AEROSPACE STANDARD

AS50881™ REV. H

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Superseding AS50881G

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 August 2019. 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 in Electrical Wiring Interconnection Systems (EWIS) 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. ARP/AIR documents listed in this specification are for reference only. Any reference in this document to Military, Air Force, Navy, Army, or Coast Guard refers to systems managed or procured by the U.S. Department of Defense (DOD) or the U.S. Department of Homeland Security (DHS).

1.1.1.1 This document does not apply to wiring inside of airborne electronic equipment, but shall apply to wiring externally attached to such equipment.

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SAE WEB ADDRESS: **http://www.sae.org**

For more information on this standard, visit
https://www.sae.org/standards/content/AS50881H/

2. REFERENCES

2.1 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 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.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS-STD-595	Colors Used in Government Procurement
AIR65	Thermoelectric Circuits and the Performance of Several Aircraft Engine Thermocouples
AIR1329	Electrical Connectors and Wiring, Compatibility of
AIR4465	Design and Handling Guide Radio Frequency Absorptive Type Wire and Cables (Filter Line, MIL-C-85485)
AIR5558	Ultraviolet (UV) Laser Marking Performance of Aerospace Wire Constructions
AIR5919	Alternatives to Cadmium Plating
AIR6151	Torque, Threaded Application, Electrical Connector, Accessory and Terminal Board Installation
AIR6540	Fundamentals in Wire Selection and Sizing for Aerospace Applications
AIR6820	Electrical Wiring Fuel Compatibility
AIR7506	Impact of High Voltage on Wiring
ARP1308	Electrical Connectors for Aerospace, Shipboard, Ground Vehicles, and Associated Equipment
ARP1350	Procedure for Installation and Mounting of Single Hole Mount, Cylindrical, Electrical Connectors (for Pressure Differential Applications)
ARP1870	Aerospace Systems Electrical Bonding and Grounding for Electromagnetic Compatibility and Safety
ARP1897	Clamp Selection and Installation Guide
ARP5614	Guidelines for Harness Critical Clamp Locator Marker Installation on Electrical Cable Assemblies
ARP6400	Recommended Practice for Processing and Handling Wire and Cable with Silver Plated Conductors and Shields
ARP6807	Guide for Identification of Terminal Lugs in Electrical Wiring Interconnect Systems (EWIS)
ARP6881	Guidelines for the Use and Installation of Bonded Cable Harness Supports
ARP6903	Guide for Achieving Plating/Finish Compatibility with Connectors and Accessories Used in Electrical Wiring Interconnect Systems (EWIS)
ARP7987	Development, Verification, and Validation of a Thermal Model for Determining Current Derating Design Limits of Aerospace Wires and Wire Bundles

ARP81490	Transmission Lines, Transverse Electromagnetic Mode
AS567	Safety Cable, Safety Wire, Key Washers, and Cotter Pins for Propulsion Systems, General Practices for Use of
AS3509	Cable, Safety, Kit, Nickel Alloy, UNS N0660
AS4372	Performance Requirements for Wire, Electric, Insulated Copper, or Copper Alloy
AS4461	Assembly and Soldering Criteria for High Quality/High Reliability Soldering Wire and Cable Termination in Aerospace Vehicles
AS4536	Safety Cable Kit Procurement Specification and Requirement for Use
AS5117	Clip, Spring Retention - Electrical Cable
AS5419	Cable, Thermocouple Extension, Shielded and Unshielded
AS5768	Tool, Stripper, Electrical Insulation, General Specification for
AS5942	Marking of Electrical Insulating Materials
AS6070	Aerospace Cable, High Speed Data, Copper
AS6136	Conduit, Electrical, Flexible, Shielded, Aluminum Alloy for Aircraft Installations
AS7351	Clamp, Loop Type Bonding
AS7928	Terminals, Lug: Splices, Conductor: Crimp Style, Copper, General Specification for
AS7928/14	Terminal, Electrical, Permanent, Crimp Style, Tin-Coated Copper, Insulated, Environment Resistant, Class 1, 150 °C, Heatless Sealing
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
AS18029	Cover Assembly, Electrical, for MS27212 Terminal Board Assembly
AS21980	Ferrule, Outer, Uninsulated Shield Terminating, Type I, Two Piece, Class I, for Shielded Cables
AS21981	Ferrule, Inner, Uninsulated, Shield Terminating, Type I, Two Piece, Class I , for Shielded Cables
AS21919	Clamp, Loop Type, Cushioned Support
AS22520	Crimping Tools, Wire Termination, General Specification for
AS22759	Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy
AS23053	Insulation Sleeving, Electrical, Heat Shrinkable, General Specification for
AS23053/5	Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Flexible, Crosslinked
AS23053/8	Insulation Sleeving, Electrical, Heat Shrinkable, Polyvinylidene Fluoride, Semi-Rigid, Crosslinked
AS23053/11	Insulation Sleeving, Electrical, Heat Shrinkable, Fluorinated Ethylene Propylene, Non-Crosslinked

AS23053/12	Insulation Sleeving, Electrical, Heat Shrinkable, Polytetrafluoroethylene
AS23053/18	Insulation Sleeving, Electrical, Heat Shrinkable, Modified Fluoropolymer, Crosslinked
AS23190	Wiring, Positioning, and Support Accessories
AS25274	Cap, Electrical (Wire End, Crimp Style, Type II, Class 1), for 105 °C Total Conductor Temperature
AS25435	Terminal, Lug, Crimp Style, Straight Type, for Aluminum Aircraft Wire, Class 1
AS25436	Terminal, Lug, Crimp Style, 90° Upright Type, for Aluminum Aircraft Wire, Class 1
AS25438	Terminal, Lug, Crimp Style, Right Angle Type, for Aluminum Aircraft Wire, Class 1
AS25439	Splice, Permanent, Crimp Style, Two Way Type for Aluminum Aircraft Wire, Class 1
AS27212	Terminal Board Assembly, Molded-in-Stud, Electric
AS33681	Strap, Tiedown, Electrical Components, Identification, Adjustable, Self-Clinching, Plastic, Type II, Class 1
AS33731	Strip, Mounting, Nut Insulating, for AS27212 Terminal Board
AS39029	Contacts, Electrical Connector, General Specification forAS39029/112Contact Bushing, Electrical Connector Contact, Wire Barrel
AS60491	Sleeve, Protection, for Cable and Harness Protection
AS70991	Terminals: Lug and Splice, Crimp Style, Aluminum, for Aluminum Aircraft Wire
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
AS81714/27	Terminal Junction System, Terminal Junction Blocks, Sectional, Grounding Modules, Stud Type Mounting, Series I
AS81714/28	Terminal Junction System, Terminal Junction Blocks, Sectional, Grounding Modules, Integral, Bracket Mounting Series I
AS81714/63	Terminal Junction System, Terminal Junction Blocks, Sectional, Grounding Modules, Stud and Flange Type Mounting, Series II
AS81790	Connectors, Receptacle, External Electric Power, Aircraft, General Specification for
AS81824	Splices, Electric, Crimp, Copper, Environment Resistant
AS81824/1	Splice, In-Line, Electric, Crimp, SN/CU, Environmental, Heat-Shrinkable Sleeve (150 °C), 1 x 1 Sealant Opening
AS81824/13	Splice, Stub, Electrical, Permanent, Crimp Style, Nickel/Copper, Insulated, Environment Resistant, 175 °C Max
AS81914	Tubing, Plastic, Flexible, Convoluted, Conduit, General Specification for

AS83519 Shield Termination, Solder Style, Insulated, Heat-Shrinkable, Environment Resistant, General Specification for

AS85049 Connector Accessories, Electrical, General Specification for

AS85049/80 Connector Accessories, Electrical, Dummy Contact, Sizes 16, 12, and 8, Category 7 (for MIL-DTL-38999 Connectors)

AS85049/93 Connector Accessories, Electrical, Termination, Shield Split Support Ring, Composite, Nonenvironmental, Straight, Category 7

AS85049/103 Connectors, Accessories, Composite, RFI/EMI, Electrical, Strain Relief, Straight, Self-Locking, Category 3C (for MIL-DTL-38999 Series III and IV Connectors)

AS85049/104 Connectors, Accessories, Composite, RFI/EMI, Electrical, Strain Relief, 45°, Self-Locking, Category 3C (for MIL-DTL-38999 Series III and IV Connectors)

AS85049/105 Connectors, Accessories, Composite, RFI/EMI, Electrical, Strain Relief, 90°, Self-Locking, Category 3C (for MIL-DTL-38999 Series III and IV Connectors)

AS85049/128 Shield Band, Connector Accessories, Electrical Backshell, Category 7 (for AS85049/82 - /90, /93, /109 - /117 Accessories)

AS85049/138 Connector Accessories, Electrical, Cap, Dust, Plastic, Category 9

AS85485 Cable, Electric, Filter Line, Radio Frequency Absorptive

AS85485/8 Cable, Electric, Filter Line, Shielded, Jacketed, Radio Frequency Absorptive, 150 °C, 600-Volt

AS85485/12 Cable, Electric, Filter Line, Small Diameter Wire, Shielded, Jacketed, Radio Frequency Absorptive, 150 °C, 600-Volt

AS90387 Wiring Installation Tools for Plastic and Metal Tiedown Straps

2.1.2 U.S. Government Publications

Copies of these documents are available online at https://quicksearch.dla.mil.

2.1.3 Specifications, Standards, and Handbooks

Unless otherwise specified, the following specifications, standards and handbooks of the issue listed in that issue of the Acquisition Streaming and Standardization Information System (ASSIST) specified in the solicitation form a part of this specification to the extent specified herein.

2.1.3.1 Specifications

2.1.3.1.1 Military

MIL-A-46146 Adhesives-Sealants, Silicone, RTV, Noncorrosive (For Use With Sensitive Metals and Equipment)

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-DTL-5846 Chromel and Alumel Thermocouple Electrical Wire

MIL-DTL-24308 Connectors, Electrical, Rectangular, Nonenvironmental, Minature, Polarized Shell, Rack and Panel, General Specification for

MIL-DTL-25516 Connectors, Electrical, Miniature, Coaxial, Environment-resistant Type, General Specification for

MIL-DTL-32554 Straps, Tie-Downs, Adjustable, Non-Metallic, Cable Bundling, General Specification for

MIL-DTL-81381 Wire, Electric, Polyimide-Insulated, Copper or Copper Alloy

MIL-DTL-83413/8 Connectors and Assemblies, Electrical, Aircraft Grounding: Type IV Jumper Cable Assembly, Lead, Electrical

MIL-DTL-83517 Connector, Coaxial, Radio Frequency for Coaxial, Strip or Microstrip Transmission Line, General Specification for

MIL-I-631 Insulation, Electrical, Synthetic-Resin Composition, Nonrigid

MIL-I-3190 Insulation Sleeving, Electrical, Flexible, Coated, General Specification for

MIL-M-24041 Molding and Potting Compound, Chemically Cured Polyurethane

MIL-PRF-8516 Sealing Compound, Polysulfide Rubber, Electric Connectors and Electric Systems, Chemically Cured

MIL-PRF-23586 Sealing Compound, Electrical, Silicone Rubber, Accelerator Required

MIL-PRF-29504 Termini, Fiber Optic Connector, Removable, 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

2.1.3.2 Standards

2.1.3.2.1 Military

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-1353 Department of Defense Standard Practice Electrical Connectors, Plug-in Sockets, and Associated Hardware

MIL-STD-1553 Digital Time Division Command/Response, Multiplex Data Bus

MIL-STD-1678 Fiber Optics Cabling System Requirements and Measurements

(Part 1: Design, Installation and Maintenance Requirements)

(Part 2: Optical Measurements)

(Part 3: Physical, Mechanical, Environmental and Material Measurements)

(Part 4: Test Samples Configuration and Fabrication Requirements)

(Part 5: Design Phase and Legacy Measurement)

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

MS27488 Plug, End Seal, Electrical Connector

2.1.3.3 Handbooks

2.1.3.3.1 Military

MIL-HDBK-502 Product Support Analysis

MIL-HDBK-516 Airworthiness Certification Criteria

MIL-HDBK-522 Guidelines for Inspection of Aircraft Electrical Wiring Interconnect Systems

MIL-HDBK-525 Electrical Wiring Interconnect System (EWIS) Integrity Program

MIL-HDBK-534 Aircraft Fuel System Service Life Extension

MIL-HDBK-863 Wiring Data and System Schematic Diagrams, Preparation of

MIL-HDBK-1646 Selection of Electrical Contacts, Connectors and Associated Servicing Tools

2.1.3.4 Technical Manuals

Documents can be obtained at the NATEC technical data website: https://mynatec.navair.navy.mil/natechome.htm.

