Designation: F2639 – 15

Standard Practice for Design, Alteration, and Certification of Aircraft Electrical Wiring Systems[1]

1. Scope

1.1 *Definition*—This practice defines acceptable practices and processes for the design, alteration, and certification of electric systems and installations in general aviation aircraft. This practice does not change or create any additional regulatory requirements nor does it authorize changes in or permit deviations from existing regulatory requirements.

1.2 *Applicability*—The guidance provided in this practice is directed to air carriers, air operators, design approval holders, Supplemental Type Certificate (STC) holders, maintenance providers, repair stations, and anyone performing field approval modifications or repairs.

1.3 *Protections and Cautions*—This practice provides guidance for developing actions and cautionary statements to be added to maintenance instructions for the protection of wire and wire configurations. Maintenance personnel will use these enhanced procedures to minimize contamination and accidental damage to electrical wiring interconnection system (EWIS) while working on aircraft.

1.4 *"Protect and Clean As You Go" Philosophy*—This philosophy is applied to aircraft wiring through inclusion in operators' maintenance and training programs. This philosophy stresses the importance of protective measures when working on or around wire bundles and connectors. It stresses how important it is to protect EWIS during structural repairs, STC installations, or other alterations by making sure that metal shavings, debris, and contamination resulting from such work are removed.

1.5 This practice includes the following sections:

[1] This practice is under the jurisdiction of ASTM Committee F39 on Aircraft Systems and is the direct responsibility of Subcommittee F39.01 on Design, Alteration, and Certification of Electrical Systems.

Current edition approved Aug. 1, 2015. Published September 2015. Originally approved in 2007. Last previous edition approved in 2007 as F2639 – 07$^{\varepsilon 1}$. DOI: 10.1520/F2639-15.

1.6 *Values*—The values given in inch-pound units are to be regarded as the standard. The values in parentheses are for information only. See Appendix X2 for SI-based prefixes and powers of 10.

NOTE 1—Where SI units are required, refer to Annex 5 of ICAO.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 Unless approved by the administrator, the latest revision of the listed documents shall be used for reference.

2.2 *ASTM Standards:*[2]

F2490 Guide for Aircraft Electrical Load and Power Source Capacity Analysis

2.3 *ANSI Standards:*[3]

ANSI/EIA-5200000 Generic Specification for Special-Use Electromechanical Switches of Certified Quality

ANSI EIA/TIA-568-B Commercial Building Telecommunications Cabling Standard

ANSI J-STD-004 Requirements for Soldering Fluxes

2.4 *FAA Standards:*[4]

Advisory Circular 20-53A Protection of Aircraft Fuel Systems Against Fuel Vapor Ignition Due To Lightning

AC 20-136 Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning

AC 21-160E RTCA Document DO-160E

AC 23.1309-1C Equipment, Systems, and Installations in Part 23 Airplanes

AC 25-16 Electrical Fault and Fire Prevention and Protection

AC 25.869-1 Electrical System Fire and Smoke Protection

AC 25.981-1B Fuel Tank Ignition Source Prevention Guidelines

AC 25.1353-1 Electrical Equipment and Installations

AC 25.1357-1 Circuit Protective Device Accessibility

DOT/FAA/CT 86/8 Determination of Electrical Properties of Bonding and Fastening Techniques

DOT/FAA/CT-83/3 Users Manual for FAA Advisory Circular 20-53a

DOT/FAA/CT-89-22 Aircraft Lightning Protection Handbook

Title14 Code of Federal Regulations Part 23 Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes

Title14 Code of Federal Regulations Part 25 Airworthiness Standards: Transport Category Airplanes

Title14 Code of Federal Regulations Part 27 Airworthiness Standards: Normal Category Rotorcraft

Title14 Code of Federal Regulations Part 29 Airworthiness Standards: Transport Category Rotorcraft

Title14 Code of Federal Regulations Part 31 Airworthiness Standards: Manned Free Balloons

Title14 Code of Federal Regulations Part 33 Airworthiness Standards: Aircraft Engines

Title14 Code of Federal Regulations Part 34 Fuel Venting and Exhaust Emission Requirements for Turbine Engine Powered Airplanes

Title14 Code of Federal Regulations Part 35 Airworthiness Standards: Propellers

Title14 Code of Federal Regulations Part 36 Noise Standards: Aircraft Type and Airworthiness Certification

2.5 *SAE Standards:*[5]

AMS-S-8802 Sealing Compound, Temperature-Resistant, Integral Fuel Tanks and Fuel Cell Cavities, High Adhesion (Replaces MIL-S-8802)

ARP 1199 Selection, Application, and Inspection of Electric Overcurrent Protective Devices

ARP 1308 Preferred Electrical Connectors for Aerospace Vehicles and Associated Equipment

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, http://www.access.gpo.gov.

[5] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

ARP 1870 Aerospace Systems Electrical Bonding and Grounding for Electromagnetic Compatibility and Safety
ARP 1928 Torque Recommendations for Attaching Electrical Wiring Devices to Terminal Boards or Blocks, Studs, Posts, Etc
ARP 4761 Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment
ARP 5369 Guidelines for Wire Identification Marking Using the Hot Stamp Process
ARP 5414 Aircraft Lightning Zoning
ARP 5583 Guide to Certification of Aircraft in a High Intensity Radiated Field (HIRF) Environment
AS 4372 Performance Requirements for Wire, Electric, Insulated Copper or Copper Alloy
AS 4373 Test Methods for Insulated Electric Wire
AS 4461 Assembly and Soldering Criteria for High Quality/High Reliability
AS 6136 Conduit, Electrical, Flexible, Shielded, Aluminum Alloy for Aircraft Installations. (Replaces MIL-C-6136)
AS 7351 Clamp, Loop Type Bonding-FSC 5340 (replaces AN735)
AS 7431 Bracket, Support Clamp-FSC 5340 (replaces AN743)
AS 7928 Terminals, Lug: Splices, Conductor: Crimp Style, Copper, General Specification for (Replaces MIL-T-7928)
AS 22759 Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy. (Replaces MIL-W-22759)
AS 23190 Straps, Clamps, Plastic and Metal, and Mounting Hardware, Plastic for Cable Harness Tying and Support Clamp, Loop, Metal, Cushioned, Adjustable, Wire Support, Type V, Class 1-FSC (replaces MIL-S-23190)
AS 25064 Conduit, Flexible, Radio Frequency Shielding [use in place of MIL-C-7931?]
AS 25281 Clamp, Loop, Plastic, Wire Support-FSC 5340 (replaces MS25281)
AS 25435 Terminal-Lug, Crimp Style, Straight Type, for Aluminum Aircraft Wire, Class 1 (Replaces MS254350)
AS 25436 Terminal-Lug, Crimp Style, 90° Upright Type, for Aluminum Aircraft Wire, Class 1 (Replaces MS25436)
AS 25438 Terminal-Lug, Crimp Style Right Angle Type, for Aluminum Aircraft Wire, Class 1 (Replaces MS25438)
AS 33671 Strap, Tie Down, Electrical Components, Adjustable, Self Clinching, Plastic, Type I, Class 1 (Replaces MS3367)
AS 50881A Wiring Aerospace Vehicle (Replaces MIL-W-5088)
AS 70991 Terminal, Lug and Splice, Crimp Style Aluminum, for Aluminum Aircraft Wire. (Replaces MIL-T-7099E)

