



## **Service Brake and Motor-On Caliper Electric Parking Brake 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 Purpose.** This document provides the standard technical requirements for the Brake Caliper Assembly. This document must only be used when invoked by a program-specific technical specification. References to the program-specific technical specification are included in this document where program-specific requirements are expected to exist. These requirements apply to a front caliper or a rear caliper.

**Note:** The program-specific technical specification may include additional program-specific requirements that are not referenced in this document and may supercede any requirements included in this document. In the case of any conflicts between this document and the program-specific technical specification, the program-specific technical specification takes precedence.

**1.2 Applicability.** The brake caliper assembly reacts to the brake apply system, brake pads, brake rotor, and knuckle to provide the vehicle with smooth, safe deceleration performance under all driving conditions.

### **2 References**

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

#### **2.1 External Standards/Specifications.**

JASO C448-80                      USCAR EWCAP-001

#### **2.2 GM Standards/Specifications.**

|         |          |          |          |
|---------|----------|----------|----------|
| GMW3059 | GMW8518  | GMW15363 | GMW15626 |
| GMW3091 | GMW14155 | GMW15367 | GMW15841 |
| GMW3097 | GMW14872 | GMW15392 | GMW16316 |
| GMW3103 | GMW15105 | GMW15394 | GMW17012 |
| GMW3191 | GMW15272 |          |          |

#### **2.3 Additional References.**

- Best Practice ELEC86-69
- Component Technical Specification (CTS)
- General Motors Lining List
- GM Drawing 13246040
- GM Global Fastener Resource Website (<https://gmweb.gm.com/sites/fastening1/Pages/Home.aspx>)
- GM Global Fastening Catalog
- GM Global Legal Database
- Interface Control Document (ICD)
- Process Control Plans
- Program-specific Technical Specification
- Statement of Requirements (SOR)

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- Validation Cross Reference Index (VCRI)
- Vehicle Technical Specification (VTS)

### 3 Requirements

**3.1 System/Subsystem/Component/Part Definition.** The brake caliper assembly transforms hydraulic pressure and displacement into braking clamp force.

**3.1.1 Appearance.** The appearance requirements will be included in the architectural homeroom program-specific Statement of Requirements (SOR) for additional requirements. Also see program-specific technical specification.

**3.1.1.1 Corrosion.** See Table B1, Appendix B for a map showing the recommended cosmetic and functional corrosion test strategy for brake calipers.

**3.1.1.2 Cosmetic Corrosion Resistance.** The front brake caliper must meet the corrosion performance and validation requirements specified in GMW15272 for both functional and cosmetic corrosion performance. When invoked by GMW15272 for caliper cosmetic corrosion testing, GMW14872 must include the following additional stresses during the ambient phase of the test:

- Parts shall be sprayed every cycle with a 3.5% chloride content solution.
- Every fifth cycle, parts shall be heated in a 150 °C environment for 1 h.

Surfaces of the caliper typically visible through the wheel must meet the cosmetic corrosion requirements for Exterior Surfaces (Table A1, Appendix A) instead of those for the underbody. Surfaces of the caliper typically not visible through the wheel must meet the requirements pertaining to underbody chassis components.

Painted calipers are subject to the additional requirements in 3.1.1.2.1.

**3.1.1.2.1 Additional Requirements for Painted Calipers.** Painted calipers must meet the corrosion requirements specified in GMW17012.

When evaluating painted calipers per these specifications, any surface discoloration relative to the main body of the caliper shall be treated as **red rust** for purposes of evaluation.

**3.1.1.3 Functional Corrosion Resistance.** There are two checks for caliper function after corrosion exposure. The first is a pad slide force check after 2 years equivalent exposure (per GMW15272, invoking GMW14872 cycles). The second is a function check after 10 years equivalent exposure (per GMW15272, invoking GMW14872 cycles).

