SAE International

SAE/USCAR-24

Issued 2004-06

USCAR INFLATOR TECHNICAL REQUIREMENTS AND VALIDATION

SUMMARY OF CONTENTS

QUESTIONS REGARDING THIS DOCUMENT: (724) 772-8518 FAX (724) 776-3036
TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX (724) 776-0790

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.

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.

Paragraph Affected	Description of Change	Date
5.2.3.7.2 Item 1d	Change slope reporting requirement to be consistent with slope requirement in Table 3.2.7A	5/28/2002 USCAR Committee S Stram M Quade L Knowlden
3.2.2.1	Stable production processes of a minimum of 1 year at a minimum of 500K/yr run rate, has been established. In no case shall the inflator structural margin fall below 1.35 as calculated per Section 5.2.4.2 *Structural Burst Test* .	
2.0	Updated to require the latest version of referenced documents	
3.1.1	over the deployment temperature range ~~of –40C to +85C~~	
Appendix D	Reporting charts and notes revised to be consistent with Table 3.2.3.2.3.B	
3.2.4	The inflator shall produce no ‘bag luminescence’ visible in standard video (standard frame rate), using an uncoated bag per program direction, or Appendix A Table IV G-1, other than item c.	
Table 3.2.7.B	±12.5% at $P_{75\% \text{ of peak}}$ or use ± 12.5% of $T_{75\% \text{ of peak}}$	
5.1.2	Temperature tolerance from ± 3 C to ± 2 C	
5.2.4.7.3	Temperature chamber, capable of maintaining -40°C to ~~+85C~~+90°C. Apply temperature cycle of 11 hours total twice during each axis of vibration testing Condition inflator for a minimum of 270 ± 5 minutes at ~~80 °C~~ 90°C. Perform visual and audio inspection of the Inflator during and after the conditioning procedure. All visual and audio discrepancies shall be documented and reported to the Responsible Vehicle Engineering Organization.	
5.2.4.7.4	1. Condition Inflator for a minimum of 288 hours with temperatures of -40°C, 23°C, and 90°C and with 95% ~~maximum~~ minimum RH according to Figure 5.2.4.8.4.A, *Humidity/Thermal Cycle*.	
5.2.4.7.6	For dual stage inflators with initiators located at opposite ends of the inflator, perform drop ~~once~~ twice with each initiator in down position. The third orientation ~~drop~~ shall be dropped twice in the direction perpendicular to the axis of the both initiators (center pin to center pin) for a total of 6 drops for all orientations.	
5.2.4.9	$P_{min} = (P_{nominal} - P_{tolerance})$ at ~~-30°C~~ -40°C	
Appendix A Section IVD	Condition ~~9~~ 12 inflators	
Appendix A Section IV H	(if previous 2 ~~reverse fire~~ second stage only deployments ignite the primary stage Requirement: The inflators shall meet the functional requirements of the body of this specification. The inflators shall not fail structurally. Otherwise, data is for informational purposes only.	
5.2.4.7	Addition of High Heat/Humidity Aging Test. Also see test matrices in appendix B for resulting inflator quantities	
Appendix D	100 ft3 Effluent Reporting Table. Added Apportionment column to table.	June 10, 2004 USCAR Committee S Stram M Quade L Knowlden

USCAR INFLATOR TECHNICAL REQUIREMENTS and VALIDATION
(FRONTAL, & SIDE SYSTEMS)

1. INTRODUCTION:

1.1 Scope:

This specification establishes the performance, and validation requirements for the inflator assembly used in airbag modules. Pretensioners are covered only in respect to their effluents as included in Section 3.2.3, Effluents and their autoignition performance as included in Section 3.2.5, Autoignition, High Temperature Oven Performance/Autoignition of Heat Aged Inflators

1.2 Preface Definitions:

Inflator: For the purposes of this specification, an inflator is a device that delivers a defined quantity or volume of gas with a defined mass flow, at a required reliability and repeatability to a cushion or chamber in order to directly provide occupant restraints as defined by the intended customer engineering group(s). Specific design elements are not limited except by the performance and reliability requirements contained herein.

Pretensioner: For the purposes of this specification a pretensioner is a device that delivers a defined quantity or volume of gas with a defined mass flow at a required reliability and repeatability to the mechanical buckle and/or retractor device in order to remove belt length in the seat belt system, thereby providing increased occupant restraints as defined by the intended customer engineering group(s). Specific design elements are not limited except by the performance and reliability requirements contained herein.

Degradation *(following environmental conditioning)*: The term "degraded" refers to a change in ballistic performance that falls outside of the reference window established by a virgin control group per Section 3.2.7, Inflator Performance and Variability Limits (i.e. DV/PV baseline group) after conditioning per Section 5.2.3.7, Closed Tank Test of this document. In addition, a failure of the inflator to meet any other requirement as stated in this document after environmental conditioning shall also be defined as degradation.

Tailorable: The ability to tune slope, onset, output (peak pressure), and output ratio (dual stage inflators) independently to meet the various program requirements.

Variability: The term "variability" refers to performance variation within a group of inflators that falls outside of the reference window established by a virgin control group (i.e. DV/PV baseline group) per Section 3.2.7, Inflator Performance and Variability Limits of this document.

Shall Requirements: The inflator 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 Responsible Vehicle Engineering Organizations. Deviations to “shall” requirements will only be considered and, if approved, granted by the Responsible Vehicle Engineering Organizations 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 applicable to the subject technology(s) or possible within current technology limitations. "Should" denotes a preference or desired conformance which, if not met, must be documented and disclosed to the Responsible Vehicle Engineering Organizations. The final determination of the subject performance requirement shall be made by the Responsible Vehicle Engineering Organizations.

Responsible Vehicle Engineering Organization: Refers to the group(s) that are sponsoring the qualification. In the case where specific shall and/or should requirements must be altered to accommodate specific technologies, the supplier shall obtain acceptance of the altered test plan, from representatives of each OEM where the inflator is intended to be used.

QFS: QFS refers to 'Qualified for Sourcing' and is synonymous with 'Bookshelving'. The procedure for attaining QFS status for an inflator is detailed in Appendix A.

For additional definitions see the Glossary (Appendix E).

1.3 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:

SAE J 1794 Restraint System Effluent Test Procedure (Dec. 2, 1996)
ISO Guide 25 Lab Certification
J2238 Airbag Inflator Ballistic Tank Test Procedure
J211-2 Instrumentation for Impact Tests
USCAR Initiator Specification
MIL STD 810
QS9000

In the case of new releases of the listed reference documents the latest version shall be applicable except where direct conflicts with this document take place. In the case of a direct conflict this document shall supercede and the previous version of the referenced document(s) shall be applicable

3. REQUIREMENTS:

3.1 General Requirements:

3.1.1 General:

The inflator supplied under this specification shall meet all of the functional requirements outlined in this specification for a fifteen-year vehicle life. The inflator shall meet these requirements 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 inflator supplier and agreed to by the Responsible Vehicle Engineering Organization(s). All testing will be based on supporting a fifteen-year vehicle life.

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 QS9000 process) for purchased materials and shall be done with the concurrence of the intended vehicle manufacturer's Supplier Quality Assurance group(s).

3.1.3 Production Requirements:

As a general assumption, inflators qualified to this specification will meet this specification on an ongoing production basis unless specifically excepted by a Responsible Vehicle Engineering Organization.

3.1.4 Reliability:

The inflator shall demonstrate, through successful completion of the PV test matrices, a reliability of 95% at 90% confidence, without any failures during deployment, degradation as defined in this specification or failure to meet any shall requirements of this specification. Failure during deployment is defined as failing to meet any of the shall requirements of this specification, or falling outside of the performance intervals defined by the baseline deployments for a given configuration per Section 3.2.7, Inflator Performance and Variability Limits.

3.1.5 Heavy Metal Compounds Reporting and Recycleability Requirements:

The inflator supplier shall provide timely information verifying product compliance with current OEM requirements in regards to the use of Heavy Metals or Heavy Metal Compounds in the manufacture of the inflator. The inflator manufacturer shall provide at the request of the Responsible Vehicle Engineering Organization, a breakdown of the materials in the inflator for recycling purposes.

3.1.6 Informational Requirements:

The inflator supplier shall provide the information as required by all sub-sections of 3.1.6 prior to, or as a subsection of the DV and PV reports. The use of the 'QFS Checklist' is highly recommended for organization and completeness of the information. The inflator DV shall not be considered complete without the prior or joint submission of the informational requirements as described in this section and all sub-sections of 3.1.6.

3.1.6.1 Inflator Pre-source Qualification (QFS) or Bookshelving:

The inflator supplier shall provide the information outlined in Appendix A Inflator Pre-source Qualification (QFS). The information shall be supplied in advance of, or as a subsection of the DV report.

3.1.6.2 Inflator Soak Back Heat:

In addition to the information supplied in the QFS, and for the specific inflator output in consideration, a temperature trace of the external surface of the inflator after deployment shall be provided after hot deployment per Section 5.2.3.6, Open Air Test. The measurements shall be taken from the highest temperature area of the inflator, showing the peak temperature reached immediately and throughout the full cool down cycle of the inflator. The data shall be provided as part of the DV and PV report. Placement of the temperature measuring probe(s) shall be based on temperature mapping for the worst case location and approved by the Responsible Vehicle Engineering Organization.

3.1.6.3 Inflator Performance Envelope and Characteristics:

In addition to the information supplied in the QFS, and for the specific inflator output(s) in consideration, the Inflator Supplier shall supply actual inflator vented tank test curves (if specifically requested), closed tank test curves, mass flow and calculated gas temperature curves, moles of gas for the output tested. The Inflator Supplier shall demonstrate Tailorability criteria, and repeatability. The Inflator Supplier shall make available on an ongoing basis, information and data to demonstrate lot-to-lot variability due to manufacturing is minimized, controlled and meets the requirements of this specification.

The Responsible Vehicle Engineering Organizations shall be the final arbiter of inflator tailorability.

3.1.6.4 Shipping Classification:

The inflator Supplier shall provide shipping 'Competent Authority' per Appendix A Inflator Pre-source Qualification (QFS) section III.H or other equivalent documentation for target jurisdictions and programs. In addition, the test data utilized to comply with all applicable government shipping regulations, including autoignition regulations, in countries where the inflator(s) are manufactured and transported, shall be provided to the Responsible Vehicle Engineering Organizations , or submitted as a subsection of the DV report. (i.e. DOT, CTC, TUV, BAM, etc.)

3.1.6.5 Module Performance:

Examples of the inflator performance in a baseline module shall be demonstrated and compared with the original configuration's inflator. This comparison shall be done in a dynamic test configuration (i.e. drop tower, pendulum, or other equivalent device) in an existing and well characterized module that meets the criteria of Appendix A Inflator Pre-source Qualification (QFS) section IV G, Table 1, Module Configuration. Modifications to the baseline module are acceptable and encouraged to enhance the new inflator's performance, so long as they are thoroughly documented. Alternate configurations with documented differences can also be used to show typical design modifications from the established baseline modules to enhance performance.

