GM	WORLDWIDE ENGINEERING STANDARDS	Material Specification Major Category	GMW14638

Thermoplastic Fuel Tubing

1 Scope

This specification 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 –40ºC to 90ºC with excursions to 115ºC. Other documents which describe the performance and dimensional requirements of these components and assemblies manufactured from these components are GME 60223, GM9060P, GM9080P, GM9676P, and Chart #10093203.

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 are to be defined by the GM Materials Engineer.

1.1 Material Description

Each material shall be defined by a construction and a grade. The construction identifies the layers utilized in the wall. The grades identifies the conductivity of the line. Grade C identifies a tube that has a conductivity greater than 10^6 Ohms/sq . Grade N identifies a tube which has less than 10^6 Ohms/sq . 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.

1.1.1 Construction (See Appendix A1)

1.1.1.1 Type A

Grade N only: This tube shall consist of a single layer of either Polyamide 12 (PA12) or Polyamide 11 (PA11).

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

Grade C consists of an inner tube of conductive ETFE and an outer tube of nonconductive 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 nonconductive 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.

1.1.1.3 Type C

Grade N only This tube is a laminated construction with an inner tube of PA12, a barrier layer of PBT and a cover of PA12. The PBT barrier layer shall have a thickness of 0.25 ± 0.05 mm.

1.1.1.4 Type D This tube is a laminated construction with an inner tube PA12, a barrier layer of 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 nonconductive 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 nonconductive PA12.

Grade N shall consist of an inner layer of nonconductive 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 nonconductive PA12.

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

1.1.1.6 Type F The tube is an inner tube 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 nonconductive 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 0.381 ± 0.050 mm. The outer layer shall be PA12. The outer layer shall be 55 to 75% of the wall thickness.

1.1.1.7 Type G EVOH

Grade N only This tube is a laminated construction with an inner tube of PA12, a barrier layer of EVOH and a cover of PA12. The EVOH barrier layer shall have a thickness of 0.15 ± 0.03 mm.

1.1.1.8 Type H The tube is a laminated construction with an inner tube of conductive ETFE (Ethylene-Tetrafluoroethylene Copolymer) 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 nonconductive 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.

1.1.1.9 Type I This tube is a laminated construction with an inner tube of EFEP (ethylene-perfluoroethylenepropylene copolymer) 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 nonconductive 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

1.2 Labeling Tubing released to this specification must be labeling based on the requirements of the region which it is released. Tubing for GMNA must be labeled per Appendix A5. Tubing for GME must be labeled per DIN 73 378. Labeling requirements for other regions shall be coordinated with the regional Materials Engineer.

2 References

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

2.1 External Standards/Specifications

DIN 73378
EN 60243-2
IEC 60093
IEC 60684-2
ISO 178
ISO 527
SAE J1681
SAE J2260
SAE J1737

2.2 GM Standards/Specifications

GME 60223
GME 60255
GME L0003
GM9005P
GM9060P
GM9080P
GM9676P
GMW3001
GMW3059
GMW14700
9984297
9986121
9986231

3 Requirements

Minimum bend diameter referenced in specific test procedures shall be calculated per SAE J2260. A quick table reference has been provided in Appendix A2.

Requirements Reference Table

Section	Test	#Samples
3.1	Burst	5
3.2	High Temperature Burst	5
3.3	Reference Stress	N/A
3.4	Cold Temperature Flexibility	5
3.5	Surface Resistivity	5
3.6	Disruptive Discharge	5
3.7	Cold Impact	5
3.8	Kink Resistance	5
3.9	Burst on Kinked Tube	5
3.10	Resistance to Stone Impact	5
3.11	Layer Adhesion	5
3.12	Tensile	5
3.13	Elongation	5
3.14	Flexural Test	5
3.15	Zinc Chloride	5
3.16	Calcium Chloride	5
3.17	Fuel Resistance – Recirculation	5/Each Fuel

3.18	Auto-oxidized Fuel Resistance	5
3.19	Permeability	5
3.20	Resistance to Brake Fluid	5
3.21	Resistance to Underbody Protective Wax	5
3.22	Resistance to Oil	5

3.1 Burst Test

3.1.1 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°C. Pressure is applied at room temperature, 23 ± 2°C, at a rate of 7MPa/minute ± 1MPa/minute. Continue at this rate until the tubing bursts. If the tube separates from the fitting the result shall not be used.

3.1.2 Acceptance Determination
Burst pressure shall exceed requirements as defined in Table 1.

Table 1: Burst Pressure

Size	Grade C(MPa)	Grade N(MPa)
≤ 8 mm	≥ 6.5 MPa	≥ 6.5 MPa
> 8 to ≤ 10 mm	≥ 5 MPa	≥ 5 MPa
> 10 to ≤ 13 mm	≥ 4 MPa	≥ 4 MPa
> 13 to ≤ 16 mm	≥ 4.5 MPa	≥ 4.5 MPa
> 16 mm	≥ 4 MPa	≥ 4 MPa

3.2 High Temperature Burst Test

3.2.1 Test Procedure The test apparatus consists of a suitable source of hydraulic pressure and the necessary gages and piping. The oil should be at 115 ± 1°C. 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 shall be stabilized for 1 h at 115°C. Pressure is applied at 115°C at a rate of 7 MPa/min ± 1 MPa/min. Continue at this rate until the tubing burst. If the tube separates from the fitting the result shall not be used.

