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| GM | WORLDWIDE ENGINEERING STANDARDS | General Specification | GMW15388 |

# Hydraulic Brake Line Assembly Technical Specification

## 1 Introduction

**Note:** Nothing in this standard supercedes applicable laws and regulations.

**Note:** In the event of conflict between the English and domestic language, the English language shall take precedence.

**1.1 Scope.** This standard establishes the quantitative requirements for brake lines and connectors. See program specific technical specification.

The brake line assemblies are used to provide fluid and pressure transfer from the vehicle master cylinder to the Chassis Control Module (CCM) and the individual wheel cylinders. The brake line assemblies work in conjunction with the foundation brake system to provide the vehicle with a smooth, safe deceleration, retardation and retention performance under all driving conditions, as specified in this document. The brake system is intended to provide world class performance. Interfaces shall be flexible enough to support the diverse packaging and processing requirements of the corporation.

Note: The terms brake line assemblies and brake lines are interchangeable within this document except where noted or where the reference is specific to the tubes or other individual components of the assemblies. The hydraulic brake hose, i.e., the outer brake hoses or the jounce hoses that attach to the wheel cylinder are not specified in this document.

**1.2 Mission/Theme.** This document applies to vehicles with hydraulic brake systems.

**1.3 Classification.** Not applicable.

## 2 References

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

**2.1 External Standards/Specifications.**

| | | | |
|---|---|---|---|
| SAE J400 | SAE J533 | SAE J1344 | SAE J2044 |

**2.2 GM Standards/Specifications.**

| | | |
|---|---|---|
| GM7400M | GMW4700 | GMW14658 |
| GMW3059 | GMW8518 | GMW14872 |
| GMW3116 | GMW14559 | GMW14991 |

**2.3 Additional References.**

Brake Design Guide – Bundy Corporation (Rev. 1/20/97)

General Motors Mechanical Stress Testing of Chassis Mounted Products – Section III

TX-132643A

## 3 Requirements

**3.1 Component Definition.** The brake line assemblies are used to provide fluid/pressure transfer from the vehicle master cylinder to the CCM and from the CCM to the outer brake hose or jounce hoses that attach to the individual wheel cylinders. The brake lines work in conjunction with the foundation brake system to provide the vehicle with a smooth and safe deceleration which meets or exceeds all applicable government and GM requirements.



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The new brake system is intended to provide world class performance from right sized components with interfaces flexible enough to support the diverse packaging and processing requirements of the corporation. The brake line assemblies will be, in most applications, received at the Assembly Facility as a bundle which may include multiple lines, clips, and end-form fittings.

**3.1.1 Appearance.**

**3.1.1.1 Color.** The nylon over steel brake lines shall be black in color. Print on brake lines shall be white in color.

The nylon clip colors shall be as follows:

- Use for 6.35 mm (1/4 in) OD line, gray in color
- Use for 4.76 mm (3/16 in) OD line, black in color

Color coding will be required at end locations for error proofing connections. The colors required shall be specified. See program technical specification.

**3.1.2 Content.** The required physical and functional content of the brake line assemblies are identified in the following paragraphs.

**3.1.2.1 Physical Content.** A brake line typically includes the following parts:

- High-pressure quick connections
- Flexible section areas
- Lines
- Threaded fittings
- T-blocks
- Positioning clips
- Brackets
- Protective sleeves

**3.1.2.2 Functional Content.** The brake line assembly shall transfer fluid/pressure from the vehicle master cylinder to the Chassis Control Module (CCM) and from the CCM to the individual wheel cylinders.

**3.1.3 Ambient Environment.** The ambient environmental conditions to which the lines may be exposed within their useful life are defined in the following paragraphs. Expected performance during or after the environmental exposure shall be defined where appropriate.

**3.1.3.1 Operating Environment.**

**3.1.3.1.1 Ambient Temperature.** The brake lines shall satisfy performance requirements within the following conditions.

**Table 1: Ambient Temperature**

| Region | Minimum Temperature | Maximum Temperature |
|---|---|---|
| Worldwide Default | -48 °C (-55 °F) | +52 °C (125 °F) |
| Russia (Siberia) | -51 °C (-60 °F) | - |
| Middle East | - | +55 °C (130 °F) |

**3.1.3.1.2 Ambient Humidity.** The brake lines shall satisfy performance requirements for relative humidity conditions with the range of (4 to 100) %.



