GLOW WIRE TESTING FOR THE APPLIANCE INDUSTRY

White Paper

BACKGROUND:

Safety is paramount in the home appliance industry. Due to the possibility of human mis-application, over-current, or short circuit failures within an appliance wiring system, fire protection requirements were created to evaluate and rate the flammability of material used within an appliance. Glow wire testing is one such requirement used within the appliance industry today.

This paper explores glow wire testing, describes the rationale behind the glow wire test procedures and briefly compares the practice to other common flammability test methods. The paper also sheds light on the specifications governing the glow wire testing practice. Finally, it shows TE Connectivity's commitment toward providing a range of products to help appliance customers meet the glow wire flammability requirements.

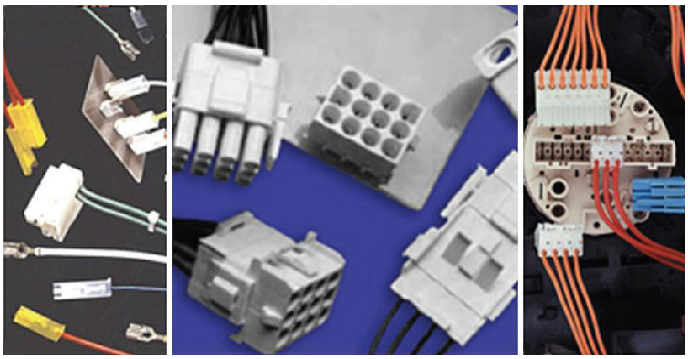
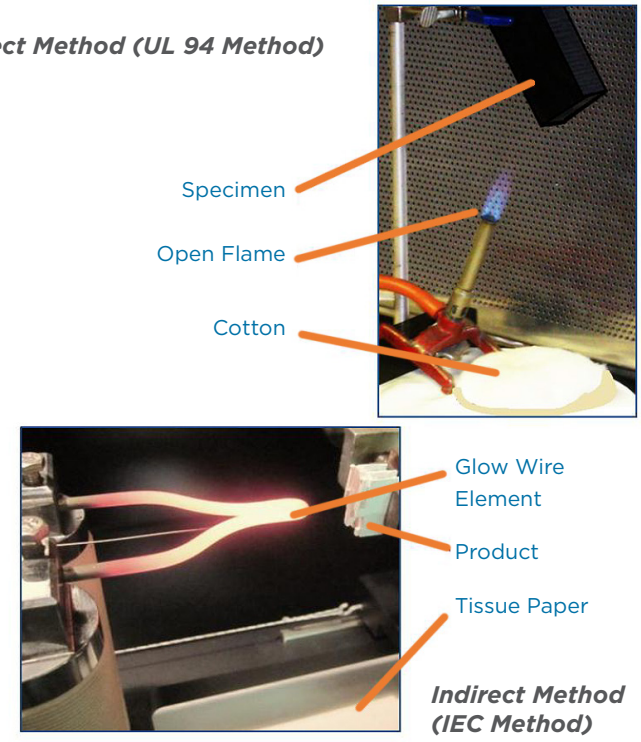


FIG. 1: *TE Connectivity offers an array of products that comply with EC 60335-1 Glow Wire flammability requirements.*

FIG. 2: *Direct open flame method (UL 94) and Indirect method (IEC Glow Wire Test).*



What Is Glow Wire Testing?

Historically many methods have been developed to evaluate material flammability and fire resistance. These include both direct flame and indirect flame testing methods. An example of the direct flame method is defined in the UL 94 specification. This long-accepted test method involves applying a flame directly to a vertically or horizontally mounted specimen under controlled conditions. On the other hand, the indirect flame method features a non-flaming heat source, such as an energized nichrome wire then applied to a specimen. Glow wire testing is an example of the indirect flame method. Test results from applying these methods provide a way to compare the materials' tendency to resist ignition, self-extinguish flames (should ignition occur), and ability to not spread or propagate fire via dripping. Visually it may be easier to better understand the differences between the direct method and the indirect method, refer to Figure 2.

The International Electrical Commission (IEC) established the glow wire testing method in 2001 because existing test methods did not cover all ignition sources. Specifically, the glow wire test is used to simulate heating effects that may arise in malfunctioning electrical equipment caused by an overloaded connection or component that is overheating.

