



Disc and Drum Brake Drag Measurement

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 standard is a laboratory test procedure to measure caliper brake drag or drum brake drag.

1.2 Applicability. This standard applies to all passenger car and light truck brake corners.

1.3 Remarks. This standard is used to measure brake drag over a range of experienced pressures and/or park brake clamp loads. This standard is also used to measure fluid displacement during pressure applies with no rotor/drum rotation.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW14925 GMW14933 GMW15392

2.3 Additional References.

- CG190 (ID)
- Appendix C2 of the Statement of Requirements (SOR): Rear Drum Brake corner Assembly
- Global Document Management (GDM) System (<https://documents.gm.com/gdm3/component/main>) (ID)

(ID) = This information is limited to internal distribution within General Motors and shall not be distributed outside this company. Contact the GM Lead Engineer for further instructions.

3 Resources

3.1 Facilities. Milford Proving Ground Brake Component Development (BCD) Rotor Thickness Variation (RTV) dynamometer or equivalent. Test Improvement Process (TIP) approved test equipment shall be used.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used, but must obtain an official GM TIP accreditation prior to submitting test data for vehicle programs.

3.2 Equipment.

3.2.1 Dynamometer capable of performing fluid displacement and brake drag measurements.

3.2.2 Adapter brackets for installing the rotor and caliper or drum and drum brake onto the test equipment shall be produced from production representative brake corner drawings or from measurements made on corner components.

3.2.3 During a brake application with no rotor/drum rotation, the measurements in 3.2.3.1 through 3.2.3.3 shall be made and digitally recorded at 50 Hz.

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3.2.3.1 Time.**3.2.3.2 Brake line pressure.****3.2.3.3 Fluid displacement.**

3.2.4 During a brake drag measurement, hydraulic pressure shall be zero and the rotor(s) or drum(s) spun at the required rotational speed. The measurements in 3.2.4.1 through 3.2.4.3 shall be made and digitally recorded at 50 Hz for a period of 120 s $\pm$ 1 s.

3.2.4.1 Time.**3.2.4.2 Rotor (or drum) speed.****3.2.4.3 Brake torque.****3.2.4.4 Brake line pressure.**

3.3 Test Vehicle/Test Piece. Corner assembly consisting of rotor, caliper assembly, and park brake cable (if applicable), or a drum and drum brake assembly (shoes, backing plate, cylinder, and all associated internal hardware).

3.4 Test Time.

Calendar time: 0.5 day to 2 days

Test time: 3 h to 10 h

Coordination time: 1 h to 2 h

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. One (1) technician trained in the operation of the RTV dynamometer and capable of performing the duties described in Section 4 is required.

4 Procedure**4.1 Preparation.**

4.1.1 For with use testing, use new hardware and run the full GMW14925 procedure to completion.

4.1.2 The RTV dynamometer load cell(s) shall be calibrate.

4.1.3 The brake corner(s) shall be installed using production representative component spacing. Alternatively, spacing can be determined through measurements taken from an assembled corner.

4.1.4 Disc Brake Setup. The brake corner(s) shall be tested with rotor rotation direction simulating forward vehicle direction of travel. An example of the disc brake corner setup is shown in Appendix B, Figures B1 through B3.

4.1.4.1 Pressurized air in the slide pin boots shall be released. Slide pin boots shall experience no damage.

4.1.4.2 Brake hose must be in a relaxed position so as to not influence caliper movement.

4.1.5 Drum Brake Setup.

4.1.5.1 The drum shall be set to the nominal tolerance for cage (shoe to drum) clearance. After running the complete test, reset the clearance to a minimum tolerance condition and re-run. Report both sets of data. An example of the drum brake setup is shown in Appendix B, Figures B4 through B6.

4.1.5.2 The brake drum should be within specification for radial runout.

4.2 Conditions.

4.2.1 Environmental Conditions. Not applicable.

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.2.2.1 Brake Drag Test Speed.

