



Front and Rear Brake Corner 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 Brake Corner Assembly. The service brake performance requirements are focused on a hydraulically actuated disc brake mechanism. 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.

Note: The program-specific technical specification may include additional program-specific requirements that are not referenced in this document and does 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.

Note: The program-specific Statement of Requirements (SOR) shall determine if this document is issued as one entity for corner level performance or as part of packet of documents that may additionally include specifications for vehicle level performance, component level performance, or both.

This specification establishes requirements for the brake corner assembly. These requirements apply to the bandwidth parameters described in the Brake Corner Assembly Program-specific Technical Specification.

1.2 Applicability. This standard applies to all front and rear brake corner assemblies with friction-based, hydraulically actuated brakes.

1.3 Remarks. The brake corner assembly reacts with the brake apply assembly, suspension and tire/wheel systems, to provide the vehicle with smooth, safe deceleration performance under all driving conditions. For all-wheel steer vehicles, the brake corner assembly works with the chassis system to provide steering capability. The brake corner assembly provides wheel speed information to the chassis electrical system for antilock brake system (ABS), traction control system (TCS) and electronic stability control (ESC) chassis controls. The brake corner assembly also may provide warning of impending lining wear-out. The park brake assembly transforms force and travel from an actuator (park brake cable system or electric motor and drive mechanism) into torque applied to the rear rotor. See program-specific technical specification.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified. See Appendix B for a listing of the titles of the references.

2.1 External Standards/Specifications.

ECE R13	FMVSS 106	FMVSS 135	JASO C419-06
FMVSS 105	FMVSS 116	ISO 6312	JASO C441-77

Note: The use/purpose of the industry standards and regulatory standards listed in 2.1 (all 8) is defined in CG3856. They are included for user awareness.

2.2 GM Standards/Specifications.

GMW3056	GMW14700	GMW14988	GMW15400
GMW3059	GMW14872	GMW15142	GMW15464
GMW3238	GMW14924	GMW15181	GMW15587

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GMW14089	GMW14925	GMW15183	GMW15862
GMW14165	GMW14926	GMW15193 (ID)	GMW16042
GMW14350	GMW14933	GMW15272	GMW16331
GMW14351	GMW14935	GMW15316	GMW16352
GMW14375	GMW14936	GMW15344	GMW16593
GMW14376	GMW14937	GMW15363	GMW16696
GMW14394	GMW14975	GMW15367	GMW17000
GMW14559	GMW14984	GMW15386	
GMW14573	GMW14985	GMW15389	
GMW14591	GMW14987	GMW15394	

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Note: The use/purpose of GMW14573, GMW14933, GMW15183, and GMW16593 listed in 2.2 is defined in CG3856. They are included for user awareness.

2.3 Additional References. Use of the following documents may be required. See the GM Global Legal Database for applicable documents. The supplier shall work with the GM Design Responsible Engineer (DRE) to comprehend Best Practice requirements.

- Architectural Homeroom Statement of Requirements (SOR)
- Best Practice 112958: Brake Noise Playbook (ID)
- Best Practice Playbook Brakes-195 (ID)
- CG1290 Knuckle Technical Specification
- CG1292 Disc Brake Pad Assembly Program Technical Specification
- CG3856 Specifications Table for GMW15392 Brake Corner Tech Specs
- Corporate Common Component Statement of Requirements (SOR)
- General Motors Decoupled Lining Development List (Appendix S of program SOR)
- GM Global Fastener Engineering web site (<https://gmweb.gm.com/sites/fastening1/Pages/Home.aspx>) (ID)
- GM Global Preferred Materials Catalog (ID)
- GM Labels and Literature web site (<https://gmweb.gm.com/sites/toolkit/48Inl/Pages/Home-Page.aspx>) (ID)
- GM Materials and Corrosion web site (https://gmweb.gm.com/sites/veh_mats/Pages/default.aspx) (ID)
- Interface Dimension Chart
- Program-specific Brake System Subsystem Technical Specification (SSTS)
- Program-specific Brake Corner Assembly Technical Specification
- Program-specific Statement of Requirements (SOR)
- Program-specific Vehicle Technical Specification (VTS)

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3 Requirements

3.1 Component Definition. The brake corner assembly transforms hydraulic pressure and displacement into braking torque transmitted to the tire/wheel system. It also transforms mechanical force and travel (such as from a cable input) into static (park) torque for park brake functionality.

