

USCAR FRONTAL AIRBAG PERFORMANCE SPECIFICATION

SAE/USCAR-52
April 2025

ISBN: 978-1-4686-0926-4



USCAR FRONTAL AIRBAG PERFORMANCE SPECIFICATION
TABLE OF CONTENTS

1.	INTRODUCTION.....	3
1.1	Foreword	3
1.2	Scope	3
1.3	Definitions	3
1.4	Changes to this Document.....	3
2.	APPLICABLE DOCUMENTS.....	4
3.	REQUIREMENTS	4
3.1	General Requirements	4
3.1.1	General.....	4
3.1.2	Quality	5
3.1.3	Production Requirements.....	5
3.1.4	Reliability	5
3.1.5	Heavy Metal Compounds Reporting and Recyclability/Sustainability Requirements.....	5
3.1.6	Shipping Classification	5
3.1.7	Dynamic Airbag Module Performance	5
3.1.8	Testing and Reporting.....	5
3.2	Deployment Setup Requirements	6
3.2.1	Deployment Conditioning	6
3.2.2	Deployment Fixture	7
3.2.3	Deployment Video.....	7
3.2.4	Data Acquisition	8
3.2.5	Deployment Pulse and Time	8
3.3	Measurement Tolerances	8
4.	VALIDATION.....	8
4.1	Design Verification (DV)/Production Validation (PV) Report Format	9
4.2	Deviations from Test Procedure	9
4.3	DV Process	9
4.3.1	DV Program Sequence	9
4.3.2	DV Test Plan	9
4.4	PV Process	10
4.4.1	PV Program Sequence	10
4.4.2	PV Test Plan	10
5.	TEST REQUIREMENTS AND SEQUENCE.....	10
5.1	General Requirements	10
5.1.1	Test Equipment	10
5.2	General Procedures	10
5.2.1	Weight Inspection Procedure.....	11
5.2.2	Electrical Check Procedure.....	11
5.2.3	Visual Inspection Procedures	11
5.2.4	Group A: Baseline Deployments and Wire Pull	11
5.2.5	Group B: Heat Age – Low Humidity Conditioning and Deployment	12

The research data, analysis, conclusion, opinions, and other contents of this document are solely the product of the authors. Neither the SAE International (SAE) nor the United States Council for Automotive Research (USCAR) certifies the compliance of any products with the requirements of nor makes any representations as to the accuracy of the contents of this document nor to its applicability for purpose. It is the sole responsibility of the user of this document to determine whether or not it is applicable for the purposes.

Copyright © 2025 USCAR

All rights reserved.

QUESTIONS REGARDING THIS DOCUMENT: (248) 273-2470 **FAX (248) 273-2494**
TO PLACE A DOCUMENT ORDER: (724) 776-4970 **FAX (724) 776-0790**

Full document details: SAE USCAR52

5.2.6	Group C: Environmental Conditioning	13
5.2.7	Group D: Deployments with Limit Inflators.....	22
5.2.8	Group E: Non-Deployment Testing.....	22
APPENDIX A	DV/PV TEST MATRIX AND VALIDATION FLOW CHARTS	25
APPENDIX B	POST-DEPLOYMENT ACCEPTANCE CRITERIA.....	31
APPENDIX C	PUSH-IN/SNAP-IN ATTACHMENT INSERTION/REMOVAL CYCLE AND FORCES.....	33
APPENDIX D	GLOSSARY	34
APPENDIX E	Change Log.....	36
Figure 1	PAB & KAB module deformation measurements	11
Figure 2	Vehicle axes.....	15
Figure 3	Vibration profile plot	15
Figure 4	Temperature profile.....	16
Figure 5	Thermal shock temperature profile	17
Figure 6	Humidity resistance profile.....	19
Figure 7	Humidity resistance profile followed by exposure to cold	20
Figure 8	Indenter fixture	23
Table 1	Module conditioning temperatures	6
Table 2	Minimum deployment fixture requirements	7
Table 3	Generic deployment times (ms)	8
Table 4	Measurement tolerances.....	8
Table 5	Dynamic shock profile	14
Table 6	DAB, PAB and KAB service durability cycle – Post conditioning	21

1. INTRODUCTION

1.1 Foreword

This frontal airbag performance specification is a result of collaborative efforts between automotive manufacturers Ford Motor Company, General Motors, and Stellantis. Achieving a common frontal airbag module performance specification aims to improve quality, reduce component complexity, and standardize test fixtures and equipment across the industry.