The setup of the calipers for functional corrosion evaluation shall allow the calipers to be hydraulically applied (against a rotor or simulated rotor), while maintaining normal running clearance (the total pad movement during one apply shall not exceed that which would occur normally by design in a fully assembled brake corner). The calipers shall be actuated via hydraulic pressure with the parameters:

- Target pressure = 50 bar.
- Pressure ramp rate = 50 bar/s.
- Pressure hold for 5 s.
- Apply every fifth cycle of GMW14872.

The definition of the brake caliper remaining functional after corrosion exposure is meeting the following requirements after 15 years equivalent exposure (unless otherwise noted) as specified in GMW15272 (invoking GMW14872 cycles):

- Pad slide meets requirement in Table A1, Appendix A (**Note:** Evaluated at 10 years exposure).
- The hydraulic integrity of the caliper is maintained, no loss of sealing.
- All threaded fasteners, including the caliper bleeder screw, can be loosened without using applied heat, and without breakage (external lubricant is permitted).
- All lubricated sliding components continue to slide freely, no seizing.

The parking brake mechanism (if applicable) remains functional with no degradation in actuator, adjuster performance, or return mechanism.

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**3.1.1.4 Finish Requirements for Painted Calipers and/or Logos.** The caliper finish must meet the requirements set forth in GMW17012 (including, but not limited to, scratch resistance, crosshatch test, resistance to solvents such as brake fluid, fuel, and cleaning agents, water jet resistance, and weathering). See full specification for details.

**3.1.2 Content.** Reference Table A2, Appendix A for tabular presentation of this section.

**3.1.2.1 Physical Content.** The caliper assembly includes the caliper housing, piston, bracket, abutment clips, suspension bolts, seals, boots, bleeder screw, protective cap for the bleeder screw, and all necessary hardware. For integral park brake style calipers, the caliper may also include park brake mechanism, lever, adjuster, cable reaction boss, return spring, bolts, etc. The caliper assembly includes the geometrical parameters of the brake shoes, linings, and noise insulator. The lining material and noise insulator material will be determined by the applicable architectural homeroom SOR. See program-specific technical specification.

**3.1.2.1.1 Guiding System Features (Rigid Guide Sliding Calipers).** Calipers using a guiding system with two rigid pins sliding within rigid bores shall provide the following content:

- Must equip at least one of the guide pins with a rubber bushing tip.
- Must provide internally fitted guide pin boots.

**3.1.2.1.2 Sizing of Fittings.**

- Fitting size for the caliper banjo bolt joint shall be M10 × 1.5 for cast iron calipers, or M10 × 1.0 for aluminum calipers.
- Fitting size for the caliper bleeder screw joint shall be a minimum of 10 mm diameter.

**3.1.2.1.3 Brake Lining – Sizing, Selection, Relationship to Caliper Design.**

**3.1.2.1.3.1 Brake Lining Selection.** Reference approved General Motors Lining List for lining selection. See program-specific technical specification.

**3.1.2.1.3.2 Lining Visibility.** The lining wear condition shall be detectable without removing the caliper (the wheel may be removed).

**3.1.2.1.3.3 Lining Area/Volume.** Requirements for the minimum front pad volume per front corner and requirements for the minimum front pad area per front corner shall be as specified in the program-specific technical specification.

**3.1.2.1.3.4 Lining Aspect Ratio.** The aspect ratio of the brake pad is defined as the ratio of the maximum linear tangential length of the footprint of the brake pad material puck on the brake rotor friction surface and the radial height of the pad along the tangential centerline.

The aspect ratio for light trucks (with Gross Vehicle Weight Rating (GVWR) ≥ 3500 kg) shall be specified in the program-specific technical specification.

For all other vehicles, the aspect ratio shall be less than the values specified as follows. The piston count refers to the number of pistons on one side of the caliper (for opposed piston designs, halve the total piston count):

- Single Piston Caliper: Aspect Ratio < 2.0.
- Twin Piston Caliper: Aspect Ratio < 2.3.
- Three Piston Caliper: Aspect Ratio < 2.6.

