



Rear Axle Brake Pipe Test

1 Scope

Note: Nothing in the 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. To evaluate the rear axle brake pipe structural integrity using a progressive decision tree approach.

1.2 Foreword. The procedure employs a decision tree type approach to evaluate the rear axle brake pipe system. The following is a brief description of the required steps:

1.2.1 Test Phase 1A. Measure pipe strains and modes during 0 to 40 Hz Hop and Tramp frequency sweeps on the Two Channel Shaker (simulated road inputs).

1.2.2 Test Phase 2A. Data acquisition on a vehicle with strain and accelerations measurements. This test phase is to determine if any of the brake pipe system modes that were marginal are excited by the vehicle. Strain levels and acceleration levels are to be recorded for analysis and in the event that an infinite life test is required.

1.2.3 Test Phase 2B. Infinite life testing using data from the Proving Ground as first choice, or optionally, using calculated loads. Conducted if required by Phase 1A testing results.

1.3 Applicability. This procedure is applicable to any vehicle with brake pipes mounted to the rear axle.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GM123M

2.3 Additional References.

- MTS498 Data Controller

- Stress, Strain, and Strength by Juvinall: Copyright 1967 McGraw-Hill Book Company, New York, St. Louis, San Francisco, Toronto, London, Sydney; page 236. (**Note:** With this publication reference with year is the identifying number as part of the document title.)

3 Resources

3.1 Facilities. Not applicable.

3.2 Equipment.

3.2.1 Accelerometers (<2 g, 0 to 750 Hz typical).

3.2.2 Direct Current Amplifiers.

3.2.3 Digital Force Meter.

3.2.4 Function Generator/White Noise.

3.2.5 Recording Device (0 to 40 Hz).

3.2.6 Spectrum Analyzer with Transfer Function Capability.

3.2.7 Strain Gages.

3.2.8 Strobe Light.

3.2.9 Thin Wire (approximately 30 American Wire Gage).

3.2.10 Axle.

3.2.11 High Performance Actuators.

3.3 Test Vehicle/Test Piece.

3.3.1 Two (2) sets of pipe assemblies.

3.3.2 Two (2) sets of brake pipe brackets.

3.3.3 Four (4) sample of brake pipes. (Typically three brake pipe samples tested to 10 000 000 cycles for validation, plus one more for strain gaging, for a total of four brake pipes.)

3.4 Test Time.

Calendar time: 9 to 12 days

Test hours: 216 to 288 hours

Coordination hours: 24 hours

3.5 Test Required Information.

3.5.1 The brake pipe tube strains and the brake pipe bracket strains for the simulated road inputs must have a positive design margin.

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3.5.2 If a primary brake tube mode exists below 50 Hz, recommend redesign or infinite life testing (Phase 2B).

3.5.3 Calculate the design margins (see 5.1 Calculations) for the torque strain with $K_f = 1.8$, the axial/bending strain with $K_f = 1.5$, and the brake tube bracket with $K_f = 1.5$. If the design margin is negative, recommend redesign or infinite life testing (Test Phase 2B).

3.5.4 If pipes that were assembled per specification break or leak fluid, recommend redesign.

3.5.5 If pipes do not leak fluid and no damage to the system was observed, recommend that the design be accepted.

3.5.6 If the *abusively* assembled brake pipes break or leak fluid, document it as design information.

3.6 Personnel/Skills. Trained technician or engineer is required to perform the instructions in Section 4.

4 Procedure

4.1 Preparation. See Appendix A (Figure A1, Figure A2 and Figure A3) for typical setup photograph, diagram of typical rear axle, calculation for point load, bending load detection method, and torque load detection method.

4.1.1 Test Phase 1A Simulated Road Inputs.

4.1.1.1 Install instrumented tubes. Mount brake pipes in design intent routing. Note any contact with the axle.

4.1.1.2 Place accelerometers on the rear axle, at the right and left spring seat.

4.1.1.3 Run Frequency Response Function (FRF) on the two channel shaker and tune to optimum response. Document in the FRF log book or test record.

4.1.2 Test Phase 2A Vehicle Data Acquisition.

4.1.2.1 Install instrumented tubes, which had the highest strain reading.

4.1.2.2 Assemble the brake pipes onto the rear axle and per design specification. Document the bench and assembled strains of the brake pipes; then zero amplifiers.

4.1.2.3 Place the vertical accelerometer on the brake pipe mounting brackets and at the brake tube mounting clips. Place fore/aft accelerometers on the brake pipe mounting brackets also.

4.1.3 Test Phase 2B Infinite Life Testing.

4.1.3.1 Install instrumented tubes which had the highest strain reading in Phase 1A. (Optionally,

conduct procedure on both tubes.) Brake pipes should be filled with brake fluid.

4.1.3.1.1 Modes due to vertical inputs: Fixture the axle in vehicle orientation with the high performance actuator attached in the vertical direction to the spring seat of the side under observation and a pivot mount at the spring seat on the opposite side.