2.6 *Military Standards:*[4]
A-A-52080 Nylon Lacing Tape (replaces MIL-T-43435)
A-A-52081 Polyester Lacing Tape (replaces MIL-T-43435)
A-A-52082 Tape, Lacing and Tying, TFE Fluorocarbon (tetra fluorocarbon) (replaces MIL-T-43435)
A-A-52083 Tape, Lacing and Tying, Glass (replaces MIL-T-43435)
A-A-52084 Tape, Lacing and Tying, Aramid (replaces MIL-T-43435)
A-A-59163 Insulation Tape, Electrical, Self Adhering, Unsupported Silicone Rubber
AN735 Clamp
AN960JD10L Conductive Washer
MIL-C-22520 Wire Termination Crimp Tools
MIL-C-26482 Connectors, Electrical, (Circular, Miniature, Quick Disconnect, Environment Resisting), Receptacles and Plugs, General Specification for
MIL-C-39029 Contacts, Electrical Connector, General Specification for
MIL-PRF-81309 Corrosion Preventative Compounds, Water Displacing, Ultra-Thin Film
MIL-DTL-22520 Crimping Tools, Wire Termination, General Specification for (replaces MIL-C-22520/2)
MIL-DTL-27500 Cable, Power, Electrical and Cable Special Purpose, Electrical Shielded and Unshielded, General Specification for
MIL-DTL-5015 Connectors, Electrical, Circular Threaded, AN Type, General Specification for
MIL-DTL-83723 Connectors, Electrical, (Circular, Environment Resisting), Receptacles and Plugs, General Specification for
MIL-F-14256F Flux, Soldering, Liquid, Paste Flux, Solder Paste and Solder-Paste Flux (for Electronic/Electrical use), General Specification for
MIL-M-81531 Marking of Electrical Insulating Materials
MIL-PRF-39016 Relays Electromagnetic, Established Reliability, General Specification for
MIL-PRF-5757 Relays, Hermetically Sealed
MIL-PRF-6106 Relays, Electromagnetic, General Specification for
MIL-PRF-83536 Relays, Electromagnetic, Established Reliability, 25 Amperes and Below, General Specification for
MIL-S-8516 Sealing Compound, Polysulfide Rubber, Electric Connectors and Electric Systems, Chemically Cured
MIL-STD-704 Aircraft, Electrical Power Characteristics
MIL-T-8191 Test and Checkout Equipment, Guided Missile Weapons Systems, General Specification for [should this be SAE AMS-T-81914 replaces MIL-T-81914?]
MIL-W-25038 Wire, Electrical, High-Temperature, Fire Resistant, and Flight Critical
MIL-W-81044 Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkine-Imide, or Polyarylene Insulated, Copper or Copper Alloy
MIL-W-81381 Wire, Electric, Fluorocarbon/Polyimide Insulated
MS21919 Cable Clamps
MS25440 Flat Washer
MS3057 Cable Clamp Adapters
MS3109 Boots, Heat-Shrinkable, Strain-Relief, Right Angle
MS3115 Connectors, Receptacle, Electrical, Dummy Stowage, Bayonet Coupling, for MIL-C-26482 Connectors, Series 1 and 2
MS3117 Boots, Heat-Shrinkable, Strain-Relief, Right Angle

MS3142 Connector, Receptacle, Electrical, Box Mounting, Solder Contact Hermetic, AN Type
MS3143 Connector, Receptacle, Electrical, Solder Mounting, Solder Contact Hermetic, AN Type
MS3158 Backshells Shrinkable Boot, for Electric Connector
MS3180 Cover, Protective, Electrical Connector Plug, Bayonet Coupling for MIL-C-26482 Connectors
MS3181 Cover, Protective, Electrical Connector Receptacle, Bayonet Coupling for MIL-C-26482 Connectors
MS3416 Backshells, Straight, for Electrical Connectors
MS3440 Connectors, Receptacle, Electric Series 2, Narrow Flange Mount, Bayonet Coupling, Solder Pin Contact Class H
MS3443 Connectors, Receptacle, Electric, Series 2, Solder Flange Mount, Bayonet Coupling, Solder Pin Contact Class H
MS3450 Connectors, Receptacle, Electrical, Wall Mounting, Rear Release, Crimp Contact, AN Type
MS3451 Connectors Receptacle, Electrical, Cable Connecting, Rear Release, Crimp Contact, AN Type
MS3452 Connector, Receptacle, Electric, Box Mounting, Rear Release, Crimp Contact, AN Type
MS3456 Connectors, Plug, Electrical, Rear Release, Crimp Contact, AN Type
MS3459 Connector, Plug, Electrical, Self-Locking, Coupling Nut, Rear Release, Crimp Contact, AN Type
MS3470 Connectors, Receptacle, Electric, Series 2, Single Hole Mount, Bayonet Coupling, Solder Pin Contact, Class H
MS3471 Connector, Receptacle, Electric, Series 2, Crimp Type, Cable Connecting, Bayonet Coupling, Classes A, L, S, and W
MS3472 Connector, Receptacle, Electric, Series 2, Crimp Type, Wide Flange Mounting, Bayonet Coupling, Classes A, L, S, and W
MS3475 Connector, Plug Electric, RFI Shielded, Series 2, Crimp Type, Bayonet Coupling, Classes L, S, and W
MS3476 Connector, Plug Electric, Series 2, Crimp Type, Bayonet Coupling, Classes A, L, S, and W
MS25437 Terminal-Lug
MS35489 Grommet
MS90387 Tool, Hand, Adjustable for Plastic and Metal Tie Down Straps
QQ-S-571 Solder, Electronic (96 to 485 Deg C)

2.7 *Other Standards:*
RTCA DO-160 Environmental Conditions and Test Procedures for Airborne Equipment[6]
EIA 471 Symbol & Label for Electrostatic Sensitive Devices[7]
National Electrical Manufacturers Association (NEMA) WC 27500 Standards for Aerospace and Industrial Electric Cable (replaces MIL-DTL-27500H)[8]
ICAO Annex 5 Units of Measurement to be used in Air and Ground Operations[9]

3. Terminology

3.1 *Definitions:*

3.1.1 *abrasion resistance, n*—ability of a material to resist intrinsic property deterioration as a result of physical abrasion.

3.1.2 *adhesive, n*—compound that adheres or bonds two items together.

3.1.2.1 *Discussion*—Adhesives may come from either natural or synthetic sources.

3.1.3 *Airworthiness Directive (AD), n*—regulation issued by the Federal Aviation Administration (FAA) that applies to aircraft, aircraft engines, propellers, or appliances when an unsafe condition exists and that condition is likely to exist or develop in other products of the same type design.

3.1.4 *ampere (A), n*—basic unit of current flow; 1 A is the amount of current that flows when a difference of potential of 1 V is applied to a circuit with a resistance of one; 1 coulomb/s.

3.1.5 *antenna, n*—device designed to radiate or intercept electromagnetic waves.

3.1.6 *appliance, n*—any instrument, mechanism, equipment, part, apparatus, appurtenance, or accessory, including communications equipment, that is used or intended to be used in operating or controlling an aircraft in flight; is installed in or attached to the aircraft; and is not part of an airframe, engine, or propeller.

3.1.7 *arc fault circuit breaker (AFCB), n*—contains circuitry to cause circuit breaker to open when arcing faults are detected.

3.1.8 *arc resistance (noncarbon tracking), n*—measure of the ability of a material to resist physical penetration by an electrical arc.

3.1.9 *avionics, n*—science and technology of electronics as applied to aviation.

3.1.10 *bond, n*—adhesion of one surface to another with or without the use of an adhesive as a bonding agent.

3.1.11 *bonding, v*—general term applied to the process of electrically connecting two or more conductive objects.

3.1.11.1 *Discussion*—In aircraft, the purpose of bonding (except as applied to individual connections in the wiring and grounding systems) is to provide conductive paths for electric currents. This is accomplished by providing suitable low-impedance connections joining conductive aircraft components and the aircraft structure. Another purpose of bonding is to ensure the safe passage of current caused by lightning or static electricity through the aircraft structure.

3.1.12 *bundle, n*—wire bundle consists of a quantity of wires fastened or secured together and all traveling in the same direction.

3.1.13 *bus or bus bar, n*—solid copper strips to carry current between primary and secondary circuits; also used as jumpers.

[6] .Available from RTCA, Inc., 1828 L St., NW, Suite 805, Washington, DC 20036.

[7] Available from Electronic Industries Alliance (EIA), 2500 Wilson Blvd., Arlington, VA 22201, http://www.eia.org

[8] Available from National Electrical Manufacturers Association (NEMA), 1300 N. 17th St., Suite 1752, Rosslyn, VA 22209, http://www.nema.org.

[9] Available from ICAO, Document Sales Unit, 999 University St., Montreal, Quebec H3C 5H7, Canada.

3.1.14 *cable (electrical), n*—assembly of one or more conductors within an enveloping protective sheath so constructed as to permit use of conductors separately or in a group.

3.1.15 *calibration, n*—set of operations, performed in accordance with a definite document procedure, that compares the measurements performed by an instrument or standard, for the purpose of detecting and reporting, or eliminating by adjustment, errors in the instrument tested.

3.1.16 *certification, n*—implies that a certificate is in existence that certifies or states a qualification.

