, or balanced shielded cable
Pulse with rise or fall time greater than 1 microsecond	Below 5 V peak	IIIe	each pair shielded
	Between 5 V and 25 V peak	IIa	each pair shielded
	Above 25 V peak	Id	none
Pulse with rise or fall time less than 1 microsecond	Below 1 V peak	IIId	each pair shielded
	Between 1 V and 10 V peak	IIb	each pair shielded
	Above 10 V peak	Vb	coax or balanced shielded cable
Electroexplosive(EED)	all	IV	each pair shielded

3.4.3.3 Shield ground terminations for category I, II, III and V circuits (no EMP).

Wire shields in these categories of circuits, that require grounding and which are not subjected to an EMP environment, should be grounded to the vehicle structure by the shortest feasible route. The length of the pigtail or connecting wire between the shield and the ground should be as short as practicable, but should not exceed 100 millimeters (mm) for harnesses containing less than 20 shielded wires. The length of unshielded, insulated wire that may show in back of the connector shell should be as short as practicable, but should not exceed 20 mm. For these circuits, the following methods of grounding the shields are acceptable, in order of preference:

a. On, and preferably within, the electrical connector to provide a low impedance path to structure when joined to the mating connector.

b. By a pigtail to a pin in the electrical connector.

c. By a pigtail directly to structure.

3.4.3.4 Ungrounded shield terminations (no EMP).

Wire shield terminations that are to be ungrounded, and are not subjected to an EMP environment, should be secured against fraying and insulated from the back shell of the connector and from adjacent shields. Where practicable, the ungrounded end of the shield should be terminated by a pigtail to a connector pin to facilitate making shield continuity and resistance measurements (see 4.5.2). The length of unshielded, insulated wire that may show in back of the connector shell should be as short as practicable but should not exceed 20 mm.

3.4.4 Wire terminations.

Wire terminations to connectors or terminal lugs should be made with a crimp device where practicable. Wires to be terminated should be stripped of insulation by methods that do not result in nicked or broken strands. The length of the stripped portion of the conductor should be long enough to reach the bottom of the crimp barrel. Not more than one wire (conductor) should be terminated to any contact of environmentally sealed connectors. Not more than one wire (conductor) should be terminated in an individual terminal lug. For screw type terminal boards, the harness design should be such that the maximum number of lugs to be connected to any one terminal on a terminal board should be four for ring type lugs, or two for spade type lugs.

3.4.5 Circuit isolation.

Interconnect wiring in each of the five categories should be isolated from wiring in other categories by maintaining, to the extent practicable, a minimum separation of 30 mm between wires and wire bundles of the different categories. When wires from circuits in different categories use the same connector, the pin assignments and layout should stress isolation between different categories, and grounded spare pins should be fully utilized to provide such isolation. Category IV circuits (electroexplosive devices) should maintain a minimum distance of 30 mm from other category circuits and should not share the same connector with other category circuits. High impedance circuits, above 1000 ohms, or sensitive circuits, below 5 V, should be isolated by routing or shielding or both from other circuits even in the same category. Antenna cables should be separated from each other and from other wiring. Where practicable, wiring to redundant subsystems or equipment should be run in separate harnesses or cable assemblies to prevent damage to one subsystem affecting the other.

3.4.6 Mockup.

A three-dimensional mockup of the space vehicle should be provided where required to determine the proper routing, wire lengths, connector configurations, support requirements, and access requirements of the wiring harnesses. The mockup may be limited to partial installations which contain the more complex wiring harnesses. The mockup should be used to support design reviews of the wiring harnesses, to fabricate wire jig boards, to demonstrate typical wiring installations, and to show all wiring practices for which deviations are requested. A development test vehicle, a qualification test vehicle, or a flight vehicle may be used for harness mockup instead of creating a separate vehicle mockup if adequate time is scheduled to support the wiring harness mockup activities.

