GM	WORLDWIDE ENGINEERING STANDARDS	General Specification	GMW14096

Steering Wheel Assembly - Verification Requirements

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations. Specific deviations must be obtained.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

Note: In the case when multiple procedures are listed to conduct a validation test, the Vehicle Engineering Center (VEC) is the final arbiter on selecting the appropriate test method.

1.1 Scope. This specification sets forth the validation procedures and associated performance requirements for the steering wheel assembly (hereinafter referred to as the steering wheel) that will be used for steering and supporting the Driver Airbag (DAB) systems in GM vehicles. This document does not address all developmental test requirements. It **shall** be the responsibility of the supplier to identify and conduct a development and concept verification test plan as defined in the program Statement of Requirements (SOR), and/or the Design Failure Mode Evaluation and Analysis/Process Failure Mode and Effects Analysis (DFMEA/PFMEA). Steering wheel development testing **shall** be completed prior to start of Design Validation (DV) Testing.

The steering wheel validation test plans **shall** be structured in accordance to the DV and Process/Production Validation (PV) test matrixes (See 4.3.1 and 4.4.1) in this document. These requirements **shall** contain but not be limited to a minimum set of tests and sample sizes for validating steering wheels. It **shall** be the supplier's responsibility to evaluate the plans and determine if additional testing and/or larger sample sizes are recommended based on the supplier's developed DFMEA and PFMEs. The steering wheel development, DV, and PV test plans **shall** be approved by the responsible VEC(s) engineer, prior to implementation.

1.2 Mission/Theme. The main purpose of the steering wheel assembly is to allow the driver to control the maneuvering of the vehicle. Also, the steering wheel is intended to function with and to supplement the restraint offered by the DAB, steering column and seat belt systems for frontal collisions. The objective of the steering wheel is to support the DAB module's cushion and potentially mitigate interior contacts in case of a frontal collision, if a specified deceleration characteristic (collision pulse) during the crash of a vehicle is exceeded. The steering wheel in conjunction with the DAB module and steering column is intended to reduce injury potential in those frontal accidents where there is a significant risk that drivers might otherwise be seriously injured, meet applicable regulations, and address GM Worldwide performance goals.

1.3 Classification. Not applicable.

2 References

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

2.1 External Standards/Specifications.

ASTM E505-01	IEC 68-2-14 Nb	ISO1431-1	SAE/USCAR-20
ECE R12	IEC 68-2-27 Ea	ISO/IEC 17025	SAE/USCAR-21
EEC 74/297	IEC 68-2-38 Z/AD	SAE/USCAR-2	SAE/USCAR-25
IEC 68-2-14 Na	IEC 68-2-64	SAE/USCAR-12	

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2.2 GM Standards/Specifications.

GM2210M	GMW3431	GMW14444	GMW15049
GM9538P	GMW6992	GMW14594	GMW15424
GMW3059	GMW14011	GMW14595	GMW15745
GMW3112	GMW14095	GMW14596	GMW15987
GMW3116	GMW14181	GMW14597	GMW16629
GMW3172	GMW14207	GMW14598	
GMW3191	GMW14264	GMW14599	
GMW3286	GMW14439	GMW15010	

2.3 Additional References.

Use of the following GM documents is recommended during steering wheel and DAB module assembly design and development.

- Dimensional Technical Specifications (DTS)
- Global Component Technical Specification Steering Wheel Controls
- Part Number 20114
- Preferred Material Catalog (PMC)

2.3.1 The following are not required for this specification and mentioned only as additional considerations:

Note: These may be used as a design guideline "checklist" for the Design Release Engineer (DRE) and Supplier and are not specified in the document.

Avoidance Plan - Assessment Worksheet Blank Template – Squeak and Rattle

- Isolation Material Selection Guide
- Material Compatibility Smart Matrix
- Material Compatibility (Subjective) Matrix
- Material Specification Database (MATSPC)
- Noise Glossary
- Steering Wheel Best Practices and Knowledge Sets
- Wire Harness Assessment (WHA)

3 Requirements

3.1 System/Subsystem/Component/Part Definition. The use of, **shall** in this document denotes a binding provision that must be met, unless a deviation is granted by the responsible VEC(s). Deviations to, the "**shall** requirements" will only be considered and, if approved, granted by the responsible VEC(s) after evaluating appropriate available technologies and balancing all steering wheel assembly and steering and restraint system performance considerations. The use of, "**should"** denotes a preference or desired conformance, which **shall** be tested and, if not met, **shall** be documented by the supplier and disclosed to the responsible VEC(s). Non-compliance to, **"should"** preferences **shall** be approved by the responsible VEC(s).

The term, "steering wheel" refers to the steering wheel assembly subsystem and not a specific component (i.e., the foam molding assembly).

The term, "airbag" refers to the airbag subsystem and not a specific component (i.e., the cushion).

Unless otherwise noted, all requirements apply over the conditions and Reliability Evaluation Point (REP) as described herein. The responsible VEC(s) **shall** be the final arbiter of performance, if the requirements stated herein are not objectively defined.

3.1.1 Appearance. The steering wheel **shall** meet the Visible Requirements of the Appearance sections in GMW14095.

3.1.2 Content.

3.1.2.1 Equipment. Test equipment **shall** be utilized as specified, by the indicated test procedures, standards and specifications.

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3.1.2.2 Samples. For test sample size requirements, see 4.3 and 4.4 (Design and Product Process Validation Requirements).

3.1.2.3 Steering Wheels. The steering wheel **shall** be fully assembled, unless otherwise specified with all hardware, i.e., a complete system as installed in the vehicle, during impact and horn testing. Hardware includes all trim plates, switches and/or emblems that are to be installed to the steering wheel assembly or complete system.

3.1.2.4 Steering Columns. Steering columns **shall** be vehicle specific fully assembled column unless otherwise specified and if necessary, an alternate 5338N build load steering column **shall** be used for testing.

3.1.3 Ambient Environment. Unless otherwise specified elsewhere in this document, tests **shall** be conducted at local ambient pressure, relative humidity 50 RH ± 10%, and room temperature 23 °C ± 3 °C.

3.1.3.1 Unless otherwise specified in this document, test condition tolerances **shall** be as follows:

Table 1: Test Condition Tolerances

Test Condition	Tolerance
Extreme Temperature	± 3 °C
Relative Humidity	± 10% of Relative Humidity
Vacuums	± 10 mm of mercury (Hg)
Height	± 0.05 m
Acceleration	± 2% except where minimums are stated
Frequency	± 4% or ± 2 Hz, whichever is greater
Amperes	± 0.01 A
Volts	± 5%
Ohm	± 1.0%
Force	± 2.0 N
Time	As specified in Test Procedure

Note: All test conditions **shall** be within the above stated tolerances at the time of test.