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**3.1.3.2 Non-Operating Pressure and Temperature.** The brake lines shall meet all operating performance requirements, without loss of function or degradation of service life, under the operating environment defined in paragraph 3.1.3.1 after exposure to the following non-operating conditions:

**3.1.3.2.1** Transport by airplane at altitudes up to 13 700 m.

**3.1.3.2.2** Free air temperature of (-48 to +93) °C.

**3.1.3.2.3** Transport by ground via haul-away carriers and train.

**3.1.3.3 Potential Contaminants.** Table 2 identifies the potential contaminants which the brake lines must either withstand prolonged exposure to or be located, packaged, or protected from to assure no degradation from its design function.

**Table 2: Potential Contaminants**

| Contaminant | Underhood | Wheel Area or Underbody |
|---|---|---|
| Engine oil | X | X |
| Transmission fluid | X | X |
| Power steering fluid | X | X |
| Coolant/Antifreeze | X | X |
| Brake fluid | X | X |
| Windshield washer fluid, ammonia glass cleaner | X | X |
| Gasoline, other fuels | X | X |
| Transaxle or differential lube | X | X |
| Wheel bearing lube | | X |
| A/C refrigerant | X | X |
| Battery acid | X | X |
| Water | X | X |
| Snow, ice | | X |
| Acid rain | X | X |
| Deicing & dust control chemicals (NaCl, Calcium Magnesium Acetate (CMA), $CaCl_2$, Calcium Lignosulfonate) | X | X |
| Dirt, grit, sand | X | X |
| Dust | X | X |
| Mud | X | X |
| Road tar, oil | | X |
| Rustproofing/undercoating | X | X |
| Ozone | X | X |
| Biological (sap, leaves, insects, bird droppings) | | |
| Biological (mold, fungus) | X | X |
| Car wash chemicals, detergents, tar remover | X | X |



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| Contaminant | Underhood | Wheel Area or Underbody |
|---|---|---|
| Waxes, paint sealants | | |
| Steam cleaning | X | X |
| Tire cleaners | | X |
| Engine cleaners | X | X |
| Carpet cleaners | | |
| Soft drinks, coffee, etc. | X | |

**3.1.4 Interfaces.** The following interfaces will affect or constrain the function, performance, and design of the brake lines.

**3.1.4.1 External-to-Vehicle to Brake Lines.** See program technical specification.

**3.1.4.2 Interfaces to Other Components.** The brake lines shall comply to the functional requirements of the following interface components. The interface components include, but are not limited to, the vehicle master cylinder, the outer hose fittings, and CCM and/or proportioning valves.

**3.1.4.2.1 Master Cylinder/Outer Hose Assemblies/Proportioning Valves.** These connections shall use common double inverted flare GM approved tube nuts. The tube end form at this location will be defined per SAE J533 double 45 degree **inverted** flare. The mating cone shall comply with the defined geometry. See program specific technical specification.

**3.1.4.2.2 Chassis Control Module (CCM).** These connections shall use high pressure GM approved quick connectors or utilize common double inverted flare GM approved tube nuts. The quick connectors or common double inverted flare GM approved tube nuts shall have a secondary latch feature and the primary latch will be self-rejecting if not completely closed.

**3.1.4.2.3 Body.** The brake lines will be mechanically attached to the underbody/frame. The design and operation of these lines shall satisfy the following conditions:

**3.1.4.2.3.1** The brake lines shall be free of squeaks and rattles. There shall be no customer annoyance due to squeaks and rattles during vehicle test procedure GMW8518. The final authority for the determination of whether a noise is objectionable lies with the Buyer Lead Engineer and/or the Squeak and Rattle (S&R) Engineer. Squeaks and rattles include, but are not limited to, all the noises described in the Squeak and Rattle Noise Glossary. (Stakeholders: 20.04 Brakes; 0C.03 Noise & Vibration.)