3.4.7 Routing.

System reliability should be a primary consideration in selecting the routing for wiring harnesses or cable assemblies. Where practicable, routing should provide accessibility for easy removal and replacement of attached equipment as well as the wire harness. Routing through small structural openings should be avoided where practicable to minimize flexing and handling of the harness during its installation. The allowable cable size and minimum radius of bends should be in accordance with MIL-W-5088. Routing should be such as to minimize the possibility of damage to the wiring. Interference with other equipments should be avoided. Routing should offer protection against possible damage through common misuses such as being a handhold or a temporary support for test equipment. Although similar connectors or cable terminations should not be used in adjacent locations, the routing and forming should be such that improper connections cannot be made. To prevent possible damage from fumes and fluids, a 50 mm minimum clearance should be maintained, where practicable, between the harnesses and lines or equipment containing oxygen, flammable liquids or gases, corrosive liquids or gases, or cryogenic liquids or gases. The clearance between wires or cables and heat generating devices should be such as to avoid deterioration of the wires or cables from the heat dissipated by the devices. Routing should provide slack to prevent mechanical strain on the wires, junctions, and supports resulting from installation and servicing of equipment, vibration, thermal environments, and tolerance buildup including vehicle and harness fabrication. Additional slack should be provided in the area of terminations to allow the replacement of terminations three times; however, excessive slack should not be provided. Where wiring harnesses must cross a moving or rotating interface, such as a deployable solar array attach fitting, the installation drawings should define dimensions including loopsizes and distances to attachments. Attachment clamps should be provided sufficiently close to any loops so that movement into the path of motion of the moving mechanical assembly cannot occur under any conditions. Connectors should be provided at each end of the loop where practicable to permit assembly and disassembly without disturbing the harness configuration in the area of the interface. Wire bundles crossing a moving or rotating interface should not contain strain-energy elements to assist deployment.

3.4.8 Protection and support.

Wiring harnesses and cable assemblies should be protected and supported in accordance with MIL-W-5088. Harness breakouts should be supported to avoid overstressing of the wires by flexing of the breakout. Accessories such as sleeving, grommets, insulation tape, clamps, straps, tying tape, and other related items, should be in accordance with MIL-W-5088. Unmated connectors should be provided with dust caps to prevent damage to the pins and the entry of foreign matter.

3.5 Wire and cable requirements.

The type of wire should be in accordance with MIL-W-81044, MIL-W-81381, or be an equivalent type with insulation that has equal to or greater resistance to cold flow than those types. For applications having constraints on allowable outgassing, it should be recognized that neither total allowable mass loss nor allowable loss of volatile condensable materials are controlled by these military specifications. Thermocouple applications may use MIL-W- 5846 wire. Coaxial cable should be in accordance with MIL-C-17. MIL-HDBK-216 should be used as a guide for the selection of coaxial cable. The selection of wire size should be based upon circuit current and cable size in accordance with the requirements of MIL-W5088. Use of the minimum wire gauges 22 AWG annealed copper and 24

AWG high strength copper alloy should be restricted in accordance with MIL-W-5088.

3.6 Connector requirements.

Connectors used in the fabrication of wire harnesses and cable assemblies should be suitable for the application. Wire harness connectors should be of the rear insertable removeable crimp contact and quick disconnect type where feasible. Except as modified herein, connectors should be in accordance with MIL-C-24308, MIL-C-38999, MIL-C-55544, MIL-C-83723, or MIL-C-83733. Coaxial connectors should be suitable for the application and be in accordance with MIL-C-39012. Connector shells should have a conductive finish, however, cadmium plating should not be used. Empty holes should not be left in connector grommets where there are unused contacts. In such cases, unused grommet holes should be filled with sealing plugs. Other related requirements such as for right angle connectors, terminals, contacts, sealing, potting, safety wiring, and connector accessories, should be in accordance with MIL-W-5088. Similar connectors located in the same physical area of the space vehicle should have different keying arrangements to preclude connectors mismating (reference harness routing and forming restrictions in 3.4.7). Connectors to be used in an EMP or high level rf environment should be capable of incorporating rf finger stock at the connector-receptacle interface to provide for shield continuity and should be mechanically capable of being subjected to the coupling nut torquing. Connectors that are not self-locking should be safety wired.

