



Convuluted Conduit 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. The standard defines the requirements and test methods for the different convoluted conduits for wire harness protection in the passenger and engine compartments.

1.2 Applicability. This standard shall be used for all passenger cars and light duty truck wire harnesses to evaluate and classify wire harness conduits for a given application. Class designations is defined in Table 1 to classify the various temperature ranges encountered in/on vehicles.

Table 1: Temperature Class Rating (TCR)

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

1.3 Remarks. Convoluted conduit is used to contain wires in a protective enclosure.

2 References

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

2.1 External Standards/Specifications.

ASTM D5374	ISO 1817	ISO 6722-1	SAE J2192
ASTM D5423	ISO 3795	SAE J369	UL 94
IEC 60304	ISO 4926	SAE J1128	

2.2 GM Standards/Specifications.

GMW3059	GMW3235	GMW15634	GMW15635
GMW3205	GMW14729		

3 Test Preparation and Evaluation

3.1 Resources.

3.1.1 Facilities.

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.

3.1.1.3 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) and not more than twenty (20) complete air changes per hour at the specified aging temperature. Reference ASTM D5423 and ASTM D5374 for temperature uniformity and air exchange measurements.

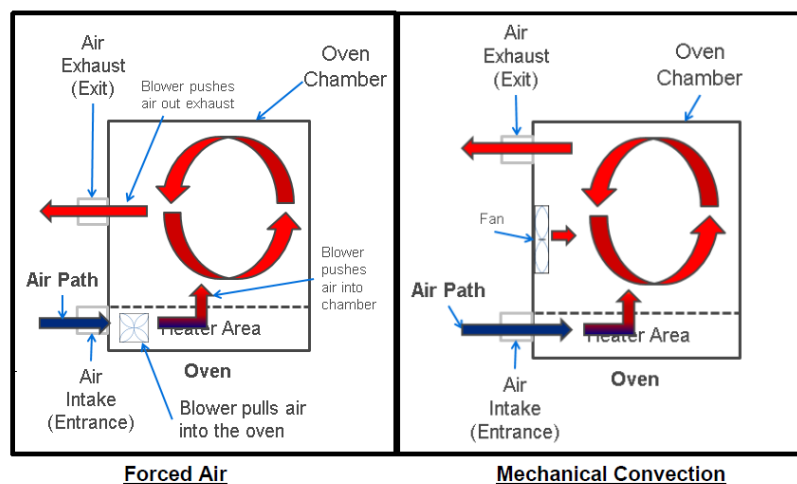


Figure 1: Ovens

3.1.2 Equipment. See each individual test in Section 4, Requirements and Procedure.

3.1.3 Test Vehicle/Test Piece. Number of test samples is specified in each test. If not stated otherwise, for testing of convoluted conduits with different diameters but equal material three (3) representative diameters of small, medium, and large shall be tested. The conduits 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 time varies based on test requirements. See Table A1, Appendix A. and Section 4, Requirements and Procedure.

3.1.5 Test Required Information. Not applicable.

3.1.6 Personnel/Skills. Person familiar with the test methods defined in Section 4, Requirements and Procedure.

3.2 Preparation. See each individual test in Section 4, Requirements and Procedure.

3.3 Conditions.

3.3.1 Environmental Conditions. If not otherwise specified, all test samples shall be maintained at $+23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ and a relative humidity of $50\% \pm 20\%$ for $\geq 24\text{ h}$ before the start of any test sequence. If not stated otherwise, all tests shall be performed at $+23 \pm 3\text{ }^{\circ}\text{C}$ and a relative humidity of $50\% \pm 10\%$. For temperatures, depending on installation position (passenger or engine compartment) the different convoluted conduits are classified into the temperature classes T1 to T8 according to Table 1.

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.

3.2.3 Test Required for Certification. The conduits shall be submitted to the tests specified in Table A1, Appendix A. Initial tests shall be performed by an instance agreed between the customer (GM) and Supplier.

3.4 Instructions. See each individual test in Section 4, Requirements and Procedure.

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 documented in a test report, see Table B1, Appendix B example, with reference of the test procedure used.

