

Initiator Technical Requirements and Validation

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Change Log

This Change Log lists all approved changes implemented in this document since the last published version. For the original release of the document the Change Log is empty.

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USCAR INITIATOR TECHNICAL REQUIREMENTS AND VALIDATION **(DRIVER, PASSENGER, & SIDE SYSTEMS)**

1. INTRODUCTION

1.1. Scope

This specification establishes the design, performance, and validation requirements for the initiator assembly used in airbag modules, seatbelt pretensioners and/or any other Electro-Explosive Devices (EED).

1.2. Preface Definitions

Initiator: For the purposes of this specification an initiator shall include an electro-explosive device (including electro-ignited micro gas generators of single charge container design). Specific design elements are not limited except by the performance and reliability requirements contained herein.

Degradation (following environmental conditioning): The term "degraded" refers to dudding, change in bridge circuit resistance out side of tolerance range, change in electrical sensitivity out side of tolerance range or an increase in average Time To First Pressure (TTFP) and/or a change in average peak pressure (as measured in a closed bomb) greater than 20% of the average of a virgin control group (i.e. DV/PV baseline group) when deployed using the all fire pulses detailed in Sections 3.2.1.3 and 3.2.1.4 of this document.

Shall Requirements: The initiator is required to meet all shall requirements without exceptions.

Should Requirements: Should requirements are to provide preferred requirements where absolute compliance is not possible within current technology limitations.

For additional definitions see Appendix H Glossary.

2. APPLICABLE DOCUMENTS

MIL-STD-202 Method 213B	Mechanical Shock
MIL-STD-202F Method 101D	Salt Spray
MIL-STD-202F Method 106E	Moisture Resistance Cycle
MIL-STD-131A Test 105.1	Temperature/Humidity Cycle
MIL-STD-833D Method 1003	Insulation Resistance
MIL-STD-1576 Method 2201	Bridge Circuit Resistance
MIL-STD-1576 Method 2205	ESD
SAE J1113-13	ESD
SAE/USCAR-2	Standard for Automotive Electrical Connection Systems
PPAP	
QS9000	

3. REQUIREMENTS

3.1. General Requirements

3.1.1. General

The initiator supplied under this specification shall meet all of the functional requirements outlined for a fifteen year vehicle life. The initiator shall meet these requirements both before and after the environmental conditioning specified and over the temperature range of -40C to +85C.

3.1.2. Reliability

All structural and performance related features shall be manufactured and/or processed in accordance with automotive industry accepted quality requirements for purchased materials and shall be done with the concurrence of the intended vehicle manufacturer's Supplier Quality Assurance group(s).

3.1.3. Tolerances for Testing & Environmental Conditioning

Unless otherwise specified, the tolerances to be used shall be as follows:

Time	± 1% (except where minimums are stated)
Temperature	± 3C
Relative Humidity (R.H.)	± 10 %
Force	± 4 Newtons
Acceleration	± 2%
Vacuum	± 10 mm Hg
Frequency	± 4% or ± 2 Hz (which ever is greater)
Current	± 0.01 amps
Voltage	± 5%
Resistance	± 1%

Note: Unless otherwise specified all test temperatures shall be at ambient (23C).

3.2. Functional Requirements

3.2.1. Electrical

3.2.1.1 Bridge Circuit Resistance

The bridge circuit resistance shall be 2.00 ± 0.30 ohms over the temperature range of -40C to +85C (per MIL-STD 1576 (USAF) Method 2201 or equivalent).

3.2.1.2 Insulation Resistance

The insulation resistance shall be a minimum of 1 megohm when tested using 500 volts DC for 2 seconds (per MIL-STD 833D Method 1003, Condition E (500 VDC) or equivalent).

3.2.1.3 All Fire Constant Current

The initiator shall demonstrate an all fire current value with 0.99999 reliability and 95% confidence (as determined by the Bruceton Method Appendix D and/or Neyer D-Optimal per Neyer, 1994 Appendix E) of no greater than 1.20 amperes DC at -40C and +23C. The current level shall be determined by varying the current in the firing circuit shown in Figure 1 of Appendix A of this document. Delivery of energy from the constant current power source to the initiator shall be terminated 2 milliseconds after initializing the discharge. The ballistic function time shall meet the requirements of 3.2.3.1 Ballistic Function Time.