**3.1.2.1.3.5 Pad Coverage of Rotor Friction Surface (All Calipers).** The features of the caliper that interface directly with and apply pressure to the outboard brake pad must span the full tangential length of the brake pad lining friction material to rotor contact surface.

**3.1.2.1.3.6 Caliper Coverage of Pad Area (Sliding Calipers).** The features of the caliper that interface directly with and apply pressure to the outboard brake pad must span the full tangential length of the brake pad lining friction material to rotor contact surface. They must also span at least 90% of the radial height of the friction material.

**3.1.2.1.3.7 Caliper Piston Coverage of Pad Area (All Calipers).** The leading and trailing edges of the brake lining friction material must not extend beyond the edges of the caliper piston(s), in the tangential direction, by more than the radius (one half (½) of the diameter) of the piston(s). If a multi-piston caliper is used, the distance between the centers of the piston shall not exceed 150% of the piston diameter.

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**3.1.2.1.3.8 Lining Backing Plate.** The lining backing plate thickness shall be greater than or equal to 5.5 mm for calipers with piston size (or equivalent total piston area for multi-piston calipers) up to and including 54 mm, and at least 6 mm for calipers with pistons size (or equivalent total piston area) of greater than 54 mm.

**3.1.2.1.3.9 Lining Chamfers.** Chamfers added to the brake pad to address noise and vibration issues (including squeal and judder) shall not reduce the full (non-chamfered) brake pad volume by more than 15%. When applied, chamfers must be designed to maintain the initial chamfered pad shape over the useable life of the lining. Useable life being defined as wear to initial contact of the wear sensor.

**3.1.2.1.3.10 Noise Insulator.** General Motors will specify the design constraints for initial noise insulator configurations. See GMW15394 Brake Pad Technical Specifications for design constraints, example constructions, and acceptable attachment methods. The design of the noise shim may be refined during the development and validation to meet the brake noise requirements. If a caliper with aluminum piston is used with a steel noise shim, material grades that are compatible for galvanic corrosion consideration and/or a protective barrier coating must be used. Final assembly of the noise insulator to the backing plate will be at the brake caliper supplier.

#### **3.1.2.1.4 Other Caliper Hardware and Features.**

**3.1.2.1.4.1 Parking Brake Return Spring.** Calipers equipped with cable actuated parking brake mechanisms shall be equipped with one or more return springs with combined return force sufficient to ensure return of the parking brake system to a completely released state when the apply lever is fully released. The required return force shall be specified by the GM parking brake system design responsible engineer.

**3.1.2.1.4.2 Caliper Piston Boot to Lining Backing Plate Clearance.** All features of the caliper piston boot must clear the lining assembly backing plate features (including noise insulator) by a minimum of 3 mm. This applies to a new pad and rotor condition, with the caliper in design position in a fully seated but released state, with nominal component dimensions.

**3.1.2.1.4.3 Caliper Housing Center of Gravity Relationship to Guiding System (Rigid Guiding System Calipers).** The center of gravity of the caliper housing assembly (including the pistons, fasteners, seals, and guide pins) must be contained within engagement length of the guide pins to the guide pin bores (as viewed from a caliper plan view perspective). This requirement applies to both new and fully worn brake pad conditions. Calipers that support the housing both from the guide pins and the outer pad via a physical connection or direct spring loaded contact are exempt from this requirement.

**3.1.2.1.4.4 Caliper Piston Engagement Length.** The brake caliper piston shall have a sufficient length of engagement in the piston bore to accommodate all of the following conditions simultaneously: full inboard and outboard lining wearout (wear to backing plate), minimum rotor thickness, 12 000 kPa applied hydraulic pressure, and the piston tilted in the bore at an angle that consumes all of the nominal piston to bore clearance (caused by pad taper wear).

Accommodating the preceding conditions is defined as the caliper maintaining hydraulic sealing integrity during dynamic brake applies. Analysis may be used for the validation of this requirement.