4 Requirements and Procedure

4.1 General.

4.1.1 Visual Appearance. All parts shall be in a proper visual condition. There should be no shrunken spots, distortions, burrs, tears, or breaks. A section of a convoluted conduit shall be cut on the wave crest. The stamped or cut-edges shall be free of burrs. The edges should not cause harm during assembly.

Note: Damage of cables at the stamped or cut edges, as well as inside the convoluted conduit is not permitted.

4.1.2 Materials. Table C1, Appendix C, shows examples of convoluted conduit materials in different temperature ranges.

4.1.2.1 Environmental Requirements. See 7.1.

4.1.2.2 Material Identification. All Suppliers are required to submit Infrared (IR) spectra for the materials during initial approval. This is done to obtain reference values that would be needed in the event of any claims. The IR spectra shall be performed on non-aged samples.

4.1.3 Marking. The different temperature classes shall be identified with a color stripe in accordance with Table 2. At the end of the lifetime of the vehicle, the identification shall be still possible. The marking for the first introduction of new temperature classes shall be defined in coordination with GM, with this standard.

4.1.4 Color of the Conduit. Standard base color for conduit is black. In some applications, e.g., high voltage, a color/color stripe conduit is required. See Table 2 for stripe colors based on temperature class. See Table 3 for conduit colors based on system voltage.

Table 2: 12 V Base Color and Stripe Color for Temperature Classes ^{Note 1}

TCR	Base Color	Stripe Color	Material Type	Color like IEC 60304	Color like SAE J1128
A (T1)	Black	No stripe	Polyethylene (PE)	Not applicable	Not applicable
B (T2)	Black	Green	Polypropylene (PP)	RAL 6018	PED C-1626 0.5 G 5.6/7.0
C (T3)	Black	Gray	Modified Polypropylene (MPP) Polyamide (PA), i.e., nylon	RAL 7000	PED C-1633 N 5.7/(10GY.0.2)
D (T4)	Black	Yellow	Thermoplastic Elastomers (TPE) Polyamide (PA), i.e., nylon Modified Polyamide (MPA), i.e., nylon, PAER	RAL 1021	PED C-1632 8Y 8.5/11.2
E (T5)	Black	No stripe ^{Note 2}	Ethylene Tetrafluoroethylene (ETFE)	Not applicable	Not applicable
F (T6)	Black	No stripe ^{Note 3}	Fluorinated Ethylene Propylene (FEP)	Not applicable	Not applicable
G (T7)	Black	No stripe	Perfluoroalkoxy (PFA) Perfluoromethylalkoxy (MFA)	Not applicable	Not applicable
H (T8)	Black	No stripe	Perfluoroalkoxy (PFA) Polytetrafluoroethylene (PTFE)	Not applicable	Not applicable

Note 1: IEC 60304 and SAE J1128 colors are targets and for reference only.

Note 2: A Blue stripe is also acceptable.

Note 3: A Brown stripe is also acceptable.

Table 3: Base Color for Voltage System Classes ^{Note 1}

System Voltage Class	Base Color	Color like IEC 60304	Color like SAE J1128
12 V	Black	RAL 9005	PED C-1661 N2.25
48 V	Blue	RAL 5015	PED C-1623 4.6 PB 3.8/10.2
600 V (systems > 48 V)	Orange	RAL 2003	PED C-1629 8.75 R5.75/12.5
Safety	Yellow	RAL 1016	Not applicable