*For tubing of ID 12.50 mm and larger, used for low pressure (≤ 6.9 kPa maximum operating pressure), and low temperature applications (≤ 90°C maximum intermittent temperature), there is no high temperature burst requirement.

3.2.2 Acceptance Determination The minimum burst pressure is identified in the table 2 below.

Table 2: High Temperature Burst Pressure

Size	Grade C(MPa)	Grade N(MPa)
≤ 13 mm	≥ 2.0 MPa	≥ 2.0 MPa
> 13 mm	≥ 1.2 MPa	≥ 1.2 MPa

3.3 Basic Stress

3.3.1 Test Procedure The reference stress, σ_V (Hoop Strength) shall be calculated from the results of 3.1 Burst Pressure by the following formula as defined by DIN 73 378:

$\sigma_V = (p_B * d_m)/(2*s)$ in MPa

σ_V : basic stress (Hoop Strength) in MPa
p_B : burst pressure in MPa
$d_m = d_1 - s$: middle diameter
d_1 : outer diameter
s : tube wall thickness

3.3.2 Acceptance Determination The tubing shall have a basic stress σ_V ≥ 25 MPa

3.4 Cold Temperature Flexibility Test

3.4.1 Test Procedure The sample, consisting of a 305.0 ± 5.0 mm length of tubing, is exposed in an air-circulating oven at 110 ± 2°C for 24 h. The sample is removed from the oven and within 30 minutes exposed for 4 h at -40 ± 2°C. A mandrel having a diameter equal to 12 times the nominal diameter (nominal OD) of the tubing is also exposed for 4 h at -40 ± 2°C. In order to obtain uniform temperatures the tubing and mandrel may be supported by a nonmetallic 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 to 8 s. For tubing of ID 12.50 mm and larger, the sample length shall be 610.0 ± 5.0 mm.

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

3.5 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 approximately 0.1 mm larger than ID of tubing).

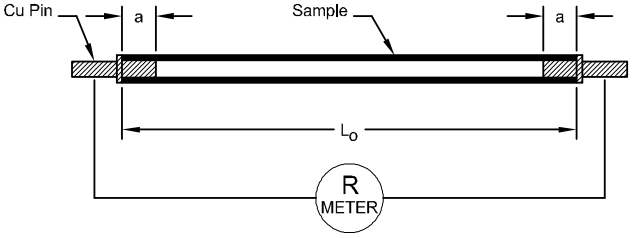


Figure 1: Schematic of Resistance Measurement Fixture

3.5.1 Test Procedure:

1. Measure sample length, record as 'L_o' (mm)
2. Measure inner diameter of sample. Record as 'd' (mm).
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 9.
4. Record the resistance 'R' (ohm).
5. Calculate: Surface Resistivity (ohm/sq) = $R(\pi d)/(L_o - 2a)$

3.5.2 Acceptance Determination

The maximum resistivity shall be 10^6 ohm/sq.

3.6 Disruptive Discharge Voltage Grade N tubes specified for fuel applications must meet the requirements of section 3.6 based on EN 60243-2 and IEC 60684-2. The test is performed with variable DC voltage according to the test-setup in Figure 2.

3.6.1 Test Procedure A ball electrode (Ø 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 min. 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.

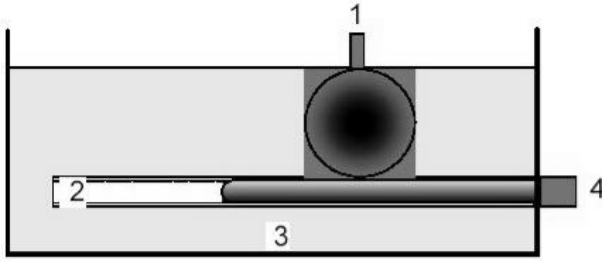


Figure 2: Test set up of Disruptive Discharge Test

1 DC voltage (+0...140) kV
2 Hose test piece
3 Silicone oil
4 Ground potential

3.6.2 Acceptance Determination The discharge must be greater than or equal to 40 kV.

3.7 Cold Impact Test Two procedures are described for cold impact testing. Only one procedure is necessary for submission. Section 3.7.1 is required for GMNA. Section 3.7.2 is required for GME. For submittal to other regions the procedure must be agreed upon by the regional GM Materials Engineer.

3.7.1 Falling weight Cold Impact

3.7.1.1 Test Procedure Test Fixture must conform to Appendix A3 requirements. The specific test procedures and equipment used must have GM Engineering approval. Sample length to be 305.0 ± 5.0 mm. Samples must be taken from the same lot as the initial samples subjected to 3.1 Burst Test. The tubing sample is exposed to –40°C for 4 h. The impact test apparatus described by Appendix A3 is exposed to –40°C for a minimum of 1 h at –40°C. The impact must 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 ± 2°C within 30 ± 5 minutes, and then subjected to the burst test procedure per 3.1.1.

3.7.1.2 Acceptance Determination Samples must meet the requirements of section 3.1 Burst Test. Additionally, each sample burst tested after cold impact exposure must achieve at least 70% of the average burst value for the five initial samples from the same tubing lot per 3.1 Burst Test.

