AEROSPACE INFORMATION REPORT

AIR5717

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Mitigating Wire Insulation Damage During Processing and Handling

RATIONALE

AIR5717 has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE

Wire and cable products progress through a series of handling or operational steps from the time they leave the manufacturer, and until a finished harness or assembly 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.

1.1 Application

This document discusses the various forms of wire and cable damage that may occur in an aerospace manufacturing environment. Characteristics of the different types of processes and/or equipment are described and associated with the types of damage as applicable. Mitigating actions are suggested where possible.

2. RELATED DOCUMENTS

There are no referenced publications specified herein.

3. EVIDENCE OR INDICATIONS OF DAMAGE

3.1 Insulation or Jacket Shrinkage

Insulation shrinkage (snapback), normally, is not immediately evident and is only discovered later in processing, or harness fabrication when the wire is cut or heated and the insulation 'snaps back'. Excessive tension on the wire will stretch it causing the entire wire to elongate. Constant tension on the wire or jerking will yield the same results. The conductor will yield, but the insulation remains in the elastic region of its stress-strain curve. Thus, when tension is relieved, and the insulation is free to move, it will return to its original dimension exposing the conductor. Frequently, this is the only evidence that the wire has been under too much tension. Measurement of conductor properties will usually not reveal the prior existence of too much tension. Wire manufacturers routinely monitor insulation shrinkage as a check of their processing conditions in addition to a constant monitoring of tension.

3.2 Abrasion and Cuts

Here, the surface of the insulation will show scuff marks from contact with rough surfaces. The culprits may be rough or improperly sized wire guides, sheaves that do not rotate, or counter wheels and pinch rollers, with rough or serrated surfaces. Serrated rollers/wheels, under too much pressure, frequently leave "tractor marks" along the surface of the insulation. If the serrations are sharp, and the impressions deep, it is possible to observe insulation cuts in some cases.

3.3 Crushing or Flattening

Crushing and flattening can occur in many situations and processes and is frequently the result of the actions of careless personnel. It is usually the result of having too much force applied by a pinch roller and its corresponding wheel. Not all systems work in the same manner. Some may be set for a predetermined force that remains constant even with dimensional changes in the wire or cable. Some may lock into position once a preset force has been reached. There have been cases where processing twisted, shielded and jacketed cables, with this type of mechanism, has caused crushing to the point of shorting the conductors of the twisted pair together without any external evidence of damage. Conductor exposure in primary wires, removed from cables, has also been observed.

3.4 Conductor Kinking

The same conditions that lead to insulation shrinkage can cause conductor kinking. The most insidious cases are with small gauge, foam dielectric coaxial cables. In these cases, when the dielectric snaps back, it causes the conductor to compress and form an omega-shaped kink. Eventually, this kink will short to the shield or even penetrate it. In very extreme cases, conductor kinks have been seen in primary wires.

Small gauge, foam dielectric coaxial cables are subject to misidentification as to their true nature and are handled as if they were a large gauge, primary wire. They are then subjected to excessive tension and tight bend radii that can create internal damage and kinking.

3.5 Jacket Wrinkles

Jacket wrinkles are a sign that the cable has been bent tighter than its specified minimum unsupported bend radius, as defined in AS50881. Wrinkles become a problem when pulling cables during an installation. Wrinkles are easily caught, snagged, and ripped. Also, the use of a hot-air gun can heat-set the wrinkles such that, when unbent, the wrinkles crack. This is a heat-set problem, not a loss of jacket elongation.

3.6 Twisting (“Live” Cables)

All wires, when bent over a radius, will tend to rotate (torque) axially due to their stranded conductors. The same mechanism can be present in multi-conductor cables with twisted primaries. Thus, de-reeling of wires, and running them over sheaves, will tend to introduce a certain amount of twist in the wire. This is visible in wire marking systems as evidenced by a series of marks that slowly spiral around the axis of the wire. Reversing the direction of bend over successive pulleys or sheaves can minimize twisting. Extreme twisting will create a ‘live’ wire, or cable, that tends to be unmanageable. Also, a live cable can be created during its manufacture if proper processes are not used.