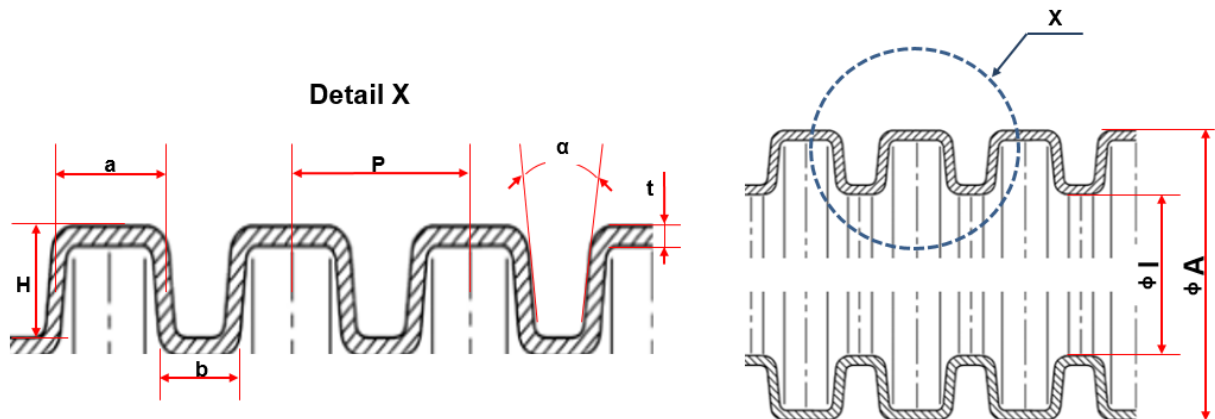
Note 1: IEC 60304 and SAE J1128 colors are targets and for reference only.

4.2 Dimensions. Measure three (3) test samples 500 mm long according to 4.2.1 through 4.2.4 at the same time and preferably on closed convoluted conduit. All values and tolerances are detailed in 4.2.1. through 4.2.4 and Table 4, Table 5, and Table 6.

4.2.1 Outer Diameter (A). The outer diameter shall be measured at two (2) points along the length of the convoluted conduit separated by a distance of ≥ 100 mm. See Figure 2. The diameter shall be taken to be the mean value of three (3) measurements at each point. The measurement shall be made peripherally with a mutual displacement of 120 degrees. Measurement accuracy: ± 0.1 mm.

4.2.2 Inner Diameter (I). The inner diameter shall be measured by a series of mandrels with a diameter of 0.1 mm being passed through a test section of the convoluted conduit. The mandrel shall be inserted 50 mm into the convoluted conduit. The inner diameter is equal to the diameter of the mandrel that can be easily inserted. Measurement accuracy: ± 0.1 mm.

4.2.3 Thickness (t). The thickness shall be measured at two (2) points along the convoluted conduit separated by a distance of > 100 mm. See Figure 2. The thickness shall be taken to be the mean value of three (3) measurements at each point. The measurement shall be made peripherally with a mutual displacement of 120 degrees. Measurement accuracy: ± 0.1 mm.



- ϕI = Inner Diameter
- ϕA = Outer Diameter
- H = Height
- a = Wave Peak
- b = Wave
- P = Pitch
- α = Angle
- t = Thickness

Figure 2: Dimensions for Convoluted Conduit

4.2.4 Round Shape conduits

4.2.4.1 Standard (Normal) Profile. This profile has lower convolute height and has the tendency to gap when routing (bending) in the vehicle, i.e., the slit has the tendency to open at bends. See Figure 3. Tape overwrap is recommended to keep the slit from opening. Type I, Type II, and Type III are available from different Suppliers.

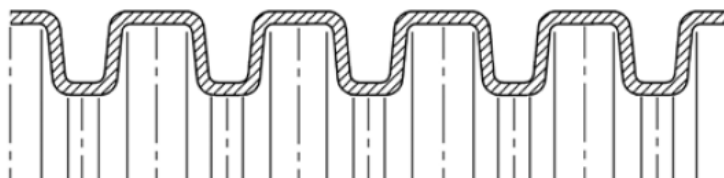


Figure 3: Standard Profile

4.2.4.2 High Wave (High Pitch) Profile. This profile has a higher convolute height, does not have tendency to gap when routing (bending) in the vehicle and is more resistant to crush. See Figure 4. It is not necessary to have tape overwrap on this type of conduit. The dimensions for High Wave Profile shall be agreed upon between customer (GM) and Tier 1 and Tier 2 Suppliers.

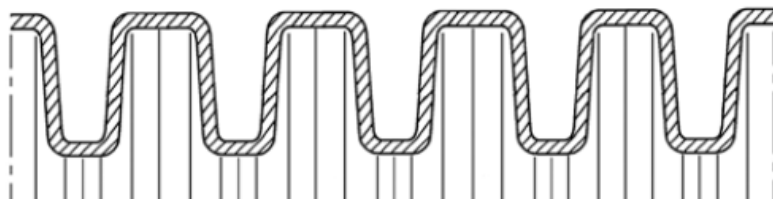


Figure 4: High Wave Profile

4.2.4.3 Ultra Flat Wave (UFW) Profile. This profile has a smoother inner wave for improved protection of wires. See Figure 5 and Table 7. There is more inner contact surface, which enables less indentation on the wires. This type also provides more flexibility of the wires for tighter bending radii.

