



Sample Selection Guideline for Design and Product Validation

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 is used to plan the selection of parts used for Design Validation (DV), Product Validation (PV) and Post-Validation Audit (PVA) testing. The intention is to capture as many sources of design and manufacturing variation as possible in the test parts **without increasing** currently specified test sample sizes or costs. The sample selection plan derived from this guideline for DV, PV and PVA shall be reviewed and approved by GM Validation Engineer.

1.2 Applicability. The objective of this guideline is to improve a DV, PV or PVA evaluation's ability to detect a potential cause of failure contributed to variation by strategically selecting parts to test that incorporate a particular set of defined key parameters at the lower specification limit (LSL) and/or upper specification limit (USL); plus, any relevant variation from the production manufacturing process in order to determine if requirements are met.

A key parameter(s) is a critical characteristic that significantly influences the ability of a component, subsystem, system or feature to meet a performance requirement (e.g., case depth, foam hardness, durometer, length, thickness, porosity etc.) Figure 1 shows some graphical examples of the relationship between Loss Function and a Characteristic's Variation within Specification as defined by Taguchi. These graphs depict a gradual decrease in customer satisfaction resulting from a characteristic value change within specification. This phenomena is dependent upon understanding the loss function and the influence of the characteristic or key parameter variation on that loss function.

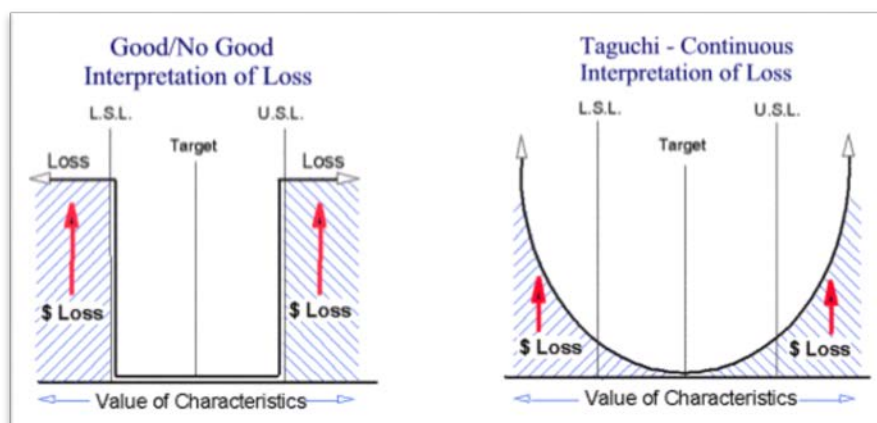


Figure 1: Example Loss Function

In order to verify that performance can be maintained across the acceptable range during DV, an evaluation may require incorporation of these key parameters at the limits based upon the Design Failure Mode and Effects Analysis (DFMEA) potential cause of failure and resulting Risk Priority Level (RPL), prior knowledge of a test driven incident due to variation, history of field issues associated to the parameter, Process Failure Mode and Effects Analysis (PFMEA), and other assessments. In PV the same approach is utilized by considering the

influence of the production manufacturing process variables such as multiple plants, lines, tools, cavities, etc. as well as including any affect from the key parameter(s) variation within specification.

1.3 Remarks. The term “Multi-Vari” comes from the Multi-Vari Chart which is a simple graphical tool used in production to detect product differences and their process-related sources. This procedure uses the Multi-Vari logic in which parts are selected **non-randomly** from process operations called “families of variation”. Upon completion of the various validation tests, the resulting test data is plotted on a Multi-Vari Chart to identify the source(s) of non-conformances, if any. A brief tutorial on constructing the Multi-Vari Chart is provided in 4.2.4.1, Figure 9.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW3059 GMW15758

2.3 Additional References.

- SOR Appendix G3 (also known as Validation Cross Reference Index and/or Program Specific Analysis/Development/Validation Plan (ADVP))
- Supplier Design Failure Mode and Effects Analysis (DFMEA) Risk Analysis and Review

3 Test Preparation and Evaluation

3.1 Resources.

3.1.1 Facilities.

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

3.1.1.2 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.