**3.1.2.1.4.5 Bracket Stiffness (Rigid Guiding System Sliding Calipers).** With the caliper attached to a mount (knuckle or adapter plate) of design representative stiffness, and with nominal (design) guide pin to bore clearances, centered guide pin to bore spacing, and nominal pad to abutment gaps, the caliper bracket must provide sufficient stiffness relative to supported braking loads to avoid guide pin to bore binding contact forced by bracket deflection and housing movement during braking, at braking loads of up to 0.5G. With **most severe case** geometry (minimum pin to bore clearance, maximum misalignment of pins to bore, and maximum pad to abutment gap), the minimum braking load to forced contact is 0.3G.

**3.1.2.1.4.6 Caliper Bore Protection From Corrosion.** The caliper piston dust boot must be assembled with grease or oil lubrication in a manner that captures lubricant inside of the boot. This captured lubricant (< 0.5 g is sufficient) acts to protect the caliper bore from corrosion damage due to temperature cycling and condensation. The lubricant must be distributed around the circumference of the boot prior to or during assembly.

**3.1.2.2 Functional Content.** Not applicable.

#### **3.1.3 Ambient Environment.**

**3.1.3.1 Environmental Definition.** The ambient and operating environments for the brake caliper are defined in the applicable Brake Corner Assembly Technical Specifications (GMW15392).

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**3.1.4 Interfaces.** The brake caliper will interface with other components as defined in the program-specific technical specification.

**3.1.4.1 Driver Information-Lining Life.** Lining wear sensors are required to provide the driver with an indication of impending lining wearout as specified in the Brake Subsystem Technical Specification. One wear sensor per caliper is the minimum required. The wear sensor must be placed at the location of highest wear. For audible wear sensor performance requirements see the Brake Corner Assembly Technical Specifications (GMW15392).

**3.1.4.2 Knuckle.** See the applicable Brake Corner Assembly Technical and Knuckle Technical Specifications. Additional requirements to be provided by the architectural homeroom applicable program specific SOR.

**3.1.4.3 Brake Shoes and Linings.** See the applicable Brake Corner Assembly Technical Specification and Brake Lining Technical Specification. Additional requirements will be provided by the architectural homeroom applicable program-specific SOR.

**3.1.4.4 Rotor.** See the applicable Brake Corner Assembly Technical Specification. Additional requirements will be provided by the architectural homeroom applicable program-specific SOR.

**3.1.4.5 Wheel Envelope – Clearance.** See GMW15392.

**3.1.4.6 Brake Apply.**

**3.1.4.6.1 Caliper/Brake Hose Connection.** The caliper assemblies will interface with the brake apply subsystem hose fittings using a banjo bolt (selected from the GM Global Fastening Catalog, which may be referenced from the GM Global Fastener Resource Website). Generally, cast iron calipers shall use the coarse thread variants (M10 × 1.5) and aluminum housing calipers shall use fine thread variants, (M10 × 1.0) flow bolts.

**3.1.4.6.2 Brake Fluid.** The caliper assemblies shall be compatible with Department of Transportation (DOT) 3, DOT 3+, DOT 4, DOT 4+, and DOT 5.1 (glycol-based) brake fluid. All components in continuous contact with the brake fluid must not degrade or be chemically altered due to contact with the brake fluid. See program-specific technical specification.

**3.1.5 Usage Definition.** Not applicable.

**3.2 Product Characteristics.** See program-specific technical specifications for exceptions to the requirements in this section.

**3.2.1 Performance Requirements.** See Table A1, Appendix A, for a tabular presentation of the performance requirements. Brake caliper components shall meet the performance requirements for all regions, when accounting for regional differences in pad material. Brake caliper components shall be able to meet the performance requirements with any lining selected from the approved General Motors Lining List. The performance characteristics invoked in this document apply to the caliper assembly (used in conjunction with approved brake linings where applicable). Performance requirements that also involve the rotor, knuckle, and bearing, and those that are evaluated as a full corner assembly, are identified in the applicable Brake Corner Assembly Technical Specifications (GMW15392).