**3.1.4.2.3.2** The brake lines shall meet crashworthiness requirements.

**3.1.4.2.3.3** The brake lines shall be easily accessible and easily assembled.

**3.1.4.2.3.4** The brake lines shall be adequately secured.

**3.1.4.2.3.5** The brake lines shall minimize transmission of subsystem noise.

**3.1.4.2.4 Rear Brake Line Cross Over.** These connections shall use high pressure GM approved quick connectors or utilize common double inverted flare GM approved tube nuts. The quick connectors or common double inverted flare GM approved tube nuts shall have a secondary latch feature and the primary latch will be self-rejecting if not completely closed. A dust cover/seal shall be incorporated to provide protection from environmental elements.

**3.1.4.2.5 Electrical Grounding.** The brake lines shall not be used for electrical ground paths.

**3.1.4.2.6 Noise Isolation.** Design of brake lines will incorporate published guidelines for Squeak and Rattle control. Features that will reduce noise potential include:

- Clip spacing no greater than 450 mm (18 in) apart
- Nylon extrusion on brake lines
- Quick Connect fittings at CCM
- 12.5 mm minimum spacing between centerline of brake lines



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**3.1.5 Usage Definition.** Usage conditions that a brake line may encounter in a vehicle in 15 years or 150 000 miles (240 000 km) are defined in the following paragraphs. These usages shall be increased proportionally for vehicle lives greater than 150 000 miles (240 000 km). The design and operation of the brake line shall comprehend the defined usage conditions.

**3.1.5.1 Road Splash.** Under-vehicle subsystem components may be exposed to water-based fluids due to vehicle usage per the following:

- Up to 15 000 occurrences
- Fluid temperature of (-3 to +50) °C
- Fluid volume of 0.25 l per occurrence (nominal)

**3.1.5.2 Water Submersion/Fording.** Under-vehicle subsystem components may be exposed to water submersion during special vehicle usage, e.g., boat launches from towed trailers and/or fording, per the following:

- Up to 60 occurrences
- Water temperature of (0 to +50) °C
- Submersion duration up to 10 minutes
- Submersion depth up to the centerline of the vehicle's rear wheels or 12 in, whichever is greater

**3.1.5.3 Underhood Wash.** The vehicle underhood area typically is washed with a wand-styled nozzle four times per year based on 15 years of customer usage for a total of 60 occurrences. Six of the 60 underhood washings include engine degreaser.

**3.1.5.4 Vehicle Wash.** The following information provides car wash occurrences, typical wash methods, typical wash chemical composition, and typical exposure parameters per washing as it pertains to the entire vehicle.

**3.1.5.4.1** The total number of car wash occurrences is 590, based on 15 years of customer usage. For the first 2 years, the vehicle is washed an average of 2.3 times per week. Afterward, the number of washes reduces by ≈ 25 % each year.

**3.1.5.4.2** Table 3 gives the distribution of customers wash, automatic drive through car wash, and manual hand held wand wash.

**Table 3: Customer Wash Methods**

| Method of Car Wash | % of Customers |
|---|---|
| Home/hand wash | 50 % |
| Drive through car wash | 35 % |
| Wand wash | 15 % |

**3.1.5.4.3** Automatic drive through car wash parameters:

**3.1.5.4.3.1** Pre-soak: Hydrofluoric acid solution (Pre-soak One) or alkaline solution (445 Pre-soak) at 827 kPa (120 psi) for 40 s.

**3.1.5.4.3.2** Wash: Detergent solution (Wonder Suds) at 827 kPa (120 psi) for 60 s.

**3.1.5.4.3.3** Rinse: Water at 552 kPa (80 psi) for 30 s.

**3.1.5.4.3.4** Wax: Petroleum based solution (Prep Rinse) and an optional polymer based solution (Poly-bond Sealer Wax) at 483 kPa (70 psi) for 60 s (combined).

**3.1.5.4.4** Wand wash spray is typically applied at a pressure of (8274 to 10342) kPa ((1200 to 1500) psi) at a rate of (11.4 to 18.9) l/minute ((3 to 5) gal/minute) and temperatures up to +70 °C via a 2.54 mm (0.1 in) nozzle.

