Hydraulic Brake Hose Assembly

1 Scope

This specification defines the requirements for hydraulic brake (jounce) hose assemblies. This hose assembly is suitable for use at temperatures of –40 to 120 °C, and operating pressures up to 20.7 MPa.

1.1 Material Description.

Hose Construction

Inner Tube. The inner tube of the hose shall consist of a smooth inner rubber tube of ethylene propylene diene monomer (EPDM), or a blend of ethylene propylene diene monomer and isobutene-isoprene rubber (EPDM-IIR). There shall be no materials in the tube compound extractable through exposure to either DOT 3 or DOT 4 brake fluids, as evidenced by 0 or positive values for volume change when the hose is tested to the requirements of 3.1.3.4 for each of the two fluids, DOT 3 and DOT 4. No halogenated butyl polymer may be added to the rubber of the inner tube.

Reinforcement. The reinforcement for the hose shall consist of two layers of polyvinyl alcohol (PVA) or rayon. A rubber cushion liner may be placed between the two layers of reinforcement. Alternative reinforcement materials may be considered after review and approval by the GM Materials Engineer issuing the specification approval.

Cover. The outer cover of the hose shall consist of a layer of ethylene propylene diene monomer.

Coupling Construction

Coupling Design. The coupling shall be designed, inserted, swaged, or crimped so that no internal tube abrasions, cuts or flaws shall result under any condition or combination of assembly component dimensioning or tolerancing allowed by supplier production specifications, or under any condition of rubber hose compression allowed by supplier production specifications.

Sharp Corners. Sharp corners shall be avoided where the coupling contacts the tube to prevent cutting of the hose when subjected to internal pressure.

Tube Insert. The tube insert must not extend past the end of the crimp shell after crimping, and the end of the tube insert must be radiused to eliminate burrs or sharp edges which might cause hose damage under conditions of assembly vibration or pressure impulse.

Damage. Damage to hose rubber or reinforcement generated by the crimping of the hose is not permissible under any possible production manufacturing conditions or supplier production tolerance stack-up, including variations in hose compression concentricity.

Tube Collapse. Metal tube insert collapse during crimping is not permissible, except when this collapse is limited, predictable, controllable, and does not increase the potential for assembly leakage or other malfunction.

Design Restrictions. Grooves, upsets, or serrations are not permitted on the tube stem OD, or on the crimp shell ID, except that these grooves, upsets, or serrations do not cause hose cutting or other damage under any condition or combination of assembly component dimensioning or tolerancing allowed by supplier production specifications, or under any condition of rubber hose compression allowed by supplier production specifications.

Skiving, Adhesives. Skiving of the hose is not permissible. Use of adhesives in the crimped joint is not permissible.

Flow Requirements. The coupling shall be designed for low flow restriction.

Fluid Compatibility. All hose assemblies supplied to this specification must be compatible with the following brake fluids:

DOT 3

DOT 4

DOT 4+

DOT 4++

Dimensions and Tolerances. Bulk hose shall conform to the following dimensions:

Table 1: Bulk Hose Dimensions

	mm	inch
Inside Diameter	3.0	1/8
	3.2	1/8
	4.0	3/16
	4.5	3/16
	4.8	3/16
	5.0	3/16

1.1.1 Material Identification. To properly define the hose, the material specification number (GMW3056) is to be referenced. Hose labeling must conform to the requirements of FMVSS106.

1.2 Cross-Reference of Replaced Specifications.

GMW	
Delta Motors	
GM do Brasil	EMS502, LTP001
GM Holdens	
GM NAO	GM6403M
ISUZU	ISD-V01-007
ITDC	GME05500
SAAB	

1.2.1 Specifications Qualified to this Material Specification. Not applicable.

1.3 Symbol. Not applicable.

1.4 Typical Application. Hydraulic brake (jounce) hose assemblies.

1.5 Remarks. Not applicable.

2 References

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

2.1 Normative.

ASTM D380
ASTM D395
ASTM D412
ASTM D413
ASTM D471
ASTM D865
ASTM D2240
ASTM E4
FMVSS106
ISD-V01–007
ISO 9227
ISO 11014-1
SAE J1401

2.2 GM.

GM4653M
GM6403M
GM9540P
GM9698P
GME05500
GME60208
GMEL-5F-7
GMEL0004
GMEL5104
GMIL-5F-5
GMI60284
GMI60285
GMW3001
GMW3059
EMS502
LTP001
OPEL 263

2.3 Additional. None.

3 Requirements

Test Conditions:

Ambient temperature test conditions shall be held to (23 ± 5) °C. All other temperatures except (23 ± 5) °C shall be held to ± 3 °C, and all pressures to –0, +690 kPa unless otherwise noted. Where DOT 3 fluid is referenced for test purposes, Delco Supreme 11 or Union Carbide PM6664 meeting specification GM4653M shall be used. Where DOT 4 fluid is referenced for test purposes, Hoechst ATE SL DOT 4 fluid meeting specification GMEL5104 shall be used.

General Test Requirements:

Additional general test requirements are referenced in 3.1.4, Requirements on Delivery/Additional Requirements. It is suggested that this section be read first before reading 3.1 through 3.4.

3.1 Requirements on Delivery.

3.1.1 Chemical Requirements.

3.1.1.1 Oil Resistance Test.

3.1.1.1.1 Test Procedure. Six hose assembly samples at nominal hose compression are to be tested using DOT 4 brake fluid meeting GM specification GMEL5104.

3.1.1.1.2 Fluid Fill and Oil Immersion. The hose assembly shall be filled with brake fluid, sealed, immersed in oil according to GMEL0004 (Shell Helix Plus) and stored for 48 h at (70 ± 3) °C.

3.1.1.1.3 Acceptance Determination. The outer diameter of the hose shall not increase more than 15 % after storage.

Test	Requirement	Pass Criteria
Oil Resistance of Rubber Cover	48 h at 70 °C	Maximum swell shall be no more than 15 %

3.1.1.2 Stress-Corrosion Cracking.

3.1.1.2.1 Test Procedure. Twelve hose assembly samples at nominal hose compression are to be exposed to an atmosphere of ammonia as the corrosive medium for 4 h. The test shall be performed at a temperature of (23 ± 3) °C.

3.1.1.2.2 Test Method. Equipment and test procedure shall be prepared in accordance with test method GME60208 (Test Method for Determining Susceptibility to Stress-Corrosion Cracking of Copper Based Alloys).

3.1.1.2.3 Acceptance Determination. Following examination under 7 X magnification, the test piece shall be free of cracks.

Test	Requirement	Pass Criteria
Stress-Corrosion Cracking	4 h at 23 °C	No evidence of cracks

3.1.1.3 Static Ozone Test.

3.1.1.3.1 Test Procedure. Six hose samples shall be tested. After removing any armor on the sample, bend a brake hose 360 degrees around a mandrel and bind the ends. Mandrel diameter is to be 76.2 mm for 3.0 mm ID hose, and 88.9 mm for 4.5 mm ID hose. In the case of a hose sample shorter than the circumference of the cylinder, bend the hose so that as much of its length as possible is in contact. The cylinder and binding shall be made of metal or materials that consume the minimum of ozone. If the hose collapses when bent around the cylinder, provide for internal support of the hose by use of a metal liner.

3.1.1.3.2 Hose Conditioning. Condition the hose on the cylinder for (24 ± 0.5)h in ozone-free air at room temperature, and then place it in an exposure chamber containing ozone in the proportion of (100 ± 10)pphm for (336 ± 2)h. Ambient air temperature in the chamber during the test shall be (40 ± 2) °C.

3.1.1.3.3 Examination Procedure. Examine the cover of the hose for cracks under 7 X magnification, ignoring the areas immediately adjacent to or within the area covered by the binding. Record whether or not cracks in the hose are present.

3.1.1.3.4 Acceptance Determination. No cracks shall be visible under 7 X magnification.

Test	Requirement	Pass Criteria
Static Ozone	336 h	No cracks shall be visible after 336 h of testing.

3.1.1.4 Dynamic Ozone Test.

3.1.1.4.1 Test Procedure. Six hose samples shall be tested. Conduct the test per SAE J1401, 3.2.13. Test duration is to be 840 h.

3.1.1.4.2 Acceptance Determination. No cracks will be visible on the hose under 7 X magnification after 840 h of testing.

Test	Requirement	Pass Criteria
Dynamic Ozone	840 h	No cracks shall be visible after 840 h of testing.

3.1.2 Mechanical Requirements.

3.1.2.1 Leak Test.

3.1.2.1.1 Test Procedure. The test assembly shall be pressurized with air or an inert gas to a minimum pressure of 10.3 MPa (1494 psig), maximum pressure of 14.5 MPa (2103 psig). Pressure shall be held for a minimum of 10 s, a maximum of 25 s.

3.1.2.1.2 Acceptance Determination. There shall be no evidence of leakage at the coupling or in the hose member.

3.1.2.1.3 Production Process Requirement. This test, or equivalent safeguard, must be employed for 100 % of production parts. The method of testing shall be determined by the manufacturer and approved by the GM Materials Engineer issuing the Engineering Source Approval for the brake hose assembly.

Test	Requirement	Pass Criteria
Leak	10.3...14.5 MPa (1495...2103 psig)	No evidence of leakage

3.1.2.2 Burst Test.

3.1.2.2.1 Test Apparatus. The test apparatus shall consist of a pressure source capable of generating fluid pressure of (172 ± 69) MPa/minute (25 000 ± 10 000 psig/minute), at an increasing rate. A system, in which the internal fluid pressure of the hose assembly can be controlled and measured, provision for filling the hose with water and hardware as required that is adapted to high-pressure work. The pressure shall be obtained by a suitable means and measured with a calibrated gage. All piping and connections shall be smooth bore with a minimum of recesses or offsets, so that air may be freely removed from the system before running each test. The apparatus described for the expansion test may be used when it conforms to these requirements.