3.1.3.2 Any environmental condition not specified does not need to be controlled.

Source: VEC(s).

Note: If the steering wheel structural material strength properties are temperature dependent, other temperature conditions may be specified.

3.1.4 Test Data. Lab testing **shall** be performed by a laboratory that conforms (meets requirements but may not be formally recognized by a third party), to ISO/IEC 17025 and is acceptable to the responsible GM department. Test reports must conform to 5.10.2 and 5.10.3 of ISO/IEC 17025. Supplier **shall** submit a letter of compliance.

3.2 Product Characteristics.

3.2.1 Performance Requirements.

3.2.1.1 Driver Airbag (DAB) Module in the Steering Wheel Static Deployment Test. Purpose is to evaluate the steering wheel performance structural integrity.

3.2.1.1.1 Fixtures and Equipment.

- Conditioning chamber, capable of holding -30 °C to 85 °C.
- Rigid fixture that represent in-vehicle steering wheel orientation and mounting system.
- Steering wheel mounting **shall** simulate vehicle environment, including reaction surfaces when applicable.

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- Steering wheel fixture mounting system **shall** allow a steering wheel, with the DAB already installed, to be mounted.
- Refer to GMW3112 (DAB System Static Deployment Test) for additional fixtures and equipment.
- Actuation device that also switches on the measuring equipment.
- Approved Data Acquisition System
- High speed cameras or videos (1000 frames/s minimum), two required.
- Lights (High intensity).
- Thermometers that can measure temperatures up to +110 °C.
- Strobe Light (to indicate T = 0).
- Identification (ID) labels (with test number)
- Video background to include method to measure reference distances (i.e., Checkerboard).

3.2.1.1.2 Data Required.

- Record conditioning temperature setting and actual temperature in test cell during the test.
- High speed films.

3.2.1.1.3 Test Procedure.

3.2.1.1.3.1 Take still photographs of the steering wheel before test.

3.2.1.1.3.2 Snap-in DAB module to the steering wheel prior to conditioning.

3.2.1.1.3.3 Mount the steering wheel to the rigid fixture. Steering wheel mounting **shall** simulate vehicle environment, including reaction surfaces when applicable.

3.2.1.1.3.4 Install thermocouple(s) to measure the steering wheel armature temperature (if requested by VEC(s)).

3.2.1.1.3.5 Refer to GMW3112 (DAB System Static Deployment Test) for test procedure.

3.2.1.1.2.6 Set up and adjust high speed cameras. Standard camera coverage is one camera in front and one camera on either side. Each camera **shall** have a lens, which allows a full view of the steering wheel, module and inflated cushion. Grid line background if required by VEC.

3.2.1.1.3.7 Document test date, sample number and serial number. Attach an identification label to front and side of the test fixture/steering wheel/Instrument Panel (IP).

3.2.1.1.3.8 Take still photographs of steering wheel, DAB module cover, cushion assembly and module housing after test.

3.2.1.1.3.9 Complete post-test documentation; Appendix A.

3.2.1.1.3.10 Evaluation and Results.

3.2.1.1.3.10.1 The steering wheel assembly **shall** meet the performance requirements stated in GMW14095, Performance Requirements.

3.2.1.1.3.10.2 All noted discrepancies **shall** be documented and reported to the responsible VEC(s) engineer(s).

3.2.1.2 Steering Wheel Sequential/Environmental Test. The purpose of the sequential/environmental tests is to evaluate the steering wheel assembly performance in a series of different environments. Complete steering wheels of each variant (urethane, leather or synthetic wrapped, wood, heated, steering wheel controls and, etc.,) are to be subjected to the sequential/environmental tests.

3.2.1.2.1 Dynamic Shock Test. The purpose is to evaluate the effect of 12G mechanical shock inputs on the horn performance.

The horn mechanism **shall not** inadvertently activate when the steering wheel assembly and DAB module assembly is accelerated and abruptly stopped. This requirement applies to any orientation that the assembly may encounter when mounted to a steering column in the vehicle environment. The steering wheel assembly **shall** withstand a deceleration of 12G, measured with a triaxial accelerometer mounted on the steering column shaft fastener. The rotational orientation of the wheel plane **shall** be consistent with normal forward driving position. GMW3112 for the DAB module requires the DAB module to withstand Dynamic shock values of 25G and 45G. The steering wheel assembly **shall** withstand a deceleration of 25 and 45G without damage, if tested as a requirement to GMW3112.

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3.2.1.2.1.1 Fixtures and Equipment.

- Rigid fixture that adjusts to represent the following steering (DAB System Static Deployment Test) column/steering wheel orientations and mounting: 0, 22.5 and 45 degrees from horizontal.
- Vertical Shaker.
- Electrical fixture, capable of recording and permanently measuring the duration of any steering wheel horn contact actuation for the steering wheel/DAB module assemblies.
- Complete steering wheel assemblies/DAB modules with respective electrical harnesses.

3.2.1.2.1.2 Test Procedure.

3.2.1.2.1.2.1 Complete steering wheel and DAB module Mass Test per 3.2.2.2 in this document.

3.2.1.2.1.2.2 Complete DAB module Snap-in Insertion Test per 3.2.1.3.9 in this document.

3.2.1.2.1.2.3 Complete GMW14595 per instructions as specified in 3.2.1.11.3 in this document. Heated steering wheels, a pretest resistance **shall** be recorded using dry circuit resistance measurement. Complete accessory control and horn continuity at the clock coil connector interface.

3.2.1.2.1.2.4 Condition steering wheels/DAB modules at +23 °C as specified in 4.2, Validation Plan in this document.

3.2.1.2.1.2.5 Refer to IEC 68-2-27 Ea for complete test procedure. Complete the dynamic shock test per Table 2. Continuously monitor (minimum data sample rate is one (1) sample per 1 ms) and permanently record steering wheel horn contacts during the test for actuation and duration.

