



Thermoplastic Fuel Tubing

1 Scope

This standard covers requirements for extruded single and multilayered lines used in fuel, vapor and evaporative emissions. The vapor and evaporative emission lines covered by this specification can either be straight or convoluted. Operating temperatures for lines covered by this specification range from (-40 to +90) °C with excursions to +115 °C. Other documents which describe the performance and dimensional requirements of these components and assemblies manufactured from these components are GMW14681, GM9060P, GM9080P, and GM9676P.

In addition to the test requirements listed in this specification, additional fuel recirculation and/or permeation testing may be required for validation of the tubing and/or quick-connectors used in the fuel line assembly. Any additional requirements shall be defined by the GM Materials Engineer.

1.1 Material Description. Each material shall be defined by a construction and a grade. See paragraph 3.2.

1.2 Symbols. Not applicable.

1.3 Typical Applications. Thermoplastic fuel lines, evaporation- and purge lines.

2 References

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

2.1 External Standards/Specifications.

ASTM D3703	IEC 60684-2	ISO 527	SAE J2260
DIN 73378	ISO 178	ISO 1817	
EN 60243-2	ISO 179	SAE J1737	

2.2 GM Standards/Specifications.

9986121	GM9676P	GMW14681	GMW15416
9986231	GMPT-3-018	GMW14700	GMW16177
GM9060P	GMPT-6-019	GMW14797	
GM9080P	GMW3356	GMW14914	

2.3 Additional References.

TMC003 Material Safety Data Sheet guidance documents (available at www.gmsupplypower.com).

3 Requirements

3.1 Requirements on Test Specimens. Reference GMW3221.

3.2 Construction, Types, and Grades. The construction identifies the layers utilized in the wall. The grade identifies the conductivity of the line. Grade C (conductive grade) identifies a tube that has a surface resistivity $< 10^6 \Omega$. Grade N (non-conductive grade) identifies a tube which has a surface resistivity $> 10^6 \Omega$. Each version shall consist of a smooth bore inner tube. All multilayer constructions shall have concentric layers. Many Grade N applications can also be supplied as corrugated or convoluted tubing and shall be identified with an alternate specification.

Typical applications are defined in Appendix A, Figure A1.

3.2.1 Construction. See Appendix A, Figure A1.

3.2.1.1 Type A. This tube is a single or laminated tube and consists of either Polyamide 12 (PA12) or Polyamide 11 (PA11).

Grade C. This tube shall consist of either PA12 or PA11 with an appropriate inner layer of conductive PA12 or PA11.

Grade N. This tube shall consist of either PA12 or PA11.

3.2.1.2 Type B. This tube is a laminated construction with an inner tube of Ethylene-Tetrafluoroethylene Copolymer (ETFE) and a cover of PA12).

Grade C. Consists of an inner tube of conductive ETFE and an outer tube of non-conductive ETFE tube. The cover shall consist of PA12. The cover shall be (70 to 80) % of the total wall thickness and the minimum thickness of the conductive ETFE layer shall be 0.05 mm.

Grade N. Consists of a single inner tube of non-conductive ETFE. The cover shall consist of PA12. The cover shall be (70 to 80) % of the total wall thickness and the minimum thickness of the conductive ETFE layer shall be 0.05 mm.

3.2.1.3 Type C. (Evaporation Tubes Only). Grade N Only. This tube is a laminated construction with an inner tube of Polybutylene Terephthalate (PBT), an adhesive layer and a cover of PA12. The PBT barrier layer shall have a thickness of (0.45 ± 0.05) mm.

3.2.1.4 Type D. This tube is a laminated construction with an inner tube PA12, a barrier layer of Polyvinylidene Fluoride (PVDF) and a cover of PA12.

Grade C. Shall consist of an inner layer of conductive PA12 with a nominal thickness of (0.1 ± 0.02) mm, and an intermediate layer of non-conductive PA12. The barrier layer shall be PVDF and have a nominal thickness of (0.2 ± 0.05) mm and will be located in the center of the tubing wall. The cover will be non-conductive PA12.