3.1.6.6 Electrical Isolation of Pyrotechnic Mixtures:

No pyrotechnic materials in the inflator shall have direct contact with the external metallic surfaces of the initiator charge cup and header assembly.

3.2 Functional Requirements:

This section describes the functional and performance requirements of the inflator. For the environmental conditioning and testing required in order to validate these performance characteristics refer to Section 5, Test Requirements.

3.2.1 General Inflator Requirements:

Prior to PV testing, as part of a DV, or prior to a DV, inflator(s) shall demonstrate the ability to successfully complete a 'Proof of Concept' test series as outlined in Appendix A Inflator Pre-source Qualification (QFS).

For dual level Inflators utilizing either two separate pressure chambers or a single pressure chamber inflator with an internal segmenting partition, the inflator(s) and all inflator segments shall meet all applicable performance requirements and validation conditions singly and in combination, referenced in this specification.

For inflators to be considered 'Pre-Qualified' (QFS) the inflators should use only approved initiators (PPAP per AIAG process or equivalent) at the time of pre-qualification. For an inflator to be considered DV'd, the inflators shall use an initiator that has, as a minimum, met all ignitor DV requirements per *USCAR Common Initiator Specification* of current issue. Inflators shall use only approved initiators (PPAP per AIAG process or equivalent) at the time PV.

3.2.2 Inflator Structural Integrity:

Inflator(s) shall maintain structural integrity when deployed in and after the conditioning environments described in Section 5, Test requirements. At no time during any portion of DV and PV testing shall an inflator eject any component or fragments. Burst foil (not including burst diaphragm fragments from hybrid inflators) shall be allowed based on their lack of potential hazard, as agreed to by the Responsible Vehicle Engineering Organization.

3.2.2.1 Inflator Burst Safety Factor:

Over the temperature range of +85C to –40C, the inflator burst safety factor, when performed and calculated per Section 5.2.4.2, Structural Burst Test, shall be greater than 1.5.

As an alternative, where:

1. Stable production processes of a minimum of 1 year at a minimum of 500K/yr run rate, has been established and,
2. A statistically significant sample size can be tested and,
3. Production margin components and process can be verified then,

The statistical model per Appendix C Statistical Inflator Structural Margin Calculations, can be utilized on a case by case basis to validate structural margins as approved by the Responsible Vehicle Engineering Organizations. In no case shall the inflator structural margin fall below 1.35 as calculated per Section 5.2.4.2, Structural Burst Test.

The burst of the inflator shall exhibit a ductile separation mode insofar that the inflator shall not fragment or eject any part of the structural components. The Inflator Supplier and the Responsible Vehicle Engineering Organizations shall jointly determine the burst test configuration. The Responsible Vehicle Engineering Organizations shall be the final arbiter of the burst test configuration.

Inflators with multiple structural, dynamically independent, pressurized chambers shall meet the required Inflator Burst Safety Factor for all pressurized chambers independently and together. External crimps, curls, swages, press fits such as end closure and initiator retaining features shall be loaded during testing and shall not fail during burst testing. Welds shall not fail in the fusion area. All crimp, curl, swage, press fit and weld design and process parameters shall be verified by margin studies and/or FEA. FEA analysis shall be confirmed by testing. Propagation of the primary failure from the parent material into external welds, crimps, curls or swages is allowed.

The inflator's structure shall comply with all applicable government regulations, including pressure vessel burst regulations, in countries where the inflator(s) are manufactured and transported, as well as the countries where the vehicle is manufactured and sold as directed by the Responsible Vehicle Engineering Organization. The inflator suppliers shall be responsible for gaining shipping approval for each jurisdiction as appropriate as directed by the Responsible Vehicle Engineering Organization. A typical minimum list of countries includes North America (USA Canada), and Europe (BAM).

3.2.3 Effluents:

3.2.3.1 General Effluents:

The inflator Supplier shall characterize and report the presence of all chemical constituents, both listed and unlisted gasses and particulates according to the following sections. Follow table 3.2.3.1A, Flow Chart of Effluent Evaluation. All gasses and particulate levels (generated by the inflator, labels, paints, glues, inks, cushions, housings, deflectors, and other Module components) shall be reviewed with the vehicle manufacturer's engineering and health effect support organization(s). Joint agreement of the supplier and vehicle manufacturer's engineering and health effect support organization(s) shall establish vehicle level limits for any gasses or materials not specified or exempted herein. Synergistic effects of the mixture of effluents shall be identified in so far as possible, and may be cause to alter the published limits of any Listed effluents (see Table 3.2.3.2.3B, Listed Compounds). Allowable levels may be subject to modification based on the specific vehicle requirements (vehicle interior volume, bag configuration, etc).

Those effluents defined as 'Unlisted', are all other effluents, gasses and particulates, generated by the inflator, labels, paints, glues, inks, cushions, housings, deflectors, and other Module components not specifically listed in this document. Unlisted compounds exclude normal, non-hazardous levels of atmospheric gasses.

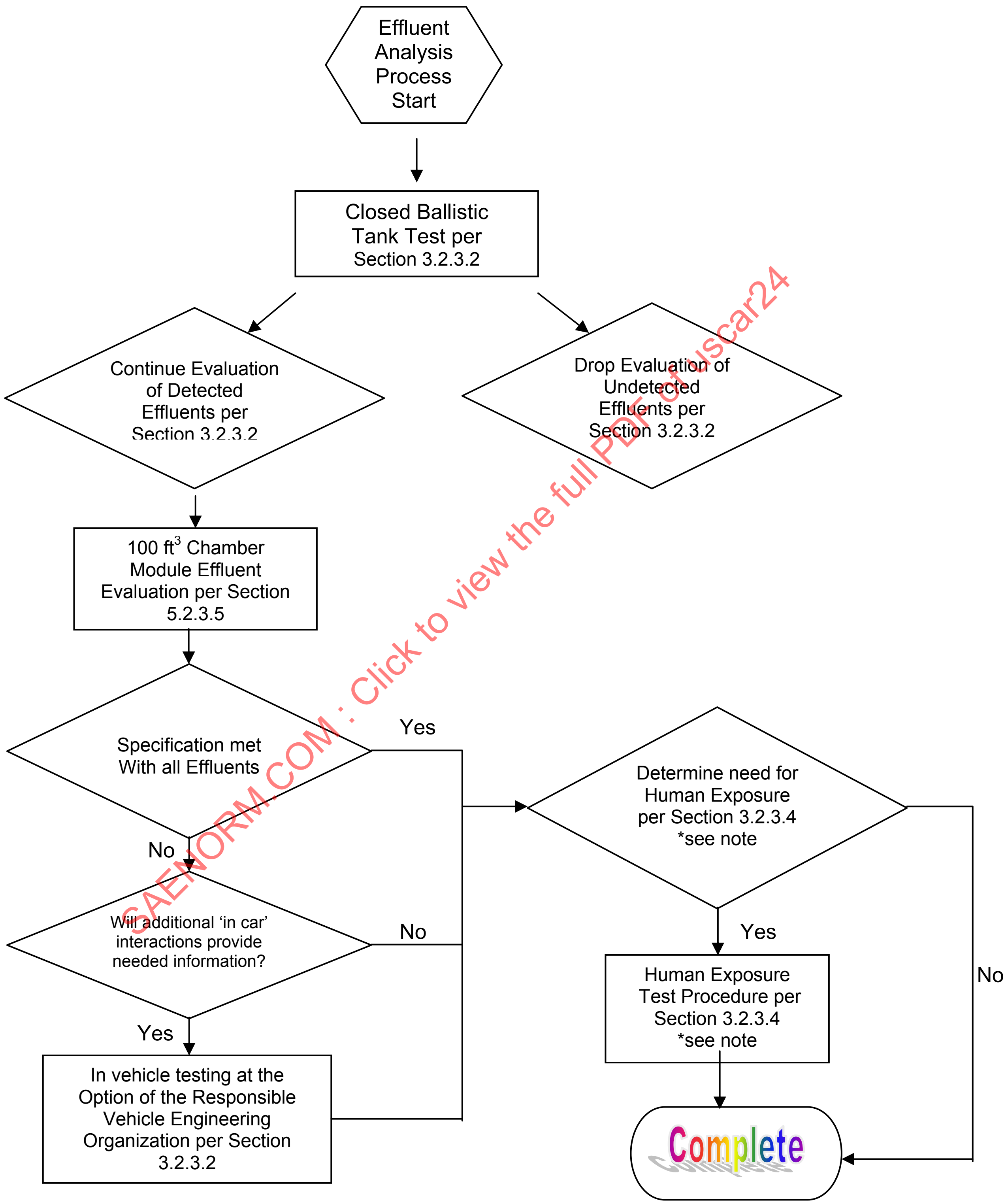
Vehicle Manufacturers may add to the effluent gas and particulate list as information becomes available. Vehicle Manufacturers may alter the specified component level allocations in order to achieve overall vehicle safety system effluent and particulate limits. However, program specific inflators should be consistent with the information for QFS status.

The Responsible Vehicle Engineering Organizations, shall be the final arbiter for each application for all effluent requirements.

The limits in all of the tables and the figure in this section are subject to change as effluent knowledge evolves and pretensioner effluent contributions are quantified.

The reporting of effluents shall use the tables provided in Appendix D 'Gas and Particulate Reporting Tables and Analysis Methods'.

TABLE 3.2.3.1 A FLOW CHART OF EFFLUENT EVALUATION



*Note: General acceptance and specific criteria for passing Human exposure testing should be verified for each OEM. Human Testing, as an alternate method of certification is not accepted in equal measure by all participants in this specification.

3.2.3.2 Gasses:

All gas concentrations defined in this section as ‘Listed’ and those defined as ‘Unlisted’, but determined to be present, shall be measured in a tank size per Section 5.2.1, Test Equipment, and per the procedure in Section 5.2.3.7, Closed Tank Test. This evaluation shall be repeated at QFS, DV and PV levels as part of the effluent evaluation. The results of the gas analysis of the ballistic tank shall be reported in the effluent subsection of the DV and PV reports, using the format given in Appendix D Gas and Particulate Reporting Tables (or equivalent). The results of the ballistic tank evaluation are for reference only. Those gasses found in the, more concentrated ballistic tank sample (i.e. in concentrations that could exceed 25% of the apportioned vehicle limit, based on calculated dilution factors), and all gasses known to be substantially soluble in water, shall be analyzed in all subsequent 100 ft^3 deployment chamber tests, per section 5.2.3.5, 100ft^3 Tank Effluent Test. The results of the 100 ft^3 Tank Effluent shall be reported in the effluent subsection of the DV and PV reports using the format given in Appendix D Gas and Particulate Reporting Tables (or equivalent). The results of the 100 ft^3 Tank Effluent will be used for evaluation of compliance to full vehicle limits (shall requirement) and the recommended apportionment values (should requirement) per table 3.2.3.2.3.A, Recommended Effluent Apportionment.