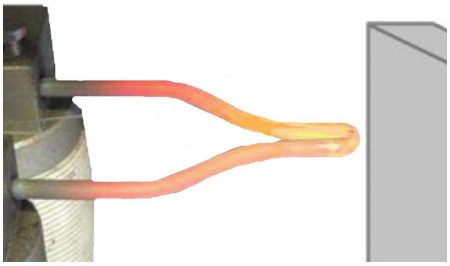


FIG. 3: *Typical glow wire setup showing heated element glowing red/yellow in color. (Temperature set to 750°C).*

Glow Wire Test Methodology

Glow wire requirements for home appliances are specified in IEC 60335-1. However, the actual glow wire test methodology and procedure is covered in the IEC 60695-2 series of specifications.

Glow wire testing is performed by energizing a heating element to a pre-determined temperature. The heated element is referred to as the "glow wire." See Figure 3 for an example of the setup typically used for the glow wire test. Preparing for the test the sample is fixed in place and a thin cotton fiber cloth or "tissue" paper is positioned directly below the sample. After reaching the pre-determined temperature, the element is then inserted and pressed into the specimen under a pre-set force of 1N for 30 seconds. If ignition occurs, measurements are made recording the ignition start time, duration, flame height, and in the case of drips, notes regarding if the drips ignited or charred the fibers of the tissue paper. The test is repeated using new specimens and performed a minimum of three times, with changing of the mounting orientation so that each unique surface is represented.

Glow wire testing is performed on both end products and raw material test plates. The terminology used to define compliance in each case is slightly different.

1. GWEPT stands for glow wire on end product test (IEC 60695-2-11). GWEPT is used when glow wire testing is performed in the manner from how the product is sold and applied in application. The results of this test will be either PASS or FAIL at a given temperature; however, there is additional criteria for each temperature setting. Generally, passing the test requires that the specimen does not ignite or self-extinguishes within a set period and with no ignition or charring of the paper fibers placed underneath if dripping occurred.
2. GWFI stands for Glow Wire Flammability Index (IEC 60695-2-12). This is a property associated with raw material used in the end product. This property is determined by conducting the glow wire test on a test plate of a raw material of a given thickness. The glow wire flammability index (GWFI) is the highest temperature at which the material does not ignite or self-extinguishes within 30 seconds after removal of the heated element, there is no ignition of a wrapping paper or the specimen is not totally consumed.
3. GWIT stands for glow wire ignition temperature (IEC 60695-2-13). This is a property associated with raw material used in the end product. This property is determined by conducting the glow wire test on a test plate of a raw material of a given thickness. The glow wire ignition temperature (GWIT) is the lowest temperature at which the material ignites and burns for longer than 5 seconds while the heated element is in contact with the test plate, there is no ignition of a wrapping paper or the specimen is not totally consumed.

Knowledge of the three terms is essential to understand how glow wire testing is applied under the overall safety standard IEC 60335-1.

Glow Wire Testing and IEC 60335-1: Safety of Household and Similar Electrical Appliances

IEC 60335-1 is a general specification that governs the safety of household appliances. Within the specification, glow wire testing is used to evaluate flammability of non-metallic materials supporting current carrying components used within the appliance.

The glow wire test severity prescribed in IEC 60335-1 is determined by whether the appliance is attended or unattended during use, and by the amount of current that is carried by the connection. Attended appliances are basically any appliance that is operated by an attending consumer such as vacuum cleaners, irons, and coffee pots. Unattended appliances are those that are set in place and operated with little supervision. Such examples include refrigerators, cooking units, dishwashers, washing machines, and dryers.

To comply with this specification, three levels of flammability evaluation may be required: components used in an application that is categorized as unattended with current greater than 0.2A are subject to the most severe evaluation.

- To pass the first level of evaluation, the material must have a minimum GWFI 850°C OR the end product must pass the glow wire test at 850°C. It is important to note that for the end product to pass, the sample must self-extinguish within 30 seconds as identified in the above passage. The test is subject to the procedure 60695-2-11.
- To pass the second level of evaluation, the material must have a minimum of GWIT 775°C OR the end product must pass the glow wire test at 750°C or the material has a minimum of GWFI 750°C or it should be checked to see if the part meets the small parts criteria. It is important to note that if the end product is tested, any ignition must self-extinguish within 2 seconds or the surrounding components must pass a third level of evaluation.
- The third level of evaluation (performed only if the connector exhibits a flame for longer than 2 seconds) is not performed directly on the connector, but instead is performed on all components within the appliance falling within a theoretical envelope of a vertical cylinder of 20 mm diameter by 50 mm long above the connector. Components within the envelope made from a material that has a minimum flammability designation as UL 94 V1 are not subject to further evaluation. However, components within the envelope that have less than UL 94 V1 are subject to a needle flame test.

