



## Double Wall Construction Steel Tubing

### 1 Scope

**1.1 Material Description.** This standard covers double wall construction tubing wherein the two walls and the joints are copper brazed in a reducing atmosphere to produce tubing satisfactory for hydraulic brake lines, lubrication oil lines, vacuum lines, air brake lines, etc. There are requirements for the base metal, the optional coating materials, and the coated tubing. These requirements are applicable to the product coming out of the tube mills and the coating application lines, which are sometimes separate facilities. This tubing is used in the production of customized parts and assemblies. It is recommended that those parts and assemblies be validated for corrosion performance, conductivity and continuity, strength, appearance, and other critical properties unique to the particular application.

**1.2 Symbols.** Not applicable.

**1.3 Applicability.** Double wall steel tubing is typically used for automotive hydraulic brake lines.

**1.4 Remarks.** Double wall steel tubing should not be used for fuel lines because residual copper can contribute to the formation of sour gas.

**1.5 Tubing Designation Code.** It is recommended that the codes in Section 3 be used on drawings and purchase orders to designate tubing type, outside diameter, wall thickness, and manufacturing process.

### 2 References

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

#### 2.1 External Standards/Specifications.

|           |           |            |          |
|-----------|-----------|------------|----------|
| ASTM A254 | ASTM B750 | ISO 6892-1 | SAE J403 |
| ASTM A875 | ASTM E8   | ISO 8493   | SAE J527 |

#### 2.2 GM Standards/Specifications.

|         |          |          |          |
|---------|----------|----------|----------|
| 9985670 | GMW3356  | GMW14700 | GMW15282 |
| GMW3059 | GMW3420  | GMW14729 | GMW15487 |
| GMW3286 | GMW14124 | GMW14829 | GMW15891 |

#### 2.3 Additional References.

- GMPT-5-001 No. 2 Diesel
- GMPT-5-036 Aggressive Bio Diesel
- GMPT-6-006 TF2 Gasoline
- GMPT-6-019 Oxidized Gasoline
- GMPT-6-023 E85 Low pHe
- GMPT-6-037 E100

### 3 Requirements

**3.1 Properties.** See Table 5 for summary.

Basic tubing material shall be cold rolled mild steel strip to SAE J403 G10060, G10080 or G10100. Brazing material should be copper or copper alloy containing  $\geq 93\%$  Cu by mass. For technical reasons the minimum coating thickness in the joint area on the zinc plated types (ZP + ZM) shall be 5  $\mu\text{m}$  minimum.

#### GMW14658 (I/II/III)

"I" = Outside diameter of as-brazed, millimeters (mm)

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"II" = Wall thickness, millimeters (mm)

"III" = Manufacturing Process (\*)

**(\*) Process Abbreviations:**

**A** = Aluminum

**G** = Zinc-aluminum-alloy

**Z** = Electroplated Zinc

**E** = Aluminum Rich Epoxy Paint

**M** = Modified Epoxy Ester Paint

**N** = Extruded Nylon 11 or 12

**Y** = Extruded Nylon 612

**P** = Polyvinyl Fluoride (PVF) Coating

**Example:** GMW14658 (6.00/0.7/ZP) – indicates double walled braze tubing, 6 mm Outside Diameter (OD), 0.7 mm wall thickness, protected from corrosion with a base coating of a zinc plate followed with a Polyvinyl Fluoride (PVF) topcoat.

