



Heat Shrink Tubes for Wiring Harness

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. This standard specifies dimensions, test methods and requirements for sealed and non-sealed heat shrinkable tubing. There is no international or national equivalent to this standard.

1.2 Applicability. The shrink tube is intended to be used as protection for splice connections, ring terminals or wherever a protected cover is needed in all passenger car and light duty truck wire harnesses.

1.3 Remarks. Shrink tube is also used to seal, unsealed joints for example splices, crimp areas.

1.4 Temperature Classes.

Eight (8) temperature class ratings (3000 h) have been defined in Table 1 to respond to the various temperatures encountered on vehicles.

Table 1: Temperature Class Rating, 3000 h

Temperature Class Rating (TCR)		Equivalent to Temperature Class
Class	Operating Temperature (°C)	
A	-40 to +85	T1
B	-40 to +100	T2
C	-40 to +125	T3
D	-40 to +150	T4
E	-40 to +175	T5
F	-40 to +200	T6
G	-40 to +225	T7
H	-40 to +250	T8

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ASTM D5374	IEC 60811-2-1	ISO 4926	ISO/IEC 17025
ASTM D5423	ISO 37	ISO 6722-1	SAE RM-66-06
IEC 60068-2-6	ISO 1817	ISO 6931-1	

2.2 GM Standards/Specifications.

GMW3059	GMW14650	GMW15635
GMW3191	GMW15634	

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3 Test Preparation and Evaluation.

3.1 Resources.

3.1.1 Facilities. Temperature controlled room with power outlets and internet connections.

3.1.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.1.2 Equipment. As specified in each single test.

3.1.2.1 Ovens. Unless otherwise specified, when an oven is required, it shall be a hot air oven. The oven type shall either be a forced air or mechanical convection. See Figure 1. The air shall enter the oven in such a way that it flows over the surface of the test pieces and exits near the top of the oven. The oven shall have not less than eight (8) complete air changes per hour and not more than 20 complete air changes per hour at the specified aging temperature. Reference ASTM D5423 and ASTM D5374 for temperature uniformity and air exchange measurements.

