

Wiring Aerospace Vehicle

RATIONALE

This document was revised to incorporate comments editorial and technical received and coordinated by the SAE AE-8A System Installation Committee since 2006. Specification reference data was also updated.

FOREWORD

This specification has been developed by the SAE AE-8A System Installation Subcommittee as an industry replacement for MIL-W-5088L. Conformance with the provisions of this document is intended to provide wiring system safety, performance, reliability, maintainability, service life and life cycle cost equivalent to that achieved when conforming to the provisions of MIL-W-5088. When practicable, paragraph numbers of this specification have been arranged to agree with their counterparts in MIL-W-5088. It is recommended that this overall set of requirements be used as a part of an aerospace vehicle specification in order to provide an overall set of requirements for wiring system provision.

1. SCOPE

1.1 Purpose

This specification covers all aspects from the selection through installation of wiring and wiring devices and optical cabling and termination devices used in aerospace vehicles. Aerospace vehicles include manned and unmanned airplanes, helicopters, lighter-than-air vehicles, missiles and external pods.

1.1.1 Application

This specification establishes design requirements guidance for wiring and optical cable installation in aerospace vehicles. Although many of the requirements are written as mandatory and shall be considered as such, there is also considerable material which is intended to denote optional, preferential or guidance type requirements. In interpreting the material contained herein, it is intended that the philosophy of the entire document be considered for the wiring of each new type of vehicle. This philosophy is safety of the personnel, safety of the vehicle, satisfactory performance and reliability of the vehicle and ease of maintenance, and service life all at the least cost to the operator. The intent of this document will be fulfilled by tailoring the requirements in each new type or class of aerospace vehicle designed, to the proper application.

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SAE WEB ADDRESS:

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of the other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE International Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AIR1329	Electrical Connectors and Wiring, Compatibility of
ARP1870	Aerospace Systems Electrical Bonding and Grounding for Electromagnetic Compatibility and Safety
AS3509	Cable, Safety, Kit, Nickel Alloy, UNS N0660
AS4372	Performance Requirements for Wire, Electric, Insulated Copper or Copper Alloy
AS4373	Test Methods for Insulated Electric Wire
AS4461	Assembly and Soldering Criteria for High Quality/High Reliability Soldering Wire and Cable Termination in Aerospace Vehicles
AIR4465	Design and Handling Guide Radio Frequency Absorptive Type Wire and Cables (Filter Line, MIL-C-85485)
AS4536	Safety Cable Kit Procurement Specification and Requirement for Use
AS5768	Tool, Stripper, Electrical Insulation, General Specification For
AS6136	Conduit, Electrical, Flexible, Shielded, Aluminum Alloy for Aircraft Installations
AS70991	Terminals:, Lug and Splice, Crimp Style, Aluminum, For Aluminum Aircraft Wire
AS7351	Clamp, Loop Type Bonding
AS7928	Terminals, Lug: Splices Conductor: Crimp Style, Copper, General Specification For
AS7974	Cable Assemblies and Attachable Plugs, External Electrical Power, Aircraft, General Specification For
AS8700	Installation and Test of Electronic Equipment in Aircraft, General Specification for
AS10380	Coupling Installations, Standard Conduit, Electrical
AS21919	Clamp, Loop Type, Cushioned, Support
AS22759	Wire, Electrical, Fluoropolymer-Insulated, PTFE and PTFE-Coated Glass, Silver-Coated Copper Conductor, 600-Volt
AS23190	Straps, Clamps, and Mounting Hardware, Plastic and Metal for Cable Harness Tying and Support
AS23190/4	Mounting Hardware, Cushion Clamp, Metal for Cable Harness Tying and Support. TYPE V, CLASS 1
AS25274	Cap, Electrical (Wire End, Crimp Style, Type II, Class 1), for 105°C Total Conductor Temperature

AS25281	Clamp, Loop, Plastic, Wire Support
AS27212	Terminal Board Assembly, Molded-In-Stud, Electric
AS33481	Contact Bushing, Electric, Wire Barrel
AS33681	Strap, Tiedown, Electrical Components, Identification, Adjustable, Self-Clinching, Plastic, Type II, Class I
AS33731	Strip, Mounting, Nut Insulating, for MS27212 Terminal Board
AS39029	Contacts, Electrical Connector, Pin, Crimp Removable (For AS81714 Terminal Junction System
AS81044	Wire, Electrical, Crosslinked Polyalkene, Crosslinked Alkane-Imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy
AS81714	Terminal Junction System (TJS), Environment Resistant, General Specification for
AS81714/11	Terminal Junction System, Terminal Junction Blocks, Sectional, Wire In-Line Junctions, Single, Series I
AS81714/12	Terminal Junction System, Terminal Junction Blocks, Sectional, Wire In-Line Junctions, Double, Series I
AS81790	Connectors, Receptacle, External Electrical Power, Aircraft General Specification For
AS81824	Splices, Electric, Permanent, Crimp Style, Copper, Insulated, Environment Resistant
AS81824/1	Splice, Electric, Permanent, Crimp Style Copper, Insulated, Environment Resistant, Class I
AS83519	Shield Termination, Solder Style, Insulated, Heat-Shrinkable, Environment Resistant, General Specification For
AS85049	Connector Accessories, Electrical, General Specification For
AS85848	Sleeving, for Identification Marking, Heat Shrinkable, General Specification for
AS90376	Cap, Dust, Plastic, Electric Connector
AMS-S-8802	Sealing Compound, Temperature Resistant, Integral Fuel Tanks and Fuel Cell Cavities, High Adhesion
AMS-DTL-23053	Insulation Sleeving, Electrical, Heat Shrinkable, General Specification For

2.2 U.S. Government Publications

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, <http://assist.daps.dla.mil/quicksearch/>.

2.2.1 Specifications, Standards and Handbooks

Unless otherwise specified, the following specifications, standards and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DODISS) specified in the solicitation form a part of this specification to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-DTL-17	Cables, Radio Frequency, Flexible and Semirigid, General Specification for
MIL-I-631	Insulation, Electrical, Synthetic-Resin Composition, Nonrigid

MIL-I-3190	Insulation Sleeving, Electrical, Flexible, Coated, General Specification for
MIL-DTL-3607	Connector, Coaxial, Radio Frequency, Series
MIL-DTL-3650	Connectors, Coaxial, Radio Frequency, Series LC
MIL-DTL-3655	Connector, Plug and Receptacle, Electrical (Coaxial, Series Twin), and Associated Fittings, General Specification for
MIL-DTL-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-PRF-8516	Sealing Compound, Polysulfide Rubber, Electric Connectors and Electric Systems, Chemically Cured
MIL-DTL-22520	Crimping Tools, Terminal, Hand or Power Actuated, Wire Termination and Tool Kits, General Specification for
MIL-PRF-23586	Sealing Compound, Electrical, Silicone Rubber, Accelerator Required
MIL-M-24041	Molding and Potting Compound, Chemically Cured Polyurethane
MIL-DTL-25038	Wire, Electrical, High Temperature and Fire Resistant, and Flight Critical, General Specification for
MIL-DTL-25516	Connectors, Electrical, Miniature, Coaxial, Environment-resistant Type, General Specification for
MIL-PRF-39012	Connectors, Coaxial, Radio Frequency, General Specification for
MIL-PRF-46846	Rubber, Synthetic, Heat-Shrinkable
MIL-PRF-49142	Connector, Plug and Receptacle, Electrical, Triaxial, Radio Frequency, General Specification for
MIL-PRF-55339	Adapter, Connector, Coaxial, Radio Frequency, (Between Series and Within Series), General Specification for
MIL-T-81490	Transmission Lines, Transverse Electromagnetic Mode
MIL-DTL-83517	Connector, Coaxial, Radio Frequency for Coaxial, Strip or Microstrip Transmission Line, General Specification for
MIL-C-85485	Cable, Electric, Filter Line, Radio Frequency Absorptive
STANDARDS	
FEDERAL	
FED-STD-595	Colors Used in Government Procurement
MILITARY	
MIL-STD-196	Joint Electronics Type Designation System
MIL-STD-464	Department of Defense Interface Standard for Electromagnetic Environmental Effects Requirements for Systems
MIL-STD-681	Identification Coding and Application of Hookup and Lead Wire
MIL-STD-704	Aircraft Electric Power Characteristics
MIL-STD-889	Dissimilar Metals

MIL-STD-1553	Digital Time Division Command/Response, Multiplex Data Bus
MIL-STD-7080	Electric Equipment, Aircraft, Selection and Installation of
MIL-STD-7179	Finishes, Coatings, and Sealings for the Protection of Aerospace Weapons Systems, General Specification for
MS18029	Cover Assembly, Electrical, for AS27212 Terminal Board Assembly
MS25435	Terminal, Lug, Crimp Style, Straight Type, for Aluminum Aircraft Wire, Class 1
MS25436	Terminal, Lug, Crimp Style, 90° Upright Type, for Aluminum Aircraft Wire, Class 1
MS25438	Terminal, Lug, Crimp Style, Right Angle Type, for Aluminum Aircraft Wire, Class 1
MS25439	Splice, Permanent, Crimp Style, 2 Way Type for Aluminum Aircraft Wire, Class 1
MS27488	Plug, End Seal, Electrical Connector
MS35489	Grommet, Synthetic and Silicone Rubber, Hot Oil and Coolant Resistant
MS90387	Tool, Hand, Adjustable, for Plastic Tiedown Straps
HANDBOOKS	
MILITARY	
MIL-HDBK-502	Acquisition Logistics
MIL-HDBK-863	Wiring Data and System Schematic Diagrams, Preparation of
TECHNICAL MANUALS	
ARMY TM55-1500-323-24-1	Installation Practices for Aircraft Electrical and Electronic Wiring
NAVAIR 01-1A-505-1	Installation Practices for Aircraft Electrical and Electronic Wiring
USAF T.O. 1-1A-14	Installation Practices for Aircraft Electrical and Electronic Wiring
COMMERICAL ITEM DESCRIPTIONS (CID)	
A-A-52080	Tape, Lacing and Tying, Nylon (Type I), -67 °F (-55 °C) to 250 °F (121 °C)
A-A-52081	Tape, Lacing and Tying, Polyester (Type II), -100 °F (-73 °C) to 280 °F (138 °C)
A-A-52082	Tape, Lacing and Tying, TFE-Fluorocarbon (Type III), -100 °F (-73 °C) to 450 °F (232 °C)
A-A-52083	Tape, Lacing and Tying, Glass (Type IV), -100 °F (-73 °C) to 800 °F (427 °C)
A-A-52084	Tape, Lacing and Tying, Aramid (Nomex), (Type V), -100 °F (-73 °C) to 500 °F (260 °C)
A-A-59163	Insulation Tape, Electrical, Self Adhering Unsupported Silicone Rubber
A-A-59178	Nipple, Electrical Terminal
A-A-59474	Insulation Tape, Electrical, High Temperature, Polytetrafluoroethylene, Pressure-sensitive

ADDITIONAL DOCUMENTS

Additional documents pertaining to the selection of wire and electrical cables are listed in Appendix A.

2.3 Non-Government Publications

The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

2.3.1 AIA Publications

Available from Aerospace Industries Association. 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, www.aia-aerospace.org.

NAS813	Cap - Protective Electrical Connector
NAS820	Plug - Protective Electrical Connector
NASM3036	Grommet, Rubber Hot-oil and Coolant Resistant
NASM20995	Wire, Safety or Lock
NASM21266	Grommet, Plastic, Edging
NASM22529	Grommet, Edging
NASM25440	Washer, for Use With Aircraft Aluminum Terminals
NASM33540	Safety Wiring and Cotter Pinning, General Practice for

2.3.2 ASME Publications

Available from the American Society of Mechanical Engineers, 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007-2900, Tel: 973-882-1170, www.asme.org.

ASME Y14.100	Engineering Drawing Practices
ASME Y14.24	Types and Applications of Engineering Drawings
ASME Y14.34M	Associated Lists
ASME Y14.35M	Revision of Engineering (Chapter Drawings and Associated Lists)

2.3.3 EIA Publications

Available from Electronic Industries Alliance, 2500 Wilson Blvd., Arlington, VA 22201-3834, Tel: 703-907-7500, www.eia.org.

EIA 364-26	Salt Spray Test Procedure for Electrical Connectors, Contacts and Sockets
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2.3.4 IEEE Publications

Available from Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854-1331, Tel: 732-981-0060, www.ieee.org.

IEEE Std. 315-1975 Graphic Symbols for Electrical and Electronics Diagrams (Including Reference Designation Letters)

(Application for copies should be addressed to the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854-1331, Tel: 732-981-0060, www.ieee.org.)

2.3.5 NEMA Publications

Available from the National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1752, Roslyn, VA 22209, Tel: 703-841-3200, www.nema.org.

WC27500 Standard for Aerospace and Industrial Electric Cable

2.4 Order of Precedence

In the event of a conflict between the text of this document and the references cited herein (except for related associated detail specifications, specification sheets, or military standards), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.5 Definitions

2.5.1 Aircraft

An airplane, helicopter or lighter-than-air vehicle.

2.5.2 Branch

A section of harness that divides off and extends to a point of termination.

2.5.3 Bundle

Any number of harnesses or branches routed and supported together along some distance within the aircraft.

2.5.4 Chafing

Repeated relative motion between wiring system components, or between a wiring system component and structure or equipment, which results in a rubbing action that causes wear which will likely result in mechanical or electrical failure during the aerospace vehicles specified service life.

2.5.5 Connector Plug

The connector containing the coupling ring or active retention device of the mating pair.

2.5.6 Connector Receptacle

The connector containing the static retention device of the mating pair.

2.5.7 Electrical Cable

Two or more insulated conductors, solid or stranded, contained in a common covering, or two or more insulated conductors twisted or molded together without common covering, or one insulated conductor with a metallic covering shield or outer conductor.

2.5.8 End Face

The end portion of a fiber optic terminus that is intended to transmit light to an adjoining end of a mated terminus. End faces are either cleaved or cleaved and polished so as to optimize their light transmission characteristics.

2.5.9 Fiber Optics Cable

A cable that is designed to transmit light waves between a light transmission source and a receiver. In signal applications, the transmitter and receiver include devices that are used to convert between optical and electronic pulses. Typical cables include a glass or plastic core, a layer of cladding having a lower refractor index to refract or totally reflect light inward at the core/cladding boundary, a buffer, strength members and jacketing to protect the inner cable from environmental damage.

2.5.10 Fireproof

The capability of a material or component to withstand a 2000 °F flame (± 150 °F) for 15 minutes minimum, while still fulfilling its design purpose.

Clarification

The term "fireproof" when applied to a connector, backshell or accessory hardware mounted and secured to a structure used to confine fires within designated fire zones means that the connector system will perform this function (conduct electrical power and prevent flame/heat penetration) under conditions likely to occur in such zones and will withstand a 2000 °F flame (± 150 °F) for 15 minutes minimum. A connector system consists of mated connectors, fully wired, backshells or conduit assemblies, and mounting hardware installed on a structural panel (firewall).

2.5.11 Fire Resistant

The capability of a connector system (as defined in "fireproof") to perform its intended function in designated fire zone areas under heat and other abnormal conditions, as encountered in powerplants and auxiliary power unit (APU) installations, that are likely to occur at the particular location or area and to withstand a 2000 °F flame (± 150 °F) for 5 minutes minimum.

2.5.12 Firewall

A structural panel designed to prevent a hazardous quantity of air, fluid, or flame from exiting a designated fire zone in which a fire may erupt and cause additional hazard to the aircraft. This structural panel permits penetration of fluid carrying lines (fuel and hydraulics) ducts, electrical power and control cables/or rods through the use of suitable fireproof components or fittings. The firewall and the attached components or fittings shall withstand flame penetration and shall not exhibit backside ignition for the required test time (15 minutes). The backside temperature should not exceed 450 °F maximum and the structural panel should have fireproof insulating material installed to limit the backside temperature.

2.5.13 Fire Zone

A designated area or enclosure generally considered to be within certain selected areas within engine nacelles and APU installations that under abnormal operating conditions can experience temperatures approaching 2000 °F. These conditions are generally the results of fuel or hydraulic line failures, heat duct failures, or engine case burn through allowing high pressure and high temperature gas to escape from the engine, and similar types of failures. Some typical fire zones are the engine nacelles, (APU) compartment, fuel burning heaters, weapon exhaust areas, and other combustion equipment installations. Other areas such as wheel wells, may also be considered a fire zone area due to the heat generated from the brakes.

2.5.14 Flammable

Capable of bursting into flame when a spark or open flame is passed sufficiently near, as with fumes and vapors from hot oils or volatile combustible liquids, and with finely powdered, combustible solids.

2.5.15 Group

A number of wires and/or electrical/optical cables and their terminations secured together within the structure of a bundle or harness. Groups normally contain wire and/or electrical/optical cables pertaining to a single circuit or routed to a single item of equipment.

2.5.16 Harness

An assembly of any number of wires, electrical/optical cables and/or groups and their terminations which is designed and fabricated so as to allow for installation and removal as a unit. A harness may be an open harness or a protected harness.

2.5.16.1 High Density Harness

A protected harness designed to save weight and space which has a majority of wire types selected from Appendix A, Table A2.

2.5.17 Open Harness

An assembly of wires and/or electrical/optical cables that does not include a protective outer covering.

2.5.18 Optical System Losses

Fiber optic system losses represent the difference between light, the intensity, emanating from a transmission source and that arriving at a receiver. Such losses are normally the result of air gaps, misalignment and angularity between termini end faces, cable bends, and the inherent characteristics of cabling materials. They can also result from irregularities in the end face finish, foreign materials between end faces and micro-cracks in the cable's glass core.

2.5.19 Primary Support

Support provided for wiring that carries the weight of the wiring and secures it in the intended position (see 3.11.1).

2.5.20 Protected Harness

A harness that employs some overall outer covering to provide additional mechanical protection for the wires and/or electrical/optical cables contained therein. The added protection may consist of an overbraid, tape wrap, conduit or some other form of protection.

2.5.21 Secondary Supports

Supports used to secure the cabling between primary supports.

2.5.22 Severe Wind and Moisture Problems (Swamp) Areas

Areas such as wheel wells, wing folds and areas near wing flaps, and areas directly exposed to extended weather conditions are considered SWAMP areas on aerospace vehicles.

2.5.23 Spot Ties

Ties other than secondary support ties used to separate a number of wires, electrical/ optical cables, groups or harnesses within a bundle.

2.5.24 Termini

Individual fiber optic terminations which perform the function generally associated with connector contacts. The various types of termini are designed either to be mechanically crimped or epoxy bonded to a fiber optic cable.

2.5.25 Wire

A single metallic conductor of solid, stranded or tinsel construction, designed to carry current in an electric circuit, but not having a metallic covering, sheath or shield. For the purpose of this specification, "wire" refers to "insulated electric wire."

2.5.26 Wiring

Wires, electrical/optical cables, groups, harnesses and bundles, and their terminations, associated hardware, and support, installed in the vehicle. When used as a verb it is the act of fabricating and installing these items in the vehicle.

2.5.27 Wiring Devices

Wiring devices are the accessory parts and materials which are used in the installation of electrical and optical wiring, such as terminals, connectors, junction boxes, conduit, clamps, insulation and supports.

2.5.28 Wire SEGMENT

A length of wire that is continuous and unbroken between its two intended points of termination. A wire segment that has been broken and then repaired is still considered to be one wire segment.

3. REQUIREMENTS

3.1 Terminology Interpretation

The term "wiring" wherever used throughout this specification shall be interpreted in accordance with 2.5.26.

3.1.1 Deviations

Deviations from this specification desired by the contractor (substitution of equipment, material or installation) shall be specifically brought to the attention of the procuring activity by letter concurrent with or prior to forwarding the design data for approval. All requests for deviations shall include sufficient engineering information to substantiate the deviations.

3.2 Conflicting Requirements

In case of discrepancies between this specification and the type or detail specification for a particular vehicle part, the type or detail specification shall prevail.