**3.1.1 Mechanical Properties.** The following requirements shall apply only to the more common type of steel tubing; brazed-as manufactured. Properties of other classes of tubing, such as work hardened tubing, shall be as specified through special agreement between supplier and purchaser. Test pieces for mechanical test shall be taken at the end of the tube manufacturing process (after coiling, etc.,) without any additional cold working. All mechanical tests shall be performed at  $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$  per ISO 6892-1 or ASTM E8.

| Property                         | Minimum Requirements |
|----------------------------------|----------------------|
| • Tensile Strength $R_m$         | 290 MPa              |
| • 0.2% Yield Strength $R_{p0.2}$ | 170 MPa              |
| • Fracture Elongation $A_{10}$   | 14%                  |

**3.1.2 Drift Expanding Test (ISO 8493)** Tubing shall be capable of being expanded over a tapered mandrel having an angle  $60^{\circ}$  until the internal diameter at expanded end is increased 20% without cracking or showing flaws (ASTM A254 Paragraph 6.3). Prior to expansion test, tubing shall be cut off square, edge crowned, and deburred. It shall be held firmly and squarely in the die, and punch must be guided on the axis of the tubing.

**3.1.3 Bending Test** Tubing shall be capable of being bent on a centerline radius of three times the tubing outside diameter without undue reduction of area of flattening when suitable bending fixtures used. Using this formula, reduction of area shall be  $\leq 6\%$  for the diameters and wall thicknesses covered by this specification.

**3.1.4 Static Burst Pressure.**

**3.1.4.1** General Motors North America (GMNA), General Motors Latin America Africa Middle East (LAAM), General Motors Asia Pacific (GMAP). Unless otherwise specified, tubing shall be capable of withstanding the following internal static hydraulic pressure:

- Through 10.0 mm OD.....35 MPa
- Over 10.0 mm through 16.0 mm OD....15 MPa

**3.1.4.2** General Motors Europe (GME) unless otherwise specified, tubing shall be capable of withstanding the internal static hydraulic pressure as specified in Table 2 and Table 3.

**3.2 Dimensions.** Tubing shall conform to the dimensions and tolerances listed by the purchaser.

**3.2.1 Braze Tubing.** Nominal diameter and wall thickness shall conform per Figure 1, and those listed in SAE J527 and Table 4 for GMNA, GMLAAM, GMAP and those listed in Table 2 and Table 3 for GME.

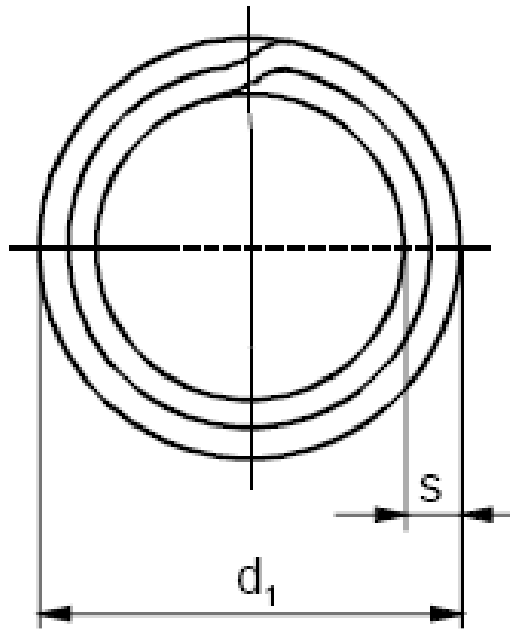


Figure 1: Dimensions for Diameter and Wall Thickness

**3.2.2 Flared Ends.** The pipe flare ends (inverted flare) shall conform to the Supplementary Requirements in ASTM A254, Section S1.