3.7 Assembly and fabrication requirements

3.7.1 Fabrication forming board.

Fabrication of all wire harnesses or cable assemblies for space vehicles should be on a three dimensional jig, or on a fabrication forming board that reproduces the size and shape of the harness when installed in the vehicle. All electrical terminations should be located with position, tilt, and index identical to the final vehicle installation. Connector shells with inserts should be used to reproduce the mating interface and facilitate testing. When desired by the contractor, the vehicle itself may be used as the jig to fabricate the harness in place.

3.7.2 Wire lay

3.7.2.1 Twisted or helical wire lay.

Wiring harnesses or cable assemblies consisting of more than four conductors which terminate in connectors, and which are subject to flexing when mated and demated, should be fabricated with a twisted or helical wire lay for that portion of the wire harness or cable assembly which is subject to movement during the connector mating or demating operations.

3.7.2.2 Parallel or straight wire lay.

A wiring harness or cable assembly may be fabricated with a parallel or straight wire lay for that portion of the wiring harness or cable assembly which is permanently installed in the spacecraft, and which is not subject to movement after installation.

3.7.3 Other requirements.

Splices are prohibited except where the use of a connector is not practicable or would reduce reliability. For example, splices may be used when wiring can be permanently joined to component leads. Each individual wire or wire grouping should be accessible for replacement in the event of some unplanned damage during harness fabrication. If potting or molding is utilized to isolate, insulate, or to provide strain relief (slug mold), the encapsulate should be, where practicable, a material that can be readily removed and replaced. Strain reliefs, preparation for termination, and other related requirements should be in accordance with MIL-W-5088.

3.8 Harness identification and data requirements.

3.8.1 Wiring data.

The preparation of wiring data should be in accordance with MIL-STD-863 or an equivalent contractor format.

3.8.2 Identification of individual conductors.

The physical marking of individual conductors is only required to the extent needed to facilitate assembly, inspection, and possible modification of the wiring harness. Although it exceeds this requirement, physical marking of individual conductors or cables may be accomplished in accordance with MIL-W-5088.

3.8.3 Identification of harnesses.

To facilitate installation on the vehicle, and servicing in the field prior to launch, each wiring harness or cable assembly and each connector should be physically marked with its reference designation established in accordance with IEEE 200. Each wiring harness or cable assembly should also be identified and physically marked with the drawing part number and a unique serial number at the time of fabrication. Each connector should also carry the reference designation of its mating connector. The method and location of the physical identification should assure legibility when installed in the vehicle and should not impair the functional characteristics of the wire harness or cable assembly.

3.9 Operability

3.9.1 Reliability.

The reliability design requirements should assure that the overall vehicle reliability requirements are met under the most severe extremes of acceptance testing, storage, transportation, preflight testing, and operational environments.

3.9.2 Interchangeability.

Any two or more wiring harnesses or cable assemblies bearing the same part number should possess such functional and physical characteristics as to be equivalent in performance and durability and should be capable of being changed, one for another, without alterations of the items themselves or of adjoining items.

3.9.3 Maintainability.

The wiring harnesses should be designed so as not to require any scheduled maintenance or repair during their service life.

3.9.4 Service life.

The service life of the wiring harnesses should be specified as one year plus the service life of the vehicle for which it has been designed.

3.9.5 Environment.

The wiring harnesses should be capable of meeting the functional characteristics and design requirements specified herein before and after exposure to preflight environmental conditions, and during all flight environmental conditions as specified in the vehicle type or detail specification.