NAVAIR 01-1A-505-1, T.O. 1-1A-14, and ARMY TM 1-1500-323-24-1: Installation and Repair Practices Volume I Aircraft Electric and Electronic Wiring

NAVAIR 01-1A-505-2, T.O. 1-1A-14-2, and TM 1-1500-323-24-2: Installation and Repair Practices Volume II Aircraft Circular Electrical Connectors and Accessories

NAVAIR 01-1A-505-3, T.O. 1-1A-14-3, and TM 1-1500-323-24-3: Installation and Repair Practices Volume III Aircraft Rectangular Electrical Connectors and Accessories

NAVAIR 01-1A-505-4, T.O. 1-1A-14-4, and TM 1-1500-323-24-4: Installation and Repair Practices Volume IV Aircraft Fiber Optic Cabling

2.1.3.5 Commercial 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-59125	Terminal Boards, Molded, Barrier Screw and Stud Types and Associated Accessories
A-A-59474	Insulation Tape, Electrical, High Temperature, Polytetrafluoroethylene, Pressure-sensitive
A-A-59877	Insulating Compound, Electrical, Embedding

2.1.3.6 Additional Documents

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

2.1.4 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 ASSIST cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the ASSIST are the issues of the documents cited in the solicitation (see 6.2).

2.1.5 AIA Publications

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

NAS831	Cap - Protective Electrical Connector
NAS837	Plug - Protective Electrical Connector
NASM3036	Grommet, Rubber Hot-oil and Coolant Resistant
NASM20995	Wire, Safety or Lock
NASM21266	Grommet, Plastic, Edging
NASM22529	Grommet, Edging
NASM22529/2	Grommet, Cushion Composite Edging
NASM25440	Washer, for Use with Aircraft Aluminum Terminals
NASM33540	Safety Wiring and Cotter Pinning, General Practice for

2.1.6 ASME Publications

Available from ASME, P.O. Box 2900, 22 Law Drive, Fairfield, NJ 07007-2900, Tel: 800-843-2763 (U.S./Canada), 001-800-843-2763 (Mexico), 973-882-1170 (outside North America), www.asme.org.

ASME Y14.100 Engineering Drawing Practices

ASME Y14.24 Types and Applications of Engineering Drawings

ASME Y14.34M Associated Lists

2.1.7 ECA Publications

EIA standards are available from Electronic Components Industry Association (ECIA), 310 Maxwell Road, STE 200, Alpharetta, GA 30009, Tel: 678-393-9990. Copies of these documents are available online at https://www.ecianow.org.

EIA/ECA-364-26 Salt Spray Test Procedure for Electrical Connectors, Contacts and Sockets

2.1.8 IEEE Publications

Available from IEEE Operations Center, 445 and 501 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, www.ieee.org.

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

2.1.9 RTCA Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

RTCA DO-160 Environmental Conditions and Test Procedures for Airborne Equipment

2.2 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.

2.3 Definitions

2.3.1 AIRCRAFT

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

2.3.2 BRANCH

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

2.3.3 BUNDLE

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

2.3.4 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 vehicle's specified service life.

2.3.5 CONNECTOR PLUG

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

2.3.6 CONNECTOR RECEPTACLE

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

2.3.7 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.

2.3.8 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.

2.3.9 FIBER OPTIC CABLE

A cable 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.

2.3.10 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).

2.3.11 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.

2.3.12 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/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.

2.3.13 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.

2.3.14 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.

2.3.15 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.

2.3.16 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.

2.3.16.1 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.

2.3.17 OPEN HARNESS

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

2.3.18 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.

2.3.19 PRIMARY SUPPORT

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

2.3.20 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.

2.3.21 SECONDARY SUPPORTS

Supports such as tape, ties, straps, or protective covering used to secure wire groups or bundles together between primary supports (see 3.11.2).

2.3.22 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.

2.3.23 SPOT TIES

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

2.3.24 TERMINUS

A fiber optic terminus is typically comprised of a tight tolerance optical fiber alignment ferrule and alignment sleeve (ferrule) and a fiber optic cable retention housing. The optical fiber is retained within the ferrule bore using a thermally cured adhesive that bonds the fiber cladding or fiber coating to the ferrule bore material. The fiber optic cable is secured to the retention housing by various methods including crimping and use of adhesives.

2.3.25 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.”

2.3.26 WIRING (EWIS)

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.

2.3.27 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.

2.3.28 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.

2.3.29 HARNESS CRITICAL CLAMP LOCATOR MARKERS

Markers are used to identify specific clamping or structural reference locations. Markers are permanent or semi-permanent. Markers can be paint, tape, or sleeving attached to electrical wires, harnesses, and cable bundles.

2.3.30 AIRBORNE EQUIPMENT CABLE ASSEMBLY (i.e., GFAE, etc.)

An airborne electronic equipment cable assembly is the external wiring supplied as an integral element attached to that equipment (see 2.3.17 and 2.3.20).

2.3.31 TELECOMMUNICATION ELECTRONICS MATERIAL PROTECTED FROM EMANATING SPURIOUS TRANSMISSIONS (TEMPEST)

A term which refers to technical investigations and studies of compromising emanations as related to wiring systems and applications.

2.3.32 QUALIFICATION

A process as defined by an SAE or U.S. Military specification and performed in advance of, and independent of, an acquisition by which a manufacturer’s capabilities, or a manufacturer’s or distributor’s products, are examined, tested, and found to be in conformance with specification requirements, and subsequent approval for inclusion of products in an electronic QPL or manufacturers in an electronic QML, which are part of the QPD.

2.3.33 QUALIFIED PRODUCT

A product that has been examined, tested, and listed in, or approved for inclusion in the applicable electronic QPL in the QPD.

2.3.34 AIRBORNE ELECTRONIC EQUIPMENT

Airborne electronic equipment is referring to line replaceable units (LRUs) and weapon replaceable assemblies (WRAs).

2.3.35 QPL

Qualified product list.

2.3.36 QML

Qualified manufacturers list.

2.3.37 QPD

Qualified products database.

3. REQUIREMENTS

3.1 Terminology Interpretation

The term “wiring” wherever used throughout this specification shall be interpreted in accordance with 2.3.26.

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. Standard Parts and materials shall have Qualification Inspection and be procured from Qualified Products List (QPL) that has been issued by the qualifying activity as required by the applicable specification. 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. For wire and cable applications, use AS4372 data configuration

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. Unless otherwise specified, all wire and cable shall meet the flammability requirements of AS4372.

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.

3.6.2.1.1 PVC Usage

PVC material shall not be used in U.S. Department of Defense contracts for aerospace applications.

3.6.2.1.2 MIL-DTL-81381 Usage

MIL-DTL-81381 shall not be used in U.S. Department of Defense contracts for aerospace applications.

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, MIL-A-46146, 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 to 93 °C (-60 to 200 °F)

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

MIL-A-46146 -62 to 200 °C (-80 to 392 °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 epoxy adhesives 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 optic cables to termini. The time and temperature used for curing of epoxy adhesive used in fiber optic terminations shall be controlled so that a consistent bond is provided under all service conditions. Only epoxies which have inherent resistance to aircraft fluids including, but not limited to, fuel, lubricating oils, and cleaners shall be used. For wiring system applications requiring resistance to petroleum based fluids, see 3.14.9.

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, arcing, arc propagation, current, ambient temperature, mechanical strength, abrasion, flexure and pressure altitude requirements, and extreme environments such as Severe Wind and Moisture Problems (SWAMP) areas or locations susceptible to significant fluid concentrations. The wire shall be selected in accordance with Appendix A of this specification. Table A1 lists approved wire types for open wiring applications, which have normal, or medium weight insulation. Table A2 lists approved wire types for protected wiring applications, which have thin wall or lightweight insulation. The wire selection shall take into account all requirements of this specification and the following design considerations. For additional information concerning wire selection and sizing, refer to AIR6540.

3.8.1 Conductor Degradation

Degradation of tin, nickel, 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

Wire using tin plated conductors can be rated to 150 °C, dependent upon the insulation. 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

Wire using silver plated conductors can be rated to 200 °C, dependent upon the insulation 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 Nickel Plated Conductors

Wire using nickel plated conductors can be rated up to 260 °C, dependent upon the insulation. Not recommended for soldering applications.

3.8.1.4 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; when required, compensating steps such as retinning shall be included in maintenance procedures for re-termination (refer to 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 and 6.12).

3.8.3 Fiber Optic Cable Selection

The type, size, construction, and distinct identification for fiber optic 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. The fiber optic cable shall be distinguishable from aircraft wire harness assemblies as defined and approved by the procuring activity (refer to MIL-STD-1678).

3.8.3.1 Strength Member

Fiber optic cable shall include a layer of suitable, approved strength member material (e.g., fiberglass, Aramid yarn, or other non-metallic material) that can be mechanically attached to termini assemblies for the purpose of resisting tensile loads (refer to MIL-STD-1678).

3.8.3.2 Jacket

External jacket of fiber optic cable shall be resistant to moisture, mechanical damage, and temperature degradation (refer to MIL-STD-1678).

3.8.4 Coaxial Cables

Coaxial cables shall be suitable for the application and shall be selected in accordance with A.3.1.5 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 ARP81490 or MIL-T-81490 need not be identified by colored markers if the color requirements of MIL-T-81490 have been met. ARP81490 is not for U.S. Navy applications.

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 (refer to AIR1329). When the diameter of the wire is smaller than the minimum allowable diameter, a length of shrink AS23053/5 Class 1 or 3, AS23053/8, AS23053/11, AS23053/12 Class 3, 4, or 5, or AS23053/18 Class 2 or 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 affected. 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 elastomeric 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 pounds 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 normal 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 2. Table 2 assumes an ambient temperature of 70 °C, a harness or harness branch of 33 or more electrical wires for sizes 26 through 10, and nine electrical wires for size 8 and larger, carrying 20% or less of rated harness or harness branch current and operating at an altitude of 60000 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 2. The use of Table 2 and Figures 3, 4, and 5 shall not eliminate other requirements for wire selection. Current carrying capacity listed in Table 2 or calculated using Figures 3, 4, and 5 are capable of handling frequencies up to 800 Hz; above 800 Hz, 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 2 current ratings for electrical wires in harnesses are based upon 33 or more electrical wires for sizes 26 through 10 and nine electrical wires for size 8 and larger operating at 60000 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 2 (or calculated from Figures 3, 4, and 5 for ambient, altitudes, or harness loading factors differing from those assumed in Table 2), 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 A, 20% of which is 59.4 A, and the maximum allowable total current in the harness is 59.4 A, and the maximum allowable current for any size 20 wire in the harness is 9 A. 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 2 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 60000 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), see 6.7.

3.8.8.1.2 Wire Terminations

The continuous current ratings of Table 2 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 SWAMP areas or both. Applications include wheel wells, near wing flaps, wing folds, and pylons.

3.8.10.2 Frequency Flexure

Wire types in accordance with AS22759, listed in Appendix A, shall be used for areas that require repeated bending and flexing of the wiring.