4.2.2.1.1 Perform the brake drag test sequence outlined in 4.3.1.1 at 100 rpm for a total of four (4) test sequences.

4.2.2.1.2 Perform the brake drag test sequence outlined in 4.3.1.1 at 400 rpm for a total of four (4) test sequences.

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4.2.2.1.3 Perform the brake drag test sequence outlined in 4.3.1.1 at 800 rpm for a total of four (4) test sequences.

4.2.3 Disc Brakes Only. The Assembled Lateral Runout (ALRO) shall be $50\text{ }\mu\text{m} \pm 5\text{ }\mu\text{m}$ when measured on the inboard rotor cheek at a position 10 mm from the Inboard Outer Diameter (IBOD) of the rotor per GMW14933. Rotate rotor by hand and record first order maximum and minimum values to determine ALRO. ALRO adjustment shall be performed by indexing rotor(s) and/or installing a steel shim, or equivalent method.

Record pretest IBOD Lateral Run Out (LRO). See Appendix A, Table A1 for example. This section not applicable to drum brake assemblies.

4.3 Instructions.

Note: Appendix A, Table A2 summarizes the test steps in 4.3.1 through 4.3.3.

4.3.1 Brake Drag Using Hydraulic Apply for Integral Park Brake (IPB), Motor on Caliper (MOC) and Non-IPB Calipers.

4.3.1.1 Test Sequence. Paragraphs 4.3.1.1.1 through 4.3.1.1.17 constitute one (1) test sequence. Four (4) test sequences constitute one (1) brake drag test at a specified rotational speed. Start test at 100 rpm per 4.2.2.1.

4.3.1.1.1 Fully retract the caliper piston(s) into the caliper housing.

4.3.1.1.2 Fully retract the inboard and outboard pads. The retracted pads shall not contact the rotor.

4.3.1.1.3 Torque measurement load cell(s) shall be zeroed prior to the start of each test sequence while the caliper piston(s) and pads are fully retracted. A load cell is considered zeroed when brake torque reading is $0.00\text{ N}\cdot\text{m} \pm 0.05\text{ N}\cdot\text{m}$. If the RTV dynamometer is dual-ended, both sides of dynamometer must be zeroed and also be within $0.05\text{ N}\cdot\text{m}$ of each other.

4.3.1.1.4 Perform pretest hydraulic apply of $300\text{ kPa} \pm 100\text{ kPa}$. Record brake application measurements per 3.2.3.

4.3.1.1.5 Perform a 2nd pretest hydraulic apply of $500\text{ kPa} \pm 100\text{ kPa}$. This apply is done to seat the pads against the rotor. Record brake application measurements per 3.2.3.