3.1.17 *circuit, n*—closed path or mesh of closed paths usually including a source of electromotive force (EMF).

3.1.18 *circuit breaker, n*—protective device for opening a circuit automatically when excessive current is flowing through it.

3.1.19 *conductor, n*—wire or other material suitable for conducting electricity.

3.1.20 *conduit, n*—rigid metallic or nonmetallic casing or a flexible metallic casing covered with a woven braid or synthetic rubber used to encase electrical cables.

3.1.21 *contact, n*—electrical connectors in a switch, solenoid, or relay that controls the flow of current.

3.1.22 *corrosion resistance, n*—ability of a material to resist intrinsic property deterioration as a result of environment.

3.1.23 *crack, n*—partial separation of material caused by vibration, overloading, internal stresses, nicks, defective assemblies, fatigue, or rapid changes in temperature.

3.1.24 *creepage, n*—conduction of electrical current along a surface between two points at different potentials.

3.1.24.1 *Discussion*—The current's ability to pass between two points increases with higher voltage and when deposits of moisture or other conductive materials exist on the surfaces.

3.1.25 *curing temperature, n*—temperature at which a resin or an assembly is subjected to cure the resin.

3.1.26 *cut-through strength, n*—measure of the effort required to sever a material.

3.1.27 *data, n*—information that supports or describes, or both, the original aircraft design, alteration, or repair including the following: *(1)* drawings, sketches, and/or photographs; *(2)* engineering analysis; *(3)* engineering orders; and *(4)* operating limitations.

3.1.28 *derating, n*—technique whereby a part is stressed in actual usage at values well below the manufacturer's rating for the part.

3.1.28.1 *Discussion*—By decreasing mechanical, thermal, and electrical stresses, the probability of degradation or catastrophic failure is lessened.

3.1.29 *dielectric strength, n*—maximum electric field that a material can withstand without failure of its electrical insulation properties.

3.1.30 *discontinuity, n*—interruption in the normal physical structure or configuration of a part such as a crack, lap, seam, inclusion, or porosity.

3.1.31 *drip loop, n*—bundle installation method used to prevent water or other fluid contaminants from running down the wiring into a connector.

3.1.32 *electrical wiring interconnection system (EWIS), n*—any wire, wiring device, or combination of these, including termination devices, installed in any area of the aircraft for the purpose of transmitting electrical energy between two or more intended termination points.

3.1.33 *electricity, n*—one of the fundamental quantities in nature consisting of elementary particles, electrons, and protons that are manifested as a force of attraction or repulsion and also in work that can be performed when electrons are caused to move; a material agency that, when in motion, exhibits magnetic, chemical, and thermal effects and when at rest is accompanied by an interplay of forces between associated localities in which it is present.

3.1.34 *electromagnet, n*—temporary magnet that is magnetized by sending current through a coil of wire wound around an iron core.

3.1.35 *electromagnetic/radio frequency interference (EMI/RFI), n*—frequency spectrum of electromagnetic radiation extending from subsonic frequency to X-rays.

3.1.35.1 *Discussion*—This term shall not be used in place of the term radio frequency interference (RFI). (See *radio frequency interference*.) Shielding materials for the entire EMI spectrum are not readily available.

3.1.36 *electron, n*—negative charge that revolves around the nucleus of an atom; a unit of a negative electrical charge.

3.1.37 *electronics, n*—general term that describes the branch of electrical science and technology that treats the behavior and effects of electron emission and transmission.

3.1.38 *expandable sleeving, n*—open-weave braided sleeving used to protect wire and cables from abrasion and other hazards (commonly called "Expando").

3.1.39 *fill, n*—threads in a fabric that run crosswise of the woven material.

3.1.40 *flame resistance, n*—ability of a material to resist intrinsic property deterioration because of immersion in flame.

3.1.41 *fluorinated ethylene propylene (FEP), n*—melt-extrudable fluorocarbon resin, very similar in appearance and performance to polytetrafluoroethylene (PTFE), but with a maximum temperature rating of 200°C.

3.1.42 *flux, n*—materials used to prevent, dissolve, or facilitate removal of oxides and other undesirable surface substances.

3.1.42.1 *Discussion*—Also, the name for magnetic fields.

3.1.43 *fuse, n*—protective device containing a special wire that melts when current exceeds the rated value for a definite period.

3.1.44 *generator, n*—device for converting mechanical energy into electrical energy.

3.1.45 *grommet, n*—insulating washer that protects the sides of holes through which wires shall pass or a metal or plastic drain attached to fabric on aircraft.

3.1.46 *grounding, v*—term usually applied to a particular form of bonding that is the process of electrically connecting conductive objects to either conductive structure or some other conductive return path for the purpose of safely completing either a normal or fault circuit.

3.1.47 *harness, n*—group of cables or wires securely tied as a unit.

3.1.48 *heat distortion temperature, n*—temperature at which a material begins to alter its intrinsic properties.

3.1.49 *impact strength, n*—ability of a material to resist intrinsic property deterioration as a result of physical impact.

3.1.50 *insulator, n*—material that will not conduct current to an appreciable degree.

3.1.51 *integrated circuit, n*—small, complete circuit built up by vacuum deposition and other techniques, usually on a silicon chip, and mounted in a suitable package.

3.1.52 *inverter, n*—device for converting direct current (DC) to alternating current (AC).

3.1.53 *magnetic field, n*—space around a source of magnetic flux in which the effects of magnetism can be determined.

3.1.54 *mechanical strength, n*—ability of a material to resist intrinsic property deterioration as a result of physical forces.

3.1.55 *multiconductor cable, n*—consists of two or more cables or wires, all of which are encased in an outer covering composed of synthetic rubber, fabric, or other material.

3.1.56 *open circuit, n*—incomplete or broken electrical circuit.

3.1.57 *plastic, n*—organic substance of large molecular weight that is solid in its finished state and, at some stage during its manufacture or its processing into a finished article, can be shaped by flow.

3.1.58 *polytetrafluoroethylene (PTFE) tape (insulation), n*—wrapped around a conductor and layered into a virtually homogeneous mass.

3.1.58.1 *Discussion*—It is used both as a primary insulation against the conductor and as an outer layer or jacket over a shield. Maximum temperature rating is 260°C.

3.1.59 *polyvinylidine fluoride (PVF2), n*—fluorocarbon plastic that, when used in aircraft wire, is invariably radiation cross-linked and used as the outer layer.

3.1.60 *radar (radio detecting and ranging), n*—radio equipment that uses reflected pulse signals to locate and determine the distance to any reflecting object within its range.

3.1.61 *rectifier, n*—device for converting AC to DC.

3.1.62 *relay, n*—electrically operated remote control switch.

3.1.63 *resin, n*—vast profusion of natural and increasingly synthetic materials used as adhesives, fillers, binders, and insulation.

3.1.64 *resistance, n*—opposition a device or material offers to the flow or current.

3.1.65 *resistance to fluids, n*—ability of a material to resist intrinsic property deterioration as a result of fluids.

3.1.66 *resistance to notch propagation, n*—ability of a material to resist propagation of breeches.

3.1.67 *severe wind and moisture problem (SWAMP) areas, n*—areas such as wheel wells, wing folds, and near wing flaps and areas directly exposed to extended weather conditions are considered SWAMP areas on aircraft.

3.1.68 *silicone rubber, n*—high-temperature (200°C) plastic insulation that has a substantial silicone content.

3.1.69 *smoke emission, n*—gases or particulate emitted from a material as a result of combustion.

3.1.70 *soldering, v*—group of welding processes that produces coalescence of materials by heating them to the soldering temperature and using a filler metal having a liquidus not exceeding 450°C (840°F) and below the solidus of the base metals and the filler metal is distributed between the closely fitted surfaces of the joint by capillary action.

3.1.71 *solenoid, n*—tubular coil for the production of a magnetic field; electromagnet with a core that is able to move in and out.

3.1.72 *special properties unique to the aircraft, n*—any characteristic of an aircraft not incorporated in other designs.

3.1.73 *swarf, n*—term used to describe the metal particles generated from drilling and machining operations.

3.1.73.1 *Discussion*—Swarf particles may collect on and between wires within a wire bundle.

3.1.74 *switch, n*—device for opening or closing an electrical circuit.

3.1.75 *tape, n*—tape or a "narrow fabric" is loosely defined as a material that ranges in width from ¼ to 12 in. (0.6 to 30 cm).