3.1.2 Equipment. Not applicable.

3.1.3 Test Vehicle/Test Piece. Test parts for DV and PV shall be selected in accordance to this guideline if;

- Required within the Statement of Requirements (SOR) Appendix G3 for Type designations of DV-Integration Vehicle (IV) Sample Selection (SS), DV SS or PV SS.
- The DFMEA potential cause of failure is contributed to variation and the resulting RPL requires action

Test parts for PVA evaluations shall be selected in accordance to the PV sample selection guideline. Refer to SOR Appendix G3 for a list of required key parameters for certain evaluations; additional characteristics may be identified based on the recommended actions generated from the program specific DFMEA.

3.1.4 Test Time. Test time will be commodity specific.

3.1.5 Test Required Information.

3.1.5.1 The Design Failure Mode and Effects Analysis (DFMEA), Process Failure Mode and Effects Analysis (PFMEA), prior test results, history of field problems, or other assessments.

3.1.5.2 The production manufacturing process flow diagram(s) used to make the product.

3.1.6 Personnel/Skills. People utilizing this guideline must have a high level of familiarity with the product, its testing, and its manufacturing processes (including relevant variation in incoming parts, such as sourcing the same part from multiple suppliers).

Note: It is important that a team of people with the skills outlined in 3.1.6 review the ADVP together to determine applicability.

3.2 Preparation. Not applicable.

3.3 Conditions.

3.3.1 Environmental Conditions. Not applicable.

3.3.2 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.

3.4 Instructions. Not applicable.

3.5 Data. Not applicable.

3.6 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.

3.7 Documentation. Samples of components or material released to this standard shall be tested for conformity with the requirements of this standard and approved by the responsible GM Department prior to the start of delivery of production level components or materials.

Any change to the component or material, e.g., design, function, properties, manufacturing process and/or location of manufacture requires a new release of the product. It is the sole responsibility of the supplier to provide the customer, unsolicited, with documentation of any change or modification to the product/process, and to apply for a new release.

If not otherwise agreed to, the entire verification test shall be repeated and documented by the supplier prior to start of delivery of the modified or changed product. In some cases, a shorter test can be agreed to between the responsible GM department and the supplier.

The supplier shall document the evaluation, type (DV-IV, DV, PV) and key parameters in the SOR Appendix G3. The rationale/methodology to select the key parameters shall be documented utilizing Multi-Vari chart or equivalent. Supplier shall obtain approval for the plan from the responsible GM Validation Engineer per the required completion date as stated in the SOR Appendix G3.

3.7.1 Test Results. The applicable Evaluation Reports shall include execution evidence of sample selection and results.

4 Requirements and Procedure

4.1 Understanding “Key Parameters” for DV Sample Selection.

4.1.1 Sources of key parameter variation frequently occur where technical specification allows a range of acceptable values for certain design aspects of a component, subsystem, system or feature such as:

- Thickness (e.g., 5.0 mm $\pm$ 0.2 mm).
- Case Hardening Depth (e.g., 4.0 mm $\pm$ 1.0 mm).
- Motor Torque (e.g., 60 N·m to 70 N·m).
- Durometer (e.g., Shore A hardness 50 $\pm$ 5).

Therefore, during DV, the key parameters allowable variation must be considered during sample selection when the variables are critical characteristics that significantly influence the ability to meet the performance requirement in order to ensure performance is maintained across the acceptable range.

4.1.2 Sample Selection Guideline to Include Variation in Design Validation. The following steps outline the requirements to include sample selection in DV:

4.1.2.1 Identify evaluation(s)/test(s) required to evaluate variation in program specific SOR Appendix G3 as Type designations of DV SS or DV-IV SS.

4.1.2.2 For the selected evaluation(s)/test(s), identify the key parameter(s) (e.g., case depth, regrind, foam hardness, durometer, length, thickness, porosity etc.) that are critical characteristics that significantly influence the ability to meet the performance requirement. Use engineering tools such as DFMEA, Best Practices, Design of Experiments (DOE), Design for Six Sigma (DFSS), P-Diagram, Variation Simulation Modeling, Computer Aided Engineering (CAE), etc. as aids to identify parameters if unknown.