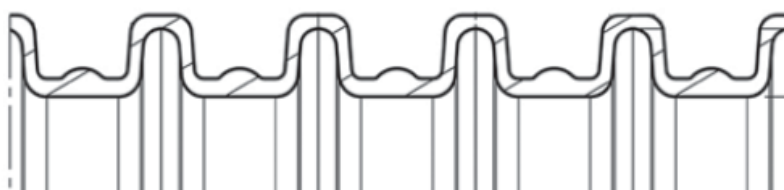


Figure 5: Ultra Flat Wave Profile

4.2.5 Closable Shape Conduit. The dimensions for High Wave Profile shall be agreed upon between customer (GM) and Tier 1 and Tier 2 Suppliers.

4.2.6 Oval Shape Conduit. The wall thickness, height and pitch should be the same as the round shape conduits. The other dimensions, i.e., ϕI and ϕA , shall be agreed upon between customer (GM) and Tier 1 and Tier 2 Suppliers.

Table 4: Type I - Standard (Normal) Round Dimensions

Size	ϕ I (mm)	ϕ A (mm)	P (mm)	a (mm)	H (mm)	α (degree)	t ^{Note 1} (mm)
3	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
4.5	4.5 ± 0.51	6.7 ± 0.51	2.79	1.70	0.88	24.5	0.17 to 0.51
5	5.4 ± 0.51	7.55 ± 0.51	2.83	1.50	0.86	38.0	0.17 to 0.51
6	6.20 ± 0.51	9.45 ± 0.51	2.69	1.50	1.30	24.2	0.17 to 0.51
7	7.15 ± 0.51	9.60 ± 0.51	2.83	1.80	0.96	14.0	0.17 to 0.51
8	7.60 ± 0.51	11.4 ± 0.51	2.83	1.60	0.96	24.6	0.17 to 0.51
9	8.75 ± 0.51	12.60 ± 0.51	3.14	1.80	1.55	18.0	0.17 to 0.51
10	10.70 ± 0.51	13.60 ± 0.51	3.14	1.80	1.13	30.6	0.17 to 0.51
12	11.55 ± 0.51	15.35 ± 0.51	3.14	1.90	1.77	15.2	0.17 to 0.51
13	13.15 ± 0.51	17.15 ± 0.51	3.32	1.90	1.72	14.0	0.17 to 0.51
14	14.50 ± 0.51	17.50 ± 0.51	3.77	1.90	1.21	42.3	0.17 to 0.51
16	16.90 ± 0.51	20.70 ± 0.51	3.53	1.80	1.55	23.2	0.17 to 0.51
19	19.35 ± 0.51	23.70 ± 0.51	3.33	1.80	1.77	19.6	0.17 to 0.51
22	22.30 ± 0.70	28.80 ± 0.70	3.53	1.94	2.77	12.7	0.17 to 0.70
23	23.30 ± 0.70	28.30 ± 0.70	3.33	2.15	2.04	11.6	0.17 to 0.70
25	25.80 ± 0.70	33.00 ± 0.70	3.53	1.98	3.04	12.7	0.20 to 0.80
28	28.00 ± 0.80	34.00 ± 0.80	4.35	2.50	2.55	22.0	0.20 to 0.80
30	30.50 ± 0.80	37.80 ± 0.80	4.19	2.15	3.26	20.6	0.20 to 0.80
32	33.10 ± 0.80	38.70 ± 0.80	4.43	2.40	2.25	30.0	0.20 to 0.80
40	39.50 ± 0.80	47.40 ± 0.80	4.71	2.90	3.38	10.1	0.20 to 0.80
50	47.50 ± 0.80	54.80 ± 0.80	3.59	2.20	3.12	12.4	0.20 to 0.80

Note 1: Approximate minimum thickness.