4.3.1.1.6 Perform a $500\text{ kPa} \pm 100\text{ kPa}$ hydraulic apply for $10\text{ s} \pm 2\text{ s}$.

4.3.1.1.7 Record brake drag measurement per 3.2.4 at speed specified in 4.2.2.1.

4.3.1.1.8 Perform a $1000 \pm 100\text{ kPa}$ hydraulic apply for $10\text{ s} \pm 2\text{ s}$.

4.3.1.1.9 Record brake drag measurements per 3.2.4 at speed specified in 4.2.2.1.

4.3.1.1.10 Perform a $1800\text{ kPa} \pm 100\text{ kPa}$ hydraulic apply for $10\text{ s} \pm 2\text{ s}$.

4.3.1.1.11 Record brake drag measurements per 3.2.4 at speed specified in 4.2.2.1.

4.3.1.1.12 Perform a $2500\text{ kPa} \pm 100\text{ kPa}$ hydraulic apply for $10\text{ s} \pm 2\text{ s}$.

4.3.1.1.13 Record brake drag measurements per 3.2.4 at speed specified in 4.2.2.1.

4.3.1.1.14 Perform a $5000\text{ kPa} \pm 100\text{ kPa}$ hydraulic apply for $10\text{ s} \pm 2\text{ s}$.

4.3.1.1.15 Record brake drag measurements per 3.2.4 at speed specified in 4.2.2.1.

4.3.1.1.16 Perform a $7000\text{ kPa} \pm 100\text{ kPa}$ hydraulic apply for $10\text{ s} \pm 2\text{ s}$.

4.3.1.1.17 Record brake drag measurements per 3.2.4 at speed specified in 4.2.2.1.

4.3.1.1.18 Perform a $10\text{ }000\text{ kPa} \pm 100\text{ kPa}$ hydraulic apply for $10\text{ s} \pm 2\text{ s}$.

4.3.1.1.19 Record brake drag measurements per 3.2.4 at speed specified in 4.2.2.1.

4.3.1.1.20 Repeat 4.3.1.1.1 through 4.3.1.1.17 for a total of four (4) test sequences at 100 rpm.

4.3.1.1.21 Repeat 4.3.1.1.1 through 4.3.1.1.18 at 400 rpm per 4.2.2.1.

4.3.1.1.22 Repeat 4.3.1.1.1 through 4.3.1.1.18 at 800 rpm per 4.2.2.1.

4.3.1.1.23 Record posttest IBOD LRO. See Appendix A, Table A1, for example.

4.3.2 Brake Drag Using Cable or Electric Park Brake (EPB) Apply for IPB Caliper, using EPB Apply for MOC Caliper, or Drum Brake Park Brake applications.

Note: The instructions in 4.3.2 should be run after completion of 4.3.1.

Note: Rotational speed for the instructions in 4.3.2 is 400 rpm only.

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Note: Definitions of EPB apply levels follow. All definitions assume nominal supply voltage and 20 °C motor temperature. These definitions and ensuing test sections (4.3.2) apply to cable actuated EPB and to MOC designs:

- EPB Level 1 (multi-stage control strategy only): Minimum EPB apply level according to control strategy.
- EPB Level 2 (multi-stage control strategy only): Medium-level EPB apply according to control strategy (if applicable).
- Maximum EPB Apply: Maximum EPB apply force for application's control strategy under nominal voltage conditions, 20 °C motor temperature.

4.3.2.1 Perform 4.3.1.1.1 through 4.3.1.1.5.

4.3.2.2 Apply 400 N $\pm$ 20 N cable force (or EPB Level 1, if applicable; skip section if not applicable) to parking brake for 10 s $\pm$ 2 s.

4.3.2.3 Record brake drag measurement per 3.2.4 at 400 rpm.

4.3.2.4 Apply 800 $\pm$ 40 N cable force (or EPB Level 2, if applicable; skip section if not applicable) to parking brake for 10 s $\pm$ 2 s.

4.3.2.5 Record brake drag measurement per 3.2.4 at 400 rpm.

4.3.2.6 Apply 1200 N $\pm$ 60 N cable force (or maximum EPB apply) to parking brake for 10 s $\pm$ 2 s.

4.3.2.7 Record brake drag measurement per 3.2.4 at 400 rpm.

4.3.2.8 Apply 1200 N $\pm$ 60 N cable force (or maximum EPB apply) to parking brake and 2500 kPa $\pm$ 100 kPa hydraulic pressure to caliper or drum brake for 10 s $\pm$ 2 s.

4.3.2.9 Record brake drag measurement per 3.2.4 at 400 rpm.

4.3.2.10 Apply 1200 N $\pm$ 60 N cable force (or maximum EPB apply) to parking brake and 5000 kPa $\pm$ 100 kPa hydraulic pressure to caliper or drum brake for 10 s $\pm$ 2 s.

4.3.2.11 Record brake drag measurement per 3.2.4 at 400 rpm.

4.3.2.12 Apply 1200 N $\pm$ 60 N cable force (or maximum EPB apply) to parking brake and 5000 kPa $\pm$ 100 kPa hydraulic pressure to caliper or drum brake for 10 s $\pm$ 2 s. Release. Apply 1000 kPa $\pm$ 100 kPa hydraulic pressure to caliper or drum brake for 10 s $\pm$ 2 s.

4.3.2.13 Record brake drag measurement per 3.2.4 at 400 rpm.

4.3.2.14 Apply 1200 N $\pm$ 60 N cable force (or maximum EPB apply) to parking brake and 5000 kPa $\pm$ 100 kPa hydraulic pressure to caliper or drum brake for 10 s $\pm$ 2 s. Release. Apply 1800 kPa $\pm$ 100 kPa hydraulic pressure to caliper or drum brake for 10 s $\pm$ 2 s.