3.1.76 *thermocouple, n*—device to convert heat energy into electrical energy.

3.1.77 *transformer, n*—device for raising or lowering AC voltage.

3.1.78 *transmitter, n*—electronic system designed to produce modulated radio frequency (RF) carrier waves to be radiated by an antenna; also, an electric device used to collect quantitative information at one point and send it to a remote indicator electrically.

3.1.79 *velocity of propagation (VOP), n*—or velocity factor is a parameter that characterizes the speed at which an electrical or radio signal passes through a medium and expressed as a percentage, it is the ratio of a signal's transmission speed compared to the speed of light.

3.1.80 *volt, n*—unit of potential, potential difference, or electrical pressure.

3.1.81 *waveguide, n*—hollow, typically rectangular, metallic tube designed to carry electromagnetic energy at extremely high frequencies.

3.1.82 *wire, n*—single, electrically conductive path.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *electrical system, n—as used in this practice*, those parts of the aircraft that generate, distribute, and use electrical energy, including their support and attachments.

3.3 *Acronyms:*

3.3.1 *AC*—alternating current

3.3.2 *AFM*—aircraft flight manual

3.3.3 *CDO*—Certified Design Organization

3.3.4 *CFR*—Code of Federal Regulations

3.3.5 *COMP*—composite

3.3.6 *COTS*—commercial off the shelf

3.3.7 *DC*—direct current

3.3.8 *EMI*—electromagnetic interference

3.3.9 *ESD*—electrostatic discharge

3.3.10 *EWIS*—electrical wiring interconnection system

3.3.11 *F*—Fahrenheit

3.3.12 *FEP*—fluorinated ethylene propylene

3.3.13 *ID*—identification

3.3.14 *NiCad*—nickel cadmium

3.3.15 *NiMH*—nickel metal hydride

3.3.16 *OD*—outside diameter

3.3.17 *ODA*—optional designation authorization

3.3.18 *OEM*—original equipment manufacturer

3.3.19 *PI*—polyimide

3.3.20 *RCCB*—remote-controlled circuit breaker

3.3.21 *RFI*—radio frequency interference

3.3.22 *SOF*—safety of flight

3.3.23 *SSPC*—solid-state power controller

3.3.24 *SWAMP*—severe wind and moisture problems

3.3.25 *TFE*—tetrafluoroethylene

4. Significance and Use

4.1 *Design*—The design procedures defined in this practice are intended to provide acceptable guidance in the original design of electrical systems.

4.2 *Alteration*—The alteration procedures defined in this practice are intended to provide acceptable guidance for modification of general aviation aircraft. Design of any modification shall follow the practices and processes defined in the design sections of this practice.

4.3 *Certification*—Certification guidance provided in this practice is intended to provide generally accepted procedures and processes for certification of original and modified electrical systems and equipment. Requirements for certification shall be coordinated with the applicable National Aeronautics Association/Civil Aeronautics Administration (NAA/CAA) regulatory agency.

5. Wire Selection

5.1 *General:*

5.1.1 Wires shall be sized to carry continuous current in excess of the circuit-protective device rating, including its time current characteristics, and to avoid excessive voltage drop. Refer to 8.2 for wire-rating methods.

5.1.2 *Electrical Wire Rating:*

5.1.2.1 Wires shall be sized so that they: have sufficient mechanical strength to allow for service conditions, do not exceed allowable voltage drop levels, are protected by system circuit protection devices, and meet circuit current carrying requirements.

5.1.2.2 *Mechanical Strength of Wires*—If it is desirable to use wire sizes smaller than #20, particular attention shall be given to the mechanical strength and installation handling of these wires, for example, vibration, flexing, and termination. Consideration shall be given to the use of high-strength alloy conductors in small gage wires to increase mechanical strength. As a general practice, wires smaller than size #20 shall be provided with additional clamps and be grouped with at least three other wires. They shall also have additional support at terminations, such as connector grommets, strain relief clamps, shrinkable sleeving, or telescoping bushings. They shall not be used in applications in which they will be subjected to excessive vibration, repeated bending, or frequent disconnection from screw termination.

5.1.2.3 *Voltage Drop in Wires*—The voltage drop in the main power wires from the generation source or the battery to the bus shall not exceed 2 % of the regulated voltage when the generator is carrying rated current or the battery is being discharged at the 5-min rate. The tabulation shown in Table 1 defines the maximum acceptable voltage drop in the load circuits between the bus and the utilization equipment ground.

5.1.2.4 *Resistance*—The resistance of the current return path through the aircraft structure is generally considered negligible. However, this is based on the assumption that adequate bonding to the structure or a special electric current return path has been provided that is capable of carrying the required electric current with a negligible voltage drop. To determine circuit resistance, check the voltage drop across the circuit. If the voltage drop does not exceed the limit established by the aircraft or product manufacturer, the resistance value for the circuit may be considered satisfactory. When checking a circuit, the input voltage shall be maintained at a constant value. Tables 2 and 3 show formulas that may be used to determine electrical resistance in wires and some typical examples.

5.1.2.5 *Resistance Calculation Methods*—Figs. 1 and 2 provide a convenient means of calculating maximum wire length for the given circuit current. Values in Tables 2 and 3 are for tin-plated copper conductor wires. Because the resistance of tin-plated wire is slightly higher than that of nickel or silver plated wire, maximum run lengths determined from these charts will be slightly less than the allowable limits for nickel or silver-plated copper wire and are therefore safe to use. Figs. 1 and 2 can be used to derive slightly longer maximum run

TABLE 1 Tabulation Chart (Allowable Voltage Drop Between Bus and Utilization Equipment Ground)

Nominal System Voltage	Allowable Voltage Drop Continuous Operation	Intermittent Operation
14	0.5	1
28	1	2
115	4	8
200	7	14

TABLE 2 Examples of Determining Required Tin-Plated Copper Wire Size and Checking Voltage Drop Using Fig. 1

Voltage Drop	Run Lengths, ft	Circuit Current, amps	Wire Size from Chart	Check Calculated Voltage Drop (VD) = (Resistance/ft) (Length) (Current)
1	107	20	No. 6	VD = (0.000 44 Ω/ft) (107)(20) = 0.942
0.5	90	20	No. 4	VD = (0.000 28 Ω/ft) (90)(20) = 0.504
4	88	20	No. 12	VD = (0.002 02 Ω/ft) (88)(20) = 3.60
7	100	20	No. 14	VD = (0.003 06 Ω/ft) (100)(20) = 6.12

TABLE 3 Examples of Determining Maximum Tin-Plated Copper Wire Length and Checking Voltage Drop Using Fig. 1

Maximum Voltage Drop	Wire Size	Circuit Current, amps	Maximum Wire Run Length, ft	Check Calculated Voltage Drop (VD) = (Resistance/ft) (Length) (Current)
1	No. 10	20	39	VD = (0.001 26 Ω/ft) (39)(20)= 0.98
0.5	—		19.5	VD = (0.001 26 Ω/ft) (19.5)(20) = 0.366
4	—		156	VD = (0.001 26 Ω/ft) (156)(20) = 3.93
7	—		273	VD = (0.001 26 Ω/ft) (273)(20) = 6.88

lengths for silver or nickel-plated wires by multiplying the maximum run length by the ratio of resistance of tin-plated wire divided by the resistance of silver or nickel-plated wire.

5.1.2.6 As an alternative method or a means of checking results from Fig. 1, continuous flow resistance for a given wire size can be read from Table 4 and multiplied by the wire run length and the circuit current. For intermittent flow, use Fig. 2.

5.1.2.7 When the estimated or measured conductor temperature (T_2) exceeds 20°C, such as in areas having elevated ambient temperatures or in fully loaded power-feed wires, the maximum allowable run length (L_2), must be shortened from L_1 (the 20°C value) using the following formula for copper conductor wire:

$$L_2 = \frac{(254.5°C)(L_1)}{(234.5°C)(T_2)} \qquad (1)$$

(1) For aluminum conductor wire, the formula is:

$$L_2 = \frac{(258.1°C)(L_1)}{(238.1°C)(T_2)} \qquad (2)$$

(2) These formulas use the reciprocal of each material's resistive temperature coefficient to take into account increased conductor resistance resulting from operation at elevated temperatures.