**Note:** The Brake Corner Assembly Technical Specifications allocate requirements to one of four major design variants of brake corner:

1. Base caliper with rotor-friendly Non Asbestos Organic (NAO) (low coefficient of friction ( $\mu$ )).
2. Base caliper with corrector-style (low-metallic or high  $\mu$  NAO corrector) linings.
3. Premium caliper with NAO or low-metallic linings.
4. Premium caliper with high performance linings.

The Caliper Component Technical Specifications involved in this document are considered applicable to calipers used as part of all four major brake corner variants.

Supplier shall provide the GM engineer with test data that verifies that performance will meet the requirements as stated in 3.2.1.1 through 3.2.1.10.

**3.2.1.1 Caliper Performance Specified as Part of Corner Assembly.** The requirements specified are described in GMW15392 Front and Rear Brake Corner Assembly Technical Specifications.

**3.2.1.2 Hold-off.** See the applicable Brake Corner Assembly Technical Specification (GMW15392).

**3.2.1.3 Apparent Piston Travel.** See the applicable Brake Corner Assembly Technical Specification (GMW15392). Test with approved linings.

**3.2.1.4 Brake Drag.** See the applicable Brake Corner Assembly Technical Specification (GMW15392).

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**3.2.1.5 Hysteresis.** See the applicable Brake Corner Assembly Technical Specification (GMW15392).

**3.2.1.6 Slide Forces.**

**3.2.1.6.1 Caliper Assembly Slide Force.** The caliper slide force shall be less than the specified value. See Table A1, Appendix A, for requirements (where applicable, does not apply to fixed caliper types).

All samples tested shall meet the requirements.

**3.2.1.6.2 Pad Slide Forces.** Pad sliding forces shall fall within the specified range when operated in a temperature range of 0 °C to 150 °C. See Table A1, Appendix A, for conditions and requirements.

Conditioning of caliper samples for the post corrosion test condition shall be per GMW15272 (invoking GMW14872).

All samples tested shall meet the requirements.

**3.2.1.6.3 Piston Slide Force.** The caliper piston slide force in the retracting direction shall be greater than the specified value. The piston displacement in the retracting direction prior to slippage of the piston relative to the seal shall be greater than the specified value. See Table A1, Appendix A, for requirements.

All samples tested shall meet the requirements.

**3.2.1.7 Knockback.** The apparent piston travel shall remain within 0.10 mm following component level lab-based simulation of rough road and lateral acceleration operating conditions. Lab conditions should be based on the GMW15105 vehicle test. An alternate piston travel increase threshold may be used if it can be proven that the associated level of piston knockback does not result in relative slippage between the piston and seal. See the Vehicle Technical Specification (VTS) for the vehicle level knockback requirement.

**3.2.1.8 Air Tightness.** The caliper shall have no leakage for 5 s when subjected to a vacuum of 0.50 bar and air pressure of 2 bar and 160 bar.

All samples tested shall meet the requirement.

**3.2.1.9 Noise.** Supplier shall be responsible to develop solutions to prevent the occurrence of brake noise during the design, development, validation, and production phases. See Brake Corner Technical Specification (GMW15392) for additional requirements.

**3.2.1.9.1 Squeal.** See the applicable Brake Corner Assembly Technical Specification (GMW15392).

**3.2.1.9.2 Frequency Response.** Supplier shall be responsible to measure and document the Frequency Response Functions (FRF) of the major caliper components (bracket and housing) during development and validation. Measurements shall be taken for all samples used for noise testing at each major design level, or when design changes that can affect the results are implemented.

**3.2.1.9.3 Squeaks and Rattles.** Brake shoe rattle or caliper suspension related noise is unacceptable at all conditions of use. For vehicle level specifications, see the applicable Brake Corner Technical Specification (GMW15392).