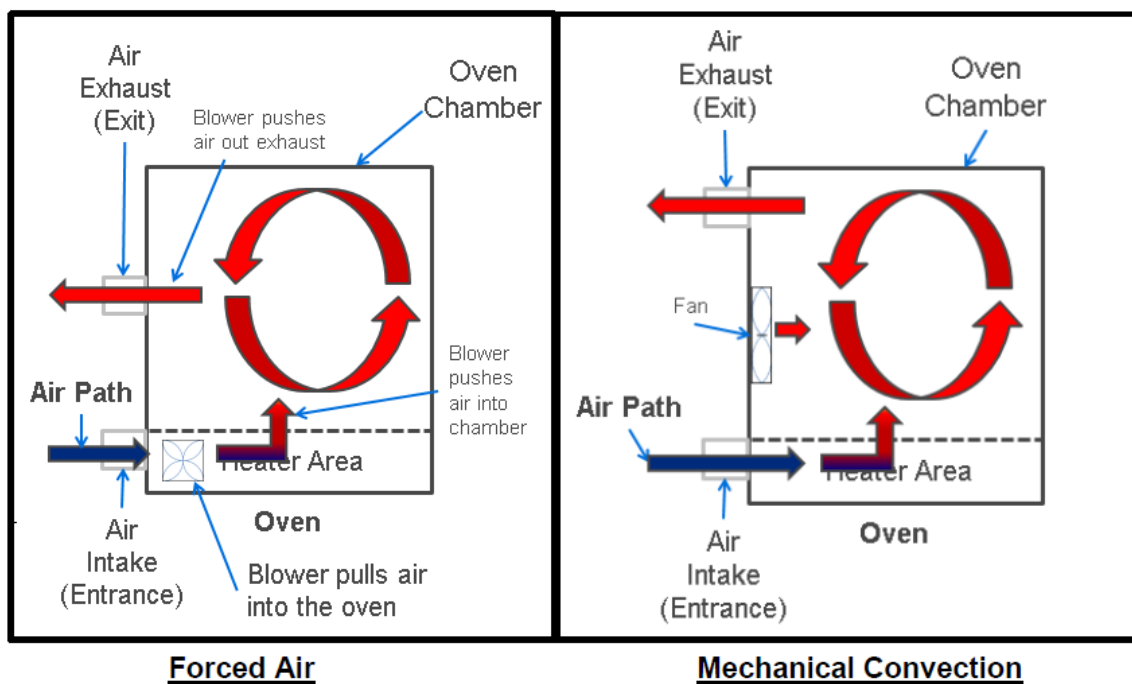


Figure 1: Ovens

3.1.3 Test Vehicle/Test Piece. Table 2 defines the material codes for the shrink tube material.

Table 2: Material Code

Material Code	Material
A	Cross Linked Polyolefin (XLPO)
B	Polyvinylidene Difluoride (PVDF)
C	Flame Retardant Cross Linked Polyolefin (FR XLPO)
D	Flame Retardant Polyvinylidene Difluoride (FR PVDF)
E	Fluoroelastomer
F	Other Fluoropolymer

Note: Specify the material compound in the test report.

The number of test samples is specified in each test. The shrink tube to be tested shall be manufactured under full production conditions. No parts out of prototype tools shall be used.

3.1.4 Test Time. Test hours are defined for each test in Section 4 Requirements and Procedure.

3.1.5 Test Required Information. See Appendix E and Table E1.

3.1.6 Personnel/Skills. Not applicable.

3.2 Preparation. See each individual test.

3.3 Conditions.

3.3.1 Environmental Conditions. Not applicable.

3.3.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

Test samples for all tests shall be preconditioned for at least 16 h at a temperature of $+23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ and a relative humidity of 45% to 75%. Unless otherwise specified, all tests other than "in process" tests shall be conducted at this temperature. Where no tolerance is specified, all values shall be considered approximately.

3.4 Instructions. See each individual test in Section 4.

3.5 Data. See 3.7.1.

3.6 Safety. This Engineering Standard may involve safety requirements for hazardous materials, the method of operations and equipment. This standard does not propose to address all the safety issues associated with its use. It is the responsibility of the user of this standard to ensure compliance with all appropriate safety and health practices. This would include any specific training that may be required. The safety and health standards include site specific rules and procedures, company rules and procedures, and Government Standards. Contact shall be made with the appropriate site Safety and Health personnel for further direction and guidance in these matters.

3.7 Documentation. Samples of components or material released to this standard shall be tested for conformity with the requirements of this standard and approved by the responsible GM Department prior to the start of delivery of production level components or materials.

Any change to the component or material, e.g., design, function, properties, manufacturing process and/or location of manufacture requires a new release of the product. It is the sole responsibility of the supplier to provide the customer, unsolicited, with documentation of any change or modification to the product/process, and to apply for a new release.

If not otherwise agreed to, the entire verification test shall be repeated and documented by the supplier prior to start of delivery of the modified or changed product. In some cases, a shorter test can be agreed to between the responsible GM department and the supplier.

3.7.1 Test Results. Test results shall be reported in the format as shown in Appendix D, Data Sheet D1. The test report shall include as minimum:

- Name of the supplier

- GM and Supplier product code for the tested part
- Date of test report
- Part Designation/GM Specification Code (Appendix C)
- International Material Data System (IMDS)_ID and information. If the IMDS datasheet has been approved by the customer
- The result and interpretation of test result
- Test report shall have the detail photos for each physical test result

4 Requirements and Procedure

4.1 Colors. Standard color for heat shrink tubes is black. Other colors are specified in Appendix C, Table C8.

4.2 Dimensions.

4.2.1 Inside Diameter (As Supplied).

4.2.1.1 Test Samples. Prepare three test samples with a length of 150 mm each.

4.2.1.2 Procedure. Measure the Inside Diameter using a series of mandrels with diameter intervals of 0.1 mm being passed through a test section of tubes. The mandrel shall be inserted into the tube approximately 30 mm. The Inside Diameter is equal to the diameter of the mandrel that can be easily inserted into the tube. Measurement accuracy: 0.1 mm.