4.1.2.3 Select parts to test with the identified key parameters at the appropriate limit (upper limit, lower limit or both) by one of the approved methods in the following:

- a. Adjust the build/manufacturing process to make parts at the limit but within specification.

- b. Measure and sort parts from the material produced and select parts as close to the limits as possible, but within specification.
- c. Select the worst case build property/condition within specification.

4.1.2.4 Qualify/measure important characteristics before start of test and label parts with clear identification (e.g., bar code, back side paint mark, hang tag, etc.) to distinguish and/or provide traceability back to the measured key parameter's value.

4.1.2.5 Conduct test, evaluate results and document within the test report the measured key parameter's value(s) (e.g., Material properties, Hardness, Durometer, Case depth, Thickness, Inclusions, X-ray, and Porosity Levels in castings etc.)

4.1.2.6 Iterations may be necessary, if the evaluation does not meet requirements and design or acceptable variation range changes are needed.

4.1.3 Examples. The following examples are provided as reference applications of the sample selection guidelines for DV.

4.1.3.1 Example 1 – Driveline Shaft. Produce and measure minimum (min) and maximum (max) case depth parts (reference Figure 2).

Critical Design Parameter identified to enable **fatigue performance**:

- Case Depth (max/min).
- Produced and Measured (2) batches in order to test (6) max and (6) min case depth shafts at the acceptable tails.
- Conduct tests and evaluate the test results to ensure that the parts at the min and max case depth meets the fatigue life performance.



Figure 2: Example Driveline Shaft

4.1.3.2 Example 2 – Seats. Measure and sort seat foam density (reference Figure 3).

Critical Design Parameter identified to enable **Wrinkle and Ingress/Egress Durability performance**:

- Foam Density.
- Produced and Measured to identify softer foam density values within the acceptable range of variation for testing.
- Evaluate test results to ensure that the parts at the seat foam hardness at LSL meets the wrinkling requirement.

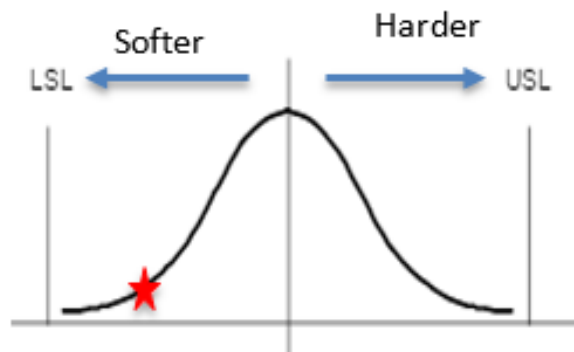


Figure 3: Example Seat Foam Density

4.1.3.3 Example 3 - Decklid Cinching Latch. Measure and sort latch motors (reference Figure 4).

Critical Design Parameter identified as Motor torque and Voltages between 9 V to 16 V to enable **switch controller output performance**.

- Produced and Measure normal functioning of the latch samples at min/max torque and voltages between 9 V to 16 V.
- Conduct tests and evaluate results to ensure that the parts are meeting switch controller/outputs requirements.

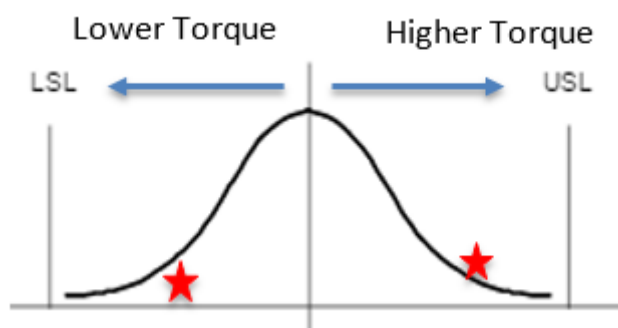


Figure 4: Example Decklid Cinching Latch

4.1.3.4 Example 4 - Wireless Entry Key Pad. Measure button key pad stability (reference Figure 5).

Critical Design Parameter identified as Button key pad stability nominal $\pm .02$ mm to evaluate **gap between button and trim**.

- Button Key Pad Stability nominal (max/min).
- Conduct tests and evaluate results to ensure that the parts are meeting performance requirements.