Evolution of ISO High Voltage Copper Cable Standards for Vehicles

Cable standards for vehicles have evolved significantly over time. For decades standards were typically regional in nature; SAE for North America, JASO for Asia and ISO-6722 and LV-112 for Europe. There were both similarities and differences of varying extremity between these standards.

In the early 2000's, ISO 6722 began emerging as the global standard for unscreened single-core copper vehicle cables, although other regional and OEM standards existed and continue to be used today.

In 2001, ISO 14572 was introduced to address single and multi core copper cables, with screened and unscreened options. 14572 referenced 6722's single-core standards. In 2011, ISO 6722-1 was published which was a revision of ISO-6722:2006. In 2013, ISO 6722-2 was published to address aluminum conductors in unshielded, single-core cables.

Still, emerging market technologies needed a single, more comprehensive standard. Higher voltages were being used in EV/HEV technologies, cable geometry and insulation material performance was affecting connector sealing, and cable flexibility continued to become more critical for both application demands and human ergonomics.

In 2019, ISO 19642 was published to expand upon and consolidate 6722-1, 6722-2 and 14572 into one standard. 19642 is divided in to 10 sections addressing terminology, test methods, and dimensions; plus it breaks out cable groups by low vs. high voltage, copper vs. aluminum, single vs. multi-core, and screened vs. un-screened. 19642 was written to allow for future expansion as technologies emerge.

With regard to high-voltage copper cables (sections -5 and -9 of 19642), the consolidation resulted in mostly minor modifications to the original standards. However there are eight somewhat pronounced differences affecting HV cables that this document will review.

CHAMPLAIN CABLE

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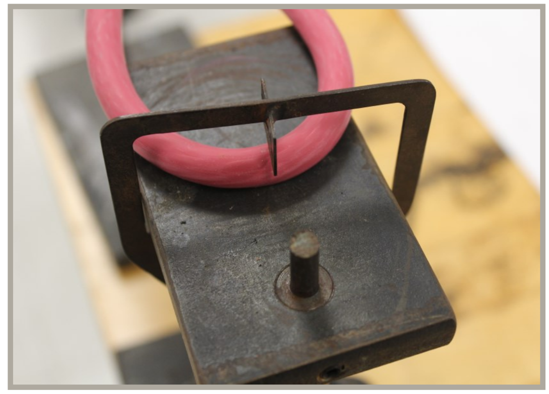
1 - Cable Deformation Test is Defined

"Compression Set" is the tendency of cable insulations to permanently deform due to pressure at elevated temperatures. This deformation can cause failure at a connector seal, allowing ingress of water or other material which can cause electrical failure. ISO 6722-1 contains a high temperature pressure test procedure, but it's only criteria is voltage withstand. There is no test or criteria that addresses the physical amount of deformation under temperature and pressure.



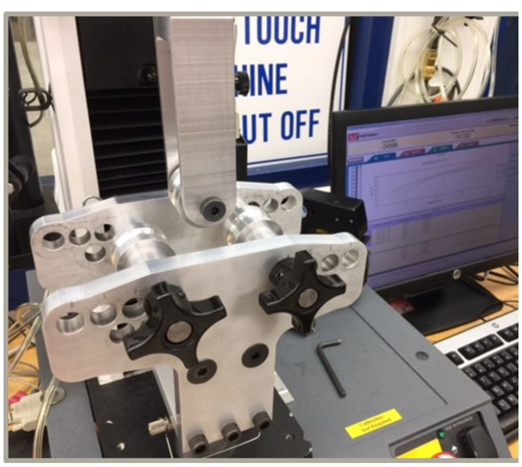
Pressure Test at High Temperature

19642-9 keeps a provision of 14572 which defines the maximum deformation under a specified load at rated temperature. The requirement is 40% retention of original cable diameter, or 60% compression/deformation. However, the test is optional at the OEM's choosing, as well as the retention/deformation percentage criteria. Several OEM's have established 80% retention minimum, or 20% maximum compression/deformation in order to ensure integrity of the cable/connector interface under operating temperature and pressure. Higher retention requires a thermally robust cable insulation. Many existing cable insulating materials cannot meet these higher retention criteria.