3.7.2 Charpy Cold Impact

3.7.2.1 Test Procedure Must be run per DIN 73378 with reference to ISO 179. The test is executed with at -40 ± 3°C.

3.7.2.2 Acceptance Determination No Breaks.

3.8 Kinking Resistance Test

3.8.1 Test Procedure The sample length for the test is to equal 1.9 times the bending diameter, as defined in Appendix A2. The minimum ball diameter for the test ball is to equal 0.4 times the minimum inside diameter, as defined in Appendix A2. The test fixture to be used for the test is as described in Figure 3. A sample of minimum thickness tubing is to be selected out of a random sample of ten pieces of tubing. The wall thickness and ovality at point A on the test sample is measured. Wall thickness is also to be measured after completion of the test. The tube is installed in the test fixture described in Figure 3. When the tube is installed, the tube is bent in the same plane and direction as its free state curvature. The tube, installed in the fixture, is placed into an oven at 115 ± 2°C and soaked for 1 h. The tube and fixture are removed from the oven, and within 5.5 minutes, the test ball is passed through the tube, with the tube still in the fixture. Additionally, tubing for Grade C shall be subjected to the surface resistivity test procedure per 3.5.1.

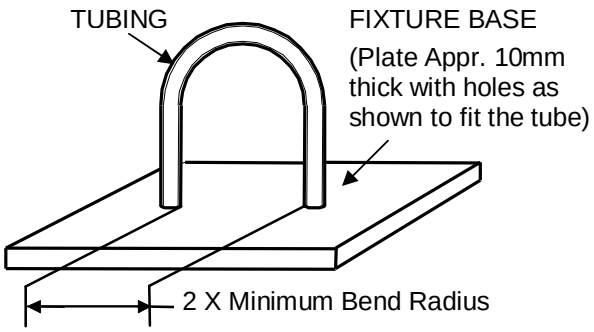


Figure 3: Kinking Resistance Test Fixture

3.8.2 Acceptance Determination Test ball must pass through the tube without restriction. Additionally, Grade C must meet the requirements of section 3.5 Surface Resistivity.

3.9 Burst Test on Kinked Tubing

3.9.1 Test Procedure Stabilize tubing for 0.5 to 3 hours at 23°C. Completely bend tubing so it is kinked and two lengths of tubing on either side of kink touch along entire length. Straighten tubing completely. Repeat so tubing is kinked a total of five times at same position. Perform burst test procedure per section 3.1.1.

3.9.2 Acceptance Determination Samples must meet requirements of the 3.1 Burst Test.

3.10 Resistance to Stone Impact

3.10.1 Test Procedure Tubing shall be subjected to Stone Impact Test Procedure per GMW14700 for 10 cycles at –40°C. Samples must be taken from the same lot as the initial samples subjected to 3.1 Burst Test. The sample length is 305.0 ± 5.0 mm. Following the Stone Impact Test, sample is subjected to burst test procedure per section 3.1.1.

3.10.2 Acceptance Determination Sample must meet all of the requirements of 3.1 Burst Test. Additionally, each sample burst tested after Stone Impact must achieve at least 70% of the average burst value for the 5 samples from the same tubing lot burst tested per 3.1 Burst Test.

3.11 Layer Adhesion Test Section 3.11.1 describes the recommended adhesion procedure. Optional adhesion procedures may be used upon agreement by regional Materials Engineer.

3.11.1 Test Procedure Cut a strip of tubing into approximately 6 mm wide helical coil equal in length to 5 times the circumferences of the tubing using a tool as shown in Figure 10. Bend the helical coil in reverse of coiling. Apply a weight of 2 kg to the uncoiled end.

3.11.2 Acceptance Determination No delamination should occur between layers.

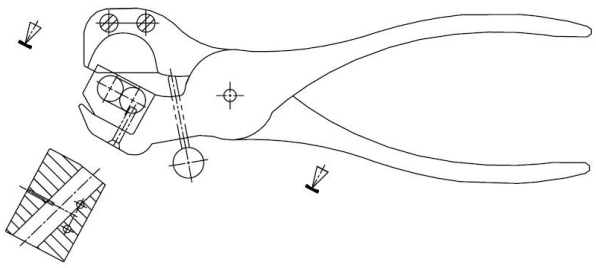


Figure 4: Adhesion Test Tool

3.12 Tensile Strength Test

3.12.1 Test Procedure Samples shall be tested per ISO 527. The tubing is clamped into a tensile test

fixture which allows tensile strength and elongation to be measured without slippage or breakage of the tubing at the tensile tester jaw. The elongation is to be measured with either an extensometer or with elongation bench marks (i.e., paper dots attached to the tubing). The initial extensometer measuring distance or the elongation bench marks separation is to equal 50 mm. The following test conditions must be met:

Test Speed = 50 mm/minute

Test Temperature = (23 ± 2) °C

RH = 50 %

The tensile strength and elongation testing is conducted under the test conditions noted above until the ultimate elongation of the test sample is reached. When the tubing breaks, the load, and length of bench marks or extensometer reading, is recorded. The specific test procedures and equipment for each supplier must have GM Engineering approval.

3.12.2 Acceptance Determination The tensile strength must be a minimum of 30 MPa.

3.13 Elongation Test

3.13.1 Test Procedure The test procedure for the Elongation Test is identical to the test procedure of 3.11, Tensile Strength Test.

The elongation is calculated using the following formula:

Elongation= [(Final Reading of Bench Marks-50)/50]X100

3.13.2 Acceptance Determination The elongation value recorded for the tubing sample must be a minimum of 175 %.

3.14 Flexural Test Samples shall be tested per ISO 178.

3.14.1 Test Procedure:
Test pieces: 120 mm long
Support distance: 80 mm, radius of support: r_2 = (2 ± 0.2) mm,
Test speed: v = 5 mm/min, preload: F_v = 0.5 N,
Test at +23 ± 5°C and 50 ± 6% relative humidity.