3.1.2.2.2 Test Procedure. Eighteen assemblies are to be tested; six at minimum hose compression, six at nominal hose compression, and six at maximum hose compression. Connect the specimen to the pressure system and fill completely with water, allowing all air to escape. Moving the hose back and forth may facilitate removal of air bubbles. Apply 41.4 + 2.1 –0 MPa (6000 + 300 –0 psig) pressure at the rate specified in 3.1.2.2.1 and hold for 2 minutes +0 –10 s. At the expiration of this *hold* period, increase the pressure at the rate specified in 3.1.2.2.1 until the hose bursts. Read the maximum pressure obtained on the calibrated gage to the nearest 0.7 MPa (100 psig) and record as the burst strength of the hose assembly. For hose assemblies preconditioned by temperature or fluid exposure, the hold pressure shall be 27.6 + 2.1 –0 MPa (4000 + 300 –0 psig), instead of 41.4 + 2.1 –0 MPa (6000 + 300 –0 psig).

3.1.2.2.3 Acceptance Determination. There must be no leaks or blisters in the hose assembly at the *hold* pressure of 41.4 MPa (6000 psig) or 27.6 MPa (4000 psig). The minimum bursting pressure for new hose assemblies shall be 78.0 MPa (11 300 psig). For hose assemblies which have been preconditioned per 3.1.2.5, 3.1.2.9 and 3.3.2.9, the minimum bursting pressure shall be 70.0 MPa (10 145 psig). For hose assemblies which have been preconditioned per 3.1.2.11 and 3.3.2.6, the minimum bursting pressure shall be 65.5 MPa (9493 psig). No more than 50 % of the samples may have a burst location within 20 mm of the crimp ferrule.

Test	Requirement	Pass Criteria
Burst	78.0 MPa (11 300 psig)	Minimum burst pressure.

Test	Requirement	Pass Criteria
Burst (3.1.2.5, 3.1.2.9, 3.3.2.9)	70.0 MPa (10 145 psig)	Minimum burst pressure.
Burst (3.1.2.11, 3.3.2.6)	65.5 MPa (9493 psig)	Minimum burst pressure

3.1.2.3 Volumetric Expansion.

3.1.2.3.1 Test Procedure. Six assemblies crimped at nominal hose compression shall be tested. Hose assemblies shall be tested to the requirements of Opel specification GMIL-5F-5. Each actuation cycle, as defined in GMIL-5F-5, 3.3.3, shall consist of pressurization from 0 MPa (0 psig) to each of the four measurement pressures, 1.0 MPa (145 psig), 2.8 MPa (400 psig), 6.9 MPa (1000 psig), and 10.4 MPa (1508 psig).

3.1.2.3.2 Acceptance Determination. The volumetric expansion at 1.0 MPa shall be equal to or less than 0.22 cm^3/m (0.07 cm^3/ft). The volumetric expansion at 2.8 MPa shall be equal to or less than 0.32 cm^3/m (0.10 cm^3/ft). The volumetric expansion at 6.9 MPa shall be equal to or less than 0.54 cm^3/m (0.17 cm^3/ft). The volumetric expansion at 10.4 MPa shall be equal to or less than 0.72 cm^3/m (0.22 cm^3/ft).

Low Pressure	
Pressure	Volumetric Expansion
1.0 MPa (145 psig)	≤ 0.22 cm^3/m (0.07 $cm^3/ft.$)
2.8 MPa (400 psig)	≤ 0.32 cm^3/m (0.10 $cm^3/ft.$)

High Pressure	
Pressure	Volumetric Expansion
6.9 MPa (1000 psig)	≤ 0.54 cm^3/m (0.17 $cm^3/ft.$)
10.4 MPa (1508 psig)	≤ 0.72 cm^3/m (0.22 $cm^3/ft.$)

3.1.2.4 Hot Plate.

3.1.2.4.1 Test Procedure. Eighteen hose samples are to be tested, six at minimum hose compression, six at nominal hose compression and six at maximum hose compression to each of the two test procedures, Procedure A and Procedure B, using DOT

4 brake fluid meeting GM specification GMEL5104. Therefore, the total number of samples to be tested is thirty-six.

3.1.2.4.2 Test Equipment. Brake hydraulic supply and pressure pump that can supply up to 150 MPa (22 000 psig). The hotplate will have adaptation for copper block, hose and temperature sensor. There shall be a control unit for temperature regulation, introduction of pressure and measured-data acquisition.

3.1.2.4.3 Preparation. The brake hose shall be mounted fully extended in the test stand. The hose fitting that is not being tested shall be connected to the pressure supply. When testing the banjo fitting (brake caliper side), the fitting shall not rest on the hotplate. The hose fitting being tested will have a vent nipple, and will be positioned on the test stand as shown in Figure 1. The female fitting (brake pipe side), shall be tested by inserting the fitting into the copper block according to Figure 2. The preparation is applicable to both Procedures A and B.

3.1.2.4.4 Test Instructions.

Procedure A

Starting at room temperature (23 ± 5) °C, the hotplate shall be heated to the measuring point temperature T of 200 °C for banjo fittings, 160 °C for female fittings, within t_1 = 20 minutes.

The temperature shall be maintained at T. Simultaneously, a constant pressure of p = (10 ± 0.2) MPa shall be applied for t_3 = 60 minutes within maximum t_2 = 20 s of temperature T being attained.

Subsequently, the complete brake hose shall be depressurized followed by immediate repressurization at the specified test temperature until burst. (The pressure and time curve is shown in Figure 3).

Procedure B

Starting at room temperature (23 ± 5)°C), the hotplate shall be heated to the measuring point temperature T of 200 °C for banjo fittings, 160 °C for female fittings, within t_1 = 20 minutes.

The temperature shall be maintained at T. Simultaneously, a constant pressure of p = (10 ± 0.2) MPa shall be applied via a pressure ramp within t_2 = 20 s of temperature T being attained. The pressure shall be maintained for at least t_3 = 40 s. The complete brake hose shall be depressurized. The pressure sequence during $t_2 + t_3$ = 60 s corresponds to a single cycle. This cycle will be repeated twenty times with a no pressure apply time of t_4 = 1 minute between cycles.

Subsequently, the complete brake hose shall be depressurized followed by immediate repressurization at the specified test temperature until burst (The pressure and time curve is shown in Figure 3).

3.1.2.4.5 Acceptance Determination. Hose assemblies must record Burst Test result equal to or greater than 30.0 MPa.

Test	Requirement	Pass Criteria
Hot Plate	T = 200 or 160 °C	No leakage or seepage
Burst Test	30.0 MPa (4350 psig)	Must meet 30.0 MPa minimum Burst Pressure

3.1.2.5 Low Temperature Resistance.

3.1.2.5.1 Test Procedure. Six assemblies crimped at nominal hose compression shall be tested. Select the proper size test mandrel as specified in Table 4. Remove the hose armor, if any, and condition the hose and the cylinder in a straight position in air at –44 to –50 °C for 70 h. While the parts are still at this temperature, bend the hose at least 180 degrees around the cylinder at a steady rate in a period of 3 to 5 s. Allow the parts to return to room temperature (23 ± 5) °C. Conduct Leak Test per 3.1.2.1, followed by Burst Test per 3.1.2.2.

3.1.2.5.2 Acceptance Determination. There shall be no cracks when hose is flexed at –44 to –50 °C. Hose assemblies will pass the requirements of the Leak Test and the Burst Test.

	Test	Requirement	Pass Criteria
1	Low Temperature Resistance	–44...–50 °C (–47...–58 °F)	No cracks when hose is flexed
2	Leak Test (3.1.2.1)	10.3...14.5 MPa (1494...2103 psig)	No leakage at coupling or hose
3	Burst Test (3.1.2.2)	70 MPa (10 150 psig)	Minimum burst pressure

3.1.2.6 Tensile Test.

3.1.2.6.1 Test Apparatus. A tension testing machine, conforming to the requirements of ASTM E4 Methods, and equipped with an indicating device to give the total pull in Newtons (pounds) at the conclusion of the test. (A machine capable of 4.5 kN (1000 lb.) capacity would be suitable).

3.1.2.6.2 Fixtures. The machine shall have suitable fixtures attached to it so the hose assembly shall have a straight centerline corresponding to the direction of the machine pull.

3.1.2.6.3 Test Procedure. Eighteen assemblies are to be tested, six at minimum hose compression, six at nominal hose compression and six at maximum hose compression. Apply an increasing tensile load at a speed such that the moving head of the testing machine travels at the rate of (25 ± 3) mm/minute (1.0 ± in/minute) until separation. Record the total load at the time of separation, and note if the hose breaks, or if the hose separates from the coupling.

3.1.2.6.4 Acceptance Determination. The hose shall not break, or pull from the crimped fitting at less than 1750 N (389 lbs.) force.

Test	Requirement	Pass Criteria
Tensile	1750 N (389 lbs.)	Hose shall not break or pull from crimped fitting at less than 1750 N.

3.1.2.7 Whip Test.

3.1.2.7.1 Test Apparatus. Mandatory hose motion is that produced by the following device, or by its equivalent. A movable header consisting of a horizontal bar mounted at each end on vertically rotating disks through bearings with centers placed 101.6 mm (4 inches) from the disk centers, and an adjustable stationary header parallel to the movable header in the same horizontal plane as the centers of the disks. The headers are each provided with end connections in which the hose assemblies are mounted in parallel. The disks are rotated at a speed of (800 ± 10) rpm, whereby the hose ends fastened to the moving header are rotated at this speed through a circle (203.20 ± 0.25) mm (8.000 ± 0.010) inch in diameter while the opposite hose ends remain stationary. The end connections on the movable header are tightly capped, while those on the stationary header are open to a manifold through which water pressure is supplied by a suitable means. The hose assemblies are subjected during testing to a constant water pressure that shall be maintained between 1.55 and 1.72 MPa (225 and 250 psig). A limit switch shall be used to stop the machine when the water pressure drops, as in the case of hose failure, since it is essential that the machine stop if the pressure drops. An elapsed time indicator shall be provided.

3.1.2.7.2 Test Procedure. Twenty-four assemblies are to be tested, eight at minimum hose compression, eight at nominal hose compression, and eight at maximum hose compression.