Recognizing the effects of individual module configurations these tests should be done in modules and at outputs that are consistent with the requirements of Appendix A Section IV-G Table IV-1. All parameters of the module configuration (bag size, vents, inflator output, etc.) shall be recorded and reported with the data. Not withstanding, and recognizing the effects of the vehicle interior on certain gasses and particulate concentration, the tests shall be conducted in 100 ft^3 chambers to provide a consistent basis of comparison. ‘In vehicle’ tests, conducted in a representative vehicle, may be accepted on a case by case basis at the discretion of the Responsible Vehicle Engineering Organization. The Responsible Vehicle Engineering Organizations shall have the option to adjust the individual module effluent requirements if acceptable overall performance can be demonstrated in a representative vehicle. Where individual inflator technologies are not capable of meeting the effluent limits stated in Section 3.2.3, Effluents (and all subsections) the Responsible Vehicle Engineering and health effects support people or Organization(s) shall develop alternative limits until such technologies can be improved.

Upon deployment, the ‘in vehicle’ gaseous and particulate effluent levels from the full Frontal System (all frontal restraint devices including Driver, Passenger and Knee Bolster airbags, as well as Belt Pretensioner devices, etc.) shall not exceed the full ‘in vehicle’ limits established for listed effluents per table 3.2.3.2.3.B Effluent Gas Limits (20 min Time Weighted Average), unlisted effluents (where determined to be present), and particulates. As a separate deployment, all side impact protection systems, shall not exceed the full ‘in vehicle’ limits established for listed effluents per table 3.2.3.2.3.B Effluent Gas Limits (20 min Time Weighted Average), unlisted effluents (where determined to be present), and particulates.

Note: The effluent data shall be evaluated by use of the average(s) of each group of tests. Each data point shall also be reported and no single measurement shall exceed 150% of the respective apportioned limits.

The Responsible Vehicle Engineering and health effects support people or Organization(s) shall be the final arbiter for each vehicle application, of the specific apportionment requirements.

3.2.3.2.1 Apportionment, Listed Compounds:

Upon deployment in a 100 ft^3 chamber, the Driver Inflator, Passenger Inflator, Side Inflator(s), Knee Bolsters and belt pretensioner devices, should not exceed apportioned fractions, listed in table 3.2.3.2.3.A, Recommended Effluent Apportionment of compounds listed in table 3.2.3.2.3.B Effluent Gas Limits (20 min Time Weighted Average). For the purposes of pairing different inflators into full vehicle systems, the individual inflator limits should not exceed the recommended apportionment as listed in table 3.2.3.2.3.A Recommended Effluent Apportionment of this section.

3.2.3.2.2 Apportionment, Unlisted Compounds:

In addition, upon deployment in a 100 ft^3 chamber, the Driver Inflator, Passenger Inflator, Side Inflator(s), Knee Bolsters and belt pretensioner devices, should not exceed apportioned limits for Unlisted compounds. Unlisted compounds, and the determination of acceptable limits, are defined in Section 3.2.3.1, General Effluents. For the purposes of pairing different inflators into full vehicle systems, the individual inflator limits should not exceed the recommended apportionment as listed in table 3.2.3.2.3.A Recommended Effluent Apportionment of this section.

3.2.3.2.3 Gas Sampling and Analysis:

The gaseous and particulate effluent levels shall be determined in a 2.83 m^3 (100 ft^3) closed tank (or 2.5 m^3 tank mathematically corrected to 2.83 m^3) per SAE J-1794 Restraint Systems Effluent Test Procedure with corrections for pressure, temperature and absorption as applicable, with the following additions:

1. Airborne particulate effluent shall be sampled at the rate of 5.0 liters per minute or greater (as appropriate for the analytical method(s) used) with a tolerance of ± 10% Liters per minute for 20 minutes. Airborne particulate shall be reported as mg/m^3, total airborne particulate.
2. Gaseous effluents shall be sampled at the rate of 10 ± 0.25 Liters per minute, or a rate deemed to be analytically appropriate to the method being used. Gas samples shall be taken at 1, 5, 10, 15, and 20 minutes minimum. It is acceptable to sample gases directly into analysis cell on a continuous basis, or at the above intervals or to use Tedlar bags. If Tedlar bags are used, the analysis shall be started in a timely fashion (less than five minutes from the time of the deployment). It is acceptable to use a single continuous (20 min) sample for analytical techniques where appropriate (i.e. absorbing/adsorbing of organics etc.).
3. Gas concentrations shall be reported in PPM as 20 minute time weighted averages. A 20 minute time-weighted average concentration for each gas shall be calculated using an appropriate mathematical formulation, i.e. the following equation if 1, 5, 10, 15 and 20 minute samples are used:

$$TWA_{20} = (1C_1 + 4C_5 + 5C_{10} + 5C_{15} + 5C_{20})/20$$

4. A maximum of the lesser of 5% or 141.5 liters total of gas volume of the test chamber shall be removed from the chamber for sample purposes. Return lines for continuous sampling loops and particulate filters shall be used if sampling flow rates would otherwise exceed 5% of the chamber volume or 141.5 liters total gas.

Recommended Apportionment is as follows:

Table 3.2.3.2.3.A Recommended Effluent Apportionment

Frontal				
Driver Airbag	**Passenger Airbag**	**Pretensioners (2)**	**Knee Bolster**	**Inflatable Belt**
1/3	2/3			
5/16	9/16	1/8		
1/4	1/2	1/8	1/8	
1/4	1/2	1/8	1/16	1/16

Side (per bag basis)		
Head Thorax	**Thorax**	**Curtain**
1/4		
	1/8	1/8
		1/4

Note: Due to the nature of most crashes Frontal and Side restraint systems will not fire together without substantial 'opening' occurring to the occupant compartment. This opening, or ventilating of the occupant compartment allows the side and frontal apportionment to exceed 100%.

Note: In cases where the sum of the frontal or side restraint systems apportionments will exceed 1 (one) the apportioned fractions shall be normalized to equal ≤ 1.

Table 3.2.3.2.3.B Effluent Gas Limits (20 min Time Weighted Average)

Listed Compounds

Effluent Gas	Vehicle Level Limit (ppm, maximum)
Ammonia (NH_3)	35.0 ppm
Benzene (C_6H_6)	22.5 ppm
Carbon Monoxide (CO)	461 ppm
Carbon Dioxide (CO_2)	30,000 ppm
Chlorine (Cl_2)	1.0 ppm
Formaldehyde (HCHO)	2.0 ppm
Hydrogen Chloride (HCl)	5.0 ppm
Hydrogen Cyanide (HCN)	4.7 ppm
Hydrogen Sulfide (H_2S)	15.0 ppm
Nitric Oxide (NO)	75.0 ppm
Nitrogen Dioxide (NO_2)	5.0 ppm
Phosgene ($COCl_2$)	0.3 ppm
Sulfur Dioxide (SO_2)	5.0 ppm
Acetylene	25,000 ppm (LEL)
Ethylene	27,000 ppm (LEL)
Methane	50,000 ppm (LEL)
Hydrogen	40,000 ppm (LEL)

3.2.3.3 Inflator Particulate:

For each inflator technology, the Inflator Supplier should demonstrate that airborne particulate from the 100^{ft} chamber meet the following requirements. In addition the inflator shall show no evidence of internal filter failure over the Inflator temperature range specified in Section 5.2.3.7, Closed Tank Test.

3.2.3.3.1 Airborne Particulate Measurement and Analysis (measured in the 100^{ft} chamber):

The particulate effluent levels shall be determined in a 2.83 m^3 (100 ft^3) closed tank per SAE J-1794 Restraint Systems Effluent Test Procedure with the following additions:

1. Airborne particulate shall be sampled at the rate of 5.0 liters per minute or greater with a tolerance of ± 10% Liters per minute for 20 minutes. Airborne particulate shall be reported as mg/m^3, total airborne particulate.
2. Total Vehicle particulate shall not exceed those limits specified in table 3.2.3.3.1.A Effluent Particulate Limits. Each inflator should not exceed the apportioned limits set forth in table 3.2.3.2.3.A Recommended Effluent Apportionment.
3. Particulate fraction of less than 10 micron shall be determined and reported per SAE J-1794 Restraint Systems Effluent Test Procedure, section 6.2.

Table 3.2.3.3.1.A Effluent Particulate Limits Airborne (100ft chamber)

	Vehicle Level Limit
Total Particulate	125.0 mg/m^3
Water Soluble Particulates*	75.0 mg/ m^3
Water Insoluble Particulates	50.0 mg/m^3
Sodium Azide (NaN_3) Particulate**	1.43 mg/m^3
Sub 10 micron particulate	Fraction to be reported only

* Calculated based on the ratio of soluble/insoluble fractions as determined in section 5.2.3.7.4 Sampling Tank Contents (Tankwash) Procedure.
** as a component of the water soluble fraction for Azide systems only

3.2.3.3.2 Tank Wash Particulate Measurement and Analysis (Measured in the ballistic tank):

The particulate effluent levels shall be determined by washing the contaminated surfaces of the ballistic tank with deionized water (per Section 5.2.3.7, Closed Tank Test). The following information shall be supplied from this sample(s).

1. Large particle weight (see Section 5.2.3.7.4 Sampling Tank Contents (Tankwash) Procedure), Water Soluble and Water Insoluble fractions of the particulate shall be individually determined and reported.
2. Total particulate (excluding large particulate) from a ballistic tank wash shall be determined and reported.
3. The total ballistic tank wash particulate of each deployment should not exceed 1.0 g at room temperature,
4. The pH of the tank wash solution, diluted to 1000 ml, shall be determined and reported. The pH shall fall in the range of 4-10.5.
5. Full speciation including metals, soluble salts and mass balance, accounting for a minimum of 90% of the measured sample weight, shall be determined and reported.
6. The speciation (derived from the tank wash sample(s)) of the tankwash, derived from inflators designated per Appendix B DV/PV Matrix, shall include a full metals scan, cation analysis, and anion analysis. A mass balance of the speciation analysis shall be provided (calculated fractional weights of each species found verses the total particulate sample mass).

Note: Gas and Particulate effluents shall be reported using the formatted tables found in Appendix D.

3.2.3.4 Human Exposure Test Criteria:

See Appendix H for criteria and procedure.

1. *Note: General acceptance and specific criteria for passing Human exposure testing should be verified for each OEM. Human Testing, as an alternate method of certification is not accepted in equal measure by all participants in this specification.