4.2.1.3 Interpretation of Results. As Supplied Inside Diameter values shall conform to Appendix A, Table A1 through Table A6.

4.2.2 Inside Diameter after Shrinkage (Maximum Recovered).

4.2.2.1 Test Samples. Prepare three test samples with a length of 150 mm each.

4.2.2.2 Procedure. Shrink the tube in accordance with the manufacturer's recommendation. Measure the Inside Diameter using a series of mandrels with diameter intervals of 0.1 mm being passed through a test section of tubes. The mandrel shall be inserted into the tube approximately 30 mm. The Inside Diameter is equal to the diameter of the mandrel that can be easily inserted into the tube.

4.2.2.3 Interpretation of Results. Maximum Recovered Diameter values shall conform to Appendix A, Table A1 through Table A6.

4.2.3 Thickness after Shrinkage.

4.2.3.1 Test Samples. Prepare three test samples with a length of 150 mm each.

4.2.3.2 Procedure. Shrink the tube in accordance with the manufacturer's recommendation. Measure the thickness of the tubing after shrinkage using an optical microscope. Measure the thickness at two (2) points along the tube separated of a distance of 20 mm. The thickness shall be the average value of three (3) measurements at each of the two points. No values should be less than the minimum requirement shown in Appendix A, Table A1 through Table A6.

4.2.3.3 Interpretation of Results. The average of the measured thickness values shall conform to Appendix A, Table A1 through Table A6.

4.3 Tensile Strength and Elongation.

The test method shall be as specified in ISO 37.

4.3.1 Test Samples. For heat-shrink tubes of recovered Inside Diameter ≤ 6 mm, three (3) tubular specimens 125 mm long shall be tested. For heat-shrink tubes of recovered Inside Diameter > 6 mm, three (3) Type 2 dumb-bell specimens shall be tested.

4.3.2 Procedure: The test shall be performed at $+23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$. Initial jaw separation shall be 50 mm and rate of jaw separation shall be 100 mm/minute ± 10 mm/minute. Take the average value of the three (3) readings. Calculate the cross-sectional area of the test specimens based on the outer jacket wall thickness only, in mm^2 , by using following formula:

$$\text{Tube Specimens: } A = \frac{\pi(D^2 - \delta^2)}{4}$$

$$\text{Type 2 dumb-bell: } A = W(t)$$

Where: A = Cross-sectional area (mm²)
D = Outside diameter (mm)
 δ = Inside Diameter of the outer wall (mm)
W = Dumb-bell width (mm)
t = Dumb-bell thickness (mm)

4.3.3 Interpretation of Results. See Appendix B, Table B1.

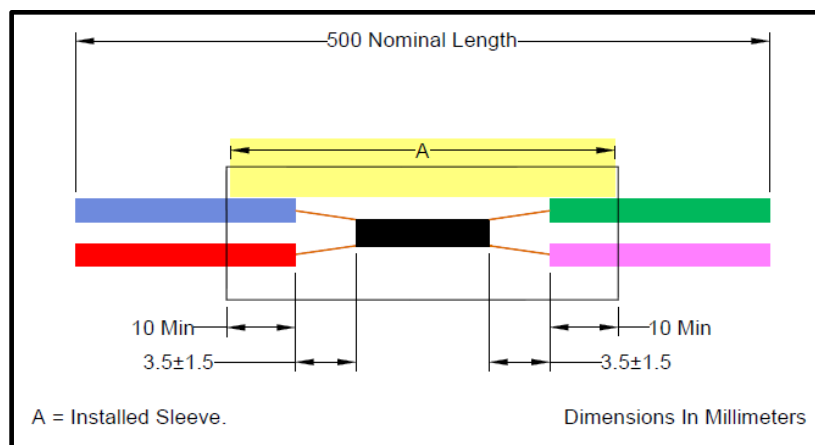
4.4 Water Tightness (Sealed Dual Wall Heat-Shrink Tubes Only).