4.3.2.15 Record brake drag measurement per 3.2.4 at 400 rpm.

4.3.2.16 Apply 1200 N $\pm$ 60 N cable force (or maximum EPB apply) to parking brake and 5000 kPa $\pm$ 100 kPa hydraulic pressure to caliper or drum brake for 10 s $\pm$ 2 s. Release. Apply 2500 kPa $\pm$ 100 kPa hydraulic pressure to caliper or drum brake for 10 s $\pm$ 2 s.

4.3.2.17 Record brake drag measurement per 3.2.4 at 400 rpm.

4.3.2.18 Apply 1200 N $\pm$ 60 N cable force (or maximum EPB apply) to parking brake and 5000 kPa $\pm$ 100 kPa hydraulic pressure to caliper or drum brake for 10 s $\pm$ 2 s. Release. Apply 5000 kPa $\pm$ 100 kPa hydraulic pressure to caliper for or drum brake 10 s $\pm$ 2 s.

4.3.2.19 Record brake drag measurement per 3.2.4 at 400 rpm.

4.3.2.20 Apply 1200 N $\pm$ 60 N cable force (or maximum EPB apply) to parking brake and 5000 kPa $\pm$ 100 kPa hydraulic pressure to caliper or drum brake for 10 s $\pm$ 2 s. Release. Apply 10 000 kPa $\pm$ 100 kPa hydraulic pressure to caliper or drum brake for 10 s $\pm$ 2 s.

4.3.2.21 Record brake drag measurement per 3.2.4 at 400 rpm.

4.3.2.22 Apply 1200 N $\pm$ 60 N cable force (or maximum EPB apply) to parking brake and 5000 kPa $\pm$ 100 kPa hydraulic pressure to caliper or drum brake for 10 s $\pm$ 2 s. Release. Apply 2500 kPa $\pm$ 100 kPa hydraulic pressure to caliper or drum brake for 10 s $\pm$ 2 s. Release. Repeat 2500 kPa $\pm$ 100 kPa hydraulic apply for 10 s $\pm$ 2 s for a total of six (6) times.

4.3.2.23 Record brake drag measurement per 3.2.4 at 400 rpm.

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4.3.3 Brake Drag for Hydraulic Drum Brakes.

4.3.3.1 Test Sequence. Paragraphs 4.3.3.1.1 through 4.3.3.1.17 constitute one (1) test sequence. Four (4) test sequences constitute one (1) brake drag test at a specified rotational speed. Start test at 100 rpm per 4.2.2.1. For drum brake assemblies, set drum brake cage clearance to nominal (or minimum), as required.

4.3.3.1.1 Torque measurement load cell(s) shall be zeroed prior to the start of the initial test sequence, and again at the start of each initial sequence for each test speed. A load cell is considered zeroed when brake torque reading is $0.00 \text{ N}\cdot\text{m} \pm 0.05 \text{ N}\cdot\text{m}$. If the RTV dynamometer is dual-ended, both sides of dynamometer must be zeroed and also be within $0.05 \text{ N}\cdot\text{m}$ of each other. Zeroing of the load cells for a drum brake test is done by backing the tailstock with the drum shoes and backing plate out of the drum, and zeroing the sensor with the drum and shoes separated. Once the torque cells have been zeroed, the brake is not disturbed again from sequence to sequence (unlike the disc brake test, the cells are not re-zeroed between sequences). Instead, the torque cell zero is checked and recorded at the completion of the set of sequences corresponding to one (1) test speed.

4.3.3.1.2 Perform pretest hydraulic apply of $300 \text{ kPa} \pm 100 \text{ kPa}$. Record brake application measurements per 3.2.3.

4.3.3.1.3 Perform a 2nd pretest hydraulic apply of $500 \text{ kPa} \pm 100 \text{ kPa}$. This apply is done to help center the shoes within the drum. Record brake application measurements per 3.2.3.