3.2.4 Inflator Flaming:

For the purposes of this test: Deflectors, diffusers, shrouds, housings, etc. , used as a standard component for applications of the inflator to suppress external flaming, redirect gasses, minimize bag damage and/or modify system performance, may be utilized. Components that block clear photographic documentation of the inflator's performance (i.e. closed bags) shall not be allowed. The configuration of the device under test shall be clearly documented as part of the test report.

The tests shall be conducted per Section 5.2.3.6, Open Air Test, using the setup per Appendix G Shadowgraph Procedure, Inflator Flaming Testing (or approved equivalent), and at temperatures of +23C and +85C as given in Section 5.2.4.9, Flaming Test. The tests shall be filmed at a minimum of 1000 fps.

Inflators Deployed at +23C:

a. shall not have flames of any length or duration other than item c,
b. shall not have burning particles other than item c,
c. shall not have flames/sparks exceeding 5 ms duration at or around the initiator.
d. There shall not be any gas leakage residue at or around the initiator excepting minimal witness marks caused by item c.
e. Burning of gasses and propellants shall not occur outside of the inflator.
f. The inflator shall produce no 'bag luminescence' visible in standard video (standard frame rate), using an uncoated bag per program direction, or Appendix A Table IV G-1, other than item c.

Inflators deployed at +85C:

a. should not have flames of any length or duration ,
b. shall not have flames exceeding 50 mm in length,
c. shall not have flames exceeding 20 ms in duration,
d. shall not have burning particles other than item e,
e. shall not have flames/sparks exceeding 5 ms duration at or around the initiator.
f. There shall not be any gas leakage residue at or around the initiator excepting minimal witness marks caused by item e.
g. Burning of gasses and propellants shall not occur outside of the inflator.
h. The inflator shall produce no 'bag luminescence' visible in standard video (standard frame rate), using an uncoated bag per program direction, or Appendix A Table IV G-1, other than item b, c, and e.

Inflators, during the time immediately post deployment (10 seconds to 2 minutes minimum), with an external ignition source applied, at temperatures of +23C and +85C as given in Section 5.2.3.6, Open Air Test:

a. shall not have flames of any length or duration (other than those detailed in the preceding paragraphs),
b. shall not have burning particles.

The Responsible Vehicle Engineering Organizations shall be the final arbiter of acceptable configurations and results of all flaming requirements.

3.2.5 Autoignition, High Temperature Oven Performance/Autoignition of Heat Aged Inflators:

3.2.5.1 High Temperature Oven (HTO) and Auto Ignition Performance:

Inflator deployment temperatures, gas venting for Hybrid inflators, shall exceed +115°C, and/or pyrotechnic components of all inflators shall autoignite at greater than +130 C when the un-aged inflator is exposed to the high temperature oven environment given in Section 5.2.4.3 High Temperature Oven (HTO) Test.

The inflator(s) shall maintain structural integrity, shall not fragment, or have any separation of components when autoignition is induced by external heating per Section 5.2.4.4 Bonfire Test, and Section 5.2.4.5 Slow heat/Autoignition Test.

3.2.5.2 Accelerated Heat Aging and Auto Ignition Performance:

The inflator(s) shall maintain structural integrity, shall not fragment, or have any separation of components when autoignition is induced by external heating after heat aging per Section 5.2.4.6 Accelerated Aging according to Sections 5.2.4.6.1 Accelerated Aging with High Temperature Oven (HTO) test, 5.2.4.6.2 Accelerated Aging with Bonfire Test, and 5.2.4.6.3 Accelerated Aging with Slow Heating Test protocols.

After exposure to Accelerated Aging of 1000 hours at 90 C* or 408 hours at 107 C as specified in Section 5.2.4.6 Accelerated Heat Aging Test, those inflators to be tested in a closed tank shall, (at the completion of the environmental exposure conditioning):

*Note: General acceptance of 1000 hours at 90 C should be verified for each OEM. All participants in this specification do not accept One thousand (1000) hours at 90 C, as an alternate method of testing in equal measure.

a) shall not leak per Section 5.2.3.1, Leak Test,
b) shall Maintain a bridgewire resistance as specified in the USCAR Initiator Specification of current issue, or as approved by the Responsible Vehicle Engineering Organization.

In addition those inflators deployed in a tank, or open air:

c) shall deploy as intended per Section 5.2.3.7, Closed Tank Test or Section 5.2.3.6, Open Air Test,
d) should meet the tank wash requirements as indicated in the Appendix B, DV/PV Validation Test Matrix, and Section 3.2.3.3.2 Inflator Particulate (Tank wash derived), and
e) shall meet all requirements of Section 3.2.7, Inflator Performance and Variability Limits where ballistic curves are obtained.

3.2.6 Sequential Test Series:

After the completion of the Sequential conditioning series the inflator(s);

a) shall not leak per Section 5.2.3.1, Leak Test,
b) shall Maintain a bridgewire resistance as specified in the USCAR Initiator Specification of current issue, or as approved by the Responsible Vehicle Engineering Organization.

In addition those inflators deployed in a tank, or open air :

c) shall deploy as intended per Section 5.2.3.7, Closed Tank Test or Section 5.2.3.6, Open Air Test,
d) should meet the tank wash requirements as indicated in the Appendix B, DV/PV Validation Test Matrix, and Section 3.2.3.3 Inflator Particulate (Tank wash derived), and
e) shall meet all requirements of Section 3.2.7, Inflator Performance and Variability Limits where ballistic curves are obtained.
f) Shall not show any loss in the measured strength or ballistic integrity of the propellant as demonstrated by ballistic performance and/or accepted break or crush strength measurement methods of live tear down inflators. (Limited dusting that does not appreciably affect ballistic performance is excepted)

3.2.6.1 Inflator Thermal Shock Resistance:

a) Expose inflators to 200 cycles of -40 C to +90 C thermal shock profile as specified in Section 5.2.4.8.1, Inflator Thermal Shock Resistance Test.

3.2.6.2 Inflator Dynamic Shock Resistance:

Expose inflators to the dynamic shock profile specified in Section 5.2.4.8.2, Dynamic Shock Test.

3.2.6.3 Inflator Drop Resistance:

Expose Inflators to the drop environments specified in Section 5.2.4.8.6, Drop Test.

3.2.6.4 Inflator Vibration/Temperature Resistance:

a) Expose inflators to the vibration and temperature profiles specified in Section 5.2.4.8.3, Vibration - Temperature Cycle Test.

3.2.6.5 Inflator Salt Spray Resistance:

Expose inflators to the salt spray profile specified in Section 5.2.4.8.5, Salt Spray Test.

3.2.6.6 Inflator Humidity Resistance:

a) Expose inflators to the humidity profile specified in Section 5.2.4.8.4, Humidity Resistance Test.

3.2.7 Inflator Performance and Variability Limits:

When Inflators are conditioned per Section 5.2.3.7, Closed Tank Test of this document, placed in a closed tank filled with ambient air at room temperature and pressure, and activated using a minimum of the "All-Fire" current of the initiator in use, the Inflator requirements of this section shall be met.

1. Closed tank inflator curves per the following shall be provided to the Responsible Vehicle Engineering Organizations by the Inflator Supplier for all validation tests:

   a) Baseline deployments at each temperature (full and first stage output for dual stage inflators);
      Scatter plots for each group with overlays of the mean curve, ±3σ curves and performance windows.
   b) Environmentally conditioned inflators deployed at each temperature;
      Comparison plot for each group with overlays of the mean curve and performance windows.
   c) Data tables showing performance against the specified windows established in Table 3.2.7.A, Inflator Variability Limits, and Table 3.2.7.B, Ballistic Variability Limits .

2. The tolerances shown in Table 3.2.7.A, Inflator Variability Limits, and Table 3.2.7.B, Ballistic Variability Limits shall be met at room temperature, hot temperature, and cold temperature by the baseline inflators full and staged output(s) (± 3σ of the mean of the baseline deployment groups at each temperature, shall fall within each defined window excepting TTFG) when deployed as specified in Section 5.2.3.7, Closed Tank Test. (Refer to Appendix F for examples.) TTFG shall be evaluated based on attributes of each individual curve.

3. The tolerances shown in Table 3.2.7.A, Inflator Variability Limits, and Table 3.2.7.B, Ballistic Variability Limits shall be met at room temperature, hot temperature, and cold temperature by each individual inflator curve (for full and first stage deployments for dual stage inflators) after inflator exposure to environments (the individual ballistic curves of each inflator shall fall within each defined window) as specified in the Section 5, Test Requirements when deployed as specified in Section 5.2.3.7, Closed Tank Test. (Refer to Appendix F for examples.)

4. A program specific closed tank mean curve shall be determined by the Responsible Vehicle Engineering Organizations from an appropriate 'baseline inflator tank deployment' series such as the baseline tests of the PV or other as determined by the Responsible vehicle Engineering Organization. For dual stage inflators full output and/or first stage output should be chosen for evaluation based on program specific needs by the Responsible vehicle Engineering Organization. Ongoing production Lot Acceptance Tests shall be measured against the tolerances determined from Table 3.2.7.A, Inflator Variability Limits, and Table 3.2.7.B, Ballistic Variability Limits for the vehicle specific baseline mean curve. Each individual Lot Acceptance Test's inflator curve shall fall within each defined window. Where individual inflator curves do not fall with in each established window a minimum of fifteen additional (15) samples may, at the discretion of the manufacturer, be deployed at the temperature of the specific individual inflator in question.

Not including the original sample that necessitated the additional testing, evaluate as follows. Report each occurrence to the following to the appropriate Responsible Vehicle Engineering Organizations:

a) With a minimum of fifteen (15) inflators a mean curve and variability limits specific to the (15) fifteen inflators in question shall be calculated.
b) The mean of the lot in question shall not deviate from the original program acceptance mean by greater than ± 33% of the original acceptance gate width (or height) in the appropriate axis (time or pressure) of each gates.
c) Using the mean curve and a ± 3σ as calculated from the fifteen (15) (or greater number of inflators) from the lot in question, the ± 3σ shall fall within the variability windows as determined from Table 3.2.7.A, Inflator Variability Limits, and Table 3.2.7.B, Ballistic Variability Limits using those specific (15) fifteen (or greater number of) inflators.

5. Based on program specific vehicle performance requirements the Responsible Vehicle Engineering Organizations may alter the program specific closed tank test tolerances to narrower or broader windows to meet their program needs.