3.3 Selection of Parts and Materials

Parts and materials covered by documents listed herein are standard and shall be used whenever they are suitable for the purpose. Parts and materials shall be procured from QPL sources when they exist. Nonstandard parts and materials must be equivalent to or better than similar standard parts and materials. When this specification fails to provide an applicable specification or standard, the contractor shall use other established specifications or standards. Parts and materials selected from other than this specification are not standard, and approval must be obtained prior to their use in aerospace vehicles. Each vendor source for a nonstandard part or material requires approval. When a nonstandard part is used where a suitable standard part exists, the contractor shall reference the standard part on the drawing, parts lists, or data package, and the installation shall provide for replacement with the standard part.

3.3.1 Requests for Approval of Nonstandard Parts

The data to be submitted with the request for approval of nonstandard parts shall be in accordance with the terms of the contract.

3.3.2 Commercial Utility Parts

Commercial utility parts, such as screws, bolts, nuts, cotter pins, etc., may be used, provided they have suitable properties and are replaceable by standard parts without alteration.

3.3.3 Contractor's Specifications

Wiring and wiring devices conforming to contractor's specifications may be used, provided each contractor's specification is approved by the procuring activity and provided no military specification exists. The contractor shall provide substantiating test data and, when required by the procuring activity, shall provide samples for test. The use of contractor's specifications shall not constitute waiver of procuring activity inspections. Contractor's specifications shall follow the format for military specifications. When a detail or general military specification exists for the class of material required, the contractor's specification shall reference the existing military specification and set forth only the needed new requirements and deviations.

3.3.4 Commonality

An objective in the selection of parts shall be to maximize commonality and minimize the variety of wiring components and related servicing tools required in the construction, installation and maintenance of the electrical wiring system.

3.3.5 Government-furnished Aircraft Equipment (GFAE)

Wiring and wiring devices furnished by the Government shall be installed without modification unless otherwise authorized or directed by the procuring activity.

3.3.6 Modification

The contractor shall not alter, rework or modify wiring or wiring devices built to and meeting Government specifications, unless authorized or directed by the procuring activity, and such modification shall be subject to Government inspection. Modified parts shall have the Government identifying part number removed and shall be identified by contractor part number.

3.4 Service Life

The wiring and associated components used for the wiring installation shall be so selected and installed to promote ease of maintenance and high reliability over the entire expected service life of the vehicle. The reliability and maintainability goals for the wiring system will be determined in the Acquisition Logistics as delineated in MIL-HDBK-502 as will the expected service life. These goals shall be subject to procuring activity approval.

3.5 Smoke and Fire Hazards

Wiring and wiring devices shall be selected and installed in such a manner as to minimize the danger of smoke and fire hazards. Adequate protective means, both physical and electrical, shall be employed to provide reliability and safety commensurate with this requirement.

3.6 Materials

Materials used in the installation of wiring and equipment shall be suitable for the purpose and shall conform to such Government specifications as are specifically applicable under the contract.

3.6.1 Metals

Metals used in the installation of wiring shall be corrosion resistant or shall be suitably protected to resist corrosion and electrolytic action during normal service life. Finish and coating shall be in accordance with MIL-STD-7179.

3.6.1.1 Dissimilar Metals

Dissimilar metals used shall conform to the requirements of MIL-STD-889. This standard establishes requirements for the selection and protection of dissimilar metal combinations and other significant corrosion behavior factors.

3.6.2 Nonmetals

Nonmetals used, including plastics, fabrics and protective finishes, shall be moisture and flame resistant, shall not support fungus growth, shall not support combustion, and shall not be adversely affected by weathering, applicable fluids and propellants, temperature and ambient conditions encountered during operation of the vehicle. Materials that give off a minimum amount of noxious gases shall be selected. Nonmetals may be treated to conform to this requirement. PVC insulating materials shall not be used unless no other materials suitable for the application are available.

3.6.2.1 Insulating Materials

Insulating materials shall have an arc resistance capability which will meet the circuit requirements.

3.6.3 Sealing Materials

Only materials that are elastomeric and reversion resistant shall be used. Sealing materials required to seal wire junctions and terminations shall be selected from MIL-PRF-8516, MIL-PRF-23586, or other material specifically approved by the procuring activity. MIL-PRF-8516 is the preferred material. The following temperature limits apply (the upper limit includes ambient plus temperature rise):

MIL-PRF-8516-51 °C (-60 °F) to 93 °C (200 °F)

MIL-PRF-23586-65 °C (-85 °F) to 232 °C (450 °F)

3.6.3.1 Process

Sealing materials shall be applied in strict conformance with the manufacturer's instructions. Overaged material shall not be used. The sealing material shall be held in place by suitable forms during the curing process.

3.6.4 Epoxy Adhesives

Only epoxies that can withstand sustained use without degradation of mechanical and adhesive properties at the maximum ambient temperatures shall be used for the bonding of fiber optics cables to termini. The time and temperature used for curing of epoxy adhesive used in fiber optics terminations shall be controlled so that a consistent bond is provided under all service conditions.

3.7 Component Selection and Installation

Components and wiring devices shall be suitable for their application and selected and installed in accordance with the requirements of this specification. In addition, selection and installation considerations shall be made relative to vehicle operation and servicing environments to ensure that they are not subjected to conditions exceeding the limits specified in the applicable wiring component specifications.

3.7.1 Maintenance Considerations

The maintainability of the wiring system shall be a prime consideration in the selection, design and installation of harnesses, electrical/optical cable assemblies and wiring system components. All wiring shall be accessible, repairable and replaceable at the maintenance level specified by the procuring activity. Other specific requirements concerning maintenance are specified in the appropriate paragraph on the subject.

3.8 Wiring Selection

Wiring shall be of a type suitable for the application. Wire shall be selected so that the rated maximum conductor temperature is not exceeded for any combination of electrical loading, ambient temperature, and heating effects of bundles, conduit and other enclosures. Typical factors to be considered in the selection are voltage, current, ambient temperature, mechanical strength, abrasion, flexure and pressure altitude requirements, and extreme environments such as Severe Wind and Moisture Problem (SWAMP) areas or locations susceptible to significant fluid concentrations. PVC insulated and jacketed wire and cable shall not be used in aerospace applications. The wire shall be selected in accordance with Appendix A of this specification. The wire selection shall take into account all requirements of this specification and the following design considerations.

3.8.1 Conductor Degradation

Degradation of tin and silver plated copper conductors will occur when exposed to continuous operation at temperature beyond their continuous rating. These effects shall be taken into account in the selection and application of wiring.

3.8.1.1 Tin-plated Conductors

Tin-copper intermetallics will form with time resulting in an increase in conductor resistance and embrittlement. This increase in resistance is inverse to size, being up to 4% for the smallest gage. Also the surface of the tin plating becomes oxidized with time which inhibits solderability (see 3.8.1.3). These potential problems should be considered in the application of tin plated copper wire.

3.8.1.2 Silver-plated Conductors

Degradation in the form of inter-strand bonding, silver migration, and oxidation of the copper strands can occur with continuous operation near rated temperature, resulting in loss of flexibility. Due to potential fire hazard, silver plated conductors shall not be used in areas where they are subject to contamination by ethylene glycol solutions. These potential problems should be considered in the application of silver plated copper wire.

3.8.1.3 Conductor Solderability

Solderability of tin plated copper wire degrades significantly within 6 months to a year after production. When significant oxidation occurs, mildly activated rosin (RMA) flux is required for proper soldering and depending upon temperature exposure, as well as storage time, an activated rosin (RA) flux may be required. Soldering of tin plated copper conductors should be avoided; but when required, compensating steps such as re-tinning shall be included in maintenance procedures for re-termination (see AS4461).

3.8.2 Aluminum Wire

The use of aluminum wire requires procuring activity approval. Aluminum wire shall be restricted to size 8 and larger. Aluminum wire shall neither be directly attached to engine mounted accessories nor installed in other areas of severe vibration. It shall not be installed where frequent connections and disconnections are required. All installations of aluminum wire shall be relatively permanent. Aluminum wire shall not be used where the length of run is less than 3 feet, nor in areas where corrosive fumes exist. Aluminum wire shall be terminated only by terminations specifically approved for this application (see 3.20.2).

3.8.3 Fiber Optics Cable Selection

The type, size, construction and distinct identification for fiber optics cable shall be suitable for the application and shall be approved for use by the procuring activity. Cable shall be of a construction which provides the required optical performance under all service conditions when the overall characteristics of end face polish, cable length, number of connections, installation bend radii and environmental degradation are taken into account. Cable shall be resistant to environmental degradation and handling damage and shall be of a continuous temperature rating that is compatible with assembly process and installation environment.

3.8.3.1 Strength Member

Fiber optics cable shall include a layer of fiberglass, aramid, or other non-metallic material that can be mechanically attached to terminus assemblies for the purpose of resisting tensile loads.

3.8.3.2 Jacket

External jacket of fiber optics cable shall be resistant to moisture, mechanical damage and temperature degradation.

3.8.4 Coaxial Cables

Coaxial cables shall be suitable for the application and shall be selected in accordance with 30.1.5 of Appendix A. For applications above 400 MHz and in critical RF circuits, critical electrical characteristics such as attenuation, capacitance, structural return loss, environmental requirements, short leads and grounding shall be considered in design. Coaxial cable operating in the Transverse Electromagnetic Mode (TEM) and coaxial cable with tubular metal outer surfaces shall be identified by a violet colored marker (1 inch nominal width) at intervals not greater than 24 inches of length and within 6 inches of termination. Transmission lines in accordance with MIL-T-81490 need not be identified by colored markers if the color requirements of MIL-T-81490 have been met.

3.8.5 Harnesses

Harnesses shall be of either open or protected design. Open harnesses are preferred for maintenance considerations. Harnesses may be designed to meet mechanical or shielding requirements. The use of protected harnesses shall be avoided unless wiring design considerations dictate their use and is subject to the approval of the procuring activity. The design details of protected harnesses are also subject to the approval of the procuring activity.

3.8.6 Insulation Compatibility with Sealing and Servicing

Wiring terminations in devices where the wiring must be sealed to provide an environment resistant joint, shall have insulation compatible with the sealing feature of the device. For wire to connector sealing grommet compatibility see AIR1329. When the diameter of the wire is smaller than the minimum allowable diameter, a length of shrink AMS-DTL-23053/5 Class 1 & 3, /8, /11, /12 Class 3, 4, & 5, or /18 Class 2 & 3 sleeving shall be installed in back of the contact and shall protrude through the environmental seal. Elastomer grommets are generally qualified to seal on wires and electrical/optical cables having smooth extruded insulations. Only one wire/optical cable per grommet hole is permitted. Sealing on tape wrapped, braided, striped, or other than smooth circular insulations shall be specifically tested for compatibility and shall be subject to procuring activity approval, unless compatibility has been demonstrated in the qualification of the terminating device. After installation in the vehicle, the integrity of the sealing features of all such devices shall be intact, and able to perform their function. A device shall be considered as sealed if the outermost sealing feature (web) is in full contact with the device when visually inspected. The wiring shall be installed so that transverse loads will not destroy the integrity of the sealing feature of the wire.

3.8.6.1 Wire Diameter

The finished wire outside diameter or finished wire diameter plus sleeving (see 3.8.6) shall be within the limits specified for the grommet specified in the appropriate component specification and shall not exceed the capability of contact servicing tools to insert and release contacts.

3.8.6.2 Potting Seal on Wire or Cable

The potting shall be bonded to the outer-most surface of the wire or electrical/optical cable in such a way to ensure an environmental resistant seal.

3.8.6.3 Insulation Degradation

Wiring shall be handled, stripped and installed so as not to distort, roughen or damage the insulation on which sealing is to be effected. Methods of marking and identification shall be applied so as not to provide a track for moisture entry. The impression left on the insulation of shielded and twisted electrical cables can also cause unacceptable degradation of the insulation in relation to the elastomer seal. Caution shall be used to avoid this condition.

3.8.7 Corona Prevention

In the selection of electrical wiring, considerations shall be given to the prevention of corona discharge. Useful information relating to corona prevention is contained in 6.6 and should be reviewed prior to the selection of all wiring.

3.8.8 Minimum Wire Size

This specification permits the general use of size 22 wire as the minimum wire size for airplanes, helicopters and lighter-than-air vehicles. Use of size 24 and smaller gage wires in harnesses shall be limited to wires which have break strength of 20 lb minimum. Size 24 and smaller gage wires shall not be installed as a single wire. Use of size 26 and smaller requires procurement activity approval. This restriction in aerospace vehicle applications is due to maintenance difficulties.

3.8.8.1 Current Carrying Capacity

Wire shall be sized so that all wires distributing current from a circuit protective device have a capacity which is equal to or greater than the rating of the device under all operating conditions. Circuits shall be individually powered with a single operating current interrupt system. Independently operated circuit protection devices shall not be paralleled or ganged together to achieve a required current rating. Power source feeder wires shall be sized for the rated capacity of the power source. A guideline for the continuous current in each wire is shown in Table 1. Table 1 assumes an ambient temperature of 70 °C, a harness or harness branch of 33 or more electrical wires for sizes 26 through 10, and 9 electrical wires for size 8 and larger, carrying 20% or less of rated harness or harness branch current and operating at an altitude of 60 000 feet. The use of this tabulation shall not eliminate other requirements for wire selection. Data from Figures 3, 4, and 5 may be used for determining wire size for conditions other than those contained in Table 1. The use of Table 1 and Figures 3, 4, and 5 shall not eliminate other requirements for wire selection. Current carrying capacity listed in Table 1 or calculated using Figures 3, 4, and 5 are capable of handling frequencies up to 800 Hertz; above 800 Hertz, the AC resistance must be corrected for skin and proximity effects. When reducing wire size, unprotected wires connecting power busses or feeders to any circuit protective devices shall be maintained within the same power panel and kept to a minimum length."

3.8.8.1.1 Wiring in Harnesses

Table 1 current ratings for electrical wires in harnesses are based upon 33 or more electrical wires for sizes 26 through 10 and 9 electrical wires for size 8 and larger operating at 60 000 feet altitude, and an ambient temperature of 70 °C. The total current carried by the harness shall not be more than 20% of the numerical total obtained by adding the carrying capacities taken from Table 1 (or calculated from Figures 3, 4, and 5 for ambient, altitudes or harness loading factors differing from those assumed in Table 1), for the appropriate wire construction temperature rating for all the electrical wires in the harness. For example, if a wire harness contains 33 size 20 electrical wires rated at 200 °C, the numerical total is 297 amperes, 20% of which is 59.4 amperes and the maximum allowable total current in the harness is 59.4 amperes and the maximum allowable current for any size 20 wire in the harness is 9 amperes. An electrical cable in a harness shall be treated as a number of individual electrical wires equal to the number of conductors in the electrical cable, excluding shields.

In smaller harnesses, the allowable percentage of total current may be increased as the harness approaches the single wire configuration. The harness ratings contained in Table 1 were derived from Figures 3, 4, and 5. Single electrical wire in free air ratings for copper wire were determined at T (200 to 70 °C) (for aluminum wire derate the free air rating of copper wire by 20%) and derated for (a) operation at 60 000 feet altitude, (b) harnesses of 33 electrical wires or more, and (c) carrying 20% or less of rated harness current. For conditions other than (a) through (c), refer to 6.7.

3.8.8.1.2 Wire Terminations

The continuous current ratings of Table 1 were derived only for wire application, and cannot be applied directly to associated wire termination devices (e.g., connector contacts, relays, circuit breakers, switches). The current ratings are limited by the design characteristics of the device. Care shall be taken to ensure that the continuous current value chosen for a particular system circuit shall not create hot spots within any circuit element which could lead to premature failure. Acceptable temperature levels of circuit components shall be those defined by the particular circuit component specification.

3.8.8.2 Ambient Temperature

The contractor shall ensure that the maximum ambient temperature that the wire bundles will be subjected to, plus the temperature rise due to the wire current loads, does not exceed the maximum conductor temperature rating found in Appendix A in Tables A1 and A2. Figures 3, 4, and 5 may be used to determine the appropriate current loads when the following conditions are known: maximum ambient temperature, maximum conductor temperature, maximum altitude and the number of electrical wires in a bundle. See example in 6.7 for method of calculation.

3.8.8.3 Deleted.

3.8.8.4 Voltage Drop

For power distribution circuits, the total impedance of supply and return paths shall be such that the voltage at the load equipment terminals is within the limits of MIL-STD-704.

3.8.9 Maintainability

Wire selection shall be affected by considerations of the types and frequency of maintenance action.

3.8.10 Wiring Selection for Special Applications

The general purpose electrical wires listed in Appendix A do not perform equally in all applications. The detail characteristics of the specific wire types shall be considered for the following special applications.

3.8.10.1 Severe Wind and Moisture Problems (SWAMP)

Suitable wire types in accordance with AS22759, listed in Appendix A, are preferred for severe wind and moisture problems (SWAMP) areas or both. Applications include wheel wells, near wing flaps, wing folds and pylons.

3.8.10.2 Frequency Flexure

Suitable wire types in accordance with AS22759, listed in Appendix A, are preferred for areas that require repeated bending and flexing of the wiring.

3.8.10.3 Electromagnetic Interference (EMI) and Electromagnetic Vulnerability (EMV) Sensitive Areas

MIL-C-85485 cable is preferred for use in EMI and EMV sensitive areas. For complete installation guidance see AIR4465 Filter Line Handbook. The following precautions must be taken when routing and installing MIL-C-85485/8 or /12 shielded and jacketed filter line wire. The black jacket is conductive and should be routed and clamped or protected to insure clearance to all exposed (uninsulated) power distribution points. The use of discrete filters or other suitable means should also be considered in instances where more effective attenuation of interference can be provided at specific frequency ranges or where replacement of existing wiring is impracticable.

3.8.10.4 Thermocouple Wiring

The following is required when using thermocouple wires (see 6.8):

- a. The use of thermocouple contacts is discouraged and should be used only if essential to meet system requirements, such as thermal gradient conditions. Crimp terminations are preferred.
- b. Transition from thermocouple wires to copper wires are permitted with the environmental sealed connectors specified in 3.14.1 or AS81714/12, type 2 in-line junction. When gold-plated crimping pairs are used, precautions should be taken to ensure that the connector external temperature ambient and internal hotspot temperature is such that both the wire to contact junctions for the thermocouple wires within the connector are at the same temperature.
- c. Splicing of thermocouple wire shall be avoided. If splicing is necessary (see 3.19) a AS81714/12, type 2 dual in-line junction (splice) or AS81714/11 single in-line junction (splice) or AS81824/1 splice shall be used.

- d. The connector, in-line junction, or splice shall provide an environmental seal on the thermocouple wire. The tensile characteristics of the contact/thermocouple combination shall be equal to or greater than the tensile characteristics of the thermocouple wire.

3.9 Wire and Electrical/Optical Cable Identification

Each wire and electrical/optical cable shall be marked with an identification code on the jacket or sleeving of the wire and electrical/optical cable. Hot stamp marking of wire and electrical/optical cable shall not be used.

3.9.1 Assignment of Identification Code

The identification code for wiring shall be significant or nonsignificant in accordance with Appendix B or C, as specified by the procuring activity. Unless specified otherwise, the identification code for the Navy shall be significant in accordance with Appendix B (see 6.2).

3.9.2 Deleted.

3.9.3 Marking

3.9.3.1 The wire identification code shall be printed to read horizontally from left to right or vertically from top to bottom. See Figures B1 and B2.

3.9.3.2 The characters shall be legible and permanent and the method of identification shall not impair the characteristics of the wiring.

3.9.3.3 Wiring shall be identified, throughout its length, at intervals not longer than 3 inches, as measured from the end of a mark to the beginning of the next mark.

3.9.3.3.1 When it is not possible to print directly upon a wire or electrical/optical cable, an identification marker shall be used. The marker shall be a AS85848 or AMS-DTL-23053 heat-shrinkable sleeve; a AS23190 (AS33681) identification strap (see 3.11.3.8) or a MIL-H-3190 glass braid. The marker shall not be used as an electrical insulating device. For repairable, protected harnesses, the marker shall be visible during maintenance within the accessible area at the rear of the connector. The markers shall be used as follows:

(NOTE: AS23190 (AS33681) identification strap shall not be used within electrical/optical cables, groups, harnesses or bundles.)