Table 1: External Finish Codes and Requirements

| Finish                                             | Finish Code | External Finish Description and Material Requirements                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|----------------------------------------------------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Zinc-Aluminum Alloy plus Aluminum Rich Epoxy Paint | GE          | Hot dip zinc-aluminum alloy coating consisting of a 5% aluminum-balanced zinc alloy per ASTM B750 with a coating mass of 50 g/m <sup>2</sup> per ASTM A875, Section 8 and a thickness of 3 μm minimum anywhere on the tube per Appendix A. The hot dip zinc-aluminum coating is then subsequently coated with an approved pretreatment process and an approved aluminum-rich epoxy coating.<br><b>Film Thickness:</b> The aluminum-rich epoxy paint of the GE finish shall have a minimum thickness of 3 μm anywhere on the tube as measured by the procedures in Appendix A. Actual thickness of the coatings in the GE finish shall be monitored circumferentially and longitudinally for each tube line. A sampling plan shall be referenced in the control plan.                                                                                                  |
| Zinc-Aluminum Alloy plus Extruded Nylon 11 or 12   | GN          | Zinc-aluminum alloy as described above followed by a conversion coating, an epoxy resin based primer, and a topcoat of Nylon 11 or 12.<br><b>Appearance:</b> The topcoat shall be uniform in color and free from discontinuities such as flow lines, pin holes, craters, or abnormal roughness. The topcoat shall be black in color unless otherwise specified on the engineering drawing.<br><b>Film Thickness:</b> The epoxy primer shall be 0.3 μm minimum and the Nylon 11 or 12 topcoat shall have a minimum thickness of 150 μm when tested by microscopic examination per Appendix A. Maximum thickness of the coating shall be controlled by the maximum OD (Table 4). Actual thickness of the coatings in the GN finish shall be monitored circumferentially and longitudinally for each tube line. A sampling plan shall be referenced in the control plan. |

| Finish                                      | Finish Code | External Finish Description and Material Requirements                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|---------------------------------------------|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Zinc-Aluminum Alloy plus Extruded Nylon 612 | GY          | <p>Zinc-aluminum alloy as described above followed by a conversion coating, an epoxy resin based primer, and a topcoat of Nylon 612.</p> <p><b>Appearance:</b> The topcoat shall be uniform in color and free from discontinuities such as flow lines, pin holes, craters, or abnormal roughness. The topcoat shall be black in color unless otherwise specified on the engineering drawing.</p> <p><b>Film Thickness:</b> The epoxy primer shall be 0.3 <math>\mu\text{m}</math> minimum and the Nylon 612 topcoat shall have a minimum thickness of 150 <math>\mu\text{m}</math> when tested by microscopic examination per Appendix A. Maximum thickness of the coating shall be controlled by the maximum OD (Table 4). Actual thickness of the coatings in the GY finish shall be monitored circumferentially and longitudinally for each tube line. A sampling plan shall be referenced in the control plan.</p>                                                                          |
| Aluminum Plate plus Extruded Nylon 11 or 12 | AN          | <p>Hot-dip aluminum, coated to a minimum thickness of 100 <math>\mu\text{m}</math> anywhere on the tube, followed by a conversion coating, an epoxy resin based primer, and a topcoat of Nylon 11 or 12.</p> <p><b>Appearance:</b> The topcoat shall be uniform in color and free from discontinuities such as flow lines, pin holes, craters, or abnormal roughness. The topcoat shall be black in color unless otherwise specified on the engineering drawing.</p> <p><b>Film Thickness:</b> The epoxy primer shall be 0.3 <math>\mu\text{m}</math> minimum and the Nylon 11 or 12 topcoat shall have a minimum thickness of 120 <math>\mu\text{m}</math> when tested by microscopic examination per Appendix A. Maximum thickness of the coating shall be controlled by the maximum OD (Table 4). Actual thickness of the coatings in the AN finish shall be monitored circumferentially and longitudinally for each tube line. A sampling plan shall be referenced in the control plan.</p> |
| Aluminum Plate plus Extruded Nylon 612      | AY          | <p>Hot-dip aluminum, coated to a minimum thickness of 100 <math>\mu\text{m}</math> anywhere on the tube, followed by a conversion coating, an epoxy resin based primer, and a topcoat of Nylon 612.</p> <p><b>Appearance:</b> The topcoat shall be uniform in color and free from discontinuities such as flow lines, pin holes, craters, or abnormal roughness. The topcoat shall be black in color unless otherwise specified on the engineering drawing.</p> <p><b>Film Thickness:</b> The epoxy primer shall be 0.3 <math>\mu\text{m}</math> minimum and the Nylon 612 topcoat shall have a minimum thickness of 120 <math>\mu\text{m}</math> when tested by microscopic examination per Appendix A. Maximum thickness of the coating shall be controlled by the maximum OD (Table 4). Actual thickness of the coatings in the AY finish shall be monitored circumferentially and longitudinally for each tube line. A sampling plan shall be referenced in the control plan.</p>           |
| Zinc Plate plus PVF Coating                 | ZP          | <p>Electroplated zinc, coated to a minimum thickness of 22 <math>\mu\text{m}</math> anywhere on the tube, followed an approved pretreatment process and an approved PVF coating.</p> <p><b>Thickness Measurements:</b> The PVF coating of the ZP finish shall have a minimum thickness of 15 <math>\mu\text{m}</math> anywhere on the tube as measured by the procedures in Appendix A. Actual thickness of the coatings in the ZP finish shall be monitored circumferentially and longitudinally for each tube line. A sampling plan shall be referenced in the control plan.</p>                                                                                                                                                                                                                                                                                                                                                                                                              |
| Zinc Plate plus Extruded Nylon 11 or 12     | ZN          | <p>Electroplated zinc, coated to a minimum thickness of 22 <math>\mu\text{m}</math> anywhere on the tube, followed by a conversion coating, an epoxy resin based primer, and a topcoat of Nylon 11 or 12.</p> <p><b>Appearance:</b> The topcoat shall be uniform in color and free from discontinuities such as flow lines, pin holes, craters or abnormal roughness. The topcoat shall be black in color unless otherwise specified on the engineering drawing.</p> <p><b>Film Thickness:</b> The epoxy primer shall be 0.3 <math>\mu\text{m}</math> minimum and the Nylon 11 or 12 topcoat shall have a minimum thickness of 150 <math>\mu\text{m}</math> when tested by microscopic examination per Appendix A. Maximum thickness of the coating shall be controlled by the maximum OD (Table 4). Actual thickness of the coatings in the ZN finish</p>                                                                                                                                      |