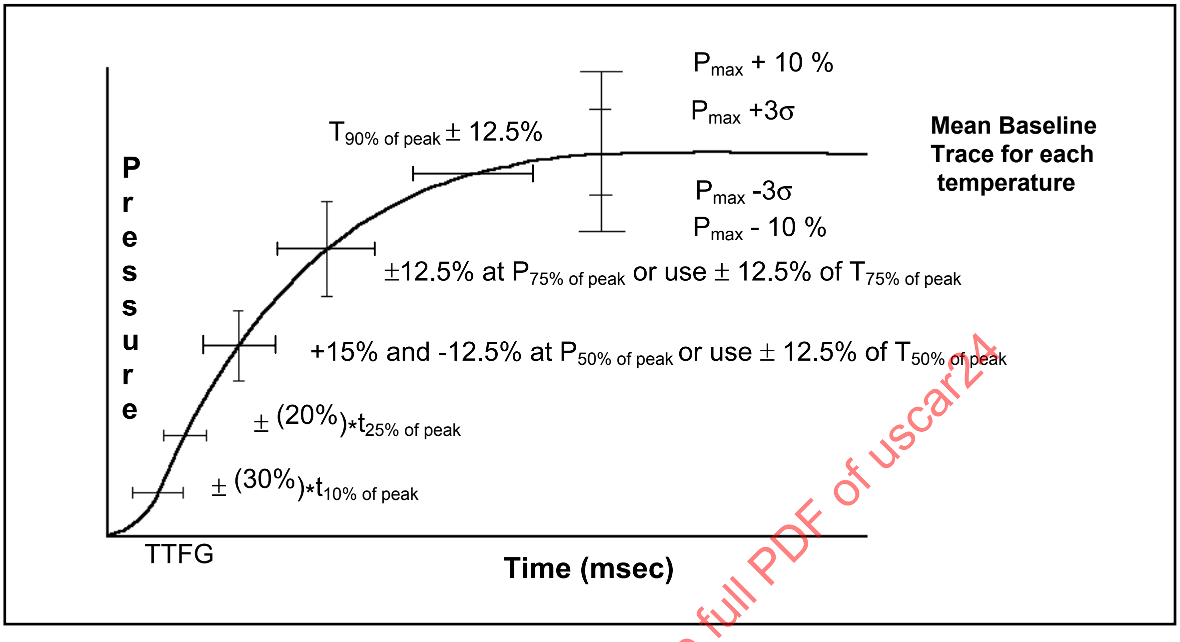
Table 3.2.7.A, Inflator Variability Limits

Inflator Variability Parameters (for Closed Tank Tests)		**±3 Standard Deviation and TTFG Attribute Limits**
Slope using the best fit line along the curve as calculated from a minimum of 9 equally spaced points from 10%-50% pressure		Nominal ± 12.5%
Time to First Gas (TTFG) (attribute based only)	TTFG	Passenger <5ms <7ms Driver Ambient <4ms Cold <6ms Side <2ms <4ms
Time at P=10% of peak	$T_{10\% \text{ of peak}}$	$t_{(10\% \text{of peak})} \pm (30\% * t_{(10\% \text{of peak})})$ i.e . $T_{10} \pm (0.3 * T_{10})$
Time at P=25% of peak	$T_{25\% \text{ of peak}}$	$t_{(25\% \text{of peak})} \pm (20\% * t_{(25\% \text{of peak})})$ i.e . $T_{25} \pm (0.2 * T_{25})$
*Pressure at P=50% of peak	$P_{50\% \text{ of peak}}$	Nominal + 15% - 12.5%
*Alternative T at P= 50% of peak	$T_{50\% \text{ of peak}}$	$t_{(50\% \text{of peak})} \pm (12.5\% * t_{(50\% \text{of peak})})$ i.e . $T_{50} \pm (0.125 * T_{50})$
*Pressure at P=75% of peak	$P_{75\% \text{ of peak}}$	Nominal ± 12.5%
*Alternative T at P= 75% of peak	$T_{75\% \text{ of peak}}$	$t_{(75\% \text{of peak})} \pm (12.5\% * t_{(75\% \text{of peak})})$ i.e . $T_{75} \pm (0.125 * T_{75})$
Time to 90% of peak pressure	$T_{90\% \text{ of peak}}$	Nominal ± 12.5%
Peak pressure	P_{max}	Nominal ± 10%

*Evaluation of either P=50% and 75% or T at P=50% and 75% is allowed at the supplier's discretion (based on curve slope at P=50% and 75%)

The Responsible Vehicle Engineering Organizations shall have the option to waive the ± tolerance variability requirements if acceptable Module performance can be demonstrated across the full range of ballistic variability. The Responsible Vehicle Engineering Organizations shall be the final arbiter of acceptable inflator variability.

Table 3.2.7.B, Ballistic Variability Limits



3.2.8 Propellant Stability:

The Inflator Supplier shall supply test data showing that all propellants, gasses and pyrotechnic compounds contained within the inflator(s) will remain within the specified performance requirements per Section 3.2.7, Inflator Performance and Variability Limits for a minimum of a inflator's target life of fifteen years. The inflator supplier shall provide basic ESD, Friction and Shock data in the unaged and aged conditions of all propellants, gasses (if applicable) and pyrotechnic compounds contained within the inflator(s). These shall not substantially increase in sensitivity over the fifteen-year life of the inflator. With the exception of Ammonium Nitrate containing propellants, this shall be demonstrated by the successful completion of the informational requirements of Appendix A, Pre-Source Qualification (QFS) or Bookshelving Requirements, Section IIIG a DV, and PV to this specification. Ammonium Nitrate containing propellants shall be required to undergo added stability evaluation for propellant strength and burn rate stability as agreed to by the Responsible Vehicle Engineering Organization.

3.2.9 Hermeticity:

For pyrotechnic inflators, hermeticity (leak) limits shall be defined by successful completion of an 'induced moisture margin study'. An 'Induced Moisture Margin Study' is defined as the purposeful introduction and equilibration of moisture into sealed inflators to determine the resulting degradation in inflator performance. The acceptable limit of maximum potential degradation in performance by induced moisture shall be less than or equal to 10% of the nominal baseline performance over the fifteen year life of the vehicle. The acceptable 'leak' limit is calculated based on the following assumptions:

1. daily respiration of 33C, 80% RH air (Reference MIL STD 810),
2. differential pressure based on a diurnal temperature range of 38 C. (Reference MIL STD 810),
3. all water is retained (i.e. no water is expired on each cycle),
4. cycles (1 per day for 15 years),
5. instantaneous min to max temperature change,
6. 6 hour duration at each condition,
7. and a circular duct of the shortest possible length.

The calculated leak rate shall allow less water intrusion into the inflator than is demonstrated by the Induced Moisture Margin Study to degrade the inflator performance by less than or equal to 10%.

The leak rate limit shall be set at a maximum of the calculated requirement, or 1 X 10^{-4} $^{cc}/_{atm\ sec}$., assuming 100% Helium (or equivalent), which ever is less.

For stored gas inflators, hermeticity limits shall be defined by the combined fifteen year loss of less than 10% of the baseline nominal performance in a closed tank test when taking into account, both an induced moisture margin studies for any pyrotechnics not inside the pressurized region, and the gas loss of the pressure vessel(s). The overall hermeticity limit shall be set at the resulting calculated value limiting the potential degradation of the inflator performance over the 15 year vehicle life to less than or equal to 10%.

3.2.9.1 Leak Detection:

All inflator(s) shall contain Helium or an equivalent substance which shall be detectable if a leak is present in the pressure vessel and pyrotechnic chamber per Section 5.2.3.1, Leak Test. Alternate procedures are acceptable (i.e. bombing, etc.) where process reliability and sensitivity are demonstrated to the Responsible Vehicle Engineering Organization.

3.2.9.2 Pressurized Inflators:

All stored gas pressure bearing components shall remain intact and shall not leak at a rate greater than that determined in Section 3.2.9, Hermeticity after exposure to pressure cycling per Section 5.2.4.10, Pressure Cycle Durability Test (pressurized inflation devices) and tested per Section 5.2.3.1, Leak Test. Temporary modifications to the inflator for test purposes (i.e. transducer ports, etc.), that do not affect the fundamental integrity of the pressure vessel, or compromise the outcome of the test, are exempt from this requirement.

3.2.10 Dual Stage Inflator(s) - Additional Requirements:

3.2.10.1 Dual Stage Inflator Tunability:

Following deployment of the primary stage of dual level inflators, the inflator's secondary stage shall have the capability of being delay deployed over a range of 0-150 milliseconds.

The inflator's primary to secondary output ratio should be tunable from 50/50 maximum to 80/20 minimum of the total available ballistic output.

3.2.10.2 Sympathetic Ignition of Secondary Stage:

The inflator's secondary stage of a dual stage inflator shall not, at any temperature from -40C to +85C, sympathetically ignite or otherwise inadvertently deploy from 0-150 ms, or during the restraint cycle of the primary stage, whichever is greater.

The secondary stage of a dual stage inflator shall be allowed to ignite or deploy as a result of residual heat or some other repeatable and reliable method, from 150 ms to a maximum of 30 seconds based on an ambient test*. Repeatable and reliable automatic or sympathetic ignition of the second stage shall be demonstrated over the full operational temperature and output range of the inflator. This demonstration shall include a minimum of six (6) tests at each temperature -40C, +23C and +85C. The mean deployment time plus 3 sigma shall be less than 30 seconds at ambient temperature.

Any automatic or sympathetic ignition of the second stage shall be well characterized in a representative module by a minimum of (3) three worst case static occupant position tests to provide no potential for increased injury to an occupant. This shall be characterized by static occupant testing using the worst case full output and primary/secondary output split as agreed to by the Responsible Vehicle Engineering Organizations.

Following deployment of the primary stage, a delayed ignition (or deactivation) of the secondary stage beyond 30 seconds in an ambient test (in a manner that will not cause hazard, decrease the protection of the system to the occupant(s), or cause audible alarm to occupants or emergency personnel) shall be permissible only as agreed to by the Responsible Vehicle Engineering Organizations.

*Note: General acceptance of any sympathetic ignition, and/or 150 ms to 30 seconds of allowable delay should be verified for each OEM. All participants in this specification do not accept sympathetic ignition and/or 150 ms to 30 seconds of allowable delay in equal measure.

4. VALIDATION:

Any change to a DV'd or PV'd inflator's structure, part configuration, propellant load, manufacturing method, or any other change that could alter the outcome of any tests included in the DV or PV test (series) contained herein shall require re-validation. Re-validation may be accomplished through a subset of the requirements (delta DV or PV) containing only those tests whose outcome is in question due to the changes in inflator's structure, part configuration, propellant load, manufacturing method, etc. Any delta DV or PV must be agreed to in advance by all affected parties at the Responsible Vehicle Engineering Organizations.

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

4.1 Design Verification/Production Validation Report Format:

DV and PV Test reports shall include as a minimum the following formatted items:

1. Summary: The summary shall include a clear and complete description of the device in test, cut away drawings of the device in test, indented bill of materials (including part numbers, rev. levels, etc.), a summary description of tests, ballistic summary charts (scatter plots, mean and variability plots, tabular performance charts as required in Section 3.2.7 Inflator Performance and Variability Limits) and analysis of test results.