- a. Electrical/optical cables upon which identification cannot be printed shall be identified by printing the identification code (and individual wire color where applicable) on a marker placed external to the outer surface. The marker shall be placed at each end within 12 inches or before the first clamp (whichever is less) and at intervals not greater than 3 feet.
- b. Wires on which identification cannot be marked shall be identified by printed markers at each end within 12 inches or before the first clamp (whichever is less) and at intervals not greater than 3 feet.
- c. Wires for which the identifications are reassigned after installation in the aircraft may be reidentified by markers at the termination of each wire segment. It is not necessary to reidentify such wires throughout their lengths.

3.9.3.3.2 Short electrical wires and electrical/optical cables less than 6 inches in length need not be identified in the aircraft, but shall be completely identified on the drawing.

3.9.3.3.3 For developmental model aircraft, wiring identification may be provided at junction and termination points only.

3.9.3.3.4 For protected harnesses and shielded, jacketed multi-conductor electrical cables and when using nonsignificant wire identification, color coding or its alphanumeric equivalent may be interchanged within the same harness. The alphanumeric equivalent of the color code shall be in accordance with MIL-STD-681. See 30.2.3.3 in Appendix C for an example of alpha-numeric equivalent of color coding.

3.9.3.3.5 All harnesses shall be identified to facilitate maintenance (see Appendix B). Identification shall be done on a nonmetallic bands affixed to the harness and shall be located within 3 inches of the connector identification band and in each bay through which the harness is routed. All markers shall be visible during maintenance within the accessible area.

3.9.4 Connector Identification

Connectors shall be identified to facilitate mating. All plugs shall have a nonmetallic band affixed to the wire group, electrical/optical cable or harness. This band shall bear the P and J number identification and optical identification (if applicable) of both the plug and the mating receptacle and the equipment nomenclature. The band shall be within 6 inches of the plug. The band shall be visible in the immediate area of the connector and shall not affect the maintainability of the harness. All receptacles shall be identified with a "J" number on both sides of the aircraft structure, in a convenient area adjacent to the receptacle. Receptacle identification may be excluded where available locations cause it to be not readily associated with the subject connector, or where it would not be visible (blind area) during installation or mating of the receptacle. In no case shall the absence of identification result in the possibility of connector mismatching. Receptacles, such as test and power, to which a mating plug is not attached, shall have, in addition, the function of the receptacle identified on the plug side of the structure.

3.9.5 Wire Size Color Code System

When approved by the procuring activity, a wire size color code system as specified below may be used to facilitate control of the wire size. When a wire size color code is used, the wire insulation shall be identified with the appropriate color by one of the following methods. Only one method may be used for each vehicle.

- a. Solid colored.
- b. Distinctively color banded.
- c. Distinctively striped.

The wire size color code is as follows:

<u>Size</u>	<u>Color</u>	<u>Size</u>	<u>Color</u>
26	Black (see 3.8.8)	10	Brown
24	Blue (see 3.8.8)	8	Red
22	Green	6	Blue
20	Red	4	Yellow
18	White	2	Red
16	Blue	1	White
14	Green	0	Blue
12	Yellow		

3.10 Wiring Installation

Design of the wiring installation shall conform to the following precedence:

- 1st - Safety in flight.
- 2nd - The ease of maintenance, removal and replacement of the wiring.
- 3rd - Cost effective aircraft production.

Wiring shall be fabricated and installed so as to achieve the following:

- a. Maximum reliability.
- b. Minimum interference and coupling between systems.
- c. Accessibility for inspection and maintenance.
- d. Prevention of damage.

3.10.1 Arrangement of Wiring

Wiring shall be arranged in groups and bundles to facilitate installation and maintenance. Individual groups shall be spot tied, and when these groups are bundled the spot ties shall not be removed.

3.10.2 Bundle and Group Size

As a design objective, bundles and groups within clamps shall be no more than 2 inches in diameter. Wiring to high density connectors may be run as a single group, provided all of the wiring in the group is pertinent to a single item, equipment or system.

3.10.2.1 High Density Harness Size

The number of electrical wires in high density harnesses shall be limited only by efficient and good design. The use of wire sizes larger than 16 is discouraged unless there are also smaller electrical wires in the same harness.

3.10.3 Inspection and Maintenance

In open wiring, groups shall be installed to permit replacement of the group without removal of the bundle. High density harnesses shall be designed so that they are readily replaceable in sections.

Fiber optics cables shall be installed to provide accessibility for inspection and maintenance. Where approved splices are an acceptable method of assembly or repair, space shall be provided for installation, inspection and testing of individual segments. Fiber optics cables that are not repairable on the aircraft shall be installed in a manner which facilitates testing and replacement of individual segments or entire harness assemblies. Replacement of fiber optics cables or segments shall not require disassembly of any riveted or bonded attachments. Conduits shall be used where necessary to protect fiber optics or to facilitate maintenance in inaccessible areas.

3.10.4 Facility for Changes

Where required by the procuring activity, the wiring for specified systems shall be installed so as to be readily removed and wiring for new systems readily installed, when system changes are undertaken. The installation of the wiring shall be such that only the equipment and wiring related to the change have to be disturbed.

3.10.5 Dead Ending

Each undesignated wire end shall be dead ended with AS25274 caps or with insulation in a manner acceptable to the procuring activity. Dead ending shall take place within 4 to 6 inches of connectors or feedthrough bushings.

3.10.6 Routing

Wiring shall be routed to ensure reliability and to offer protection from the following hazards:

- a. Chafing as defined in 2.4.4.
- b. Use as handhold or as support for personal equipment.

- c. Damage by personnel moving within the vehicle.
- d. Damage by stowage or shifting of cargo.
- e. Damage by battery or acid fumes and fluids.
- f. Abrasion in wheel wells where exposed to rocks, ice, mud, etc.
- g. Combat damage (to the maximum extent practicable).
- h. Damage by moving parts.
- i. Harsh environments such as SWAMP areas, high temperatures, or areas susceptible to significant fluid or fume concentration.
- j. Crushing, kinking or stretching fiber optic cable. Precaution should be taken to prevent the cable from being accidentally crushed, kinked or stretched.
- k. Fiber optics cable shall be routed and installed so as to avoid the application of axial, lateral and torsion loads to the cable and terminations.
- l. When installing fiber optics, additional support, routing techniques and maintenance requirements must be considered. Methods of addressing these requirements shall be approved by the procuring activity.
- m. Wiring shall not be routed through equipment mounting bases.
- n. Fiber optic cabling route shall be located so that optical fiber cables will not be disturbed by disassembly or removal of equipment

3.10.7 Slack in Wiring

In addition to slack provided for drip loops (3.11.8), slack shall also be provided to meet the requirements of 3.10.7.1 through 3.10.7.5. Slack requirements shall be met on every production vehicle as well as developmental models. In production wire harness fabrication, provisions shall be incorporated into the harness design and fabrication process to ensure that the installed harness meets these requirements without the need for straining, forcing or modifying the harness.

3.10.7.1 Connector Termination

When wiring is terminated in a connector or terminal junction, a minimum of 0.5 inch of slack for complete connector replacement shall be provided. This slack shall be between the connector and the second wiring support clamp. The 0.5 inch slack requirement shall be interpreted to mean that with the connector unmated and the first wiring support clamp loosened, the wiring will permit the front end of the connector shell to extend 0.5 inch beyond the point normally required to properly mate the connector. Slack for replacement of potted connectors shall be, as a minimum, the length of the potting plus one inch. Connectors terminating size 8 and larger electrical wires, RF cables, and fiber optics cables shall not be subjected to retermination slack requirements.

For fiber optic cabling, cable slack at the connector ends of the cabling (i.e., slack from the last primary support at the connector end) shall allow the cabling to extend from 0.5 to a maximum of 1 inches beyond the point required for mating the connector.

3.10.7.2 Lug Termination

At each end of a wire terminated by a lug, a minimum length of slack equal to twice the barrel length of the lug shall be provided. For copper wire, size 2 and larger, and aluminum wire, size 4 and larger, the minimum length of slack shall be equal to one barrel length of the lug. The slack shall be in the vicinity of the lug and available for replacement of the lug by maintenance personnel.

3.10.7.3 Strain Prevention

The wiring installation shall be designed to prevent strain on wires and electrical/optical cables, junctions and supports.

3.10.7.4 Free Movement

The wiring shall permit full extension of shock mounts and vibration isolators mounted on equipment.

3.10.7.5 Wire Shifting

The wiring installation shall permit shifting of wiring and equipment necessary to perform maintenance within the vehicle.

3.10.8 Electromagnetic Compatibility

Electrical wiring, including RF and antenna cables, shall be routed so as to minimize electromagnetic interference in accordance with MIL-STD-464.

3.10.9 Ignition

Flexible metallic conduit of a type specifically approved by the procuring activity shall be used for magneto cable circuits. Magneto ground cables (except the induction vibrator output cable) shall not run through conduit or junction boxes containing other electrical cables.

3.10.10 Compass Deviation

Electrical wiring and ground return paths shall be installed so as not to cause a compass deviation. Each wire carrying direct current in the area of compasses or the sensitive pickup elements of compasses shall have a corresponding ground return wire twisted with it to neutralize the magnetic field.

3.10.11 Lug Terminated Wires

Lug terminated wires shall be installed so as to reduce human error in assembly to adjacent terminals. In addition to code identification, wiring shall be so routed and supported so as to reduce human error in assembly to adjacent terminals. This may be accomplished by use of fanning strips; different stud sizes or control of wire lengths from tie down points. Fanning strips are preferred except in junction boxes, fuel tanks, ground studs, and areas where space is not adequate.

3.10.12 Sensitive Circuits

Sensitive circuits such as low-power level signal circuits shall be kept separate from other circuits at junctions. This shall be accomplished by using separate connectors for the sensitive circuits and by having at least one grounded terminal stud between sensitive circuits and other circuits on a common terminal board.

3.10.12.1 Electroexplosive Subsystem Wiring

All circuits associated with electroexplosive subsystems shall be routed in twisted shielded pairs. All circuits and junctions shall be shielded without discontinuities or gaps in the shielding. Wire shields shall be bonded around the circumference of connectors. All firing and control circuits associated with ordnance and explosive subsystems shall be kept separate from other circuits at junctions.

3.10.12.2 Electroexplosive Subsystem Wiring (for Air Force use)

All firing and control circuits associated with ordnance and explosive subsystems contained within junction boxes shall be coded with a red stripe in accordance with FED-STD-595, color 11105.

3.10.12.3 Sensitive Circuits

Fuel probe wiring shall be physically separate from power wiring throughout its entire length including connectors, terminations, and junction boxes.

3.10.13 Power Systems

Electrically unprotected wiring of the primary electrical power system shall not be bundled or grouped with distribution circuit wiring. Wiring from two or more sources shall not be in the same bundle or group to prevent a single damage from affecting more than one power source.

3.10.14 Essential Equipment

Wiring to each system which must operate to maintain flight control of the vehicle under normal or emergency conditions shall be separately routed from other wiring. Essential engine circuits shall have their wiring so routed as to prevent damage to any circuit for one engine from affecting circuits of any other engine. Propeller circuits shall be routed separately from all other circuits.

3.10.14.1 Full authority Fly-By Wire systems: In addition to the related wire routing/separation and shielding requirements of paragraph 3.10.6, 3.10.8, 3.10.13, 3.10.14, 3.10.15 and 3.14.6 the following provisions shall be incorporated:

- a. Channel separation: Each channel of such systems shall be routed in separate bundles that are distinctively marked throughout their length in a manner which associates that bundle with a specific channel. Color coded harness jacketing material, closely spaced color-coded identification sleeves or similar means may be used for this purpose.
- b. Primary Flight Control Wiring: For helicopters wires having functions that can directly affect the flight path of the aircraft or otherwise affect flight safety shall be size 20 minimum except that size 22 annealed copper wires may be used when routed in twisted triples or with at least three other wires. Wires shall be of a type specified in Appendix "A" that is suitable for use in circuits where during a fire, maintenance of electrical integrity is required for a limited time. For all other aerospace vehicles wire selection shall be per Appendix "A".
- c. Connectors and connector accessories for use in such applications shall be military qualified for use in aerospace applications. Threaded coupling mated pairs of connectors shall employ self-locking coupling rings. Connector backshells that do not include self-locking coupling mechanisms shall be secured in accordance with 3.14.7 to avoid loosening.

3.10.15 Redundant Circuits

Wiring to equipment performing duplicate functions shall be run in separate bundles to prevent damage to one system affecting the other. On airborne vehicles that employ dual or multiple redundant MIL-STD-1553 multiplex data bus systems, the redundant data bus cables shall be run in separate bundles and routed to prevent damage to one data bus cable affecting the operation of the redundant data bus or buses.

3.10.16 High-temperature Equipment

Wiring shall be kept separate from high-temperature equipment, such as resistors, exhaust stacks, heating ducts and de-icers, to prevent insulation deterioration.

3.10.17 Nacelle Wiring

Wiring in an engine nacelle, from the point of disconnection for removal of the engine, shall be interchangeable between all engine installations having identical equipment and for the same series of vehicle. A means for positively ascertaining clamp locations shall be provided for wiring that must be unclamped for engine removal. This shall be accomplished by permanently attaching clamp brackets to supporting parts.

3.10.18 Wiring in Bilges

Wiring in bilges shall be installed at least 6 inches from the centerline of the aircraft except where attachment to equipment located in this area is required. Wire types susceptible to moisture degradation shall not be used in bilges.

3.10.19 Engine Mounted Accessories

For direct attachment to engine mounted accessories, wire smaller than size 20 shall not be used. When size 20 wires are used, they shall be high-strength alloy conductor and when terminated in connectors, the connector shall provide support and prevent strain on terminations. The wires shall be adequately grouped, spot tied and supported.

3.10.20 Wheel Well Areas

Conduit or other protection shall be provided for all wiring in wheel well areas. Flexible tubing, abrasion resistant tape or braided outer jackets are acceptable for use where wiring is properly supported. When tubing is used, drainage holes shall be provided at all trap points and at the lowest point between each set of support clamps. Taping shall be in accordance with 3.11.6. Wire types susceptible to moisture degradation shall not be used in wheel well areas.

3.10.21 Slide Mounted Equipment

When connecting wires or electrical/optical cable to slide mounted equipment, sufficient wire or electrical/optical cable shall be provided to permit the slide mounted equipment to slide in and out without damage, and permit unmating of the connectors.

3.11 Protection and Support

Wiring shall be supported to meet the following requirements:

- a. Prevent chafing as defined in 2.4.4.
- b. Secure wiring where routed through bulkheads and structural members.
- c. Properly group, support and route wiring in junction boxes, panels and bundles.
- d. Prevent mechanical strain or work hardening that would tend to break the conductors, optical fibers and connections.
- e. Prevent arcing or overheated wiring from causing damage to mechanical control cables, and associated moving equipment.
- f. Facilitate reassembly to equipment terminal boards.
- g. Prevent interference between wiring and other equipment.
- h. Provide support for wiring to prevent excessive movement in areas of high vibration.
- i. Dress the wiring at connectors and terminating devices in the direction of the run without deformation of grommet seals.

3.11.1 Primary Support

Primary support of wiring shall be provided by metal cushion clamps and plastic clamps (See 3.11.1.1) in accordance with AS23190, AS21919, spaced at intervals not to exceed 24 inches. AS23190/4 is the preferred wiring support clamp. In addition, where wiring is routed through cutouts in any aircraft structure, clamps shall be installed as necessary to meet the protection and anti-chafing requirements of this specification. Open wiring contained in troughs, ducts or conduits is exempt from this requirement. Rigid portions of harnesses shall be supported by clamps spaced at intervals not to exceed 42 inches. Clamps for harnesses other than round shall be shaped to fit the contour of the harness and shall provide a snug fit. Plastic clamps shall not be used to support rigid portions of harnesses. Use of plastic cable straps as primary support is prohibited. The primary support of wiring shall not be attached to adjacent wiring. Only metal clamps with cushions shall be used to support fiber optics cables.

3.11.1.1 Plastic Clamps

Plastic cable clamps in accordance with AS23190 may be used on horizontal wiring runs provided every fourth clamp is a rubber cushion type. The first clamp immediately adjacent to wiring terminations for wire bundles greater than 0.125 inch diameter shall be a metal cushion clamp. The use of plastic cable clamps on other than horizontal wiring runs shall be avoided unless the installation is such that slack cannot accumulate between clamping points, and then every fourth clamp shall be a metal cushion type. Any clamp that incorporates a plastic strap is prohibited.

3.11.1.2 Clamp Size

Primary supporting devices shall be of the size, which holds the wiring in place without damaging the wire insulation or degrading the performance of optical or RF cables. If the called out clamp size is too large to properly grip the harness and the next size smaller would crush the harness, tape types in accordance with 3.11.2.3 may be used to provide a proper fit in the clamp or as fillers under the clamp. Build up with tape only to the point that the original clamp provides grip.

3.11.1.3 Support at Connectors

Wiring terminating in plugs shall be supported to dress the wiring in the direction of the run. This may be accomplished by adapters, clamps, potting, wire guides, or other means acceptable to the procuring activity.

3.11.1.4 Metal Cushion Clamps

When metal cushion clamps are used for primary support, their physical properties must be compatible with their installation environment. Cushion compounds are formulated to meet specific requirements and may not be suitable in other applications.

3.11.2 Secondary Support

Secondary support of wiring harnesses, bundles or groups shall be provided by devices selected from 3.11.2.1 through 3.11.2.4. Lacing ties shall be placed as secondary supports at a spacing no greater than 6 inches.

3.11.2.1 Tying tapes shall be in accordance with A-A-52080, A-A-52081, A-A-52082, A-A-52083, or A-A-52084. The physical properties of the tapes must be compatible with the installation environment.

3.11.2.1.1 The A-A-52084 Aramid Finish C (sizes 2 or 3) tape is preferred for general applications. The A-A-52083 Glass Finish D with the additional Finish C (sizes 2 or 3) tape is preferred for high temperature (engine area) applications.

3.11.2.2 Plastic cable straps in accordance with AS23190 installed with tools in accordance with MS90387. Use of plastic cable straps as secondary support shall not be permitted on aircraft intended for military procurement or use

3.11.2.3 Insulation Tape

Insulation tape shall be in accordance with 3.11.3.9 or 3.11.6.1.

3.11.2.4 Protective outer covering for a protected harness.

3.11.3 Limitations on Support

3.11.3.1 Continuous lacing shall not be used, except in panels and junction boxes where this practice is optional.

3.11.3.2 Deleted.

3.11.3.3 The use of insulating sleeving for the protection of wiring shall be kept to a minimum. Provisions shall be included to eliminate the possibility of entrapment of liquids.

3.11.3.4 Deleted.

- 3.11.3.5 Wiring shall not be tied or fastened together in conduit or insulation sleeving.
- 3.11.3.6 Electrical/optical cable supports shall not restrict the wiring in such manner as to interfere with operation of shock mounts.
- 3.11.3.7 Tape or cord shall not be used for primary support.
- 3.11.3.8 Plastic cable straps shall not be used in areas when the restrictions of 3.11.3.8.1 through 3.11.3.8.8 apply.
- 3.11.3.8.1 Where the total temperature (ambient plus rise) exceeds 85 °C (185 °F).
- 3.11.3.8.2 Where failure of the strap would permit movement of the wiring against parts which could damage the insulation or allow wiring to foul mechanical linkages.
- 3.11.3.8.3 Where failure would permit the strap to fall into moving mechanical parts.
- 3.11.3.8.4 In high vibration areas.
- 3.11.3.8.5 In areas of severe wind and moisture problems (SWAMP), such as wheel wells, near wing flags, wing folds, umbilical or other areas specified in the detail specification or contract.
- 3.11.3.8.6 Where exposure to ultra-violet light might exist, unless the straps are resistant to such exposure.
- 3.11.3.8.7 To tie wires, electrical cables, groups or harnesses within bundles.
- 3.11.3.8.8 Where the bundle contains any fiber optics cable.
- 3.11.3.9 Silicone adhesive polytetrafluoroethylene (PTFE) Type 1 tape in accordance with A-A-59474 may be used as a secondary support to wrap wires or bundles together to provide a proper fit or as additional electrical protection. When additional mechanical protection is needed, see 3.11.6.1. The choice of tape must take into consideration temperature and fluid conditions. Alternate tape types may be considered if the characteristics of the tapes specified cannot fulfill the intended application. Plastic tapes that absorb moisture or have volatile plasticizers that produce chemical reactions with other wiring shall not be used.