3.2.1.4 All Fire Constant Voltage All Fire Constant Resistance

The initiator shall demonstrate an all fire current value with 0.99999 reliability and 95% confidence (as determined by the Bruceton Method, Appendix D and/or Neyer D-Optimal per Neyer, 1994 Appendix E) of no greater than 6 Volts at -40C and +23C. The current level shall be determined by varying voltage and holding the resistance of the total circuit to 4.0 ohms as shown in Figure 2 of Appendix A of this document. Delivery of energy from the power source to the initiator shall be terminated 2 milliseconds after initializing the discharge. The ballistic function time shall meet the requirements of 3.2.3.1 Ballistic Function Time.

3.2.1.5 No Fire

The initiator shall demonstrate a no fire current value with 0.999 reliability and 95% confidence (as determined by the Bruceton Method Appendix D and/or Neyer D-Optimal per Neyer, 1994 Appendix E) of no less than 0.400 amperes constant current DC pulse at +23C and +85C. Delivery of energy from the constant current power source to the initiator shall be terminated 10 seconds after initializing the discharge.

3.2.1.6 High Current

The initiator shall deploy when subjected to 40 amperes $\pm 5\%$, nominal of DC current for a duration of 2 milliseconds at -40 C and +85 C per the matrix in appendix C.

3.2.1.7 Monitor Current

3.2.1.7.1 Continuous

The initiator shall not degrade and shall not deploy when subjected to a 160 milliampere DC continuous current at +85C for 42 days (1008 hours).

3.2.1.7.2 Pulsed

The initiator shall not degrade and shall not deploy when subjected to 60,000 cycles of a periodic current pulse of 50 milliseconds 'on' duration, 160 milliamperes amplitude, 1 second 'off' duration.

3.2.1.8 Electrostatic Discharge (ESD)

3.2.1.8.1 Standard ESD

The initiator shall not degrade and shall not deploy when subjected to the following capacitive discharge test.

Charge a 500 picofarad capacitor (+/- 10 %) to 25,000 volts (+/- 250 V) and then discharge through a 5000 ohm resistor (+/- 10%) connected in series to the initiator. Subject the initiator to 5 discharges with a minimum of 5 seconds between discharges (per MIL-STD-1576, Method 2205) via each of the following connections:

- 1) pin to pin or lead to lead
- 2) pin A or lead A to body
- 3) pin B or lead B to body
- 4) shorted pins or leads to case

3.2.1.8.2 SAE J1113-13 ESD

The initiator shall not degrade and shall not deploy during testing. Each unit shall be subjected to five positive and five negative polarity discharges at each voltage level using direct contact discharge for a total of 200 pulses. There shall be a minimum of 5 seconds between discharges as detailed in SAE procedure J1113-13 using a 150 picofarad capacitor through a 500 ohm resistor at $\pm 4, 8, 15, 20, 25$ Kilovolt levels, via each of the following connections:

- 1) pin to pin or lead to lead
- 2) pin A or lead A to body
- 3) pin B or lead B to body
- 4) shorted pins or leads to case

3.2.1.9 Electromagnetic Interference (EMI)

The initiator shall not degrade and shall not deploy when exposed to large-signal RF energy over 10 to 1500 Megahertz.

RF Absorbed Power Withstand shall be 3 watts for a duration of 60 seconds. Pin type initiator shall be tested with a standard RF filtered connector as specified by the Vehicle Engineering Organization and intended for production. The type and part number of the connector shall be reported as part of the test configuration.

Note: See Appendix G for detailed procedure.

3.2.1.10 Transient Pulse

The initiator shall not degrade and shall not deploy when subjected to the transient pulse (see detail in Appendix A Figure 3 of this specification) at 250 Hz for 24 hours.

3.2.2. Mechanical

3.2.2.1 Overall Dimensions

The initiator's overall dimensions and external configuration shall conform to the requirements set forth in the standard interface drawing (Appendix F) or by the applicable airbag inflator or pretensioner manufacturer.