3.1.2.7.3 Hose External Attachment Requirements. All external appendages such as chafing collars, mounting brackets, date bands and spring guards shall be removed from the brake hose assembly prior to testing on the whip machine.

Note: Per NHTSA interpretation, hose assemblies incorporating intermediate collars or fittings (not external appendages such as brackets) which are located between the end fittings and are not readily removable are considered as having separate free lengths for the purposes of whip testing.

3.1.2.7.4 Hose Attachment to Apparatus. Equip the non-rotating header to permit attachment of each hose assembly with individual adjustment for length. When mounted in the whip test machine, the projected length of the hose assembly shall be less than the free length by the amount indicated as slack in Table 5.

3.1.2.7.5 Error Sensitivity. Inasmuch as the whip test results are very sensitive to error in setting this length, take measurements carefully. The reduction from free length to projected length, on the machine, shall be within the limits specified. Take the projected length parallel to the axis of the rotating head.

3.1.2.7.6 Installation and Bleed Procedure. Install the test specimen assemblies in the apparatus without any twist. Bleed all hoses and passages to eliminate air pockets or bubbles. Apply the water pressure and start the motor rotating the movable head and set elapsed time indicator to zero to record the duration of the test. Periodically check the rpm. Failure of the specimen by water leakage and consequent loss of pressure within 50 h constitutes a failure of the test. At the completion of 50 h of testing, remove a section of hose from the center portion of each sample and conduct the Adhesion Test per 3.1.3.6.

3.1.2.7.7 Acceptance Determination. There shall be no leakage of the hose or crimped assembly for 50 h of test duration. All hose samples must meet the adhesion requirements of 3.1.3.6.

	Test	Requirement	Pass Criteria
1	Whip Test Duration	50 h	No leakage of hose or crimped assembly.
2	Adhesion Test (3.1.3.6)	1.4 N/mm (8.0 lbs./inch)	Shall not delaminate.

3.1.2.8 Torsion Test, Center Fitting.

3.1.2.8.1 Test Procedure. If the brake hoses include a center fitting, the center fitting shall be subjected to a torsion test. The center fitting shall not slip on the brake hose below a torque of 0.8 Nm. The hose shall be grasped and held within 5 mm of the center fitting before the torque is applied. Six hose assemblies at nominal hose compression are to be tested.

3.1.2.8.2 Acceptance Determination. The center fitting shall not slip when a torque of 0.8 Nm (7.08 inch-lbs.) is applied.

Test	Requirement	Pass Criteria
Torsion Test for Center Fitting	0.8 Nm (7.08 inch-lbs.)	Center fitting shall not slip.

3.1.2.9 Heat Age/Cold Bend.

3.1.2.9.1 Test Procedure. Six assemblies crimped at nominal hose compression shall be tested. Assemblies are to be aged at (100 ± 2) °C for (504 ± 2) h. Assemblies are to be removed from the oven and conditioned at room temperature for 6 to 12 h. Select mandrel per Table 4 and condition both mandrel and sample for (48 ± 1) h in a cold chamber at –44 to –50 °C. Without removing the sample or mandrel from the chamber, bend the hose 180 degrees around the mandrel within 5 s. Remove the hose from the cold chamber and condition it at room temperature for 1 to 6 h. Wrap the hose around the mandrel and inspect, with 7 X magnification, for cover cracks. Conduct Leak Test per 3.1.2.1, followed by Burst Test per 3.1.2.2.

Test	Requirement	Pass Criteria
Heat Age Cold Bend	100 °C 504 h	There shall be no cracks visible at 7 X magnification.

Test	Requirement	Pass Criteria
Leak Test (3.1.2.1)	10.3 to 14.5 MPa (1494 to 2103 psig)	No evidence of leakage at the coupling, or in hose member.
Burst Test (3.1.2.2)	70 MPa (10 150 psig)	Minimum burst pressure.

3.1.2.10 Fitting Rotation.

3.1.2.10.1 Test Procedure. Twelve assemblies are to be tested, six at minimum hose compression and six at nominal hose compression using DOT 4 brake fluid meeting GM specification GMEL5104.

3.1.2.10.2 Assembly Preparation. Assemblies are to be filled with brake fluid and aged (168 ± 1) h at (110 ± 2) °C. Cool assemblies at room temperature for a minimum of 1 h. Cut each test assembly 50.8 mm from the caliper (banjo) fitting skirt. Insert a mandrel of diameter equal to the nominal hose inner diameter (to prevent hose collapse) and secure in a vise such that the distance between the fitting skirt and the vise is approximately 6 mm. Using a calibrated torque wrench, measure the torque required to turn the fitting on the hose.

3.1.2.10.3 Acceptance Determination. Banjo fittings must record values of 2.00 Nm or greater.

Test	Requirement	Pass Criteria
Fitting Rotation	> = 2.00 Nm (17.70 inches-lbs.)	Value must be > = 2.00 Nm.

3.1.2.11 Brake Fluid Compatibility.

3.1.2.11.1 Test Procedure. Twelve assemblies are to be tested, six at nominal hose compression and six at minimum hose compression with each of two brake fluids, DOT 3 brake fluid meeting GM4653M and DOT 4 brake fluid meeting GMEL5104. Therefore, the total number of samples to be tested is twenty-four. The hose assembly will be filled with brake fluid, capped, and placed in an oven at (125 ± 3) °C for 504 h. At completion of the aging period, the assembly shall be drained, conditioned at room temperature (23 ± 5) °C for a minimum of 30 minutes, checked for constriction of fluid path per 3.1.3.1, leak tested per 3.1.2.1, and then burst tested in accordance with 3.1.2.2. The Burst Test must be completed within 3 h of sample removal from the oven.

3.1.2.11.2 Acceptance Determination. There must be no constriction of the fluid path. Hose assemblies must meet the constriction requirement of 3.1.3.1. Hose assemblies must meet the leak test requirement of 3.1.2.1. Hose assemblies must meet the burst test requirements of 3.1.2.2.

	Test	Requirement	Requirement
1	Brake Fluid Compatibility	504 h at 125 °C	See following tests.
2	Constriction Test (3.1.3.1)	Probe must fall freely	Probe must fall freely through assembly.
3	Leak Test (3.1.2.1)	10.3 to 14.5 MPa (1494 to 2103 psig)	No evidence of leaks or blisters
4	Burst Test (3.1.2.2)	65.5 MPa (9500 psig)	Minimum burst pressure

3.1.3 Physical Requirements.

3.1.3.1 Constriction Test.

3.1.3.1.1 Test Procedure.

3.1.3.1.2 Probe Requirements. Select a spherical or 25.4 to 76.2 mm cylindrical Constriction Test Probe (Figure 4) having an *A* diameter of 64 % of the nominal inside diameter of the test hose. Typical *A* diameters are listed in Table 6. The cylindrical probe is to be used except where impractical (e.g., curved tube and block assemblies).

3.1.3.1.3 Constriction Procedure. Hold the assembly vertically at one fitting. Insert the specified probe into the end of the upper fitting. The probe shall fall through the assembly without assist. Manual straightening of the hose is permissible; no other manipulation of the assembly is allowed. Record whether or not the probe entered the full length of the hose.

3.1.3.1.4 Acceptance Determination. The probe must freely fall through the assembly.

3.1.3.1.5 Production Process Requirement. Constriction testing must be performed on 100 % of production parts. The method of constriction testing shall be determined by the manufacturer and approved by the GM Materials Engineer issuing the Engineering Source Approval for the brake hose assembly.

3.1.3.2 End Fitting Corrosion Resistance.

3.1.3.2.1 Cyclical Corrosion Test.

3.1.3.2.1.1 Test Procedure. Six assemblies at nominal hose compression are to be tested. Test assemblies to the requirements of GM9540P, Duration D, 80 cycles. GM9540P testing is to be done only for Engineering Source Approval.

3.1.3.2.1.2 Acceptance Determination. There shall be no greater than 10 % base metal corrosion after 80 cycles per GM9540P, Duration D. If assemblies do not pass the requirement, the number of cycles at which point there is greater than 10 % base metal corrosion must be reported.

3.1.3.2.2 Salt Spray Test.

3.1.3.2.2.1 Test Procedure. Six assemblies at nominal hose compression are to be tested. Subject assemblies to 480 h salt spray per ISO 9227.

3.1.3.2.2.2 Acceptance Determination. After 480 h salt spray test per ISO 9227, there must be no greater than 10 % base metal corrosion. If the assemblies do not meet the requirement, the number of hours of salt spray exposure at which point there is greater than 10 % base metal corrosion must be reported.

3.1.3.3 Water Permeability.

3.1.3.3.1 Test Procedure. Six assemblies crimped at nominal hose compression and six assemblies crimped at minimum hose compression shall be tested. Hose assemblies shall be tested to the requirements of Opel 263. Hoechst ATE SL DOT 4 fluid meeting GMEL5104 shall be used for the test.

3.1.3.3.2 Acceptance Determination. Water content of the DOT 4 fluid at the end of the test shall be equal to or less than 12.5 Wt %. Per the requirements of Opel 263, the relative difference in water content between the two specimens tested cannot exceed 10 %. If the relative difference between the two specimens exceeds 10 %, the test is invalid and must be repeated.

3.1.3.4 Physical Properties.

3.1.3.4.1 Test Procedure.

3.1.3.4.2 Press-Cured Slab Stock. Press-cured slap stock, representative of the hose compounds used for the hydraulic brake hose, must be tested per the test procedures detailed in Table 7, and the test values reported. Equivalent cure state between the press-cured slab stock and the hose material must be confirmed by testing both the slab stock and the hose material to the requirements of GM9698P.

3.1.3.4.3 Hose Compound Physical Properties. Unless indicated otherwise, hose material which is

representative of tube material, cover material, and intermediate rubber layer materials must be tested to the requirements of Table 7.

3.1.3.4.4 Acceptance Determination. Hose slab stock tests, as described in Table 7 must be performed and the results reported.