Grade N. Shall consist of an inner layer of non-conductive PA12. The barrier layer shall be PVDF and have a nominal thickness of (0.2 ± 0.05) mm and will be located in the center of the tubing wall. The cover will be non-conductive PA12.

3.2.1.5 Type E. This type construction shall be specified on the drawing and can be identified as either Grade C or N.

3.2.1.6 Type F. The tube is an inner layer of Polytetrafluoroethylene (PTFE) and a cover of PA12.

Grade C. Shall consist of an inner barrier layer of conductive PTFE with a minimum thickness of 0.076 mm. The intermediate layer shall be non-conductive PTFE. The total barrier layer thickness for both grades shall be (0.38 ± 0.05) mm. The outer layer shall be PA12. The outer layer shall be (55 to 75) % of the wall thickness.

Grade N. Shall consist of an inner layer of PTFE. The total barrier layer thickness for both grades shall be (0.38 ± 0.05) mm. The outer layer shall be PA12. The outer layer shall be (55 to 75) % of the wall thickness.

3.2.1.7 Type G. This tube is a laminated construction with an inner layer PA12, a barrier layer of Ethylene Vinyl Alcohol (EVOH) and a cover of PA12.

Grade C. Shall consist of a an inner layer of conductive PA12 with a nominal thickness of (0.1 ± 0.02) mm, an intermediate layer of PA12, an intermediate adhesive layer, a barrier layer of Ethylene Vinyl Alcohol (EVOH), an intermediate layer of adhesive and a cover of PA12. The EVOH barrier layer shall have a thickness of (0.15 ± 0.03) mm.

Grade N. Shall consist of an inner layer of PA12, an intermediate adhesive layer, a barrier layer of Ethylene Vinyl Alcohol (EVOH), an intermediate layer of adhesive, and a cover of PA12. The EVOH barrier layer shall have a thickness of (0.15 ± 0.03) mm.

3.2.1.8 Type H. The tube is a laminated construction with an inner layer of ETFE an intermediate layer of adhesive and a cover of PA12.

Grade C. Shall consist of a conductive ETFE with a thickness of (0.200 ± 0.076) mm. The intermediate layer of adhesive shall have a thickness of (0.10 ± 0.05) mm. The cover shall consist of PA12 with a thickness of (0.70 ± 0.13) mm. The cover shall be (70 to 90) % of the wall thickness.

Grade N. Shall consist of a non-conductive ETFE with a thickness of (0.200 ± 0.076) mm. The intermediate layer of adhesive shall have a thickness of (0.10 ± 0.05) mm. The cover shall consist of PA12 with a thickness of (0.70 ± 0.13) mm. The cover shall be (70 to 90) % of the wall thickness.

3.2.1.9 Type I. This tube is a laminated construction with an inner layer of Ethylene-perfluoroethylenepropylene copolymer (EFEP) and a cover of PA12.

Grade C. Shall consist of a conductive EFEP with a thickness of (0.200 ± 0.050) mm. The cover shall consist of PA12 with a thickness of (0.80 ± 0.05) mm.

Grade N. Shall consist of a non-conductive EFEP with a thickness of (0.200 ± 0.050) mm. The cover shall consist of PA12 with a thickness of (0.80 ± 0.05) mm.

3.2.1.10 Type J. The tube is a laminated construction with an inner layer of conductive ETFE an intermediate layer of non-conductive ETFE and a cover of PA612.

Grade C. Shall consist of a conductive ETFE with a thickness of (0.10 ± 0.05) mm. The intermediate layer of non-conductive ETFE shall have a thickness of (0.20 ± 0.05) mm. The cover shall consist of PA612 with a thickness of (0.70 ± 0.10) mm. The cover shall be (70 to 90) % of the wall thickness.

Grade N. Shall consist of a non-conductive ETFE with a thickness of (0.30 ± 0.05) mm. The cover shall consist of PA612 with a thickness of (0.70 ± 0.10) mm. The cover shall be (70 to 90) % of the wall thickness.