4.3.3.1.4 Perform a $500 \text{ kPa} \pm 100 \text{ kPa}$ hydraulic apply for $10 \text{ s} \pm 2 \text{ s}$.

4.3.3.1.5 Record brake drag measurement per 3.2.4 at speed specified in 4.2.2.1.

4.3.3.1.6 Perform a $1000 \text{ kPa} \pm 100 \text{ kPa}$ hydraulic apply for $10 \text{ s} \pm 2 \text{ s}$.

4.3.3.1.7 Record brake drag measurements per 3.2.4 at speed specified in 4.2.2.1.

4.3.3.1.8 Perform a $1800 \text{ kPa} \pm 100 \text{ kPa}$ hydraulic apply for $10 \text{ s} \pm 2 \text{ s}$.

4.3.3.1.9 Record brake drag measurements per 3.2.4 at speed specified in 4.2.2.1.

4.3.3.1.10 Perform a $2500 \text{ kPa} \pm 100 \text{ kPa}$ hydraulic apply for $10 \text{ s} \pm 2 \text{ s}$.

4.3.3.1.11 Record brake drag measurements per 3.2.4 at speed specified in 4.2.2.1.

4.3.3.1.12 Perform a $5000 \text{ kPa} \pm 100 \text{ kPa}$ hydraulic apply for $10 \text{ s} \pm 2 \text{ s}$.

4.3.3.1.13 Record brake drag measurements per 3.2.4 at speed specified in 4.2.2.1.

4.3.3.1.14 Perform a $7000 \text{ kPa} \pm 100 \text{ kPa}$ hydraulic apply for $10 \text{ s} \pm 2 \text{ s}$.

4.3.3.1.15 Record brake drag measurements per 3.2.4 at speed specified in 4.2.2.1.

4.3.3.1.16 Perform a $10\,000 \text{ kPa} \pm 100 \text{ kPa}$ hydraulic apply for $10 \text{ s} \pm 2 \text{ s}$.

4.3.3.1.17 Record brake drag measurements per 3.2.4 at speed specified in 4.2.2.1.

4.3.3.1.18 Repeat 4.3.3.1.1 through 4.3.3.1.17 for a total of four (4) test sequences at 100 rpm.

4.3.3.1.19 Repeat 4.3.3.1.1 through 4.3.3.1.18 at 400 rpm per 4.2.2.1.

4.3.3.1.20 Repeat 4.3.3.1.1 through 4.3.3.1.18 at 800 rpm per 4.2.2.1.

4.3.3.1.21 If the drum brake is used as a parking brake also, run section 4.3.2 on the drum brake assembly after resetting cage clearance to nominal (or minimum), as required.

4.3.3.1.22 Measure and record post-test drum radial runout.

5 Data

5.1 Calculations.

5.1.1 Data Analysis.

5.1.1.1 Burnished Apparent Piston Travel. Calculate the Burnished Apparent Piston Travel (APT) according to GMW14925 for 4.3.1 or 4.3.3, as applicable.

5.1.1.2 Sequence Steady State Brake Drag. For each brake corner and test sequences 1, 2, 3, and 4, calculate the steady state brake drag torque for each experienced pressure at each rotational speed.

5.1.1.3 Average Steady State Brake Drag. For each brake corner, calculate the average steady state brake drag (sequences 2, 3 and 4) for each experienced pressure at each rotational speed.

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5.1.1.4 Overall Average Steady State Brake Drag. Calculate the overall average steady state brake drag versus the experienced pressure at each experienced pressure at each rotational speed.

5.2 Interpretation of Results.

Note: All test results shall be compared to currently released Corner Assembly Technical Specification requirements listed in GMW15392 or Appendix C2 of the Statement of Requirements (SOR). Highlight results that do not meet specification requirements. See Tables A4 and A5 in Appendix A for example highlighting.

5.2.1 Graphical Summaries.

5.2.1.1 Sequence Steady State Brake Drag. See example plot in Figure A1, Appendix A. A plot is required at each rotation speed and each caliper tested.

5.2.1.2 Caliper/Drum Average Steady State Brake Drag. See example plot in Appendix A, Figure A2. A plot is required at each rotation speed tested.