Calipers shall be evaluated for rattle at a component level (caliper assembly only on test rig per GMW16316) and at a vehicle level (GMW8518). Power Spectral Density (PSD) data to drive the test.

The caliper assembly must meet the requirements specified in 3.2.1.9.3.1 and 3.2.1.9.3.2 when tested per GMW16316 in a new and 50% worn pad condition. Calipers must also meet these requirements after durability testing. Applicable subsystem and component level durability tests include GMW15363 (tramp resonance) for body on frame light trucks and GMW15367 for all others.

**3.2.1.9.3.1 Requirements for Calipers for Vehicles < 3500 kg Gross Vehicle Weight (GVW).**

- Instationary Zwicker Loudness < 5.0 sones N10 during medium random excitation input (per GMW8518). Use application specific PSD recorded from brake corner knuckle or caliper adapter plate position when possible; if not available, use available PSD from similar vehicle.
- Instationary Zwicker Loudness < 10.0 sones N10 (< 12.0 sones for calipers equipped with electrically actuated parking brake) during high random excitation input (per GMW8518). Use application specific PSD recorded from brake corner knuckle or caliper adapter plate position when possible; if not available, use available PSD from similar vehicle.
- Instationary Zwicker Loudness < 15.0 sones N10 on Brazilian Belgium Blocks (D2) Road Profile. Use application specific PSD recorded from brake corner knuckle or caliper adapter plate position when possible; if not available, use available PSD from similar vehicle.

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**Note:** Certain vehicle applications may cause equipment commonly used for this type of testing to become stroke-limited during high random excitation inputs. In these cases, consult with GM Engineering to determine an appropriate alternate test plan.

### 3.2.1.9.3.2 Requirements for Calipers for Vehicles $\geq 3500$ kg GVW.

- Instationary Zwicker Loudness  $< 5.0$  sones N10 during medium random excitation input (per GMW8518). Use application specific PSD recorded from brake corner knuckle or caliper adapter plate position when possible; if not available, use available PSD from similar vehicle.
- Instationary Zwicker Loudness  $< 12.0$  sones N10 during high random excitation input (per GMW8518).

**Note:** Certain vehicle applications may cause equipment commonly used for this type of testing to become stroke-limited during high random excitation inputs. In these cases consult with GM Engineering to determine an appropriate alternate test plan.

All samples tested shall meet the requirement.

**3.2.1.9.4 Sound Quality during Actuation and Release (for Electrically Actuated Parking Brake Calipers only).** All sounds shall convey solid construction and smooth operation. All sounds shall meet the requirements listed in Table 1 and Figure 1 of electric park brake sound quality, when measured in a free-free boundary at a distance of 500 mm perpendicular to the face opposite the mounting bracket.

**Table 1: Electric Park Brake Sound Quality**

| Requirement Suffix |                               |                | .a                                       | .b                                       | .c                                    | .d                                                                                                               | .e                                      | .f                             |
|--------------------|-------------------------------|----------------|------------------------------------------|------------------------------------------|---------------------------------------|------------------------------------------------------------------------------------------------------------------|-----------------------------------------|--------------------------------|
|                    | Operating Condition           | Test Procedure | Specific Loudness<br>(Summed Exceedance) | Steady State Average Loudness<br>(Sones) | Maximum Transient Loudness<br>(Sones) | Relative Pitch Allowed Variation<br>(Summed Exceedance at $\pm 0.3$ scale-steps, Relative Pitch Slope Variation) | Relative Pitch Slope<br>(scale steps/s) | Warble<br>(Percent Difference) |
| .1                 | Electric Park Brake Engage    | GMW14155       | $\leq 10$                                | $\leq 10$                                | $\leq 12$                             | $\leq 0$                                                                                                         | $\geq -0.3$<br>and<br>$\leq +0.3$       | $\leq 10$                      |
| .2                 | Electric Park Brake Disengage | GMW14155       | $\leq 10$                                | $\leq 10$                                | $\leq 12$                             | $\leq 0$                                                                                                         | $\geq -0.3$<br>and<br>$\leq +0.3$       | $\leq 10$                      |