3.1.3.5 Innertube Thermoplasticity Test.

3.1.3.5.1 Test Procedure. Twelve assemblies crimped at nominal hose compression shall be tested.

3.1.3.5.2 Test Probe Selection. Select probe per 3.1.3.1.2, Constriction Test.

3.1.3.5.3 Probe Test Procedure. Conduct test per 3.1.3.1.3, Constriction Test

3.1.3.5.4 Temperature Aging Requirements. Age six of the assemblies for 1 h and six of the assemblies for 24 h, in an over at 82 ± 3 °C. Within 30 minutes of removal from the oven, repeat 3.1.3.5.2 and 3.1.3.5.3 on each assembly.

3.1.3.5.5 Acceptance Determination. Probe must freely enter the full length of the hose after oven aging per 3.1.3.5.4 for all samples tested.

3.1.3.6 Adhesion.

3.1.3.6.1 Test Procedure. Six hose samples shall be tested. The test shall be conducted by cutting the specimens circumferentially from the samples into rings 25.0 ± 0.5 mm long using a sharp tool that will leave clean edges. These specimens shall be tested in ring form and shall be referred to as *ring specimens*. The cover shall be cut through to the hose outer braid layer parallel to the longitudinal axis of the hose. The ring specimen shall be placed on a mandrel having a diameter equal to the nominal inner diameter of the hose. Parts of the ring specimen will be separated sufficiently by hand to permit attachment of the jaws of a test clamp to the separated portion of the cover. With the mandrel supported so that it revolves freely with minimum friction, pull the cover from the specimen circumferentially at a rate of 25.4 mm/minute until the cover is completely separated from the rest of the ring specimen. The recording of the data and the determination of the adhesion strength shall be as described in ASTM D413.

3.1.3.6.2 Acceptance Determination. The minimum force that is required to separate each sample shall be 1.4 Newtons per millimeter of width.

Test	Requirement	Pass Criteria
Adhesion	1.4 N/mm (8.0 lbs./inches)	Minimum force required to delaminate layers.

3.1.4 Additional Requirements.

3.1.4.1 Referenced Specifications. Hydraulic brake hose assemblies furnished to this specification shall conform to all requirements published in the latest dated issue of the FMVSS106 specification. Assemblies furnished to this specification shall conform to all requirements published in the latest dated issue of the SAE J1401 specification.

3.1.4.2 Engineering Source Approval.

3.1.4.2.1 Approval Requirements. Approval will require the following information to be submitted:

1. Blueprints showing the design, dimensions and tolerances for all components of the assembly, including allowed eccentricity in the hose, tube insert, and coupling OD, and also including the range of hose compression possible under all conditions of dimensional tolerance stack-up.
2. The submission of sectioned coupling samples to demonstrate that all of the above mentioned construction requirements have been met.
3. A description of the statistical process control procedures for the coupling diameter dimensions and the hose compression range.
4. The value for hose compression necessary to induce:
   - **a** Hose rubber damage (any layer).
   - **b** Hose reinforcement damage.
5. Data presented in both tabular and graph form, showing values of hose compression (calculated using both linear and area methods) vs. tensile test performance, (3.1.2.6), burst test performance, (3.1.2.2), hot plate performance (3.1.2.4) and fitting insert collapse. The dimensions of the crimped assembly components for each data point need to be listed, as well as the resultant hose compression.
6. Copies of test fixture traces, confirming pressure and temperature regimens imposed on the samples during test.

Note: Values of hose compression must be reported both in terms of linear compression and area compression (see Table 10 for the formula for each calculation).

3.1.4.2.2 Engineering Approval Factors. Engineering source approvals generated through testing to prove compliance to this specification are specific for combinations of the following factors:

- Size of hose and coupling components
- Hose material and construction
- Coupling design
- Tube insert material, plating, finish and hardness
- Coupling shell material, plating, finish and hardness
- Supplier specifications and manufacturing procedures, supplier (both hose and assembly) manufacturing sites.

Testing of one construction of assembly can result in Engineering Source Approvals for two crimp designs or materials by placing each design or material variant on one end of the assembly.

3.1.4.2.3 Design Level Requirements. All tube/hose assemblies manufactured for testing to this specification for engineering source approval purposes shall be completely representative of production level materials, components, processes and tooling. The exceptions are those assemblies needing to be specially manufactured under extremes of dimensions and/or tolerancing to meet the test requirements of the specification. Any exceptions to this requirement, or to any criteria referenced in Sections 1, 3, 4, 5, or 6 must be reviewed beforehand and approved by the GM Materials Engineer issuing the approval.

3.1.4.2.4 Engineering Source Approval Testing of Minimum and Maximum Dimensioned Hoses/Components. All testing conducted on assemblies and hoses manufactured with minimum and maximum dimensions is to be conducted one time only, for the initial Engineering Source Approval. Testing to 3.1.3.2.1, The Cyclical Corrosion Test, is to be conducted one time only, for the initial Engineering Source Approval.

3.1.4.2.5 Re-Approval of Material and Crimping. The following tests will be used to generate new Engineering Source Approvals for crimped brake hose assemblies in which there is a change in the manufacturing location of either the brake hose or the crimped brake hose assembly. A change in any of the other Engineering Approval Factors as defined in 3.1.4.2.2, above, will require a complete retest to all of the requirements of GMW3056 to generate a new Engineering Source Approval for the crimped brake hose assembly. Manufacturing location change retest requirements:

- 3.1.2.1
- 3.1.2.2
- 3.1.2.6
- 3.1.2.7
- 3.1.2.10
- 3.1.3.1
- 3.3.2.7
- 3.3.2.9

3.1.4.2.6 Coupling Assembly Required Tests. All test samples must be qualified dimensionally. All data points must be reported. For samples destructively tested, mode of failure must be reported. Testing to 3.1.1.3, 3.1.1.4, 3.1.3.4, 3.1.3.6 involve testing only hose, or hose materials. Coupled hydraulic brake hose assemblies, including the crimped ferrule as part of the assembly, must be tested to the remaining test sections of the specification. Each set, or subset, of samples tested to the requirements of a test procedure shall consist of samples taken from three lots of production hose. Equal numbers of hose shall be taken from each lot for each set, or subset, of samples tested. Tests that must be conducted on each specific part number are 3.3.2.1 and 3.3.2.5. All test specimens must be retained by the supplier and supplied to the GM Materials Engineer for review, if requested. Test Procedures referencing specific minimum test values that must be met, must be met by the linear –3 sigma limit of the sample population tested.

Table 2: Test Tables

Section	Test	# Samples
3.1.1	Oil Resistance	6
3.1.1.2	Stress-Corrosion Cracking	12
3.1.1.3	Static Ozone	6
3.1.1.4	Dynamic Ozone	6
3.1.2.1	Leak	(Note 1)
3.1.2.2	Burst	18
3.1.2.3	Volumetric Expansion	6
3.1.2.4	Hot Plate	36
3.1.2.5	Low Temperature Resistance	6

Section	Test	# Samples
3.1.2.6	Tensile	18
3.1.2.7	Whip	24
3.1.2.8	Torsion Test, Center Fitting	6
3.1.2.9	Heat Age/Cold Bend	6
3.1.2.10	Fitting Rotation	12
3.1.2.11	Brake Fluid Compatibility	24
3.1.3.1	Constriction	6
3.1.3.2	End Fitting Corrosion Resist	12
3.1.3.3	Water Permeability	12
3.1.3.4	Physical Properties	
3.1.3.5	Innertube Thermoplasticity	12
3.1.3.6	Adhesion	6
3.1.4.4.1	Overcrimp to 3 Sigma Limits	24
3.1.4.4.2	Overcrimp to Damage	Design
		Depen-dent
3.3.1.1	Stricter Aging Resistance	6
3.3.2.1	Durability	6
3.3.2.2	Water Absorption, Burst	6
3.3.2.3	Water Absorption, Tensile	6
3.3.2.4	Water Absorption, Whip	6
3.3.2.5	Combination Test	12
3.3.2.6	Aging Resistance/Brake Fluid Compatibility	114
3.3.2.7	Pressure, Temperature Cycling	18
3.3.2.8	Cold Fatigue	6
3.3.2.9	ABS Impulse	36

Note 1: Performed in conjunction with other tests, 3.1.2.2 through 3.3.2.9, except for 3.1.2.8, 3.1.3.1, 3.1.3.4, 3.1.3.6, 3.1.4.4.1, and 3.1.4.4.2.

3.1.4.2.7 Standard Test Samples. Length and Configuration: The free lengths of the hose samples to be tested are as follows:

Table 3: Hose Length

Section	Free Length of Hose
3.1.1	
3.1.1.2	
3.1.1.3	392 MM
3.1.1.4	305 MM
3.1.2.1	
3.1.2.2	305 MM
3.1.2.3	
3.1.2.4	305 MM
3.1.2.5	305 MM
3.1.2.6	305 MM
3.1.2.7	392 MM
3.1.2.8	
3.1.2.9	305 MM
3.1.2.10	152 MM
3.1.2.11	305 MM
3.1.3.1	
3.1.3.2	152 MM
3.1.3.3	
3.1.3.4	
3.1.3.5	305 MM
3.1.3.6	25 MM
3.1.4.4.1	
3.1.4.4.2	
3.3.1.1	
3.3.2.1	Part Number
3.3.2.2	305 MM
3.3.2.3	305 MM
3.3.2.4	392 MM
3.3.2.5	Part Number
3.3.2.6	Per Ref. Test
3.3.2.7	305 MM
3.3.2.8	229 MM
3.3.2.9	305 MM

Note: All hose lengths shall be ± 3 mm. For those test sections that a hose length is not specified, the test is either part number specific, or the test may be done on hose assemblies the length of which may be determined by the supplier.

3.1.4.3 Crimp Compression. Test samples throughout this specification will be referred to as minimum hose compression, nominal hose compression or maximum hose compression samples. The following sections describe the requirements for these conditions. If not specified, the test samples shall be of nominal hose compression.