A diagram of force (N) to deflection (mm) is recorded during the test. The following values are identified in the diagram:

- F_{max} = Maximum Flexural Force
- δ_{max} = Deflection at F_{max}
- $F_{3.5}$ = Flexural Force at 3.5 mm deflection

Note to the documented values:
The larger the deflection at F_{max} and $F_{3.5}$, the stronger the kink resistance of the tubing.

3.14.2 Acceptance Determination Tubing must meet the requirements of Table 3.

Table 3: Flexural Force

Size	Fmax (N)	δ_{max} (mm)	$F_{3.5}$ (N)
≤ 8 mm	≤ 34	≥ 6	≤ 44
> 8 to ≤ 10 mm	≤ 45	≥ 5	≤ 50
> 10 to ≤ 13 mm	≤ 50	≥ 5	≤ 60
> 13 to ≤ 16 mm	≤ 100	≥ 6	≤ 90
> 16 mm	≤ 110	≥ 7	≤ 110

3.15 Resistance to Zinc Chloride Test Test in fixture per Figure 5.

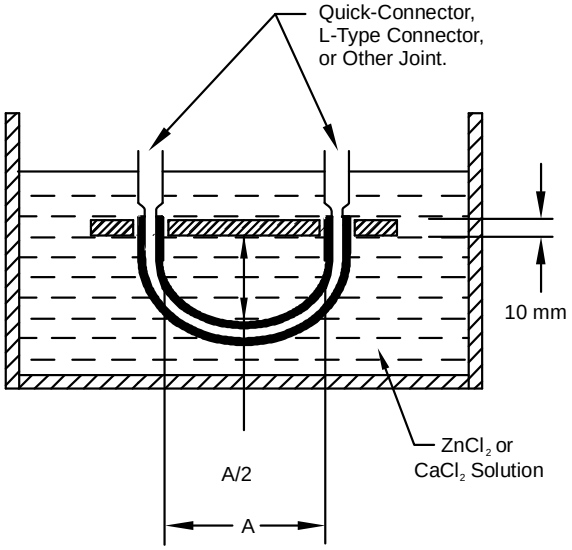


Figure 5: Chloride Test Fixture

3.15.1 Test Procedure Samples shall be prepared using the free tubing length as specified in Appendix A2. The sample is bent to the minimum bend diameter as specified in Appendix A2 and immersed in a 50 % aqueous solution (by weight) of zinc chloride for 200 h at 23 ± 2°C. All interfaces between the tubing and the components directly connected to the tubing must also be immersed for the duration of the test when performing this procedure. The ends of

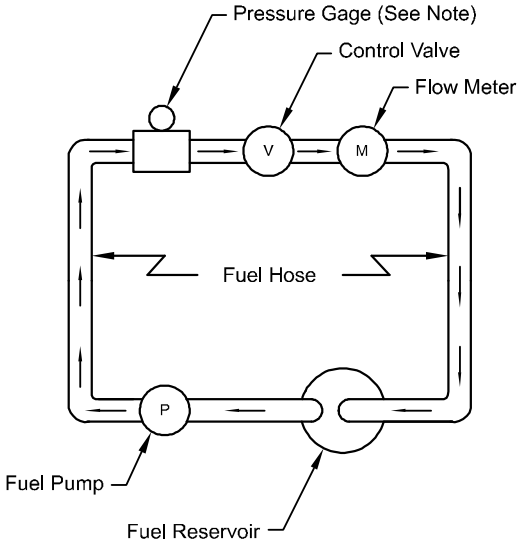
the assembly are to remain unplugged. The sample is removed from the solution and subjected to Cold Impact and Burst procedure of section 3.7.1. The sample may be rinsed with fresh water to clear salt residue from the tubing before bursting.

3.15.2 Acceptance Determination There shall be no visible cracks or crazing in the sample. Sample must meet section 3.7 Cold Impact with Burst Testing.

3.16 Resistance to Calcium Chloride Test in fixture per Figure 5.

3.16.1 Test Procedure The sample is bent to the minimum bend diameter and immersed in a 50% aqueous solution (by weight) of calcium chloride for 200 h at 60 ± 2°C and 200 h out of solution at 60 ± 2°C. All interfaces between the tubing and the components directly connected to the tubing must also be immersed for the duration of the test when performing this procedure. The ends of the assembly are to remain unplugged. The sample is removed from the solution and subjected to Cold Impact and Burst procedure of section 3.7.1. The sample may be rinsed with fresh water to clear salt residue from the tubing immediately before the burst test.

3.16.2 Acceptance Determination There shall be no visible cracks or crazing in the sample. Sample must meet section 3.7 Cold Impact with Burst Testing.



Note: Optional for Monitoring Flow

Figure 6: Fuel Recirculation Test Apparatus

3.17 Fuel Resistance – Recirculation Test

3.17.1 Test Fuels The recirculation test procedure must be conducted for the following types of fuel and must meet the requirements in section 3.17.3

- **A.** CE10 per SAE J1681 or 10% BioEthanol in Gasoline according to ISO 1817 Liquid 1.
- **B.** CM15A per SAE J1681 or ISO 1817 Liquid 2 with additional 20 PPM formic acid.