Table 2: Steering Wheel Dynamic Shock Schedule

Low Gravity-Force Test
Acceleration: 12G perpendicular (toward the 12:00 o'clock rim position) and axially (relative to the steering column shaft) measured at the steering column/wheel fastener (See Figure 3).
Nominal Shock Duration: 10 ms
Nominal Shock Shape: Sine Wave (a positive and a negative pulse is one cycle)
Number of Shocks: 10 cycles at each specified orientation. (The steering wheel **shall** represent the worst case range of in-vehicle orientations.) Standard testing orientations are 22.5 degrees to represent a typical in-vehicle design position, 45.0 degrees to represent worst case column full up and 0.0 degrees to represent worst case column full down steering wheel positions. All angles are measured from the horizontal table of the vertical shaker.
Test Method:
Apply 12G perpendicular to column shaft (toward the 12:00 o'clock rim position) at the wheel fastener) 10 times at the 22.5 degree (nominal) orientation.
Apply 12G perpendicular to column shaft (toward the 12:00 o'clock rim position) at the wheel fastener) 10 times at the 0.0 degree (full down) orientation.
Apply 12G perpendicular to column shaft (toward the 12:00 o'clock rim position) at the wheel fastener) 10 times at the 45.0 degree (full up) orientation.
Apply 12G perpendicular to column shaft (toward the 12:00 o'clock rim position) and axially along column shaft at the wheel fastener 10 times at each orientation.
Note: Set the table "G" such that both the perpendicular and axial values are at least 12.0G.
During the above tests, monitor steering wheel horn contact duration.
Horn contact duration **shall** be less than 4 ms.

Note: G = gravity

3.2.1.2.1.3 Evaluation and Results.

3.2.1.2.1.3.1 The steering wheel **shall not** be visibly damaged and **shall** meet the appearance requirements stated in GMW14095, (Visible Appearance).

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3.2.1.2.1.3.2 The force required to insert and seat the DAB module with the steering wheel assembly **shall** meet the insertion requirements stated in GMW14095, (Driver Airbag Module Insertion/Removal).

3.2.1.2.1.3.3 The steering wheel/DAB module shall meet the Horn Actuation Effort requirements per GMW14095; (Horn Blow Effort and Location).

3.2.1.2.1.3.4 The steering wheel/DAB module horn contact duration **shall** be less than 5 ms. Also, the steering wheel/DAB module shall meet the inadvertent Horn Actuation requirements per GMW14095; (Inadvertent Horn Actuation).

3.2.1.2.1.3.5 All noted discrepancies **shall** be documented and reported to the responsible VEC(s) engineer(s).

3.2.1.2.2 Vibration/Temperature Cycle Test. The purpose is to evaluate the effect of vibration and temperature on steering wheel performance.

3.2.1.2.2.1 Fixtures and Equipment.

- Temperature chambers, capable of maintaining -30 °C to +85 °C.
- Rigid fixture that represents the in-vehicle steering wheel orientation and design intent mounting with a representative clock spring coil to emulate wire routing. The wire routing **shall** be positioned such that it represents the worst case production capability routing (in contact with any potential sharp edges or components) within the system constraints.

3.2.1.2.2.1.1 Heated steering wheels: a pretest resistance **shall** be recorded using dry circuit resistance measurement. Complete accessory control and horn continuity at the clock coil connector interface.

3.2.1.2.2.1.2 Condition all steering wheels/DAB modules/Clock Coils at +23 °C, as specified in the Validation Plan in this document (See 4.2).

3.2.1.2.2.1.3 Refer to IEC 68-2-64 and IEC 68-2-14 Nb for complete test procedure. Apply the applicable random vibration profile shown in Table 3 for 22 h in the vehicle X-axis. (The vibration profile is to be measured at the steering wheel hub. The steering wheel angle shall represent the in-vehicle design position orientation.)

Note: If there is a mass damper, the mass damper must be grounded out to prevent it from vibrating. The Mass Damper performance is validated by 3.2.1.12.1 in this document.

Also, order of axis X, Y, Z should be randomized within the sample set and document order for each sample number.

Table 3: Steering Wheel Vibration Profile

Power Spectral Density - Steering Wheel	
10 Hz	1.37 E-01 g^2/Hz
95 Hz	5.41 E-03 g^2/Hz
216 Hz	5.30 E-03 g^2/Hz
465 Hz	3.89 E-04 g^2/Hz
645 Hz	3.14 E-05 g^2/Hz
685 Hz	1.82 E-04 g^2/Hz
1000 Hz	8.37 E-06 g^2/Hz
Total Acceleration Effective	10 to 1 000 Hz = 1.75G

Note: Apply temperature cycle shown in Figure 1, twice per axis, during vibration testing. One temperature cycle consists of:

a. Drop temperature to -30 °C at the rate of 2°C/minute.
b. Condition steering wheels/DAB modules for minimum of 272.5 minutes at -30 °C.
c. Raise temperature to +85 °C at the rate of 2 °C/minute.
d. Condition steering wheels/DAB modules for minimum of 272.5 minutes at +85 °C.
e. Bring steering wheels/DAB modules to 23 °C at the rate of 2 °C/minute.

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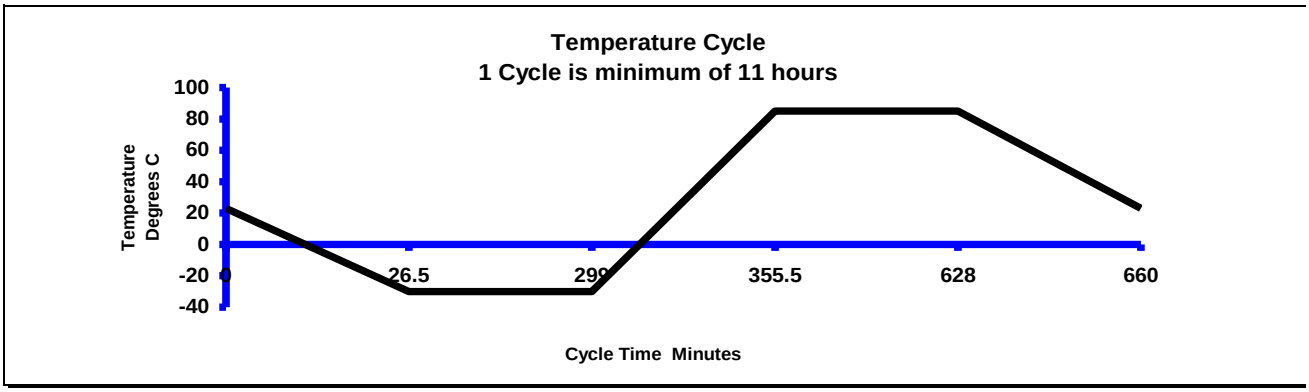
Figure 1: Steering Wheel Temperature Profile



3.2.1.2.2.1.4 Condition steering wheels/DAB modules at +23 °C, as specified in 4.2; Validation Verification Plan in this document. Change vibration direction to the vehicle Y-axis (The vibration profile is to be measured at the steering wheel hub. The steering wheel angle **shall** represent the in-vehicle orientation), repeat 3.2.1.2.2.2.3 in this document.