3.1.1 Appearance. Caliper and bracket finish shall meet any applicable GM Perceptual Quality requirements. This includes matching the color of the housing to the bracket.

Aluminum calipers used for high performance applications shall be anodized or use an alternative finish that maintains its color through high energy driving conditions such as applicable race track test conditions.

See 3.2.11.3 and 3.2.11.4 for appearance and performance specifications related to corrosion exposure. See program-specific technical specifications for additional requirements.

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3.1.2 Definition of Operating and Non-Operating Environment.

3.1.2.1 Environmental Definition. The brake corner assembly will be exposed to the following environmental conditions in either customer usage or in the manufacturing and assembly process. The brake corner assembly shall provide satisfactory performance during and after these exposures. Appropriate laboratory tests may be used to demonstrate this performance.

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 greater than 160 000 km, the hours and cycles should be adjusted accordingly. See program-specific technical specification.

3.1.2.2 Temperature Range. The temperature range for ambient conditions is -40 °C to +50 °C. The temperature range of each component during operation and storage shall range from -40 °C (-48 °C for Siberia) to a maximum temperature (TMAX) which is specified per the component. Excursion conditions represent elevated temperature exposure not to exceed 30 minutes continuous. Materials and component geometries shall be selected/designed that allow the following operating temperature conditions to be met:

- a. **Lining:** TMAX = 600 °C; 800 °C Excursion. TMAX for the lining insulator/backing plate is determined through static (rotor not spinning and vehicle not moving) physical test or heat transfer analysis with the rotor set at 600 °C and heat transfer driven through conduction from the rotor, through the pad assemblies, and to the back of the backing plate.
- b. **Cast Iron Rotor:** TMAX = 700 °C; 800 °C Excursion for cast iron rotors. See program specific technical specifications for rotors constructed from alternate materials.
- c. **Caliper:** TMAX = 125 °C; 150 °C excursion for ethylene propylene diene monomer (EPDM) rubber components; TMAX = 300 °C for Silicon rubber components. Caliper TMAX is determined through static (rotor not spinning and vehicle not moving) physical test or heat transfer analysis with the rotor set at 600 °C and heat transfer driven through conduction and radiation to nearby caliper surfaces, for a total exposure time of 45 minutes. High performance applications with race track usage may specify additional requirements to account for convective heat transfer from rotor vent exhaust into caliper surfaces higher rotor temperatures. See program-specific technical specifications for additional requirements.
- d. **Bearing:**
 - TMAX = 120 °C
 - TMAX = 180 °C Excursion with no seal damage
- e. **Fluid:**
 - TMAX = 180 °C (for Department of Transportation (DOT) 3 fluid)
 - TMAX = 190 °C (for DOT 4 fluid)
 - TMAX = 200 °C (for DOT 5 fluid)

3.1.2.3 Humidity Range. The relative humidity range for each component during operation and storage shall range from 0 to 100% in the specified ambient temperature range of -40 °C to +50 °C.

3.1.2.4 Atmospheric Pressure. The brake corner assembly will be exposed to between 330 mmHg and 860 mmHg during operation and storage.

3.1.2.5 Potential Contaminants. The brake corner assembly must either be able to withstand prolonged exposure to contaminants which could be encountered in vehicle use or must be packaged to protect from them.

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Validation is accomplished through physical testing or through prior knowledge of material and coating compatibility with contaminants.

Coatings or exposed construction material used on the caliper assembly, rotor splash shield, wheel bearing seal protection (slinger), and the rotor must withstand the application of a film (the viscosity of the liquid will define the film thickness) of the following contaminants, applied at ambient temperature, for a duration of 2 h, without penetration of the coating or damage (pitting or erosion) of the base material: Engine oil, transmission fluid, power steering fluid, coolant/antifreeze, brake fluid, windshield washer fluid, ammonia glass cleaner, applicable fuels (gasoline, diesel, ethanol, or methanol), transaxle or differential lube, wheel bearing lube, air conditioning refrigerant, water, salt water, snow, ice, acid rain, road tar, rust proofing/undercoating, ozone, acid rim cleaner, and urea (Diesel Emission Fluid).

Any brake corner components that move relative to other components must be sealed against dirt, dust, grit, sand, and mud exposure, or feature a design that can withstand this exposure over the life of the vehicle while remaining functional.

3.1.2.6 Cooling Coefficient. Shall be specified for selected rotor geometry and working mass to support meeting system-level thermal performance requirements. See program-specific technical specification.