5.1.2.8 To determine T_2 for wires carrying a high percentage of their current-carrying capability at elevated temperatures, laboratory testing using a load bank and a high-temperature chamber is recommended. Such tests shall be run at anticipated worst-case ambient temperature and maximum current-loading combinations.

5.1.2.9 Approximate T_2 can be estimated using the following formula:

$$T_2 = T_1 + (T_R - T_1)\sqrt{(I_2/I_{max})} \qquad (3)$$

where:

T_1 = ambient temperature,
T_2 = estimated conductor temperature,
T_R = conductor temperature rating,
I_2 = circuit current (A = amps), and
I_{max} = maximum allowable current (A = amps) at T_R.

(1) This formula is quite conservative and will typically yield somewhat higher estimated temperatures than are likely to be encountered under actual operating conditions.

5.1.2.10 *Effects of Heat Aging on Wire Insulation*—Since electrical wire may be installed in areas where inspection is infrequent over extended periods of time, it is necessary to give special consideration to heat-aging characteristics in the selection of wire. Resistance to heat is of primary importance in the selection of wire for aircraft use, as it is the basic factor in wire rating. Where wire may be required to operate at higher temperatures because of either high ambient temperature, high-current loading, or a combination of the two, selection shall be made on the basis of satisfactory performance under the most severe operating conditions.

5.1.2.11 *Maximum Operating Temperature*—The current that causes a temperature steady state condition equal to the rated temperature of the wire shall not be exceeded. Rated temperature of the wire may be based upon the ability of either the conductor or the insulation to withstand continuous operation without degradation.

5.1.2.12 *Single Wire in Free Air*—Determining a wiring system's current-carrying capacity begins with determining the maximum current that a given-sized wire can carry without exceeding the allowable temperature difference (wire rating minus ambient °C). The curves are based upon a single copper wire in free air. (See Figs. 3 and 4.)

5.1.3 Aircraft service imposes severe environmental condition on electrical wire. To ensure satisfactory service, schedule wire inspections annually for abrasions, defective insulation, condition of terminations, and potential corrosion. Grounding connections for power, distribution equipment, and electromagnetic shielding shall be given particular attention to ensure that electrical bonding resistance will not be significantly increased by the loosening of connections or by corrosion during service.

5.1.4 *Insulation* of wires shall be appropriately chosen in accordance with the environmental characteristics of wire routing areas. Routing of wires with dissimilar insulation, within the same bundle, is not recommended, particularly when relative motion and abrasion between wires having dissimilar insulation can occur. Soft insulating tubing cannot be considered as mechanical protection against external abrasion of wire since, at best, it provides only a delaying action. Conduit or ducting shall be used when mechanical protection is needed. Refer to 9.8 and 10.7 for conduit selection and installation.

5.1.5 *Insulation Materials*—Insulating materials shall be selected for the best combination of characteristics in the following categories:

5.1.5.1 Abrasion resistance,

5.1.5.2 Arc resistance (non-carbon tracking),

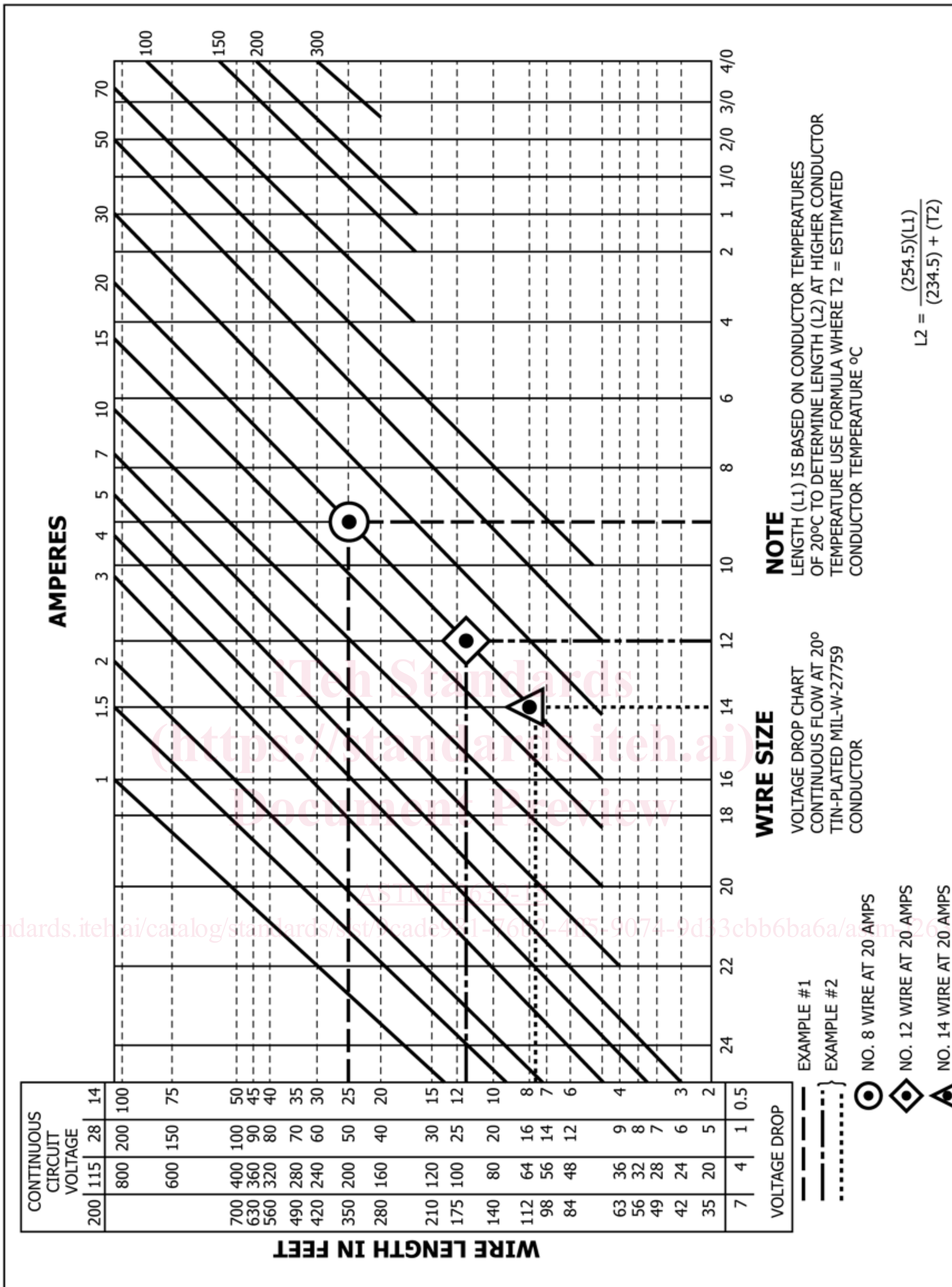

FIG. 1 Conductor Chart, Continuous Flow

5.1.5.3 Corrosion resistance,
5.1.5.4 Cut-through strength,
5.1.5.5 Dielectric strength,
5.1.5.6 Flame resistance,
5.1.5.7 Heat distortion temperature,
5.1.5.8 Impact strength,
5.1.5.9 Mechanical strength,
5.1.5.10 Resistance to fluids,
5.1.5.11 Resistance to notch propagation,
5.1.5.12 Smoke emission, and
5.1.5.13 Special properties unique to the aircraft.