1.2 Scope

This specification establishes the DV/PV performance and validation requirements for frontal airbag modules, namely driver, passenger, and knee airbags. In cases where airbag designs fall outside the scope of this standard, the Responsible Vehicle Engineering Organization (RVEO) is the final arbiter of all performance requirements within this specification.

Additional system level requirements may be introduced by the RVEO but are outside the scope of this specification.

1.3 Definitions

ACTIVE VENTING DEVICE: Pyrotechnic devices used to actuate cushion venting via strap or cord.

AIRBAG MODULE: Typically comprised of an inflator, a canister, a cushion assembly, and potentially a protective cover, horn system, wire harness and/or active venting device.

DRIVER AIRBAG (DAB): Deployable airbag module generally housed within the vehicle steering wheel.

INFLATOR: For the purposes of this specification, an inflator is a device that delivers a defined quantity or volume of gas with a defined rate of mass flow to a cushion or chamber, to directly provide occupant restraints as defined by the intended customer engineering group(s).

KNEE AIRBAG (KAB): Deployable airbag module generally housed within or under the vehicle instrument panel on either/both the driver and passenger side of the vehicle.

PASSENGER AIRBAG (PAB): Deployable airbag module generally housed within the instrument panel of the vehicle.

SHALL REQUIREMENTS: The airbag module is required to meet all shall requirements. The use of “shall” in this document denotes a binding provision that must be met unless a deviation is granted by the RVEO. Deviations to “shall” requirements will only be considered and, if approved, granted by the RVEO after evaluating appropriate available technologies and balancing all Module and restraint system performance considerations.

SHOULD REQUIREMENTS: Should requirements are to provide preferred requirements where absolute compliance is not required. “Should” denotes a preference or desired conformance which, if not met, require acceptance by the RVEO. The final determination of the subject performance requirement shall be made by the RVEO.

RESPONSIBLE VEHICLE ENGINEERING ORGANIZATION (RVEO): Intended vehicle manufacturer; OEM responsible for approving airbag module technology for use in their vehicles.

ROOF-MOUNTED PAB (RPAB): PAB modules generally housed within the vehicle headliner region that deploys downward in front of a seated passenger occupant.

For additional definitions, see Appendix D - Glossary.

1.4 Changes to this Document

This document is to be considered a living document. Revisions are to be based on relevant experience and changes to the application environments of the participating OEMs. All changes to the document are to be decided upon by a joint USCAR committee as appointed by the participating OEMs and ratified by their respective organizations.

2. APPLICABLE DOCUMENTS

In the case of new releases of the listed reference documents, the latest version shall be applicable except where direct conflicts with this specification take place. In the case of a direct conflict, the requirements defined in this specification shall be applicable.

- ASTM B117, Standard Practice for Operating Salt Spray (Fog) Apparatus
- IATF 16949:2016
- IEC 60068-2-14, Environmental testing - Part 2-14: Tests - Test Na: Change of temperature
- IEC 60068-2-27, Environmental testing - Part 2-27: Tests - Test Ea and guidance: Shock
- IEC 60068-2-38, Environmental testing - Part 2-38: Tests - Test Z/AD: Composite temperature/humidity cyclic test
- ISO 12097-2, Road vehicles - Airbag components - Part 2: Testing of airbag modules, Section 5.4 Simultaneous Vibration Temperature Test
- ISO 9001:2015, Quality management systems - Requirements
- ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories
- MIL-STD-810G, Environmental Engineering Considerations and Laboratory Tests
- SAE J1630, Airbag Module Deployment Test Procedure
- SAE J211, Instrumentation for Impact Test
- SAE J2238, Airbag Inflator Ballistic Tank Test Procedure, Gas Generating Devices Used in Inflatable Restraint Systems
- SAE/USCAR-24, Inflator Technical Requirements and Validation
- SAE/USCAR-28, Initiator Technical Requirements and Validation
- USCAR Standard Connector Pocket Chart Drawing 999-U-002-1-Z02

3. REQUIREMENTS

3.1 General Requirements

3.1.1 General

The airbag module supplied under this specification shall meet all functional requirements outlined in this specification, both before and after the environmental conditioning specified and over the deployment temperature range. This specification represents a minimum set of requirements.