Refer to the flow diagram located in Appendix A for an illustration of the testing required for materials supporting connections carrying current greater than 0.2 A in unattended appliances.

Connectors used in appliances that are categorized as unattended with a current less than 0.2A or categorized as attended appliances are subjected to less severe testing methods. It is important for the appliance manufacturer to understand the appropriate categorization of their finished product, to apply the correct level of testing per IEC 60335-1 to the components.

This document covers a summary version of the IEC 60335-1 standard where it applies to GWEPT on appliance connector products. It is important for individuals who rely on meeting the requirements of the IEC 60335-1 standard do obtain a copy of the latest standard and closely follow the detailed guidelines provided.

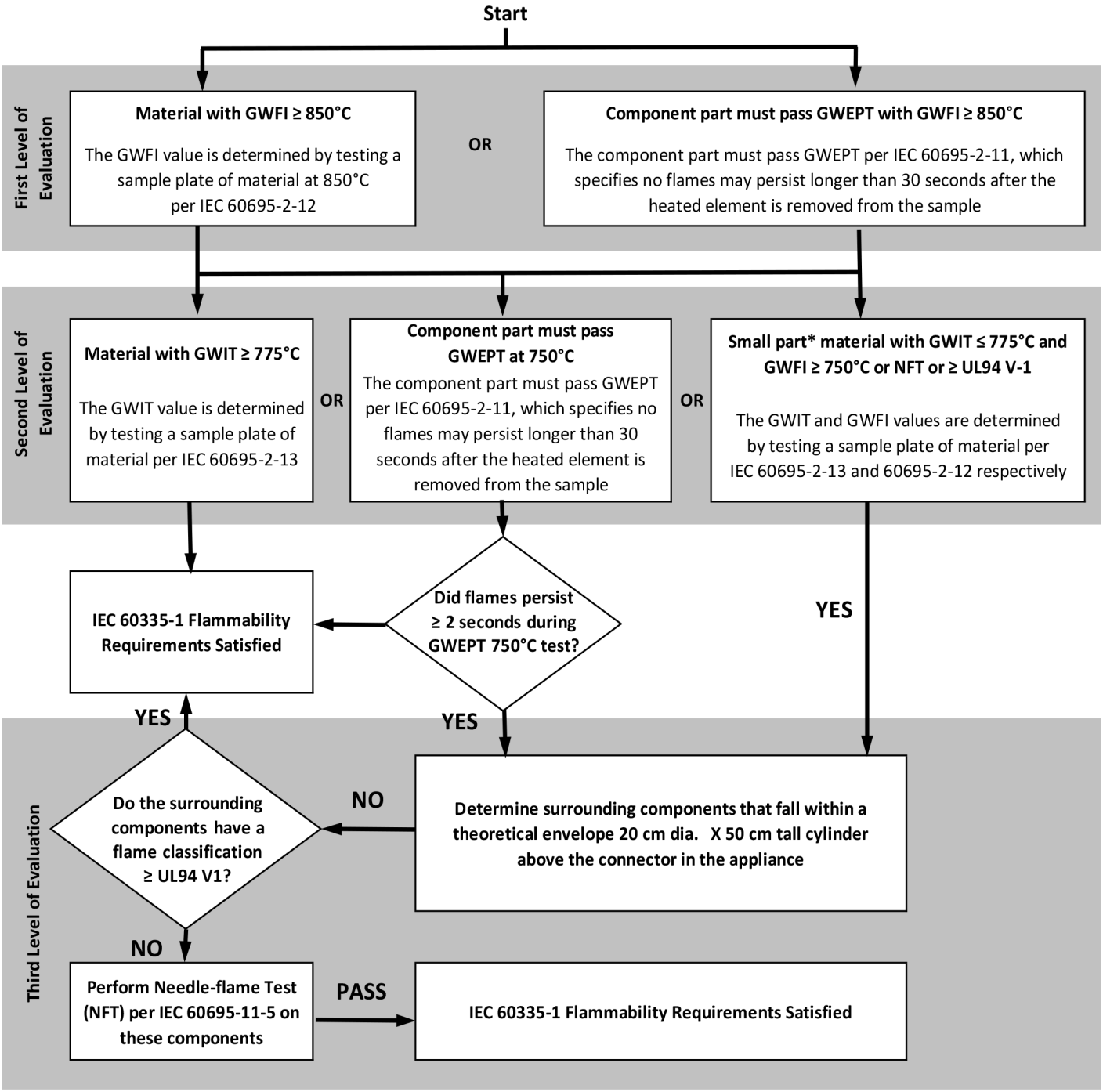
Conclusion

TE Connectivity is committed in providing a range of products to help appliance customers meet the flammability requirements of IEC 60335-1. TE is continuously evaluating new resins to determine if these materials are suitable for applications where glow wire compliance is needed.

It is important to keep in mind that GWFI and GWIT values are derived from testing performed on test plates, while the GWEPT is performed on end products. Our experience has shown that simply using a resin material based solely upon data card values for a material used in a component will not always produce a component meeting the glow wire test (GWEPT). This is why it is necessary to perform the evaluation. **At TE, we strive to eliminate any doubt regarding the performance of our products in glow wire test. Because of this, TE Appliances team only declares a product to be "Glow Wire Compliant" when the end "component" has satisfactorily passed TE testing. TE testing follows the most stringent current glow wire requirements within the IEC 60335-1 and UL standards. Please look to TE Connectivity to answer any questions regarding our commitment to offering the best solutions for your needs.**