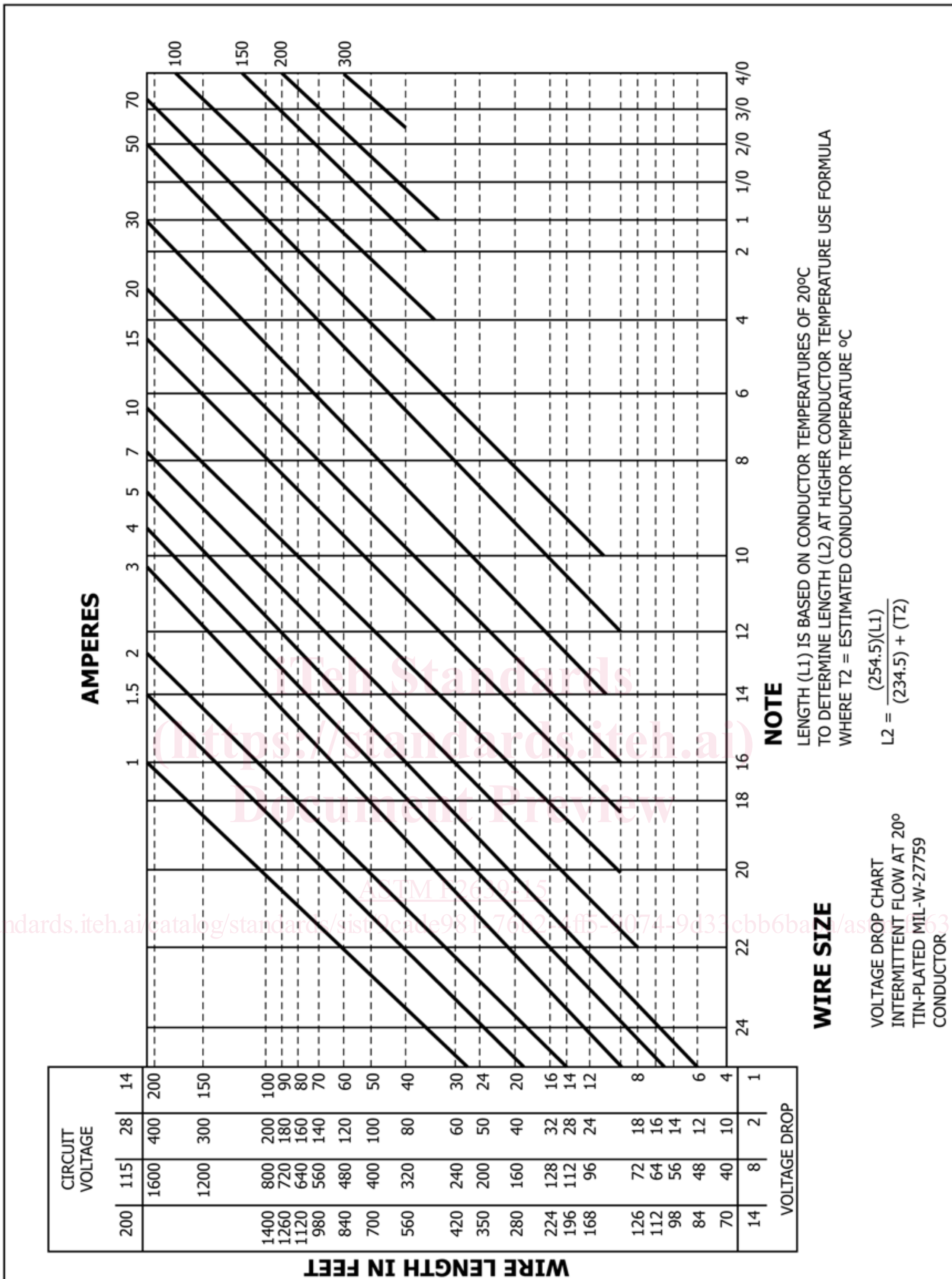

FIG. 2 Conductor Chart, Intermittent Flow

NOTE 2—See 5.2.10 for additional insulation properties.

5.1.6 For a more complete selection of insulated wires, refer to SAE AS 4372 and SAE AS 4373.

5.1.7 Wires are typically categorized as being suitable for either "open wiring" or "protected wiring" application.

5.2 *Aircraft Wire Materials:*

5.2.1 *Open Airframe Interconnecting Wire:*

5.2.1.1 *Aircraft Wire Materials*—Only wire that meets the performance and environmental standards for airborne use shall be installed in aircraft.

TABLE 4 Current-Carrying Capacity and Resistance of Copper Wire

Wire Size	Continuous Duty Current (amps)—Wires in Bundles, Groups, Harnesses, or Conduits[A] Wire Conductor Temperature Rating 105°C	150°C	200°C	Max. Resistance Ω/1000 ft at 20°C Tin-Plated Conductor[B]	Nominal Conductor Area circ.mils
24	2.5	4	5	28.40	475
22	3	5	6	16.20	755
20	4	7	9	9.88	1 216
18	6	9	12	6.23	1 900
16	7	11	14	4.81	2 426
14	10	14	18	3.06	3 831
12	13	19	25	2.02	5 874
10	17	26	32	1.26	9 354
8	38	57	71	0.70	16 983
6	50	76	97	0.44	26 818
4	68	103	133	0.28	42 615
2	95	141	179	0.18	66 500
1	113	166	210	0.15	81 700
0	128	192	243	0.12	104 500
00	147	222	285	0.09	133 000
000	172	262	335	0.07	166 500
0000	204	310	395	0.06	210 900

[A] Rating is for 70°C ambient, 33 or more wires in the bundle for sizes 24 through 10, and 9 wires for size 8 and larger, with no more than 20 % of harness current-carrying capacity being used at an operating altitude of 60 000 ft (18 288 m). For rating of wires under other conditions or configurations, see 8.2.
[B] For resistance of silver- or nickel-plated conductors, see wire specifications.

5.2.1.2 *Open Airframe Interconnecting Wire*—Interconnecting wire is used in point-to-point open harnesses, normally in the interior or pressurized fuselage, with each wire providing enough insulation to resist damage from handling and service exposure. (See Table 5.) Electrical wiring is often installed in aircraft without special enclosing means. This practice is known as open wiring and offers the advantages of ease of maintenance and reduced weight.

5.2.2 *Protected Wiring:*

5.2.2.1 *Protected Wire*—Airborne wire that is used within equipment boxes, or has additional protection, such as an exterior jacket, conduit, tray, or other covering is known as protected wire. (See Table 6.)

5.2.3 *Coaxial Cables*—Table 7 lists coaxial cables acceptable for use in aircraft. Use in aircraft of cables not listed in Table 7 requires demonstration of their acceptability for the application.

5.2.3.1 *Low Temperature Coaxial and Triaxial Cables*—Coaxial and Triaxial cables with low temperature dielectrics and jackets such as Polyethylene (–40ºC to +80ºC) shall not be used. The minimum high temperature tolerance of a cable material shall be +150ºC. Use of low temperature cables near a heat source, or in a high heat area, such as behind an instrument panel, can cause the dielectric to soften and permit the center conductor to migrate. This will result in a change of impedance and will cause high signal reflections. The resultant cable heating can damage connected equipment. The center conductor may also migrate sufficiently to short circuit the cable shielding. An acceptable cable, commonly specified in aerospace applications, is RG142. This –55ºC to +200ºC rated cable has a PTFE dielectric and an FEP jacket.

5.2.4 *Plating*—Bare copper develops a surface oxide coating at a rate dependent on temperature. This oxide film is a poor conductor of electricity and inhibits determination of wire. Therefore, all aircraft wiring has a coating of tin, silver, or nickel, which has far slower oxidation rates.

5.2.5 Tin-coated copper is a very common plating material. Its ability to be successfully soldered without highly active fluxes diminishes rapidly with time after manufacture. It can be used up to the limiting temperature of 150°C.

5.2.6 *Silver-Coated Wire* is used where temperatures do not exceed 200°C (392°F).

5.2.7 *Nickel-Coated Wire* retains its properties beyond 260°C, but most aircraft wire using such coated strands have insulation systems that cannot exceed that temperature on long-term exposure. Soldered terminations of nickel-plated conductor require the use of different solder sleeves or flux than those used with tin- or silver-plated conductor.

5.2.8 *Conductor Stranding*—Due flight vibration and flexing, stranded round conductor wire shall be used to minimize fatigue breakage on smaller gauge wire. Some coaxial cables such as RG142 use a solid center conductor although, it is a copper clad steel, which has a much higher tensile strength than a tin or solid copper and therefore is acceptable for use. A coaxial cable, which is exposed to frequent or constant flexure, should always have a stranded center conductor.

5.2.9 *Wire Construction versus Application*—The most important consideration in the selection of aircraft wire is properly matching the wire's construction to the application environment. Wire construction that is suitable for the most severe environmental condition to be encountered shall be selected. AS 50881A, Appendix A, Table A-I lists wires considered to have sufficient abrasion and cut-through resistance to be suitable for open-harness construction lists wires for protected applications. These wires are not recommended for aircraft interconnection wiring unless the subject harness is covered throughout its length by a protective jacket. The wire temperature rating is typically a measure of the insulation's ability to withstand the combination of ambient temperature and current related conductor temperature rise. AS 50881A, Appendix A, Table A2 lists wires for protected applications.