3.9.6 Storage and transportability.

It is a preferred practice that completed wire harnesses not be removed from their three-dimensional forming board until all quality assurance requirements have been met. The wiring harness should have dust caps installed on all connectors and then be moved from the fabrication forming board directly to installation on the vehicle without intermediate storage to avoid unnecessary handling. Whenever production schedules, alternate practices, or other considerations, require harness storage, the wire harness should be packaged, handled, and transported in a manner that minimizes possible damage or environmental degradation. When a wiring harness is removed from the fabrication forming board for storage, dust caps should be installed on all connector and the entire harness placed in an protective bag or box. Unsupported handling should be avoided. When a harness has been in storage for longer than 6 months, the quality assurance requirements should be verified by test or retest immediately prior to the harness installation on the space vehicle.

3.9.7 Workmanship

All details of workmanship concerned with the fabrication and installation of wiring harnesses should be controlled such that the finished item is of sufficient quality to ensure proper operation, safety, reliability, and service life.

4. QUALITY ASSURANCE REQUIREMENTS

4.1 Responsibility for inspections and tests.

Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection and test requirements as referenced herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection and test requirements referenced herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2 Classification of inspections and tests.

The tests and inspections specified herein are classified as follows:

a. Parts, materials, and process controls (4.3)

b. Physical configuration audit (4.4)

c. Acceptance tests (4.5)

d. Qualification tests (4.6)

4.3. Parts, materials, and process controls.

To ensure that reliable wiring harness assemblies are fabricated, all parts and materials should be adequately controlled and inspected prior to assembly. During fabrication, the tools and processes, as well as the parts and materials, should be adequately controlled and inspected. Each wiring harness assembly should have inspection records and test records maintained by serial number to provide traceability. Complete records should be maintained and be available for review during the service life of the wiring harness. The records should document all relevant test data, all rework or modifications, and all installations or removals for whatever reason. The records should include such items as crimp tool pull test data and mechanical stripper test data made at the beginning and end of each working day.

4.4 Physical configuration audit.

The first complete vehicle assembly should be made available for inspection of the wiring harnesses as installed. There should be no discrepancies among the installed wiring harness, the fabrication tooling used, the vehicle mockup, the released drawings, the test data, and the specification requirements.

4.5 Acceptance testing.

The configuration and workmanship of the completed hardware should be verified by inspection prior to the start of acceptance testing. Each wiring harness delivered for acceptance should have received, as a minimum, the following tests in the order listed in the following subparagraphs.

4.5.1 Contact retention test.

Each rear insertable removable crimp contact (pin or socket) of the harness connectors should be subjected to a retention push test, following insertion of the contact in the connector insert. The force should be applied at the mating face of the connector to check the retention of the contact in the insert by the retention mechanism. The contact should be retained when the applied force is 21 newtons.

4.5.2 Circuit resistance test.

The continuity of each conductor and of each shield in the assembled wiring harness should be determined by measuring the circuit resistance. This measurement should be made using direct current with a voltage not exceeding 50 V and a current not exceeding 2 A. The measured resistance of each circuit should be compared to its calculated value but should not exceed 0.5 ohms, except when the length of the conductor is such that that its calculated resistance exceeds 0.3 ohms. The calculated resistance should always be rounded to the next highest tenth ohm. For a calculated resistance between 0.3 ohms and 0.9 ohms, a test tolerance of 0.2 ohms should be added to determine the maximum measured value allowed. For a calculated resistance value above 0.9 ohms, a test tolerance of 1.0 ohm should be added to determine the maximum measured value allowed. The calculated resistance of shields should be based on actual shield resistance values but should not exceed 0.31 ohms per meter.

4.5.3 Insulation resistance test.

This test should be performed at a minimum dc potential of 500 V or at two times the peak voltage, whichever is greater. The insulation resistance should be measured between each conductor and every other conductor, between each conductor and every conductor shield, and between each conductor and connector shell. The test potential should be applied for 5 seconds and the measured resistance should be greater than 10 megohms. A lesser test time may be used if the measured insulation resistance exceeds 10 megohms immediately following application of the test voltage, and continues to rise. For thermocouple instrumentation wiring, an insulation resistance of 1 megohm is acceptable.

