



AEROSPACE RECOMMENDED PRACTICE

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Wire and Cable Splices: Preferred Methods for Use with Automated Wire Processing Systems

RATIONALE

Suppliers of aerospace electrical wire typically supply wire and cable on reels. However, due to manufacturing limitations, it is extremely difficult to manufacture the required lengths ordered by the end user as a single piece without any faults. It is therefore the norm to supply wire and cable as multiple segment lengths on the reel to make up the required overall length for an order. Consequently, the wire or cable is either left with the unjoined ends of each segment protruding from the side of the reel, “ends out,” or with the wire segments spliced together.

It is an aerospace industry requirement that splices in wiring shall never pass through the harness manufacturing process and into the aircraft or vehicle. To help ensure this does not happen, it is typical to use a knot and splice detector on wire processing equipment, such as the laser wire markers used in the initial stages of wire harness preparation. This will automatically detect any splices and stop the wire processing machine. On an attended machine, the operator can then check the fault and, if it is a splice, manually remove this and restart the machine. As more automated machines are introduced, there is a need for splices to be not only automatically detected but automatically managed and rejected by the machine. This will require the splices to be of a size and form that can easily pass through the machine without operator intervention. In this way, the machine can detect a splice, reject the wire in process, and restart production to remanufacture the faulty wire, and then continue in operation without the need for manual assistance. This feature is critical to automatic systems where there may not be an operator immediately on hand and particularly for “lights out” operation on an unattended overnight shift.

Where wire is spliced, there are no standards applied and no guidance on how to join the wire ends. Wire manufacturers and distributors therefore use a range of in-house methods for splicing the wire they supply. This can often result in unacceptable, bulky splices that can be too large to pass freely through a typical wire processing machine. Such unacceptable splices are a distraction to manufacturing that cause unplanned downtime. Dependent on machine design, improper splices could cause wire jams that require maintenance intervention. As a result, wire waste multiplies, production comes to a halt, and costs increase. While an operator can manually remove the splice on an attended machine, this becomes an impediment to automated wire processing machines. It is therefore necessary to define the methods and the physical forms for splicing wires to facilitate the automated processing of splices on an automatic wire processing machine, such that it can continue operation without requiring operator intervention to resolve the problem of a splice once detected.

This SAE Aerospace Recommended Practice (ARP) aims to set out acceptable means and forms of splices that will generally support the use of automated wire processing equipment.

Discussion of splice techniques in this ARP are focused on their suitability for automated wire processing equipment and are not intended to represent all manufacturing or user needs for splices, splice design, or splice quality.

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1. SCOPE

The purpose of this ARP is to provide information on splices, and the definition of the preferred methods of splicing single core wires and multi-conductor cables supplied on reels by vendors, to facilitate their processing on automated wire processing systems to allow continued uninterrupted machine operation without requiring operator intervention.

2. REFERENCES

2.1 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.1.1 NASA Publications

Copies of these documents are available online at <https://standards.nasa.gov/>.

NASA-STD-8739.4A Workmanship Standard for Crimping, Interconnecting Cables, Harnesses, and Wiring

2.2 Definitions

CABLE: 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 a common covering, or one insulated conductor with a metallic covering shield or outer conductor.

COMPONENT: For the purposes of this document, this shall be an electrical wire or multi-conductor cable.

GAUGE: The wire size specified for a wire in a wire harness assembly by the wire harness assembly drawing.

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.

INSULATION: For the purposes of this document, the outer polymer covering of an electrical wire or multi-conductor cable.

JACKET: An outer protective covering for a cable.

PURCHASER: A purchaser is an activity that can issue a purchase order or contract.

SPLICE: The means of joining the ends of two discontinuous wire or cable segments together. This may be tying, knotting, taping, crimping, soldering, or otherwise joining the ends together to provide a single continuous filament and to create a strong attachment.

SUPPLIER: A supplier is an original equipment manufacturer (OEM) or a value-added manufacturer which has design and/or production control of the processes used to produce the final product in accordance with the document.

VERIFICATION INSPECTION: Verification inspection is a process that demonstrates that a product is capable of fully conforming to all the requirements defined in a standard. Verification inspection includes definition of the measurements, tests, analysis, and associated data that provides consistent rationale for acceptance of a particular supplier's design as meeting the standard requirements typically prior to acquisition by the purchaser.

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 document, "wire" refers to insulated electric wire.

3. TYPES OF SPLICES

Wire and cable manufacturers face significant difficulties in producing long continuous lengths of wire and cable without encountering manufacturing defects. These may be pinholes or lumps and bumps in the insulation or other faults. In any case, where these defects occur, they need to be excised from the wire to ensure they are not incorporated into harnesses and eventually pass through into the aircraft. When a wire defect is detected during production, manufacturers mostly cut the wire and remove the faulty section before either splicing the wire or leaving it unspliced. In some cases, they may just remove the insulation with a “skin splice” leaving the conductor intact.

Manufacturers of wire and cable, along with end users, have developed and employed a range of splices over time for joining the ends of wires and cables for various purposes. However, there has been no clear guidance to date regarding the form of splices to be used when supplying wire and cable on reels for use in harness production. Examples of splices used in industry include the following.

3.1 Skin Splice

A skin splice is created by taking a faulty section of wire and removing the insulation along a length of the wire on either side of the fault to expose the bare conductor. In this case, the wire or cable is not cut and remains intact, so this is not a true splice in the full sense of the word. As such, there is no requirement to join the wire or cable ends together.



Figure 1 - Example of single core wire with skin splice

3.2 Butt Welded Splice

A butt welded splice is created by cutting out the faulty section of wire and stripping back the insulation to expose the conductors on the two wire ends. The cut ends are then placed together and welded to form a joint. The resulting joint should be of the same diameter as the conductor.



Figure 2 - Example of single core wire with butt welded splice

3.3 Crimped Butt/In Line Splice

A crimped butt/in line splice is created by stripping back the insulation to expose the conductors on two wire ends and then crimping the cut ends together to form a joint. This may be done with insulating or non-insulating crimps.



Figure 3 - Example of single core wire with uninsulated crimped butt splice