3.11.4 Anti-chafing Provisions

Chafing shall be prevented by routing and clamping bundles to prevent contact with equipment and structure. Metal braided or shielded harnesses shall have a protective external non-metallic covering except for fire zone areas where it is an option. Spiral wrap and other chafe guard materials shall not be used in lieu of primary supports for separation from equipment and structure.

- 3.11.4.1 Edge and Ring Grommets (see 3.11.6.4) shall be used when physical separation between wiring and equipment or structure edges is less than 0.375 (3/8) inches apart. The grommets shall be securely fastened. The choice of grommets shall be determined by the grommet characteristics described in the component specification and the environmental application. When mounted in feed through holes (cutouts), the remaining opening (split or gap between grommet and adjacent clip) in edge grommets shall be no wider than 0.063 (1/16) inches. The split shall be a diagonal cut. The split or gap shall be placed in such a manner that, if the wiring comes in contact with the grommet, the split shall be on the opposite side located away from the wire pressure direction. Edge grommets shall be selected to conform with the sheet thickness (structure thickness) ranges and geometric configuration (flat versus flanged or beaded hole) specified in the grommet specification. NASM22529 cushioned metal edge grommets shall not be used on holes smaller than 2 inches in diameter.

3.11.5 Special Cable Support

Support of individual optical or RF cables and of bundles containing optical or RF cables shall be subject to the following additional requirements.

- a. Both primary and secondary support devices shall be installed so as not to exert greater pressure on the cable than the minimum required to prevent slipping.
- b. Pressure shall be evenly distributed around bundles containing cables, or around the cable if individually supported.
- c. The support devices shall not deform the cables so that the characteristics of the cables are degraded.
- d. Only tape as specified in 3.11.2.1 shall be used for tying bundles containing RF cables. Selection of the tape and installation shall meet the requirements of 3.11.5a, b and c, except that plastic straps in accordance with AS23190 installed with tools in accordance with MS90387 may be used for tying bundles containing RF cables with solid dielectrics. The tension adjustment on the MS90387 tool shall be set so that the requirement of 3.11.5a is met. See 3.11.3.8.8 for optical cables.

3.11.6 General Purpose Protection and Support Hardware

The following items may be used for the protection and support of wiring and related equipment.

3.11.6.1 Tape Protection

Self-adhering unsupported silicone tape in accordance with A-A-59163 may be used to wrap around wires or bundles for additional protection, such as in wheel wells. The tapes shall be applied so that overlapping layers shed liquids and shall be provided with drainage holes at all trap points and at each low point between clamps. The tape shall have the ends tied or otherwise suitably secured to prevent unwinding. When alternate tapes are considered, see 3.11.3.9 for guidance.

3.11.6.2 Insulation Sleeving

Unless preinsulated splices and terminal lugs are used, they shall be protected with insulation sleeving. The sleeving shall cover the splices or terminal barrels and at least 0.5 inches of the adjacent wire insulation. Sleeving temperature ratings shall be compatible with the temperature service requirements of the wire and splices or terminals or the temperature service requirements in which they are installed.

3.11.6.2.1 Insulating Sleeving, Heat Shrinkable

Heat shrinkable insulating sleeving shall conform to AMS-DTL-23053 or MIL-PRF-46846.

3.11.6.2.2 Insulating Sleeving, Non-heat-shrinkable

Insulation sleeving shall conform to MIL-I-631 or MIL-I-3190. Non-heat-shrinkable sleeving shall be tied securely in place.

3.11.6.3 Terminal Nipples

A-A-59178 terminal nipples shall be used to provide overall insulation and protection on terminal lugs and studs.

3.11.6.4 Grommets

Edge grommets shall be in accordance with NASM22529 (NASM21266, NASM22529/1 and /2 etc.). The NASM21266 grommet shall be permanently bonded. Ring grommets shall be in accordance with NASM3036.

3.11.6.4.1 Deleted.

3.11.7 Radius of Bend Measured to Inside Surface

- a. Wire, electrical cable and harness. For wiring groups, bundles or harnesses and single wires and electrical cables individually routed and supported, the minimum bend radius shall be ten times the outside diameter of the largest included wire or electrical cable. At the point where wiring breaks out from a group, harness or bundle, the minimum bend radius shall be ten times the diameter of the largest included wire or electrical cable, provided the wiring is suitably supported at the breakout point. If wires used as shield terminators or jumpers are required to reverse direction in a harness, the minimum bend radius of the wire shall be three times the diameter at the point of reversal providing the wire is adequately supported.
- b. Protected harnesses. The minimum bend radius, as measured on the inside radius of a protected harness, shall be six times its outer diameter. In no case shall the bend radius of a protected harness be less than ten times the diameter of the largest included wire or electrical cable.
- c. Coaxial cables. The minimum radius of bend shall not adversely affect the characteristics of the cable. For flexible type coaxial cables, the radius of bend shall not be less than six times the outside diameter. For semi-rigid types, the radius shall not be less than ten times the outside diameter.
- d. Fiber optics cable. The minimum radius of bend for fiber optics cables shall be in accordance with the cable manufacturer's recommendations and shall be sufficient to avoid excessive losses or damage to the cable.
- e. These requirements also apply during shipping, handling and storage.

3.11.8 Drip Loop

Where wiring is dressed downward to a connector, terminal block, panel or junction box, in addition to the requirement of 3.10.7.1, a trap or drip loop shall be provided in the wiring to prevent fluids or condensate from running into the above devices. Potted connectors and connectors containing only fiber optics termini are exempt from this requirement.

3.11.9 Wiring Near Moving Parts

Wiring attached to assemblies where relative movement occurs (such as at hinges and rotating pieces) shall be installed or protected in such manner as to prevent deterioration of the wiring by the relative movement of the assembly parts. This deterioration includes abrasion of one wire or electrical/optical cable upon another and excess twisting and bending. Bundles shall be installed to twist instead of bending across hinges. Electrical/optical cables in the vicinity of line replaceable units (LRUs) and weapon replaceable assemblies (WRAs) shall be protected against damage caused by flexing, pulling, abrasion and other effects of frequent removal and replacement of equipment.

3.11.9.1 Wiring Near Flight Controls

Clamping of wires routed near movable flight controls must be attached with steel or titanium hardware and must be spaced so that failure of a single attachment point can not result in interference with controls. The minimum separation between wiring and all components of movable flight controls shall be at least $\frac{1}{2}$ inch throughout the full range of movement.

3.11.10 Special Protection

Power feeders, including wires, electrical cables and busses shall be given particular mechanical protection such as in the form of extra insulation, standoff mounting and separation. Bus centers shall be located within insulated enclosures, isolated in order to prevent a fault to ground or phase-to-phase fault that would disrupt the electrical power system. Wiring installed in locations, such as bilges and on decks or floors, shall be so located or protected that they will not be damaged by maintenance personnel during normal maintenance or crew movement. Wiring installed in locations where fluids may be trapped and the wires and cables contaminated, shall be properly routed and protected against fluid damage. Also see 3.8.10.3 for installation guidelines on Filter Line Cable.

3.11.11 Gas and Fluid Carrying Lines and Tubes

Wiring shall be supported independent of and with the maximum practicable separation from all fluid-carrying lines, tubes and equipment. Separation clamps shall not be used for primary support (see 2.4.19) but are permitted to maintain separation requirements for wiring. Wiring shall be routed above, rather than below liquid carrying lines, tubes and equipment to prevent contamination or saturation of the wiring in the event of leakage. Where this routing is not practicable, the wiring shall pass below the lines at an angle rather than parallel to the lines. Terminating devices shall not be placed under any lines. Wiring shall not be attached to fluid carrying lines, tubes and equipment unless they require electrical connections or their separation is less than two inches. In areas where separation is less than 2 inches, the wiring shall be installed to maintain positive separation of at least 0.500 inch. Examples: (a) separate the wiring from the line with a suitable separation device, (b) attach the wiring to primary support(s) at the closest proximity of the wiring to the line. Where lines and wiring are installed such that they are separated by rigid nonmetallic conduit, metal conduit, ribs, webs, frames, channels, extrusions, stringers, or other suitable barriers, the above minimum separation requirements do not apply.

3.11.12 Wiring Through Fuel Tanks

Wiring should not be routed through fuel tanks except where there is no alternative. Wiring that must be routed through fuel tanks, but that is not part of the fuel management or control wiring shall be routed through a dry access channel or passage so as to preclude contact of the wiring insulation and the fuel. The channel or passage shall be of a size to facilitate the removal and repair of the wiring without removal of the fuel tank, and shall have a fluorocarbon liner which will preclude electrical contact. Fiber optics cables are not recommend for routing through fuel tanks.

3.11.13 Wiring Inside Fuel Tanks

Wiring that is essential to the operation of fuel management or control system, may be routed inside fuel tanks only if there is no alternative. Wiring that is used in circuits that are capable of generating energy levels greater than 0.02 millijoules must be encased in a grounded metal conduit having a fluorocarbon liner. Wiring that comes in contact with fuel must have an insulation system which is compatible with the fuel and fuel vapor. Clamps and hardware used to attach wiring inside fuel tanks must also be compatible with the fuel and fuel vapor. Tie tape, string, mechanical straps, or other items that could become loose and clog fuel filters shall not be used inside fuel tanks. Fiber optics cables shall not be used inside fuel tanks.

3.11.14 GFAE Equipment Wiring

GFAE equipments furnished with wiring and connectors which are excessive in length shall not have the wiring length reduced. The excess length shall be grouped and supported in a manner which will prevent damage to the wiring and possible fouling of moving parts.

3.12 Ground Return

The electrical power source ground terminals shall be connected to the primary metallic structure of the vehicle. Individual ground wire connections shall be made using terminal lugs secured by threaded fasteners. Assembly procedures in accordance with ARP1870 are recommended for electrical bonding and grounding. For current return leads of size AN-4 (AWG-4) or larger wire, the bonding connection shall not be made directly to primary structure but shall be made by connecting the ground wire's terminal to a tab of sufficient size to conduct ground current, attached to the structure with at least three fasteners not arranged in a straight line pattern. The vehicle structure shall serve as the ground return circuit unless system considerations require separate ground return wiring. Equipment that incorporates a ground terminal shall be grounded by the shortest suitable ground wire. Equipment that is internally grounded and that does not incorporate a ground terminal shall be grounded by the shortest practicable ground wire if suitable grounding is not provided by the equipment mounts, or if corrosion of the mounts is likely to occur. Ground return wiring shall not be connected to magnesium. Electromagnetic environmental effects interface requirements and verification criteria shall be in accordance with MIL-STD-464.

3.12.1 Shielded Wire Grounding

Shielding shall be in accordance with vehicle system requirements. In harness applications, shields shall be terminated as close as practicable to the connectors, and specifically within the booted areas of breakout terminations. Electromagnetic environmental effects interface requirements and verification criteria shall be in accordance with MIL-STD-464.

3.12.1.1 AS83519 shield terminators shall be used in terminating tin and silver coated shields except when the operating temperature they are to be installed in exceeds the maximum rated operating temperature of the device. Control temperature solder devices shall be installed in accordance with AS4461. The unterminated end of a shield shall be covered with shrink sleeving.

3.12.2 Multiple Grounds

No more than four ground wires shall be connected to a common ground stud. Ground module in accordance with AS81714 may be used for multiple grounds. No more than 16 ground wires shall be connected in a ground module. Each ground for electric power sources (primary, secondary, conversion, emergency) shall be connected to separate ground points. Grounds for utilization equipment may be connected to a common ground point only when supplied from the same power source provided these equipments do not perform duplicate or overlapping functions.

3.12.3 Insulated Equipment Boxes

Electrical equipment such as relays mounted on insulated surfaces shall be individually connected to ground rather than series connected and then grounded by a single wire to a ground stud.

3.12.4 Bonding Surface Preparation

Surface preparation for an electrical ground shall be accomplished by removing all anodic film, grease, paint, lacquer, or other high-resistance materials from the immediate area to insure a suitable minimum radio frequency (RF) impedance connection between the terminal and adjacent structure. The means used to remove any protective finish shall produce a smooth surface without removing excessive material under the protective finish. After cleaning, but before grounding hardware installation, cleaned surfaces shall be protected with a corrosion resistant conductive protective film in accordance with MIL-DTL-5541 Class III. After hardware assembly, the mating surfaces around the ground hardware shall be restored to the original finish, or if subject to fuel exposure, shall be sealed with a compound in accordance with environmental requirements of the area.

3.12.5 Bonding and grounding attachments hardware shall be of conductively plated material and construction that is suitable for the temperature and the other environmental and mechanical requirements of the connection. All threaded hardware connections shall utilize a split lockwasher with either plain or self-locking hardware to ensure a tight connection under all conditions. Aluminum hardware and MS25083 bonding jumpers shall not be used at temperatures above 300 °F. Cadmium plated steel hardware shall not be used at temperatures above 550 °F. Cadmium plated hardware shall not be used in space applications. Self-tapping screws, zinc plated, unplated and anodized hardware, shall not be used. Internal or external tooth lockwashers shall not be used. Bonding jumpers shall be the non-quick disconnect type and shall be in accordance with MS25083 or contractor designed equivalent.

3.12.6 External Ground Terminals

Equipment which includes a ground terminal or pin, which is internally connected to exposed metallic frames or parts, shall have a ground wire connection to the terminal or pin.

3.13 Conduit

Conduit may be used where necessary to protect wiring or to facilitate maintenance in inaccessible areas. Use of conduit requires procuring activity approval unless specifically required elsewhere in this specification. Metallic conduit may be used for shielding to meet the requirements of MIL-STD-464, subject to approval by the procuring activity.

3.13.1 Rigid Metallic

Rigid metallic conduit shall be aluminum or aluminum alloy tubing.

3.13.2 Flexible Metallic

Flexible metallic conduit shall conform to AS6136 and shall be used only when rigid metallic conduit is impractical.

3.13.3 Nonmetallic

Nonmetallic conduit shall be of a material satisfactory for the installation environment. Polyvinyl chloride shall not be used.

3.13.4 Size

In determining the diameter of conduit to be used, the wiring which is to be installed therein shall be bundled together and the maximum diameter measured. The maximum diameter shall not exceed 80% of the internal diameter of the conduit. Maximum diameter wire and electrical/ optical cable permitted by applicable specifications shall be used or allowed when taking this measurement.

3.13.5 Fittings

Conduit fittings in accordance with AS10380 or other applicable drawings shall be used in conjunction with metallic conduit. Nonmetallic conduit shall be terminated with approved AN or MS fittings. Rigid metallic and nonmetallic conduit used for wiring inaccessible areas need not be terminated provided the conduit is suitably flared or rounded and sharp edges removed.

3.13.6 Conduit Installation

Conduit shall be installed to withstand vibration and normal service abuse.

3.13.7 Support

Conduit shall be supported so that strain on the ferrules is relieved.

3.13.8 Drainage

Where practicable, metallic and nonmetallic conduit shall be installed so that fluids or condensate will not be trapped. Suitable drainage holes shall be provided at the low points, except for magneto ground cable conduit and metallic flexible conduit. Tape (nonadhesive) used as a wrap around wiring shall also have drainage holes at the low points. Burrs shall be removed from drainage holes in metallic conduit and from the conduit fittings.

3.13.9 Grounding

Metallic conduit carrying electrical wiring shall have a low-resistance bond of less than 0.10 ohm to structure at each terminating end and break point. The bonding path may be through the equipment at which the conduit terminates. Bonding connections to the conduit shall be made with an AS7351 clamp and a bonding jumper, with one terminal secured to the clamp with threaded fasteners. Surfaces between clamp and conduit and between terminal lug and clamp tab shall be prepared to insure a suitable low-resistance bond. After cleaning, but before clamp installation, aluminum conduit surfaces shall be conductive conversion coated in accordance with MIL-DTL-5541. After bonding hardware assembly, mating surfaces around the ground hardware shall be restored to the original finish or, if subject to fuel exposure, shall be sealed with a compound in accordance with AMS-S-8802.

3.13.10 Ignition Conduit

The ignition ground conduit for each engine shall be separately routed to prevent a single damage from affecting more than one engine.

3.13.11 Radius of Bends

The radius of bend of conduit shall allow the bend radius requirements of 3.11.7 to be met. Conduit and conduit fitting bends shall not cause chafing of the wiring.

3.14 Connectors

Except for hermetic connectors with only pin type design, connectors shall be selected so that contacts on the "live" or "hot" side of the connection are socket type rather than pin type to minimize personnel hazard and to prevent accidental shorting of live circuits when the connector is unmated. When using special contacts such as thermocouple or coaxial, circular electrical connectors shall be specified on installation drawings using the A and B suffix when applicable in the connector part number. The "A" designation without pins and the "B" designation without sockets, indicate special applications for the connector. The selection and use of connectors for fiber optics cable shall be approved by the procuring activity. Only connectors that withstand a minimum of 500 hours salt spray when tested per EIA 364-26 or equivalent shall be used.

3.14.1 Environment Resisting Connectors

Circular power and circular signal connectors shall be sealed against the ingress of water and water vapor under all service conditions including changes in altitude, humidity and temperature. The connectors shall have an interfacial seal as well as sealing at wire ends. Environment resisting connectors having wire sealing grommets are preferred; however, potting may be used where a grommet seal connector would not be suitable (see 3.14.8). The outside diameter of the wiring terminated at the connector that has a wire sealing grommet shall comply with the wire diameter range specified for that connector (see 3.8.6).

3.14.2 Contacts

Connectors using removable crimp type contacts are preferred to solder contact types. Contacts shall be in accordance with AS39029 or the applicable connector specification. Wire size shall be within crimp barrel size range as specified in contact specification. Wire barrel contact bushings, in accordance with AS33481, shall be used when crimping some wire sizes in size 0, 4 and 8 contacts. Contractors may use automatic, semi-automatic, or hand crimp tools for production. Contacts crimped with contractor's tooling will provide the same performance as specified by AS39029 or the connector specification. Contractors will only specify MIL-DTL-22520 tools for the tools specified in the component specification or contract replacement.

3.14.2.1 Spare Contacts

When crimp contact connectors are used, the unused contacts shall be installed in unused cavities. MS27488 or applicable sealing plugs shall be inserted in unused grommet holes of environment resistant connectors. Sealing plugs shall not be installed where they interfere with the free movement of the spring loaded socket termini on connectors containing fiber optic termini. For potted connectors, each spare contact shall have a pigtail attached, consisting of a wire of the largest size that can be accommodated by the contact and extends 5 to 7 inches beyond the potting material. The pigtails shall be identified and dead-ended. In firewall applications there shall be no unwired spare contacts. All unused contact cavities shall be wired. Stub wires shall be capped with polytetrafluoroethylene insulated dead-end caps or equivalent. M85049/80-XX Shielded, Coaxial and Twinax dummy contacts shall be installed in designated unused pin contact cavities in the unpressurized areas (except firewall).

3.14.2.2 Electrical connectors that contain fiber optic termini shall have empty cavities filled with either spare electrical contacts or dummy termini unless they interfere with the configuration of the mating connector. Connectors with fiber optic pin termini, whose mating connector have the alignment sleeves built-in, must use special contacts with a shorter pins to preclude damage to the mating termini.

3.14.3 Fireproof and Firewall Connectors

These connectors shall be thread-coupled, self-locking connectors with crimp contacts and corrosion-resistant steel shells. Where it is necessary to maintain electrical continuity for a limited time under continuous flame, both the receptacle and mating plug shall be fireproof. If only flame integrity is necessary without the need for electrical continuity, only the receptacle needs to be fire-proof. Fireproof and firewall connectors shall meet the Class K, KT or KS requirements of the applicable military specification.