Any technology that presents functional, quality, and/or durability issues that are not addressed in this specification shall be required to complete additional testing. Test requirements of such systems shall be proposed by the airbag module supplier and agreed to by the RVEO.

NOTE: Nothing in this specification supersedes applicable laws and regulations.

3.1.2 Quality

All structural and performance related features shall be manufactured and/or processed in accordance with automotive industry accepted quality requirements (PPAP per AIAG or IATF 16949 process) for purchased materials and shall be done with the concurrence of the RVEO Supplier Quality Assurance group(s). External laboratory and test facilities shall be accredited to ISO 17025 or equivalent by the American Association for Laboratory Accreditation (A2LA), the Standards Council of Canada (SCC), ISO, or other locally accepted laboratory accreditation program.

All inflators used in module testing outlined within this specification shall be QFS approved to SAE/USCAR-24. All other pyrotechnic devices (i.e., pin puller, micro gas generators, etc.) shall be QFS approved to SAE/USCAR-28, SAE/USCAR-24 or RVEO approved test plan.

3.1.3 Production Requirements

Airbag modules qualified to this specification shall meet this specification on an ongoing production basis throughout the life of the program unless specifically excepted by the RVEO. This specification does not apply to production lot acceptance test (LAT) requirements. Refer to RVEO requirements.

3.1.4 Reliability

Reliability/durability test procedures are required to demonstrate at engineering level (with a given probability and level of confidence) that a system or component will perform its intended functions over the expected useful life, under all anticipated operating conditions and environments as specified in preceding sections. The tests must ensure that expected design and process variations are covered, resulting in adequate product robustness. Test to Failure (TTF) is the preferred test methodology.

a. Vehicle Useful or Service Life Requirements: 15 years/150000 miles

b. Minimum Reliability and Confidence Demonstration: R95/C90

3.1.5 Heavy Metal Compounds Reporting and Recyclability/Sustainability Requirements

The airbag module supplier shall provide timely information verifying product compliance with current RVEO requirements regarding the use of heavy metals or heavy metal compounds in the manufacture of the airbag module. At the request of the RVEO, the airbag module supplier shall provide a breakdown of the materials in the airbag module for recycling purposes.

3.1.6 Shipping Classification

The airbag module supplier shall provide evidence of shipping 'Competent Authority' approval for target jurisdictions and programs. In addition, the test data utilized to comply with all applicable government shipping regulations, including auto-ignition regulations, in countries where the module(s) are manufactured and transported, shall be summarized (with conclusions) and provided to the RVEO through submission as a subsection of the DV report (i.e., UN Class 9, DOT, CTC, TUV, BAM, CE, UKCA, etc.).

3.1.7 Dynamic Airbag Module Performance

Dynamic airbag module performance (i.e., drop tower, pendulum, linear impactor, or other equivalent device) shall be demonstrated if requested by the RVEO.

3.1.8 Testing and Reporting

3.1.8.1 Ethics in Testing and Reporting

Airbag module supplier shall adhere to the highest levels of ethical standards in all aspects of engineering testing, analysis, and reporting of data. All testing non-conformances/failures should be reported to the RVEO within 24 hours of occurrence during testing or detection during post-test parts review. RVEO shall review and approve as required before proceeding with additional validation testing within the test group.

3.1.8.2 Test Sample Control

All airbag modules produced for the sole purpose of validation testing and evaluations (including “extra”/mistake protection stock) shall be serialized in original planned sequence, secured, and stored as “validation parts” and shall not be intermingled with production stock.

All test samples shall be saved for review and shall not be scrapped without prior approval from the RVEO. Consult with the RVEO for any additional tested sample retention requirements.