3.2.2.2 Assembly

3.2.2.2.1 Pin-Type Initiator

The initiator assembly shall include an EED and pins to provide an interface for an integral electrical connector containing an EMI suppression device in accordance with SAE/USCAR-2 "Standard for Automotive Electrical Connection Systems".

3.2.2.2.2 Leadwire Initiator

The initiator assembly shall include an EED and EMI suppression device and leadwires.

3.2.2.2.3 Hermetic Seal

The initiator pyrotechnic chamber assembly shall pass a gross and fine Helium leak (or equivalent test) check at $< 1.0 \times 10^{-6}$ cc/sec at 1 atm differential pressure with an assumed internal He concentration of 100%.

3.2.2.3 Initiator Pins

3.2.2.3.1 Dimensions

The pins shall be 1.00 ± 0.03 mm in diameter. The pin spacing from centerline to centerline shall be 3.06 ± 0.25 mm. See Appendix F for common interface drawing.

3.2.2.3.2 Durability of Plating

Pin-type initiators shall have gold plated contact pins (or other noble metal or noble metal alloy approved by intended vehicle manufacture(s)). For pin-type initiators, the gold plating (or other approved plating) shall not exhibit signs of cracking, lifting, or wear-through after being subjected to 10 mate/unmate cycles using the appropriate mating connector. Evaluation of mating surfaces to be done at 10X magnification.

3.2.2.4 Leadwire

3.2.2.4.1 Size

The leadwires should be of sufficient strength to carry the full weight of the intended module (18 gauge/.8mm, 41 strand, tinned core wire is recommended or as defined by the intended vehicle manufacturer).

3.2.2.4.2 Strength

The tensile force required to separate, or otherwise damage, the electrical leads and the initiator pin to lead connection points shall be a minimum of 45 Newtons and should be a minimum of 100 Newtons.

3.2.2.4.3 Colors

3.2.2.4.3.1 Inert Initiators

Inert initiators shall have two blue leadwires and/or be clearly and permanently marked as inert by some other means. Inert pin-type initiators shall be identified by blue paint on the initiator cup, by blue molding material, and/or be clearly and permanently marked as inert by some other means.

3.2.2.4.3.2 Live Initiators

Wire color combinations for live initiators shall be determined by the inflator manufacturer and/or vehicle manufacturers to comply with their internal requirements and standards.

3.2.2.5 Structural Integrity

Upon deployment, no leakage of the pin to header seal shall occur. Separation of the charge cup at the weld interface shall not occur.

3.2.3. Ballistic

3.2.3.1 Ballistic Function Time

When deployed using the all fire pulses described in Sections 3.2.1.3 and 3.2.1.4, the time from the application of first current to the time of first pressure or first light emission, or some other accepted method of defining the initial moment of initiator output in a closed bomb, shall be 2 milliseconds maximum.

3.2.3.2 Ballistic Output

To be determined as required by the applicable airbag inflator manufacturer unless otherwise stated herein.

4. VALIDATION

A single validation shall suffice for a given configuration with various output charge sizes, however, any change to the bridge mix / ignition element interface, header / pin interface, or any other change that might alter the outcome of any test (series) contained herein shall require re-validation.

Laboratory and test facilities must be accredited by Association for Laboratory Accreditation (A2LA), the Standards Council of Canada (SCC), or an equivalent accrediting organization.

4.1. Characterization of New Initiator Technologies

Prior to undergoing validation, any and all new initiator technologies should first complete a characterization test program in order to provide compatibility information with the control and diagnostic module. This information shall be supplied to the vehicle manufacturers upon request. The requirements of the characterization test program are given in Appendix B of this document.

4.2. Radio Frequency Interference (RFI) Suppression Device Presence

For leadwire type initiators containing RFI suppression devices, the presence of the RFI suppression device shall be verified via 100% final inspection. Prior to validation testing, each supplier shall establish an inspection plan for this component. The inspection plan shall detail the inspection process and success criteria. Upon request, the plan shall be provided to vehicle manufacturers for review.

4.3. Design Verification/Production Validation Report Format

DV and PV Test reports shall be reported in the following format:

1. Summary:

The summary shall include a description of the device in test, cut away drawing of the device in test, indentured bill of materials (including part numbers, rev. levels, etc.), summary description of test results including performance and/or test deviation(s), and ballistic summary charts.