APPENDIX A:

Summary: Flammability Requirements of IEC 60335-1, Edition 5.1 for Components Carrying ≥0.2A Current and Parts Within 3 mm In Unattended Appliances



**Refer to Appendix B for explanation of small part*

APPENDIX B:

Explanation of Small Part:

If a part has a material GWIT less than 775°C and a GWFI greater than 750°C, or the material already passed the needle-flame test (NFT), or the material has a flammability rating UL94 V-1 or better, it can satisfy the IEC 60335-1 flammability requirement. This step is a visual check to see if the part surface is considered a "small part" or too small to effectively test with the heated glow wire. To determine this, the surface of the part tested must be measured and compared using two theoretical concentric circles. These circles are 8 mm and 15 mm in diameter. A part surface must be larger than the 8 mm diameter circle, representing the tip area of the heated glow wire element, while at the same time is larger than a 15 mm diameter circle, representing the clamp holder of the part. The 15 mm diameter circle is referred to as the grips within the IEC 60335-1 standard. So, for example, if a test specimen has a GWIT ≤775°C and GWFI ≥750°C and is a flat plate less than 8 mm in thickness, the edge surface of the plate is considered small part and is too small to test with the glow wire element. For cases like this, a needle-flame test (NFT) is required to test the surface and surrounding components need further testing in application. Refer to Figure 4 for visual interpretation and Figure 5 to show examples of the circles as applied to TE connector parts.

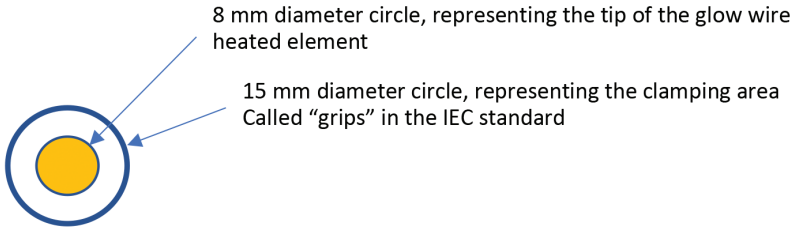
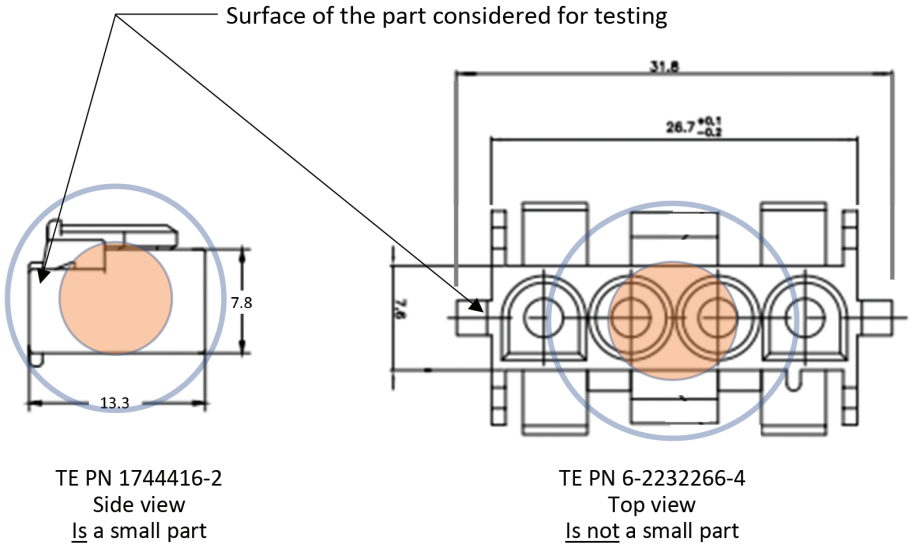