3.1.2.7 Air Flow Requirements. When applicable, body or underbody structure(s) shall provide an opening to route air flow to the appropriate brake corner component. See program-specific technical specification.

3.1.2.8 Chassis Electronics and Controls. The chassis electronics and controls subsystem may provide electrical power to the brake corner for wheel speed sensors. As required, the brake corner assembly may provide wheel speed signals from each corner to the chassis electronics and controls subsystem. See program-specific technical specification.

3.1.2.9 Non-Operating Environmental Exposure. The brake corner shall meet all operating performance requirements, without loss of function or degradation of service life, under the operating environment defined in 3.1.3.1 thru 3.1.3.4 after exposure to the following non-operating conditions:

- a. Component transport by airplane at altitudes up to 13 700 m, with air temperature of -50 °C and pressure of 125 mmHg.
- b. Free air temperature up to 93 °C.
- c. Vehicle transport by ground via haul-away carriers and train.
- d. Vehicle transport via ocean transport cargo ship (vibration and corrosion).

3.1.3 Content and Splash, Debris, and Corrosion Protection.

3.1.3.1 Physical Content. The brake corner assembly includes the knuckle (if applicable), caliper assembly, brake pads, brake rotor, wheel bearing, rotor splash shield, and may include wheel speed sensors, hydraulic brake hoses, and wheel bearing shield. Brake corners contain the park brake mechanism (as part of the caliper or as a separate mechanism).

3.1.3.2 Functional Content. The brake corner assembly creates decelerating torque at each wheel in response to input from the service brake apply system. The brake corner assemblies transform vehicle kinetic and potential energy into heat. The brake corner assembly provides for temporary storage and dissipation of heat. The brake corner assembly provides wheel speed information to the chassis electrical system for chassis control systems. The brake corner assembly also provides warning of impending lining wear out.

3.1.3.3 Wheel Bearing Seal Protection. The brake corner must include a method of protecting the wheel bearing seals (and if applicable, the wheel speed sensor tone ring) from debris exposure. Preferred methods of protecting non-driving bearings are direct protection from the knuckle (no through hole) or bearing cap. Preferred method of protecting driven bearing is a slinger. See program-specific technical specification.

Consult the appropriate materials catalog for wheel bearing slinger material recommendations.

3.1.3.4 Rotor Splash Shield. The brake corner must include a rotor splash shield. The splash shield must extend beyond the outer edge of the rotor (in the radial direction) to provide coverage from under-vehicle airborne debris flow. The splash shield must have features (such as central vents or louvered slots) to provide airflow to the rotor air inlet without allowing for direct exposure of the rotor friction surface to debris flow.

For a reference of suitable splash shield materials, refer to the GM Global Preferred Materials Catalog. A coating must be used to separate the shield from interfaces constructed of dissimilar materials. See GM Materials and Corrosion web site.

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3.1.3.5 Galvanic Corrosion Protection. Materials for adjoining components shall be selected to minimize the potential for galvanic corrosion. This means employing similar materials at interfaces and/or employing a suitable barrier coating.

3.1.3.5.1 Corrosion Protection for Bearing to Knuckle Interface. The interface between the wheel bearing pilot and knuckle bore shall be greased to reduce corrosion in this area and to permit removal of the bearing from the knuckle in service.

3.1.3.6 Fastener Selection. GMW17000 contains recommended fasteners for the brake caliper to knuckle attachment, the brake rotor to wheel bearing attachment (rotor retention screw), the brake hose to caliper attachment (banjo bolt), and the wheel bearing to knuckle attachment. See the GM Global Fastening Engineering web site. The design of these interfaces shall accommodate the use of the recommended fasteners. Exceptions can be made for non-standard interfaces or special packaging situations. The brake hose to caliper attachment (banjo bolt) recommendation does not apply to a screw-in type brake hose attachment.

Torque, Tension, and Angle Evaluation of Fastened Joints shall be evaluated per GMW14165 to determine the correct torque specifications.

3.1.4 Vehicle Interfaces, Driver Interfaces, and Loads.

3.1.4.1 Structure Interface. The brake corner assembly shall interface with the suspension and chassis structure as shown in the appropriate drawing file. See program-specific technical specification.

3.1.4.2 Load Capacity. The rear suspension shall provide support and reaction capability for the brake corner assembly. See paragraph 3.2.3.1 for brake corner torque capacity requirements.