**3.2 Product Characteristics.** The functional performance requirements for the brake lines are specified in the following paragraphs. All requirements apply for the conditions specified in paragraph 3.1.3 and 3.1.5, except where noted otherwise. Special vehicle, operational or ambient conditions may be identified in the performance requirement paragraphs.



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**3.2.1 Performance.** The following performance requirements apply to the brake line assemblies, including quick connections, over the target life. Unless otherwise specified, designated environmental conditions (see paragraph 3.1.3.1) shall apply to all performance characteristics. All brake line assemblies and connections must meet the performance requirements listed in this section. The brake line assembly design must also successfully perform its intended function with respect to all failure modes. Reference the applicable Component Design Failure Mode and Effects Analysis (DFMEA) generated by the supplier and approved by the buyer.

**3.2.1.1 Brake Line Assemblies.**

**3.2.1.1.1 Leakage.** The brake line assemblies with joints that are crimped or torqued by supplier shall demonstrate no fluid leakage up to 34 475 kPa (5000 psig [3000 psig + 0.67 * 3000]) over the complete environmental and dynamic ranges. All brake line assemblies shall be validated to demonstrate less than a 0.5 mm HG drop when a –5.0 mm HG vacuum is applied for a period of one minute. See program specific technical specification.

**3.2.1.1.2 Volumetric Expansion.** No volumetric expansion is allowable for any steel brake line section. Maximum allowable volumetric expansions on other sections of brake line assembly are as follows:

**3.2.1.1.2.1** Flexible sections requirements specified. See program specific technical specification.

**3.2.1.1.2.2** Quick Connect Fitting requirement is 0.01 $cm^3$ of volume displacement from (0 to 20 700) kPa ((0 to 3000) psig) per connection.

**3.2.1.1.2.3** This standard requires testing to comprehend/include full travel allowed by the primary latch design.

**3.2.1.1.2.4** This test shall be performed over complete temperature range defined in paragraph 3.1.3.1.

**Note:** Outer Brake Hoses, to wheel cylinder, or **jounce** hoses are not specified in this document.

**3.2.1.1.3 Brake Line and Brake Fluid Temperatures.** The brake line assemblies shall be capable of operation within the following temperatures:

**3.2.1.1.3.1** Underhood: +125 °C maximum continuous, +160 °C maximum excursion.

**3.2.1.1.3.2** Underbody: +115 °C maximum continuous, +135 °C maximum excursion.

**3.2.1.1.3.3** Minimum Temperature: -40 °C.

The minimum temperature is the minimum temperature at which a component will be expected to operate. Assisted vehicle starting shall be permitted. Temporary degradation of the component function shall be permitted, but permanent loss of function shall not result in a walk home situation.

The maximum continuous temperature is the maximum temperature a component will experience on a continuous basis and be expected to maintain design functional life. The vehicle shall be able to experience 1200 h/12 000 cycles per 160 000 km of operation during continuous thermal conditions. Occupant safety shall not be compromised during continuous thermal conditions.

The maximum excursion temperature is the maximum temperature the component will experience on an infrequent basis and be expected to maintain functional life. The vehicle shall be able to experience 60 h/400 cycles per 160 000 km of operation during excursion thermal conditions. Occupant safety shall not be compromised during excursion thermal conditions.

If the vehicle target life is > 160 000 km, the hours and cycles should be adjusted accordingly. See program technical specification. (Stakeholders: 20.04 Brakes; 0D.02 Thermal Management.)

**3.2.1.1.4 Temperature Shock - Water Splash.** The brake lines must be capable of cycling from +125 °C (air) to 0 °C (salt water – 1 % sodium chloride by weight) for 3 cycles without loss of function.

**3.2.1.1.5 Mechanical Vibration.** The following requirements shall be met.

**3.2.1.1.5.1 Frequency Sweep.** A modified SAE J2044 Vibration Schedule will be utilized for Quick Connect Validation (Component Level). Specific modifications to this schedule will be allowed in three areas as follows:

**3.2.1.1.5.1.1** Tubing length up to 1 m is allowed to permit use of a **coil** to prevent abnormal side loading of connectors.