4.4.1 Test Sample. Three (3) test samples shall be prepared of each combination (Test Configuration 1 and 2), see Table 3. The wire used for the test shall comply with the temperature class of the shrink tube. The splice assembly is constructed as shown in Figure 2. Installation shall be per manufacturer's recommendations.

Table 3: Splice Configurations

	Sample Tube Length (mm)	Splice Configuration ^{Note 1}	Wire Size (mm ²)	Wire Length (mm)
Test Configuration 1	50	2:2	0.5	250
Test Configuration 2	65	7:4	1.5	250

Note 1: Other splice configurations can be tested, upon agreement between customer and supplier.



Min = minimum

Figure 2: Splice Configuration

4.4.2 Procedure. See GMW3191, Water Submersion Test. The measurements shall be taken between each cable and the electrode. The water tightness test for sealed shrink tubing should be tested for water tightness before and after each of the short term aging test, long term aging test, cold impact, and resistance to liquid chemicals test.

4.4.3 Interpretation of Results. The leakage current measured per GMW3191 shall not exceed 5 μ A at 14 V $\pm$ 0.5 V applied voltage.

4.5 Short Term Heat Aging.

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4.5.1 Test Samples. For non-sealed shrink tubes, prepare three test samples according to 4.3. For sealed shrink tubes, prepare three test samples according to 4.4.

4.5.2 Apparatus. Perform the short-term aging test using an oven at the appropriate temperature as specified in Table 4.

Table 4: Short Term Heat Aging

Class	Test Temperature °C
A	110 ± 2
B	125 ± 3
C	150 ± 3
D	175 ± 3
E	200 ± 3
F	225 ± 4
G	250 ± 4
H	275 ± 4

Note: Upper value of temperature class rating (see Table 1) +25 °C.

4.5.3 Procedure. Place the samples, in a vertically orientation, in a hot oven for 240 h. The samples shall be separated by ≥ 50 mm from each other and from the inner surface of the oven. Tubes made of different materials shall not be tested at the same oven. Immediately after aging, withdraw the samples and maintain them at +23 °C ± 3 °C for at least 16 h. After aging, perform the relevant verification tests. See 4.3 for non-sealed shrink tubes (tensile strength and elongation) and 4.4 for sealed shrink tubes (water tightness).

4.5.4 Interpretation of Results. See Appendix B, Table B1.

4.6 Long Term Heat Aging.

4.6.1 Test Samples. For non-sealed shrink tubes, prepare three (3) test samples according to 4.3. For sealed shrink tubes, prepare three (3) test samples according to 4.4.

4.6.2 Apparatus. Perform the long-term aging test using an oven at the appropriate temperature as specified in Table 5.

Table 5: Long Term Heat Aging

Class	Test Temperature °C
A	85 ± 2
B	100 ± 3
C	125 ± 3
D	150 ± 3
E	175 ± 3
F	200 ± 3
G	225 ± 4
H	250 ± 4

Note: Upper value of temperature class rating (see Table 1).

4.6.3 Procedure. Place the samples, in a vertically orientation, in a hot oven for 3000 h. The samples shall be separated by ≥ 50 mm from each other and from the inner surface of the oven. Tubes made of different materials

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shall not be tested at the same oven. Immediately after aging, withdraw the samples and maintain them at $+23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ for at least 16 h. After aging, perform tensile strength and elongation. See 4.3 for non-sealed shrink tubes and 4.4 for sealed shrink tubes.

4.6.4 Interpretation of Results. See Appendix B, Table B1.

4.7 Abrasion Resistance.

4.7.1 Test Samples. Four (4) samples of 200 mm each, shall be shrunk onto mandrels. The mandrels shall be 5.0 mm and manufactured from a solid steel rod. The size of the samples shall have a maximum recovered ID of 5.0 mm or less. See Appendix A, Table A1 through Table A6.