3.1.8.3 Testing/Evaluation Errors

If a testing (i.e., equipment, facilities) error occurs, a thorough engineering analysis of the “root cause” of the error shall be performed. RVEO shall be notified of any testing errors or within 24 to 72 hours of occurrence. RVEO review and approval is required before proceeding with validation testing utilizing “extra”/mistake protection stock. Examples of testing errors include (but not limited to) samples conditioned at the incorrect temperature, reversed firing lines, and instrumentation malfunction. Testing errors do not include sample failures/non-conformances to this performance specification.

3.1.8.4 Data Integrity

All data gathered from all tested airbag modules shall be reported, including any testing/evaluation errors as described in 3.1.8.3. Data is to be communicated in its “native collection form” upon request. No truncation or exclusion of data is permitted.

3.2 Deployment Setup Requirements

This section describes the different testing setup parameters. Calibration of all equipment shall be done at an appropriate time interval as determined by the usage or recommendation of the equipment manufacturer. Records of the calibration shall be maintained and made available at the request of the RVEO.

3.2.1 Deployment Conditioning

Pre-deployment module conditioning temperatures are defined per Table 1.

Table 1 - Module conditioning temperatures

Module Type	Hot Temperature	Ambient Temperature	Cold Temperature
DAB	+80 °C	+23 °C	-30 °C
PAB	+70 °C	+23 °C	-30 °C
KAB	+70 °C	+23 °C	-30 °C
RPAB	+75 °C	+23 °C	-30 °C

Airbag modules shall be conditioned for 4 hours at the temperatures per Table 1 prior to deployment. If the supplier desires to condition less than 4 hours, a temperature study shall be conducted to show the module core temperature is reached sooner than 4 hours. RVEO shall approve temperature study results.

Temperature and environmental conditioning chambers shall be within stated tolerance in Table 4 throughout the entire chamber volume and large enough to permit air circulation between the samples.

Deployment test area environment (e.g., laboratory) should be at ambient temperature (+23 °C). If the test area environment cannot be maintained within the ± 5 °C tolerance, the parts shall be conditioned in a chamber at +23 °C for 1 hour prior to deployment.

Module deployment shall occur within 2 minutes $\pm$ 5 seconds after opening the climate chamber or after removing the airbag module from the conditioning chamber.

The relative humidity (RH) within the laboratory/deployment test area should be 50%. The supplier shall note the laboratory RH at the time of deployment.

3.2.2 Deployment Fixture

Each module type will require a unique fixture to accommodate vehicle program specific fastening strategies, connections, etc. Thus, there is no one fixture design in this specification. Module mounting shall simulate vehicle environment, including reaction surfaces when applicable.

All fasteners, clips, and attachments, including installation torque, shall be vehicle program representative. Any deviation from program/design intent shall be approved by the RVEO.

The deployment fixture shall be of “rigid” design in vehicle position/orientation, constructed of steel or similar material, and designed for little to no deformation after being subjected to repeated deployments. Exception: DAB per Table 2 - Minimum deployment fixture requirements. Fixture shall be validated and dimensionally verified prior to use per RVEO direction. The RVEO shall be the final arbiter for fixture design and execution. Minimum fixture requirements for each airbag type are defined in Table 2 - Minimum deployment fixture requirements. A typical DAB and PAB setup is detailed in SAE J1630 Appendix C.

Table 2 - Minimum deployment fixture requirements

Module Type	Fixture
DAB	Use program intent or RVEO approved steering wheel armature and DAB mounting interface (e.g., SW fixtures with springs)
PAB	- Use rigid steel fixture with intended IP profile, PAB attachment points and uncovered opening or RVEO approved fixture design (e.g., PAB fixture with spring or torsion bar). - Windshield reaction surface must be included. - Can be acrylic (Plexiglass), polycarbonate (Lexan), or Teflon coated aluminum material. - Program intent windshield angle set at occupant centerline section coordinates. - No curvature required. - Any other IP components that could interact with PAB (screens, grab handles, etc.) can be simulated on the rigid fixture at RVEO's request.
KAB	- Use rigid steel fixture with intended IP Profile and KAB attachment points. - Knee bolster or glove box reaction surface must be included. - Program intent gaps and clearances to KAB module. - Bolster angle and geometry set at program intent. - If driver side KAB, include representative lower steering column cover in fixture. - If mid-mounted KAB and includes discrete Class-A deployment door: - Program intent gaps and clearances to KAB module. - Include provisions to attach the discrete door, if required.