4.5.4 High potential withstanding test.

This test should be performed using either a 60 Hz ac test potential or a dc test potential. Because the wiring capacitance results in higher ac currents that may give an erroneous indication of breakdown, only the dc test is recommended for cables longer than 3 meters. Coaxial cables and thermocouple instrumentation wiring are excluded from these high potential withstanding test requirements.

4.5.4.1 For 60 Hz ac test.

When a 60 Hz ac test potential is used, the test should be performed at a potential of 1000 V plus twice the maximum working voltage of the harness or at 1500 V, whichever is the greater; or at the test potential specified by the connector manufacturer(s) for the connectors in which the harness is terminated, if less than either of the previous. The test potential should be applied for at least 5 seconds at a rate of no less than 500 V per second until the desired test potential is reached. The test potential should be applied between each conductor and every other conductor, between each conductor and every conductor shield, and between each conductor and connector shell. There should be no electrical breakdown or arc-over.

4.5.4.2 For dc test.

When a dc test potential is used, the test should be performed in the same manner as described for the ac test except that the dc potential used should be not less than 1.4 times the appropriate ac test potential. For the dc test, the time of application of the test potential may be reduced to the time required for steady state current to be established. There should be no electrical breakdown or arc-over. If a dc test potential is used for the high potential withstanding test, the insulation resistance required by 4.5.3 may be measured simultaneously.

4.5.5 Insulation resistance retest.

The insulation resistance test of 4.5.3 above should be repeated to determine any damage caused by the high potential withstanding test, unless the insulation resistance test and high potential withstanding test are conducted simultaneously. The measured resistance should be not less than 10 megohms.

4.5.6 Contact separation force test.

Each socket contact of the harness connectors should be subjected to a contact separation test to check the minimum separation force exerted on a hardened and polished steel test pin. The applicable test pin should be inserted to fully bottom in each socket contact and the force required to remove the pin should then be measured. The applicable test pin diameters, and the minimum separating forces, should be as shown in Table II. For contact sizes not shown in Table II, an appropriate test pin diameter and minimum separating force should be used.

Table 2 Contact Separating Force Requirements

Mating End Size (AWG)	Separating Test Pin Diameter (millimeters)	Minimum Separation Force (newtons)
22	0.737 + 0.000 - 0.005	0.139
20	0.991 + 0.000 - 0.005	0.139
16	1.562 + 0.000 - 0.005	0.370
12	2.362 + 0.000 - 0.005	0.556
10	3.150 + 0.000 - 0.005	0.648
8	3.581 + 0.000 - 0.005	0.741

4.5.7 Environmental testing.

Thermal vacuum, vibration, shock, and electromagnetic interference test requirements of wiring harnesses and cable assemblies may be performed in conjunction with the vehicle level tests.

4.5.8 Acceptance criteria.

The acceptance criteria for wiring harnesses is the satisfactory completion of all contractually imposed acceptance tests. If a test discrepancy occurs during an acceptance test, the test should be interrupted and the discrepancy verified. The disposition of the discrepancy should be completed before the testing resumes. If the discrepancy dispositioned is due only to the test setup, test cable, or to a failure in the test equipment, the test being conducted at the time of the failure may be continued after the repairs are completed, as long as the discrepancy did not result in an overstress test condition. If an overstress test condition occurred or if the discrepancy dispositioned as a failure in the wiring harness under test, the preliminary failure analysis and appropriate corrective action should be completed in accordance with the established procedures for handling nonconforming supplies. The acceptance test in which the failure occurred, and any previous tests whose results could possibly have induced the failure, or whose validity was comprised by the corrective action, would then be entirely repeated.