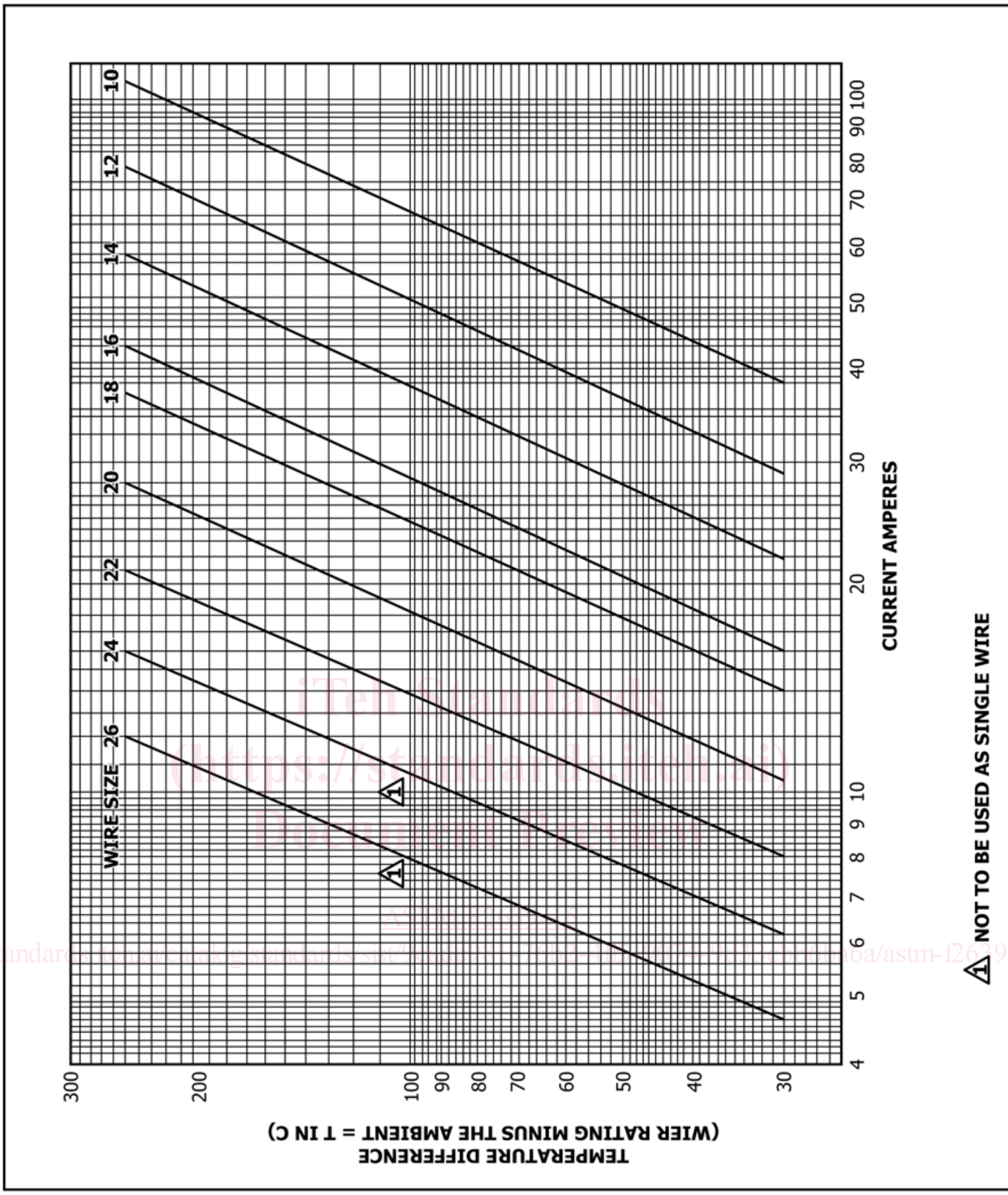

FIG. 3 Single Copper Wire in Free Air

5.2.10 *Insulation*—There are many insulation materials and combinations used on aircraft electrical wire. Characteristics shall be chosen based on environment; such as abrasion resistance, arc resistance, corrosion resistance, cut-through strength, dielectric strength, flame resistance, mechanical strength, smoke emission, fluid resistance, and heat distortion. Table 8 ranks various wire insulation system properties in a number of categories and may be used as a guide when selecting wiring insulation for a particular application.

5.2.11 An explanation of many of the acronyms used is given in 3.3.

5.2.12 *Aluminum Wire:*

5.2.12.1 Voltage drop calculations for aluminum wires can be accomplished by multiplying the resistance for a given wire size (defined in Table 9) by the wire run length and circuit current.

5.2.12.2 For aluminum wire from Table 4 and Table 9, note that the conductor resistance of aluminum wire and that of copper wire (two numbers higher) are similar. Accordingly, the electric wire current in Table 4 can be used when it is desired to substitute aluminum wire and the proper size can be selected by reducing the copper wire size by two numbers and referring to Table 4. The use of aluminum wire size smaller than No. 8 is not recommended.

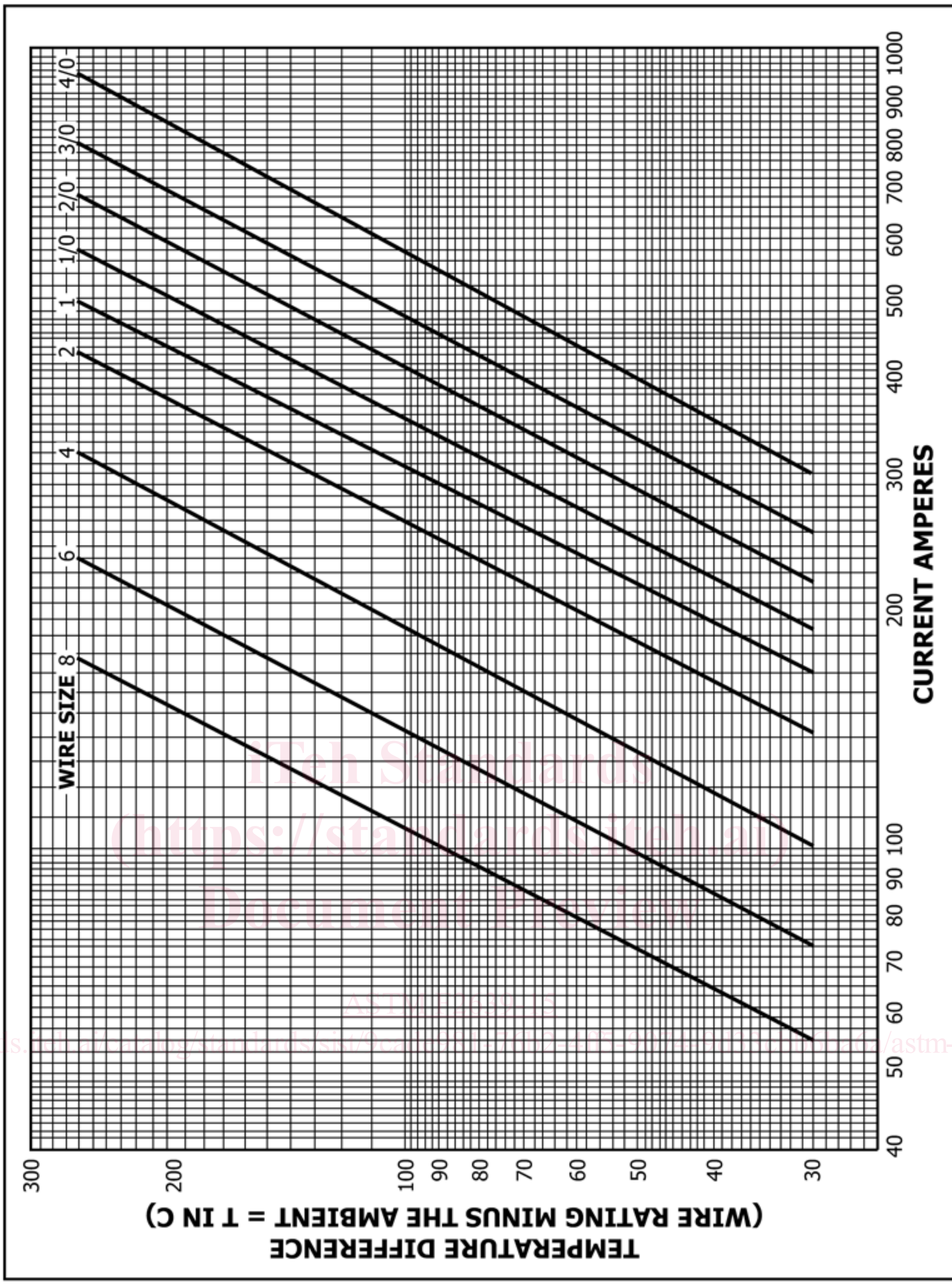

FIG. 4 Single Copper Wire in Free Air

5.2.12.3 *Aluminum Conductor Wire*—When aluminum conductor wire is used, sizes shall be selected on the basis of current ratings shown in Table 9. The use of sizes smaller than #8 gauge is discouraged (Refer to AS 50881A). Aluminum wire shall not be attached to engine-mounted accessories or used in areas having corrosive fumes, severe vibration, mechanical stresses, or where there is a need for frequent disconnection. Use of aluminum wire is also discouraged for runs of less than 3 ft (0.9 m) (Refer to AS 50881A). Termination hardware shall be of the type specifically designed for use with aluminum conductor wiring.