FIG. 4: *Visual interpretation of the definition of a small part.*



TE PN 1744416-2
Side view
Is a small part

TE PN 6-2232266-4
Top view
Is not a small part

FIG. 5: *Examples with circles applied to common TE connector products.*

APPENDIX C:

Glossary of Terms:

Attended – Refers to *"Attended Appliance."* Person is present with the appliance during normal operation. Opposite of *Unattended*.

Current – Electrical Current. Flow of electric charge through an electrical conductor (wire).

End Product – In the context of glow wire testing, it refers to the connector, housing, or insulator product used in conjunction of making a connection.

GWEPT – Glow Wire Test, performed on end product per IEC 60695-2-11.

GWFI – Glow Wire Flammability Index, property associated with raw material used in the end product. GWFI is the highest temperature at which the material does not ignite or self-extinguishes within 30 seconds after removal of the heated element per IEC 60695-2-12.

GWIT – Glow Wire Ignition Temperature, property associated with raw material used in the end product. GWIT is the lowest temperature at which the material ignites and burns for longer than 5 seconds while the heated element is in contact with the test plate per IEC 60695-2-13.

IEC – International Electrotechnical Commission. IEC is a non-profit, non-governmental international standards organization that prepares and publishes International Standards for all electrical, electronic and related technologies.
http://www.iec.ch/

Needle Flame Test – Test used to simulate the effect of small flames. A 12 mm high flame held at a 45° angle is applied to the base of a test specimen for a specified period of time per IEC 60695-11-5.

Short Circuit – Low resistance electrical circuit path that causes current to flow unintentionally.

Small Part – See Appendix B

Test Plate – Raw material molded to be 4" x 4" x specified thickness.

Unattended – Refers to *"Unattended Appliance."* Person is NOT present with the appliance during normal operation. Opposite of *Attended*.

UL – Underwriters Laboratories, Global independent safety science company offering expertise across five key strategic businesses: Product Safety, Environment, Life & Health, Verification Services and Knowledge Services.
http://www.ul.com/global/eng/pages/

UL94 – Standard for evaluating flammability using a direct flame method of testing.
http://www.ul.com/global/eng/pages/offerings/industries/chemicals/plastics/testing/flame/

VDE – VDE, the Association for Electrical, Electronic & Information Technologies, is one of the largest technical and scientific associations in Europe.
http://www.vde.com/en/Pages/Homepage.aspx

APPENDIX D:

The Following Specifications Govern the Practice of Glow Wire Testing and How It Applies to Household Appliances:

IEC 60335-1 Edition 5.2; 2016: Household and Similar Electrical Appliances — Safety

UL 60335-1 Edition 6.0; 2016: Safety of Household and Similar Electrical Appliances

IEC 60695-2-10: Glowing/hot-wire based test methods — Glow-wire apparatus and common test procedure.

IEC 60695-2-11: Glow-Wire Flammability (Ignitability) for End Products

IEC 60695-2-12: Glow-Wire Flammability Index (GWFI) Test Method for Materials

IEC 60695-2-13: Glow-Wire Ignition Temperature (GWIT) Test Method for Materials.

IEC 60695-11-5: Needle-flame test method — Apparatus, confirmatory test arrangement and guidance

TE Connectivity — Consumer Solutions — Appliances

Written by members of the technical staff, TE Connectivity Appliances Business Unit.
Edited by Raymond Landon, Staff Project Manager Global Engineering, located in Middletown, Pennsylvania, USA.

te.com

503-32020 11/18 Revision B