3.14.4 Coaxial and Triaxial Connectors

Coaxial and triaxial connectors shall be suitable for the application and shall be covered by military specification. Series N, C, BNC, TNC, SC, SMA, SMB and SMC shall be in accordance with MIL-PRF-39012. Category B connectors of this specification shall be used only on original equipment. When using Category B connectors, the contractor shall specify an equivalent field replaceable connector as defined on the latest issue of MIL-PRF-39012 for replacement as a maintenance or repair item. Category B connectors are not recommended for maintenance or repair. Category E and F connectors of this specification shall be used for applications using semi-rigid coaxial cables. Pulse series connectors shall be in accordance with MIL-DTL-3607, LC series with MIL-DTL-3650, twin series with MIL-DTL-3655, environment resisting series with MIL-DTL-25516, strip line with MIL-DTL-83517, adapters with MIL-PRF-55339, and triaxial connectors with MIL-PRF-49142. Where connector parameters beyond the scope of the military specification are required, nonstandard commercial types may be utilized provided that they meet the general requirements of the applicable military specification and are approved by the procuring activity.

3.14.4.1 Coaxial Rigid Lines

Coaxial rigid lines that employ air dielectric shall be provided with air passage bulkhead connectors and pressure fitting connectors for purging and pressurization of the lines.

3.14.5 Connector Installation

Connectors shall be used to join harnesses to equipment or other harnesses when frequent disconnection is required to remove or service equipment, components, or wiring. Connectors shall be located and installed so that they will not provide hand holds or foot rests to operating and maintenance personnel, or be damaged by cargo and stored material. Receptacles in pressurized structure shall preferably be installed with the flange to the high pressure side. Fasteners shall be used in all holes of flange mated connectors.

3.14.5.1 Circular Connector Installation

Adequate space shall be provided for mating and unmating circular connectors without the use of tools. At least one inch shall be provided around the coupling rings of circular connectors, unless size of the equipment or area available for connector installation, and the number and size of the connectors prohibit this spacing. In such cases, at least 3/4-inch clearance shall be provided around the connector. Where connectors can be sequentially mated and unmated a 1-inch clearance in a swept area of at least 270 degrees around the connector at the start of the removal and replacement sequence shall be provided. Where the 3/4 inch or 1 inch/270 degree swept area requirement cannot be met, demonstration of connector removal and installation shall constitute compliance, when approved by the procurement activity.

Airframe connectors, when installed with the axis in a horizontal direction, shall be positioned so that the master keyway is located to the top. When the connector axis is vertical, the master keyway shall be positioned to the front of the vehicle. Both plug and receptacle shall be visible for engagement and orientation of the polarizing key(s).

3.14.5.2 Rectangular Connector Installation

Adequate space shall be provided for mating and unmating rectangular connectors. Rectangular connectors may be mounted in close proximity, or stacked, provided that each one can be mated or unmated without first unmating adjacent connectors. Access for tools during mating or unmating is required.

3.14.5.3 In-line Connector Installation

Except for coaxial and data bus connectors, in-line connectors shall be installed using primary support (see 3.11.1 and 2.4.19).

3.14.5.4 External Ground Power Installation

The safe and convenient location of an external power receptacle shall be a prime consideration to facilitate servicing and to minimize hazards to the ground crew. The external power receptacle shall be in accordance with AS81790 and installed in accordance with MIL-STD-7080. The receptacle shall be installed with the small contact at the bottom (6 o'clock position). For 270 volt DC external power receptacles, a means shall be provided to eliminate potential arcing by automatically shutting off ground power before the electrical separation of power pins and sockets can occur. This can be accomplished by controlling electrical engagement of the control contacts so the continuity necessary to enable continued application of 270 volt DC power is interrupted before electrical disengagement of power pins/sockets occurs. The receptacle shall not be located in or near hazardous areas such as air inlets or exhausts, auxiliary power unit or jet fuel starter exhaust, propellers or propeller blasts, or fuel servicing or vent areas. The external power receptacles shall be accessible from ground level. The receptacle shall not be located more than 6 feet above the bottom of the air vehicle wheels. At no time shall there be more than 10 feet of cable hanging unsupported from the receptacle. The receptacle shall be located in a position such that the plug will fully mate with the receptacle without the plug being modified. The external power plug shall be in accordance with AS7974. The external power receptacles shall be protected from dirt, fluids, and other contaminants when it is not in use. The receptacle shall be prominently identified to facilitate air vehicle servicing. The receptacle location shall take into consideration the ease of repair and replacement.

3.14.6 Locations with Multiple Connectors

Connectors used to provide separation of or connections to multiple electric circuits in the same location shall be installed so that it will be impossible to mate the wrong connector in another mating unit. It is preferred that wiring be routed and supported such that an improper connection cannot be made. The order of precedence for making the connector selection for a multiple connector location shall be as follows:

- a. First, the connectors shall be different sizes or have different insert arrangements.
- b. Second, the connectors with the same insert arrangements shall have alternate insert positions or keying positions.
- c. Third, if none of the above requirements can be met, identical connectors shall have color coded sleeves attached to the wiring near the connector which identifies the associated connector mating half. In cases where one of the connectors is mounted, the connector shall be coded by a color identifier on the adjacent structure.

3.14.6.1 Connector Drainage

Receptacles shall be so positioned that when unmated for maintenance operations, fluids and condensate will drain out of and not into the receptacle. Connectors installed external to the vehicle proper, such as in engine compartments, wheel wells, etc., shall be given special attention to protect against entry of oil and moisture into the connector such as taping or sealing mated connectors and providing protective covers for receptacles and plugs which may be left unmated. Connectors shall not be mounted or located in a position where they will support standing water.

3.14.7 Safety Wiring

Non-self-locking threaded coupled connectors located in engine nacelles, areas of high vibration (excluding connectors on shock-mounted equipment), and in areas which are normally inaccessible for periodic maintenance inspection, shall have the coupling nut safety-wired or otherwise mechanically locked to prevent opening of the connector due to vibration. When safety wiring is required on electrical connectors or connector accessories which use threaded coupling rings, or on plugs which employ screws or rings to fasten the individual parts of the plug together, the components shall be safety wired in accordance with NASM33540 using 0.020 inch wire (Inconel or Monel) in accordance with NASM20995. Safety wire may also be installed in accordance with AS4536 using 0.020-inch diameter wire (Inconel) in accordance with AS3509.

3.14.8 Potting

Connectors that require potting shall be potted with MIL-PRF-8516 sealant for operating temperatures not exceeding 93 °C (200 °F). Where operating temperatures exceed 93 °C but do not exceed 232 °C (450 °F), sealing compound in accordance with MIL-PRF-23586 may be used. Where resistance to oil and fuel is required and temperatures do not exceed 125 °C (275 °F), MIL-M-24041 molding and potting compound may be used. For higher temperatures, potting shall not be used unless specifically approved by the procuring activity. If protective sleeving, identification sleeves, jacketing or braiding is terminated at a potted connector, it shall not extend into the potted material. Insulated sleeving shall not be used within the potted material of the connector. For Air Force procurement, all potting of connectors is discouraged and requires specific application approval.

3.14.9 Delete.

3.14.10 Delete.

3.14.11 Dust Protection

Through production (except when uncovered for assembly operations) unmated connectors shall be suitably covered. Plastic dust caps such as those conforming to AS90376, NAS813 and NAS820 may be used for this purpose. Unmated connectors containing fiber optic termini shall be protected from dust and contamination.

3.14.11.1 Final Assembly Covers

Unmated connectors on final installed assemblies, such as those intended for test, future or optional wiring shall be engaged to approved vapor-tight covers such as dummy receptacles or chained protective covers.

3.14.12 Dummy Receptacles

Dummy receptacles shall be provided for stowing unmated plugs or caps or protective covers when the related connectors are not in operational use. The dummy receptacle shall be conspicuously marked and conveniently located to accommodate the unmated connector or protective cover. The dummy receptacle shall conform to the requirements of the related connector specification.

3.14.13 Provision Plugs

Connector plugs that are for equipment to be installed later or for test purposes shall be secured by clamps, or to dummy receptacles provided for that purpose, in order that the plugs cannot swing on wiring and cause damage to themselves, wiring, or adjacent equipment, or foul mechanical linkage.

3.14.14 Connector Accessories

Circular electrical connectors shall be provided with strain relief accessories in accordance with AS85049. Accessories shall not be used to terminate ground wires or shields unless the accessory was specifically designed to terminate ground wires or shields. Ground wires shall not be terminated to saddle clamp screws. Fiber optic connectors shall be provided with strain relief in accordance with the individual connector specifications.

NOTE: When flexible conduit is used, additional strain relief is not required.

3.15 Deleted.

3.15.1 Deleted.

3.16 Deleted.

3.17 Junctions

An uninterrupted wire and fiber optics cable is preferable to a junction. Only approved devices, such as permanent splices, feed-thru bushings, terminal boards, terminal junction systems and connectors, shall be used for wire junctions. The need and choice of junctions shall be determined by consideration of reliability factors, maintenance factors and manufacturing procedures, in that order of selection. Solderless junctions are preferred. The use of solder junctions shall be kept to a minimum.

3.17.1 Junction Installations

Junctions shall be installed so that they are mechanically, electrically, and optically reliable. They shall not be subject to mechanical strain or used to support insulating materials, except for insulation on terminals and splices. Junctions shall not depend upon insulators under compression for maintaining the connection tightness. Circuit continuity shall not depend upon nonmetallic parts retaining original shape when subjected to compression loading.

3.17.2 Preparation for Crimp Termination

Wires and electrical cables, when stripped for termination, shall not have more nicked or broken strands than specified in Table 2. Wires and filter line cables shall be stripped in accordance with AS5768. Wire stripping tools shall be inspected in accordance with AS5768. When the stripped portion of the conductor is visible in the crimp contact inspection hole, no more than 0.031 inch of the conductor shall be exposed at the end of the barrel for size 12 AWG and smaller, 0.063 inch for size 10 and larger, when the conductor is terminated. These dimensions shall be applicable for contacts, terminal lugs and splices. For terminal lugs, the stripped portion of the conductor shall extend to a point beyond the open end of the crimp barrel, which will not interfere with the stud, washer, nut or similar attachment device. For splices, the stripped portion of the conductor shall be visible in the inspection window.

3.17.2.1 Multiple Wire Terminations

Multiple wire may be crimped in the crimp barrel of terminal lugs or splices, provided that their total circular mil area is within the range of the crimp barrel and are crimped under proper process control. The wires shall fit into the diameters of the insulation support without altering their insulation.

3.17.3 Junction Resistance

Permanent junction resistance shall not be greater than the resistance over that of an uninterrupted wire of the same size. The resistance of other junctions shall not exceed the maximum resistance allowed by the specification for that device.

3.17.4 Spacing and Creepage Distance

Electrical junctions shall have adequate spacing and creepage distance to prevent arcing and detrimental leakage currents between circuits. Suitable insulating barrier material may be used to provide necessary creepage distance.

3.17.5 Protection

Special attention shall be given to ensure that electrical junctions are adequately protected from damage or short circuits resulting from movement of personnel, cargo, shell cases, clips, and other loose or stored materials. This protection may be provided by covering the junctions, by installing them in junction boxes, by locating them in such manner that additional protection is not required, or by other means acceptable to the procuring activity.

3.17.6 Exposed Junctions

Exposed junctions and buses shall be protected with insulating materials. Reusable devices are preferred to non-reusable material. Junctions and buses located within enclosed areas containing only electrical and electronic equipment are not considered as exposed. Compartments housing electrical and electronic equipment but which are naturally adaptable as stowage areas or which are not protected against occasional debris, etc., shall not be considered as enclosed areas. Terminal junctions located in wheel wells shall be protected against the effects of water thrown by the wheels.

3.17.7 Essential Circuit Junctions

Junctions in circuits that affect the operational safety of the vehicle shall be particularly protected to ensure a maximum degree of reliability. These junctions shall be individually encased with insulating material to insure electrical insulation and isolation from foreign material.

3.17.8 Aluminum Wire Junctions

Special attention shall be given to aluminum wire and cable installation to guard against conditions that would result in excessive voltage drop and high resistance at junctions that may ultimately lead to failure of the junction. Examples of such conditions are improper installation of terminals and washers, improper torsion (“torquing”) of nuts, and inadequate terminal contact areas.

3.17.9 Accessibility

All junctions shall be accessible for inspection and maintenance without requiring electrical, hydraulic, or other operational power for any vehicle system or equipment. This shall include those junctions that are installed for manufacturing convenience.

3.17.10 Nonmetallic Covers

Nonmetallic junction covers, such as fabric or plastic, shall maintain a high dielectric resistance and shall not absorb or be affected by applicable fluids. They shall be installed in such a manner that mechanical movements are free from interference, that fasteners are unable to cause short circuits, and that proper drainage is provided. Nonmetallic covers in proximity with high temperature equipment, such as resistors, shall be capable of withstanding the maximum temperature encountered without damage.

3.18 Junction Boxes

Junction boxes may be used to provide special protection for wire and cable junctions.

3.18.1 Junction Box Construction

Junction boxes may be made of metal or of nonmetallic material. Metallic junction boxes shall have their interiors coated with an insulating material to minimize the possibility of grounding faults. The inside of all junction boxes shall be white to facilitate inspection and maintenance. Except for vapor tight boxes, drainage holes shall be provided, allowing drainage of the boxes with the vehicle on the ground and in flight, with wings, wheels, and surfaces both folded and extended, as applicable. Metal junction boxes shall be fabricated from a metal gage size sufficient to provide stiffness and rigidity, to adequately support multiple attachments without flexing or deforming under service conditions, and to provide proper support and alignment for hinged or removable covers.

3.18.2 Hinges

When electrical or electronic equipment is mounted on junction box covers, such covers shall be hinged in a manner to prevent damage to electrical/optical cables and equipment when the covers are opened and closed. Hinges shall not be used to provide an electrical ground path.

3.18.3 Junction Box Identification

Junction boxes shall be externally identified to facilitate correlation of the box with the wiring diagrams. Vapor tight junction boxes shall be externally labeled “Vapor-tight.”

3.18.4 Junction Box Wiring

Wiring in junction boxes shall be adequately supported at convenient intervals to meet the following requirements:

- a. Provide neat and orderly arrangement of wiring.
- b. Provide ease of inspection and maintenance.
- c. Provide relief of strain on terminals.
- d. Minimize possibility of faults.
- e. Prevent vibration from damaging wiring or terminals.

3.19 Splices for Wire and Electrical/Optical Cables

Insulated in-line wire splices may be used to assemble subassemblies, to incorporate changes or to facilitate repairs and maintenance. Splices for fiber optics cable shall be suitable for use and shall be approved by the procuring activity.

3.19.1 Permanent Splices

Permanent splices may be used to assemble subassemblies, to incorporate changes or to facilitate repairs. Splices for copper conductors shall be in accordance with AS81824 or equivalent sealed splice. For the Navy and Air Force, only AS81824 environment resistant splices shall be used. Environment resistant sealed splices shall be used in areas of severe wind and moisture problems (SWAMP), such as wheel wells, near wing flaps, wing folds and other areas specified in the detail specification or contract. Splices for aluminum conductors shall be in accordance with AS7099 and MS25439.

3.19.2 Quick Disconnect Splices

Quick disconnect splices designed for disconnection without the use of tools shall not be used.

3.19.3 Terminal Junction Disconnect Splices

When splices are used for in-line connections of two or more wires, where disconnect is required, disconnect splices in accordance with AS81714/11 and AS81714/12 shall be used. Sealing plugs in accordance with MS27488 shall be installed in unused grommet holes.

3.19.4 Splice Restrictions

Splices are subject to the following restrictions:

- a. There shall not be more than one splice in any one wire segment between any two connectors or other disconnect points, except as allowed by e, g and h, below.
- b. Installation of splices in bundles shall not increase the size of the bundle so as to prevent the bundle from fitting in its designated space or cause congestion which will adversely affect maintenance.
- c. Splices shall not be used to salvage scrap lengths of wire.
- d. Splices shall not be used within 12 inches of a termination device, except for e, below.
- e. For voltage drop issues, splices may be used within 12 inches of a termination device when attaching to the pigtail spare lead of a potted termination device, or to splice multiple wires to a single wire, or to adjust the wire sizes so that they are compatible with the contact crimp barrel sizes. This is not applicable for power distribution circuits.
- f. The application of splices shall be under design control and shall be authorized by engineering drawings.

- g. Splices may be used to repair manufactured harnesses or installed wiring when approved by engineering.
- h. (For Air Force use) Splices shall not be used on firing or control circuits associated with ordnance or explosive sub-systems.
- i. All wires spliced in current carrying circuits must be of a size adequately protected by the circuit protection device.
- j. Splices shall not be used on wires inside of fuel tanks.
- k. Conductor splices shall not be used for new design or repair on wiring in areas in which flexing may occur during operations or maintenance.
- l. Splices shall not be located under clamps.
- m. Fiber optics splices shall be string tied to the harness for support. The spliced fiber cable shall not be tied to the harness within 3 inches from the end of the splice.

3.19.5 Splice Areas

Splices installed for assembly of subassemblies shall be contained in splice areas and identified as such on all applicable drawings. Splice areas shall be selected so that they are readily accessible for maintenance and inspection including splices contained in the center of the bundle.

3.20 Terminal Lugs

Wire terminal lugs shall be used to connect wiring to terminal board studs, equipment terminal studs and ground studs. No more than four terminal lugs or three terminal lugs and a bus bar shall be connected to any one stud (total number of terminal lugs per stud includes a common bus bar joining adjacent studs. Four terminal lugs plus a common bus bar thus are not permitted on one stud). When the terminal lugs attached to a stud vary in diameter, the greatest diameter shall be placed on the bottom and smallest diameter on top. Terminal lugs shall be selected with a stud hole diameter which matches the diameter of the stud. Tightening terminal connections shall not deform the terminal lugs or the studs. The terminal tongue of a straight lug may be bent up to 90 degrees maximum, provided the bend radius is not less than twice the thickness of the lug tongue, and the distance from the tip of the tongue to the beginning of the bend is not less than the diameter across the lug. Bending shall not be required to remove the fastening screw or nut. The position of the terminal lug shall be such that movement of the lug will tend to tighten the fastening screw or nut.

Wire terminal lugs shall be used to connect wiring to circuit breakers terminals. No more than two terminal lugs, or one terminal lug and a bus bar shall be connected to any one terminal.

3.20.1 Copper Terminal Lugs

Solderless crimp style copper wire terminal lugs shall be used. Terminal lugs shall conform to AS7928. Spacers or washers are not permitted between the tongues of terminal lugs.

3.20.2 Aluminum Terminal Lugs

Aluminum terminal lugs conforming to AS7099 (MS25435, MS25436, and MS25438) shall be crimped to aluminum wire only. The tongue of the aluminum terminal lugs or the total number of tongues of aluminum terminal lugs when stacked, shall be sandwiched between two NASM25440 flat washers when terminated on terminal studs. Spacers or washers are not permitted between the tongues of terminal lugs.

3.20.3 Class 2 Terminal Lugs

Class 2 terminal lugs conforming to AS7928 may be used for installation by contractors, provided that in such installations Class 1 terminal lugs are adequate for replacement without rework of installation or terminal lugs. Class 2 terminal lugs shall be the insulated type unless the conductor temperature exceeds 105 °C, in which case uninsulated terminal lugs shall be used. Parts lists shall indicate the appropriate Class 1 terminal lugs to be used for service replacement of any Class 2 terminal lugs installed.

3.21 Terminal Boards and Terminal Junction Modules

Terminal boards or terminal junction modules shall be used for junctions of wiring requiring infrequent disconnection or for joining two or more wires to a common point.

3.21.1 Terminal Boards

Terminal boards shall be in accordance with AS27212 and shall be installed with MS18029 covers. Terminal board mounting screw insulators shall be installed in accordance with AS33731. Ammeter shunts shall not be used as terminal boards.

3.21.2 Terminal Junction Modules

Terminal junction modules and their mounting tracks and brackets shall be in accordance with AS81714. Sealing plugs in accordance with MS27488 shall be installed in unused grommet holes. AS81714 terminal junction modules shall not be used in SWAMP areas.

3.21.3 Terminal Board and Terminal Junction System Identification

Each AS27212 terminal board shall be assigned an individual item number, and the studs for each board shall be assigned consecutive numbers or letters beginning with 1 or A, to correlate with the wiring diagrams. For example, TB75-4 shall designate stud #4 of terminal board 75. Each terminal junction track, per AS81714, shall also be assigned an individual TB number. For example, track #76 would be designated as TB76. Individual terminal junction modules shall be identified by numbers or letters permanently applied to the individual track as specified in AS81714. The identification of terminal boards, studs and tracks shall be of a permanent nature affixed to the vehicle and shall be so located that the information is readable with minimal disturbance to wiring or equipment. Tracks shall be positioned so that the module identification reads left to right, or top to bottom. Removal of the board or track shall leave the identification intact.