3.2.3 Deployment Video

Laboratory shall capture deployment video with a minimum 2000 fps (frames/second) in high definition.

Deployment video shall be recorded from 5 ms before $t = 0$ ms and of sufficient duration to capture the entire deployment event.

Lights shall be setup in a manner that provides sufficient lighting for all camera views but does not wash out cushion images, nor influence temperature characteristics of the airbag module.

Minimum two cameras shall be used, one for rear view and one LH or RH side view. Additional cameras shall be included per RVEO direction.

A grid board (or equivalent method) as approved by RVEO shall be utilized in each camera view. Digital tracking software should be used (e.g., TrackImage, TrackEye) in addition to the grid to record variable cushion trajectory data during deployment. Digital gridlines are also allowed (e.g., non-physical grid generated by the tracking software).

The test number shall have a unique, non-repeating identifying format for each test and shall be visible in all camera views.

3.2.4 Data Acquisition

All pyrotechnic devices' trigger voltage and amperage versus time shall be measured and recorded via data acquisition system per SAE J211. Deployment data shall be recorded starting at 5 ms before $t = 0$ ms and for a minimum of 200 ms.

3.2.5 Deployment Pulse and Time

All airbag module pyrotechnic devices shall be triggered with a USCAR24 compliant all-fire pulse of 1.20 A/2.0 ms or 1.75 A/0.5 ms.

Program airbag fire timing shall be used as defined by the RVEO. If program airbag fire timing is not specified, generic deployment times per Table 3 - Generic deployment times should be used.

Table 3 - Generic deployment times (ms)

Dual Stage (DS) Deployment Times			
	DS Stage 1	DS Stage 2	DS w/Active Vent
High Output	0	5	150
Low Output	0	150	35
Single Stage (SS) Deployment Times			
	SS No Active Vent	SS w/Active Vent	
Hot Deploy	0	150	
Ambient Deploy	0	35	
Cold Deploy	0	35	

3.3 Measurement Tolerances

Measurement tolerances shall be as shown in Table 4 - Measurement tolerances.

Table 4 - Measurement tolerances

Time	±1% (except where minimums are stated)
Temperature (except Lab Environment)	±3 °C
Lab Environment Ambient Temperature	±5 °C
Relative Humidity	±10% of RH
Height	±1 mm
Frequency	±4% or ± 2 Hz, whichever is greater
Current	±0.01 A
Voltage	±5%
Resistance	±1.0%
Firing Pulse	±25%
Mass	±1 g
Force	±2 N

All test conditions shall be within the above stated tolerances at the time of test. These tolerances shall not be used independently.

4. VALIDATION

The airbag module supplier shall develop the test plan (DVP&R) and determine if further testing and/or larger sample sizes are required based on the DFMEA and PFMEA. The airbag module development, DV, and PV test plans shall be approved by the RVEO prior to implementation.

Any change to a DV- or PV-qualified airbag module's structure, part configuration, manufacturing method, or any other change that could alter the outcome of any tests included in the DV or PV specification contained herein shall require re-validation. Re-validation may be accomplished through a subset of the requirements (delta DV or PV) containing only tests where the outcome is influenced by those changes. Any delta DV or PV shall be agreed to in advance by all affected parties at the RVEO.

Laboratory and test facilities shall be accredited by the American Association for Laboratory Accreditation (A2LA), the Standards Council of Canada (SCC), ISO (e.g., ISO 16949) or other locally accepted laboratory accreditation program.

4.1 Design Verification (DV)/Production Validation (PV) Report Format

DV and PV test reports shall include as a minimum the following formatted items. Additional items shall be included as required by the RVEO.

1. Summary: The summary shall include a clear and complete description of the device tested, including part numbers, revision levels, etc., a description of tests performed, and analysis of test results.
2. Test Plan: The test plan shall include the configuration document detailing the exact configuration tested, future product changes not included in the current test configuration (if applicable), test schedule (projected or actual dates) and test plan (including test location and equipment).
3. Appendices: Upon request by RVEO, appendices should include detailed build records, conditioning records, detailed test results, equipment description and certification or any other supporting data.