3.17.2 Test Procedure Three sets of samples shall be prepared for exposure. Each set shall be exposed to recirculating fuel per section 3.17.1 using the test apparatus as shown in Figure 6. The rate of flow shall be at least 10 liters/hour for tubing ≤ 8mm and 40 liters/hour for tubing > 8mm. The temperature of the fuel must be maintained at 60 ± 2°C. The internal fuel volume including the fuel reservoir must be at least 1 liter/ 5 meters of test line. Any fuel filters incorporated into the test sample assemblies for test purposes are to be inserted between the flow meter and fuel reservoir. The recirculating fuel is to be replaced with fresh fuel every week. The total test time shall be 5040±4 hours. One set of tubing shall be removed from the test fixture every 1680±4 hours.

3.17.3. Acceptance Determination Each sample set shall meet the requirements of the following tests conducted sequentially. If preferred, samples tested to Sections E and F can be from an additional sample set tested to the requirements of Sections A through C omitting section D Burst Test:

- **A.** The maximum tubing length change permitted ≤ 2.0 % measured at 23 °C.
- **B.** Attach fuel system assembly to a suitable fixture, which has mating fittings identical to those used on the vehicle. The outer diameter of the fitting must be the minimum allowed by the design of the vehicle fuel system. Pressurize with air to 1035 ± 35 kPa**.** The maximum leak rate shall be 5 cc/minute.
- **C.** Sample must be tested per 3.4 Cold Temperature Flexibility Test, omitting the 110°C oven-age step, and meet the requirements of 3.4.2.
- **D.** Sample must meet the requirements of 3.1 Burst Test.
- **E.** Sample must meet the requirements of 3.11 Layer Adhesion.
- **F.** Type F tubing must meet the requirements of section 3.5 Surface Resistivity.

3.18 Sour Gasoline Recirculation Test

3.18.1 Test Procedure The assembly is exposed to recirculating sour gasoline (Indolene HO-III/T-Butyl Hydroperoxide Mixture) for 1008 ± 4 hours as shown in Figure 6 with a modified fuel reservoir as shown in Figure 7 according to the following procedures:

- **A.** Connect the test sample as per the fuel recirculation test (See Figure 6). Any fuel filters incorporated into the test sample assemblies for test purposes are to be inserted between the flow meter and the fuel reservoir.
- **B.** Mix 3.8 mL of 70% T-Butyl Hydroperoxide per 1000 mL of Indolene. Stir vigorously. Allow the water to settle out of the mixture (no less than 3 h). Decant the fuel into a new container.
- **C.** Remove 5 mL of fuel for the peroxide number measurement per GM9055P. The peroxide number should equal 50 ± 3 initially. Pour the fuel into the reservoir.
- **D.** The rate of flow shall be set to at least 10 liters/hour for tubing ≤ 8mm and 40 liters/hour for tubing > 8mm.
- **E.** Maintain the temperature at 40 ± 2°C.
- **F.** Measure the peroxide once every 84±4 hours.
- **G.** Run the test for 1008±4 hours. Change the sour gasoline after the first 24 h and thereafter:
    1. When the peroxide number is less than 40 or greater than 55, or
    2. Once a week if the peroxide number remains between 40 and 55.
- **H.** Correct for evaporative losses when necessary by adding sour gasoline of peroxide number = (50 ± 3).

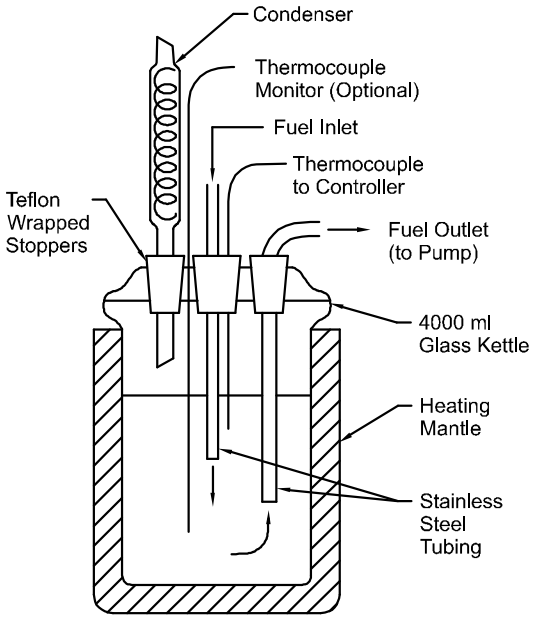


Figure 7: Sour Gasoline Fuel Reservoir

3.18.2 Acceptance Determination After 1008 hours of sour gasoline exposure, the samples shall meet the requirements of the following tests conducted sequentially. If preferred, samples tested to Sections E and F can be from an additional sample set tested to the requirements of Sections A through C omitting section D Burst Test:

- **A.** The maximum tubing length change permitted shall be ≤ 2.0% measured at 23°C.
- **B.** Attach fuel system assembly to a suitable fixture, which has mating fittings identical to those used on the vehicle. The outer diameter of the fitting must be the minimum allowed by the design of the vehicle fuel system. Pressurize with air to 1035 ± 35 kPa**.** The maximum leak rate for the assemblies shall be 5 cc/minute.
- **C.** Sample must be tested per 3.4 Cold Temperature Flexibility Test, omitting the 110°C oven-age step, and meet the requirements of 3.4.2.
- **D.** Sample must meet the requirements of 3.1 Burst Test.
- **E.** Sample must meet the requirements of 3.11 Layer Adhesion.
- **F.** Type F tubing must meet the requirements of section 3.5 Surface Resistivity.

3.19 Permeability Test

3.19.1 Test Fuels The permeability test procedure must be conducted for the following types of fuel and must meet the requirements in section 3.19.3

- **A.** CE10 per SAE J1681 or 10% BioEthanol in Gasoline according to ISO 1817 Liquid 1.
- **B.** CM15A per SAE J1681 or ISO 1817 Liquid 2 with additional 20 PPM formic acid.