3.22 Deleted.

3.22.1 Deleted.

3.23 Workmanship

Workmanship shall be in accordance with aerospace vehicle electrical wiring and equipment installation practices to ensure safety, proper operation and service life. Details of workmanship shall be subject to the inspection and approval of the procuring activity.

3.23.1 Loose Parts

Chips, scraps, excess hardware, tools or other unessential material that can cause damage to the electrical system by shorting terminals, abrading wiring or puncturing insulation, shall not be left in the vehicle.

3.24 Solder Type Terminations

All soldering shall be in accordance with AS4461.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Procuring Activity. The Procuring Activity reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.2 General

The inspection checks and tests required herein for wiring installation are classified as quality conformance inspections.

4.3 Wiring Mockup

When specified in the contract, the contractor shall conduct a wiring mockup for inspection by the procuring activity, prior to delivery of the first vehicle and in time to permit needed changes. On this mockup, the contractor shall demonstrate typical wiring installations and specific wiring practices for which deviations are required. This mockup may be conducted on a production vehicle.

4.4 Inspection of First Vehicle

The wiring installation of the first complete vehicle shall be inspected at the contractor's plant by the contractor under supervision of the procuring activity to determine conformance to the requirements of this specification, and shall be subject to approval by the procuring activity.

4.5 Changes in Wiring

Vehicles in which changes have been made in the wiring shall be inspected at the contractor's plant by the contractor under the supervision of the procuring activity to determine compliance with the requirements of this specification.

4.6 Individual Tests

Functional checks shall be conducted by the contractor on each vehicle to ensure proper operation of all wiring.

5. PACKAGING

(not applicable)

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended Use

The wiring requirements covered by this specification are intended for use in the selection and installation of wiring and accessories for the interconnection of electrical and electronic equipment in aerospace vehicles. The requirements specified herein are applicable to development, prototype, production, rework and modification wiring, on new or in-service vehicles. All wiring that is completely internal to electrical and electronic equipment, should be in accordance with the applicable equipment specifications rather than this specification.

6.1.1 Modification Programs

When this specification is invoked in a modification program for an existing aerospace vehicles, wiring provisions that are not directly affected by such modification shall be in accordance with the revision of this specification applicable to the initial aerospace vehicle construction or subsequent rewiring programs identified by the procuring activity (see 6.1.2).

6.1.2 Wiring Upgrades

The following items have a significant impact on aerospace vehicle design effort, cost and weight and should only be required when performance, reliability and maintainability will significantly benefit.

<u>Paragraph</u>	<u>Title</u>
3.4	Service Life
3.8.8	Minimum Wire Size
3.8.10.3	Electromagnetic Interference (EMI) and Electromagnetic Vulnerability (EMV) Sensitive Areas
3.9.1	Assignment of Identification Codes
3.10.7.1	Connector Terminations
3.10.8	Electromagnetic Compatibility
3.10.10	Compass deviation
3.11.7	Radius of Bend
3.12.1	Shielded Wire Grounding
3.14	Connectors
3.14.5	Connector Installation
3.14.14	Connector Accessories
6.2	Ordering Data
Table AI & All	Wiring Applications

6.2 Ordering Data

Specify the type of identification code in accordance with Appendix B or C (see 3.9.1). Unless specified otherwise, the identification code for the Navy shall be "significant" in accordance with Appendix B. When wiring data in accordance with MIL-HDBK-863 is required by contract, nonsignificant wire identification in accordance with Appendix C will be specified by that standard.

6.2.1 Contract Data Requirements

The selected data requirements in support of this specification will be reflected in a Contract Data Requirements List (DD Form 1423) attached to the request for proposal, invitation for bid, or the contract as appropriate.

6.3 Deleted.

6.4 Installation of Electrical and Electronic Equipment

The installation of electrical and electronic equipment is covered by MIL-STD-7080 and AS8700, respectively.

6.5 Technical Manuals

Technical Manual NAVAIR 01-1A-505-1, USAF T.O. 1-1A-14, and Army TM 55-1500-323-24-1, "Installation Practices for Aircraft Electric and Electronic Wiring," contains useful information and guidance on aircraft wiring installation techniques.

6.6 Corona Prevention Related Information

In order to prevent ionization, also referred to as corona, or partial discharges between the outside of an unshielded wire covering and grounded structural elements over which the wire passes, or between the insulation and a braided shield, the wire covering should have adequate "equivalent insulation thickness" for the conditions of operation. "Wire covering" means any combination of extruded or taped insulations and insulating jackets. Ionization causing chemical and mechanical deterioration of the coverings, is a source of radio frequency interference, and produces by-products which can corrode adjacent metallic components. For AC operating voltages not exceeding 240 volts RMS, any given thickness of flaw-free insulation is adequate to support this voltage at any pressure or temperature; thickness is dictated by mechanical requirements. For higher AC voltages the "equivalent insulation thickness" can be found in Figure 1.

Select the appropriate curve for the simultaneous minimum pressure and maximum temperature of the ambient air to which the wire will be exposed and read the "equivalent insulation thickness" corresponding to the operating RMS voltage. In aircraft and space applications due to partial or complete enclosure for pressurization and due to local heating, the ambient pressures and temperatures in the equipment may not correspond to those at the same altitude outside of the craft. Equipment operating pressures and temperatures should be used in the determination. The "equivalent insulation thickness" is related to the wire covering and is shown in Figure 2 where t_1 , t_2 , etc., are the successive thicknesses and k_1 , k_2 , etc., are the respective relative dielectric constants of these same wire coverings. The value determined is independent of power frequency up to at least several kilo-hertz. The values of Figure 1 and Figure 2 are based on the inception voltage (corona starting voltage). In many instances once ionization has started it does not extinguish until the applied voltage is lowered to the corona extinction voltage, which may be as much as 20% lower. Thus, a factor of safety should be allowed so that a transient voltage will not initiate ionization which will not disappear at the operating voltage. For DC, electrical cables can be used without ionization to a maximum voltage of 340 volts independent of the usual practical range of wire covering thicknesses. Under certain conditions (notably at high ambient temperatures and/or high altitude) some wire types may not be free from corona at rated voltage.

6.7 Wire Current Ratings

The wire current rating in 3.8.8.1.1 is based upon the curves of Figures 3, 4, and 5. The following examples illustrate the procedure for using these curves for applications other than 70 °C and 33 wire harness for size 26 through 10 gauge, and 9 wire harness for size 8 and larger as referenced for Table 1 values. Current carrying capacity listed in Table 1 or calculated using Figures 3, 4, and 5 are capable of handling frequencies up to 800 cycles per second; above 800 cycles, the AC resistance must be corrected for skin and proximity effects

Bundle capacity is determined by finding the derated wire current of each wire size in the bundle. The derated wire current is then multiplied by the total number of wires in the bundle for that gage size and then by the bundle loading percent for that gage size. The bundle capacity is determined by adding the harness capacity for each wire size.

Derated Wire Current = (Figure 3) X (Figure 4) X (Figure 5)

Harness Capacity for Each Wire Size = (Derated Wire Current) X (Total Number of Wires in Harness for a Specific Size) X (Bundle Loading Percent)

Total Bundle Capacity = Harness Capacity of Wire Size # 1 + Harness Capacity of Wire Size # 2 + Harness Capacity of Wire Size N

1. Assume a harness/bundle (open or protected) consisting of 10 size 20, 200 °C rated wires and 25 size 22, 200 °C rated wires. It will be installed in an area where the ambient temperature is 60 °C and the vehicle is capable of operating at 60,000 feet altitude. Circuit analysis reveals that 7 of the 35 wires in the bundle (7/35 - 20%) will be carrying power currents.
 - a. Referring to the "single copper wire in free air" curves in Figure 3, determine the ΔT of the wire to determine free air ratings (for aluminum, derate these values by 20%). Since the wire will be in an ambient of 60 °C and the wire is rated at 200 °C, the ΔT is 200 - 60 = 140 °C. Following the 140 °C ΔT line on Figure 3, the free air rating of size 20 is 21.5 amps and the free air rating of size 22 is 16.2 amps.
 - b. Referring to the "bundle derating curves" in Figure 4, the 20% curve is selected since circuit analysis indicated that 20% or less of the wire in the harness would be carrying power currents. Find 35 (on the abscissa) since there are 35 wires in our bundle and determine a derating factor of 0.52 (on the ordinate) from the 20% curve.
 - c. Derate the size 22 free air rating of 16.2 amps by 0.52 to get 8.4 amps harness rating and the size 20 free air rating of 21.5 by 0.52 to get 11.2 amps harness rating.
 - d. Referring to the "altitude derating curve" of Figure 5, look for 60 000 feet (on the abscissa) since that is the altitude the vehicle will be operating at. The wire must be derated by a factor of 0.79 (found on the ordinate).

- e. Derate the size 22 harness rating of 8.4 amps by 0.79 to get 6.6 amps and the size 20 harness rating of 11.2 amps by 0.79 to get 8.8 amps.
 - f. To find the total bundle capacity, multiply the total number of size 22 wires by the derated capacity ($25 \times 6.6 = 165.0$ amperes) and add to that the number of size 20 wires multiplied by the derated capacity ($10 \times 8.8 = 88$ amperes) and multiply the sum by the 20% bundle capacity factor. Thus, the total bundle capacity is $(165.0 + 88.0) \times 0.20 = 50.6$ amperes.
 - g. It has been determined that the total bundle current should not exceed 50.6 amps, no size 22 wire should carry more than 6.6 amps and no size 20 wire should carry more than 8.8 amps.
2. Assume a harness/bundle (open or protected) consisting of 12, size 12, 200 °C rated wires. The harness will be operated in an ambient of 25 °C at sea level and 60 °C at 20,000 feet altitude. All 12 wires will be operated at their maximum capacity.
- a. Referring to the “single wire in free air” curve in Figure 3, determine the ΔT of the wire to determine free air ratings. Since the wire will be in an ambient of 25 °C and 60 °C and is rated at 200 °C the ΔT s are $200\text{ °C} - 25\text{ °C} = 175\text{ °C}$ and $200\text{ °C} - 60\text{ °C} = 140\text{ °C}$. Following the 175 °C and the 140 °C ΔT lines on Figure 3, the free air ratings of size 12 are 68 amps and 61 amps, respectively.
 - b. Referring to the “bundle derating curves” in Figure 4, the 100% curve is selected because we know all 12 wires will be carrying full load. Find 12 (on the abscissa) since there are 12 wires in the bundle and determine a derating factor of 0.43 (on the ordinate) from the 100% curve.
 - c. Derate the size 12 free air ratings of 68 amps and 61 amps by 0.43 to get 29.2 amps and 26.2 amps, respectively.
 - d. Referring to the “altitude derating curve” of Figure 5, look for sea level and 20 000 feet (on the abscissa) since these are the conditions at which the load will be carried. The wire must be derated by a factor of 1.0 and 0.91, respectively.
 - e. Derate the size 12 bundle ratings of 29.2 amps at sea level and 26.6 amps at 20 000 feet by 1.0 and 0.91, respectively, to obtain 29.2 amps and 23.8 amps.
 - f. The total bundle capacity at sea level and 25 °C ambient is $29.2 \times 12 = 350.4$ amps and at 20 000 feet at 60 °C ambient is $23.8 \times 12 = 285.6$ amps. Each size 12 wire can carry 29.2 amps at sea level, 25 °C ambient or 23.8 amps at 20 000 feet, 60 °C ambient.

6.8 Thermocouples

A thermoelectric circuit consists of two wires composed of dissimilar metals permanently joined at both ends (thermocouple) and one thermocouple is heated to a different temperature than the other. The signal from the heated thermocouple is a function of the temperature gradient of the thermocouples and the composition of the two metals.

6.9 Wiring Diagrams

Wiring diagrams when contractually required on the DD 1423 shall be prepared in accordance with ASME Y14.100, ASME Y14.24, ASME Y14.34M, ASME Y14.35M, IEEE 315-1975.

6.9.1 Schematic Diagrams (except for Air Force use)

Schematic diagrams (functional) for electrical wiring shall show each circuit and may be on multiple sheets. The presentation of these circuits in a straight line (elementary) form is acceptable. Each electronic wiring diagram of an equipment or system shall be included on one sheet, if practicable.

6.9.2 Master Diagrams (except for Air Force use)

Master diagrams and wire data list shall be in accordance with ASME Y14.100, ASME Y14.24, ASME Y14.34M, ASME Y14.35M. Each system, such as AC power, DC power, exterior lighting and engine control shall be presented on one sheet, if practicable, without undue crowding.

6.9.2.1 Terminal Board and Terminal Module Symbols (except for Air Force use)

On the master interconnection diagrams, each terminal board stud symbol and terminal module contact cavity symbol shall be identified to exactly correlate with that established in 3.21.1. The wiring diagram shall have complete representation for each terminal board, module-track assembly and wire connected thereto, including information as to location of the board or assembly. Terminal boards and module-track assemblies shall be identified in accordance with the requirements of IEEE 315-1975.

6.10 International Standardization Agreement

Certain provisions (3.8, Appendix A and Appendix B) of this specification are the subject of international standardization agreement ASCC 104/19, STANAG 3317 and STANAG 3347. When amendment, revision or cancellation of this specification is proposed that will affect or violate the international agreement concerned, the preparing activity will take appropriate action through international standardization channels, including departmental standardization offices, to change the agreement or make other appropriate accommodations.

7. NOTE

A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

TABLE 1 - CURRENT RATING OF WIRES 1/
(SEE 3.8.8.1, 3.8.8.2, 3.8.8.3)

CONTINUOUS DUTY CURRENT (AMPERES) 2/
WIRES IN BUNDLES, GROUP OR HARNESSSES, WIRE TEMPERATURE RATING

Conductor Material	Wire Size	105 °C	150 °C	200 °C
Copper or Copper Alloy	<u>3/26</u>	2	3	4
	24	3	4	5
	22	3	5	6
	20	4	7	9
	18	6	9	12
	16	7	11	14
	14	10	14	18
	12	13	19	25
	10	17	26	32
	8	38	57	71
	6	50	76	97
	4	68	103	133
	2	95	141	179
	1	113	166	210
	1/0	128	192	243
2/0	147	222	285	
3/0	172	262	335	
4/0	204	310	395	
Aluminum <u>3/</u>	8	30	45	
	6	40	61	
	4	54	82	
	2	76	113	
	1	90	133	
	1/0	102	153	
	2/0	117	178	
	3/0	138	209	
	4/0	163	248	

1/ Current rating of wire terminating hardware is not covered by this table (see 3.8.8.1.2).

2/ Current rating for wire in this table are based on 33 or more wires for sizes 26 through 10 and 9 wires for size 8 and larger operating at 60,000 feet altitude, an ambient temperature of 70 °C and with no more than 20% of harness current capacity used.

3/ The use of these wires requires procurement activity approval.

TABLE 2 - MAXIMUM ALLOWABLE NICKED AND BROKEN STRANDS (SEE 3.17.2)

Conductor Materials	Number of Strands Per Conductor	Total Allowable Nicked and Broken Strands
Copper	7	None nicked, broken or severed
Copper or	19	2 nicked, none broken
Copper Alloy	37	4 nicked, none broken
	Above 37	6, nicked or broken
Aluminum	All number of strands	None nicked or broken

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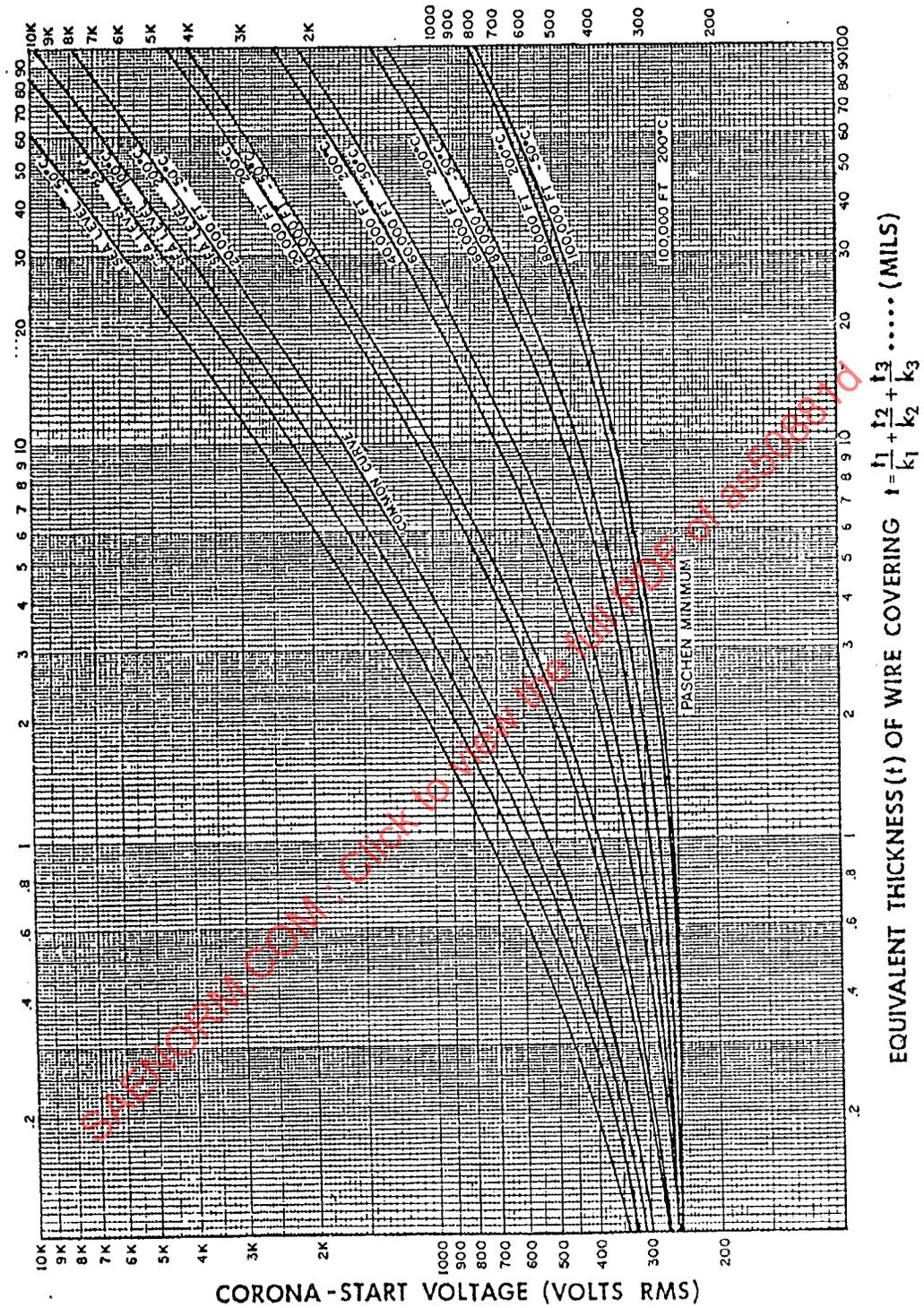


FIGURE 1 - EQUIVALENT THICKNESS OF WIRE COVERING VS CORONA STARTING VOLTAGE VS ALTITUDE AND TEMPERATURE. (SEE 6.6)