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

AS85485 cable is preferred for use in EMI and EMV sensitive areas. For complete installation guidance, refer to AIR4465. The following precautions must be taken when routing and installing AS85485/8 or /12 shielded and jacketed filter line wire. The black jacket is conductive and should be routed and clamped or protected to ensure 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. Qualified examples of such devices include active components integrated in terminal junctions (refer to AS81714).

3.8.10.4 Thermocouple Wiring

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

a. Thermocouple contacts shall not be used except to meet system requirements (see 3.8.10.4 (b)), such as thermal gradient conditions. Thermocouple crimp contacts in accordance with AS39029 shall be used to meet system requirements such as thermal gradient conditions.

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), an 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.

e. AS5419 thermocouple extensions or MIL-DTL-5846 thermocouple wires shall be used to meet system requirements such as thermal gradient (see 3.8.10.4 (b) for exception).

f. For aircraft engine application and configuration information, refer to AIR65.

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. Identification marking (wire, cable, sleeves, labels, tags, etc.) shall be in accordance with AS5942 or AIR5558 when laser marking is used.

3.9.1 Assignment of Identification Code

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

3.9.2 High Voltage (600VAC/600VDC or Greater)

For U.S. Military applications, wire used in high voltage applications (600 VAC/600 VDC or greater) shall be distingished from other wire/cables by using an orange (preferred International Orange 12197) color as the preferred primary insulation/jacket color. The wire shall be identified with a mark or marker sleeve with HIGH VOLTAGE preceding the existing wire ID marking, at intervals or 6 to 60 inches.

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 an AS23053 heat-shrinkable sleeve; an AS23190 (AS33681) identification strap (see 3.11.3.8) or a MIL-I-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 1: AS23190 (AS33681) identification strap shall not be used within electrical/optical cables, groups, harnesses, or bundles.

NOTE 2: AS23190 (AS33681) Identification strap is not authorized for U.S. Military aircraft.

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 C.3.2.3.2 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 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.

3.9.3.3.6 Harness critical clamp locator markers are used when there is a design requirement to control harness movement or slack in critical locations and maintain specified adequate clearance and separation from equipment and structure. Clamp locator markers may be up to 2 inches wide. Color and location shall be specified by the design organization and approved by the procuring activity. (Refer to ARP5614.)

3.9.3.3.6.1 For U.S. Department of Defense Contracts for Air Force and Navy

Markers shall be located under the harness clamp, such that the colored marker is exposed on both sides of the clamp. When required, clamp locator markers, as a minimum, shall be placed at each harness endpoint (i.e., last clamp prior to termination) and at the mid-point harness clamp locations. Additional clamp locator markers should be added as necessary, for areas in close proximity to fluid carrying lines, tubes, hoses, moving parts, and components.

a. For harnesses that connect with moving components or surfaces that flex or move, clamp locator markers shall be located at the last clamp point prior to area of harness movement.

b. When required at harness breakouts, clamp locator markers shall be located at the clamp position closest to breakout point except for breakouts that occur within 18 inches of a previously established clamp locator mark location.

3.9.3.4 Identification Requirement for TEMPEST Wire and Cable

For wiring system installation requiring TEMPEST certification, wiring shall be clearly marked independent of their EMI category. Circuits which process classified information shall be identified with a marker label sleeve of the appropriate classification color, with “TEMPEST” printed on the sleeve, followed by the category, or system identification as determined by the procuring activity. These identification sleeves shall be installed every 3 feet as per 3.9.3.3.1 (a) and (b), along the length of the wire or cable. Special routing, shielding, and separation requirements shall meet procuring activity requirements.

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 (see Table 4 for size color code).

a. Solid colored.

b. Distinctively color banded.

c. Distinctively striped.

3.9.6 EWIS Components Identification

EWIS components installed on the aircraft shall be assigned a unique reference designator identification (RDI) number. Components are divided into three major categories: electrical equipment (i.e., WRAs/LRUs, terminal boards, relays, etc.), splice areas, and ground points. Each RDI will have a label or stencil visible on the aircraft structure adjacent to the assigned component. For U.S. Military applications, refer to the RDI format in MIL-HDBK-863 for guidance in identification of EWIS components.

3.10 Wiring Installation

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

First: Safety in flight.

Second: The ease of maintenance, removal, and replacement of the wiring.

Third: 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 (see Figure 6).

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 optic 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 optic 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 optic cables or segments shall not require disassembly of any riveted or bonded attachments. Conduits shall be used where necessary to protect fiber optic or to facilitate maintenance in inaccessible areas (refer to MIL-STD-1678).

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. All dead ended wires shall be de-energized or disconnected at their power sources so as not to present a hazard to personnel and to prevent accidental shorting of live circuits. Wires to be dead ended shall be due to a repair scenario or temporary stowage and not part of a wiring modification. Wiring no longer required, due to a modification, shall be removed from the aircraft when directed by the procuring activity (see 6.1.1 for additional considerations).

3.10.6 Routing

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

a. Chafing as defined in 2.3.4.

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 (refer to MIL-STD-1678).

k. Fiber optic cable shall be routed and installed so as to avoid the application of axial, lateral, and torsion loads to the cable and terminations (refer to MIL-STD-1678).

l. When installing fiber optic, additional support, routing techniques, and maintenance requirements must be considered. Methods of addressing these requirements shall be approved by the procuring activity (refer to MIL-STD-1678).

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 (refer to MIL-STD-1678).

3.10.7 Slack in Wiring

In addition to slack provided for drip loops (see 3.11.8), slack shall also be provided to meet the requirements of 3.10.7.1 through 3.10.7.6. 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 1 inch. Connectors terminating size 8 and larger electrical wires, RF cables, and fiber optic cables shall not be subjected to re-termination 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 inch beyond the point required for mating the connector (refer to MIL-STD-1678).

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.

3.10.7.6 Wiring Pressure Bulkhead

Consideration should be given to wiring and bundle lengths to ensure enough slack or service loops are designed in, so that it allows for flexing, expansion, and relative motion of structure and bulkheads.

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 AMS-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. For secondary distribution circuit wiring from a single source required at multiple component pins, see requirements in 3.19.4 (o) and 3.20. Guidelines for assessing the impact of various voltage and power levels on EWIS can be found in MIL-STD-704 and for commercial applications use RTCA DO-160. Power wires size 10 or larger shall be separated from signal wiring and/or communication cables per MIL-STD-464.

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 including the use of separate connectors. 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 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 helicopter 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 with separate connectors to prevent damage to one system affecting the other. On airborne vehicles that employ dual or multiple redundant, e.g., 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 deicers, 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.

3.10.22 Airborne Equipment Cable Assembly

Wiring and wiring devices utilized to make up airborne equipment cable assemblies are to comply with the requirements herein.

3.11 Protection and Support

Wiring shall be supported to meet the following requirements:

a. Prevent chafing as defined in 2.3.4.

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 (see 6.12).

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 and AS21919, spaced at intervals not to exceed 24 inches. 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. 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 optic cables (refer to MIL-STD-1678). Primary wire support clamps and fasteners used in structural applications shall not be used for bonding and grounding connections. The AS5117 clip shall not be used to support electrical wire harnesses. For additional clamp selection and installation guidance, refer to ARP1897.

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 metal 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.

3.11.1.5 Adhesive Mounted or Bonded Wire Harness Supports/Studs

Mechanically attached supports and studs are the preferred wiring support method. For U.S. Military aircraft, the use of adhesive mounted harness supports/studs shall be avoided in conjunction with flight critical wiring, power carrying wiring, areas of frequent crew/maintainer access, and areas with high vibration and temperature extremes. Positive separation shall be maintained between supported wiring and fluid carrying lines. Install areas should be in areas that are visually inspectable for periodic inspection and readily accessible for repair. Usage of these devices requires procurement authority approval. It is recommended that every fourth support/stud be mechanically attached to structure. Guidance on use and installation of adhesive mounted supports is given in ARP6881 (see 6.12).

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 3.11.2.5. Lacing ties shall be placed as secondary supports at a spacing no greater than 6 inches.

3.11.2.1 Harness Lacing Tape

Tying tapes shall be in accordance with A-A-52080, A-A-52081, A-A-52082, A-A-52083, or A-A-52084 or MIL-DTL-32554 (see 3.11.2.5). The physical properties of the tapes must be compatible with the installation environment. Use of tying tapes shall be in accordance with types, finish, and sizes as defined in 3.11.2.1.1 on aircraft intended for military procurement or use.

3.11.2.1.1 Harness Lacing Tapes for U.S. Military Applications

For U.S. Military applications, the A-A-52084 Aramid Finish C (sizes 2 or 3) and A-A-52083 Glass Finish C (size 3) tapes and MIL-DTL-32554 (see 3.11.2.5) shall be used for general applications. The A-A-52083 Glass Finish C (size 3) or Finish D with the additional Finish C (sizes 2 or 3) tape shall be used for high temperature (engine area) applications. For areas requiring low reflectivity compatibility (i.e., flight deck), use A-A52084 Aramid Finish C (sizes 2 or 3) BLACK (example: A-A-52084-C2-BLK).

3.11.2.1.2 Lacing tape shall be tied using a clove hitch knot followed by a separate square knot except for harness break-out, and special applications defined on Engineering drawings. Tying tapes shall be placed as secondary support in panels and junction boxes at a spacing no greater than 1-1/2 inches.

3.11.2.1.3 Tying tapes shall not be placed within 1 inch of the back of connector as secondary support in panel and junction boxes. This is to prevent undue stress on the contact crimp terminations.

3.11.2.2 Plastic cable straps in accordance with AS23190 installed with tools in accordance with AS90387. 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 and may be used for additional protective covering for a protected harness (see 2.3.20).

3.11.2.4 Deleted

3.11.2.5 Cable Lacing Fastener (CLF) System Usage

Cable lacing fastener (CLF) shall be in accordance with MIL-DTL-32554. The physical properties of the tapes must be compatible with the installation environment (see 6.13).

3.11.2.5.1 CLF shall be installed with MIL-DTL-32555 tools.

3.11.2.5.2 Use of CLF is for general EWIS applications and same environment as A-A-52084.

3.11.2.5.3 When installed with three wraps, CLF may be used as secondary support in fuel exposure areas.

3.11.2.5.4 CLF shall be placed as secondary support in panels and junction boxes at a spacing no greater than 1-1/2 inches.

3.11.2.5.5 CLF shall not be placed within 1 inch of the back of connector as secondary support in panel and junction boxes. This is to prevent undue stress on the contact crimp terminations.

3.11.2.5.6 When installed with three wraps, CLF may be used for tying bundles containing RF cables with solid dielectric and optical cables (see 3.11.3.10.3), so long as the provision of 3.11.5 are met.

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 Usage Restriction

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 (see 6.12).

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 optic cable (refer to MIL-STD-1678).

3.11.3.9 Silicone Adhesive Polytetrafluoroethylene (PTFE) Tape

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.

3.11.3.10 Cable Lacing Fastener (CLF) System Usage Restriction

CLF shall not be used in areas when the restriction of 3.11.3.10.1 through 3.11.3.10.3 apply:

3.11.3.10.1 Where failure would permit the strap to fall into moving mechanical parts.

3.11.3.10.2 To provide secondary support to wire, electrical cables, groups, or harnesses within bundles where CLF fastener may impose damage to adjacent wires or cables where supported would be on top of another fastener.

3.11.3.10.3 Where the bundle contains a fiber optics cable unless approved by the procuring activity and the cable is conducive to its usage.

3.11.4 Anti-Chafing Provisions

Chafing shall be prevented by routing and clamping bundles to prevent contact with equipment and structure. Spiral wrap and other chafe guard materials shall not be used in lieu of primary supports for separation from equipment and structure. Wiring inside slip on, loose braid sock, or otherwise medal braided shielded harnesses shall be protected from chafing on the braid sock (EMI backshell) or shield. Protection shall be accomplished by using AS60491, AS23053 material or a 25% overlap of A-A59474 tape. Any protection must extend the full length of slip on or braid sock. Metal braided or shielded harnesses shall have a protective external nonmetallic covering, except for fire zone areas where it is optional.