Takeaway: Although optional, 19642-9 defines a test methodology for jacket deformation which can help to ensure long-term connector sealing performance.

2 - Cable Flexibility Is Defined

Cable flexibility is important for cable routing in tight areas and also for human safety and ergonomics. Traditionally, "flexibility" was subjective with no quantitative criteria.



Flex Force Device

19642-5 and -9 define test methodology and criteria in order to define cable flexibility. The procedure calls for a cable sample to be placed on top of two mandrels of specified size and distance, and a 3rd mandrel presses down on the sample and measures the force required to bend the cable for a specified offset.

Takeaway: 19642-5 and –9 provide methodology to measure and quantify cable flexibility.

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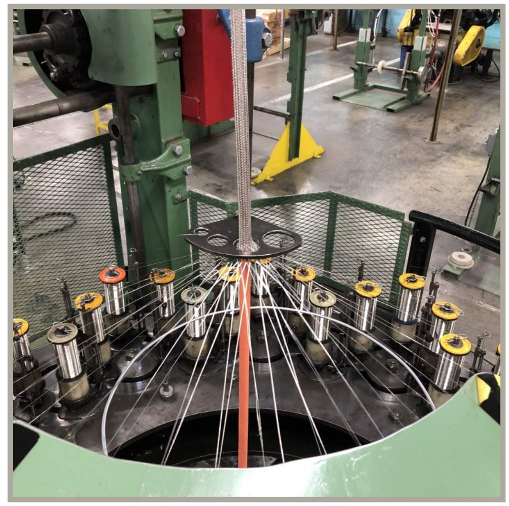
3 - Screening Effectiveness is Revised

Screens / Shields are used on HV cables to minimize emissions of Electromagnetic Interference (EMI). The effectiveness of the screening can be an important factor in HV cable selection. Screens/shields on HV cables are designed to reduce the transfer of interference from the cable out to the environment where EMI can corrupt digital signals and electronics.

19642-9 modifies the screening effectiveness test requirements of 14572 and defines parameters for screen/shield DC Resistance, Surface Transfer Impedance, and two measures of Screening Attenuation. These tests are optional as determined by the OEM, and if required, criteria must be set and achievable with existing shield/screen cable design.



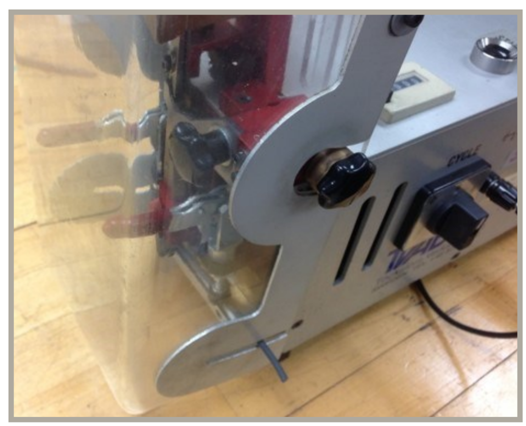
Screen / Shield Application

Take Away: Screening effectiveness is an important factor in HV cable performance and is refined and updated in 19642-9.

4 - Abrasion Testing Becomes Required

The abrasion resistance of a cable determines the life of the cable when in contact with a rough surface under dynamic movement or vibration. Both ISO 6722-1 and 14572 had abrasion tests as optional tests.

19642-5 requires that cables 0.35mm2 to 6.0mm2 meet one of two abrasion tests; sandpaper or scrape. Of note, 0.13mm2 and 0.22mm2 sizes were included in 6722-1, but omitted in 19642-5.