3.1.4.3.1 Minimum Crimp Compression Condition. Test samples referred to in this specification, as minimum hose compression samples shall adhere to the following requirements:

Hose Wall:	Minimum wall thickness (as determined by the 3 sigma value of the hose manufacturer)
Crimp/Swage OD:	Maximum crimp/swage OD (3 sigma value of the assembly manufacturer)
Tube Insert OD:	Minimum tube insert OD (3 sigma value of the metal insert manufacturer)
Ferrule Wall:	Minimum ferrule wall thickness (3 sigma value of the ferrule manufacturer)

Assemblies manufactured as above, but with the substitution of nominally dimensioned tube insert OD and nominally dimensioned ferrule wall thickness components may be used for evaluation with the submittal of SPC data confirming minimal tolerances and acceptable CPk values for these dimensions. The acceptability of nominal insert OD and ferrule wall thickness dimensions for this testing must be reviewed beforehand and approved by the GM Materials Engineer issuing the approval. If the use of nominal insert OD and ferrule wall thickness dimensions for the testing is found to be acceptable, the crimp OD must be adjusted to result in a value of minimum hose compression which would have resulted if minimum ferrule wall thickness and minimum tube insert OD had been used in the preparation of the samples.

3.1.4.3.2 Nominal Crimp Compression Condition. Test samples referred to in this specification, as nominal hose compression samples, shall consist of components manufactured to nominal dimensions, and crimped to a mean specification value of crimp/swage OD.

3.1.4.3.3 Maximum Crimp Compression Condition. Test samples referred to in this specification as maximum hose compression samples shall adhere to the following requirements:

Hose Wall:	Maximum wall thickness (as determined by the 3 sigma value of the hose manufacturer)
Crimp/Swage OD:	Minimum crimp/swage OD (3 sigma value of the assembly manufacturer)
Tube Insert OD:	Maximum tube insert OD (3 sigma value of the metal insert manufacturer)
Ferrule Wall:	Maximum ferrule wall thickness (3 sigma value of the ferrule manufacturer)

Assemblies manufactured as above, but with the substitution of nominally dimensioned tube insert OD and nominally dimensioned ferrule wall thickness components may be used for evaluation with the submittal of SPC data confirming minimal tolerances and acceptable CPk values for these dimensions. The acceptability of nominal insert OD and ferrule wall thickness dimensions for this testing must be reviewed beforehand and approved by the GM Materials Engineer issuing the approval. If the use of nominal insert OD and ferrule wall thickness dimensions are found to be acceptable, the Crimp OD must be adjusted to result in a value of maximum hose compression which would have resulted if maximum ferrule wall thickness and maximum tube insert OD had been used in the preparation of the samples.

3.1.4.4 Crimp Examination Procedure.

3.1.4.4.1 Overcrimp – 3-Sigma Limits. Twenty-four assemblies must be manufactured with maximum wall thickness (as determined by the 3–sigma value of the hose manufacturer, not the dimensions allowed per the GM specification for the hose), minimum crimp/swage OD (3 sigma value of the assembly manufacturer), maximum metal tube insert OD (3 sigma value of the metal tube insert manufacturer), and maximum ferrule wall thickness (3 sigma value of the ferrule manufacturer). These assemblies shall be disassembled and examined for hose tube, cover, and reinforcement damage as described in 3.1.4.4.3

3.1.4.4.1.1 Acceptance Determination. Supplier evaluation of these parts (and the parts themselves), must be returned to the GM Materials Engineer issuing the approval for evaluation. No hose rubber or reinforcement damage generated by the crimping operation is permissible in these samples. Assemblies manufactured as above, but with the substitution of nominally dimensioned metal tube insert OD and nominally dimensioned ferrule wall thickness components may be used for this evaluation with the submittal of SPC data confirming minimal tolerances and acceptable CPk values for these dimensions. The acceptability of nominal insert OD and ferrule wall thickness dimensions for this testing must be reviewed beforehand and approved by the GM Materials Engineer issuing the approval.

3.1.4.4.2 Overcrimp to Damage. Additional samples must be crimped and examined to determine the value of hose compression necessary to induce damage to either the hose material, or to the reinforcement.

3.1.4.4.2.1 Overcrimp Procedure. The additional samples are to be over-crimped per the conditions described in 3.1.4.4.1, except that progressive increments of increased hose compression are to be induced through reduction of crimp OD until hose damage is incurred. These increments may not number less than two, nor be more than 4 % incremental hose wall compression as calculated by the area method of calculating compression.

3.1.4.4.2.2 Sample Size and Acceptance. Twelve samples are to be prepared for each increment, and tested to the requirements of 3.1.4.4.3. Three samples shall be tested to the requirements of each of the sections 3.1.4.4.3.1 through 3.1.4.4.3.4. After the compression that induces damage is determined, confirmation shall be obtained by a repetition of twelve additional samples.

3.1.4.4.2.3 Determination of Damage. Determination of damage shall be done in accordance with 3.1.4.4.3 of this specification.

3.1.4.4.2.4 Exceptions. Other engineering experimental plans are permissible, providing that the approval of the GM Materials Engineer issuing the approval has been obtained.

Any exceptions or deviations to this section must have the approval of the GM Materials Engineer issuing the approval and must be addressed completely and clearly in certification packages.

3.1.4.4.3 Hose Examination Procedure.

3.1.4.4.3.1 Outer Braid Reinforcement Damage. For six of the twenty-four assemblies to be tested, make a circumferential cut through the crimp shell at the position of the end of the hose. The depth of the cut should be such to cut through the metal only; only minimal hose cover damage and no reinforcement damage is permissible. Remove the head of the fitting and the stem insert from the ID of the hose by pulling the head of the fitting longitudinally, away from the hose. Make two longitudinal cuts along the crimp shell, 180 degrees apart. These cuts should be nearly through the metal crimp shell, and should cause no or minimal cover damage and no reinforcement damage. Use vise of needle-nose pliers to work the crimp shell metal back and forth to break through any remaining metal along the two longitudinal cuts of the crimp shell. Remove the individual halves of the crimp shell from the brake hose. Inspect the cover of the hose for damage under the crimp impression, excluding points directly under the longitudinal saw cuts. Photograph and document any cover damage seen. Using a razor knife, carefully slit the cover along its longitudinal axis, inflicting minimal damage to the underlying yarn. Peel the cover away from the yarn using needle-nosed pliers. Inspect the outer braid reinforcement for yarn fracture under the crimp impression, excluding points immediately under the longitudinal knife cuts. Photograph and document any reinforcement damage seen. Save the samples for review by the GM Materials Engineer issuing the approval.

3.1.4.4.3.2 Cushion Liner Damage. For six of the twenty-four samples tested, repeat the procedures detailed in 3.1.4.4.3.1, but continue the dissection of the samples, rather than saving the samples. Use needle-nosed pliers to unbraid the outer reinforcement layer or to peel the layer back; using scissors, cut to relieve tangling. If a cushion liner is used in the hose construction, inspect the cushion liner for damage under the crimp impression. Photograph and document any cushion liner damage seen. Save the samples for review by the GM Materials Engineer issuing the approval.

3.1.4.4.3.3 Inner Reinforcement – Yarn Fracture. For six of the twenty-four samples tested, repeat the procedures detailed in 3.1.4.4.3.1 and 3.1.4.4.3.2, but continue the dissection of the samples, rather than saving the samples. If a cushion liner is used in the hose construction, use needle-nosed pliers to carefully roll the cushion liner away from the inner reinforcement layer, taking care not to damage the inner braid. Inspect the inner reinforcement layer for yarn fracture under all parts of the crimp shell. Photograph

and document any inner reinforcement damage seen. Save the samples for review by the GM Materials Engineer issuing the approval.

3.1.4.4.3.4 Inner Tube Bore – Cuts and Tears. For six of the twenty-four samples tested, repeat the procedures detailed in 3.1.4.4.3.1 through 3.1.4.4.3.3, but continue the dissection of the samples, rather than saving the samples. Use scissors to make one longitudinal cut through the innertube and inner reinforcement layer. Open and invert this section and inspect the inner tube bore for cuts or tears. Photograph and document any inner tube bore damage seen. Save the samples for review by the GM Materials Engineer issuing the approval.

3.1.4.4.3.5 Alternatives and Exceptions. Alternative methods for performing the hose examination procedure may be permitted. The acceptability of alternative methods for performing the hose examination procedure must be reviewed beforehand and approved by the GM Materials Engineer issuing the Engineering Source approval.

3.2 Processing Requirements.

3.2.1 Chemical Requirements. Not applicable.

3.2.2 Mechanical Requirements. Not applicable.

3.2.3 Physical Requirements.

3.2.3.1 Curing. Hose must be cured in a straight position

3.2.4 Additional Requirements. Not applicable.

3.3 Performance Requirements.

3.3.1 Chemical Requirements.

3.3.1.1 Stricter Aging Resistance.

3.3.1.1.1 Test Procedure. Six assemblies crimped at nominal hose compression shall be tested. Assemblies shall be tested to the requirements of Opel GMI60285. In 3.3.2 of GMI60285, hose assemblies shall be evaluated both by X-ray, and also by checking for constriction of the hose. Constriction of the hose shall be checked by holding the assembly vertically at one fitting and inserting a spherical constriction test probe as defined in Figure 4, Option 2 into the end of the upper fitting. The probe shall fall through the assembly without assist. Manual straightening of the hose is permissible; no other manipulation of the assembly is allowed. The size of the spherical constriction test probe for the hose tested shall be as defined in Table 6. For the X-ray evaluation, the X-Ray equipment must be adjusted to maximize the contrast between the rubber and the ID passage of the hose. Low kV, high mA output from the X-ray tube may maximize the contrast. A hose without PVA gel formation should show a clear, light ID passage bordered by the darker walls of the hose. If darker areas impinge on the tube ID of the hose, this is evidence of PVA gel formation and resultant bulging of the hose ID inward. The entire length of the hose must be examined, including those areas of the hose entering the crimp shell.

Note: The Stricter Aging Resistance test is not required for hoses incorporating rayon reinforcement.

3.3.1.1.2 Acceptance Determination. X-ray of the hose assemblies shall show no formation of any gel-like substance between the elastomeric lining and the first reinforcement layer, and there shall be no bulging of the lining (the hose tube) inward. The spherical constriction test probe shall pass freely from one end of the hose assembly to the other end without restriction.