3.11.4.1 Edge and Ring Grommets (see 3.11.6.4)

Edge and ring grommets are designed for incidental contact only, and shall not be used as a primary or secondary means of chafe protection. The wire harness/cable shall be supported with a primary support clamp adjacent to the hole in the structure so that a minimum clearance (grommet to closest wire) is no less than 1/8 inch (0.125 inch). If harness routing requires a change in direction through the hole then primary support is required on both sides, unless 3/8 inch (0.375 inch) minimum wire clearance can be maintained. Grommets shall be used when physical separation between wiring and equipment or structure edges is less than 3/8 inch (0.375 inch) inch 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 1/16 inch (0.063 inch). 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.

3.11.4.2 Metallic Shielded/Braided Protected Harnesses

Where a separator/binder layer is used, the tape must be of a fungus resistant material with a temperature rating equivalent to, or higher than, the cable rating down the entire length of the harness. Non adhesive backed tapes shall be installed using a minimum 50% overlap to increase harness flexibility and reduce weight. A 25% overlap may be employed when using an adhesive backed tape such as A-A-59474.

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. Lacing tape as specified in 3.11.2.1 (see 3.11.2.5.6 for CLF usage) shall be used for tying bundles containing RF cables. Selection of the tape and installation shall meet the requirements of 3.11.5 (a), (b), and (c), except that AS23190 plastic straps may be used when approved (see 3.11.2.2) for tying bundles containing RF cables with solid dielectrics. Straps shall be installed with tools in accordance with AS90387. The tension adjustment on the AS90387 tool shall be set so that the requirement of 3.11.5 (a) 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 for Uninsulated Terminal Lugs and Splices

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 inch of the adjacent wire insulation. Sleeving temperature ratings shall be compatible with the temperature service requirements in the area where they are installed.

3.11.6.2.1 Insulating Sleeving, Heat Shrinkable

Heat shrinkable insulating sleeving shall conform to AS23053 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. PVC material is not approved. 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 where termination covers or potting is not employed.

3.11.6.4 Grommets

Edge grommets shall be in accordance with NASM21266 or NASM22529/2. 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 10 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 10 times the outside diameter.

d. Fiber optic cable. The minimum radius of bend for fiber optic 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 optic termini are exempt from this requirement (refer to MIL-STD-1678).

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 and Rotating Shafts

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 cannot result in interference with controls or shafts. The minimum positive separation between wiring and all components of movable flight controls and rotating shafts shall be at least 0.5 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 2.3.19), 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, so as to minimize the length of wiring directly beneath the lines and in the path of a potential leak. 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 2 inches. In areas where separation is less than 2 inches, the wiring shall be installed to maintain positive separation of at least 0.5 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. The routing of fiber optic cables through fuel tanks is not recommended (refer to MIL-STD-1678).

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 and requires the approval of the procuring activity. Wiring that is used in circuits that are capable of generating energy levels greater than 0.02 mJ must be isolated from fuel. Isolation may be achieved by using grounded metal conduit having a fluorocarbon liner, approved components, approved materials for sealing, potting (3.14.8); routing through conduit or use a fuel-resistant Fluoropolymer molded harness, etc. (refer to MIL-HDBK-534). 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. Environmentally sealed connectors and terminations 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 optic cables and silver plated conductors (see 6.11) shall not be used inside fuel tanks. Refer to AIR6820 for extended fuel performance characteristics of common wire types and wire selection guidance.

3.11.14 Airborne Equipment External Wiring

GFAE equipment shall be considered the same as airborne equipment.

Equipment 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 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, and applications containing multi-conductor, shielded cable, shields shall be terminated within the booted areas of breakout terminations. When pig tails are used in military EMC environments, extra precautions need to be taken to maintain electromagnetic shielding; this is typically achieved by using a 360 degree shield similar to AS85049/103, /104, and /105 type terminations on all harness connectors. Electromagnetic environmental effects interface requirements and verification criteria shall be in accordance with MIL-STD-464.

3.12.1.1 Shield Terminations

AS83519 shield terminators shall be used in terminating 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 an appropriate temperature-rated AS23053 or equivalent shrink sleeving. For elevated temperature shield terminations, employ the uninsulated two-piece AS21980 and AS21981 crimp ferrule combination and cover with an appropriate temperature-rated AS23053 or equivalent shrink sleeving. All shielded cable terminations shall be installed no closer than 1.5 inches from the rear of the connector grommet to allow for contact extraction. All shield terminations shall be staggered to allow for accessory removal and shall not be located under the saddle clamp of the connector accessory or primary support. Shield terminator leads shall not be terminated to saddle clamp hardware. Multiple shield terminator leads shall not be linked in series (daisy chained).

Wire harness flexible metallic shield or EMI accessory shall extend beyond the shield terminations to provide suitable EMI protection to the affected system in accordance with MIL-STD-464.

3.12.1.2 Shielded Wire Harness

When selecting harness or cable shielding material, ensure careful consideration is given to both the mating accessory (i.e., AS85049) and the shielding material. For metallic, non-metallic, and blended shielding designs, careful attention shall be given to the plating to ensure galvanic compatibility for the anticipated service life of the system. In order to prevent wire chafing against the inside of shielded harnesses, see 3.11.4. For shield splice, employ AS85049/93 split ring secured with AS85049/128 bands.

3.12.1.3 Shield Terminations for High Speed Data Cable

For high speed cable terminations (i.e., AS6070) with signals faster than 10 kHz, shield terminations shall be per connector manufacturer's requirements.

3.12.2 Multiple Grounds

No more than four ground wires shall be terminated in one lug provided that their total circular mil area is within the range of the crimp barrel. No more than four lugs shall be connected to one common ground stud. Ground modules in accordance with AS81714/27, AS81714/28, AS81714/63 may be used for multiple grounds. No more than 16 ground wires shall be connected in a ground module. Unwired contacts shall not be installed in unused terminal junction module cavities. Sealing plugs in accordance with MS27488 shall be installed in unused module holes. Sealing plugs shall be installed headfirst. The AS81714/27 and AS81714/63, Type S grounding module mounting studs shall have the same bonding surface preparation requirements as per 3.12.4 and shall employ hardware attachment requirements as per 3.12.5. 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 equipment 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. For recommended fastening hardware, tightening methods, and torque values (refer to AIR6151).

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 ensure 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 3. For U.S. Military applications, use MIL-DTL-5541 Type II Class 3. 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 Hardware

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 MIL-DTL-83413/8 bonding jumpers shall not be used at temperatures above 300 °F. Cadmium plated steel hardware shall not be used at temperatures above 450 °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 MIL-DTL-83413/8 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 Flexible, Nonmetallic

Nonmetallic conduit shall conform to AS81914 and 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 an approved AN or MS fitting. Rigid metallic and nonmetallic conduit used for wiring in an accessible area(s) 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 handling (see 6.12).

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 wraparound on 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 Ω 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 ensure 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 MIL-PRF-8516.

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.

3.13.12 Wire Conduit Support

Wiring entering or exiting metallic conduits shall be supported with a primary support clamp within 10 inches from the end of a conduit to secure the wiring and prevent chafing. See Figure 6.

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 optic cable (refer to MIL-STD-1678) shall be approved by the procuring activity. Only connectors that withstand a minimum of 500 hours salt spray when tested per EIA/ECA 364-26 or equivalent shall be used. Rack and panel connectors known as D Sub connectors (such as MIL-DTL-24308) shall not be used except for mating to receptacles on airborne electronic equipment (WRAs/LRUs) and shall be subject to procuring activity approval. Galvanic compatibility of materials and platings used for mating connector plugs, receptacles, and accessories shall be assured (ARP6903). Approved Cadmium alternate finish/plating configurations are identified in AIR5919. For connector selection, refer to MIL-STD-1353 and ARP1308.

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). No corrosion preventative compound (CPC) shall be applied on any internal surfaces of connectors (i.e., on the exposed pins, sockets, or termini). CPCs are also prohibited externally on connectors containing fiber optic or coaxial connectors (refer to MIL-STD-1678).

3.14.2 Contacts

Connectors using removable crimp type contacts are preferred to solder contact types for general use. For flight control system cables, crimp type contacts are required; solder type contacts are prohibited. 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 AS39029/112, 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 AS22520 tools for the tools specified in the component specification or contact replacement.

Improper crimp joint of conductors may deteriorate with temperatures which will cause high voltage drops in low signal applications and hot spots in power applications. The use of the designated and calibrated crimp tools is essential. In crimped applications, tin and nickel plated wire have considerable resistance increases when subject to elevated temperature cycle aging tests.

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 (refer to MIL-STD-1678). When installing sealing plugs in connectors, components, or terminal junction module grommets, the head of the sealing plug shall be inserted first. 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. The pigtails shall be identified and dead-ended with M81824/13 end caps (for applications exposed up to 175 °C) or with polytetrafluoroethylene insulated end caps (for applications exposed to temperatures above 175 °C). AS85049/80 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 with Fiber Optic Termini

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 shorter pins to preclude damage to the mating termini (refer to MIL-STD-1678).

3.14.2.3 Fiber Optic Termini

Termini shall be in accordance with MIL-PRF-29504 or the applicable connector specification (refer to MIL-STD-1678).

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 fireproof. 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 a 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 footrests 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 mounted connectors. Cadmium plated connectors or accessories shall not be used inside fuel tanks or anywhere that connectors can come in direct contact with titanium or carbon fiber composite components or structure. For recommended fastening hardware, tightening methods, and torque values, refer to AIR6151 and ARP1350.

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 1 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 0.75 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 0.75 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 2.3.19).

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 VDC 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 VDC 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

For installation, inspection and related requirements of securing devices use AS567. 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 Code NC “Nickel-Copper” or Code N “Nickel Alloy” 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 (see 6.12).

3.14.8 Potting

Connectors that require potting shall be potted with MIL-PRF-8516 (fuel resistant) 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 (not fuel resistant) may be used. Where resistance to sea water, 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 U.S. Military procurement, all potting of connectors is discouraged and requires specific application approval.

3.14.9 Fuel Exposure

For connectors subjected to extended fuel exposure, or inside fuel tank, A-A-59877 130°C (266°F) epoxy based molding compound may be used. User must verify the acceptability of A-A-59877 to their specific application. MIL-PRF-8516 (fuel resistant) sealant for operating temperatures not exceeding 93 °C (200 °F).may also be used with procuring activity approval.

3.14.10 Deleted

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 AS85049/138, NAS831, and NAS837 or equivalent may be used for this purpose. Unmated connectors containing fiber optic termini shall be protected from dust and contamination (refer to MIL-STD-1678).

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 (refer to MIL-STD-1678). For recommended fastening hardware, tightening methods, and torque values, refer to AIR6151.

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

3.14.15 Contact Voltage Ratings

Unless specified in the individual connector specification, or determined through testing the maximum operating voltage for an electrical connector or coaxial connector contacts shall be limited to one third of the dielectric withstand voltage test voltage quoted in the connector specification.

3.15 Deleted

3.15.1 Deleted

3.16 Deleted

3.17 Junctions

An uninterrupted wire and fiber optic cable is preferable to a junction. Only approved devices, such as permanent splices, feed-through 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 3. 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 0.039 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. 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. For the AS7928/14, the stripped portion of the conductor shall be flush with the front end of the crimp barrel.

3.17.2.1 Multiple Wire Terminations

Multiple wires 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. Multiple wire terminations in terminal lugs and splices shall not be used for primary power distribution. Multiple wire terminations in terminal lugs and splices used for secondary power distribution shall meet the requirements set forth in 3.19.4 (o) and 3.20.

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 ensure 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 (see 6.12).

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 optic cable (refer to MIL-STD-1678) 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 environmentally sealed splice. Splices for aluminum conductors shall be in accordance with AS70991 and AS25439.