3.1.4.2.1 Suspension/Knuckle Loads. See CG1290 Knuckle Technical Specification.

3.1.4.3 Knuckle Mounting Boss Stiffness. See CG1290 Knuckle Technical Specification. The template requirements are as follows:

- a. Maximum caliper mounting boss cross-car deflection < 0.20 mm under 5 kN load.
- b. Maximum angle of deflection of caliper mounting boss ear between bolt center and edge of wheel bearing pilot diameter < 0.23 degrees.
- c. The deflection of the trailing boss must be greater than or equal to that of the leading boss during a brake application in the forward direction.
- d. The difference in stiffness between the two (2) bosses shall be less than or equal to 5%.

3.1.4.4 Steering. The brake corner assembly will react all cornering loads. Loads are to be provided as part of Architectural Homeroom SOR package for the specific program.

3.1.4.5 Tire/Wheel/Trim. See program-specific technical specification. The wheel assembly files should include:

- a. Nominal composite wheel profile.
- b. One (1) mm radial, 3 mm axial offset minimum allowable clearance to nominal wheel.
- c. Five (5) mm radial, 6 mm axial offset nominal clearance to nominal wheel profile.

For flatness and concavity requirements of the corner components, see GMW15389 and GMW15400.

3.1.4.5.1 Mounting. Wheel studs must be selected from GMW17000. See program-specific technical specification for mounting configuration.

3.1.4.6 Lining Life Indicator. Lining wear sensors are required to provide the driver with an indication of impending lining wear out as specified in the Brake Subsystem Technical Specification. One wear sensor per friction surface per caliper (two per caliper) is required. The wear sensor must be placed at the location of highest wear. If an audible wear sensor is used, it must meet the requirements set forth in 3.2.12.7.

3.1.4.7 Interfaces. The program-specific technical specification must reference the necessary Interface Dimension Chart (provided by GM Chassis) and appropriate drawing files. See program-specific technical specifications.

3.1.5 Clearance to Surrounding Components.

3.1.5.1 Minimum Allowable Wheel Clearance. The maximum envelope of the brake corner assembly (including build tolerances, lining wear, and deflections) will be less than the minimum envelope of the wheel (including build tolerances, runout, wheel balance weights, tire chains, and deflections under load). The design envelope will be 3.0 mm lateral and radial clearance between the brake corner and the wheel. The supplier shall provide

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component design information, including the component packaging envelope and all positioning dimensions and tolerances. See program-specific technical specification.

3.1.5.2 Caliper Clearance with Lining Wear. The caliper (including the park brake lever, if an integral park brake design) shall clear all nearby components, including suspension components, with the lining in a fully worn state. The lining fully worn state shall be simulated (in sliding calipers) by removing the outboard lining completely and touching the caliper fingers (or outer housing pad interface surface, if applicable) to the nominal (new) rotor outboard surface. Position variation and movement of other components shall be comprehended in this study. A minimum design clearance (nominal caliper in fully worn pad and rotor condition) to nearby components on the inboard side of the caliper is 8 mm.

3.1.5.3 Nominal Caliper Envelope. All features of the caliper with nominal design dimensions must be contained within the nominal caliper assembly design envelope. See program-specific technical specification.

3.1.6 Fluid and Actuation.

3.1.6.1 Brake Corner/Brake Hose Connection. See program-specific technical specification. If a banjo bolt attachment is used, allowance for the banjo block fitting and banjo bolt and initial length of tube shall be included in the caliper envelopes shown in the drawing files.

3.1.6.2 Brake Fluid. The brake corner assemblies shall be compatible with all glycol-based fluids: DOT 3, DOT 3+, DOT 4, DOT 4+, and DOT 5.1. 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.

3.1.6.3 Engine Control Unit Wiring Connector. Appropriate routing, protection and consideration needs to be applied for the wiring and wiring connector for the sensors for the brake control systems. See program-specific technical specification.

3.1.7 Parking Brake Interface.

3.1.7.1 Rear Foundation Brake Knuckle/ Backing Plate. The rear brake assembly will provide a reaction point for the park brake rear cable conduits. The conduit reaction element will allow end-fitting insertion with less than 50 N insertion force. Stiffness of the reaction element will be such that loaded deflections will consume less than 5% of required cable travel. The reaction element will provide a cable exit angle that allows a minimum of 40 mm of clearance between the tire/wheel and rear park brake cables.