4.7.2 Apparatus. See ISO 6722-1. The apparatus shall:

- Record the number of cycles to failure when the needle abrades through the insulation and makes contact with the mandrel.
- Use a needle of diameter $0.45\text{ mm} \pm 0.01\text{ mm}$ made from spring wire according to ISO 6931-1.
- Operate at a frequency of $55\text{ cycles/minute} \pm 3\text{ cycles/minute}$ (one cycle consists of one reciprocating movement).
- Create an abrasion length of $15\text{ mm} \pm 1\text{ mm}$.
- Produce consistent vertical force on the test piece under dynamic conditions.
- Not allow the test sample to move during test. If clamping is necessary, the longitudinal force applied on the conductor shall not exceed 100 N/mm^2 .
- Have a stable base.

4.7.3 Procedure. Mount a trial sample in the apparatus and adjust the static load applied on the test sample to $7\text{ N} \pm 0.05\text{ N}$. Run the trial sample and insure all the conditions in 4.7.2 are met. Remove the trial sample and discard. Run four (4) tests on each of the four (4) specimens. Record the number of cycles when needle abrades through the insulation and makes contact with the mandrel, or stop the test when it exceeds 150% of the minimum required cycles as shown in Appendix B. Test at a temperature of $+23\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$. After the initial abrasion through to the mandrel, each test sample shall be moved approximately 20 mm and rotated clockwise 90 degrees and the test repeated. A clean needle shall be used for each abrasion test.

4.7.4 Interpretation of Results. The resistance to scrape abrasion shall meet or exceed the minimum number of cycle requirements according to Appendix B, Table B1.

4.8 Cold Impact.

4.8.1 Test Samples. For non-sealed shrink tubes, three (3) samples of 50 mm each, shall be shrunk onto mandrels. The mandrels shall be manufactured from a solid steel rod. The size of the mandrel shall represent the fully shrunk Inside Diameter of the shrink tube. For sealed shrink tubes, prepare three (3) test samples according to 4.4.

4.8.2 Apparatus. Perform the impact test using the apparatus shown in ISO 6722-1, positioned on a sponge rubber pad of 40 mm thickness. The mass of the hammer shall be 200 g. Set the chamber temperature to $-40\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$.

4.8.3 Procedure. Perform the impact test in the middle of the test samples. Place the apparatus, positioned on the sponge rubber pad, together with the test samples in the chamber for at least 16 h. If the apparatus is precooled, a cold soak time of 4 h is sufficient providing that the test samples have reached the specified temperature. At the end of the cold soak time, place the test sample parallel to the steel base. The hammer shall then be allowed to fall from a height of 100 mm. Allow non-sealed shrink tubes to attain $+23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ visually examine it for cracks. For sealed shrink tubes, perform the water tightness test according to 4.4.

4.8.4 Interpretation of Results. See Appendix B, Table B1.

4.9 Pressure/Vacuum Leak (Sealed Shrink Tubes Only - Test Only for the Harness Manufacturer).

4.9.1 Test Samples. Three (3) samples of each combination tube/splice and tube/ring terminal shall be tested. For the harness manufacturers, all different splice-combinations used in the vehicle(s) shall be tested. Shrink tubes on ring terminals shall also be tested.

4.9.2 Apparatus. The apparatus shall contain a:

- Regulated pressure/vacuum source.
- Container for sample immersion.

- Temperature chamber capable of -40 °C to +175 °C or as required by appropriate temperature class in Table 1.