5.2.1.3 Overall Average Steady State Brake Drag. See example plot in Appendix A, Figure A2.

5.2.1.4 Post Park Brake Apply Brake Drag. See example plot in Appendix A, Figure A3.

5.2.2 Tabular Summaries.

5.2.2.1 Burnished Apparent Piston Travel. Report average APT for all four (4) sequences per rotational speed. See example table in Appendix A, Table A3.

5.2.2.2 Sequence Steady State Brake Drag. See example tables in Appendix A, Table A4 and A6. A table is required at each rotation speed and each caliper/drum tested.

5.2.2.3 Caliper/Drum and Overall Average Steady State Brake Drag. See example tables in Appendix A, Table A5 and A7. A table is required at each rotation speed tested.

5.3 Test Documentation. Publish the test results using the GM Evaluation Report Template (CG190) or equivalent and Global Document Management (GDM) system.

6 Safety

This Engineering Standard may involve safety requirements for hazardous materials, the method of operations and equipment. This standard does not propose to address all the safety issues associated with its use. It is the responsibility of the user of this standard to ensure compliance with all appropriate safety and health practices. This would include any specific training that may be required. The safety and health standards include site specific rules and procedures, company rules and procedures, and Government Standards. Contact shall be made with the appropriate site Safety and Health personnel for further direction and guidance in these matters.

7 Notes

7.1 Glossary.

Apparent Piston Travel: The measured fluid displacement divided by the piston area.

Brake Drag: The residual torque experienced by brake rotors after a brake apply and release.

Caliper Experienced Pressure: The maximum hydraulic pressure applied to the brake caliper prior to the brake drag measurement.

Steady State Caliper Brake Drag: The average caliper brake drag torque during the final 10% of a brake drag measurement time period.

7.2 Acronyms, Abbreviations, and Symbols.

ALRO	Assembled Lateral Run Out
APT	Apparent Piston Travel
BCD	Brake Component Development
DBATS	Drum Brake Assembly Technical Specification
DRR	Drum Radial Runout
EPB	Electric Park Brake
BCATS	Brake Corner Assembly Technical Specification
GDM	Global Document Management

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GSSLT	Global Subsystem Leadership Team
IBOD	Inboard Outer Diameter
IPB	Integral Park Brake
LRO	Lateral Run Out
MOC	Motor on Caliper
No.	Number
RTV	Rotor Thickness Variation
TIP	Test Improvement Process

8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

Test to GMW14351

9 Release and Revisions

This standard was originated in September 2005. It was first approved by Global Brake Test Procedures Team. It was first published in September 2005.

Issue	Publication Date	Description (Organization)
1	SEP 2005	Initial publication.
2	OCT 2006	Added additional data format example tables and instructions. Removed Confidential status. (Global Brake Sub-system Leadership Team)
3	OCT 2007	Wording changes to 3.1; 4.1.1; 4.1.5. Added 4.3.1.15; 5.1.1.1. Figure A1 instructions corrected. (Global Brake Sub-system Leadership Team)
4	MAR 2010	Addition of park brake cable inputs to 4.3.2. Wording and paragraph numbering changes to 4.3.1. (Global Brake Sub-system Leadership Team)
5	JUN 2012	Document Title Changed. Added 100 rpm speeds. Added 7000 kPa pressure level. Added definitions for Electric Parking Brake applies for parking brake section. Added paragraph 4.3.3 for drum brake drag measurements. Changed pressure apply tolerance range to ± 100 kPa. Corrections: Publication Date SEP 2007 revised to OCT 2007. Additional Correction: Inserted Publication Date OCT 2006 which caused renumbering of issue numbers. (Global Brake Subsystem Leadership Team)
6	JUL 2012	Error corrected in paragraphs 4.3.2.18 thru 4.3.2.23; Table A2, Table A3. An instruction for a 7000 kPa apply was inadvertently inserted and has been removed. Renumbering of paragraphs was required after correction. (Global Brake Subsystem Leadership Team)
7	AUG 2017	Revised to current template. (Chassis Brake Global Subsystem Leadership Team (GSSLT))

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