3.19.2 Test Procedure One set of samples shall be subjected to permeability test per SAE J1737 using the test fuels described in Section 3.19.1 using a temperature of 60°C and 2 bar pressure. All permeability testing shall be performed on samples with minimum barrier wall thickness.

Permeation test methods equivalent to SAE J1737, using identical fuel compositions, temperature, and pressure may be used to meet the requirements of this test, upon the review and approval of the test method by the regional GM Materials Engineer issuing the Engineering Source Approval to the GMW14638 specification.

3.19.2 Acceptance Determination. Sample permeability must not exceed the limits specified in Table 4.

Table 4: Permeability Limits*

Type	CE10 or ISO 1817 Liquid 1	CM15A or ISO 1817 Liquid 2 w/20 PPM formic acid
A	50.0 g/m^2/ 24 h	100 g/m^2/ 24 h
B	18.0 g/m^2/ 24 h	TBD
C	0.5	TBD
D	21 g/m^2/ 24 h	35 g/m^2/ 24 h
E	TBD	100 g/m2/24 h
F	6.0 g/m^2/ 24 h	TBD
G	3.0 g/m^2/ 24 h	35 g/m^2/ 24 h
H	13.0 g/m^2/ 24 h	27 g/m^2/ 24 h
I	***TBD***	***TBD***

*See Appendix A4 for a reference table which converts the Table 4 limits into permeation per meter by tubing size.

3.20 Resistance to Brake Fluid

3.19.1 Test Procedure Seal ends of 200mm sample and expose external surface only to brake fluid for 72h at 23°C per GME 60255 - brake fluid L 000 0102 - A2. Optional test fluid is 9986121. Perform tensile test per Sections 3.12 and 3.13.

3.20.2 Acceptance Determination
A. Change of Yield Stress must be ±10% of original Yield Stress per section 3.12.
B. Change of Strain at Break must be ±30% of original Strain at Break per section 3.13.

3.21 Resistance to Underbody Protective Wax
3.21.1 Test Procedure Seal ends of 200mm sample and expose external surface only to underbody protective wax for 72h at 23°C per GME 60255 – underbody protective wax L 000 0125 - A2. Optional test fluid is 9984297. Perform tensile test per sections 3.12 and 3.13.

3.21.2 Acceptance Determination
A. Change of Yield Stress must be ±15% of original Yield Stress per section 3.12.
B. Change of Strain at Break must be ±15% of original Strain at Break per section 3.13.

3.22 Resistance to Oil
3.22.1 Test Procedure Seal ends of 200mm sample and expose external surface only to engine oil for 72h at 100 C per GME 60255 – engine oil B 040 0900 - C2. Optional test fluid is 9986231. Perform tensile test per sections 3.12 and 3.13.

3.22.2 Acceptance Determination
A. Change of Yield Stress must be ±20% of original Yield Stress per section 3.12.
B. Change of Strain at Break must be ±35% of original Strain at Break per section 3.13.

4 Manufacturing Process

Not Applicable

5 Rules and Regulations

5.1 All materials supplied to this specification must comply with the requirements of GMW3001, **Rules and Regulations for Material Specifications.**

5.2 All materials supplied to this specification must comply with the requirements of GMW3059, **Restricted and Reportable Substances for Parts.**

6 Approved Sources

Engineering qualifications of an approved source is required for this specification. Only sources listed in the GM Materials File (i.e., MATSPC) under this specification number have been qualified by engineering as meeting the requirements of this specification.

For other GM locations, the responsible engineering group should be contacted to obtain the approved source in that individual country.

7 Notes

Not Applicable

8 Coding System

This material specification shall be referenced in other documents, drawings, VTS, CTS, etc. as follows:

Material per GMW14638 Type X Grade Y

X = Specific Type from section 1.1

Y = C or N

Note: Type E must also include a description of the construction that was chosen for that specific application.