4.6 Qualification.

Wiring harness qualification may be partially or totally satisfied by qualification of higher levels of assembly that include the harness. Qualification tests should be conducted to approved test plans that indicate what tests and test procedures will be conducted at what levels of assembly. Applications having constraints on allowable outgassing should qualify to that requirement either by test, or by an analysis using applicable materials test data to determine the estimated total mass loss and the estimated loss of volatile condensable materials for each wiring harness during its service life. Applications of harnesses that cross moving or rotating interface should include harness stiffness measurements and fatigue testing that may be appropriate. These tests and measurements should be conducted under the worst case dimensional conditions, with maximum motion, at ambient conditions as well as under worst case design environmental conditions.

4.7 Modifications, rework and retesting.

Completed wiring harnesses should be modified and reworked with the same high quality assurance provisions and criteria as an original harness. Unless specifically limited by the approved change proposal, the inspection and retesting requirements following modification should not be limited to the changes or modifications but the complete harness must be retested including the changes. Inspection and retesting requirements following rework should be consistent with the type and extent of the rework, the location where the rework is accomplished, and the inspection and testing criteria for the original harness.

5. PACKAGING (Not Applicable)

6. NOTES

6.1 Tailored application.

This handbook is intended for use in equipment specifications or contracts to incorporate those requirements which are common to most space vehicle wiring harnesses. The requirements stated in the handbook are a composite of those that have been found to be cost effective for high reliability space vehicle applications. The handbook therefore establishes the minimum requirements for most space vehicle applications. Where possible the requirements are stated in ways that are self-tailoring to each application. For example, the EMP requirements are not imposed by this handbook unless an EMP environment is indicated by some other compliance document. Nevertheless, all requirements of this handbook should *be* evaluated for each application and those that are not appropriate, or clearly increase program life cycle costs, should be excluded or changed. Contractors are encouraged to identify to the contracting officer, for program office review and reconsideration, any requirements imposed by this handbook that are believed excessive. However, contractors are reminded that deviations from contractually imposed requirements can be granted only by the contracting officer. Tailoring of shielding requirements should be based upon electromagnetic compatibility analysis or tests for particular applications. Because of the similarity of requirements, this handbook may be used to specify requirements for interconnect wiring on launch vehicles, intercontinental ballistic missiles, reentry vehicles, or other vehicles. For those applications the term “space vehicle" is to be interpreted as the applicable vehicle. All wiring which is completely internal to electrical or electronic equipment should be in accordance with the applicable equipment specifications rather than this handbook. For clarification, the terms “aerospace vehicle” or "aircraft" in MIL-W-5088 are to be interpreted as including space vehicles or other applicable vehicles.

6.2 Definitions

6.2.1. Wire.

A single metallic conductor of solid, or stranded construction, designed to carry current in an electric circuit, but which does not have a metallic covering, sheath, or shield. For this handbook , “wire” refers to "insulated electric wire.”

6.2.2. Shield.

A metallic sheath surrounding one or more wires, cables, cable assemblies, or a combination of wires and cables that is used to prevent or reduce the transmission of electromagnetic energy to or from the enclosed conductors.

6.2.3. Cable.

Two or more insulated conductors, solid or stranded, of equal length, contained in a common covering; or two or more insulated conductors, of equal length, twisted together without common covering; or one insulated conductor with a metallic covering shield or outer conductor (shielded wire or coaxial cable).

6.2.4. Cable Assembly.

A cable with all conductors and shields insulated and terminated to connectors, terminal lugs, or other suitable devices.

6.2.5. Wiring harness.

A group of wires, shields, cables, or cable assemblies, or any combination of these, all insulated and properly terminated to connectors, terminal lugs, or other suitable devices and mechanically held together by ties, straps, clamps, insulating jacket, or other means so that it can be installed as a single unit for the interconnection of two or more electrical or electronic equipments. A cable assembly that is a complete unit ready for installation in a vehicle is considered wiring harness.

6.3 Supersession data.

This issue of DOD-HDBK-83575 is a complete revision that supersedes the previous issue of DOD-W-83575 for new designs.

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CONCLUDING MATERIAL

PREPARING ACTIVITY
Air Force 19
Project 1820-9805

REVIEW ACTIVITIES
Air Force 33, 99, US
Coast Guard CG
NASA NA

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

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