3.2.1.2.2.1.5 Condition steering wheels/DAB modules at +23 °C, as specified in the Validation Verification Plan in this document (See 4.2). Change vibration direction to the vehicle Z-axis (The vibration profile is to be measured at the steering wheel hub. The steering wheel angle **shall** represent the in-vehicle orientation), repeat 3.2.1.2.2.2.3 in this document.

3.2.1.2.2.1.6 The vehicle and steering wheel (column shaft) axes are shown in Figure 2 and Figure 3.

Figure 2: Vehicle Axis

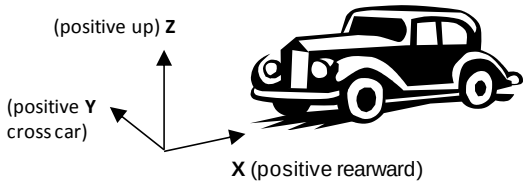
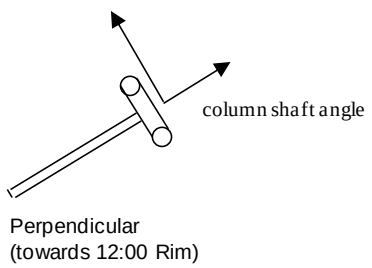


Figure 3: Vehicle and Steering Wheel Axis



3.2.1.2.2.2 Evaluation and Results.

3.2.1.2.2.2.1 The steering wheel and related components **shall not** be visibly damaged and **shall** meet the appearance requirements stated in GMW14095 (Visible Appearance).

3.2.1.2.2.2.2 There **shall** be no fatigue fractures of any component within the steering wheel assembly or DAB module mounting.

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3.2.1.2.2.2.3 All wiring, clock spring coils, circuit boards, electrical hardware **shall not** show sign of loosening, damage abrasions or cuts. Perform continuity checks of all electrical connections including horn prior to disconnecting from coil verifying functionality post vibration.

3.2.1.2.2.2.4 Heated steering wheels, a post-test resistance **shall** be recorded using dry circuit resistance measurement. The post-test system resistance change **shall** be within ± 1% of the baseline dry circuit resistance.

3.2.1.2.2.2.5 Post-test heated steering wheels **shall** perform per Heating Warm-up Time Test 3.2.1.12.2.2.6 in this document and 3.2.1.12.2.7 post-test in this document.

Post-test complete accessory control and horn continuity at the clock coil connector interface to verify functionality.

3.2.1.2.2.2.6 All noted discrepancies **shall** be documented and reported to the responsible VEC(s) engineer(s).

3.2.1.2.3 Thermal Shock Test. The purpose is to evaluate performance effects on materials within the steering wheel and Horn Switch due to rapid temperature changes.

3.2.1.2.3.1 Fixtures and Equipment.

- Temperature chambers, capable of maintaining -30 °C, +23 °C, and +85 °C
- Fixture that represents the in-vehicle Design Position for steering wheel orientation and the mounting.
- Electrical fixture, incorporating a “Representative Vehicle Horn System for the Desired Program”, to record horn actuation and duration for the steering wheel/DAB module assemblies.

3.2.1.2.3.2 Test Procedure.

3.2.1.2.3.2.1 Complete Vibration/Temperature Test (See 3.2.1.2.2 in this document).

3.2.1.2.3.2.2 Condition all steering wheel/DAB modules at +23 °C as specified in 4.2 the Validation Plan in this document.

3.2.1.2.3.2.3 Refer to IEC 68-2-14 Na for complete test procedure. Apply 60 temperature cycles as shown in Figure 4. One (1) temperature cycle consists of:

- Place steering wheel/DAB module into -30 °C chamber within 30 s.
- Condition steering wheel/DAB module assemblies at -30 °C as specified in 4.2 the Validation Plan in this document, until the Core steering wheel Temperature is to the desired value.
- Place steering wheel/DAB module into +85 °C chamber within 30 s.
- Condition steering wheel/DAB module assemblies at +85 °C specified in 4.2 the Validation Plan in this document, until the Core steering wheel Temperature is to the desired value.
- Continuously Monitor Horn Switch continuity for Inadvertent Horn Actuation (minimum data sample rate is one sample per second) during the test cycle.

3.2.1.2.3.2.4 On the 60th temperature cycle, modify cycle as below.

- Place steering wheel/DAB module into -30 °C chamber within 30 s.
- Condition steering wheel/DAB module assemblies at -30 °C as specified in 4.2 the Validation Plan in this document, until the Core steering wheel Temperature is to the desired value.
- Remove the steering wheel/DAB module from the chamber; within 30 s depress the horn blowing mechanism (e.g., DAB Cover) in the ten (10) specified areas (See GMW14095, Horn Blow Effort and Location) to assure that there are no spots where the horn will not activate.
- Place steering wheel/DAB module into +85 °C chamber.
- Condition steering wheel/DAB module assemblies at +85 °C specified in 4.2 the Validation Plan in this document, until the Core steering wheel Temperature is to the desired value.
- Remove the steering wheel/DAB module from the chamber; within 30 s depress the horn blowing mechanism (e.g., DAB Cover) in the specified areas (See 3.2.1.11.3 in this document) to assure that there are no spots where the horn will not activate.

3.2.1.2.3.3 Evaluation and Results.

3.2.1.2.3.3.1 The steering wheel **shall not** be visibly damaged and **shall** meet the appearance requirements stated in GMW14095, Visible Appearance.

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3.2.1.2.3.3.2 The steering wheel assembly **shall not** have cracking or crazing when observed with the unaided eye.

3.2.1.2.3.3.3 The steering wheel assemblies' horn actuation subcomponent(s) **shall** meet the horn temperature requirement stated in GMW14095, Horn Blowing Mechanism Humidity and Temperature Sensitivity.

3.2.1.2.3.3.4 There **shall** be no discernible movement (except for floating horn activation) of the DAB module or cover relative to the steering wheel assembly, after the DAB module is installed in the steering wheel assembly and while the horn is being used in its intended function.

