



Exhaust System Hanger Component Durability Test and Validation For Use Without Physically Measured Strain Data

1 Scope

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. To determine the component Load (L) vs. Life (N) characteristics of the exhaust system hanger. Secondly, to provide a component level Design Validation (DV), Product Validation (PV) and/or Post Validation Audit (PVA) assessment on the durability performance of the exhaust system hanger based on a set of generic component level hanger loads derived from static hanger loads of the exhaust system. Reference GM Design for Six Sigma (DFSS) Project Number 3653 for assumptions in criteria defined in this procedure.

1.2 Foreword. This procedure is intended to evaluate the durability performance criteria of the exhaust system hanger at a component level. The overall validation of the exhaust system shall be based on GMW15263. The validation is not limited or completely defined in this document. The requirements given in the Statement of Requirements (SOR) supercede any requirements given in this document. The requirements given in this document are given as the best standards, at the time of this procedure's publication.

1.3 Applicability. This procedure is valid for all exhaust system hanger to vehicle attachments. This includes all vehicle platforms.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW15263

2.3 Additional References.

DFSS Project Number 3653

Statement of Requirements

Subsystem Technical Specification (SSTS)

Vehicle Technical Specification (VTS)

3 Resources

3.1 Facilities. A bedplate large enough for securing the test rig and capable of withstanding dynamic loading of the rig/specimen is required.

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. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.2 Equipment.

3.2.1 A hydraulic power system and test machine that is compatible with the strength of the components being tested. Normally, a machine capable of dynamic forces of 2 kN with regard to a test frequency of

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10 Hz to 20 Hz should be sufficient. The test facility shall have a valid International Organization for Standardization (ISO) certificate which is noted in the test report. Since the fatigue test will be carried out using load control mode, the testing machine must have servo-hydraulic load-monitoring system mounted in series with specimen. The load and displacement must be monitored continuously until the failure occurs.

3.2.2 The main parts in the test machine consist of hydraulic actuators and a control system.

3.2.3 Adequate physical equipment for fixation of the exhaust hanger component. An example of a test rig is shown in Appendix B, Figure B1.

3.3 Test Vehicle/Test Piece. A minimum of two (2) load levels and six (6) samples per load level, for a total of twelve (12) samples per component shall be tested.

3.4 Test Time. The test time is defined by the test setup time, the frequency of the test, the number of samples at each load level and the number of cycles to failure for each sample. The test time is the variable sum of all of the above. The numbers below are based on a test frequency of 10 Hz, testing six (6) samples to failure, targeting 100 000 cycles for high load and 1 000 000 cycles for low load and are based on an 8 h (one (1) shift) and a 24 h (three (3) shift) day.

Calendar time: 8 days to 24 days

Test hours: 183 hours

Coordination hours: 8 hours

3.5 Test Required Information. The GM requesting engineer is responsible for identifying the durability schedule to be simulated and providing test specifications, SSTS paragraph numbers and static hanger loads appropriate to the particular exhaust system hanger component being tested.

3.6 Personnel/Skills. Prior experience in setting up and running similar tests and experience in the use of the referenced test equipment.

4 Procedure

4.1 Preparation. All samples should be inspected for geometrical conformance with the appropriate specimen drawing and weld specification. Any non-compliant specimens should be set aside and a compliant specimen should be tested in its place.

4.1.1 Check that all parts and fixtures needed are included for the mounting.

4.1.2 Paint critical areas with an appropriate color (e.g., white) to make it easier to find cracks.

4.1.3 Test Stand Setup. The exhaust system hanger component should be mounted in fixture so that it is in vehicle position with the force actuator aligned in the vehicle vertical direction. The holding fixture should be close enough to the hanger to allow proper dynamic load while not inducing unrealistic stiffness to the hanger component, see Appendix B, Figure B1 (u-joint attachment).

4.2 Conditions.

4.2.1 Environmental Conditions. The test shall be performed at $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.

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 Exhaust System Hanger Testing.

4.3.1.1 Unless otherwise specified, tests should be conducted with the R-ratio ($P_{\text{minimum}}/P_{\text{maximum}}$) of negative one (-1). At least two (2) load levels should be tested, and six (6) replicates are required for each load level and R-ratio combination. The two (2) different load levels should be targeted to produce failures at 100 000 cycles and 1 000 000 cycles.

4.3.1.2 The test should be carried out in the load control mode using a sine wave, without encountering any specimen resonance or dynamic effects.

4.3.1.3 Shut off criterion for the test is the increase of the oscillation amplitude of 20%, which should automatically shut off the testing machine as soon as the adjusted limiting value is exceeded. If no visible crack occurs, restart testing and increase the change in oscillation amplitude by another 10%, repeat until

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failure (visible crack). If the specimen does not fail after 3×10^6 cycles, the test will be terminated and designated as a run out.

4.3.1.4 Test shall be controlled and monitored by a computer program. Load, displacement and cycles of the specimen should be monitored through entire test until failure.

4.3.1.5 Failure mode is to be recorded and failure location shall be identified for each test specimen. Pictures shall be taken for typical failure modes and any anomalous failures documented and photographed.

5 Data

5.1 Calculations.

5.1.1 The Load (L) vs. Life (N) curve of the exhaust system hanger component can be fitted to the failure data obtained in Section 4 using many methods, one of which is described in Appendix A.

Once the L-N curve has been fitted to the failure points, including calculation of the associated scatter, use the following block loads, in Table 1, which are based on static hanger loads, to assess the design at B1 life (R99C50). This block needs to be repeated per 100 repeats of the total amount of the Belgian block events, or similar event, that encompasses the vehicle target life per the durability test procedure and life requirement stated in SSTS (i.e., if there is a total of 4000 Belgian block events to be run per life according to the durability test procedure and life requirement, then this block would be repeated 40 times per life.)

Table 1: Block Loads used to Assess Hanger Component Validation

Block	Load Range	Mean	Cycles
1	10G	0	170
2	6G	0	3000
3	4G	0	15 000

B1 life can be calculated with the following equation:

$$B1\ Life = \frac{1}{\sum_{i=1}^{i=3} \frac{N_i}{\left(\frac{L_i}{L_0}\right)^{\frac{1}{b}} \cdot 10^{z\sigma_{IS}}}}$$

Where:

B1 Life = Life estimate at R99C50

N_i = Number of total cycles at load level 1, 2 or 3

L_i = Load range at load level 1, 2 or 3

L_0 = Load range intercept of L-N curve

b = Slope of L-N curve

z = Number of standard deviations from mean ($z = -2.33$ for R99C50)

σ_{IS} = Standard error of failure data

5.2 Interpretation of Results. The requesting engineer is responsible for providing specifications appropriate to the particular vehicle line being tested (reference VTS/SSTS paragraph numbers if applicable).

5.3 Test Documentation. Report the L-N data and B1 life calculations on a data sheet. Reference Appendix C, Table C1 for minimum reporting requirements.

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

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