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. Unwired contacts shall not be installed in unused splice cavities. Sealing plugs in accordance with MS27488 shall be installed in unused grommet holes. Sealing plugs shall be installed head first.

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 3.19.4 (e) and (g).

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 3.19.4 (e).

e. Splices may be used within 12 inches of a terminating device when attaching to the pigtail spare lead of a potted termination device or to splice multiple wires to a single wire when attaching to the same gauge wire. In order to limit voltage drop, splices may be used to accommodate large gauge wires to be compatible with smaller contact crimp barrel sizes. This is not applicable for primary power distribution circuits. For secondary power distribution, see 3.19.4 (o).

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. 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 optic 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 (refer to MIL-STD-1678).

n. Splices shall not be installed inside conduits (flexible or rigid), nor within 3 inches of conduit ends.

o. For secondary power distribution circuits, splicing of a single wire into multiple wires to provide power to multiple component pins shall not be permitted unless all the following conditions are met:

    1. No other design options for separate power distribution (i.e., additional circuit breakers, wire runs, terminal junction modules).

    2. Maximum number of parallel wires is limited to two per splice.

    3. Each individual parallel wire is sized to be capable of carrying entire source load if failure of one of the parallel wires occurs.

    4. Final circuit design is approved by procuring activity.

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

AS7928 copper terminal lugs (see 3.20.1) shall be used to connect wiring to terminal board studs, equipment terminal studs, and ground studs. ARP6807 provides a method for AS7928 terminal lug part number identification. 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. For recommended fastening hardware, tightening methods, and torque values, refer to AIR6151. Tightening terminal hardware shall not deform the terminal lugs or the studs. The terminal tongue of a straight lug may be bent up to 90 degrees maximum away from the barrel, 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. Terminal lugs may be bent one time during installation, only. Any additional deformation/unbending of the lug requires terminal lug replacement. 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. Terminal lugs shall be installed to ensure no terminal lug or attached wiring comes into contact with other stud lugs, hardware, components, or structure. There shall be no more than two terminal lugs on the studs used to mount the terminal board cover.

Copper 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 or a bus bar shall be connected to any one breaker terminal. provided the attaching screw has thread protrusion (minimum of two visible threads). Multiple wire terminations in terminal lugs for secondary power distribution circuits shall not be permitted unless all the following conditions are met:

1. No other design options for separate power distribution (i.e., additional circuit breakers, wire runs, terminal junction modules).

2. Maximum number of parallel wires is limited to two per terminal lug.

3. Each individual parallel wire is sized to be capable of carrying entire source load if failure of one of the parallel wires occurs.

4. Final circuit design is approved by procuring activity.

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. Terminal lug temperature rating shall be compatible with the wire and temperature service requirement in the area where terminals are installed.

3.20.2 Aluminum Terminal Lugs

Aluminum terminal lugs conforming to AS70991 (AS25435, AS25436, and AS25438) 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 150 °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. For recommended fastening hardware tightening methods and torque values (refer to AIR6151).

3.21.1 Terminal Boards

Terminal boards shall be in accordance with AS27212 and shall be installed with AS18029 covers. Terminal board mounting screw insulators shall be installed in accordance with AS33731. Ammeter shunts shall not be used as terminal boards. The A-A-59125 terminal boards are not approved for aerospace applications.

3.21.2 Terminal Junction Modules

Terminal junction modules and their mounting tracks and brackets shall be in accordance with AS81714. Unwired contacts shall not be installed in unused module cavities. Sealing plugs in accordance with MS27488 shall be installed in unused grommet holes. Sealing plugs shall be installed head first. 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/Foreign Object Debris (FOD)

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 AND DESIGN CONFORMANCE 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 design conformance assessments/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 and design 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 article/vehicle and in a time period to permit inspection, review or needed changes. On this mockup, the contractor shall demonstrate the latest typical wiring installations and up-to-date specific wiring practices for which deviations are required. This mockup may be conducted on a production vehicle.

4.4 Inspection of First Article/Vehicle (Production and Modification)

The wiring installation of the first production, or modified article/vehicle shall be inspected at the article/vehicle facility at the direction of the procuring activity. These inspections may be accomplished at various degrees of installation completion, completed article/vehicle, or both. Inspections shall determine conformance to the requirements of this specification, and shall be subject to approval by the procuring activity. Non-conformance to this specification may result in additional design conformance assessments/inspections as determined by the procuring activity.

4.5 Individual Tests

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

4.6 Flight Test Wire Installation

The flight test harnesses required for the test and certification phase of the air vehicle are temporary in nature and shall be removed once testing is complete. All test wire and harnesses shall be distinguished by color marking orange and for the U.S. Military applications shall be identified with “Flight Test” followed by voltage level (e.g., 28 VDC, or 115 VAC) on the wire ID label. If orange/test wire is routed in an existing harness it shall comply with all existing harness installation and routing requirements. For test wire harness installed in line/parallel with an existing flight control harness, it shall be installed, routed/separated, and supported, meeting the same requirements as the existing flight control harness. Components shall not be supported and secured to the aircraft existing harness. If attached to a flight test harness, the components shall meet existing mounting, security, and performance requirements and must be approved by procuring activity cognizant engineering.

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 vehicle, 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.

Paragraph	Title
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
Tables A1 and A2	Wiring Applications

6.2 Ordering Data

Specify the type of identification code in accordance with Appendices B or C (see 3.9.1). Unless specified otherwise, the identification code for the U.S. Military 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 and Grounding 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

The following documents contain useful information and guidance on aircraft wiring installation techniques.

Technical Manual NAVAIR 01-1A-505-1, T.O. 1-1A-14, and TM 1-1500-323-24-1 Installation and Repair Practices Volume I Aircraft Electric and Electronic Wiring. Contains information on approved aircraft wiring system and component installation and repair methods, tools and equipment aircraft wiring. Other important technical manuals containing approved aircraft wiring system support and maintenance information include:

NAVAIR 01-1A-505-2, T.O. 1-1A-14-2, and TM 1-1500-323-24-2: Installation and Repair Practices Volume II Aircraft Circular Electrical Connectors and Accessories

NAVAIR 01-1A-505-3, T.O. 1-1A-14-3, and TM 1-1500-323-24-3: Installation and Repair Practices Volume III Aircraft Rectangular Electrical Connectors and Accessories

NAVAIR 01-1A-505-4, T.O. 1-1A-14-4, and TM 1-1500-323-24-4: Installation and Repair Practices Volume IV Aircraft Fiber Optic Cabling

MIL-HDBK-516: Airworthiness Certification Criteria

MIL-HDBK-522: Guidelines for Inspection of Aircraft Electrical Wiring Interconnect Systems

MIL-HDBK-525: Electrical Wiring Interconnect System (EWIS) Integrity Program

MIL-HDBK-1646: Selection of Electrical Contacts, Connectors and Associated Servicing Tools

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 Vrms, 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 Figures 1 and 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 V 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. For additional information on impact of high voltage on wiring, refer to AIR7506.

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 harnesses for size 26 through 10 gauges, and 9 wire harnesses for size 8 and larger as referenced for Table 2 values. Current carrying capacity listed in Table 2 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

Bundle Loading Percent = Percentage of wires in a bundle used for carrying power

(# Power Carrying Wires)/(Total Wires in Bundle) * 100%

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 60000 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 A and the free air rating of size 22 is 16.2 A.

   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 A by 0.52 to get 8.4 A harness rating and the size 20 free air rating of 21.5 by 0.52 to get 11.2 A harness rating.

   d. Referring to the “altitude derating curve” of Figure 5, look for 60000 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 A by 0.79 to get 6.6 A and the size 20 harness rating of 11.2 A by 0.79 to get 8.8 A.

   f. To find the total bundle capacity, multiply the total number of size 22 wires by the derated capacity (25 x 6.6 = 165.0 A) and add to that the number of size 20 wires multiplied by the derated capacity (10 x 8.8 = 88 A) and multiply the sum by the 20% bundle capacity factor. Thus, the total bundle capacity is (165.0 + 88.0) x 0.20 = 50.6 A.

   g. It has been determined that the total bundle current should not exceed 50.6 A, no size 22 wire should carry more than 6.6 A, and no size 20 wire should carry more than 8.8 A.

   ARP7987 can be used as guidance in developing wire and wire bundle current rating requirements given in this document.

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 20000 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 ΔTs are 200 °C - 25 °C = 175 °C and 200 °C - 60 °C = 140 °C. Following the 175 °C and the 140 °C ΔT lines on Figure 3, the free air ratings of size 12 are 68 A and 61 A, 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 A and 61 A by 0.43 to get 29.2 A and 26.2 A, respectively.

   d. Referring to the “altitude derating curve” of Figure 5, look for sea level and 20000 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 A at sea level and 26.6 A at 20000 feet by 1.0 and 0.91, respectively, to obtain 29.2 A and 23.8 A.

   f. The total bundle capacity at sea level and 25 °C ambient is 29.2 A x 12 wires = 350.4 A and the same bundle at 20000 feet at 60 °C ambient is 23.8 A x 12 wires = 285.6 A. for the total bundle capacity. Each size 12 wire can carry 29.2 A at sea level, at 25 °C ambient or 23.8 A at 20000 feet, at 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, and 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, and ASME Y14.34M. 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 3.21.3. 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 Guidelines for Inspecting of Aircraft Electrical Wiring Interconnect Systems

Use MIL-HDBK-522 or a similar internal guideline to inspect and verify that EWIS components are properly installed.

6.11 Use of Silver Plated Wire in Fuel Tanks.

Silver can combine with sulfur or water and form silver-sulfide or oxide deposits between exposed conductors (terminal block connections, etc.). The silver-sulfide deposits reduce the insulation resistance between conductors and can ignite fuel vapor when exposed to very low levels of electrical energy. If use of silver in electrical components and wiring in the tank is determined to be critical, it should be defined as a critical design configuration control limitation.

6.12 Vibration

When referenced within this document, vibration—including level, zone, and any specific component—is defined by the procurement or design authority. High or severe vibration levels are also defined by the procurement or design authority.

6.13 Cable Lacing System Usage

Due to the possibility of snagging of the buckle/catching on structure such as cutouts and conduit caution must be used when the MIL-DTL-32554 or AS23190 plastic strap is installed on those harnesses which must pass through these types of structure while being installed into the aircraft.