In order to insure adequate space for a cable return spring, the minimum distance from the reaction bracket to the apply lever shall be 80 mm. This requirement will be waived if the internal mechanisms of the component provide adequate force to fully return the cable system.

The drum-in-hat (DIH) shall have an access window (with appropriate seal plug) that allows shoe diameter adjustment without removal of corner assembly parts. This access window is not required if the rotor lining interface is designed so as to insure that the rotor can be easily removed throughout the life of the vehicle (i.e., the rotor cannot develop a corrosion ridge that hinders removal for service).

3.1.7.2 Rear Brake Interface to the Park Brake Cable. After assembly, the park brake cable strand end shall not disengage from the brake lever assembly when the strand is pushed from the input end.

3.1.8 Usage Definition. The customer usage data given in this section are for high levels of usage in 160 000 km of retail customer driving. (Trucks may require higher mileage. See program-specific technical specification.) Note that low levels of usage may be more appropriate for certain failure mechanisms, such as corrosion.

Components may be exposed to water-based fluid spray due to vehicle usage. Components may be exposed to water submersion during special vehicle usage, e.g., boat launches from towed trailers and/or fording. The vehicle may be subjected to under hood wash including engine degreaser. The vehicle may be subjected to home or hand washing, drive-through washing or wand washing throughout its life. The wheel bearing assemblies will be exposed to the corrosive environment, which occurs in the Scandinavian countries, the North East United States of America and South East Canada. The environment is composed of temperature, humidity, salt, splash, mud, and component usage. Corrosion will be evaluated on durability vehicles completing ten (10) year corrosion schedule. Test procedures will be listed in the vehicle program-specific Vehicle Technical Specification (VTS). See program-specific technical specification.

3.1.8.1 Antilock Brake System Applications. The ABS will operate up to 2 h total duration. The longest individual ABS application is expected to be 27 s, equivalent to ABS activation from 100 km/h to 0 km/h on a 0.1 coefficient surface. The ABS will be activated up to 5000 times.

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3.1.8.2 Traction Control System Applications. The TCS will operate up to 6 h total duration. The TCS will be activated up to 3000 times.

3.1.8.3 Line Pressure Distribution. The brake corner assembly will have a hydraulic pressure distribution listed in Table A1. See program-specific technical specification.

3.1.8.4 Fade Assist System. The Fade Assist System, if used in the vehicle application, will operate as described in the program-specific technical specification. See program-specific technical specifications for information on expected peak hydraulic pressures of fade assist system.

3.1.8.5 Electronic Stability Control Applications. The ESC, if used in the vehicle application, will operate as described in the program-specific technical specification. See program-specific technical specifications for information on expected peak hydraulic pressures of ESC system.

3.2 Performance Requirements. The following performance characteristics apply to the brake corner assembly. These requirements are in addition to requirements contained in other applicable technical specifications.

There are four (4) main brake corner family-variants defined: (1) Base Caliper with rotor-friendly Non-Asbestos Organic (NAO) (low coefficient of friction (Low-Mu)); (2) Base Caliper with Low-Metallic (Low-Met) corrector linings (variant includes corrector high coefficient of friction (High-Mu) NAO linings); (3) Premium caliper with NAO or Low-Met linings; and (4) Premium caliper with High Performance (HP) linings. The brake corner shall use an approved lining material selected from the applicable General Motors Decoupled Lining Development (DLD) List (Appendix S of the program SOR). Brake corner components shall meet the performance requirements of the applicable family variant types for all applicable regions defined in the program-specific technical specifications, using the selected DLD-approved lining material(s).

Supplier shall provide the GM engineer with test data that verifies that performance will meet the following stated requirements. For all procedures for which an applicable Test Improvement Process (TIP) Certification program exists, data must be generated using TIP certified equipment. Inertia dyno procedures that do not have a TIP certification program established must be TIP certified to run GMW14925. Consult the GM engineer responsible for administering the TIP program for the most current list of procedures with TIP certification programs.

3.2.1 Performance Requirements.

3.2.1.1 Tiered Specification System. Performance specifications are assigned a priority “tier” to assist the Product Development Teams in determining whether a non-compliance to specification should become cause for making design changes. There are possible three priority tiers, which are defined as follows:

Tier 1 Priority: This is the highest priority tier. Specifications assigned tier 1 priority are considered to be fundamental performance requirements. They will have direct impact on brake system/vehicle level performance and/or direct impact on warranty/customer satisfaction. Non-conformities to Tier 1 specifications are expected to result in documentation of the issue and design changes or detailed and extensive analysis/rationale for acceptance without change.

