



Thermoplastic Fuel Tubing

1 Scope

This standard covers the 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 °C 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, GMW17568, GMW17560, GMW17823, GMW14754, GMW17560, GMW17823, GMW17568, and GMW15986.

In addition to the test requirements listed in this specification, as listed in Table 1, 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 are to be defined by the GM Materials Engineer.

This specification is used to qualify the materials and construction of a thermoplastic fuel tubing. The approval of the tubing is specific for supplier, size, manufacturing location, raw materials, and manufacturing process. Successful testing of assemblies consisting of tubing with specific quick connectors or other fittings to 3.6, 3.7, 3.20, 3.21, 3.22, and 3.23 of this specification can be used to meet the requirements of GMW17560, 3.6, 3.7, 3.14, 3.15, 3.16, 3.17. After a tube has been qualified to the requirements of this specification, testing to the specification GMW17560 can be used to qualify other assemblies incorporating the tube with other quick-connectors or fittings.

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

1.2 Symbols. Not applicable.

1.3 Applicability. Thermoplastic fuel lines.

1.4 Remarks. Not applicable.

2 References

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

2.1 External Standards/Specifications.

ASTM D3703	ISO 178	SAE J1737	SAE J2260
DIN 73378	ISO 527		

2.2 GM Standards/Specifications.

GMW3059	GMW14681	GMW14797	GMW17560
GMW3221	GMW14700	GMW14914	GMW17568
GMW14270	GMW14754	GMW15986	GMW17823

2.3 Additional References.

- Safety and Industrial Hygiene (S&IH) Technical Standard (TS), S&IH TS 3.4-160-02 (available at www.gmsupplypower.covisint.com).

3 Requirements

3.1 Requirements on Test Specimens. Reference GMW3221.

3.1.1 All materials supplied to this standard must comply with GMW3059, **Restricted and Reportable Substances**, including the requirement to submit a full material composition disclosure to GM via the International Material Data System (IMDS) or via a completed GMW3059 report form.

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. All multilayer tubing constructions may be qualified with PA610 or PA612 outer layers as alternatives to PA11 or PA12 upon review and approval by the General Motors Materials Engineer generating the specification approval.

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), Polyamide 11 (PA11), Polyamide 610 (PA610) or Polyamide 612 (PA612).

Grade C. This tube shall consist of either PA12, PA11, PA610, or PA612 with an appropriate inner layer of conductive PA12, PA11, or PA612.

Grade N. This tube shall consist of either PA12, PA11, PA610, or PA612. Tubing of this construction of 12.70 mm nominal OD which is used only for fuel vapor applications shall have a minimum Burst Pressure per 3.6 of 3.3 MPa.

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 an inner layer of conductive PA12 with a minimum thickness of 0.08 mm, an intermediate layer of PA12 if needed, 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 between 0.05 mm and 0.18 mm.

Grade N Only. 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 between 0.05 mm and 0.18 mm. Tubing of this construction of 9.53 mm nominal OD which is used only for fuel vapor applications shall have a minimum Burst Pressure per 3.6 after fuel recirculation per 3.22 of 4.1 MPa.

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

Grade C. Shall consist of a conductive ETFE with a thickness of between 0.08 mm and 0.276 mm. An intermediate layer of adhesive may be used. If used, the intermediate layer of adhesive shall have a thickness between 0.05 mm and 0.200 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 between 0.08 mm and 0.276 mm. An intermediate layer of adhesive may be used. The intermediate layer of adhesive shall have a thickness between 0.05 mm and 0.200 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 an inner layer of conductive PA12 with a nominal thickness of (0.1 ± 0.02) mm, an intermediate layer of PA12 if needed, 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, PA11, or PA612.

Grade C. Shall consist of an inner layer of conductive PA9T and a cover of PA12, PA11, or PA612. The PA9T inner layer shall have a thickness between 0.1 mm and 0.3 mm. An optional construction of the PA9T inner layer is an innermost layer of conductive PA9T combined with an outer layer of nonconductive PA9T.

Grade N. Shall consist of an inner layer of nonconductive PA9T and a cover of PA12, PA11, or PA612. The PA9T inner layer shall have a thickness between 0.1 mm and 0.3 mm.

3.2.1.13 Type M. This tube is a laminated construction with an inner layer of ETFE, and intermediate layer of PA12, a barrier layer of Ethylene Vinyl Alcohol (EVOH) and a cover of PA12 or PA612.

Grade C. Shall consist of an inner layer of conductive ETFE, and 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 or PA612. The EVOH barrier layer shall have a thickness of (0.15 ± 0.03) mm.

Grade N. Shall consist of an inner layer of ETFE, 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 or PA612. The EVOH barrier layer shall have a thickness of (0.15 ± 0.03) 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 per Appendix A, A4, and Figure A3. Labeling requirements for other regions shall be coordinated with the regional Materials Engineer.

3.4 Minimum Bend Diameter. See Appendix A, Table A1.

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	Basic 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
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	Sour Gasoline Recirculation Test	5
3.24	Permeability	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 (1) 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 h to 3 h) at +23 °C. Pressure is applied at room temperature, $(+23 \pm 2)$ °C, at a rate of (7 ± 1) MPa/minute. Continue at this rate until the tubing bursts. Report the failure mode for all samples and report all data points. Describe all quick-connectors/fitting types tested to the Burst Test requirements per this test, whether the assembly met the Burst Test requirements or not. If the tube separates from the fitting, test additional samples until a minimum number of samples per the test requirements burst through tubing burst, not fitting blow out. If tubing burst is not possible due to consistent fitting

blow out, retest with connection attachments that do result in tubing burst. All Burst Test data points, regardless of quick-connector or fitting used, and regardless of failure mode, must meet the Burst Test requirements. For all additional GMW14638 test procedures that involve a Burst Test determination after conditioning for assemblies containing fittings, (see 3.20, 3.21, 3.22, 3.23) failure mode of the assembly must be reported.

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 MPa	≥ 3 MPa

Note: MPa = Megapascal.

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 (1) 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. If the tube separates from the fitting, test additional samples until a minimum number of samples per the test requirements burst through tubing burst, not fitting blow out. If tubing burst is not possible due to consistent fitting blow out, retest with connection attachments that do result in tubing burst. All data points must be reported. All fitting types used to conduct the test must be described, whether the assembly met the requirements of this test or not.

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 3.6 Burst Pressure by the following formula as defined by DIN 73378:

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

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

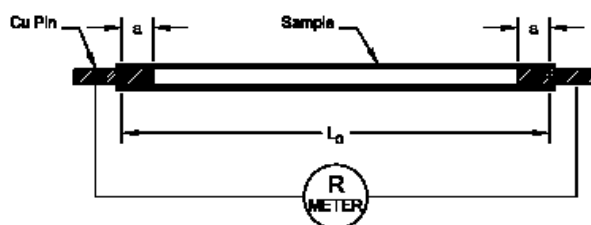
3.9 Cold Temperature Flexibility Test.

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 degrees over the mandrel with this bending motion completed within a period of (4 s to 8 s). For tubing of inner diameter (ID) 12.00 mm and larger, the sample length shall be $(610.0 \text{ mm} \pm 5.0 \text{ mm})$.

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. Copper pins must make contact with the inner diameter of the tubing only. 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:

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

Where:

R = Resistivity in Ω

d = inner diameter in mm

L_o = sample length in mm

a = depth of the copper pin in mm

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