7. NOTES

7.1 Revision Indicator

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 and 3.8.8.2)

Continuous duty current (amperes) 2/
wires in bundles, group, or harnesses, wire temperature rating

Conductor Material	Wire Size	105 °C	150 °C	200 °C
Copper or Copper Alloy	— 3/26	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 3/	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 copper alloy	19	Two nicked, none broken
	37	Four nicked, none broken
	Above 37	Six, nicked or broken
Aluminum	All number of strands	None nicked or broken

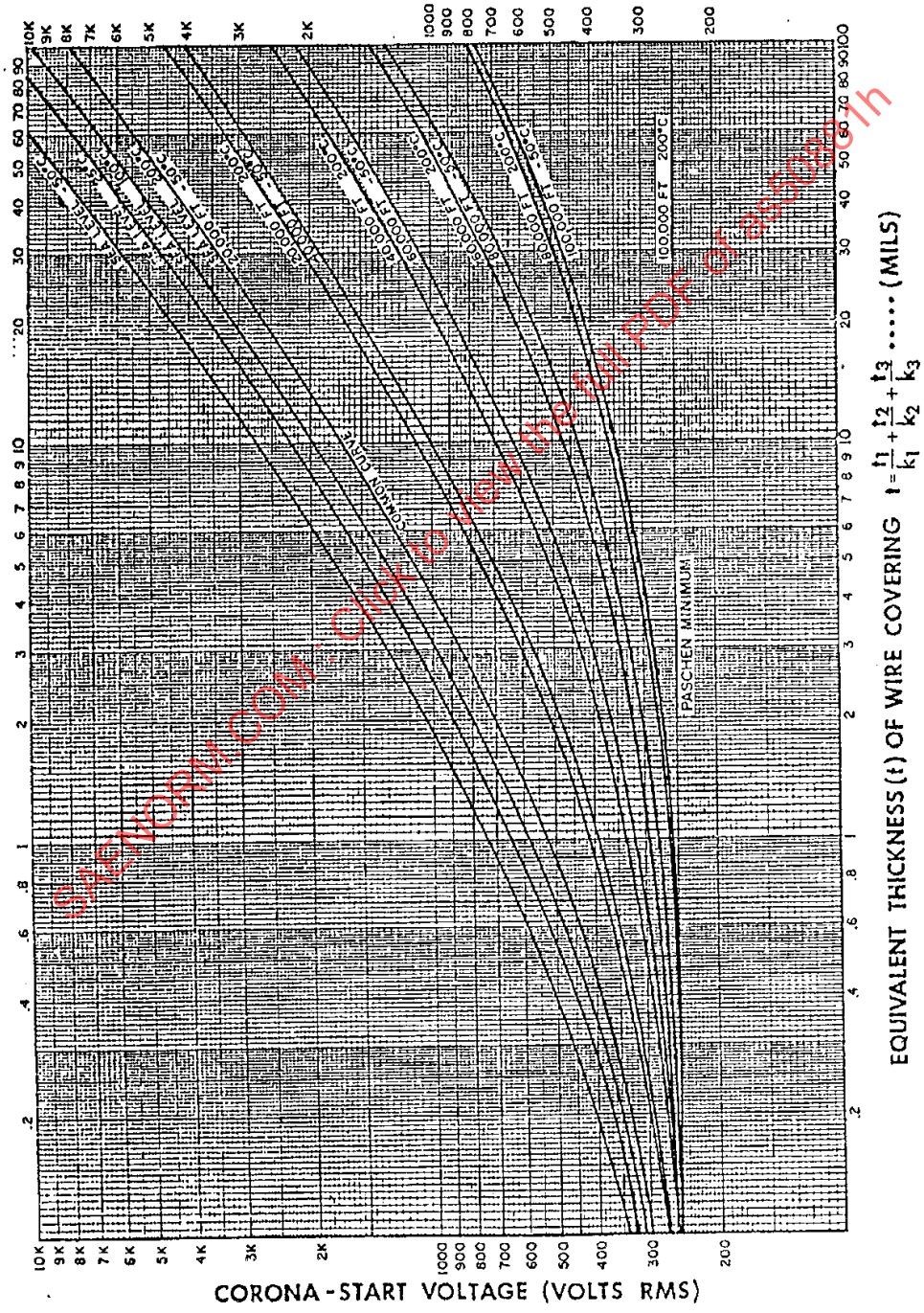

Figure 1 - Equivalent thickness of wire covering versus corona starting voltage versus altitude and temperature (see 6.6)

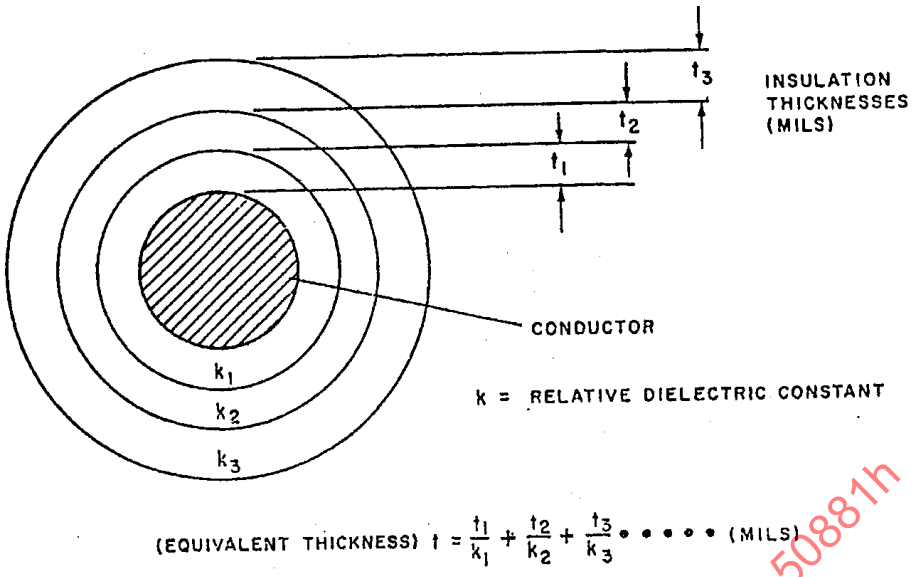

Figure 2 - Equivalent insulation thickness of wire covering (see 6.6)

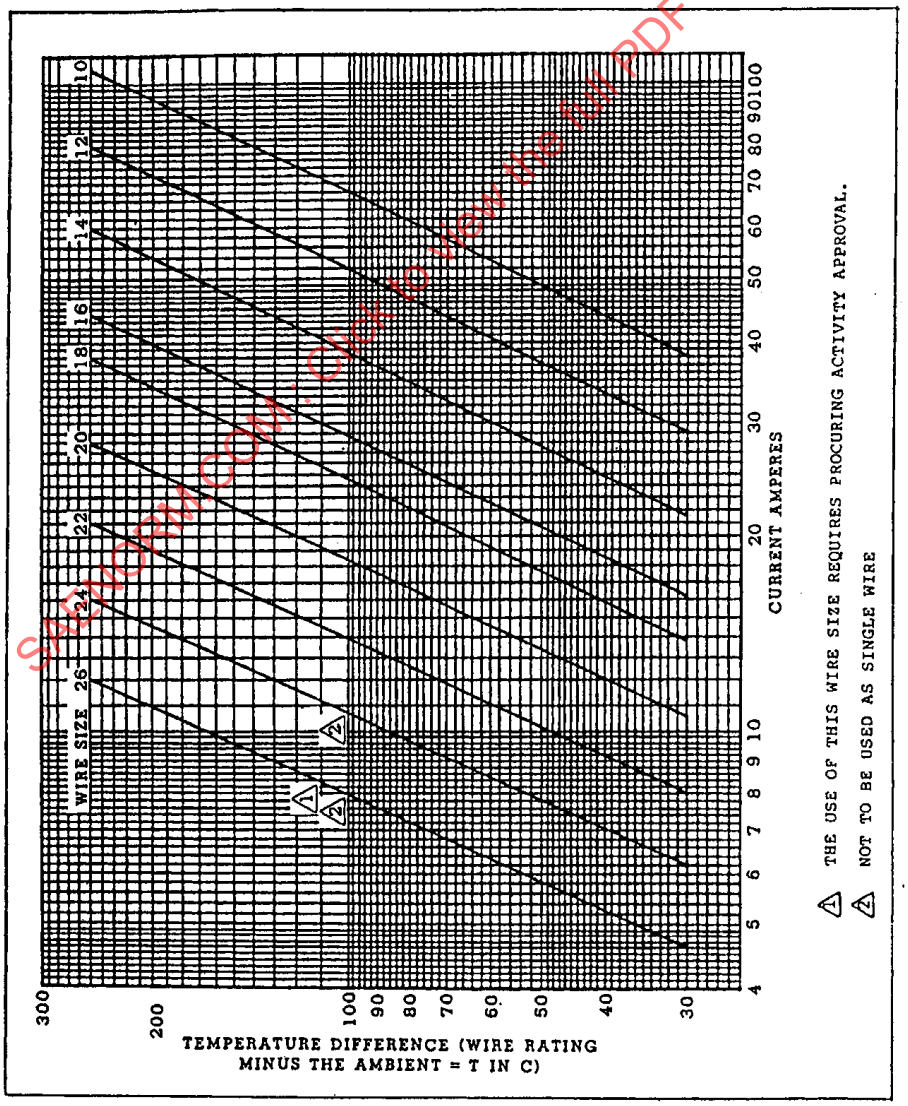

Figure 3 - Single copper wire in free air

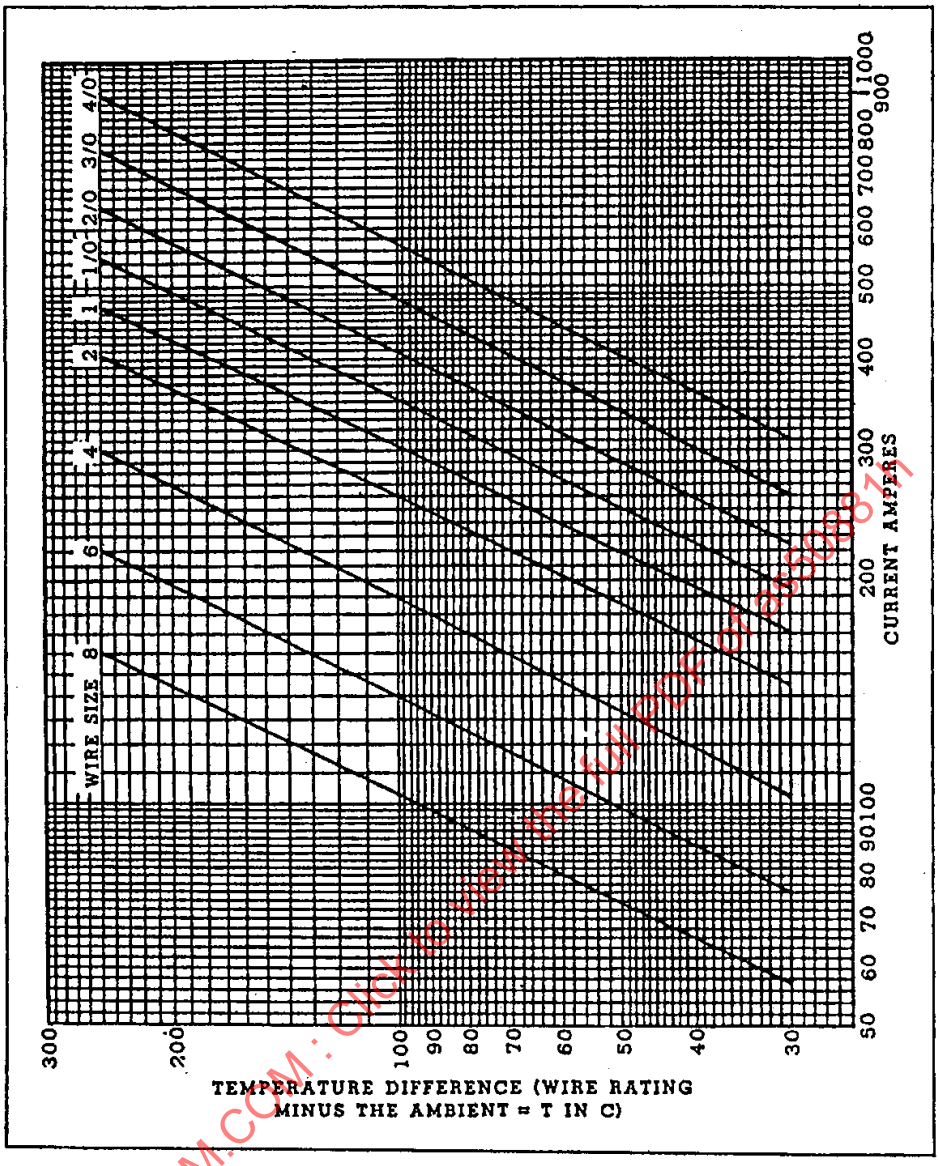

Figure 3 - Single copper wire in free air (continued)

Table 3 - Single copper wires in free air

Wire Size	Figure 3 Curves	Wire Size	Figure 3 Curves (Continued)
26	x=10^((LOG(ΔT)-0.0116)/2.2113)	8	x=10^((LOG(ΔT)+2.1299)/2.0543)
24	x=10^((LOG(ΔT)+0.295)/2.2365)	6	x=10^((LOG(ΔT)+2.2747)/1.9948)
22	x=10^((LOG(ΔT)+0.5069)/2.197)	4	x=10^((LOG(ΔT)+2.515)/1.9833)
20	x=10^((LOG(ΔT)+0.7304)/2.1617)	2	x=10^((LOG(ΔT)+2.9844)/2.0642)
18	x=10^((LOG(ΔT)+0.9326)/2.1083)	1	x=10^((LOG(ΔT)+3.1733)/2.085)
16	x=10^((LOG(ΔT)+1.0895)/2.122)	1/0	x=10^((LOG(ΔT)+3.2055)/2.0448)
14	x=10^((LOG(ΔT)+1.2923)/2.0753)	2/0	x=10^((LOG(ΔT)+3.2937)/2.0282)
12	x=10^((LOG(ΔT)+1.5785)/2.0895)	3/0	x=10^((LOG(ΔT)+3.2965)/1.9767)
10	x=10^((LOG(ΔT)+1.834)/2.0959)	4/0	x=10^((LOG(ΔT)+3.479)/1.9893)

NOTES:
1. Temperature difference (wire rating minus the ambient = ΔT in C).
2: Single copper wire current in amperes in free air = X.