Scrape Abrasion Test

Sandpaper Abrasion Test

Take Away: 19642-5 requires at least one abrasion test for 0.35mm2 - 6.0mm2 wires, which ensures adherence to a benchmark. These were optional tests in 6722-1 and 14572. Sizes larger than 6.0mm2 do not require an abrasion test.

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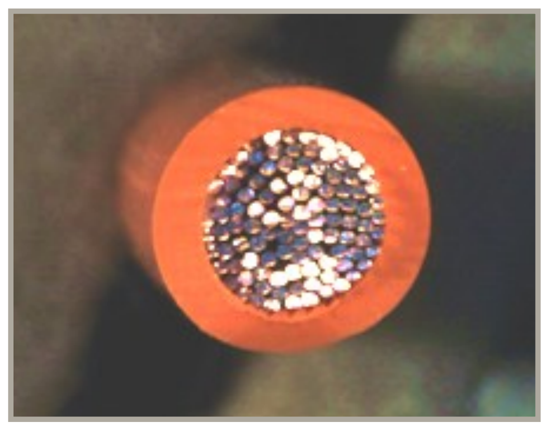
5 - High-Voltage Becomes Better Defined

19642-5 and –9 address multiple high voltage options. 6722-1 and 14572 defined high-voltage as only 600V (DC or AC). 19642 further defines high voltages as 600VAC/900VDC, and 1,000VAC/1,500VDC.

Takeaway: 19642-5 better defines high voltage by adding DC references, and adding a 1,000VAC/1,500VDC category.

6 - Conductor Requirements are Revised

ISO 6722-1 allowed three stranding options: Class A Symmetrical, Class B Asymmetrical, and Class C Asymmetrical Flex. Strand size, number of strands, and maximum resistance were defined. However conductor cross sectional area (CSA) was not defined. ISO 14572 referenced 6722-1 stranding. The criteria rested solely with conductor resistance as no criteria existed for strand size.



Conductor Cross-Section

ISO 19642-5 reduced the stranding options to two; Standard and Flexible. This change resulted in improved standardization and consistency. In sizes larger than 2.5mm^2, the strand options resulted in higher flexibility of all conductor classes.

Furthermore, cross sectional area requirements were added, which results in more consistent cable dimensions and works in concert with existing conductor resistance criteria to ensure that a minimum copper content requirement is met by all suppliers.

Take away: 19642-5 conductor stranding is generally more flexible, and better defined resulting in improved conductor requirements overall.

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7 - OD Tolerances Become More Defined

ISO 14572 mentions single and multi-core dimensions and cable ovality, but the only criteria is meeting the customer requirement. This led to an array of cable and connector dimensions across the market, diminishing cable & connector interoperability. Additionally, suppliers were forced to support multiple part numbers. 19642-9 provides suggested dimensions for single and multi conductor cables, thin and thick wall; and a maximum ovality of 10% measured immediately after extrusion.

Terminated Screened HV Cables

Takeaway: 19642-9 brings consistency to cable dimensions, which improves interoperability and serves to reduce the number of customized cables and connectors, ultimately reducing cost .

8 - Fluid Resistance Procedures Change

The evolution of ISO-6722, 6722-1 and 19642-5 significantly changed fluid resistance test procedures. 6722's procedure was a 20hr immersion in the required fluids at 23°C, followed by a winding and voltage test.

6722-1 established a new "Test Method 1" which required a 10 second immersion in the required fluids followed by heat age at rated temperature. This was repeated 4 times. The cumulative heat age was 1,000hrs followed by a winding and voltage test.

Cables Immersed in Fluid per 19642

6722-1 also allowed "Test Method 2" for materials marketed to the industry prior to the publication of 6722-1. This test method was the old 6722 procedure and criteria, and could be used by customer / supplier agreement.

19642-5 keeps 6722-1 fluid procedures, and eliminates the option of using the original 6722 20hr immersion procedure.

Take away: Materials that pass Test Method 1 may or may not pass Test Method 2, and vice-versa. OEM's should be aware of their fluid resistance needs and address as necessary.