3.7 Reel Set

This is usually evidenced by the wire or cable forming tight coils as it is removed from a spool. This is a result of respooling onto spools with hub diameters that are less than recommended by the specification. This can occur in a user’s shop or from a distributor that breaks down large lots.

4. PROCESSES AND OPERATIONAL STEPS

Many of these processes listed below can occur more than once, and in various sequences, during the journey from the wire and cable manufacturer and up to the final installation on the vehicle. Frequently, a specific type of damage can be associated with more than one process (see 3.).

4.1 Packaging, Transportation, and Storage

This can be a potential area for abrasions and cuts.

Manufacturers try to package reels and spools to survive reasonable transportation conditions, but the unexpected can always happen. Careless forklift operation can penetrate boxes or protective wraps on large reels. Outdoor storage can invite water damage or ingress of moisture laden air into the conductor due to temperature cycling. Long-term storage should be in a temperature and humidity controlled environment. Always inspect packaging for mechanical or moisture damage upon receipt.

4.2 Handling Reels and Spools

Abrasion, cuts, crushing, and tangles are prominent problems.

Unrestrained wire or cable ends are prone to damage if not secured within the confines of the reel flanges. Loose ends may be crushed by the spool flange itself or actions by personnel who are not observant.

If samples are removed from a spool, always rewind tightly and secure the ends. Handling of spools with unsecured wire or cable can cause layers to shift and create tangles.

These types of problems also may cause personnel injuries.

4.3 Payoffs, Take-ups, and Respooling

These processes have the potential for creating all of the identified forms of damage.

Start-stop processes, such as automated cut and strip operations, can also stretch wires due to jerking motions unless closed-loop controllers are used. Another source is the most basic of de-reeling set-ups where a spool, or reel, is supported on a horizontal shaft, and the wire, or cable, is pulled off by hand. If the weight of the total spool is very large, it can require considerable force to start the de-reeling process. Another complication is that the spool is usually left to revolve on its own, thus leading to loose, overlapping coils that then become tangled. This is identical to the birds-nests that occur on fishing reels.

High-speed systems, such as marking lines, automated cut and strip operations, and commercial respooling lines, are often supplied as integrated packages. That is, they will have powered payoffs and take-ups, tension control via feedback loops, and, frequently, wire accumulators (dancers). These features are designed to control the acceleration and deceleration of the wire and ultimately the tension on the wire. When building an “in-house” system, these features should be incorporated. Failure to do so may result in wires being subjected to sharp jerks or excessive tension.

When paying off from a revolving spool, always pay off from the bottom of the spool. Again, tightly secure the ends before removing the spool.

As the quantity of wire on a large spool is used up in processing, it is frequently a common practice to respool it onto a smaller capacity spool. Care should be taken to use a spool with the same hub diameter as was used originally. Hubs that are too small will introduce “reel set” and will result in unmanageable wire. The same precautions should be observed for take-up spools in “single-filament” operations where multiple lengths of wire are marked and taken up as one length to be cut up at the harness board level. In this sort of system, a closed-loop, tension control system is absolutely mandatory.

4.4 Marking, Measuring, Cutting, and Coiling

These processes share many of the similarities found in Section 4.3.

Some systems use driven wheels and pinch rollers to move the wire through the system. If the various parts of the system are not synchronized, the wheels may be trying to move the wire while another part of the system has stopped the wire. This is not uncommon in rapid start-stop processes such as automated cut and strip operations.

These systems may cause stretched, crushed, or abraded wire. If any damage is noted, trace the wire as it goes through the process to see where damage is occurring. The output of some systems may go into coiling pans while others may have takeup spools. In the latter is used, be aware of spool hubs that are too small.

4.5 Stripping and Termination

Some of the concerns here are abrasions, cuts, and crushing.

Sometimes these processes are semi-automated. Attention should be directed at grippers used to hold the wire. Even in hand stripping, an incorrect gripper choice can damage the insulation of a wire. In a fully automated system, all of the previously noted processes come into play.