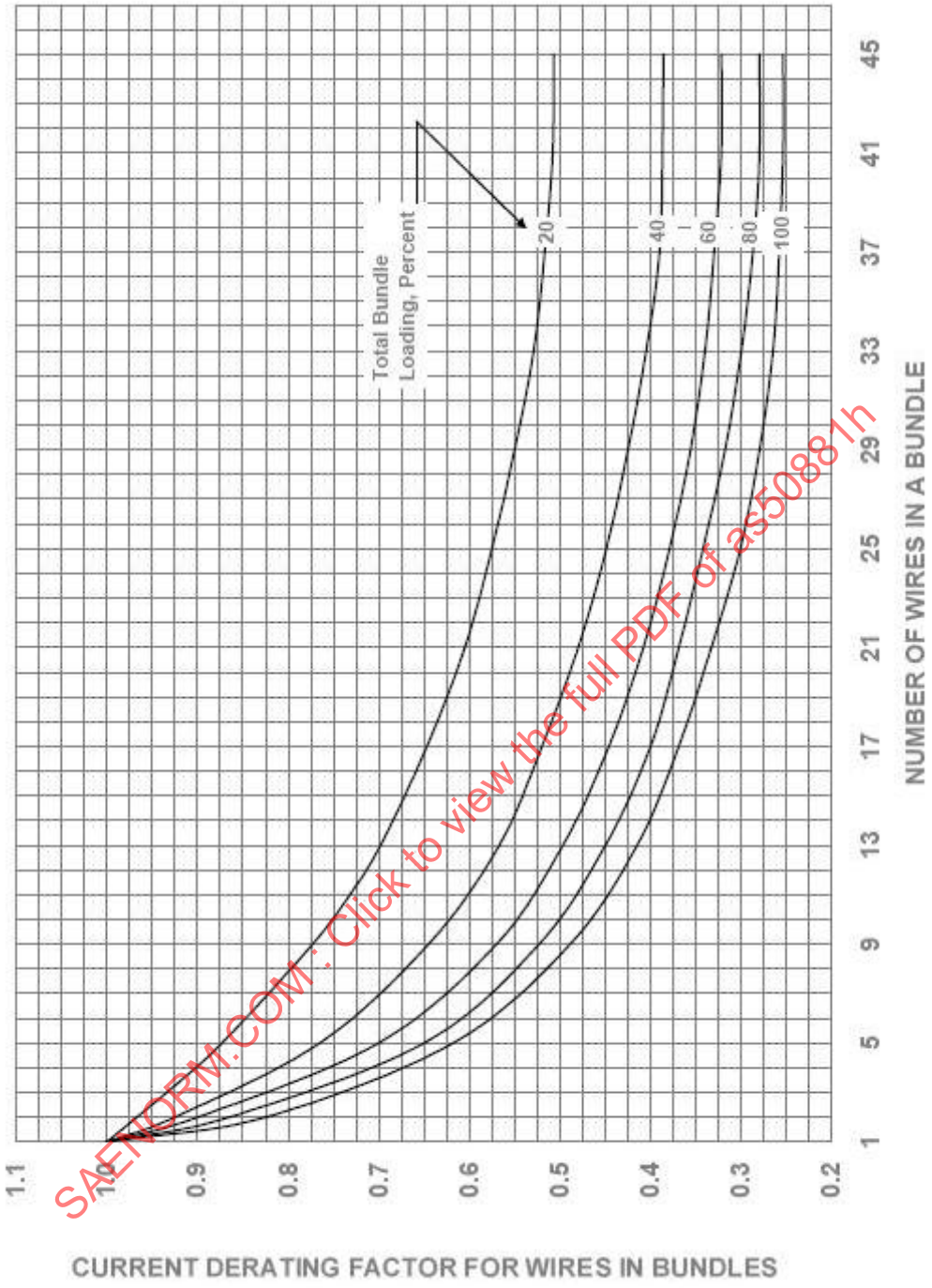

Figure 4 - Bundle derating curves
(see 3.8.8.1, 3.8.8.1.1, 6.7)

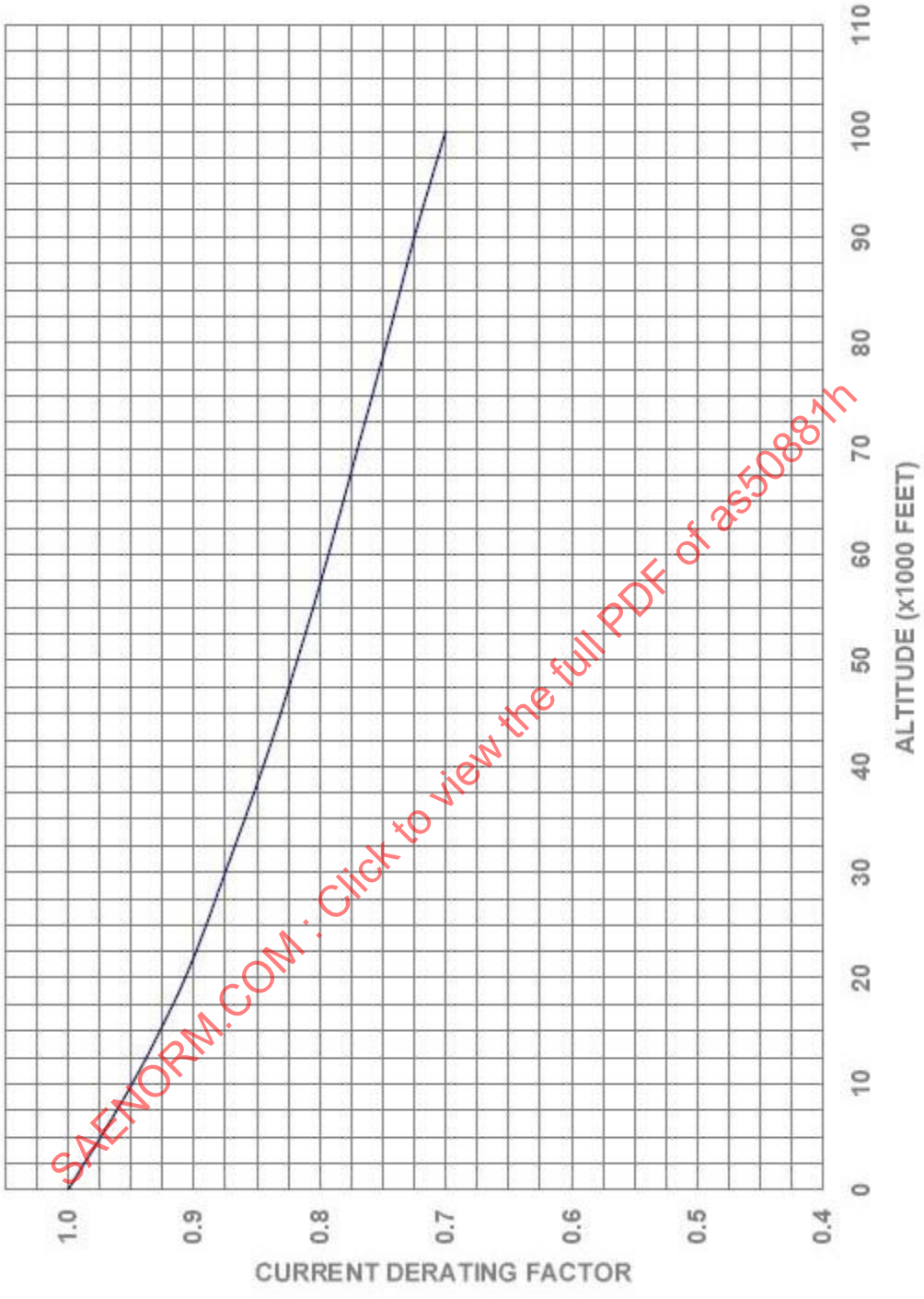

Figure 5 - Altitude derating curve
(see 3.8.8.1, 3.8.8.1.1, and 6.7)

Equation for calculating current derating factor:

$$Y=-1*10^{-7}*(X)^3+3*10^{-5}*(X)^2-0.0049*(X)+0.9977$$

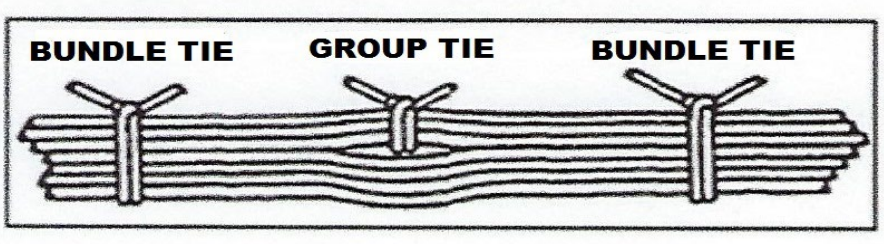

Figure 6

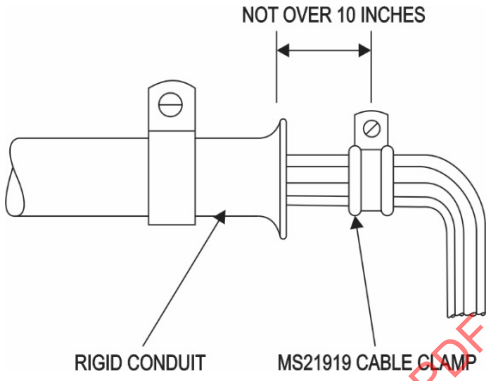

Figure 7

7.2 Size Color Code (see 3.9.5)

Table 4

Size	Color	Size	Color
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		

APPENDIX A - OPEN OR PROTECTED HARNESSES

A.1 SCOPE

This appendix governs the selection and application 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 Acquisition Streaming and Standardization Information System (ASSIST) specified in the solicitation form a part of this specification to the extent specified herein.

A.2.1.1.1 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

(Unless otherwise indicated, copies of federal and military specifications, standards and handbooks are available from the DLA Document Services, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6396, https://assist.daps.dla.mil/quicksearch/.)

A.2.2 Non-Government Documents

A.2.2.1 NEMA Publications

Available from the National Electrical Manufacturers Association, 1300 North 17th Street, Suite 900, Arlington, VA 22209, Tel: 703-841-3200, www.nema.org.

WC27500 Standard for Aerospace and Industrial Electric Cable

A.2.2.2 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

ARP6400 Recommended Practice for Processing and Handling Wire and Cable with Silver Plated Conductors and Shields

ARP81490 Transmission Lines, Transverse Electromagnetic Mode

AS4372 Performance Requirements for Wire, Electric, Insulated Copper or Copper Alloy

AS4373 Test Methods for Insulated Electric Wire

AS5768 Tool, Stripper, Electrical Insulation, General Specification for

AS22759 Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy

AS85485 Cable, Electric, Filter Line, Radio Frequency Absorptive

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 Tables 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. High speed data cables shall be in accordance with AS6070. Shielded unjacketed cables shall not be used. Avoid using PTFE/polyimide smooth surface insulation over tin-coated copper conductors, as the high temperature processing required may promote excessive inter-metallic growth which negatively impacts solderability, contact resistance, and crimp tensile strength.