4.1.3.1.2 Modes due to brake (chatter) inputs: Fixture the axle in vehicle orientation with angle stands. Attach a high performance actuator to the brake anchor pin in the direction of the brake shoe load input.

4.1.3.2 During the test, document any unusual performance characteristics of the brake pipe system.

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.

4.3 Instructions.

4.3.1 Test Phase 1A Simulated Road Inputs.

4.3.1.1 Actuators are attached to the rear axle using clevises.

4.3.1.2 Articulate the rear axle from 0 to 40 Hz in tramp and in bounce at a 2 s/Hz sweep rate.

4.3.1.3 Monitor the brake pipe system with strobe lights, accelerometers and strain gages to determine peak responses and unusual behavior. Putting the strobe light at a slightly different frequency than the input frequency helps amplify the visual difference making the excitation frequency identification easier.

4.3.1.4 If possible, use a strobe light to determine whether the strain gages are measuring the peak strain locations.

4.3.1.5 Document the peak strain responses, input frequency, and axle acceleration for each vibration mode on a data recorder for post analysis and reporting. Use the Auto Spectral Density of the gage response to identify the peak frequency response of the pipe during the frequency sweep.

4.3.1.6 Contact Design Engineering to review the brake tube system response. Point out any unusual performance characteristics and major modes of the brake pipe system.

4.3.1.7 Post test, Document any observation about the brake pipe system.

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4.3.1.8 Get photograph of the test setup for the report.

4.3.2 Test Phase 2A Vehicle Data Acquisition.

4.3.2.1 Record all Proving Ground schedules that may excite the brake pipe system (vertical and braking inputs).

4.3.2.2 Attempt to record brake chatter and/or brake squeal event.

4.3.2.3 During the test, document any unusual performance characteristics of the brake pipe system.

4.3.2.4 Post test, document any observations on the brake pipe system.

4.3.2.5 Get photographs of the test setup for the report.

4.3.3 Phase 2B Infinite Life Testing.

4.3.3.1 If Proving Ground data is available, reproduce the maximum response(s) record for ten million cycles.

4.3.3.2 If no Proving Ground data is available, reproduce the peak response modes at 3G input at the spring seat for modes from 0 to 25 Hz, and at 6G input at the spring seat for modes from 25 to 50 Hz. The frequency sweeps are conducted and the data recorded in time history format, using MTS498 Data Controller along with Remote Parameter Control software or equivalent.

4.3.3.3 Install a new set of brake tubes and cycle for 10 000 000 cycles at each mode. Modes must be monitored with accelerometer on the bracket or a strain gage on the brake pipe for changes that would indicate a structural deviation.

4.3.3.4 Repeat 4.3.3.3 for a total of three samples.

4.3.3.5 Repeat 4.3.3.3 for a total of three samples while installing the brake pipes in an *abusive* manner by starting the flare nut and then torque to maximum torque specification without supporting the tube.

4.3.3.6 Post test, document any observations on the brake pipe system.

4.3.3.7 Get photographs of the test setup for the report.

5 Data

5.1 Calculations.

5.1.1 Design Margin = $[1/\{(\sigma_a \times K_f / S_n) = \sigma_m / S_u\} - 1] \times 100\%$

5.1.2 σ_a = Alternating Stress (1/2 of peak to peak stress) $\sigma_a = E \times \epsilon_a$.

5.1.3 S_n = Endurance Limit of Fatigue Stress (Approximation; $S_n = 0.5 \times S_u$: Geometry correction factors can be found in Stress, Strain, and Strength by Juvinall: Copyright 1967 McGraw-Hill Book Company, New York, St. Louis, San Francisco, Toronto, London, Sydney; page 236.)

5.1.4 K_f Fatigue Notch Factor (1.5 unless otherwise indicated).

5.1.5 σ_m = Mean Stress (static stress due to assembly) if σ_m is negative use $\sigma_m = 0$ (obtain from stress – strain curve).

5.1.6 S_u = Ultimate Tensile Strength.

5.1.7 E = Modules of Elasticity (Approximately 30 000 ksi).

5.1.8 Typical Tubing Material $S_u = 42$ ksi (per GM Engineering Standard GM123M).

5.2 Interpretation of Results. Results should be compared to applicable technical specifications.

5.3 Test Documentation.

5.3.1 Document the bench (not installed) and installed strain offsets.

5.3.2 Document all strains and strain offsets recorded in Test Phase 1A and 2B in Table A1 in Appendix A.

5.3.3 Document the major modes and the associated strains and accelerations recorded in Test Phase 1A.

5.3.4 Document the peak responses of the brake tube and brake tube brackets.

5.3.5 Document the test setups with photographs.

5.3.6 Publish entire test report following GM corporate protocol using the GM Evaluation Report template and publishing in Engineering Document Management system or its successor.

6 Safety

This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7 Notes

7.1 Glossary.

Design Margin: A quantitative value used to estimate the localized structural integrity of a component using measured strain data and published material properties. This calculation is

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