3.2.1.11 Type K. This tube is a laminated construction with an inner layer PA12, a barrier layer of Ethylene Vinyl Alcohol (EVOH) and a cover of PA612.

Grade C. Shall consist of a an inner layer of conductive PA12 with a nominal thickness of (0.1 ± 0.02) mm, an intermediate layer of PA12, an intermediate adhesive layer, a barrier layer of Ethylene Vinyl Alcohol (EVOH), an intermediate layer of adhesive and a cover of PA612. The EVOH barrier layer shall have a thickness of (0.15 ± 0.03) mm.

Grade N. Shall consist of an inner layer of PA12, an intermediate adhesive layer, a barrier layer of Ethylene Vinyl Alcohol (EVOH), an intermediate layer of adhesive, and a cover of PA612. The EVOH barrier layer shall have a thickness of (0.15 ± 0.03) mm.

3.2.1.12 Type L. This tube is a laminated construction with an inner layer of PA9T and a cover of PA12 or PA11.

Grade N Only. Shall consist of an inner layer of nonconductive PA9T and a cover of PA12 or PA11. The PA9T inner layer shall have a minimum thickness of 0.2 mm.

3.3 Labeling. Tubing released to this specification shall be labeling based on the requirements of the region in which it is released. Tubing for GMNA shall be labeled according to Appendix A, paragraph A4. Tubing for GME shall be labeled according to DIN 73378. Labeling requirements for other regions shall be coordinated with the regional Materials Engineer.

3.4 Minimum bend diameter referenced in specific test procedures shall be calculated according to SAE J2260.

3.5 Samples. See Figure 1.

Table 1: Requirements Reference Table

Paragraph	Test	No. of Samples
3.6	Burst	5
3.7	High Temperature Burst	5
3.8	Reference Stress	Not applicable
3.9	Cold Temperature Flexibility	5
3.10	Surface Resistivity	5
3.11	Disruptive Discharge	5
3.12	Cold Impact	5
3.13	Kink Resistance	5
3.14	Burst on Kinked Tube	5
3.15	Resistance to Stone Impact	5

Paragraph	Test	No. of Samples
3.16	Layer Adhesion	5
3.17	Tensile	5
3.18	Elongation	5
3.19	Flexural Test	5
3.20	Zinc Chloride	5
3.21	Calcium Chloride	5
3.22	Fuel Resistance – Recirculation	5/each Fuel
3.23	Auto-oxidized Fuel Resistance	5
3.24	Permeability	5
3.25	Resistance to Brake Fluid	5
3.26	Resistance to Underbody Protective Wax	5
3.27	Resistance to Oil	5

Note: No. = Number

3.6 Burst Test.

3.6.1 Test Procedure. The test apparatus consists of a suitable source of hydraulic pressure and the necessary gages and piping. The length of the tubing should be (305.0 ± 5.0) mm. Plug one end of the test specimen and mount in the apparatus with the other end unrestrained. The samples shall be assembled to ensure that the result will be a burst in the tube. The tubing is stabilized for (1 to 3) h at $+23^\circ\text{C}$. Pressure is applied at room temperature, $(+23 \pm 2)^\circ\text{C}$, at a rate of (7 ± 1) MPa/minute. Continue at this rate until the tubing bursts. If the tube separates from the fitting the result shall not be used.

3.6.2 Acceptance Determination. Burst pressure shall exceed requirements as defined in Table 2.

Table 2: Burst Pressure

Size OD	Grade C in MPa	Grade N in MPa
≤ 8 mm	≥ 6.5 MPa	≥ 6.5 MPa
> 8 mm to ≤ 10 mm	≥ 5 MPa	≥ 5 MPa
> 10 mm to ≤ 13 mm	≥ 4 MPa	≥ 4 MPa
> 13 mm to ≤ 16 mm	≥ 3.5 MPa	≥ 3.5 MPa
> 16 mm	≥ 3.5 MPa	≥ 3.5 MPa