**3.2.1.1.5.1.2** Accelerations shall be continuous at 10G with frequency sweeps from (40 to 100) Hz with 3 sweeps per hour of test.

**3.2.1.1.5.1.3** Brake lines may be retained just before the connection to the flexible hose, on both sides, to simulate vehicle configuration (maximum unsecured length is 457 mm).



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These modifications are allowed to better represent Quick Connector environment. This test should be accomplished as part of the Life Cycle Testing.

**3.2.1.1.5.2 Simulated Vehicle Vibration Testing.** Under Development. See program specific technical specification.

**3.2.1.1.6 Functional Corrosion.** The brake line assemblies must remain functional for a minimum of 15 years field exposure. The brake line assemblies will be exposed to the 95th percentile corrosive environment, which occurs in the N.E. United States and S.E. Canada. The environment is composed of temperature, humidity, salt, splash, mud, and component usage.

**3.2.1.1.7 Cosmetic Corrosion.** Brake line assemblies shall be corrosion free upon initial delivery to the customer, based on corrosion rating scale of 8 or better per GMW3116 after two (2) years of exposure to the 95$^{th}$ percentile severe corrosive environment.

**3.2.1.1.8 External Contaminants.** The brake line assemblies shall remain functional after prolonged exposure to external contaminants (see paragraph 3.1.3.3).

**3.2.1.1.9 Crashworthiness.** The brake system shall complement the ability of the vehicle to conform to the corporate and legal requirements for crashworthiness.

**3.2.1.2 Quick Connects.**

**3.2.1.2.1 Leakage.** Quick Connectors must meet acceptance criteria defined in paragraph 3.2.1.1.1 for both low and high pressure.

**Note:** Leak rate criteria are specified for compressed air and in no way implies allowance for fluid leakage. It should also be noted that testing is performed with a maximum dimension bore allowed by manufacturing tolerances. All test configurations should be reviewed and approved by the appropriate representatives from the Product Development Team (i.e., Design Engineer, supplier quality, and product validation). This test must be performed over complete temperature range defined in paragraph 3.1.3.1.2.

**Note:** Each level of the design that would affect the primary sealing components, i.e.; O-ring, back up washer, or fitting geometry, must be evaluated for blow out if the primary latch is not connected. In an unlatched condition, the connector must demonstrate visible leakage when < 690 kPa (< 100 psi) is applied.

**3.2.1.2.2 Assembly Effort.** Quick connector assembly effort is the force required to fully assemble (latch and retain) the tube into the connector housing. Maximum first time assembly effort is to be less than 67 N (15 lb). Maximum assembly effort after life testing shall be < 111 N (25 lb). The above also applies to removal forces for new and aged quick connects.

**Note:** From ergonomics guidelines: The linear force of the hand shall be < 75 N (18 lb) when wrist is in a neutral posture, < 40 N (9 lb) with flexion/extension wrist deviation of > 45°. The linear force of the finger/thumb shall be < 45 N (10 lb) when wrist is in a neutral posture, < 22 N (5 lb) with ulnar/radial wrist deviation of > 20°.

**3.2.1.2.3 Pull Apart Effort.** Quick connector pull apart effort is the force required to pull the mating tube end out of the quick connector. The minimum force required to separate the quick connector is 2000 N (450 lb) or 1330 N (300 lb) after life testing.

**3.2.1.2.4 Side Load Capability.** Quick connector side load capability is measured by a side load leak test and a side load fracture test. No fracture or rupture of the quick connector shall be permitted below 225 N (50 lb).

**3.2.1.2.5 Life Cycle.** Quick connectors shall demonstrate no functional failures after exposure to one million pressure impulses of 3450 kPa and 13 800 kPa (500 psig and 2000 psig) (500 000 each) with representative ABS event every 75$^{th}$ cycle. Each pressure segment will be maintained through a complete temperature cycle. This test must also include evaluation of a quantity of aged components (after completion of corrosion cycle and tested with aged brake fluid).

**3.2.1.2.6 Corrosion.** The brake line assemblies must remain functional upon completion of all corrosion exposure testing to a minimum of 15 years exposure. The brake line quick connectors will be exposed to the 95$^{th}$ percentile corrosive environment, which occurs in the N.E. United States and SE Canada. The environment is composed of appropriate combinations of temperature, humidity, salt, splash, mud, and component usage.