Tier 2 Priority: Tier 2 specifications relate to one of two categories. This includes (1) performance characteristics that, when observed concurrently with other issues, may signify risk to vehicle level performance, customer satisfaction, or warranty, and (2) performance characteristics that are important to map for purposes of brake system integration, but whose impact on system level performance is highly integration-dependent. Non-conformities to Tier 2 specifications should be tracked by the Product Development Team and either addressed with design change or closed with rationale (to be documented with the results).

Tier 3 Priority: Tier 3 specifications also relate to 1 of 2 categories. The first is characteristics that are useful to understand for system integration, but that do not represent a primary performance characteristic that is easily translated into customer satisfaction. The second relates to characteristics that may have important correlation to customer satisfaction, but that are associated with new test procedures or specifications that are likely to change as knowledge is generated. In the latter category, new specifications are introduced as a Tier 3 specifications and then moved to a higher tier if successful in accomplishing their intended purpose. Tier 3 specifications may be tracked as “information only”.

The tier of importance associated with each requirement in Section 3.2 is documented in CG3856, Specifications Table for GMW15392 Brake Corner Tech Specs.

3.2.1.2 Reliability and Sample to Sample Variation Limits for Performance Requirements. Reliability requirements, as well as maximum single-sample deviation to the specifications, for the brake corner

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performance requirements (invoked in Section 3.2 of this document) are documented in CG3856, Specifications Table for GMW15392 Brake Corner Tech Specs.

3.2.2 Performance Requirements.

3.2.2.1 Assembled Lateral Runout. The assembled lateral runout with and without the wheel attached using production fasteners torque specifications (mean plus 3 sigma) shall meet the requirements in CG3856, Specifications Table for GMW15392 Brake Corner Tech Specs. The assembled lateral runout shall be measured 10 mm inboard from the outside diameter of outer cheek. Assembled Lateral Runout must be checked on 100% of corner modules at the location of assembly.

3.2.2.2 Balance. Out-of-Balance measurement for the rotating mass of the Brake corner shall meet the requirement in Table A1. The applicable Supplier or Assembler of the referenced component or subsystem shall provide the GM engineer with test data that verifies the worst case (± 3 sigma) assembly performance will meet the requirements.

3.2.2.3 Mass. The mass of the brake corner and the corner components shall meet the requirements specified in the program-specific technical specification. Mass requirements shall be specified for at least the following components: Rotor, Caliper, Pad (shoe; lining; insulator), Knuckle, Wheel Bearing, Total Corner, and Splash Shield.

3.2.2.4 Impact. Analysis may be used for impact validation. Reference the listed procedures for vehicle impact testing. See program-specific technical specification.

- GMW3238
- GMW14937
- GMW15193
- GMW14559

3.2.2.5 Plastic Deformation. The brake corner assembly shall show plastic deformation prior to fracture in a crash. See program-specific technical specification.

3.2.2.6 Squeaks and Rattles. There shall be no customer annoyance due to squeaks and rattles of brake corner components, including wheel hub and wheel bearing assembly, during vehicle test procedure GMW16352.

3.2.3 Output Characteristics. The brake corner assembly shall meet the following requirements when tested per GMW14925, GMW14350, and if applicable, GMW16042, and/or GMW14936, unless otherwise specified. Reference the test procedure(s) for data processing and reporting method.

3.2.3.1 Holdoff. The corner shall develop braking torque at the specified hydraulic pressure. See requirements under 3.2.3.1 in CG3856, Specifications Table for GMW15392 Brake Corner Tech Specs.

3.2.3.2 Apparent Friction. The apparent friction for any proposed lining must be reviewed and approved by GM engineering. All linings to be used must be selected from the approved General Motors Lining List. Apparent friction requirements are tested per GMW14925, GMW16042, GMW14936 and other specified procedures. The effective radius shall be the radial location of the piston (if known), or the radial center of the swept area of the rotor (if the piston center location is not known).

3.2.3.3 Apparent Friction vs. Temperature. The apparent friction shall remain within the requirement range during GMW14350.

3.2.4 Brake Torque Hysteresis. The brake corner assembly torque hysteresis shall meet the requirements when tested to GMW14925 (and GMW14936 or GMW16042 if applicable). See CG3856, Specifications Table for GMW15392 Brake Corner Tech Specs.