2. Deviations: All deviations from the specified test protocol and performance requirements, design issue resolutions and any other relevant supporting information generated during the prosecution of the DV or PV shall be included or summarized in a subsection of the completed test report. All agreements or approvals by the Responsible Vehicle Engineering Organizations that alter the requirements of this document shall be documented in the DV or PV report.

3. 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).

4. Informational Requirements: The informational requirements of Section 3.1.6, Informational Requirements shall be included in the DV and PV reports. The informational requirements of Appendix A Presource Qualification (QFS) shall also be included in the DV and PV report if they have not been previously submitted. Informational requirements may be bound as a separate volume

5. Appendices: Appendices should include detailed build records, conditioning records, detailed test results, equipment description and certification (if required) and any other supporting data. Appendices may be bound as a separate volume.

4.2 Deviations From Test Procedure:

Deviations from specified test requirements and 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 verbally and 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.

4.3 Design Verification Process:

4.3.1 DV Program Sequence:

Following is the recommended Design Verification (DV) process:

1) Supplier completes Appendix A Presource Qualification (QFS) and makes it available to all intended customer(s) for review see section 3.2.1 General Inflator Requirements.
2) Supplier completes DFMEA and makes it available to all intended customer(s) for review.
3) Supplier completes configuration document, test plan, and makes them available to all intended customer(s) for Engineering review.
4) The intended vehicle manufacturer's engineering group(s) review the DFMEA and DV test plan. Any and all proposed changes to the plan shall be submitted for review to all of the intended customer(s) Responsible Engineering Organizations for agreement prior to implementation.
5) DV build proceeds. The Responsible Vehicle Engineering Organization shall be given the opportunity to attend the DV build and subsequent testing.

NOTE: Proceeding with a DV without customer review and approval is at the suppliers 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 B, DV/PV Test Matrix, of this document.

Delta DVs are allowed per the opening paragraph, Section 4 Validation. All tests in which the results could be altered by the considered changes to the inflator shall be repeated. The delta DV shall clearly reference the previously completed DV.

The use of surrogate data, where agreed to in advance by the Responsible Vehicle Engineering Organization, is allowed. 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.

For Section 5.2.4.8, Inflator Sequential/Environmental Test exposures shall follow the sequence given in Appendix B, DV/PV Test Matrix, without exception.

4.4 Production Validation Process:

4.4.1 PV Program Sequence:

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

1) Supplier prepares package for all Supplier Quality Assurance and/or responsible engineering groups of intended customer(s) showing compliance with design and manufacturing requirements as required by PPAP.
2) Supplier completes PFMEA and provides completed document to all Supplier Quality Assurance and/or Responsible Vehicle Engineering Organization(s) of the intended customer(s) for review and approval as required by PPAP.
3) Supplier completes configuration document, test plan, and time schedule and provides completed documents to all Supplier Quality Assurance and/or or Responsible Vehicle Engineering Organization(s) of the intended customer(s) for review and agreement. PV test plan shall be structured from three lots of inflators (a, b, and c) in accordance with Appendix B, DV/PV Test Matrix of this document.
4) Supplier Quality Assurance and/or Responsible Vehicle Engineering Organization(s) of intended customer(s) approves documentation including PFMEA and PV test plan. Once the PV test plan has been agreed to, any and all proposed changes to the plan shall be submitted to Supplier Quality Assurance for agreement prior to implementation.
5) PV build proceeds. The PV build shall be built at production capacity planing cycle time. The Responsible Vehicle Engineering Organization shall be given the opportunity to attend the PV build and all subsequent testing.

4.5 Validation Tests & Environments:

4.5.1 General Requirements:

4.5.1.1 Ballistic Test Device:

All ballistic deployments shall be performed in tank sizes per Section 5.2.1, Test Equipment.

4.5.1.2 Allowable Time Period for Ballistic Test:

Test inflators shall be deployed within 3 minutes of removal from the conditioning chamber. (Other methods where ‘at temperature’ deployments are demonstrated are acceptable as approved by the Responsible Vehicle Engineering Organizations.) On occasions an inflator can not be deployed within the required 3 minutes. The at temperature inflator shall be returned to the conditioning chamber within 5 minutes and reconditioned for a minimum of 1 hour or 125% of the time required for the inflator core temperature to reach equilibrium at the required deployment temperature.

4.5.1.3 Pass/Fail Criteria:

The inflators shall meet the requirements of Section 3.2.7, Inflator Performance and Variability Limits or as amended by the Responsible Vehicle Engineering Organization based on vehicle specific criteria.

5. TEST REQUIREMENTS:

5.1 General Requirements:

5.1.1 Dual Stage Inflator Delay:

Unless otherwise specified elsewhere in this document, for dual level inflators, tests shall be conducted by deploying both the primary and secondary stages simultaneously.

5.1.2 Test Tolerances:

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

Time	± 1% (except where minimums are stated)
Temperature	± 2 C
Ambient Temperature	23 C
Relative Humidity	± 10% of R.H.
Force	± 4 Newtons
Vacuums	± 10 mm of Hg
Height	± 0.05 m
Acceleration	± 4% except were minimums are stated
Frequency	± 4% or ± 2 HZ, whichever is greater
Current (Amps)	± 0.01 A
Voltage (Volts)	± 5%
Resistance (Ohms)	± 1.0%
Tank Volume	± 5.0%
Firing Pulse Duration	± 0.5 ms

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

5.2 General Tests:

5.2.1 Test Equipment:

Test Equipment shall be utilize as specified, by the indicated test procedures, standards and specifications.

All Inflators shall be prepared for testing and attached to a sealed tank with chemically inert internal surfaces according to Table 5.2.1.A, Closed Tank Sizes. The attachment shall allow the Inflator to discharge all gases (all gases shall be collected in the tank after deployment) into the tank when activated. The closed tank test procedure of Section 5.2.3.7, Closed Tank Test of this document shall be referenced for tank testing of Inflators.

Table 5.2.1.A Closed Tank Sizes

Inflator Type	Tank Size
Passenger	60 liter
Driver	60 liter
Side	28.3 liter (1 ft3)
Pretensioner	1 liter

5.2.1.1 Calibration of Equipment:

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 Responsible Vehicle Engineering Organization(s).

5.2.2 Test Samples:

For test sample size requirements, reference Appendix B DV/PV Test Matrix.

5.2.3 General Procedures:

5.2.3.1 Leak Test Procedure:

For pyrotechnic inflators: For the purposes of this test series the supplier shall provide leak check procedure(s) compatible with the inflator technology(s). The leak checking procedure shall be demonstrated capable of detecting leaks from 'gross' through one (1) order of magnitude more sensitive than the leak rate established in Section 3.2.9, Hermeticity.

For pressurized inflation devices: The supplier shall provide leak check procedure(s) compatible with the inflator technology(s). The leak checking procedure shall be demonstrated capable of detecting leaks from 'gross' through one (1) order of magnitude more sensitive than the maximum allowable leak rate per Section 3.2.9.1 Leak Rate.

5.2.3.2 Weight Inspection Procedure:

All inflators shall be weighed and reported in Grams, with a calibrated balance to a minimum of two decimal places (i.e. xxx.xx g). The weights shall be recorded along with the inflator serial number for comparison to manufacturing, pre-environmental, post-environmental and post-test weights. All weights shall be reported in chart form in the supplemental data section of the inflator QFS, DV and PV reports.

5.2.3.3 Visual Inspection Procedure:

All inflators shall be carefully examined taking note of all external physical features such as nozzle holes present, seal integrity, weld or crimp appearance and integrity as well as any other physical characteristics that can be noted by external physical examination. Post environmental examination shall include any changes to the physical appearance of the inflator as well as the presence or absence of normal features. All visual observations shall be reported in chart form in the supplemental data section of the inflator QFS, DV and PV reports.

5.2.3.4 Electrical Check Procedure:

All inflators shall be evaluated for proper electrical isolation and continuity requirements per appropriate safety procedures. All electrical measurements shall be recorded along with the inflator serial number for comparison to manufacturing, pre-environmental and post-environmental measurements. All electrical measurements shall be reported in chart form in the supplemental data section of the inflator QFS, DV and PV reports.

5.2.3.5 100 ft^3 Tank Effluent Test Procedure:

Inflators shall be tested in standard modules (see appendix A Pre-source Qualification Section IV G Table 1 for module definition) per SAE Procedure J 1794 with flow rates as defined in Section 3.2.3.2.3 Gas Sampling and Analysis. Quantities for testing are defined in Appendix A Pre-source Qualification and Appendix B DV/PV Test Matrix. The results of the test shall be reported in the tables supplied in Appendix D Gas and Particulate Reporting Tables, or equivalent.

5.2.3.6 Open Air Test Procedure:

Inflators that require open air deployment shall use the following (or equivalent) equipment and procedure.

Purpose: To define procedure for testing Inflator assemblies on an open air stand.

Required Equipment & Material:

1. *Equipment*

The following equipment shall be calibrated as required per the associated calibration procedures:

Constant Current/Voltage Supply
Actuation equipment and Ohmmeter
Approved Data Acquisition and camera Systems
Temperature chamber, capable of maintaining -40°C, 23°C, and 85°C

2. *Procedure*

1. Condition inflators as required per section 5.2.3.7.1, Conditioning of Inflators.
2. Verify ready condition of all cameras, lighting, transducers, etc. for the deployment.
3. Remove inflator from conditioning chambers and make all necessary preparations for deployment.
4. Deploy the Inflator at the conditioning temperature of -40°C, 23°C, or 85°C using a minimum of the allfire current rating of the initiator in use within the proper time interval per Section 4.5.1.2 Allowable Time Period for Ballistic Test.
5. The results including any residue, flame observed, and a visual post deployment inspection of the inflators shall be reported in a clear concise manner in the DV and PV reports.

5.2.3.7 Closed Tank Test Procedure:

Inflators that require Closed Tank deployment shall use the following (or equivalent) equipment and procedures.

Purpose: To define procedure for testing Inflator assemblies in a closed tank.

Required Equipment & Material:

1. *Equipment*

The following equipment shall be calibrated as required per the associated calibration procedures:

Constant Current/Voltage Supply
Actuation equipment and Ohmmeter
100-200 psi Pressure Transducer (or as required)
Sealed Test Tank

a. 28.3 liter (1 ft^3) for Side Air Bag Inflators
b. 60 liter for Driver or Passenger Air Bag Inflators

Approved Data Acquisition System
Temperature chamber, capable of maintaining -40°C, 23°C, and 85°C

Note: Refer to SAE J2238 and SAE J211 for expanded equipment requirements.