**3.2.1.2.7 Zinc Chloride Resistance.** The quick connectors must not indicate any cracks or fractures when exposed to zinc chloride as tested according to paragraph 4.2.1.2.7.



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**3.2.1.2.8 Burst Pressure.** The quick connectors must not burst below 34 475 kPa (5000 psig) as tested according to paragraph 4.2.1.2.8.

**3.2.1.2.9 External Contaminants.** The quick connectors shall meet all functional requirements defined in paragraph 3.2.1.2.1 and 3.2.1.2.8 after exposure to typical automotive fluids defined in Table 7.

**3.2.1.2.10 Fluid Compatibility.** The quick connectors shall meet all functional requirements when exposed to any specified hydraulic brake fluid.

**3.2.1.2.11 Flow Restriction.** The inside diameter of any section of the brake line, including quick connect end form, shall not be less than 64 % of the nominal inside diameter of the brake line. Any flexible section of hose shall demonstrate compliance specifications. All minimum bend radii should be such that there is no restriction of flow due to partial kinking of the pipe. Typical minimum bend radii are shown below. The type of bend tooling (i.e., hand bender, power/mechanical bender, or mandrel) may affect bend radii. Therefore, the final design must be approved by GM supplier quality engineer and design release engineer. See Table A1 Flow Restriction. See program technical specifications.

**3.2.1.2.12 Gravelometer Test.** Test requirements and successful completion criteria are defined in the SAE J400 documentation.

**3.2.1.2.13 Drop/Shipping Requirements.** Produced assemblies must be capable of demonstrating the ability to retain all functionality, i.e.; quick connect mechanism(s) remain in pre-assembly position, when subjected to random vibration levels and drops such as the parts may be exposed to during typical shipping and handling.

**3.2.1.3 Clips.** All clips utilized in the brake line assemblies shall meet or exceed all requirements defined in this section. All tests performed to meet clip requirements must encompass the complete temperature range defined in paragraph 3.1.3.1.2.

**3.2.1.3.1 General.** The reference name for the nylon clip(s) method of attachment to platform hardware will be pin-clip. This requirements document will encompass the above mentioned pin-clip fasteners and free-floating clips. Clips may be utilized with a nylon bushing interface to frame/panel if required for commonization.

**3.2.1.3.2 Force Requirements.** The force requirements listed in this section will be tested dry (not lubricated), with specified steel or nylon panel thickness, with specified hole size (molded in if using nylon panel), and tube sizes that represent complete tolerance range (i.e., minimum/nominal/maximum).

**Note:** From General Motors Ergonomics Guidelines: The linear force of the hand shall be < 75 N (18 lb) when wrist is in a neutral posture, < 40 N (9 lb) with flexion/extension wrist deviation of > 45°. The linear force of the finger/thumb is to be < 45 N (10 lb) when wrist is in a neutral posture, < 22 N (5 lb) with ulnar/radial wrist deviation of > 20 degrees.

**3.2.1.3.2.1 Clip Installation Force.** The installation force of the clip to panel shall be < 66 N (15 lb).

**3.2.1.3.2.2 Clip Insertion Force.** The insertion force of the tube(s) into clip receiver(s) shall be < 44 N (10 lb).

**3.2.1.3.2.3 Clip Cover Closure Force.** The force required to close the cover mechanism, if equipped, shall be < 44 N (10 lb). This force will be tested with the appropriate size and number of gage pin(s).

**3.2.1.3.2.4 Clip Cover Opening Force.** The minimum force required to open the cover mechanism, if equipped, is 223 N (50 lb). This force may be applied at any point on the cover or gage pin.

**3.2.1.3.2.5 Clip Attachment Force.** The clip must provide a secure attachment to platform component that will exceed 223 N (50 lb) with force applied axially to the attachment point.

**3.2.1.3.2.6 Pin Removal Force.** The pin removal force, in the pre-driven state, shall be > 90 N (20 lb).

**3.2.1.3.2.7 Clip Repositioning Force.** The clip, after being positioned and secured to the brake tube(s), shall be able to be repositioned with an applied force defined in paragraph 4.1.2.3.2.7.