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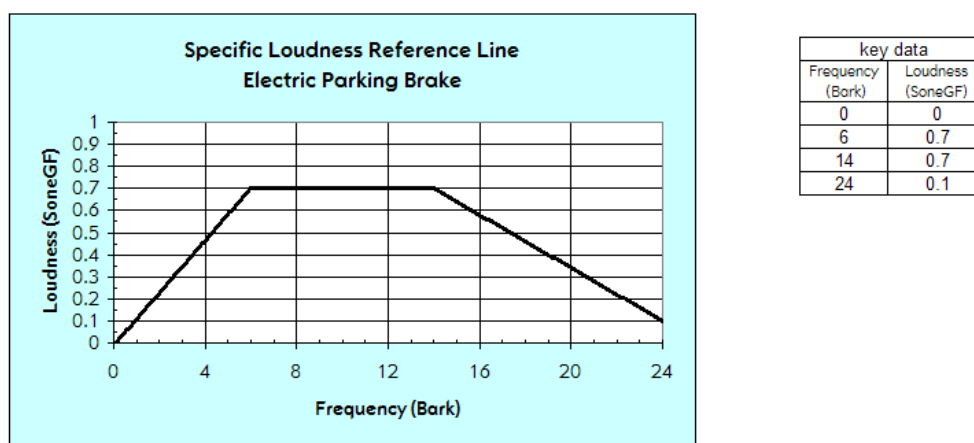


Figure 1: Electric Park Brake Sound Quality Specific Loudness Reference Line

**3.2.1.10 Electric Parking Brake Specific Requirements.** The requirements in 3.2.1.10 apply only to calipers equipped with an electrically actuated parking brake mechanisms.

**3.2.1.10.1 Electromagnetic Compatibility (EMC).** The brake caliper shall meet both the component level and vehicle level electromagnetic compatibility requirements according to GMW3091, GMW3097 and GMW3103. It is required that GMW3103 (Component EMC Test Plan) be completed by the supplier and submitted to GM for approval 60 days prior to the start of EMC Motor on Caliper (MOC) – Electronic Control Unit (ECU) testing.

**3.2.1.10.2 Connection System Requirements.** The electric park brake control module shall have an integral connection system. The size, shape, orientation, electrical connection location of the electric park brake control module components shall meet GM Engineering and United States Council for Automotive Research (USCAR) requirements.

**3.2.1.10.2.1 Connector Requirements.**

- The standalone parking brake caliper shall have one electrical interface (one connector). The connector design should be reviewed and approved by GM Connector Engineering.
- The electrical connection system shall be sealed against dust immersion, direct splash/spray and humid atmospheric conditions as would be typically exposed to in a wheelhouse and underbody environment. Sealing performance should be per GMW3191 Sealing Class 3 (IP 6K9K).
- The required connector maximum engagement must meet requirements defined in GMW3191.
- Durability under connector engagement and disengagement cycles shall meet requirements defined in GMW3191.
- Connector orientation shall meet requirements defined in Best Practice ELEC86-69 (to avoid water retention). The supplier shall work with the GM Design Responsible Engineer to comprehend this requirement.
- Mating connector will be per the Interface Control Document (ICD) available from the GM Release Engineer with agreement from GM Connector Engineering.

**3.2.1.10.2.2 Wiring Harness and Connector.**

**3.2.1.10.2.2.1 Wiring.** The electrical wiring of the MOC shall meet the requirements of GMW15626.

**3.2.1.10.2.2.2 Electrical Connector.** The electrical connectors of the MOC shall be designed to GMW15841. They shall meet the requirements according to GMW3191 (TCw, VCx, SCy, MFCz). (**Note:** w, x, y, and z to be defined for the specific MOC by the Design Release Engineer (DRE) or MOC document owner according to GMW3191, dependent on location and operation profile.)