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

For U. S. military applications Transverse Electromagnetic Mode transmission lines shall be in accordance with MIL-T-81490. For other T.E.M. Transmission Line applications, refer to ARP81490 for guidance.

A.3.1.6 Filter Line Cable

Radio absorptive filter line cable shall be in accordance with AS85485.

A.3.1.7 Wire and cables are to be stripped in accordance with AS5768.

A.3.1.8 Silver Plated Copper Conductors and Shields

Silver plated copper conductor or shield requires special handling to mitigate the development of corrosion. Refer to ARP6400 for recommended practice for processing and handling.

A.3.1.9 Recommended Handling of Insulated Wires and Cables

Wire and cable products progress through a series of handling or operational steps to complete a finished harness or assembly that is ready for installation on a vehicle. Throughout these many steps, environmental or processing conditions may be present which can generate damage detrimental to the wire or cable and/or its intended application.

A.3.1.10 Arc Propagation Damage

Selection of wires and protection schemes shall take into account known characteristics in relation to each installation and application to minimize the risk of wire damage, including voltage level and arc tracking phenomena. The intensity and consequence of the arc and its mitigation shall be substantiated using appropriate arc propagation evaluation methods. Specific requirements shall be determined by the procurement or design authority.

A.3.1.11 Corrosion Preventive Compounds

Corrosion preventative compounds (CPC) shall not be sprayed onto wiring harnesses or sleeving since certain CPCs can adversely impact flammability and electrical and mechanical properties. Wires, cables, and/or protective sleeving of harnesses shall be protected from CPC contact. The CPCs shall be removed if contact occurs.

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/, 4/, 6/

Document	Voltage Rating (Max)	Rated Wire Temp (°C)	Insulation Type	Conductor Type	Application
AS22759/1	600	200	Fluoropolymer insulated PTFE and PTFE coated glass	Silver coated copper	
AS22759/2	600	260	Fluoropolymer insulated PTFE and PTFE coated glass	Nickel coated copper	
AS22759/3	600	260	Fluoropolymer insulated TFE-glass-TFE	Nickel coated copper	
AS22759/4	600	200	Fluoropolymer insulated TFE-glass-FEP	Silver coated copper	
AS22759/5	600	200	Fluoropolymer insulated extruded PTFE	Silver coated copper	
AS22759/6	600	260	Fluoropolymer insulated extruded PTFE	Nickel coated copper	
AS22759/7	600	200	Fluoropolymer insulated extruded PTFE	Silver coated copper	
AS22759/8	600	260	Fluoropolymer insulated extruded PTFE	Nickel coated copper	
AS22759/9	1000	200	Fluoropolymer insulated extruded TFE	Silver coated copper	
AS22759/10	1000	260	Fluoropolymer insulated extruded TFE	Nickel coated copper	
AS22759/16	600	150	Fluoropolymer insulated extruded ETFE	Tin coated copper	
AS22759/17	600	150	Fluoropolymer Insulated extruded ETFE	Silver coated high strength copper alloy	
AS22759/20	1000	200	Fluoropolymer insulated extruded TFE	Silver coated high strength copper alloy	
AS22759/21	1000	260	Fluoropolymer insulated extruded TFE	Nickel coated high strength copper alloy	
AS22759/28	600	200	Fluoropolymer insulated extruded TFE polyimide coated ROHS	Silver coated copper	
AS22759/29	600	260	Fluoropolymer insulated extruded TFE polyimide coated ROHS	Nickel coated copper	

Table A1 - Open wiring applications 1/, 3/, 4/, 6/ (continued)

Document	Voltage Rating (Max)	Rated Wire Temp (°C)	Insulation Type	Conductor Type	Application
AS22759/30	600	200	Fluoropolymer insulated extruded TFE polyimide coated ROHS	Silver coated high strength copper alloy	
AS22759/31	600	260	Fluoropolymer insulated extruded TFE polyimide coated ROHS	Nickel coated high strength copper alloy	
AS22759/34	600	150	Fluoropolymer insulated crosslinked modified ETFE	Tin coated copper	
AS22759/35	600	200	Fluoropolymer insulated crosslinked modified ETFE	Silver coated high strength copper alloy	
AS22759/41	600	200	Fluoropolymer insulated crosslinked modified ETFE	Nickel coated copper	
AS22759/42	600	200	Fluoropolymer Insulated crosslinked modified ETFE	Nickel coated high strength copper alloy	
AS22759/43	600	200	Fluoropolymer insulated crosslinked modified ETFE	Silver coated copper	
AS22759/53	600	200	Fluoropolymer insulated crosslinked modified ETFE low fluoride ROHS	Silver coated high strength copper alloy	
AS22759/54	600	200	Fluoropolymer insulated crosslinked modified ETFE low fluoride ROHS	Silver coated copper	
AS22759/83	600	200	Polytetrafluorethylene/ polyimide	Silver coated copper	
AS22759/84	600	260	Polytetrafluorethylene/ polyimide	Nickel coated copper	
AS22759/85	600	150	Polytetrafluorethylene/ polyimide	Tin coated copper	5/
AS22759/86	600	200	Polytetrafluorethylene/ polyimide	Silver coated copper	
AS22759/87	600	260	Polytetrafluorethylene/ polyimide	Nickel coated copper	
AS22759/88	600	150	Polytetrafluorethylene/ polyimide	Tin coated copper	5/
AS22759/89	600	200	Polytetrafluorethylene/ polyimide	Silver coated high strength or ultra-high strength copper	

Table A1 - Open wiring applications 1/, 3/, 4/, 6/ (continued)

Document	Voltage Rating (Max)	Rated Wire Temp (°C)	Insulation Type	Conductor Type	Application
AS22759/90	600	260	Polytetrafluorethylene/ polyimide	Nickel coated high strength or ultra-high strength copper	
AS22759/183	600	200	Polytetrafluorethylene/ polyimide	Silver coated copper	
AS22759/184	600	260	Polytetrafluorethylene/ Polyimide	Nickel coated copper	
AS22759/185	600	150	Polytetrafluorethylene/ polyimide	Tin coated copper	5/
AS22759/186	600	200	Polytetrafluorethylene/ polyimide	Silver coated copper	
AS22759/187	600	260	Polytetrafluorethylene/ polyimide	Nickel coated copper	
AS22759/188	600	150	Polytetrafluorethylene/ polyimide	Tin coated copper	5/
AS22759/189	600	200	Polytetrafluorethylene/ polyimide	Silver coated high strength or ultra-high strength copper	
AS22759/190	600	260	Polytetrafluorethylene/ polyimide	Nickel coated high strength or ultra-high strength copper	
MIL-DTL-25038/12/	600	260	See specification sheet	See specification sheet	
MIL-DTL-25038/32/	600	260	See specification sheet	See specification sheet	

NOTES:

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.

4/ This insulation system has been used in aerospace applications using 115 V (phase to neutral) 400 Hz AC and 28 VDC. Verification of the suitability of this product for use in other electrical system configurations is the responsibility of the user.

5/ Not for U.S. Military. Sintering of tin plated wire is adversely affecting the performance of the seamless construction wire, and multi conductor cable jackets. The heats used in applying these jackets can cause deterioration of the primary conductor or shielding materials.

6/ For U.S. Military applications, due to the critical performance verification requirements, the procurement of approved wire shall only be from a qualified source tested and qualified by an approved military qualification activity.

Table A2 - Protected wiring applications 1/, 2/, 3/, 5/

Document	Voltage Rating (Max)	Rated Wire Temp (°C)	Insulation Type	Conductor Type	Application
AS22759/11	600	200	Fluoropolymer insulated extruded TFE	Silver coated copper	
AS22759/12	600	260	Fluoropolymer insulated extruded TFE	Nickel coated copper	
AS22759/18	600	150	Fluoropolymer insulated extruded ETFE	Tin coated copper	
AS22759/19	600	150	Fluoropolymer insulated extruded ETFE	Silver coated high strength copper alloy	
AS22759/22	600	200	Fluoropolymer insulated extruded TFE	Silver coated high strength copper alloy	
AS22759/23	600	260	Fluoropolymer insulated extruded TFE	Nickel coated high strength copper alloy	
AS22759/32	600	150	Fluoropolymer insulated crosslinked modified ETFE	Tin coated copper	
AS22759/33	600	200	Fluoropolymer insulated crosslinked modified ETFE	Silver coated high strength copper alloy	
AS22759/44	600	200	Fluoropolymer insulated crosslinked modified ETFE	Silver coated copper	
AS22759/45	600	200	Fluoropolymer insulated crosslinked modified ETFE	Nickel coated copper	
AS22759/46	600	200	Fluoropolymer insulated crosslinked modified ETFE	Nickel coated high strength copper alloy	
AS22759/51	600	200	Fluoropolymer insulated crosslinked modified ETFE low fluoride ROHS	Silver coated high strength copper alloy	
AS22759/52	600	200	Fluoropolymer insulated crosslinked modified ETFE low fluoride ROHS	Silver coated copper alloy	
AS22759/80	600	150	Polytetrafluorethylene/ polyimide	Tin coated copper	4/
AS22759/81	600	200	Polytetrafluorethylene/ polyimide	Silver coated high strength or ultra-high strength copper	
AS22759/82	600	260	Polytetrafluorethylene/ polyimide	Nickel coated high strength or ultra-high strength copper	

Table A2 - Protected wiring applications 1/, 2/, 3/, 5/ (continued)

Document	Voltage Rating (Max)	Rated Wire Temp (°C)	Insulation Type	Conductor Type	Application
AS22759/91	600	200	Polytetrafluorethylene/ polyimide	Silver coated copper	
AS22759/92	600	260	Polytetrafluorethylene/ polyimide	Nickel coated copper	
AS22759/93	600	200	Polytetrafluorethylene polyimide insulated ROHS	Silver coated extra high strength copper alloy	
AS22759/94	600	200	Polytetrafluorethylene polyimide insulated ROHS	Nickel coated high strength or ultra-high strength copper alloy	
AS22759/180	600	150	Polytetrafluorethylene/ polyimide	Tin coated copper	4/
AS22759/181	600	200	Polytetrafluorethylene/ polyimide	Silver coated high strength or ultra-high strength copper	
AS22759/182	600	260	Polytetrafluorethylene/ polyimide	Nickel coated high strength or ultra-high	
AS22759/191	600	200	Polytetrafluorethylene/ polyimide	Silver coated copper	
AS22759/192	600	260	Polytetrafluorethylene/ polyimide	Nickel coated copper	

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.

3/ This insulation system has been used in aerospace applications using 115 V (phase to neutral) 400 Hz AC and 28 VDC. Verification of the suitability of this product for use in other electrical system configurations is the responsibility of the user.

4/ Not for U.S. Military. Sintering of tin plated wire is adversely affecting the performance of the seamless construction wire, and multi conductor cable jackets. The heats used in applying these jackets can cause deterioration of the primary conductor or shielding materials.

5/ For U.S. Military applications, due to the critical performance verification requirements, the procurement of approved wire shall only be from a qualified source tested and qualified by an approved military qualification activity.

APPENDIX B - SIGNIFICANT WIRE IDENTIFICATION
(SEE 3.9.1)

B.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 Acquisition Streaming and Standardization Information System (ASSIST) and the supplement thereto, cited in the solicitation.

B.2.1.1.1 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 DLA Document Services, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6396, https://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 equipment 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 Figures 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.3.5.4 Each color-coded wire that is part of a jacketed, shielded, and/or twisted conductor cable shall be assigned a different wire number.

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 all wiring from the load to the grounding point. 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 B.3.1 and B.3.4 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
(see B.3.1 and B.3.4 of Appendix B) (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.	