



Generic Data Processing Flow

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 procedure explains the generic data processing flow for structural durability projects.

1.2 Applicability. This procedure is applicable as a general guide for all projects performing data processing related to time-based structural durability testing. It may be adapted for use with various commercial software packages, but was originally developed for use with RPC Pro software from MTS Corporation.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW15219	GMW15243	GMW15245
GMW15242	GMW15244	GMW15269

2.3 Additional References.

- <https://gmweb.gm.com/sites/SDL/Pages/RPCproProcesses.aspx>. (ID)
- MTS RPC Pro User Manual

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

3 Resources

3.1 Facilities.

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. See 1.2.

3.3 Test Vehicle/Test Piece. Not applicable.

3.4 Test Time. Variable depending on data volume. Typically, 16 h to 80 h for 4.3.2 and 4.3.3. Frequency Response Function (FRF) measurement and preparation dependent on channel counts and test complexity. Test duration will be determined by test complexity, number of samples and lives tested.

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. Experience and training in RPC software and GM durability schedules, as well as the type of test being conducted.

4 Procedure

4.1 Preparation. Not applicable.

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 Overall Process. The overall process is shown in Figure A1 (Figures are in Appendix A). The following material provides details on the steps in this process. Throughout this discussion, parenthetical numbers in the text refer to the processing steps illustrated in the figures.

Each of the 5 high-level data processing steps is detailed in the following sections as follows:

- 4.3.2 – Read and Validate.
- 4.3.3 – Quantify and Summarize.
- 4.3.4 – Edit Data.
- 4.3.5 – Develop Test.
- 4.3.6 – Run Test.

4.3.2 Read and Validate. Data acquired for Structural Durability will generally be validated following a data process as shown in Figure A2.

4.3.2.1 Export and Rename. Generally, data will need to be exported from the recorded data format and converted to RPC format or other format as needed by the data processing system. During the export, files may be renamed to GM standard naming. The standard naming convention is documented in GMW15219.

4.3.2.2 Visual Review. Review the data visually for correct behavior. Examine carefully for anomalies and compliance to standards (see GMW15243). Some of the standards in this procedure may not be met until step 4.3.2.5.

4.3.2.3 Corrections. This step is a “toolbox” of options depending on the issues discovered in the preceding review, including standards for process channels. Options include:

- a. Header corrections - Repeats, points-per-frame, points-per-group.
- b. Sample rate adjustment.
- c. Filtering (High-Pass, Low-Pass, Notch, Band Pass).
- d. Deglitching (removal of spikes or dropouts).
- e. Steer angle correction.
- f. Wheel Force Transducer Ripple Correction.
- g. Coordinate transformation.
- h. Drift correction.
- i. Point maneuvering.
- j. Rescaling.
- k. Conversion of Engineering Units.
- l. Channel Transformation.

4.3.2.4 Statistics. Minimum statistics to calculate include Maximum (Max), Minimum (Min), Mean, Standard Deviation, Root Mean Square (RMS) and Crest. See also step 4.3.3.1.

4.3.2.5 Final Preparation. Includes offset correction, channel extraction, common channel full scale, file format conversion (if needed) to complete meeting the standards of GMW15243.

4.3.2.6 Archive. Archive and upload to database per local procedure.

4.3.3 Quantify and Summarize. See Figure A3 for these processing steps. This set of steps is a “toolbox” of various tools that can be used to provide a means to understand, quantify and summarize the data. They are called from various locations within the software. Not all steps within this toolbox are used for all data processing projects.

4.3.3.1 Statistics. Statistics are calculated per channel for entire road surface (file). Minimum statistics include Maxima, Minima, Mean, Standard Deviation, RMS and Crest Factor. Optional statistics include Skewness and Kurtosis.

4.3.3.2 Rainflow Counting. Details for rainflow counting can be found in procedure GMW15269. An option exists for calculating composite rainflow. Rainflow counting for the purpose of providing rainflow histograms to others is often considered part of 4.3.3.7.

4.3.3.3 Fatigue Calculations. Fatigue calculations are to be performed per GMW15269.

4.3.3.4 Pseudo Energy. Pseudo Energy calculations may be calculated per procedure GMW15244. Output includes total energy per road surface, as well as Power time-histories for later editing.

4.3.3.5 Summarize Data. Statistics, time, fatigue, and pseudo-energy should be summarized in standard reports. These summaries can be used to compare two datasets, e.g., "road" and "edited". When a comparison is involved, it can be used to optimize the repetitions to match damage. Reference GMW15269, Section 4.3.10 for the optimization criteria. The summaries can also be used to create initial data editing limits.

4.3.3.6 "Baseline and Post-Edit". Frequently, processing steps 4.3.3.1 to 4.3.3.5 may be combined in a single processing tool to create "baseline" data summaries or "Post-edit" summaries.

4.3.3.7 Cycle Counting. Cycle counting includes time-history condensation, level crossing, Markovian peak-valley, and composites of these.

4.3.3.8 Auto-Spectral Density (ASD) Calculations. This processing step calculates the Auto-Spectral Densities for the road surfaces, as well as time-weighted composite ASDs.