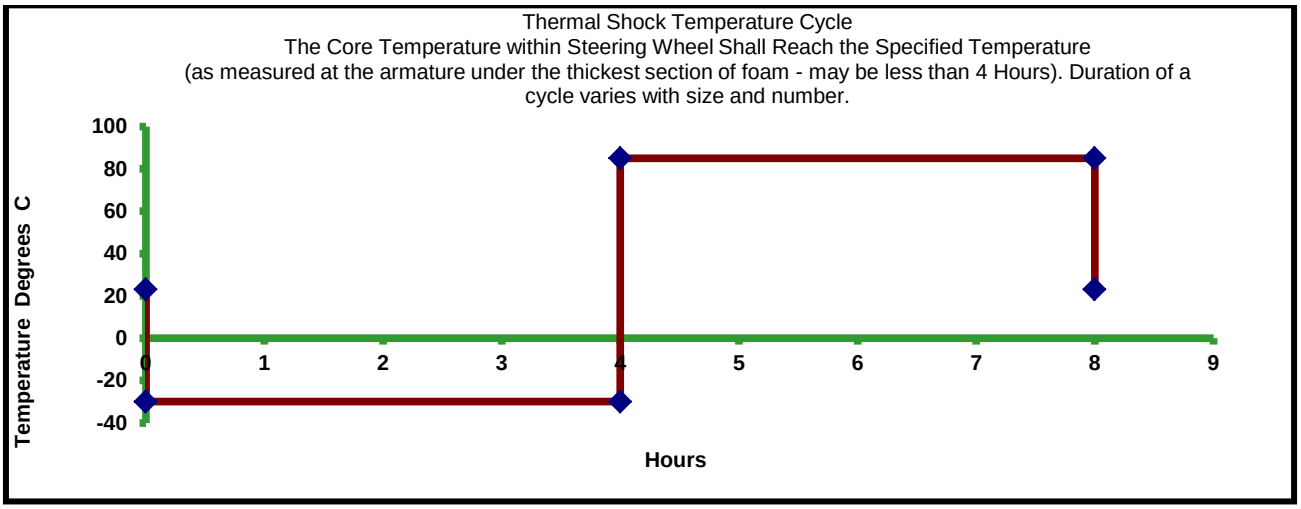
3.2.1.2.3.3.5 The steering wheel/DAB module **shall** meet the inadvertent horn actuation requirements per GMW14095 (See Inadvertent Horn Actuation).

Post-test heated steering wheels shall perform per Heating Warm-up Time Section 3.2.1.12.2.2.6 in this document and Steady State Heating Temperature Control 3.2.1.12.2.7 post-test in this document.

Post-test complete accessory control and horn continuity at the clock coil connector interface to verify functionality.

3.2.1.2.3.3.6 All noted discrepancies **shall** be documented and reported to the responsible VEC(s) engineer(s).

Figure 4: Steering Wheel Thermal Shock Profile



3.2.1.2.4 Humidity Resistance Test. Purpose is to evaluate the effect of humidity on steering wheel and Horn Switch performance.

3.2.1.2.4.1 Test Fixtures and Equipment.

- Temperature chambers, capable of maintaining -10 °C and +65 °C, and up to 100% RH.
- Fixture that represents the in-vehicle Design Position for steering wheel orientation and the column mounting system.
- Electrical fixture, incorporating a Representative Vehicle Horn System for the Desired Program, to record horn actuation and duration for the steering wheel/DAB module assemblies.

3.2.1.2.4.2 Test Procedure.

3.2.1.2.4.2.1 Complete Thermal Shock Test (See 3.2.1.2.3 in this document).

3.2.1.2.4.2.2 Condition for steering wheel/DAB modules at +23 °C, as specified 4.2 the Validation Plan in this document.

3.2.1.2.4.2.3 Heated steering wheels, a pre-test resistance **shall** be recorded using dry circuit resistance measurement.

3.2.1.2.4.2.4 The heated steering wheel **shall** be powered at 14.5 vdc ± 0.25 vdc and turned on, during humidity cycle.

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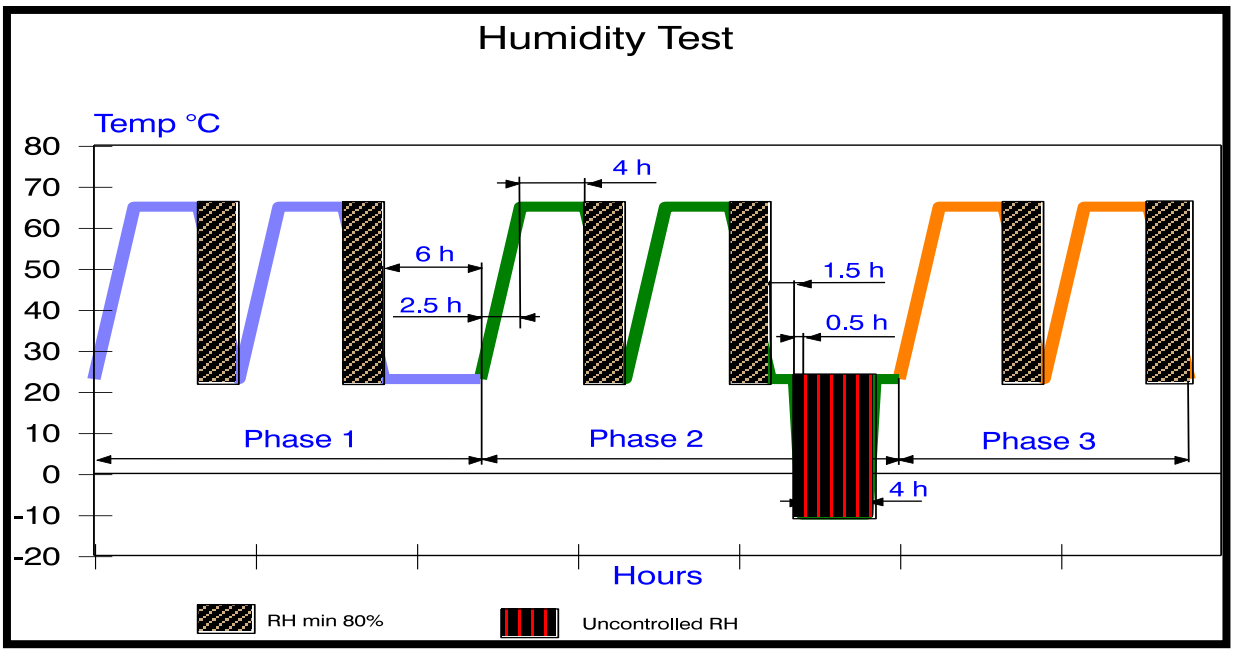
3.2.1.2.4.2.4.1 Refer to IEC 68-2-38 Z/AD for complete test procedure. Test the steering wheel/DAB module for 244 h with temperatures of: -10 °C, +23 °C, +65 °C and with 95% maximum RH according to Figure 5.