3.3.2 Mechanical Requirements.

3.3.2.1 Durability Test.

3.3.2.1.1 Test Procedure. Six hose samples are to be tested at nominal hose compression with brake fluid, (Testing fluid will be vehicle specific. DOT 3 brake fluid meeting GM4653M or DOT 4 brake fluid meeting GMEL5104. In the case of dual fluid applications DOT 4 fluid will override the use of DOT 3 fluid in this test). At the discretion of the platform design release engineer, this test may be waived in favor of successful completion of durability test.

3.3.2.1.2 Test Method. Test samples shall be mounted on a fatigue test fixture that is designed to duplicate the hose and suspension areas of the specified vehicle hose routing. Determination of front/rear, left/right brake hose shall be made by design engineer, in conjunction with supplier.

3.3.2.1.3 Temperature, Suspension Travel and Steering. The temperature at which the hoses are tested shall be ambient (23 ± 5) °C. The motion for simulation of suspension shall be moving in and upward and downward direction throughout 88 % of the jounce and rebound travel, at 90 cpm. Concurrently, the simulated suspension shall rotate through 88 % of the steering travel at 12 cpm.

The hose assemblies shall be pressure cycled using GM specified brake fluids per 3.3.2.1.1. The pressure cycle shall be from 0 to 10.350 MPa each 15 s. For example, at 10.350 MPa for 15 s, and then at 0 MPa for 15 s. The maximum ramp time for the square wave pressure waveform is 12 msec from 0 pressure to maximum pressure, and 12 msec from maximum pressure to 0 pressure.

Hose assemblies shall be tested until failure, or 1 000 000 cycles – whichever comes first. Record the results, and continue testing the remaining samples, repeating the instructions listed above.

Note: One (1) cycle is defined as a completed jounce and rebound travel motion.

If any hose assembly shall fail, a description of the failure must be recorded. All test results shall be recorded, and a compilation of these failures shall be utilized in a Weibull distribution of failures. The B10 life must exceed 250 000 cycles.

If the hoses do not exceed 250 000 cycles, GM design engineers shall be consulted for determination of acceptability. All test data must be provided at sample submission.

Note: Brake assemblies used for the rear of the vehicle shall not be tested for steering travel.

3.3.2.1.4 Acceptance Determination. Since this test is designed to determine the statistical fatigue life of hose assemblies, each hose assembly under test shall be tested to 1 000 000 cycles, or until failure – whichever comes first. Hose failure will have occurred if the hose assembly blisters, bursts, leaks, or brake fluid seepage occurs.

Test	Requirement	Pass Criteria
Vehicle Simulation Test	250 000 cycles	Meet requirements of B10 criteria.

3.3.2.2 Water Absorption, Burst.

3.3.2.2.1 Test Procedure. Six assemblies crimped at nominal hose compression shall be tested. Remove 25...30 mm of the hose cover from the center of the hose assemblies so that the outer braid is exposed but without causing injury to any reinforcing material or elongation of the hose assemblies. Immerse the hose assemblies in distilled or deionized water at the testing room temperature (23 ± 5)°C for 70 to 72 h. Within 10 to 30 minutes after removal of the samples from the water, conduct the Burst Test per 3.1.2.2.

3.3.2.2.2 Acceptance Determination. Hose assemblies must meet the Burst Test requirements per 3.1.2.2.

Test	Requirement	Pass Criteria
Burst Test (3.1.2.2)	78 MPa (11 300 psig)	Minimum burst pressure

3.3.2.3 Water Absorption, Tensile.

3.3.2.3.1 Test Procedure. Six assemblies crimped at nominal hose compression shall be tested. Prepare and immerse the samples in water per 3.3.2.2.1. Within 10 to 30 minutes after removal of the samples from the water, conduct the Tensile Test per 3.1.2.6.

3.3.2.3.2 Acceptance Determination. Hose assemblies must meet the requirements of the Tensile Test per 3.1.2.6.

Test	Requirement	Pass Criteria
Tensile Test (3.1.2.6)	1750 N (389 lbs.)	Hose shall not break or pull from crimped fitting at less than 1750 N.

3.3.2.4 Water Absorption, Whip.

3.3.2.4.1 Test Procedure. Six assemblies crimped at nominal hose compression shall be tested. Prepare and immerse the samples in water per 3.3.2.2.1. Within 10 to 30 minutes after removal of the samples from the water, conduct the whip test per 3.1.2.7, omitting the Adhesion Test (3.1.3.6).

3.3.2.4.2 Acceptance Determination. Hose assemblies must meet the requirements of the Whip Test per 3.1.2.7 to 50 h of the requirement.

Test	Requirement	Pass Criteria
Whip Test (3.1.2.7)	50 h	No leakage of hose or crimped assembly.

3.3.2.5 Combination Test.

3.3.2.5.1 Purpose. To evaluate the durability of front and rear axle brake hoses under influence of pressure, temperature, water and dynamic stress.

3.3.2.5.2 Test Procedure. Six new assemblies are to be tested at nominal hose compression with brake fluid. In addition to this, six assemblies at nominal hose compression that have been preconditioned per GMI60284, Aging Resistance/Brake Fluid Compatibility of Brake Hoses, shall be tested. Testing fluid for

both GMI60284 and the Combination Test will be vehicle specific. DOT 3 brake fluid meeting GM4653M or DOT 4 brake fluid meeting GMEL5104 shall be used. In the case of dual fluid applications, DOT 4 fluid will override the use of DOT 3 fluid in this test. The total number of samples to be tested to the Combination Test is 12. Although this test is part number specific, a GM release engineer has the option to allow for the approval of two part numbers with the testing of only one part number, assuming the two part numbers are located on opposite sides of the same vehicle, are identical in material content, and are symmetrical with respect to shape, length, routing, and geometry of dynamic motion.

3.3.2.5.3 Equipment. Equipment and test procedure shall be prepared in accordance with test method GMEL-5F-7 (Combination Test on Brake Hoses).

3.3.2.5.4 Preparation. The minimum permissible bending radius (r=25 to 100 mm) and the vertical immersion travel of the brake hose end (caliper side) shall be determined for the specific brake hose assembly part number and application.

3.3.2.5.5 Hose Installation. The brake hose shall be installed in the device according to the geometry and the caliper-side fitting shall be connected to the air cylinder.

3.3.2.5.6 Brake Fluid. The line system shall be filled with the brake fluid designated above and then bled.

3.3.2.5.7 Deviation Conditions. Deviations from the requirements of this test procedure shall have to be agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

3.3.2.5.8 Test Instructions. The immersion bath shall be filled with water and heated to (70 ± 3)°C. The center point of the lower hose radius shall at no time (also during the test) lie above the water line. It shall be ensured that the evaporated water is topped up. The following parameters shall then be tested:

- Brake Pressure: 0.5...10 MPa
- Brake Pressure Waveform: sinusoidal
- Brake Pressure Apply Frequency: 1 ± 0.1 Hz
- Immersion stroke corresponding to the spring rate in the vehicle
- Stroke Frequency: 1.4 ± 0.1 Hz
- Caliper Travel: sinusoidal

It shall be ensured that 1: the evaporated water is topped up, and 2: one part of the hose bend is always in the water. The hose shall be burst after completion of the test.

3.3.2.5.9 Acceptance Determination. The hoses shall pass 1 000 000 immersion cycles without leakage. Minimum burst pressure (–3 sigma) for new parts shall be 37.5 MPa. The minimum burst pressure for preconditioned parts shall be 12.0 MPa. In addition to this, each preconditioned sample tested shall record a minimum burst value of greater than or equal to 20 MPa. Formation of gel, blisters, or cracks is not permitted for any samples. All test results shall be documented, and presented in the test report.

Test	Requirement	Pass Criteria
Combination	1 000 000 cycles	No blisters, or cracks
Burst (3.1.2.2)	37.5 MPa (–3 sigma)	Minimum burst pressure (new)
	12.0 MPa (–3 sigma)	Minimum burst pressure (preconditioned)
	20.0 MPa (each sample)	

3.3.2.6 Aging Resistance/Brake Fluid Compatibility.

3.3.2.6.1 Test Procedure – Preconditioning. One Hundred fourteen (114) hose assemblies are to be preconditioned per the requirements of GMI60284, prior to being evaluated per the test procedures listed below. Thirty eight (38) of these hose assemblies at minimum hose compression, thirty eight assemblies at nominal hose compression, and thirty eight assemblies at maximum hose compression are to be preconditioned per GMI60284. The brake fluid to be used for the preconditioning is to be DOT 4 fluid meeting specification GMEL5104.

3.3.2.6.1.1 Pressure, Temperature Cycling Test.

3.3.2.6.1.1.1 Test Procedure – Pressure, Temperature Cycling Test. Following the preconditioning of 3.3.2.6.1, eighteen hose assembly samples are to be tested to the requirements of 3.3.2.7, the Pressure, Temperature Cycling Test. These hose samples are to consist of six at minimum hose compression, six at nominal hose compression, and six at maximum hose compression.

3.3.2.6.1.1.2 Acceptance Determination – Pressure, Temperature Cycling Test. All eighteen hose assembly samples must pass the requirements of 3.3.2.7, The Pressure, Temperature Cycling Test.

3.3.2.6.1.2 Whip Test.

3.3.2.6.1.2.1 Test Procedure – Whip Test. Following the preconditioning of 3.3.2.6.1, twenty four hose assembly samples are to be tested to the requirements of 3.1.2.7, the Whip Test. These hose samples are to consist of eight at minimum hose compression, eight at nominal hose compression, and eight at maximum hose compression.

3.3.2.6.1.2.2 Acceptance Determination – Whip Test. All twenty four hose assembly samples must pass the requirements of 3.1.2.7, the Whip Test.

3.3.2.6.1.3 Hotplate Test.

3.3.2.6.1.3.1 Test Procedure - Hotplate Test. Following the preconditioning of 3.3.2.6.1, thirty six hose assembly samples are to be tested to the requirements of 3.1.2.4, the Hotplate Test. These hose samples are to consist of twelve at minimum hose compression, twelve at nominal hose compression, and twelve at maximum hose compression.