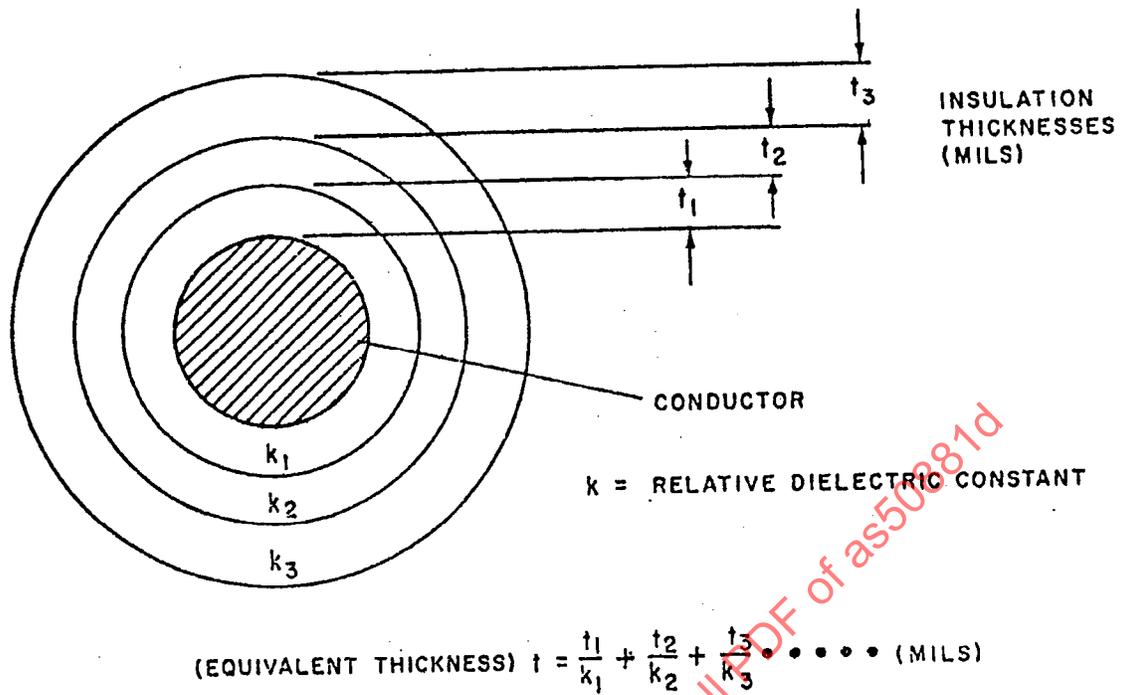


FIGURE 2 - EQUIVALENT INSULATION THICKNESS OF WIRE COVERING (SEE 6.6)

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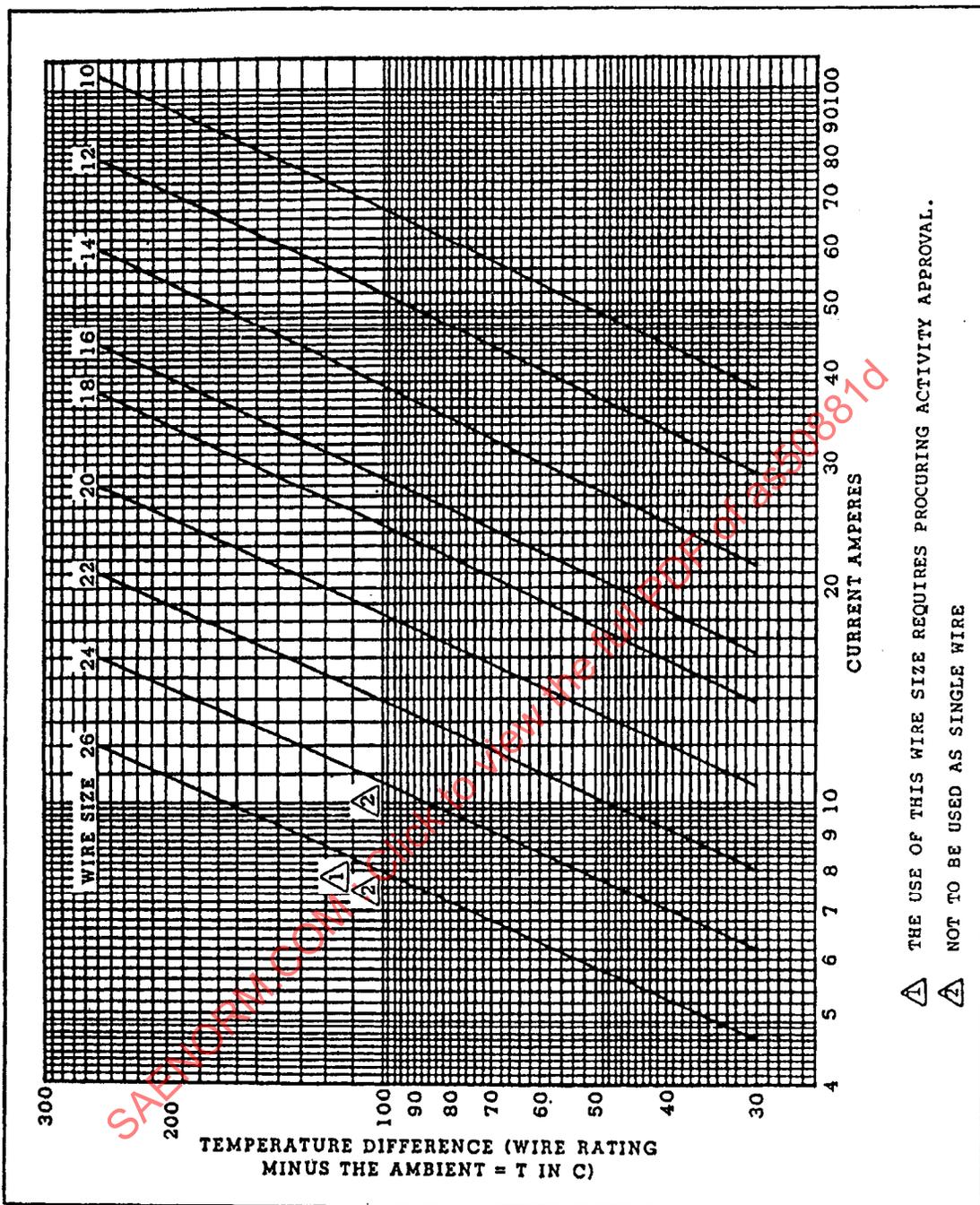


FIGURE 3 - SINGLE COPPER WIRE IN FREE AIR

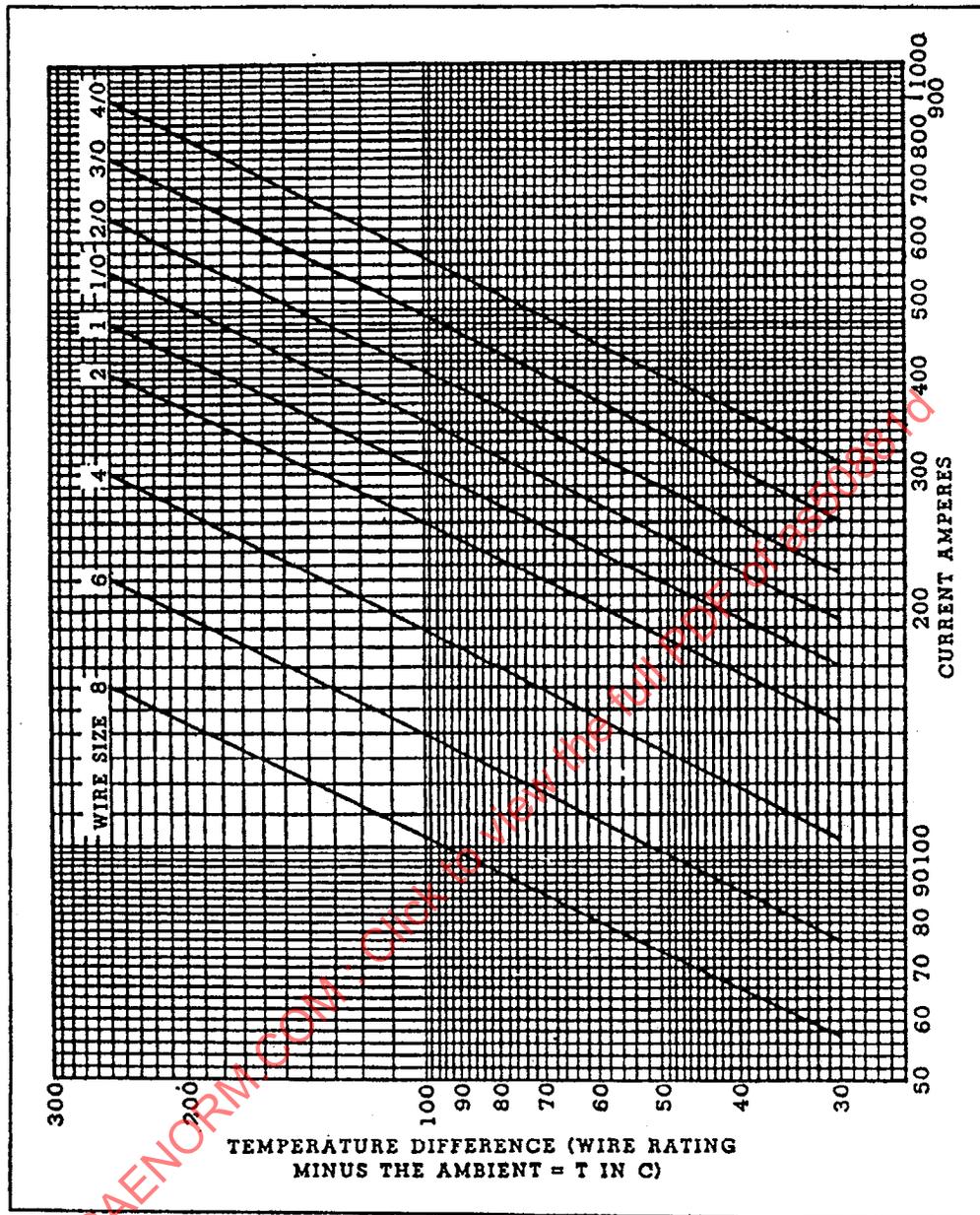


FIGURE 3 - SINGLE COPPER WIRE IN FREE AIR (CONTINUED)

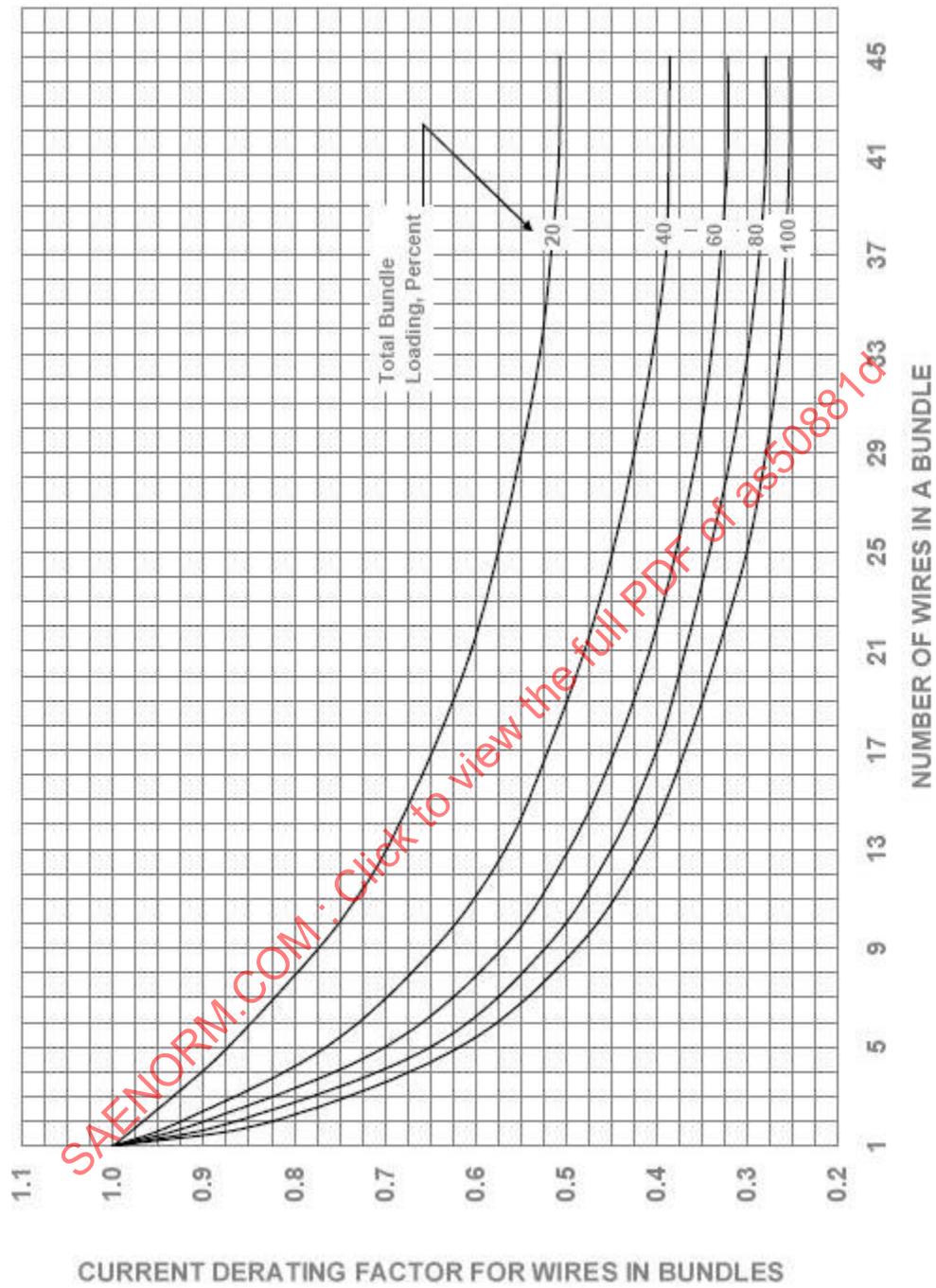


FIGURE 4 - BUNDLE DERATING CURVES
(SEE 3.8.8.1, 3.8.8.1.1, 6.7)

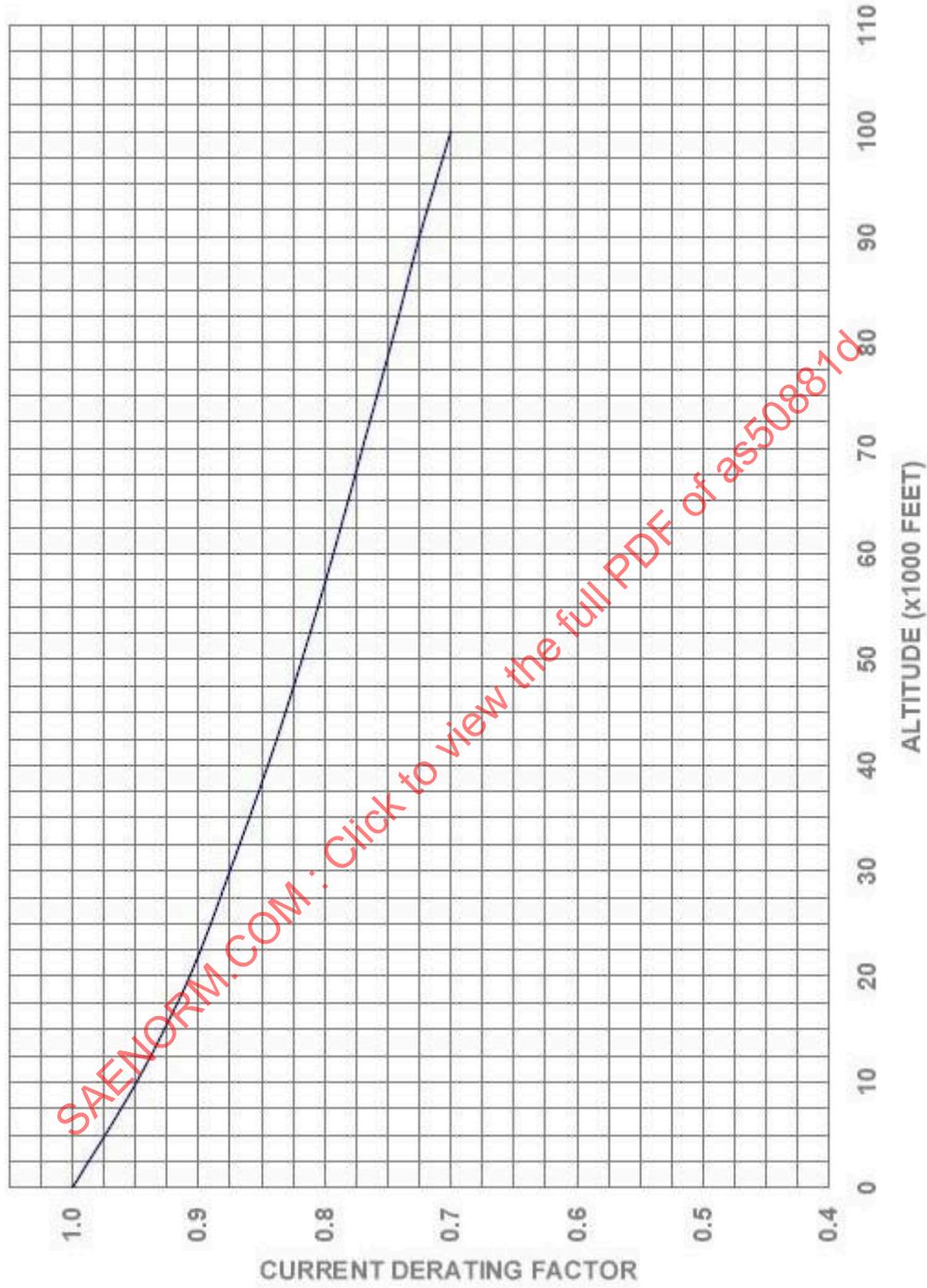


FIGURE 5 - ALTITUDE DERATING CURVE
(SEE 3.8.8.1, 3.8.8.1.1, 6.7)

APPENDIX A – OPEN OR PROTECTED HARNESSSES

A.1 SCOPE

A.1.1 Scope

This appendix governs the selection of electric wire and cable to be used for the interconnection of equipment in aerospace vehicles. This Appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

A.2 APPLICABLE DOCUMENTS

A.2.1 Government documents

A.2.1.1 Specifications, Standards and Handbooks

Unless otherwise specified, the following specifications, standards and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DODISS) specified in the solicitation form a part of this specification to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-DTL-17	Cable, Radio Frequency, Flexible and Semi-Rigid, General Specification For
MIL-DTL-25038	Wire, Electrical, High Temperature and Fire Resistant, General Specification For
MIL-T-81490	Transmission Lines, Transverse Electromagnetic Mode
MIL-C-85485	Cable, Electric, Filter Line, Radio Frequency Absorptive

(Unless otherwise indicated, copies of federal and military specifications, standards and handbooks are available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, <http://assist.daps.dla.mil/quicksearch/>.)

A.2.2 Non-government Documents

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

WC27500	Standard for Aerospace and Industrial Electric Cable
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SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

(Application for copies should be addressed to SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.)

AS22759	Wire, Electric, Fluoropolymer-insulated, Copper or Copper Alloy
AS5768	Tool, Stripper, electrical Insulation, General specification For
AS81044	Wire, Electric, Crosslinked Polyalkene, Cross-linked Alkane-imide Polymer or Polyarylene Insulated, Copper or Copper Alloy

A.3 REQUIREMENTS

A.3.1 Selection of Wire and Cable

Unless otherwise approved by the procuring activity, only wires and cables conforming to one of the documents listed in Table A1, Table A2, A.3.1.4, A.3.1.5, A.3.1.6, of this Appendix shall be used for interconnection of electric and electronic equipment in aerospace vehicles. The limitations and other selection criteria of Section 3 of this specification shall also be imposed on the selection and use of these wires and cables. AS4372 and AS4373 are recommended for the evaluation and proposed selection of wire construction not listed in Tables A1 and A2. The contractor shall become familiar with all requirements of this specification before any wires and cables are selected for use.

A.3.1.1 Harness Wiring

Wires shall be selected from Table A1.

A.3.1.2 Protected Harnesses

Wires shall be selected from Table A2, but may also include wires from Table A1. Any harness that uses wire selected from Table A2 shall have an outer covering throughout its length for mechanical protection.

A.3.1.3 DELETED

A.3.1.4 Cable

Cable shall be in accordance with WC27500. Only constructions utilizing basic wires in accordance with Tables A1 and A2 shall be used. Shielded unjacketed cables shall not be used.

A.3.1.5 Coaxial Cable

Coaxial cable shall be in accordance with MIL-DTL-17.