| Finish                                     | Finish Code | External Finish Description and Material Requirements                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------------------------------------------|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                            |             | shall be monitored circumferentially and longitudinally for each tube line. A sampling plan shall be referenced in the control plan.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Zinc Plate plus Extruded Nylon 612         | ZY          | <p>Electroplated zinc, coated to a minimum thickness of 22 <math>\mu\text{m}</math> anywhere on the tube, followed by a conversion coating, an epoxy resin based primer, and a topcoat of Nylon 612.</p> <p><b>Appearance:</b> The topcoat shall be uniform in color and free from discontinuities such as flow lines, pin holes, craters or abnormal roughness. The topcoat shall be black in color unless otherwise specified on the engineering drawing.</p> <p><b>Film Thickness:</b> The epoxy primer shall be 0.3 <math>\mu\text{m}</math> minimum and the Nylon 612 topcoat shall have a minimum thickness of 150 <math>\mu\text{m}</math> when tested by microscopic examination per Appendix A. Maximum thickness of the coating shall be controlled by the maximum OD (Table 4). Actual thickness of the coatings in the ZY finish shall be monitored circumferentially and longitudinally for each tube line. A sampling plan shall be referenced in the control plan.</p> |
| Zinc Plate Plus Modified Epoxy Ester Paint | ZM          | <p>Electroplated zinc as described above followed by an approved pretreatment process and approved modified epoxy ester paint.</p> <p><b>Thickness Measurements:</b> The modified epoxy ester paint of the ZM finish shall have a minimum thickness of 30 <math>\mu\text{m}</math> anywhere on the tube as measured by the procedures in Appendix A. Actual thickness of the coatings in the ZM finish shall be monitored circumferentially and longitudinally for each tube line. A sampling plan shall be referenced in the control plan.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                       |