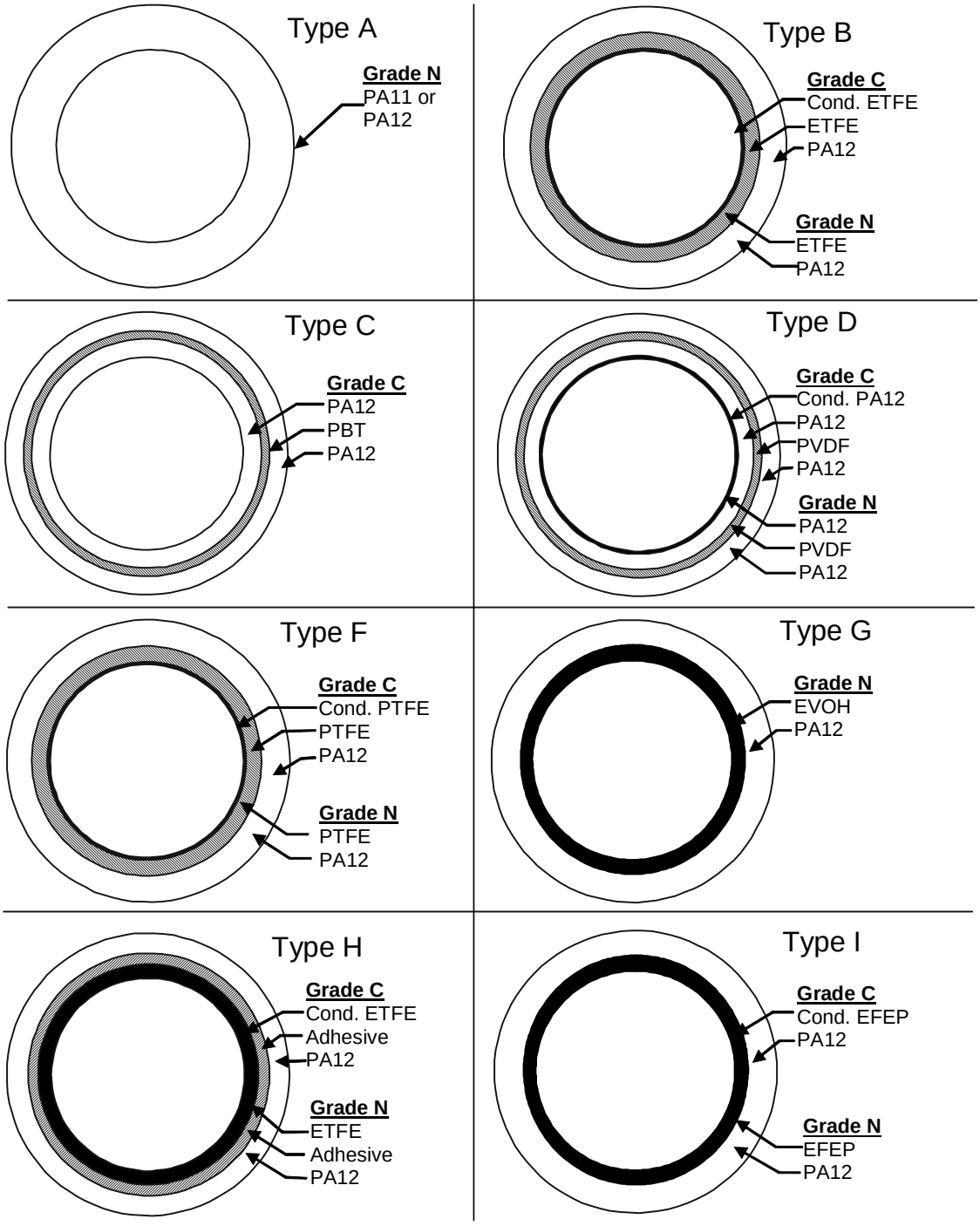
9 Release and Revisions

9.1 Release. This standard originated in 06/2006. It was first approved by (replace with approving organization's name) in (replace with original approval date [month/year]). It was first published in (replace with original publication date [month/year]).

It supersedes all regional material specifications for Multilayer Fuel Lines for use on Global Engineered materials including but not limited to: GME 08100, GM123M, GM6264M, and GM6406M.

Thermoplastic Fuel Tubing

Appendix A1 Detail of Construction Types



A2 Bend Diameter Reference Table

Nominal OD	Inside diameter	Wall Thickness	Bend diameter, min	Tubing Length
6.35	3.89-4.14	0.98-1.41	76.2	450
7.93	6.20-6.50	0.90-1.15	101.6	630
9.53	7.77-8.07	0.90-1.15	152.4	870
15.30	12.35-12.65	1.20-1.60	236.3	1330
28.40	25.25-25.55	1.35-1.65	380.4	2115