5.2.13 *Shielded Wire:*

5.2.13.1 *Shielded Wire*—With the increase in number of highly sensitive electronic devices found on modern aircraft, it has become very important to ensure proper shielding for many electric circuits. Shielding is the process of applying a metallic covering to wiring and equipment to eliminate interference caused by stray electromagnetic energy. Shielded wire or cable is typically connected to the aircraft's ground at both ends of the wire or at connectors in the cable. Electromagnetic interference (EMI) is caused when electromagnetic fields (radio waves) induce high-frequency (HF) voltages in a wire or

TABLE 5 Open Wiring

Document	Voltage Rating (Maximum)	Rated Wire Temperature, °C	Insulation Type	Conductor Type
MIL-W-22759/1[A]	600	200	Fluoropolymer-insulated TFE and TFE coated glass	Silver-coated copper
MIL-W-22759/2[A]	600	260	Fluoropolymer-insulated TFE and TFE coated glass	Nickel-coated copper
MIL-W-22759/3[A]	600	260	Fluoropolymer-insulated TFE–glass–TFE	Nickel-coated copper
MIL-W-22759/4[A]	600	200	Fluoropolymer-insulated TFE–glass–FEP	Silver-coated copper
MIL-W-22759/5[A]	600	200	Fluoropolymer-insulated extruded TFE	Silver-coated copper
MIL-W-22759/6[A]	600	260	Fluoropolymer-insulated extruded TFE	Nickel-coated copper
MIL-W-22759/7[A]	600	200	Fluoropolymer-insulated extruded TFE	Silver-coated copper
MIL-W-22759/8[A]	600	260	Fluoropolymer-insulated extruded TFE	Nickel-coated copper
MIL-W-22759/9[A]	1000	200	Fluoropolymer-insulated extruded TFE	Silver-coated copper
MIL-W-22759/10[A]	1000	260	Fluoropolymer-insulated extruded TFE	Nickel-coated copper
MIL-W-22759/13[A]	600	135	Fluoropolymer-insulated FEP PVF2	Tin-coated copper,
MIL-W-22759/16[A]	600	150	Fluoropolymer-insulated extruded ETFE	Tin-coated copper,
MIL-W-22759/17[A]	600	150	Fluoropolymer-insulated extruded ETFE	Silver-coated high-strength copper alloy
MIL-W-22759/20[A]	1000	200	Fluoropolymer-insulated extruded TFE	Silver-coated high-strength copper alloy
MIL-W-22759/21[A]	1000	260	Fluoropolymer-insulated extruded TFE	Nickel-coated high-strength copper alloy
MIL-W-22759/34[A]	600	150	Fluoropolymer-insulated cross-linked modified ETFE	Tin-coated copper
MIL-W-22759/35[A]	600	200	Fluoropolymer-insulated cross-linked modified ETFE	Silver-coated high-strength copper alloy
MIL-W-22759/41[A]	600	200	Fluoropolymer-insulated cross-linked modified ETFE	Nickel-coated copper
MIL-W-22759/42[A]	600	200	Fluoropolymer-insulated cross-linked modified ETFE	Nickel-coated high-strength copper alloy
MIL-W-22759/43[A]	600	200	Fluoropolymer-insulated cross-linked modified ETFE	Silver-coated copper
MIL-W-25038/3/2/	600	260	See specification sheet *	See specification sheet[B]
MIL-W-81044/6	600	150	Cross-linked polyalkene	Tin-coated copper
MIL-W-81044/7	600	150	Cross-linked polyalkene	Silver-coated high-strength copper alloy
MIL-W-81044/9	600	150	Cross-linked polyalkene	Tin-coated copper
MIL-W-81044/10	600	150	Cross-linked polyalkene	Silver-coated high-strength copper alloy
MIL-W-81044/12	600	150	Cross-linked polyalkene	Tin-coated copper

[A] MIL-W-22759 has been replaced by SAE AS 22759.
[B] Inorganic fibers—glass—TFE.

TABLE 6 Protected Wiring

Document	Voltage Rating (Maximum)	Rated Wire Temperature, °C	Insulation Type	Conductor Type
MIL-W-22759/11[A]	600	200	Fluoropolymer-insulated extruded TFE	Silver-coated copper
MIL-W-22759/12[A]	600	260	Fluoropolymer-insulated extruded TFE	Nickel-coated copper
MIL-W-22759/14[A]	600	135	Fluoropolymer-insulated FEP-PVF2	Tin-coated copper
MIL-W-22759/15[A]	600	135	Fluoropolymer-insulated FEP-PVF2	Silver-plated high-strength copper alloy
MIL-W-22759/18[A]	600	150	Fluoropolymer-insulated extruded ETFE	Tin-coated copper
MIL-W-22759/19[A]	600	150	Fluoropolymer-insulated extruded ETFE	Silver-coated high-strength copper alloy
MIL-W-22759/22[A]	600	200	Fluoropolymer-insulated extruded TFE	Silver-coated high-strength copper alloy
MIL-W-22759/23[A]	600	260	Fluoropolymer-insulated extruded TFE	Nickel-coated high-strength copper alloy
MIL-W-22759/32[A]	600	150	Fluoropolymer-insulated cross-linked modified ETFE	Tin-coated copper
MIL-W-22759/33[A]	600	200	Fluoropolymer-insulated cross-linked modified ETFE	Silver-coated high-strength copper alloy
MIL-W-22759/44[A]	600	200	Fluoropolymer-insulated cross-linked modified ETFE	Silver-coated copper
MIL-W-22759/45[A]	600	200	Fluoropolymer-insulated cross-linked modified ETFE	Nickel-coated copper
MIL-W-22759/46[A]	600	200	Fluoropolymer-insulated cross-linked modified ETFE	Nickel-coated high-strength copper alloy
MIL-W-81044/13	600	150	Cross-linked polyalkene – PVF2	Silver-coated high-strength copper alloy
MIL-W-81381/17	600	200	Fluorocarbon polyamide	Silver-coated copper
MIL-W-81381/18	600	200	Fluorocarbon polyamide	Nickel-coated copper
MIL-W-81381/19	600	200	Fluorocarbon polyamide	Silver-coated high-strength copper alloy
MIL-W-81381/20	600	200	Fluorocarbon polyamide	Nickel-coated high-strength copper alloy
MIL-W-81381/21	600	150	Fluorocarbon polyamide	Tin-coated copper

[A] MIL-W-22759 has been replaced by SAE AS 22759.

TABLE 7 Coaxial Cable Selection

Document	Part Number	Impedance (Ω)	Rated Cable Temperature (°C)	Outer Diameter, Nominal (in.)	Jacket Type/ Dielectric type
MIL-C-17/060	M17/060-RG142	50	200	0.195	FEP/PTFE
MIL-C-17/93	M17/93-RG178	50	200	0.071	FEP/PTFE
MIL-C-17/94	M17/94-RG179	75	200	0.100	FEP/PTFE
MIL-C-17/113	M17/113-RG316	50	200	0.098	FEP/PTFE
MIL-C-17/127	M17/127-RG393	50	200	0.390	FEP/PTFE
MIL-C-17/128	M17/128-RG400	50	200	0.195	FEP/PTFE