2. Test Plan:

The Test Plan shall include the configuration document detailing the exact configuration tested, any known future product changes not included in the current test configuration, test schedule (projected dates) and test plan (including test location and equipment).

3. Appendices:

Appendices should include detailed build records, conditioning records, detailed test results, equipment description and certification (if required) and any other supporting data.

4.4. Deviations From Test Procedure

Deviations from specified test requirements and/or procedures, shall be approved in writing by the intended vehicle manufacturer's engineering personnel, prior to beginning the test procedure. In the case that the deviation occurs during the conditioning and/or testing of the device, the intended vehicle manufacturer's engineering personnel, shall be notified as soon as practical in writing as to the circumstances of the deviation. The intended vehicle manufacturer's engineering personnel will determine if further testing is required to maintain the intent of the test requirements. All deviations shall be included in the Test Report Summary. The respective detailed documentation shall be included under an addendum titled, 'Deviations' in the DV and PV reports.

4.5. Design Verification Process

4.5.1. DV Program Sequence

Following is the recommended Design Verification (DV) process:

- 1) Supplier completes DFMEA and makes it available to intended customer(s) for review.
- 2) Supplier completes configuration document, test plan, and makes them available to intended customer(s) for engineering review.
- 3) The intended vehicle manufacturer's engineering group(s) review the DFMEA and DV test plan. Once the DV test plan has been approved, any and all proposed changes to the plan shall be submitted for review to the intended customer(s) responsible engineering groups for approval prior to implementation.
- 4) DV build proceeds. OEM shall be given the opportunity to attend the DV build.

NOTE: Proceeding with a DV without customer review and approval is at the suppliers own risk and may result in additional testing.

4.5.2. DV Test Plan

The DV test plan shall be structured in accordance with Table 1 of Appendix C of this document. It consists of 9 initiator test sub-groups (A through H).

Sub-groups A and B establish the initiator's baseline Bruceton or Neyer D-Optimal and ballistic performance. Sub-groups C₁ and C₂ establish the initiator's Bruceton or Neyer D-Optimal and ballistic performance following exposure to the "Sequential" environment. For this sub-group, the series of environmental exposures shall follow the sequence given in Table 1 of Appendix C without exception. The purpose of sub-groups D through H is to establish the initiator's ballistic performance after exposure to a variety of other specialized environments.

4.6. Production Validation Process

4.6.1. PV Program Sequence

The production validation (PV) process shall proceed according to the following sequence:

- 1) Supplier prepares package for Supplier Quality Assurance and/or responsible engineering groups of intended customer(s) showing compliance with design and manufacturing requirements as required by PPAP or QS9000.
- 2) Supplier completes PFMEA and provides completed document to Supplier Quality Assurance and/or responsible engineering groups of the intended customer(s) for review and approval PPAP and QS9000.
- 3) Supplier completes configuration document, test plan, and time schedule and provides completed documents to Supplier Quality Assurance and/or responsible engineering groups of the intended customer(s) for review and approval. PV test plan shall be structured in accordance with Table 1 as given in Appendix C of this document.
- 4) Supplier Quality Assurance and/or responsible engineering groups of intended customer(s) approves documentation including PFMEA and PV test plan. Once the PV test plan has been approved, any and all proposed changes to the plan shall be submitted to Supplier Quality Assurance for approval prior to implementation.
- 5) PV build proceeds. OEM shall be given the opportunity to attend the PV build.

4.7. Validation Tests & Environments

4.7.1. General Requirements

4.7.1.1 Ballistic Test Device

All ballistic deployments shall be performed in a closed bomb.

4.7.1.2 Allowable Time Period for Ballistic Test

Test initiators shall be deployed at temperature, and within 2 minutes of removal from the conditioning chamber. On occasions where the initiator cannot be deployed at conditioned temperature, the initiator shall be reconditioned for a minimum of 1 hour at the required temperature.

4.7.1.3 Pass/Fail Criteria

The initiators shall not degrade and shall not deploy (except where indicated) during exposure to the following environments and tests.