A.3.1.5.1 T.E.M. Transmission Lines

Transverse electromagnetic mode transmission lines shall be in accordance with MIL-T-81490.

A.3.1.6 Filter Line Cable

Radio absorptive filter line cable shall be in accordance with MIL-C-85485.

A.3.1.7

Wire and cables are to be stripped in accordance with AS5768.

A.4 NOTES

A.4.1 Intended Purpose

The purpose of this Appendix is to present the contractor with a working list of approved documents to be used in the selection of wire and cable for aerospace vehicle wiring.

TABLE A1 - OPEN WIRING APPLICATIONS 1/ 3/

Document	Voltage rating (maximum)	Rated wire temperature(°C)	Insulation Type	Conductor Type	Application
AS22759/1	600	200	Fluoropolymer insulated TFE and TFE coated glass	Silver coated copper	Approved for use in Army, Navy and Air Force applications
AS22759/2	600	260	Fluoropolymer insulated TFE and TFE coated glass	Nickel coated copper	Approved for use in Army, Navy and Air Force applications
AS22759/3	600	260	Fluoropolymer insulated TFE-glass- TFE	Nickel coated copper	Approved for use in Army, Navy and Air Force applications
AS22759/4	600	200	Fluoropolymer insulated TFE-glass- FEP	Silver coated copper	Approved for use in Army, Navy and Air Force applications
AS22759/5	600	200	Fluoropolymer insulated extruded TFE	Silver coated copper	Approved for use in Army, Navy and Air Force applications
AS22759/6	600	260	Fluoropolymer insulated extruded TFE	Nickel coated copper	Approved for use in Army, Navy and Air Force applications

TABLE A1 - OPEN WIRING APPLICATIONS (CONTINUED)

Document	Voltage rating (maximum)	Rated wire temperature(°C)	Insulation Type	Conductor Type	Application
AS22759/7	600	200	Fluoropolymer insulated extruded TFE	Silver coated copper	Approved for use in Army, Navy and Air Force applications
AS22759/8	600	260	Fluoropolymer insulated extruded TFE	Nickel coated copper	Approved for use in Army, Navy and Air Force applications
AS22759/9	1000	200	Fluoropolymer insulated extruded TFE	Silver coated copper	Approved for use in Army, Navy and Air Force applications
AS22759/10	1000	260	Fluoropolymer insulated extruded TFE	Nickel coated copper	Approved for use in Army, Navy and Air Force applications
AS22759/13	600	135	Fluoropolymer insulated FEP PVF2	Tin coated copper	Approved for use in Army, Navy and Air Force applications
AS22759/16	600	150	Fluoropolymer insulated extruded ETFE	Tin coated copper	Approved for use in Army, Navy and Air Force applications

TABLE A1 - OPEN WIRING APPLICATIONS (CONTINUED)

Document	Voltage rating (maximum)	Rated wire temperature(°C)	Insulation Type	Conductor Type	Application
AS22759/17	600	150	Fluoropolymer insulated extruded ETFE	Silver coated high strength copper alloy	Approved for use in Army, Navy and Air Force applications
AS22759/20	1000	200	Fluoropolymer insulated extruded TFE	Silver coated high strength copper alloy	Approved for use in Army, Navy and Air Force applications
AS22759/21	1000	260	Fluoropolymer insulated extruded TFE	Nickel coated high strength copper alloy	Approved for use in Army, Navy and Air Force applications
AS22759/34	600	150	Fluoropolymer insulated crosslinked modified ETFE	Tin coated copper	Approved for use in Army, Navy and Air Force applications
AS22759/35	1000	200	Fluoropolymer insulated crosslinked modified ETFE	Silver coated high strength copper	Approved for use in Army, Navy and Air Force applications
AS22759/41	600	200	Fluoropolymer insulated crosslinked modified ETFE	Nickel coated copper	Approved for use in Army, Navy and Air Force applications

TABLE A1 - OPEN WIRING APPLICATIONS (CONTINUED)

Document	Voltage rating (maximum)	Rated wire temperature (°C)	Insulation Type	Conductor Type	Application
AS22759/42	600	200	Fluoropolymer Insulated crosslinked modified ETFE	Nickel coated high strength copper alloy	Approved for use in Army, Navy and Air Force applications
AS22759/43	600	200	Fluoropolymer Insulated crosslinked modified ETFE	Silver coated copper	Approved for use in Army, Navy and Air Force applications
AS22759/83	600	200	Polytetrafluorethylene/ polyimide	Silver coated copper	Approved for use in Army & Air Force applications Navy: Not for use
AS22759/84	600	260	Polytetrafluorethylene/ polyimide	Nickel coated copper	Approved for use in Army & Air Force applications Navy: Not for use
AS22759/85	600	150	Polytetrafluorethylene/ polyimide	Tin coated copper	Approved for use in Army & Air Force applications Navy: Not for use
AS22759/86	600	200	Polytetrafluorethylene/ polyimide	Silver coated copper	Approved for use in Army & Air Force applications Navy: Not for use

TABLE A1 - OPEN WIRING APPLICATIONS (CONTINUED)

Document	Voltage rating (maximum)	Rated wire temperature (°C)	Insulation Type	Conductor Type	Application
AS22759/87	600	260	Polytetrafluorethylene/polyimide	Nickel coated copper	Approved for use in Army & Air Force applications Navy: Not for use
AS22759/88	600	150	Polytetrafluorethylene/polyimide	Tin coated copper	Approved for use in Army & Air Force applications Navy: Not for use
AS22759/89	600	200	Polytetrafluorethylene/polyimide	Silver coated high strength or ultra high strength copper	Approved for use in Army & Air Force applications Navy: Not for use
AS22759/90	600	260	Polytetrafluorethylene/polyimide	Nickel coated high strength or ultra high strength copper	Approved for use in Army & Air Force applications Navy: Not for use
MIL-DTL-25038/3 2/	600	260	See specification sheet	See specification sheet	Approved for use in Army, Navy and Air Force applications
AS81044/6	600	150	Crosslinked polyalkene	Tin coated copper	Approved for use in Army, Navy and Air Force applications

TABLE A1 - OPEN WIRING APPLICATIONS (CONTINUED)

Document	Voltage rating (maximum)	Rated wire temperature (°C)	Insulation Type	Conductor Type	Application
AS81044/7	600	150	Crosslinked polyalkene	Silver coated high strength copper alloy	Approved for use in Army, Navy and Air Force applications
AS81044/9	600	150	Crosslinked polyalkene	Tin coated copper	Approved for use in Army, Navy and Air Force Applications
AS81044/10	600	150	Crosslinked polyalkene	Silver coated high strength copper alloy	Approved for use in Army, Navy and Air Force Applications

1/ For sealing capability of wire, see 3.8.6 and 3.14.1

2/ For use in circuits where during a fire, maintenance of electrical integrity is required for a limited Time.

3/ Wiring with insulation thickness of 8 mil and greater is included in this table

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TABLE A2 - PROTECTED WIRING APPLICATIONS 1/ 2/

Document	Voltage rating (maximum)	Rated wire temperature (°C)	Insulation Type	Conductor Type	Application
AS22759/11	600	200	Fluoropolymer insulated extruded TFE	Silver coated copper	Approved for use in Army, Navy and Air Force applications
AS22759/12	600	260	Fluoropolymer insulated extruded TFE	Nickel coated copper	Approved for use in Army, Navy and Air Force applications
AS22759/14	600	135	Fluoropolymer insulated FEP-PVF2	Tin coated copper	Approved for use in Army, Navy and Air Force applications
AS22759/15	600	135	Fluoropolymer insulated FEP-PVF2	Silver plated high strength copper alloy	Approved for use in Army, Navy and Air Force applications
AS22759/18	600	150	Fluoropolymer insulated extruded ETFE	Tin coated copper	Approved for use in Army, Navy and Air Force applications
AS22759/19	600	150	Fluoropolymer insulated extruded ETFE	Silver coated high strength copper alloy	Approved for use in Army, Navy and Air Force applications

TABLE A2 - PROTECTED WIRING APPLICATIONS (CONTINUED)

Document	Voltage rating (maximum)	Rated wire temperature (°C)	Insulation Type	Conductor Type	Application
AS22759/22	600	200	Fluoropolymer insulated extruded TFE	Silver coated high strength copper alloy	Approved for use in Army, Navy and Air Force applications
AS22759/23	600	260	Fluoropolymer insulated extruded TFE	Nickel coated high strength copper alloy	Approved for use in Army, Navy and Air Force applications
AS22759/32	600	150	Fluoropolymer insulated crosslinked modified ETFE	Tin coated copper	Approved for use in Army, Navy and Air Force applications
AS22759/33	600	200	Fluoropolymer insulated crosslinked modified ETFE	Silver coated high strength copper alloy	Approved for use in Army, Navy and Air Force applications
AS22759/44	600	200	Fluoropolymer insulated crosslinked modified ETFE	Silver coated copper	Approved for use in Army, Navy and Air Force applications
AS22759/45	600	200	Fluoropolymer insulated crosslinked modified ETFE	Nickel coated copper	Approved for use in Army, Navy and Air Force applications

TABLE A2 - PROTECTED WIRING APPLICATIONS (CONTINUED)

Document	Voltage rating (maximum)	Rated wire temperature (°C)	Insulation Type	Conductor Type	Application
AS22759/46	600	200	Fluoropolymer Insulated crosslinked modified ETFE	Nickel coated high strength copper alloy	Approved for use in Army, Navy and Air Force applications
AS22759/80	600	150	Polytetrafluorethylene/polyimide	Tin coated copper	Approved for Air Force & Army applications Navy: Not for use
AS22759/81	600	200	Polytetrafluorethylene/polyimide	Silver coated high strength or ultra high strength copper	Approved for Air Force & Army applications Navy: Not for use
AS22759/82	600	260	Polytetrafluorethylene/polyimide	Nickel coated high strength or ultra high strength copper	Approved for Air Force & Army applications Navy: Not for use
AS22759/91	600	200	Polytetrafluorethylene/polyimide	Silver coated copper	Approved for Air Force & Army applications Navy: Not for use
AS22759/92	600	260	Polytetrafluorethylene/polyimide	Nickel coated copper	Approved for Air Force & Army applications Navy: Not for use

TABLE A2 - PROTECTED WIRING APPLICATIONS (CONTINUED)

Document	Voltage rating (maximum)	Rated wire temperature (°C)	Insulation Type	Conductor Type	Application
AS81044/12	600	150	Crosslinked polyalkene	Tin coated copper	Approved for use in Army, Navy and Air Force applications
AS81044/13	600	150	Crosslinked polyalkene	Silver coated high strength copper alloy	Approved for use in Army, Navy and Air Force applications

NOTES:

- 1/ For sealing capability of wire, see 3.8.6 and 3.14.1
- 2/ Wiring with insulation thickness of 6 mil and less is included in this table

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APPENDIX B - SIGNIFICANT WIRE IDENTIFICATION
(SEE 3.9.1)

B.1 SCOPE

B.1.1 Scope

This appendix establishes the procedure for assigning the identification codes for each individual wire and harness within the scope of this specification when the type of identification code is specified as "significant" in accordance with 3.9.1 and 6.2. The wire identification is "significant" in that it indicates the function of the circuit. This identification shall be for use in wiring data and for physical identification of installed wiring. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

B.2 APPLICABLE DOCUMENTS

B.2.1 Government Documents

B.2.1.1 Specifications, Standards and Handbooks

The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and the supplement thereto, cited in the solicitation.

STANDARDS

MILITARY

MIL-STD-196 Joint Electronics Type Designation System

(Unless otherwise indicated, copies of federal and military specifications, standards and handbooks are available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, <http://assist.daps.dla.mil/quicksearch/>.)

B.3 REQUIREMENTS

B.3.1 Assignment Responsibility

The contractor (installing activity) shall assign the identification code for circuit functions except those listed under R, S, T and Y in Table B1. The equipment contractor shall assign the identification code in accordance with the equipment specification for equipments falling under categories R, S, T, and Y.

B.3.2 Wiring Identification Code

The wiring identification code shall be in accordance with the pattern illustrated in Figure B1 or B2 as applicable, and as follows:

B.3.3 Unit Number

Where two or more identical items of equipment are installed in the same vehicle, the unit numbers "1," "2," "3," "4," etc., may be prefixed to differentiate between wires when it is desired that the equipment have the same basic identification. To facilitate interchangeability requirements, identical wiring located in left and right wings, nacelles, and major interchangeable structural assemblies may have identical identification and the unit number is not required.

B.3.4 Circuit Function Letter

The circuit function letter is used to identify the circuit function specified in Table B1. Where a wire is used for more than one circuit function, the circuit function letter of that circuit which is functionally predominant shall apply. When functional predominance is questionable, the circuit function letter for the wire having the lowest wire number shall be used.

B.3.5 Wire Number

The wire number consisting of one or more digits is used to differentiate between wires in the circuit. A different number shall be used for wire not having a common terminal or connection.

B.3.5.1 Wires with the same circuit function having a common terminal connection or junction shall have the same wire number but different segment letters.

B.3.5.2 Numbers 2000 to 4999, inclusive, shall be reserved for use by the procuring activity to identify wires installed by service modifications.

B.3.5.3 Beginning with the lowest number, a number shall be assigned to each wire in numerical sequence, as far as practicable.

B.3.6 Wire Segment Letter

A wire segment is a conductor between two terminals or connections. The wire segment letter is used to differentiate between conductor segments in a particular circuit. A different letter shall be used for wire segments having a common terminal or connection. Wire segments shall be lettered in alphabetical sequence and the letter "A" should identify the first segment of each circuit starting at the power source. If a circuit contains only one wire segment, the wire segment shall be marked "A." The letters "I" and "O" shall not be used as segment letters. Double letters "AA," "AB," "AC," etc., shall be used when more than 24 segments are required. Two permanently spliced wires do not require separate segment letters if the splice is used for modification or repair.

B.3.7 Wire Size Number

The wire size number is used to identify the size of the wire or cable. For coaxial cables and thermocouple wires, the wire size number shall not be included. For thermocouple wires, a dash (-) shall be used in lieu of the wire size number.

B.3.8 Ground, Phase or Thermocouple Letter(s)

B.3.8.1 Unless otherwise specified by the procuring activity, ground cable letter "N" shall be used as a suffix to the wire identification code to identify any wiring that completes the circuit to the ground network. Such wiring shall be capable of being connected to the ground network of the aircraft electrical system without causing malfunctioning of any circuit. Critical and sensitive electronic systems which have interconnecting "ground" leads, but only one segment actually grounded to the structure shall be identified with the "N" suffix.

B.3.8.2 Phase letter "A," "B" or "C" shall be used as a suffix on the wire identification code to identify the phase of wires that are in the three-phase power distribution wiring of AC systems. The phase sequence shall be "A-B-C." The letters "A," "B" and "C" shall indicate the phase sequence corresponding to "T₁," "T₂" and "T₃," respectively. For grounded delta systems, "T₂" shall be considered as corresponding to the grounded phase. (Examples of wire identification coding, as applied to AC power wiring, are illustrated by Figure B3.)

B.3.8.3 Phase letter "V" shall be used as a suffix on the identification code to identify the ungrounded wire that is in a single-phase system.

B.3.8.4 For thermocouple wire, the following suffixes shall be used as applicable. Where space considerations dictate, the two letter suffixes shown may be used:

CHROM - Chromel - CR
ALML - Alumel - AL
IRON - Iron - FE
CONST - Constantan - CN
COP - Copper - CU

B.3.9 Electromagnetic Compatibility (EMC) Identification

When EMC category number identification is used, it shall be accomplished by marking applicable category number at the end of each significant wire code. Category number definition shall be as specifically approved by the procuring activity.

B.3.9.1 Alternate Methods for EMC Identification

Alternate methods such as identification sleeving, color codes or other methods may be used for EMC category identification when approved by procuring activity.

B.3.10 Aluminum Wire

For aluminum wire, ALUMINUM or ALUM shall be added as a suffix to the wire identification code.

B.3.11 Spare Contacts

Wires attached to spare contacts of connectors shall be identified by the contact designation.

B.3.12 Harnesses

Each harness shall be identified by the identification as shown in the Aircraft Design and Maintenance Manuals.

B.3.13 Code for Type Designated Equipment

For equipment type designated in accordance with MIL-STD-196, the wire identification code shall be derived utilizing that portion of the military type designation (AN nomenclature) following the /, but excluding the hyphen and any suffix letters. The block of wire numbers for each equipment shall start with 1 and continue for as many numbers as are needed to identify all wires. For example, wires of an AN/APS-45 would be identified APS45-1A20 --- APS45-975C22; wires of the AN/ARC-52A would be ARC52-1A22 --- ARC52-999C22; and the MX94 would be the MX94-1A20 --- MX94-62D20.

TABLE B1 - CIRCUIT FUNCTION LETTERS
(SEE B3.1, B3.4 OF APPENDIX B)

Circuit Function Letter	Circuit	Examples
A	Armament	Stores Management System Missiles/Rockets Gun Chemical
B	Photographic	Camera Camera Doors Camera Heating
C	Control Surface	Autopilot Flight Control Wing Sweep Trim Control Airbrakes Hydraulic System
D	Instrument (other than flight or engine instruments)	Position Indicator Pressure Gauge Temperature Gauge Clock
E	Engine Instrument	Temperature Gauge Pressure Gauge Quantity Meter Flow Meter Tachometer Power Indicator Nozzle Indicator
F	Flight Instrument	Gyroscopic Instrument Attitude Indicator Compass Head Up Display Altitude
G	Landing Gear Wing Folding	Extension and Retraction Braking Locking Steering Anti-Skid Arrestor Hook Utilities Hydraulics

TABLE B1 - CIRCUIT FUNCTION LETTERS (CONTINUED)

Circuit Function Letter	Circuit	Examples
H	Heating Ventilating and De-icing	Heating De-icing Cabin conditioning Galley Equipment Bay Cooling
I	In order to avoid confusion with the numeral one, the letter "I" shall not be used for circuit or cable identification.	
J	Ignition	Engine Ignition Jet-Assisted Take-Off
K	Engine Control	Vent and Flap Propeller Control Carburetor Supercharging Power Control Nozzle Control Thrust Reverser Engine Starting
L	Lighting (Illumination)	Internal External
M	Miscellaneous (Electrical)	Windshield Wiper & Spray Doors Hoist and Winch Position (Seat & Pedal) Auxiliary Power Unit Emergency Power Unit Cigarette Lighter
N	Unassigned	
O	In order to avoid confusion with the numeral zero, the letter "O" shall not be used for circuit or cable identification.	

TABLE B1 - CIRCUIT FUNCTION LETTERS (CONTINUED)

Circuit Function Letter	Circuit	Examples
P	DC Power	Generation Distribution Battery Rectifier External Power
Q	Fuel and Oil	Valves Pumps Refueling/Defueling Transfer Dump
R	Radio (Navigational and Communication)	Instrument Landing Homing Liaison Marker Beacon VHF Radio UHF Radio HF Radio Intercommunication Direction Finding
S	Radar (Pulse Technique)	Radar Altimeter Interception Gun Aiming Mapping Navigation Bomb Aiming Search Recognition (IFF) Terrain Following
T	Special Electronics	Active Electronic Counter Inertial Navigation Television Measures Reconnaissance Computer Weapon Aiming Chaff Dispensing Infra-Red

TABLE B1 - CIRCUIT FUNCTION LETTERS (CONTINUED)

Circuit Function Letter	Circuit	Examples
U	Miscellaneous (Electronic)	Electronic wiring for which the "R," "S" or "T" identification is not applicable shall be assigned the circuit function letter "U." An example would be common leads to electronic equipments and systems, inter-connection wiring, such as antenna or power circuits common to more than one equipment.
V	Both DC power cables and DC control cables for AC systems shall be identified by the circuit function letter "V."	
W	Warning and Emergency (except those listed under other circuit functions)	Bail-Out Alarm Oxygen Indicator Passenger Sign Central/Master Warning
X	AC Power	Generation Distribution External Power
Y	Armament Special Equipment (except those listed under circuit function "A")	
Z	Experimental Circuits. When flight test and experimental research wiring is installed, the appropriate Circuit Function Letter shall be used, preceded by the letter "Z." When any such circuit has been adopted and becomes part of a standard installation, the letter "Z" shall be removed.	