Figure 5: Steering Wheel Humidity Profile



3.2.1.2.4.2.5 The following steps briefly describe the procedure for this test. Refer to IEC 68-2-38 Z/AD for detailed test procedure. Continuously (minimum data sample rate is one sample per second) monitor horn switch continuity for Inadvertent Horn Actuation during test cycle.

3.2.1.2.4.2.5.1 Steering wheels/DAB modules **shall** complete four (4) cycles of phase one (1) conditioning for total of 96 h. During this phase, the relative humidity level **shall** be a minimum 90% except during the temperature rise and drop (as shown above). In that case, the minimum relative humidity level **shall** be 80%.

3.2.1.2.4.2.5.2 Steering wheels/DAB modules **shall** complete five (5) cycles of phase two (2) conditioning for total of 130 h. The relative humidity level **shall** be a minimum of 90% except during the temperature rise and drop. In that case, the minimum RH level **shall** be 80%. The relative humidity cannot be controlled when the temperature is below 0 °C.

3.2.1.2.4.2.5.3 Steering wheels/DAB modules **shall** complete one (1) cycle of phase three (3) conditioning for total of 18 h. During this phase, the relative humidity level **shall** be a minimum of 90% except during the temperature rise and drop (as shown above). In that case, the minimum RH level **shall** be 80%.

3.2.1.2.4.2.5.4 At the end of phase three (3), remove the steering wheel/DAB module from the chamber, within 30 s depress the horn blowing mechanism (DAB Cover) in the specified areas (See 3.2.1.11.3) to assure that there are no spots where the horn will not activate.

3.2.1.2.4.3 Evaluation and Results.

3.2.1.2.4.3.1 The steering wheel assemblies horn actuation subcomponent(s) **shall** meet the Horn Temperature/Humidity Sensitivity requirement stated in GMW14095, (Horn Blowing Mechanism Humidity and Temperature Sensitivity).

3.2.1.2.4.3.2 The horn assembly **shall** meet the operational requirement per GMW14599 as referenced in 3.2.1.11.1 in this document).

3.2.1.2.4.3.3 There **shall** be no discernible movement (except for floating horn activation) of the DAB module or cover relative to the steering wheel assembly, after the DAB module is installed in the steering wheel assembly and while the horn is being used in its intended function.

3.2.1.2.4.3.4 The steering wheels/DAB module **shall** meet the Inadvertent Horn Actuation requirements per GMW14095, Inadvertent Horn Actuation.

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3.2.1.2.4.3.5 Heated steering wheels, a post-test resistance **shall** be recorded using dry circuit resistance measurement. The post-test system resistance change **shall** be within ± 1% of the baseline dry circuit resistance.

3.2.1.2.4.3.6 Post-test heated steering wheels **shall** perform per Heating Warm-up Time Test (See 3.2.1.12.2.2.6 in this document) and Steady State Heating Temperature Control (See 3.2.1.12.2.2.7 in this document).

Note: Post-test complete accessory control and horn continuity at the clock coil connector interface to verify functionality.

3.2.1.2.4.3.7 All noted discrepancies **shall** be documented and reported to the responsible VEC(s) engineer(s).

3.2.1.2.5 Corrosion.

3.2.1.2.5.1 Functional Corrosion. Purpose is to evaluate the corrosion resistance of the steering wheel.

3.2.1.2.5.2 Fixtures and Equipment.

- Refer to GMW3286 for complete list of equipment
- Complete steering wheel assemblies/DAB modules with respective electrical harnesses.
- Fixture that represents the in-vehicle Design Position for steering wheel orientation and the column mounting system.

3.2.1.2.5.3 Test Procedure.

3.2.1.2.5.3.1 Complete Humidity Resistance Test (See 3.2.1.2.4 in this document).

3.2.1.2.5.3.2 In the steering wheels install design representative DAB modules.

3.2.1.2.5.3.3 Condition steering wheels/DAB modules at +23 °C, as specified in 4.2 the Validation Plan in this document.

3.2.1.2.5.3.4 Test steering wheels/DAB modules for minimum of 24 h with 5% salt solution per GMW3286.

3.2.1.2.5.3.5 Steering wheels/DAB modules **shall** not be cleaned or have surface corrosion wiped off after this test.

3.2.1.2.5.4 Evaluation and Results.

3.2.1.2.5.4.1 The steering wheels **shall** meet the Corrosion Resistance requirements stated in GMW14095, (See 3.2.1.2.6).

3.2.1.2.5.4.2 The horn assembly **shall** meet the operational requirement per GMW14599 as specified in 3.2.1.11.1 in this document.

3.2.1.2.5.4.3 All noted discrepancies **shall** be documented and reported to the responsible VEC(s) engineer(s).

3.2.1.2.6 Service Durability Test. Purpose is to evaluate steering wheel performance service durability performance.

3.2.1.2.6.1 Fixtures and Equipment. Steering wheel and DAB module assembly that represents the in-vehicle Design Position for steering wheel orientation and design intent mounting.

3.2.1.2.6.2 Test Procedure.

3.2.1.2.6.2.1 Complete Corrosion Test (See 3.2.1.2.5) in this document. Complete half quantity of Noise Test, (per 3.2.1.2.7 in this document) parts as shown in appropriate Validation Test Matrix steering wheels/DAB modules **shall not** be cleaned or have surface corrosion wiped off after the corrosion test.

3.2.1.2.6.2.2 Condition steering wheels and DAB modules at +23 °C as specified in 4.2 the Validation Plan in this document.

3.2.1.2.6.2.3 Perform a service durability cycle test as shown in Table 4.

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Table 4: Steering Wheel Service Durability Cycle – Post Conditioning

Steering Wheel Component/Subsystem	Cycles
Driver Airbag	10
Horn Mechanism	3
Trim Plates	3
Back Cover	3
Switches	3
Heat Control Module	3
Mass Damper	3
Wire Harness	3
Steering Wheel to Column	6

Each complete cycle consists of the following steps.

a. Remove DAB module from the steering wheel.

b. Remove all steering wheel Subcomponents per Table 4 (skip to step (d.), if all component cycles are complete).

c. Reattach all steering wheel Subcomponents per Table 4.

d. Attach DAB module to the steering wheel. For the last cycle in Table 4, complete DAB module Snap-in Insertion Test (See 3.2.1.3.9 in this document).

3.2.1.2.6.2.4 Evaluation and Results.

3.2.1.2.6.2.4.1 Steering wheels shall meet the Attachment Insertion/Removal cycles requirements stated in GMW14095.

3.2.1.2.6.2.4.2 The steering wheel assembly shall not pinch any horn or accessory control wires.

3.2.1.2.6.2.4.3 Trim Plates, Back Cover and Switches **shall not** deflect (relative to the steering wheel interfacing foam surface) more than 0.80 mm with a 40.0 N load applied. Conduct deflection tests in directions normal to surface or function of switch.