4.2 Deviations from Test Procedure

Pre-test deviations from specified test requirements and procedures shall be approved in writing by the RVEO prior to beginning the test procedure.

In the case that a deviation occurs during the conditioning and/or testing of the device, the RVEO shall be notified as soon as practical, verbally and in writing, as to the circumstances of the deviation. The RVEO shall determine if further testing is required to maintain the intent of the test requirements. All deviations and supporting information shall be included in the test report.

4.3 DV Process

4.3.1 DV Program Sequence

Following is the recommended DV process:

1. Airbag module supplier completes requirements as outlined in Section 3.2 - Deployment setup requirements and reviews with the RVEO for approval.
2. Airbag module supplier completes configuration document/test plan and makes them available to the RVEO for review.
3. The RVEO reviews the information and DV test plan. All proposed changes to the plan shall be submitted for review to the RVEO for agreement prior to implementation.
4. DV Build proceeds. The RVEO should be given the opportunity to attend the DV Build and subsequent testing.
5. The RVEO should approve the parts supplied for DV testing and authorizes the supplier to proceed with the test plan.

NOTE: Proceeding with a DV without RVEO review and approval is at the supplier's own risk and may result in refusal to accept the test report and/or additional testing.

4.3.2 DV Test Plan

The DV test plan shall be structured in accordance with Appendix A - DV/PV test matrix and validation flow charts.

Samples utilized for DV shall meet specified drawings tolerance range.

Any delta DV report shall clearly reference the previously completed DV report(s) containing the surrogate data used to fulfill all DV requirements.

Upon request by RVEO, copies of the original data shall be included in the DV report along with a detailed description of the source and applicability of the data.

4.4 PV Process

4.4.1 PV Program Sequence

The PV process shall proceed according to the following sequence.

1. Airbag module supplier prepares package for Supplier Quality Assurance and/or RVEO showing compliance with design and manufacturing requirements (including PFMEA) as required by PPAP.
2. Airbag module supplier completes configuration document, test plan, and time schedule and provides completed documents to all Supplier Quality Assurance and/or RVEO for review and agreement.
3. Supplier Quality Assurance and/or RVEO approves documentation including PFMEA and PV test plan. Once the PV test plan has been approved, any additional changes to the plan shall be submitted to Supplier Quality Assurance and/or RVEO for approval prior to implementation.
4. PV build proceeds. The PV build should be built at production capacity planned cycle time. The RVEO should be given the opportunity to attend the PV build and all subsequent testing.
5. The RVEO shall approve the parts supplied for PV testing and authorizes the supplier to proceed with the test plan.

4.4.2 PV Test Plan

The PV test plan shall be structured in accordance with Appendix A - DV/PV test matrix and validation flow charts.

PV shall meet statistical capabilities for machine and manufacturing processes.

PV samples shall be produced off the production line, preferably at the production rate. All sub-components shall be produced at the production location with production tooling and under production processes.

Any delta PV report shall clearly reference the previously completed PV report(s) containing the surrogate data used to fulfill all PV requirements.

Copies of the original data should be included in the PV report along with a detailed description of the source and applicability of the data.

5. TEST REQUIREMENTS AND SEQUENCE

5.1 General Requirements

5.1.1 Test Equipment

Test equipment shall be utilized as specified by the indicated test procedures, standards, and specifications. Calibration of all equipment shall be done at an appropriate time interval as determined by the usage or recommendation of the equipment manufacturer. Records of the calibration shall be maintained and made available at the request of the RVEO.

5.2 General Procedures

All static deployment tests shall be conditioned per Table 1 - Module conditioning temperatures, fixtured per Table 2 - Minimum deployment fixture requirements, and deployed per Appendix A - DV/PV test matrix and validation flow charts schedule based on restraint type. See Section 3.2 - Deployment setup requirements for all test setup, fire times, camera coverage, etc.

All static deployment tests except Group D (Limit Testing) shall utilize "Nominal" inflator output per program and not inflator ballistic tank curves according to USCAR-24.