4.3.3.9 Simultaneous Peaks. Simultaneous peaks are similar to time-history condensation, but each channel only votes twice: Once at its maxima and once at its minima.

4.3.3.10 Archive. Data must be archived and uploaded per local procedure. As an example, the GMNA process for archiving in the Loads Database is documented on the Global Structural Durability Laboratory Expert Team (GSDLET) RPC Pro Process web page as "SDL Data Archive". The supplier shall work with the GM Responsible Engineer to comprehend this requirement.

4.3.4 Edit Data. This section is shown in Figure A4. Data editing is the removal of "non-damaging" data to reduce test time. This can include filtering to a known bandwidth of the test rig, removal of before-run and end-run zeros, removal of smooth or non-damaging sections of data, etc. The data can be removed visually (graphical editing) or via a statistical method. Care must be taken to prevent removing excessive data or creating unrealistic data via excessive joining of edited sections (tapering), which can create unrealistic test loading. Statistical tools should be used to verify that "damage" is retained (See GMW15245),

4.3.5 Develop Test. The processing is shown in Figure A5. Reference MTS RPC User Manual, or the documentation of whatever test development software package is being used, for additional details of the following processing steps.

4.3.5.1 Measure Frequency Response Function (FRF). A system response transfer function of the test rig and specimen is measured. A shaped white noise file is generated with amplitudes based on desired road response amplitude. This shaped white noise is played out into the test rig and specimen. During the play-out the specimen and system responses are measured. The white noise drive and system response are transformed into the spectral domain and convolved. The resultant frequency response function (FRF) is reviewed, band-limited, inverted and expanded. This expanded inverted FRF is used in 4.3.5.2 to create a linear estimate of the drive file.

4.3.5.2 Iterations. Using the expanded and inverted FRF from 4.3.5.1 and the desired road response from 4.3.4, a linear estimate is convolved. This linear estimate is played into the system, the response measured, and the error between the desired and actual response calculated. This error is convolved with the FRF and this correction added to the previous drive. This corrected drive is used as input to another iteration loop and this process continues until the error is reduced to an acceptable level or the error starts to increase (divergence). Determination of error may be made by RMS of the error, amplitude of the extreme error, or occasionally fatigue comparisons.

4.3.5.3 Post Iteration. Once all road surfaces have drive files developed, the final responses are processed through a Post Iteration Process. This would be the same tool as 4.3.3.6. The results are compared to the Baseline results in 4.3.3.6. These results are reviewed to determine if acceptable test correlation has been achieved (see GMW15245 for typical criteria).

4.3.5.4 Archive. Final drive files and related files are archived per local procedure.

4.3.6 Run Test. This processing is illustrated in Figure A6.

4.3.6.1 Setup Test Matrix and Test Monitoring. The test matrix is based on the optimized repeats. Reference GMW15269, Section 4.3.10 for the optimization criteria.

4.3.6.2 Test Monitoring. Test monitoring can include one or more of the following:

- Point by point monitoring. Point-by-point monitoring establishes upper and lower limits at each data point. If the data falls above or below a limit, the limit is tripped. When point-by-point monitoring is active the test will stop when the limit is tripped.
- Periodic ASDs.
- Periodic time-history overlays or error calculations.
- Periodic damage.
- Statistical trend monitoring.
- Statistical trend plots. A trend is defined as either continuous or periodic (every n^{th} or manual repetition of one or more surface files) data collection with statistical calculation with comparison to a reference response. Use Trend Monitoring to specify the types of statistics that the system should monitor while running the test, and select a calculation method for setting upper and lower limits. Statistic options are the same as the statistics tool. When statistical trend monitoring is active the test will stop at the end of the file after the statistics are calculated and compared to the reference file.

The test monitoring tool is used to stop a test when the response from the system or test specimen is different than the original reference response in order to ensure test quality. For setup information reference <https://gmweb.gm.com/sites/SDL/Pages/RPCproProcesses.aspx>. Test monitoring is set up to:

- Ensure the test system is consistently reproducing the durability events as originally developed.
- Discover equipment issues.
- Detect early specimen defects.
- Track on-going simulation quality.

4.3.6.3 Play Test. Play back the tests according to the test matrix and monitor per setup information. Periodic inspections are allowed as well as tracking for exposure (how much of test is completed).

5 Data

5.1 Calculations. Not applicable.

5.2 Interpretation of Results. Not applicable.

5.3 Test Documentation. All data is to be archived per local process in RPCIII file format, with a sample rate of 409.6 or 512 and a frame size of 2048 (Group Point size of 2048).

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. Refer to GMW15242 for a list of definitions.

7.2 Acronyms, Abbreviations, and Symbols.

ASD	Auto-Spectral Density
FRF	Frequency Response Function
GSDLET	Global Structural Durability Laboratory Expert Team
R&V	Read and Validate
RLDA	Road Load Data Acquisition
RMS	Root Mean Square
RPC	Remote Parameter Control
SDL	Structural Durability Labs

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