3.2.1.2.6.2.4.4 Steering wheel trim plate/accessory retention requirements of GMW14095 **shall** be met. Pull off evaluation location(s) to be determined by the responsible VEC(s) engineer(s) (See 3.2.1.2.6.2.4.5). The steering wheel **shall not** be visibly damaged and **shall** meet the appearance requirements stated in GMW14095, (Visible Appearance).

3.2.1.2.6.2.4.5 All noted discrepancies shall be documented and reported to the responsible VEC(s) engineer(s).

3.2.1.2.7 Noise Test: Subsystem-Level Validation. Purpose is to evaluate if there is any discernible noise originating from the steering wheel.

Random vibration testing of the steering wheel and DAB module assembly **shall** be conducted per GMW14011 at room temperature. Vibration input frequencies and amplitudes to be used are defined in Tables 5 through 7 or as specified by the responsible VEC(s).

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Table 5: Vertical Input

Frequency (Hertz)	Acceleration $((m/s^2)^2/Hz)$
8	0.35415
11	2.41168
13	1.00952
26	0.34914
28	0.47733
33	0.44221
46	0.05615
56	0.04140
66	0.8773
87	0.0651
100	0.00329

Note: Overall G_{rms} level to be adjusted to 4.62 m/s^2 RMS.

Table 6: Fore-Aft Input

Frequency (Hertz)	Acceleration $((m/s^2)^2/Hz)$
8	0.23000
10	0.20595
12	0.48599
15	0.16562
19	0.24251
25	0.07352
30	0.21268
40	0.04177
74	0.02290
100	0.00161

Note: Overall G_{rms} level to be adjusted to 2.55 m/s^2 RMS.

Table 7: Lateral Input

Frequency (Hertz)	Acceleration $((m/s^2)^2/Hz)$
8	0.14435
10	0.16456
13	0.38976
15	0.17707
26	0.07410
35	0.16553
48	0.02194
60	0.05264
79	0.00823
100	0.00815

Note: Overall G_{rms} level to be adjusted to 2.42 m/s^2 RMS.

Note: This is an objective evaluation of the steering wheel noise when subjected to a vibration spectrum.

3.2.1.2.7.1 Test Fixtures and Equipment. Refer to GMW14011 for appropriate test fixture and equipment.

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3.2.1.2.7.2 Test Procedure.

3.2.1.2.7.2.1 Complete Service Durability Test (See 3.2.1.2.6 in this document).

3.2.1.2.7.2.2 Condition steering wheels with DAB modules at +23 °C as specified in 4.2 the Validation Plan in this document.

3.2.1.2.7.2.3 Perform objective evaluation of the steering wheel noise as described in GMW14011 using the vibration spectrum shown in Tables 5 through 7.

3.2.1.2.7.3 Evaluation and Results.

3.2.1.2.7.3.1 Steering wheels **shall** meet the steering wheel noise requirements stated in GMW14095, (Squeak, Rattle and Other Audible Noise Avoidance: Subsystem Level)

3.2.1.2.7.3.2 All noted discrepancies **shall** be documented and reported to the responsible VEC(s) engineer(s).

3.2.1.2.8 DAB Module in the Steering Wheel Deployment.

3.2.1.2.8.1 Test Fixtures and Equipment. Not applicable.

3.2.1.2.8.2 Test Procedure.

3.2.1.2.8.2.1 Complete Noise Test (See 3.2.1.2.7 in this document).

3.2.1.2.8.2.2 Randomly select one steering wheel for static tear down.

3.2.1.2.8.2.3 Perform static deployments on the remaining steering wheels, per DAB module in the steering wheel static deployment test (See 3.2.1.1 in this document).

3.2.1.2.8.3 Evaluation and Results.

3.2.1.2.8.3.1 The steering wheel **shall** meet the functional requirements stated in GMW14095, (Steering Wheel Performance During DAB Module Deployment).

3.2.1.2.8.3.2 DAB module **shall** be retained in the steering wheel.

3.2.1.2.8.3.3 During or after deployment, distortion or loosening of the mechanism and/or fasteners is acceptable provided the system meets the other requirements as stated in 3.2 Product Characteristics in this document.

3.2.1.2.8.3.4 During deployment, the steering wheel assembly **shall not** inhibit the opening of the DAB module/cover or cause fragmentation of the module.

3.2.1.2.8.3.5 The steering wheel assembly **shall not** fragment during deployment.

3.2.1.2.8.3.6 Components such as horn switches, accessory controls, etc., **shall not** separate or fragment from the steering wheel assembly/DAB module that would result in impaired occupant restraint or injury.

3.2.1.2.8.3.7 The steering wheel assembly and its components **shall not** produce any tears or cuts in the cushion.

3.2.1.2.8.3.8 All noted discrepancies **shall** be documented and reported to the responsible VEC(s) engineer(s).

3.2.1.3 Steering Wheel Strength Test Requirements.

3.2.1.3.1 Steering Wheel Bending Strength. Purpose is to evaluate steering wheel bending strength for all variants of wheels.

3.2.1.3.1.1 Test Fixtures and Equipment. Refer to GMW14594. This test shall be conducted with the complete steering wheel assembly and design representative DAB module assembly.

3.2.1.3.1.2 Test Procedure. Refer to GMW14594.

3.2.1.3.1.3 Evaluation and Results.

3.2.1.3.1.3.1 The steering wheel assembly 12:00 rim force/deflection **shall** comply with curves in GMW14095, (Steering Wheel Bending Strength).

3.2.1.3.1.3.2 The steering wheel assembly 6:00 rim force/deflection **shall** comply with curves in GMW14095, (Steering Wheel Bending Strength).

3.2.1.3.1.3.3 A minimum of 65 mm of axial deformation **shall** be reached prior to any separation of spoke-to-hub or rim.

3.2.1.3.1.3.4 All noted discrepancies **shall** be documented and reported to the responsible VEC(s) engineer(s).

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3.2.1.3.2 Steering Wheel Static Torsional Strength. Purpose is to evaluate steering wheel Static Torsional Strength.

3.2.1.3.2.1 Test Fixtures and Equipment. Refer to GMW14598.

This test **shall** be conducted with the complete steering wheel assembly and Design Representative DAB module assembly.