3.7 High Temperature Burst Test.

3.7.1 Test Procedure. The test apparatus consists of a suitable source of hydraulic pressure and the necessary gages and piping. The oil shall be at $(115 \pm 1)^\circ\text{C}$. The length of the tubing shall be (305.0 ± 5.0) mm. Plug one end of the test specimen and mount in the apparatus with the other end unrestrained. The samples shall be assembled to ensure that the result will be a burst in the tube. The tubing shall be stabilized for 1 h at $+115^\circ\text{C}$. Pressure is applied at $+115^\circ\text{C}$ at a rate of (7 ± 1) MPa/minute. Continue at this rate until the tubing burst. If the tube separates from the fitting, the result shall not be used.

Note: For tubing of inner diameter (ID) 12.50 mm and larger used for low pressure (≤ 6.9 kPa maximum operating pressure) and low temperature applications ($\leq +90^\circ\text{C}$ maximum intermittent temperature), there is no high temperature burst requirement.

3.7.2 Acceptance Determination. The minimum burst pressure is identified in Table 3.

Table 3: High Temperature Burst Pressure

Size OD	Grade C in MPa	Grade N in MPa
≤ 8 mm	≥ 2.0 MPa	≥ 2.0 MPa
> 8 mm to ≤ 10 mm	≥ 1.5 MPa	≥ 1.5 MPa
> 10 mm to ≤ 13 mm	≥ 1.0 MPa	≥ 1.0 MPa
> 13 mm	≥ 1.0 MPa	≥ 1.0 MPa

3.8 Basic Stress.

3.8.1 Test Procedure. The reference stress, σ_v (Hoop Strength) shall be calculated from the results of paragraph 3.6 Burst Pressure by the following formula as defined by DIN 73378:

$$\sigma_v = (p_B \cdot d_m) / (2 \cdot s) \text{ in MPa}$$

Where:

σ_v = basic stress (Hoop Strength) in MPa

p_B = burst pressure in MPa

d_m = $d_1 - s$: middle diameter in mm

d_1 = outer diameter in mm

s = tube wall thickness in mm

3.8.2 Acceptance Determination. The tubing shall have a basic stress $\sigma_v \geq 20$ MPa.

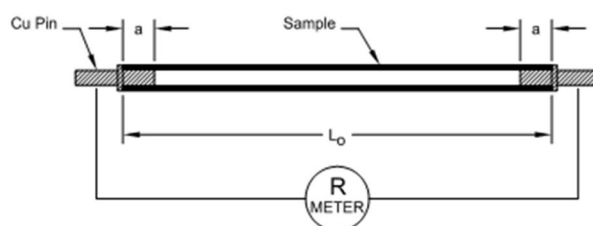
3.9 Cold Temperature Flexibility Test.

3.9.1 Test Procedure. The sample, consisting of a (305.0 ± 5.0) mm length of tubing, is exposed in an air-circulating oven at $(110 \pm 2)^\circ\text{C}$ for 24 h. The sample is removed from the oven and within 30 minutes exposed for 4 h at $(-40 \pm 2)^\circ\text{C}$. A mandrel having a diameter equal to 12 times the nominal outer diameter (OD) of the tubing is also exposed for 4 h at $(-40 \pm 2)^\circ\text{C}$. In order to obtain uniform temperatures the tubing and mandrel may be supported by a non-metallic surface during the entire period of the exposure. Immediately following this exposure, the tubing is bent 180° over the mandrel with this bending motion completed within a period of (4 to 8) s. For tubing of inner diameter (ID) 12.00 mm and larger, the sample length shall be (610.0 ± 5.0) mm.

3.9.2 Acceptance Determination. The tubing shall show no evidence of fracture.

3.10 Surface Resistivity. This section is required for Grade C only. The test apparatus consists of a resistivity meter (MEG-CHECK 2100A R-meter from Associates Research Inc. or equivalent) and a set of copper pins (diameter ≈ 0.1 mm larger than ID of tubing).