2. *Materials*

Mild, Non Abrasive Detergent
Deionized or Distilled Water

5.2.3.7.1 Conditioning of Inflators:

1. Condition Inflator at -40°C, 23°C, or 85°C for minimum of 4 hours or 125% of the demonstrated time for the inflator core temperature to reach equilibrium with the conditioning temperature. (The time to equilibrium temperature shall be demonstrated with the worst case positioning and maximum number of inflators in the chamber.)
2. Upon removal of the Inflator from the conditioning chamber, the Inflator shall be deployed within the time constraints of section 4.5.1.2, Allowable Time Period for Ballistic Test.

5.2.3.7.2 Test Procedure:

1. Where tank content samples are required per Appendix B DV/PV Matrix, clean the test tank per tank cleaning procedure Section 5.2.3.7.3, Tank Cleaning Procedure, of this document. Tank shall be at ambient temperature and pressure prior to deployment.
2. Remove inflator from conditioning chambers and make all necessary preparations for deployment.
3. Deploy the Inflator at the conditioning temperature of -40°C, 23°C, or 85°C using a minimum of the allfire current rating of the initiator in use within the proper time interval per Section 4.5.1.2 Allowable Time Period for Ballistic Test.
4. After the completion of data acquisition, and allowing time for suspended particulate to settle (up to one minute or as required), vent the gases from the tank via the bleed valve into the exhaust system.
5. Remove the Inflator from the tank and visibly inspect the inflator for any leakage or residue. Note any findings for inclusion in the DV and PV reports.
6. Sample tank contents as indicated in Appendix B DV/PV Matrix per Section 5.2.3.7.4, Sampling Tank Contents (Tankwash) Procedure of this document.

Data Processing and Reporting :

1. Standard data to include:

   a) All pressures to be reported in kPa
   b) Time to first pressure
   c) Pressure vs. Time curve (Data filtered with SAE Class 60 filter).
   d) Slope using the best fit line along the curve as calculated from a minimum of 9 equally spaced points from 10%-50% pressure
   e) Time at 10% peak output
   f) Time at 25% peak output
   g) Pressure at 50% peak output
   h) Pressure at 75% peak output
   i) Time to 90% peak output
   j) Peak pressure
   k) Time to peak pressure
   l) Firing current vs. time trace.
   m) Tank wash particulate as indicated in Appendix B DV/PV Matrix.

2. Supplemental data (temperatures, chemical analysis, etc.) shall be provided as required in Appendix B DV/PV Matrix.
3. All curves shall be formatted to include test description (title), test temperature, test number, tank size, company name, and any other information required to identify the specific test. For sample data formatting refer to Appendix F Ballistic Samples. For all mean curves include the number of data sets used.
4. Report any anomalies, residue, etc. for inclusion in the DV or PV report.

5.2.3.7.3 Tank Cleaning Procedure (pre test and post test with no sampling):

Purpose: To define the general procedure for washing test tanks and purging them prior to sampling tank contents.

Test Samples:

Distilled or deionized water
Mild, nonabrasive detergent (e.g., Ivory soap) where applicable
Clean brush
Spray gun

Pre-test Tank cleaning Procedure:

1. Use spray gun (or equivalent) to spray and wash the residue off the tank walls, lid, and fixtures with deionized or distilled water.
2. Using a nonabrasive detergent (if any oily substances are present) and a clean brush, scrub the entire interior surface of the tank. Make sure all openings, bulkheads, and seals of the tank are clean and free of deposits.
3. Drain the tank completely through the appropriate tank opening.
4. Thoroughly flush the tank, openings, fittings and fixtures a final time with deionized or distilled water. Drain the tank and allow for the tank to dry completely. A clean, dry, lint-free cloth or clean dry lab air can be used to dry the tank.

5.2.3.7.4 Sampling Tank Contents (Tankwash) Procedure:

Purpose: To define a general procedure for sampling tank contents after an Air Bag Inflator deployment.

Required Equipment:

1000 ml deionized or distilled water
1 liter chemically inert bottle or flask
30-40 psi spray gun (or equivalent)

Test Procedure to weigh Particulate from Tank Test:

1. Use spray gun (or equivalent) to spray and wash the residue off the tank walls, lid, and fixtures using approximately 500 ml of deionized or distilled water.
2. Capture all liquid and residue in an appropriate clean container.
3. Repeat step 1 with an additional approximately 500 ml of deionized or distilled water to equal less than 1000 ml of total liquid. Take special care to assure all openings, bulkheads, and seals of the tank are thoroughly rinsed and clean.
4. Add the second 500 ml of liquid and residue into the sample from item 1 (i.e. 1 liter chemically inert bottle or flask). Submit the entire 1000 ml to the chemistry lab as required per Appendix B, DV/PV Matrix for analysis per Section 5.2.3.7.5, Tankwash Solution and Particulate Analysis, and/or Section 5.2.3.7.6, Tankwash Solution and Particulate Speciation of this document.

5.2.3.7.5 Tankwash Solution and Particulate Analysis:

Purpose: To describe general requirements for the analysis of the tankwash solution and particulate from the inflator closed tank tests.

Test Requirements:

Analysis of the tankwash solution and particulate shall include:

1. pH of tankwash solution in the original 1000 ml volume
2. Total weight of particulate
3. Soluble and Insoluble fractions
4. Speciation of Soluble and Insoluble fractions where indicated in appendix A Pre-source Qualification Section III F.

Determination of the pH, Particulate Weight, and Soluble /insoluble Fractions

1. Measurement of the pH of the tankwash solution:

   a) Volumetrically dilute the sample to 1000 ml. Transfer an aliquot of the sample to a clean beaker, measure and report the pH of the tankwash solution.
   b) The accuracy of this analysis should be ± 0.1 pH unit.
   c) The pH meter calibration shall be verified before and after the measurement using a buffered standard within two (2) pH units of the measured value.

2. Particulate Analysis (Large, Soluble, Insoluble and Total weight of particulate):

   a) Using the sample from part 1, filter the sample through a 10 mesh (or less, i.e. larger). Weigh, report origin and include the large particulate weight for informational purposes only.
   b) Filter the insoluble material from the sample using a clean pre-weighed filter paper.
   c) Dry the filter paper, weigh and subtract the filter paper weight providing the weight of the insoluble fraction.
   d) Evaporate the entire filtered (or an aliquot of a minimum 200 ml) sample to dryness in a drying oven at a temperature that will not decompose the sample. Total dissolved solids method is acceptable where controlled experiments have demonstrated their accuracy.
   e) Weigh and report the full soluble particulate weight.
   f) Report the sum of the soluble and insoluble particulate fractions as the Total particulate weight.

5.2.3.7.6 Tankwash Solution and Particulate Speciation:

Purpose: To describe the general requirements for the full species analysis of the tankwash solution and particulate from the inflator closed tank tests. Specific situations may require additional procedures.

Test Requirements:

Analysis of the tankwash solution and particulate obtained per Section 5.2.3.7.4, Sampling Tank Contents (Tankwash) Procedure shall include:

As required in Section 3.1.6.1, Inflator Pre-source Qualification (QFS) or Bookshelving, and Appendix B, DV/PV Matrix, elemental and /or molecular composition (salts) of the soluble and insoluble fractions of particulate shall be determined and reported per the tables supplied in Appendix D, Gas an Particulate Reporting Tables. In addition to providing a full analysis of all major components, the concentration and calculated mass of the following elements in the particulate shall be determined: aluminum, cadmium, chromium, copper, iron, lead, nickel, mercury, arsenic, and zinc. A single set of analysis for each inflator family with a specific chemistry is acceptable for DV and PV.

A. Insoluble Fraction analysis

  a. Dissolve the insoluble particulate fraction from a tank wash in an appropriate carrier to prepare for analysis (i.e. *aqua regia*. Note: Use approx. 2 ml per 1 mg of sample weight.)
  b. Perform elemental analysis for metals including a minimum of aluminum, cadmium, chromium, copper, iron, lead, nickel, mercury, arsenic, and zinc. Allowable methods are:

    - Atomic absorption spectroscopy
    - Inductively coupled plasma - atomic emission spectroscopy
    - Inductively coupled plasma - mass spectroscopy
    - Equivalent analytical technique

  c. Report the mass concentration for each element.

B. Soluble Fraction analysis

  a) Perform elemental analysis for metals including a minimum of aluminum, cadmium, chromium, copper, iron, lead, nickel, mercury, arsenic, and zinc. Allowable methods are:

    - Atomic absorption spectroscopy
    - Inductively coupled plasma - atomic emission spectroscopy
    - Inductively coupled plasma - mass spectroscopy
    - Ion Chromatography
    - Equivalent analytical technique

b) Perform ionic analysis for anionic and cationic (where applicable) soluble species. Allowable methods are:

- Ion Chromatography
- HPLC
- Equivalent analytical technique

c) Report the concentration and calculated mass for each element.

Calibration Check or Routine Calibration:

1. The general calibration of instrumentation and the analysis specific calibration shall be consistent with common analytical practices for each type of analysis.

2. A minimum of one calibration check shall be performed for each group of analysis. The calibration check shall include all reported elements. The concentrations of each element in the standard shall bracket the range of the measured concentration for that element in the sample.

3. For all analyses where applicable (AA, ICP, HPLC, etc), a (matrix) blank shall be carried through the entire analytical procedure along with the actual samples to account for background concentrations, matrix affects and potential losses during sample handling. Results from the background sample analyses shall be reported along with that for the actual samples.

5.2.3.8 Live Dissection Procedure:

Purpose: To provide a general procedure for evaluation of Inflator internal components.

Procedure:

Fixture the inflator and vent any stored gas per appropriate safety protocol.
Open body chamber(s) of inflator per appropriate safety protocol, in a way that does not disturb the internal components of the inflator.

Remove and document any degradation, deformation, or other changes to the internal components, propellants and assemblies using both a written description and photographs. Retain components for review of the Responsible Vehicle Engineering Organization for a minimum of 1 (one) year after submission of the DV or PV report. Where hazardous components are clearly documented to be within normal requirements ands such documentation is immediately available, those components can be discarded with the Responsible Engineering Groups approval.

5.2.4 Specific Tests:

5.2.4.1 Inflator Base Line Test:

Purpose: To evaluate Inflator base line performance and variability.

Test Fixtures and Equipment:

Closed tank Fixture
Temperature chamber, capable of maintaining -40°C to 85°C

Test Procedure:

1. Inspect Inflators visually for dimensional integrity.

2. Randomly select the inflators for live dissection. See Section 5.2.3.8, Live Dissection Procedures, for requirements after live dissection. For PV testing, randomly select one inflator from each lot.

3. Perform closed tank test per Section 5.2.3.7, Closed Tank Test of this document. Measure inflator's internal pressure (using pressure transducer) for all baseline deployments. For dual stage inflators measure internal pressure on only full output deployments. Where the measurement of internal pressures could affect the baseline performance (DV and PV), or the ability to use production processes (PV), a separate series of inflators shall be utilized for baseline deployments and internal pressure measurements.