3.2.5 Apparent Piston Travel (APT).

Pressure Limit: If the deceleration cutoff during a ramp stop prevents 12 000 kPa hydraulic pressure from being reached, then the 12 000 kPa values are reported and the requirements applied to the APT value predicted at 12 000 kPa by a linear-exponential regression model fitted to the APT vs. pressure curve through the range that was measured. The model is of the form:

$$APT = [1 - \exp(-c \cdot P)] \cdot (K \cdot P + b)$$

Where:

c, K, and b are regression coefficients and P is hydraulic pressure.

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Requirements: The apparent piston travel at the brake corner assembly shall meet the requirements during the first and second warm ramp applies per GMW14925, GMW14936, and GMW16042 if applicable. See CG3856, Specifications Table for GMW15392 Brake Corner Tech Specs. These requirements apply to the caliper and hose together, with the dynamometer fluid displacement subtracted from the measurement.

Note: In this revision of the brake corner specifications, the APT values were adjusted downward relative to the values in previous revisions by the value associated with a 60 mm piston and the dyno fluid consumption measured on the General Motors North America Twin Dynamometer. The measured fluid consumption of both ends of this dynamometer was 10/80/170 mm³ at 500/5000/12 000 kPa, respectively, which translates to APT of 0.00/0.03/0.06 mm at 500/5000/12 000 kPa, respectively.

3.2.6 Pressure Distribution. The Nominal the Best Signal to Noise Ratio for the pad-to-rotor pressure distribution must be as specified in CG3856, Specifications Table for GMW15392 Brake Corner Tech Specs, Section 3.2.6. Pressure distribution may be evaluated by Computer Aided Engineering (CAE) analysis (dynamic) or statically by GMW15464. The "Nominal The Best" Signal to Noise Ratio is computed by the following formula:

$$SN = 10 \log \frac{y^2}{\theta^2}$$

Where:

y = Mean pressure over the entire pad surface (including areas that do not show measurable contact).

θ = Standard deviation of pressure over the same surface.

3.2.7 Brake Thermal Abuse. The brake corner assembly shall meet the requirements for rotor cracking when tested per GMW14984. See CG3856, Specifications Table for GMW15392 Brake Corner Tech Specs, 3.2.7.

3.2.8 Brake Drag.

3.2.8.1 Drag Torque. The caliper shall meet the specified brake drag requirements, following the pressure apply conditions listed, per GMW14351. See CG3856, Specifications Table for GMW15392 Brake Corner Tech Specs, Section 3.2.8 for requirements. The requirements with park brake applications specified apply to both mechanical and electric (Motor-On-Caliper) integral park brake designs.

3.2.8.2 Pad Slide Forces. Refer to GMW15386 for requirements.

3.2.9 Brake Noise.

3.2.9.1 Low Frequency Brake Groan/Grind. The brake corner must produce no objectionable groan or grind noise when evaluated per GMW14975. Objectionable noise is defined as audible or tactile noise rated below 8 per GMW14975 by trained evaluators. See Architectural Homeroom SOR to determine specific suspension packages and applications. See program-specific technical specification for additional requirements.

3.2.9.2 High Frequency Brake Squeal. All brake corner assemblies tested shall meet the requirements when tested per GMW14591. See CG3856, Specifications Table for GMW15392 Brake Corner Tech Specs, 3.2.9.2 for requirements. A minimum of nine samples must be tested from a new condition and demonstrated to meet the performance requirements. The nine samples are to be obtained by testing three samples at three different Test Improvement Process (TIP) accredited laboratories per Best Practice 112958 Brake Noise Playbook (the supplier shall work with the GM Design Responsible Engineer to comprehend this requirement.) The selection criteria for the components used in the testing is described in Appendix B of the Brake Noise Playbook. In addition, a minimum of three samples must be tested after with-use conditioning as specified in Section 3.2.15 (for a total of 12 samples, including 9 new and 3 use).

All brake corners must meet the requirements for high frequency squeal when evaluated at a vehicle level on GMW14975.

3.2.9.3 Modal Separation. See GMW15389 (rotor) and GMW15386 (caliper) for requirements. See program specific technical specification.

3.2.10 Brake Roughness.

3.2.10.1 Thermal Roughness. Brake thermal roughness is evaluated as torque variation during GMW14985. Requirements are specified for the maximum peak-to-peak in-stop torque variation and for the ratio of the

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