Figure 1: Schematic of Resistance Measurement Fixture

**3.10.1 Test Procedure.**

3.10.1.1 Measure sample length. Record as L_o (mm).

3.10.1.2 Measure inner diameter of sample. Record as d (mm).

3.10.1.3 Insert the copper pins to full depth in ends of tube assuring a tight fit. Measure the depth of the copper pin "a" in mm. Attach the leads to the resistivity meter as shown in Figure 1.

3.10.1.4 Calculate:

$$\text{Surface Resistivity } (\Omega) = R(\pi d)/(L_0 - 2a)$$

Where:

R = Surface resistivity in Ω

d = inner diameter in mm

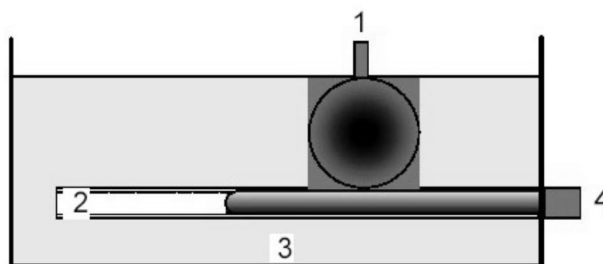
L₀ = sample length in mm

a = depth of the copper pin in mm

3.10.2 Acceptance Determination. The maximum resistivity shall be $10^6 \Omega$.

3.11 Disruptive Discharge Voltage. Grade N tubes specified for fuel applications must meet the requirements of paragraph 3.11 based on EN 60243-2 and IEC 60684-2. The test is performed with variable direct current (DC) voltage according to the test setup in Figure 2.

Figure 2: Test Setup of Disruptive Discharge Test



1 DC voltage (+0 to 140) kV

2 Hose test piece

3 Silicone oil

4 Ground potential

3.11.1 Test Procedure. A ball electrode ($\varnothing$ 50 mm) and a metal bar (in the tube) are used as electrodes. The diameter of the metal bar shall not be smaller than the inner diameter of the tube minus 0.1 mm. With weakly inhomogeneous field, positive polarity is applied to the ball and the metal bar is grounded. In order to prevent sliding charges along the tubing surface, the test piece is embedded in silicone oil.

Voltage is increased to +40 kV with a speed of 1 kV/s. This value shall be kept for 1 minute. Then the voltage is increased with a speed of 1 kV/s until a disruptive or a creeping discharge appears or the maximum voltage of 140 kV is reached. The voltage when discharge appears is defined as discharge voltage. At discharge the type of discharge, disruptive or creeping discharge, shall be noted.

3.11.2 Acceptance Determination. The discharge shall be ≥ 40 kV.

3.12 Cold Impact Test. Two procedures are described for cold impact testing. Only one procedure is necessary for submission. Paragraph 3.12.1 is required for GMNA. Paragraph 3.12.2 is required for GME. For submittal to other regions, the procedure shall be agreed upon by the regional GM Materials Engineer.

3.12.1 Falling Weight Cold Impact.

3.12.1.1 Test Procedure. Test Fixture shall conform to Appendix A, paragraph A2 requirements. The specific test procedures and equipment used shall have GM Engineering Approval. Sample length to be (305.0 ± 5.0) mm. Samples shall be taken from the same lot as the initial samples subjected to paragraph 3.6 Burst Test. The tubing sample is exposed to -40°C for 4 h. The impact test apparatus described by Appendix A, paragraph A2 is exposed for a minimum of 1 h at -40°C . The impact shall be performed at -40°C . The sample is inserted into the test apparatus and impacted by allowing the head to fall (305.0 ± 3.0) mm. The sample is allowed to return to $(+23 \pm 2)^\circ\text{C}$ within (30 ± 5) minutes, and then subjected to the burst test procedure according to paragraph 3.6.1.

3.12.1.2 Acceptance Determination. Samples shall meet the requirements of paragraph 3.6 Burst Test. Additionally, each sample burst tested after cold impact exposure shall achieve 70 % minimum of the average burst value for the five initial samples from the same tubing lot according to paragraph 3.6 Burst Test.