3.3.2.6.1.3.2 Acceptance Determination – Hotplate Test. All thirty six hose assembly samples must pass the requirements of 3.1.2.4, the Hotplate Test.

3.3.2.6.1.4 Tensile Strength.

3.3.2.6.1.4.1 Test Procedure - Tensile Strength. Following the preconditioning of 3.3.2.6.1, eighteen hose assembly samples are to be tested to the requirements of 3.1.2.6, the Tensile Test. These hose samples are to consist of six at minimum hose compression, six at nominal hose compression, and six at maximum hose compression.

3.3.2.6.1.4.2 Acceptance Determination – Tensile Strength. All eighteen hose assembly samples must pass the requirements of 3.1.2.6, the Tensile Test.

3.3.2.6.1.5 Burst Test.

3.3.2.6.1.5.1 Test Procedure – Burst Test. Following the preconditioning of 3.3.2.6.1, eighteen hose assembly samples are to be tested to the requirements of 3.1.2.2, the Burst Test. These hose samples are to consist of eight at minimum hose compression, eight at nominal hose compression, and eight at maximum hose compression.

3.3.2.6.1.5.2 Acceptance Determination – Burst Test. All eighteen hose assemblies must pass the requirements of 3.1.2.2, the Burst Test. Bursting pressure for the assemblies must be equal to or greater than 65.5 MPa.

3.3.2.7 Pressure, Temperature, Cycling Test.

3.3.2.7.1 Test Procedure. Eighteen hose samples are to be tested, six at minimum hose compression, six at nominal hose compression and six at maximum hose compression using DOT 4 brake fluid meeting GMEL5104.

3.3.2.7.2 Test Cycling. Test samples shall be mounted in an environmental chamber and subjected to temperature cycling and pressure cycling as described in Table 8. Brake fluid will be used as the pressure medium. Temperatures and pressures must be monitored such that the pressures and temperatures at the test hose assemblies comply with Table 8. The maximum ramp time for the square wave pressure waveform is 12 msec from 0 pressure to maximum pressure, and 12 msec from maximum pressure to 0 pressure.

3.3.2.7.3 Hose Test and Failure Determination. Test hose assemblies to the conditions specified in 3.3.2.7.2, repeating schedule defined in Table 8 until hose assembly failure occurs. Hose failure will have occurred if the hose assembly blisters, bursts, leaks or brake fluid seepage occurs.

3.3.2.7.4 Acceptance Determination. All assemblies tested must complete a minimum of one schedule as defined in Table 8. Repeat test and document cycles when failure occurred, as stated in 3.3.2.7.3

3.3.2.8 Cold Fatigue.

3.3.2.8.1 Test Procedure. Six assemblies crimped at nominal hose compression shall be tested with DOT 4 brake fluid meeting GMEL5104.

3.3.2.8.2 Test Sample Preparation. Samples will be filled with brake fluid, capped and aged 24 h in a chamber at (125 ± 3) °C. After aging the brake fluid will be drained and the samples will be rinsed thoroughly with water, both inside and outside. Samples are to be dried, inside and out, with a high-velocity air stream. Samples are to be cooled at room temperature for 1 h minimum. Load samples on test fixture detailed on drawing #9442997. Place fixture in cold chamber and reduce temperature to –40 °C. Cycle at 30 cpm.

3.3.2.8.3 Recording Procedure. Record cycles at initiation of cover cracking, and also when cracking has propagated through the cover to expose the outer braid layer.

3.3.2.8.4 Acceptance Determination. Hose assemblies must record 150 000 cycles without evidence of cover cracking. Hose assemblies must record 200 000 cycles without evidence of braid exposure.

Test	Requirement	Pass Criteria
Cold Fatigue	–40 °C at 30 cpm 200 000 flexes	Must survive 150 000 flexes without cover cracking. Must survive 200 000 flexes without braid exposure.

3.3.2.9 ABS Impulse.

3.3.2.9.1 Test Procedure. Eighteen assemblies are to be tested; six at minimum hose compression, six at nominal hose compression, six at maximum hose compression with each of two brake fluids, DOT 3 brake fluid meeting GM specification GM4653M and DOT 4 brake fluid meeting GMEL5104. Therefore, the total number of samples to be tested is thirty-six.

3.3.2.9.2 Hose Connection. Connect test hoses in series and install on impulse apparatus capable of generating pressure sequences at temperature per the listing in Table 9. High frequency impulse cycles are to be superimposed onto the primary impulse cycle. The maximum ramp time for the square wave pressure waveform is 12 msec from 0 pressure to maximum pressure, and 12 msec from maximum pressure to 0 pressure.

3.3.2.9.3 Test Protocol. Conduct the test sequence as defined in Table 9. Periods of ramp to high or low temperatures are not included in the schedule listed in the table. Record any blisters, seeps, or leaks that occur during the cycling. Run the Burst Test per 3.1.2.2 on all hose assemblies that successfully complete the impulse testing.

3.3.2.9.4 Acceptance Determination. All assemblies must complete pressure impulse test sequences without blisters, seeps, or leaks. All assemblies must pass Burst Test per 3.1.2.2, with a minimum Burst Pressure of 70.0 MPa.

Test	Requirement	Pass Criteria
ABS Impulse	Table 9	There shall be no evidence of seepage, blisters, or leakage.
Burst Test (3.1.2.2)	70 MPa (10 150 psi)	Minimum Burst Pressure

3.3.3 Physical Requirements. Not applicable.

3.3.4 Additional Requirements. Not applicable.

3.4 Requirements on other Stages during Life Cycle. Subparagraphs were not applicable.

4 Manufacturing Process

Hose must be cured in a straight position.

5 Rules and Regulations

5.1 Legal Regulations. For use of this material the valid laws and other regulations and recommendations in the country of usage shall be followed.

5.2 Language. In the event of any conflict between the English and domestic language regarding this document, the English language will take precedence.

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

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

5.5 Inspection and Rejection. All shipments of materials or parts under contract or purchase order manufactured to this specification shall be equivalent in every respect to the initial samples approved by engineering. There shall be no changes in the formulation or manufacturing process permitted without prior notification and approval by engineering. Lack of notification by the supplier constitutes grounds for rejection of any shipment. While samples may be taken from incoming shipments and checked for conformance to this specification, the supplier shall accept the responsibility for incoming shipments meeting this specification without dependence upon the purchaser's inspection.

5.6 Initial Source Approval. No shipments shall be made by any supplier until representative initial production samples have been approved by Materials Engineering as meeting the requirements of this specification.

5.7 Safety Data Sheets. Completed copies of the Material Safety Data Sheets (MSDS) meeting GM information requirements, consistent with the ISO 11014-1 standard, must be submitted with any new material submissions or where a composition change has occurred.

6 Approved Sources

Suppliers to this specification must be approved by the respective specialist teams/TDG's. GMNA approved suppliers names are available on the on-line MATSPC system. For other GM locations, the responsible engineering group shall be contacted to obtain the approved sources in the individual countries.

7 Coding System

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

Test to GMW3056

8 Release and Revisions

8.1 Release. The specification was first approved in May 2000 and released in June 2000.

8.2 Revisions.

Rev.	Date	Description (Org.)
A	JUN 2001	Reformated (GMNA)
B	APR 2002	Fixed Typo in 3.3.2.1.3 (GMNA)

Appendix A

Table 4: Test Cylinder Dimensions 3.1.2.5, 3.1.2.9

Hose Nominal Inside Diameter	Cylinder Diameter	
	mm	inches
3 to 3.2 mm (1/8 inch)	76	(3.0)
4 to 5 mm (3/16 inch)	88	(3.5)
Test Cylinder Diameter Tolerance:	+1 mm (+0.04 inch)	
	–0 mm (–0.0 inch)	

Table 5: Slack Distances Allowed (3.1.2.7)

Hose Assembly Free Length(s)		Hose Nominal Inside Diameter			
		3 mm or less (1/8 inch)		over 3 mm (1/8 inch)	
mm	(inches)	mm	(inches)	mm	(inches)
≥ 203, ≤ 394	(≥ 8, ≤ 15.5)	44.45 + 0.40	(1.750 + 0.015)		
> 395, ≤ 483	(> 15.5, ≤ 19)	31.75 + 0.40	(1.250 + 0.015)		
> 483, ≤ 600	(> 19, ≤ 24)	19.05 + 0.40	(0.750 + 0.015)		
≥ 254, ≤ 394	(≥ 10, ≤ 15.5)			25.40 + 0.40	(1.000 + 0.015)

Table 6: Test Probe Diameter "A"(3.1.3.1)

Hose Nominal Inside Diameter		"A" Diameter	
mm	inches	mm	inches
3.0	(1/8)	1.92	(0.076)
3.2	(1/8)	2.04	(0.080)
4.0	(3/16)	2.56	(0.101)
4.5	(3/16)	2.88	(0.113)
5.0	(3/16)	3.20	(0.126)
Test Probe Diameter "A" Tolerance:		+0.01 mm (+0.002 inch)	
		–0.00 mm (–0.000 inch)	

Table 7: Hose Compound Physical Properties (3.1.3.4)

Properties	Test Method
As Received	
Hardness	ASTM D2240, Durometer, Shore A
Tensile Strength	ASTM D412, Method A
Elongation	ASTM D412, Method A
Compression Set, 70 h at 125 °C	ASTM D395, Method B
Heat Age	ASTM D865, 168 h at 125 °C
Hardness Change	ASTM D2240, Durometer, Shore A
Tensile Strength Change, Percent, Maximum	ASTM D412, Method A
Elongation Change, Percent, Maximum	ASTM D412, Method A
Brake Fluid Exposure, DOT 3	ASTM D471, 168 h at 125 °C
(Hose Tube Material Only)	
Hardness Change	ASTM D2240, Durometer, Shore A
Tensile Strength Change, Percent, Maximum	ASTM D412, Method A
Elongation Change, Percent, Maximum	ASTM D412, Method A
Volume Change, Percent, Maximum	ASTM D380
Brake Fluid Exposure, DOT 4	ASTM D471, 168 h at 125 °C
(Hose Tube Material Only)	
Hardness Change	ASTM D2240, Durometer, Shore A
Tensile Strength Change, Percent, Maximum	ASTM D412, Method A
Elongation Change, Percent, Maximum	ASTM D412, Method A
Volume Change, Percent, Maximum	ASTM D380
Brake Fluid Exposure, DOT 3	ASTM D471, 1000 h at 125 °C
(Hose Tube Material Only)	
Elongation Change, Percent, Maximum	ASTM D412, Method A
Brake Fluid Exposure, DOT 4	ASTM D471, 1000 h at 125 °C