3.2.1.3.2.2 Test Procedure. Refer to GMW14598.

3.2.1.3.2.3 Evaluation and Results.

3.2.1.3.2.3.1 The permanent set after application of 135 ± 3 Nm Torque, **shall not** exceed 2 degrees.

3.2.1.3.2.3.2 The steering wheel assembly **shall** withstand a torque-deflection of 340 ± 7 Nm of torque at a rate of 10 ± 1 degree per minute, without cracking or breaking the covering, weldments or any structural elements of the steering wheel assembly.

3.2.1.3.2.3.3 All noted discrepancies **shall** be documented and reported to the responsible VEC(s) engineer(s).

3.2.1.3.3 Steering Wheel Assembly-Heat Distortion. Purpose is to evaluate steering wheel assembly Heat Distortion.

3.2.1.3.3.1 Test Fixtures and Equipment. Refer to GMW14596. This test shall be conducted with the complete steering wheel assembly and design representative DAB module assembly. Also, a representative steering column or fixture to represent the column interface is required.

3.2.1.3.3.2 Test Procedure. Refer to GMW14596.

3.2.1.3.3.3 Evaluation and Results.

3.2.1.3.3.3.1 There **shall** be no objectionable distortion greater than 1.0 mm in steering wheel to column or airbag Gaps and 2.0 mm in other areas or as specified in the Statement of Requirements (SOR/SOR Appendix) that will detract from the overall function/appearance of the steering wheel assembly.

3.2.1.3.3.3.2 There **shall** be no functional interference with the column, levers, or protrusions when tested with a “clearance test column”.

3.2.1.3.3.3.3 There **shall** be no rattling of the steering wheel assembly due to loosening parts.

3.2.1.3.3.3.4 The horn circuit **shall** be continuously monitored (minimum data sample rate is one sample per second) during this test.

3.2.1.3.3.3.5 All noted discrepancies **shall** be documented and reported to the responsible VEC(s) engineer(s).

3.2.1.3.4 Armature Integrity-Impact Test. Purpose is to evaluate the armature Integrity of the steering wheel assembly for all variants of wheels.

Note: Non-ferrous metallic steering wheel armatures **shall** be accelerated heat aged equivalency of 2000 h at 93.3 °C, except AM50A/AM60B/Modified 515 Aluminum Alloy formulations (as of July 2004) which are exempt from the heat aging requirement. The heat aging requirement includes characterization of material properties and to determine accelerated heat aged equivalency (on test bars) for all new non-ferrous materials. Armature Integrity-Impact Testing **shall** be required on both accelerated heat aged and non-aged materials (if heat aging has significant effects on material properties).

3.2.1.3.4.1 Fixtures and Equipment. Refer to GMW16629 and ECE R12 and EEC 74/297.

This test **shall** be conducted with complete design intent steering wheels, representative steering columns and representative DAB modules.

3.2.1.3.4.2 Test Procedure. Refer to GMW16629. Both Body Block and Head Impact testing is to be conducted by the steering wheel supplier. To determine the “most rigid spoke” and the “most flexible part of the steering wheel”, the test positions at a minimum, shall be 3:00 o’clock (center of upper spoke), 6:00 o’clock and 12:00 o’clock rim positions rotated downward. If the center of a spoke is not located close to the 3:00 o’clock or 6:00 o’clock position, then additional tests shall be conducted at that position.

Note: This test **shall** be conducted without the deployment of the DAB module and with a design representative steering column. If the steering wheel supplier cannot meet the 11 120 N requirement, the responsible VEC(s) engineer(s) will notify the steering wheel supplier, if additional tests with DAB deployments are required.

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3.2.1.3.4.3 Evaluation and Results.

3.2.1.3.4.3.1 The steering wheels **shall** meet the requirements stated in GMW14095.

3.2.1.3.4.3.2 There **shall** be no fractures of the steering wheel structural armature that would cause a loss of attachment integrity to either the column or driver airbag module. There **shall** be no fractures of the steering wheel rim or spokes. This test is to be conducted in the same manner as ECE R12/EEC 74/297/GMW16629.

3.2.1.3.4.3.3 Armature attachment integrity verification will be validated by the steering wheel withstanding a torque of 340 Nm per GMW14598.

3.2.1.3.4.3.4 All noted discrepancies **shall** be documented and reported to the responsible VEC(s) engineer(s).

3.2.1.3.5 Steering Wheel Hub Draw-Down Taper Engagement Tests.

3.2.1.3.5.1 For Global 60 Degree Attachment. Purpose is to evaluate the drawdown integrity and serviceability of the steering wheel assembly.

3.2.1.3.5.1.1 Test Fixtures and Equipment.

- Fixture to support the column shaft.
- Tensile compression test machine or equivalent capable of transmitting up to 2500 ± 25 N.
- Height gage.
- Design representative steering column shaft with a scribed mark and steering wheel armatures.

3.2.1.3.5.1.2 Test Procedure.

a. Clamp column shaft holding fixture base plate to the loading machine table.
b. Install the steering column shaft on the holding fixture and place the steering wheel assembly on the shaft using the alignment mark on the shaft and the alignment arrow on the armature.
c. Preload the steering wheel to 100 ± 5 N.
d. Measure and record the distance from the hub face surface (furthest from the rim) to a scribed mark on the column shaft.
e. Increase the load on the steering wheel to 16 kN ± 0.8.
f. Repeat step (d.).
g. Subtract step (d.) distance from step (f.) distance; this is the draw-down. Record draw-down.
h. Repeat steps (b.) thru (g.) (above) four (4) more times.
i. Use new column for each steering wheel sample.

3.2.1.3.5.1.3 Evaluation and Results.

3.2.1.3.5.1.3.1 The steering wheel minimum draw-down is to be ≥ 0.0 mm.

The steering wheel maximum draw-down is to be ≤ 0.7 mm.

The armature alignment arrow is to line up with the center of the largest blocked tooth in the hub splines. The arrow is to be raised 0.60 mm and be 6.0 mm long.

3.2.1.3.5.1.3.2 All noted discrepancies **shall be documented and reported to the responsible VEC(s) engineer(s).**

3.2.1.3.5.2 For 11 Degree Taper. The steering wheel draw-down is to be within 0.0 to 1.0 mm when tested according to the following procedure.

3.2.1.3.5.2.1 Test Fixtures and Equipment.

- Fixture to support the column shaft.
- Hand torque wrench. A power wrench can affect test results.
- Height gage.

3.2.1.3.5.2.2 Test Procedure.

a. Clamp holding fixture base plate to rigid base.
b. Install the steering column shaft and the steering wheel assembly on the holding fixture.
c. Tighten the steering column nut as follows.

- Jam Nuts: 2.7 ± 2 Nm.

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