4.9.3 Procedure. Attach a hose of sufficient size from the pressure/vacuum source to the free wire ends of the test specimen. Make sure that the connection is sealed. Prepare enough salt water solution to completely submerge all samples to a depth of 300 mm to 400 mm below the surface. Use tap water at $+23\text{ °C} \pm 3\text{ °C}$ and 15 g to 16 g of table salt (NaCl) per liter of water. 10 ml of liquid dish washing soap per liter of water may also be added. Mix well before pouring into the test apparatus container. Submerge the samples in the container of salt water solution. Slowly increase the air pressure supplying the tube in each sample until gauge reads 48 kPa. Observe samples for 15 s and verify that there are no air bubble(s). Switch the regulated source from pressure to vacuum and slowly apply 48 kPa of vacuum to the samples for 15 s. Perform the Water Tightness test according to 4.4. After the test, place the samples in a hot air oven for 240 h at the temperature specified in short term aging. If the cables and the shrink tube have different temperature classes, the aging temperature shall be according to the product with the lowest temperature class. The samples shall be fixed in the conductor to avoid any contact between the insulation and the supports, and shall be separated at least 20 mm from each other and from the inner surface of the oven. Test samples made of different material shall not be tested at the same time. After aging, repeat the pressure/vacuum test.

4.9.4 Interpretation of Results. When samples are subjected to pressure/vacuum, there shall be no loss in pressure and no bubbles visible. The leakage current measured per GMW3191 shall not exceed 5 μA at $14\text{ V} \pm 0.5\text{ V}$ applied voltage. See Appendix B, Table B1.

4.10 Resistance to Liquid Chemicals. These tests are intended to verify resistance of the shrink tubes to chemical loads in automotive environment where the exposure is limited. This test is required for gasoline, diesel fuel, ethanol, engine oil, windshield washer fluid and salt water. All other fluids shall be tested and the results shall be reported. Depending on the specific application, additional fluids may be required and shall be established by agreement between General Motors and the supplier.

4.10.1 Test for Sealed Shrink Tube.

4.10.1.1 Test Samples. Prepare samples using four (4) wires of 0.5 mm² according to 4.4 Test Configuration 1, one sample for each liquid and requested time, which means that (e.g., salt water) four (4) samples are required.

4.10.1.2 Apparatus. Use an oven in according to Section 3 at the respective maximum operating temperature according to Table 1. The oven shall be equipped with grids, making it possible to hang the test samples on them. A collecting tray shall be placed in the bottom of the oven to gather spill of chemicals.

4.10.1.3 Procedure. The test shall consist of one or several exposures to chemicals with intermediate exposures to heat aging conditions. Two different test fluid groups in accordance with Table 6 shall be tested. Fluid Group 1 shall be heat aged for a period of 1000 h at the upper limit of the heat shrink tube Temperature Class Rating (TCR). Fluid Group 2 shall be heat aged for a period of 240 h at the upper limit of the heat shrink tube Temperature Class Rating (TCR). See Table 1 for reference on temperature classes.

For each fluid to be tested: Immerse the test samples 10 s in the fluid, then remove from the fluid and allow draining off for 3 minutes before storage in the oven. Care shall be taken that the ends are not exposed to the fluid. Test samples from one and the same type of tested shrink tube, but exposed to the different test fluids can be stored in the same oven. Test samples from different types of shrink tubes are not allowed to be stored in the same oven.

For Fluid Group 1 samples, the immersing in the respective fluid shall be repeated after 240 h, 480 h and 720 h of the 1000 h test in the following way: Initially immerse eight (8) test samples for each fluid and store them in the oven. At 240 h take out two samples for each tested fluid and maintain them at $+23\text{ °C} \pm 3\text{ °C}$ for $> 0.5\text{ h}$ and then perform the water tightness test according to 4.4. The remaining samples shall be re-immersed and stored in the oven again. Repeat this procedure for 480 h, 720 h, and 1000 h.

For Fluid Group 2, the samples shall only be immersed once, before exposure, in the actual shrink tube class temperature rating (TCR) for 240 h.

4.10.1.4 Interpretation of Results. The leakage current measured per GMW3191 shall not exceed 5 μA at $14\text{ V} \pm 0.5\text{ V}$ applied voltage. See Appendix B, Table B1.