A3 Cold Impact Test Fixture Requirements

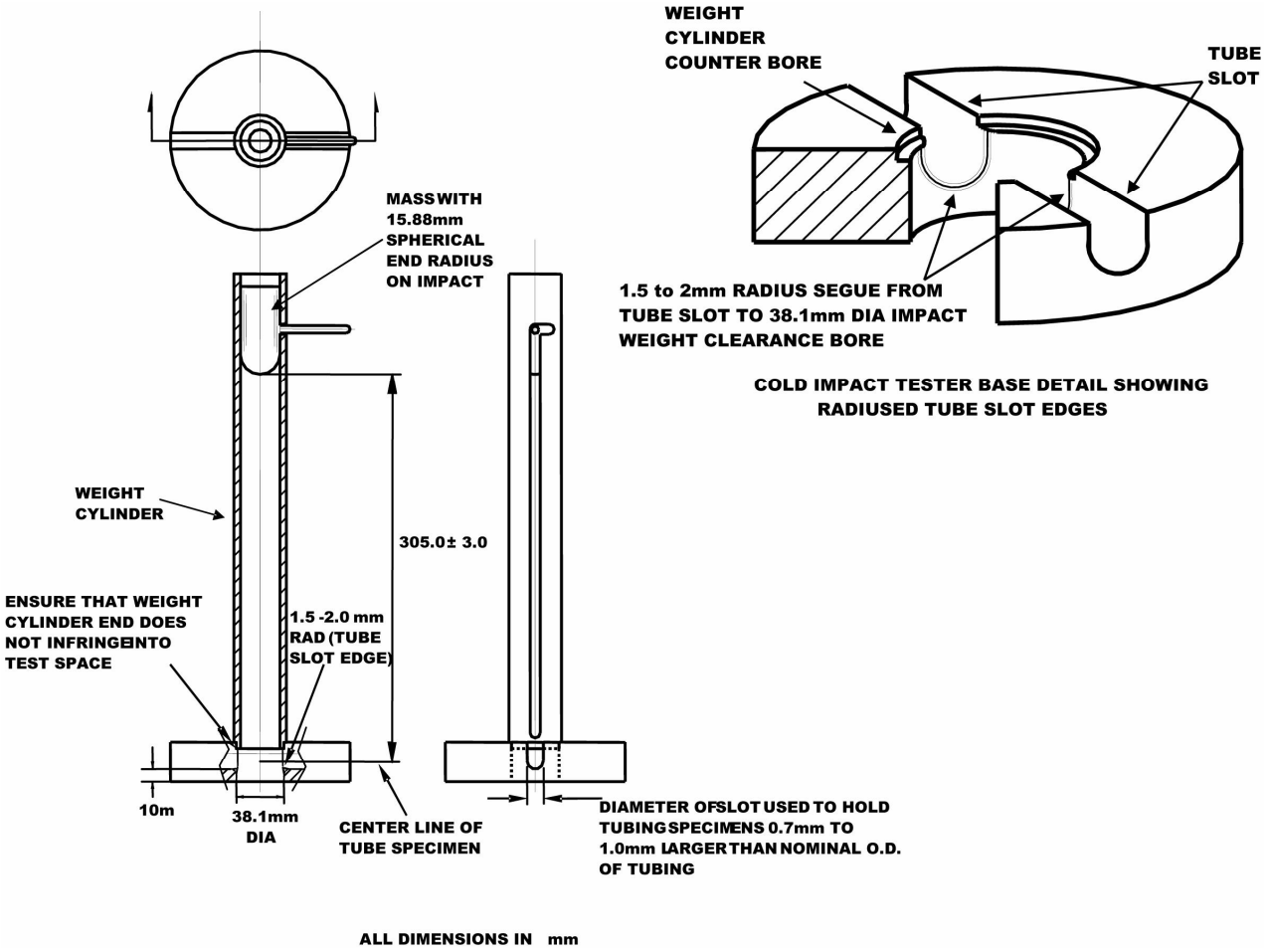


Figure A1: Cold Impact Test Fixture

A. Mass of the impact head = (0.912 ± 0.003) kg.

B. The distance from the impact head to the center of the tubing sample = (305.0 ± 3.0) mm.

C. The temperature of the fixture and the tubing = (-40 ± 2) °C.

D. The spherical end radius of the impacting mass = 15.88 mm.

E. The maximum radius of curvature of the edge of the supporting platform of the tubing at the circumference of the impact area = 1.3 mm.

F. A chest type cold chamber is required to cold soak the tubing and the fixture (not an upright cold chamber).

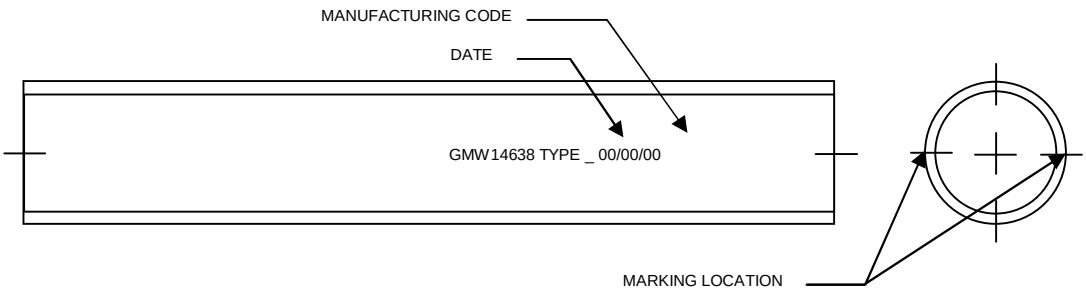
G. The mass must be free to impact the tubing throughout the length of the impact without hindrance by any portion of the fixture.

A4 Permeability per Length Reference

The conversion table has been added to show approximate permeation per meter of tubing by size. The results for permeation testing per SAE J1737 are not correlated to Sealed Housing Evaporative Determination (S.H.E.D.) tests in this document.

Permeability Reference in g/m/24 h							
Tubing Size in mm (inch)		7.93 (5/16)	8	9.53 (3/8)	10	12	15.30 (5/8)
	Inner Diameter in mm	6.2	6	7.77	8	10	12.35
Permeability Limit in g/m²/24 h	10	0.19	0.19	0.24	0.25	0.31	0.39
	20	0.39	0.38	0.49	0.50	0.63	0.78
	30	0.58	0.57	0.73	0.75	0.94	1.16
	40	0.78	0.75	0.98	1.01	1.26	1.55
	50	0.97	0.94	1.22	1.26	1.57	1.94
	60	1.17	1.13	1.46	1.51	1.88	2.33
	70	1.36	1.32	1.71	1.76	2.20	2.72
	80	1.56	1.51	1.95	2.01	2.51	3.10
	90	1.75	1.70	2.20	2.26	2.83	3.49
	100	1.95	1.88	2.44	2.51	3.14	3.88

A5 Tube Labeling



Markings: As shown above

Shall be legible

Shall be typical for all fuel lines including coextruded tubing.

Shall be parallel along axis on both sides 180 degrees apart ±10 degrees.

Marking must appear on at least one side, parallel to the fuel line axis. If markings are printed on both sides, they must be 180 degrees apart ±10 degrees.

Shall be a minimum of 2.5 mm high for ≥ 8mm Nominal OD tubing.

Shall be a minimum of 2.0 mm high for < 8mm Nominal OD tubing.

The open space between the markings shall be not more than 100.0 mm.

Color: White or Yellow

Printing must be placed on tubing as extruded (No Pre and Post Treatment Allowed)

Printing must conform to GM4350M Class A0 A,B,C only except (A) 75% minimum, (C) 50% minimum

Tubing Color: Black