**3.2.1.10.2.3 Connector Mounting.** The Electric Park Brake (EPB) actuator shall provide a provision to support the wiring harness near the connector, if required to prevent vibrational fretting on the internal pins. This strain-relief provision design must be presented and agreed to by the GM engineer.

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**3.2.1.10.2.4 Connector Terminal Plating.** Connector terminal plating shall comply with the requirements specified on GM Drawing 13246040 or USCAR Electrical Wiring Component Applications Partnership (EWCAP)-001.

**3.2.1.10.2.5 Connector Pin Out.** The portion of the connector that is integral to the EPB shall include designations to indicate the positions of the pins. The connector shall utilize the pin out shown in the ICD available from the GM Release Engineer.

### **3.2.1.10.3 Electrical Characteristics Requirements.**

**3.2.1.10.3.1 Operating Voltage Range Requirements.** The operating voltage ranges and modes (Table 2) shall apply to the MOC at the MOC connector.

**Table 2: Operating Voltage Ranges and Modes**

| Battery Voltage at the EPB Connector      | Operational Mode           |
|-------------------------------------------|----------------------------|
| $-16.0 \leq \text{Voltage} < 6.0\text{V}$ | Not Operational            |
| $6.0 \leq \text{Voltage} \leq 16$         | Fully Operational          |
| $16.0 < \text{Voltage} \leq 27.5$         | Not Operational            |
| Above 27.5 V                              | Potential Hardware Failure |

**3.2.1.10.3.2 Fully Operational Mode.** When in a **Fully Operational** mode, the EPB shall (all assumptions must be documented at sourcing) meet the requirements defined in this document.

**3.2.1.10.3.3 Not Operational Mode.** When in a **Not Operational** mode the EPB shall stop all software functions and be allowed to be in a hardware reset state. It shall experience no permanent damage from this event.

**3.2.1.10.3.4 Potential Hardware Failure Mode.** When in a **Potential Hardware Failure** mode, permanent damage is allowed.

**3.2.1.10.3.5 Determination of Low Voltage Power Down Conditions.** For the determination of low voltage power down conditions and voltage related diagnostic trouble codes, the EPB shall utilize voltage sensing circuitry on its battery source. It shall have a sensing accuracy of  $\pm 0.04\text{ V}$  throughout the fully and partially operational voltage ranges.

**3.2.1.10.3.6 Reverse Voltage Protection.** The electric park brake control module shall function without degradation after exposure to a reverse voltage of  $-16.0\text{ V}$  Direct Current (DC), measured at the EPB Voltage Battery (VBAT) terminal, for a period of 1 minute. The EPB shall not activate the motor during the reverse battery application.

**3.2.1.10.3.7 Over Voltage Protection.** The electric park brake control module shall function without degradation after exposure to an over voltage condition of  $26.0\text{ VDC}$ , measured at the EPB VBAT terminals, for a period of 1 minute. This signal interface protection requirement applies to both active and inactive Input/Output (I/O).

**3.2.1.10.3.8 Ground Isolation.** The EPB housing shall be electrically isolated or connected to EPB ground (Alternating Current (AC) coupled). An accidental electric park brake control module case/housing short to ground of series resistance  $> 1\text{ m}\Omega$  shall cause no performance degradation, create no diagnostic trouble codes, nor create any damage to the electric park brake control module.

### **3.2.1.10.4 Functional Content Requirements.**

**3.2.1.10.4.1 Feature Chart.** The supplier shall provide the state transition diagrams for EPB features and functions.

**3.2.1.10.4.2 Feature List.** The detailed information required to complete all of the required functionality of the EPB shall be provided by the supplier in their final Component Technical Specification (CTS) document. All features except static apply, static release, and dynamic apply backup, shall be able to be disabled via calibration, or by driver demand (if allowed via driver-vehicle interface). Parameters affecting the performance of the system shall be calibrateable in order to tune features for specific vehicles.

#### **3.2.1.10.4.2.1 Normal Operation.**

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February 2016

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