Table 7: Hose Compound Physical Properties ()

Properties	Test Method
(Hose Tube Material Only)	
Elongation Change, Percent, Maximum	ASTM D412, Method A

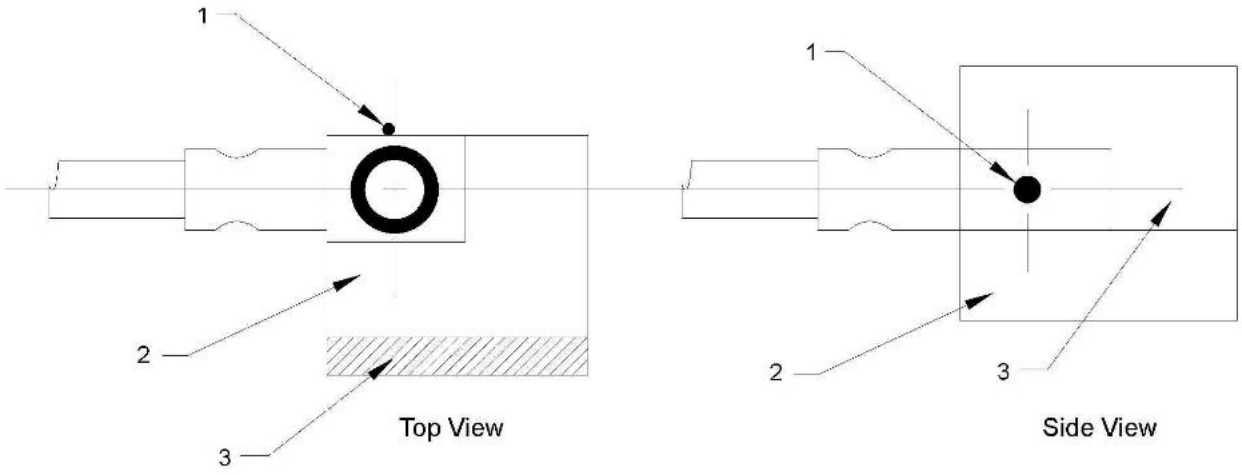
Table 8: Test Schedule

Pressure, Temperature, Cycling Test (3.3.2.7)						
Time (Hour)	Chamber Temp (°C)	Impulse Pressure	Impulse Wave Frequency	Impulse Wave Duration		Impulse Waveform
				On	Off	
2	–40	11...17.3 MPa	8 ± 0.5 Hz	4 s	4 s	Square
2	–40...125	11...17.3 MPa	8 ± 0.5 Hz	4 s	4 s	Square
2	125	11...17.3 MPa	8 ± 0.5 Hz	4 s	4 s	Square
2	125...–40	11...17.3 MPa	8 ± 0.5 Hz	4 s	4 s	Square
2	–40	11...17.3 MPa	8 ± 0.5 Hz	4 s	4 s	Square

Table 9: Test Schedule

ABS Impulse Test (3.3.2.9)							
Sequence #	Chamber Temp	Impulse Pressure	Impulse Wave Frequency	Impulse Wave Duration		Impulse Waveform	Number of Cycles
				On	Off		
1	120 °C	0...11.0 MPa		1 minute	1 minute	Square	720
2	23 °C	7.6...13.7 MPa	8 ± 0.5 HZ	4 s	4 s	Square	10 000
3	120 °C	7.6...13.7 MPa	8 ± 0.5 HZ	4 s	4 s	Square	10 000
4	120 °C	11...17.3 MPa	8 ± 0.5 HZ	4 s	4 s	Square	500
Hold	23 °C	27.6 MPa		2 minutes		Square	1

Figure 1: Top & Side View for Hot Plate (3.1.2.4)



1. Temperature measurement point
2. Copper Block
3. Hot Plate

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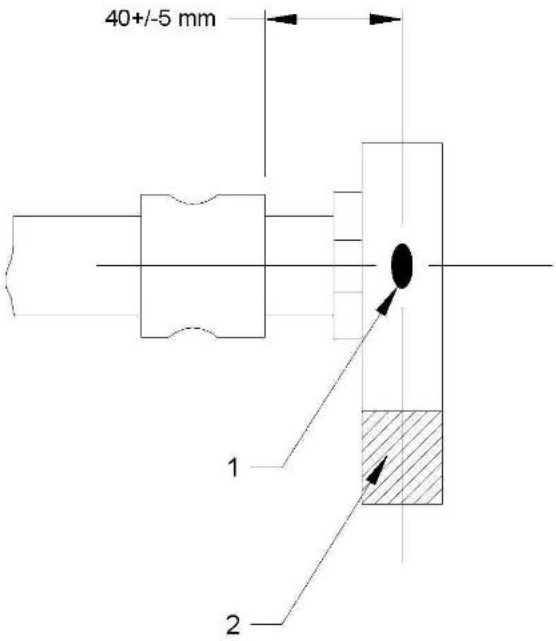
Figure 2: Side View of Female Fitting (3.1.2.4)



1. Temperature measurement point
2. Hot Plate

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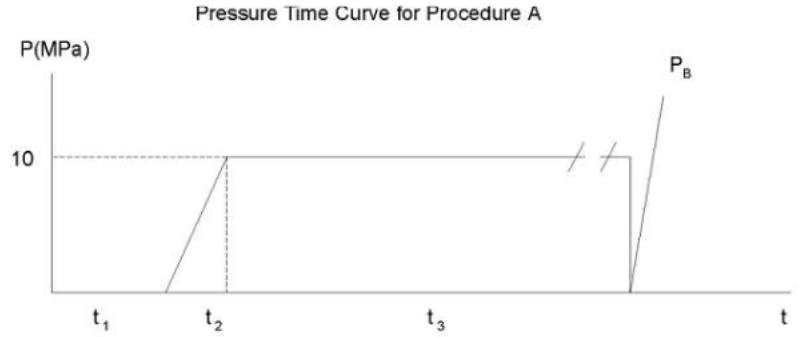
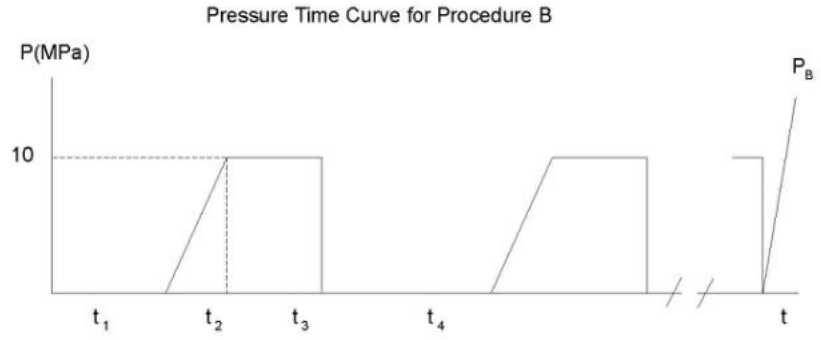
Figure 3: Hot Plate Pressure Time Curves for Procedures A & B (3.1.2.4)



t_1 Heating time until temperature T is attained
t_2 Pressure build-up time
t_3 Pressure hold time
P_B Bursting pressure



t_1 Heating time until temperature T is attained
t_2 Pressure build-up time
t_3 Pressure hold time
t_4 No pressure apply time
P_B Bursting pressure

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Figure 4: Constriction Test Probe (3.1.3.1)

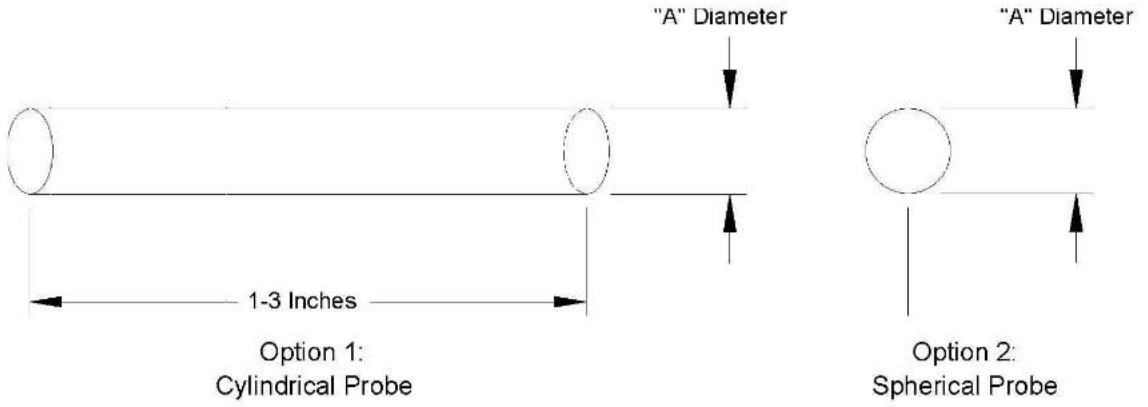

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Table 10: Hose Compression Calculations

I. Linear Compression:

Linear Hose Wall Compression = $[(T_o - T_f)/T_o] \times 100\ \%$

Where:

T_o = Initial hose wall thickness (prior to crimping)

T_f = Final hose wall thickness (after crimping)

II. Area Hose Wall Compression:

Area Hose Wall Compression = $(1 - ([R^2_{OD-F} - R^2_{ID-F}]/[R^2_{OD-I} - R^2_{ID-I}])) \times 100\ \%$

Where:

R_{ID-I} = Initial ID radius of the hose (prior to crimping).

R_{OD-I} = Initial OD radius of the hose (prior to crimping).

R_{ID-F} = Final ID radius of the hose (after crimping).

R_{OD-F} = Final OD radius of the hose (after crimping).