4.7.2. Tests

4.7.2.1 Electrical Resistance & Low Temperature Baseline Test

The test initiators shall be conditioned for 4 hours at -40C. The bridge circuit resistance shall be measured and the units shall be deployed at the conditioned temperature.

4.7.2.2 Electrical Resistance & Room Temperature Baseline Test

The test initiators shall be conditioned for 4 hours at +23C. The bridge circuit resistance shall be measured and the units shall be deployed at the conditioned temperature.

4.7.2.3 Electrical Resistance & High Temperature Baseline Test

The test initiators shall be conditioned for 4 hours at +85C. The bridge circuit resistance shall be measured and the units shall be deployed at the conditioned temperature.

4.7.3. Environments

Tests 4.7.3.1 through 4.7.3.9 are sequential per the test matrix (Appendix C). Tests 4.7.3.10 through 4.7.3.13 are stand alone tests per the test matrix (Appendix C). The initiator(s) in test shall not deploy when subjected to the environments and shall not degrade based on subsequent deployment per the test matrix (Appendix C).

4.7.3.1 Mechanical Shock

The test initiators shall be exposed (per MIL-STD-202, Method 213B, or equivalent) to a half sine shock of 60 g's magnitude and 6 milliseconds duration. The shock shall be applied 2 times each in the plus and minus directions, and in each of 3 mutually perpendicular axes, for a total of 12 shocks. One axis shall be parallel to the primary axis of the initiator (i.e., parallel to the centerline of the initiator's pins or lead wires).

4.7.3.2 Thermal Shock Cycle

The test initiators shall be exposed to 25 thermal shock cycles where one cycle is defined as:

- Step 1) 40 minute soak at -40C
- Step 2) 40 minute soak at +107C

The maximum transition time between steps (outlet air temperatures) shall be 5 minutes as measured by the outlet air temperature of the conditioning chamber.

4.7.3.3 Random Vibration/Thermal Profile

Apply the random vibration profile for a minimum of 22 hours along each axis. The X-axis is an axis parallel to the centerline of the initiator's pins. Y- and Z-axes are mutually perpendicular to this axis. The vibration profile is shown in the following table.

NOTE: The test initiators shall be firmly mounted to a rigid test fixture in a manner approximating that of the intended application. The bridge circuit continuity shall be continuously monitored throughout the vibration exposure using an appropriate low current measuring technique. For this test the production initiator connector is not required; any reliable connection can be used.

1. Condition Initiator for a minimum of 1 hour at 23°C.

Table 4.7.3.3.A

Frequency range: 5 - 1000 Hz		
PSD (Power Spectral Density) Level at:	5 Hz	$20 \text{ m}^2 / \text{s}^3 = 0.21 \text{ g}^2/\text{Hz}$
	30 Hz	$20 \text{ m}^2 / \text{s}^3 = 0.21 \text{ g}^2/\text{Hz}$
	200 Hz	$1.1 \text{ m}^2 / \text{s}^3 = 0.011 \text{ g}^2/\text{Hz}$
	1 kHz	$0.22 \text{ m}^2 / \text{s}^3 = 0.0023 \text{ g}^2/\text{Hz}$
Maximum acceleration:		$33 \text{ m} / \text{s}^2 = 3.365 \text{ g RMS}$

2. Apply temperature cycle of 11 hours total twice during each axis of vibration testing. One temperature cycle consists of the following steps:
 - Drop temperature to -40°C at the rate of 2°C / minute
 - Condition Initiator for a minimum of 270 ± 5 minutes at -40°C
 - Raise temperature to 90°C at the rate of 2°C / minute
 - Condition Initiator for a minimum of 270 ± 5 minutes at 90°C.
 - Bring inflators to 23°C at the rate of 2°C / minute
3. Optional: Verify Initiator terminal-to-terminal resistance.
4. Condition Initiator for a minimum of 1 hour at 23°C. Change vibration direction to Y-axis (Inflator's axis) repeat steps 2 and 3.
5. Condition Initiator for a minimum of 1 hour at 23°C. Change vibration direction to Z-axis (Inflator's axis), repeat step 2 and 3.

The temperature profile is shown in the following figure.