Table 2: GME Material Supplied for Passenger Car Applications

| d <sub>1</sub> <small>Note 1</small><br>in mm | s <small>Note 1</small><br>in mm | Weight<br><small>Note 2</small><br>in<br>kg/1000 m<br>± 2 kg | Burst<br>Pressure<br>in MPa | Permissible<br>Operating<br>Pressure<br>in MPa | Smallest Bending Radius r <small>Note 3</small><br>In mm |                                      |                           |
|-----------------------------------------------|----------------------------------|--------------------------------------------------------------|-----------------------------|------------------------------------------------|----------------------------------------------------------|--------------------------------------|---------------------------|
| Tolerances                                    |                                  |                                                              |                             |                                                | Cylinder<br>Roller                                       | Profile Roller <small>Note 4</small> |                           |
| ± 0.05<br>mm                                  | ± 0.03 mm                        |                                                              |                             |                                                |                                                          | Without<br>Internal<br>Punch         | With<br>Internal<br>Punch |
| 2.5                                           | 0.5                              | 25                                                           | 141                         | 58                                             | 5                                                        | -                                    | -                         |
|                                               | 0.7                              | 31                                                           | 203                         | 83                                             |                                                          |                                      |                           |
| 3.2                                           | 0.5                              | 33                                                           | 108                         | 44                                             | 6                                                        | 6                                    | -                         |
|                                               | 0.7                              | 43                                                           | 156                         | 64                                             |                                                          |                                      |                           |
| 4                                             | 0.5                              | 42                                                           | 84                          | 34                                             | 8                                                        | 7                                    | -                         |
|                                               | 0.7                              | 57                                                           | 122                         | 50                                             |                                                          |                                      |                           |
| 4.75                                          | 0.7                              | 70                                                           | 101                         | 41                                             | 13                                                       | 8                                    | -                         |
| 5                                             | 0.7                              | 73                                                           | 94                          | 38                                             | 15                                                       | 9                                    | -                         |
| 6                                             | 0.7                              | 89                                                           | 80                          | 32                                             | 25                                                       | 12                                   | -                         |
| 6.35                                          | 0.7                              | 93                                                           | 73                          | 30                                             | 28                                                       | 13                                   | -                         |
| 7                                             | 0.7                              | 107                                                          | 66                          | 27                                             | 35                                                       | 16                                   | 13                        |
| 8                                             | 0.7                              | 125                                                          | 57                          | 23                                             | 46                                                       | 19                                   | 14                        |
|                                               | 1.0                              | 174                                                          | 84                          | 34                                             |                                                          |                                      |                           |
| 9                                             | 0.7                              | 144                                                          | 50                          | 21                                             | 59                                                       | 23                                   | 15                        |
| 9.5                                           | 0.7                              | 151                                                          | 47                          | 19                                             | 68                                                       | 25                                   | 16                        |
| 10 <small>Note 5</small>                      | 0.7                              | 154                                                          | 45                          | 18                                             | 76                                                       | 27                                   | 17                        |
|                                               | 1.0                              | 219                                                          | 66                          | 27                                             |                                                          |                                      |                           |
| 12 <small>Note 5</small>                      | 0.7                              | 192                                                          | 37                          | 15                                             | 128                                                      | 41                                   | 24                        |
|                                               |                                  | 257                                                          | 54                          | 22                                             |                                                          |                                      |                           |

**Note 1:** Underlined values and wall thickness of 0.7 mm preferred. The specified tolerances are applicable only for Type A tubes: For Type B tubes the upper tolerance limit may be exceeded by 0.04 mm, for Type C by 0.08 mm and for Type E by 0.17 mm. The limiting sizes of the outside diameters may deviate on bending locations by about 10% from the respective actual diameter of the straight portion of the tube caused by non-circularity (ovality) as far as the specified smallest binding radii are not exceeded.

**Note 2:** For zinc coated tubes the weight will be increased by ≈ 2.5% and for plastic coated tubes ≈ 3.0%.

**Note 3:** Bending radius at bending in cold condition without filling.

**Note 4:** With these radii the maximum stress within the wall is obtained.

**Note 5:** A tolerance of ± 0.07 mm is valid.