**3.2.1.3.3 Specifications.**

**3.2.1.3.3.1** Clip to meet GM7400M specifications (Plastics Parts).

**3.2.1.3.3.2** Clip to meet restricted and reportable chemicals specifications per GMW3059.

**3.2.1.3.3.3** Production parts to be marked with corresponding recycling code symbol per SAE J1344.

**3.2.1.3.3.4** Clip shall demonstrate function within temperature ranges defined in paragraph 3.1.3.1.2 without loss of function.

**3.2.1.3.4 Shipping.** Nylon clips may have moisture added to container prior to shipping (≈ 3 % by Vol.).



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**3.2.1.3.5 Serviceability.**

**3.2.1.3.5.1 Clip Usage.** When properly serviced, the clip must be re-usable. See program specific technical specification.

**3.2.1.3.5.2 Standard Tools.** The clips must be removable, serviceable and replaceable with standard hand tools.

**3.2.2 Physical Characteristics.**

**3.2.2.1 Dimensions.** The overall dimensions of the brake lines shall be specified. See program technical specification.

**3.2.2.2 Mass Properties.** The mass of the brake lines shall be specified. See program technical specification.

**3.2.3 Dependability.**

**3.2.3.1 Target Life.** The Reliability Evaluation Point (REP) of the brake pipe assemblies shall at least equal the vehicle target life. For this subsystem one REP shall be defined in the program technical specification.

**3.2.3.2 Reliability Requirements.** Seven (7) samples of brake pipe assemblies shall pass tests specified herein unless otherwise specified.

**3.2.4 Serviceability.** The following paragraphs define the constraints and requirements associated with serviceability of the brake line subsystem. Serviceability is the ease and cost of performing the maintenance, diagnosis, and repair operations necessary to preserve the original performance level of the vehicle throughout its target life.

**3.2.4.1 Service Infrastructure.**

**3.2.4.1.1 Essential Tools.** The subsystem should not require the development of any new essential tools as defined below, for the performance of diagnosis, maintenance, and repair procedures. (Essential tool = a tool called out in the manufacturer's service manual diagnosis or repair procedure, which is required to perform that operation.)

**3.2.4.1.2 Fasteners/Fittings/Connectors/Seals.**

**3.2.4.1.2.1** Fasteners with a service specification of torque plus angle should be avoided in the areas where customer performed maintenance or service is recommended (wheel lug nuts, oil pan drain plug etc.).

**3.2.4.1.2.2** Effort should be made to avoid the use of torque to yield fasteners in areas where fasteners are typically reused or in areas where an adjustment point is located.

**3.2.4.1.2.3** All serviceable fasteners that are considered reusable shall withstand a minimum of five (5) remove and replace procedures.

**3.2.4.1.2.4** Fasteners requiring a back-up wrench for removal shall have adequate clearance for back-up tools.

**3.2.4.1.2.5** The system shall use fasteners that are readily available from GM.

**3.2.4.1.2.6** Dynamic torque values shall be provided for service publications.

**3.2.4.1.2.7** Quick connectors/fittings and seals should be reusable and serviceable separately.

**3.2.4.2 Customer Interface.**

**3.2.4.3 Maintenance.**

**3.2.4.3.1 Performance of Scheduled/Un-scheduled Maintenance.** System components shall not interfere with normal maintenance procedures.

**3.2.4.3.2 Lubricants and Chemical Products.** Lubricants and chemical should be compatible with current products already released by GM.

**3.2.4.3.3 Exterior and Interior Cleaning.** The system shall be capable of being cleaned with any current cleaning agents currently released by GM.

**3.2.4.4 Repair.**

**3.2.4.4.1** Mechanical and electronically integrated components shall be serviced separately.

**3.2.4.4.2** System components should be accessible for adjustment or replacement with standard shop hand tools and without removal of unrelated parts or components.

**3.2.4.4.3** Repairs shall consist of replacement with new or remanufactured service parts.

**3.2.4.4.4** System components shall not interfere with normal maintenance procedures.



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