Evaluation and Results:

The Inflator assembly shall meet the functional requirements specified in Section 3.2.7, Inflator erformance and Variability Limits.

5.2.4.2 Structural Burst Test:

Purpose: To evaluate Inflator burst strength and to determine the burst mode of Inflator (Structural components only)

Test Fixtures and Equipment:

Hydrostatic (or fluid) pressure equipment.

Test Procedure:

1. The inflators shall be tested at 23°C as specified in Section 5.2.3.7, Closed Tank Test of this document.

2. Seal inflator gas ports in a manner that allows burst but does not change the structural strength of the inflator's body.

   (Note: Use only production intent body for all structural burst units.)

3. Increase pressure gradually (i.e. < 150 psi / ms) until burst occurs. For dual level Inflators, conduct structural burst of each pressure vessel separately and both chambers simultaneously by pressurizing both chambers in parallel.

4. Document Burst Mode with a description and photographs.

5. Calculate mean burst pressure and standard deviation for use in the following formula.

6. Calculate the Maximum Expected Operating Pressure (MEOP) and standard deviation from the internal pressure measurements of the Baseline Inflators Section 5.2.4.1, Inflator Base Line Test at -40C, +23C, and +85C for use in the following formula.

Note: Dynamic burst testing may be used when no reasonable alternative can be found. Prior agreement of the Responsible Vehicle Engineering Organization, and by prior agreement to the specific test method and pass/fail criteria shall be obtained.

Evaluation and Results:

Method 1
The mean burst pressure, minus 3 standard deviations, of the structural container shall exceed the maximum expected operating pressure by a factor greater than 1.5 at all three temperatures.

$$\text{Safety Factor} = \frac{\overline{x}_{\text{Burst}} - 3_{S_{\text{Burst}}}}{\text{MEOP}} > 1.5$$

Where:

MEOP	Maximum Expected Operating Pressure
$\overline{x}_{\text{Burst}}$	Average of Hydroburst pressure
S_{Burst}	Sample standard deviation of Hydroburst pressure

The following calculations are necessary to determine the MEOP

$$MEOP_{-40C} = \overline{x}_{-40C} + 3_{S_{-40C}}$$
$$MEOP_{+23C} = \overline{x}_{+23C} + 3_{S_{+23C}}$$
$$MEOP_{+85C} = \overline{x}_{+85C} + 3_{S_{+85C}}$$

Where:

$\overline{x}_{-30C}$	Average internal pressure at -40°C
S_{-30C}	Sample standard deviation of internal pressures at -40°C
$\overline{x}_{+23C}$	Average internal pressure at +23°C
S_{+23C}	Sample standard deviation of internal pressures at +23°C
$\overline{x}_{+85C}$	Average internal pressure at +85°C
S_{+85C}	Sample standard deviation of internal pressures at +85°C

Choose the largest of the above MEOPs for calculation of the Safety Factor.

Note: MEOP shall be measured using pressure transducers.
MEOP shall be determined using unfiltered data (use of class 1000 filters so as not to remove short duration peaks is acceptable).
For Inflators with multiple pressurized chambers, all safety factors shall be calculated (i.e. initiator chamber, gas bottle, diffuser or multiple pyrotechnic combustion chambers, etc.). All shall meet the factor of safety requirements as specified.
For dual level inflators structural failure in a common component or wall is allowed only if such a failure is the standard operating mode of the component and does not eject components or fragments (exempting burst foils).

Method 2
Refer to Appendix C Statistical Inflator Structural Margin Calculations, for statistical evaluation method for PV's where stable production processes are established, a statistically significant sample size can be tested, and production margin components and process can be verified. Statistical models can be utilized on a case by case basis to validate structural margins per Appendix C Statistical Inflator Structural Margin Calculations, as approved by the Responsible Vehicle Engineering Organizations.

The Inflator shall exhibit a ductile separation mode when it bursts.

5.2.4.3 High Temperature Oven (HTO) Test:

Purpose: Verify that the Inflator will not deploy at or below 115 C or autoignight below 130 C.

Test Fixtures and Equipment:

Temperature chamber or equipment, capable of maintaining 107 C. The same equipment or other as required to raise the inflator temperature at up to ≤14 C per minute until the inflator deploys.

Test Procedure:

1. Inspect all Inflators for gas leaks (pressure vessel type Inflator).

2. Condition 3 of the base line Inflators for minimum of 4 hours at 107 °C (HTO test). Inflators shall not deploy.

3. The temperature of the Inflators shall then be increased at a rate not to exceed 14C/min until all gas and pyrotechnic materials are spent.

Evaluation and Results:

1. Inflators shall retain all stored gas (pressure vessel type inflators) and shall not deploy during the HTO +107C heat soak environment.
2. For stored gas inflators the temperature at which the gas in the inflator vents, shall for each individual inflator be > +130C, or the mean gas venting temperature minus 3 sigma shall be > +115C. No structural failure, except internal components that do not result in the ejection of any inflator fragments, shall occur. No time/pressure data is required. Additional quantities of inflators can be used to minimize the sigma as required.
3. The auto ignition temperature for all pyrotechnic mixtures (such as propellants, boosters, combustible gasses etc.) shall be > +130C as measured from the surface of the inflator nearest the thermal path to the specific pyrotechnic mixture in question. No structural failure, except internal components that do not result in the ejection of any inflator fragments, shall occur. No time/pressure data is required. Additional quantities of inflators can be used to minimize the sigma as required.

5.2.4.4 Bonfire Test:

Purpose: Verify that the Inflator will deploy and not fragment when subjected to a bonfire per DOT requirements.

Test Fixtures and Equipment:

Bonfire test equipment
Video recording equipment

Test Procedure:

1. Conduct Bonfire test per DOT on the subject Inflators.

Evaluation and Results:

1. Inflators shall deploy without structural failure.

2. The Inflators shall not fragment or expel any component or part thereof. The Inflator's traceability identifier shall be legible (excepting components that melt or are consumed). Inconsequential fragments (such as burst foil) shall be allowed based on their lack of potential hazard, as agreed to by the Responsible Vehicle Engineering Organization.

5.2.4.5 Slow Heat/Autoignition Test:

Purpose: Verify that the Inflator will deploy and not fragment when subjected to a surface heating rate of ≤14 C/min.

Test Fixtures and Equipment:

Slow Heat equipment capable of ≤14 C/min controlled slow heating of the inflator surface
Protective enclosure
Video recording equipment.

Test Procedure :

1. Starting at 23 C conduct controlled slow heating, at ≤14 C/min of the inflator surface, until deployment of each of the six Inflators.
2. Heating shall continue until all energetic materials in the inflator(s) deploy.

Evaluation and Results:

1. Inflators shall deploy without structural failure.

2. The Inflators shall not fragment or expel any component or part thereof. The Inflator's traceability identifier shall be legible. Inconsequential fragments shall be allowed i.e. burst foil, based on their lack of potential hazard, as agreed to by the Responsible Vehicle Engineering Organization.

5.2.4.6 Accelerated Heat Aging Test:

Purpose: Evaluate Inflator resistance to temperature aging in a dry condition.

Test Fixtures and Equipment:

Temperature chamber, capable of maintaining 90°C and/or 107°C.

Test Procedure:

1. Condition Inflators at 90°C for minimum of 1000 hours*, or 107°C for 408 hours with maximum of 20% RH.

2. Inspect Inflator for gas leaks (pressure vessel type Inflator).

3. Verify Inflator terminal-to-terminal resistance after each conditioning.

4. Perform closed tank test of required (see Appendix B, DV/PV Test Matrix) heat aged inflators per 5.2.3.7, Closed Tank Test of this document. Reserve required (see Appendix B, DV/PV Test Matrix) inflators for the completion of Section 5.2.4.6.1 Accelerated Aging/High Temperature Oven (HTO) Test, Section 5.2.4.6.2, Accelerated Aging/Bonfire Test and Section 5.2.4.6.3 Accelerated Aging/Slow Heat Test.

*Note: General acceptance of 1000 hours at 90 C should be verified for each OEM. All participants in this specification do not accept One thousand (1000) hours at 90 C, as an alternate method of testing in equal measure.

Evaluation and Results:

The Inflator shall meet the functional requirements specified in Section 3.2.7 Inflator Performance and Variability Limits

5.2.4.6.1 Accelerated Aging with High Temperature Oven (HTO) Test:

Purpose: Verify that the Inflator will not deploy at or below 115 C or autoignight below 130 C after heat aging.

Test Fixtures and Equipment:

Temperature chamber or equipment, capable of maintaining 107 C and then raising the inflator temperature at up to 14 C per minute until the inflator deploys.

Test Procedure :

Follow test procedure as outlined in Section 5.2.4.3 High Temperature Oven (HTO) Test

Evaluation and Results:

Results shall be as outlined in Section 5.2.4.3 High Temperature Oven (HTO) Test

5.2.4.6.2 Accelerated Aging with Bonfire Test:

Purpose: Verify that the Inflator will deploy and will not fragment when subjected to a bonfire per DOT after heat aging.

Test Fixtures and Equipment:

Bonfire test equipment
Video Recording equipment.

Test Procedure :

Follow test procedure as outlined in Section 5.2.4.4 Bonfire Test

Evaluation and Results:

Results shall be as outlined in Section 5.2.4.4 Bonfire Test

5.2.4.6.3 Accelerated Aging with Slow Heating Test:

Purpose: Verify that the Inflator will deploy and will not fragment when subjected to a heating rate of less than 14 C/min after heat aging.

Test Fixtures and Equipment:

Slow Heat equipment capable of less than 14 C/min controlled slow heating of the inflator surface
Protective enclosure
Video Recording equipment.

Test Procedure:

Follow test procedure as outlined in Section 5.2.4.5 Slow Heat/Autoignition

Evaluation and Results:

Results shall be as outlined in Section 5.2.4.5 Slow Heat/Autoignition

5.2.4.7 Inflator High Humidity/Heat Age Test:

Purpose: Evaluate Inflator resistance to temperature aging in an environment of high humidity.

Test Fixtures and Equipment:

Loosed tank fixture
Temperature/Humidity chamber capable of maintaining 95% RH at 70C.

Test Procedure:

1. Condition Inflators at 70°C with a minimum of 95% RH for minimum of 408 hours.

2. Inspect Inflator for gas leaks (pressure vessel type Inflator).

3. Verify Inflator terminal-to-terminal resistance after conditioning.

4. Perform closed tank test of required (see Appendix B, DV/PV Test Matrix) heat/humidity aged inflators per Section 5.2.3.7, Closed Tank Test of this document.

Evaluation and Results:

The Inflator <u>shall</u> meet the functional requirements specified in Section 3.2.7 Inflator Performance and Variability Limits

5.2.4.8 Inflator Sequential/Environmental Test:

Purpose: To evaluate Inflator performance in a series of different environmental conditions.

5.2.4.8.1 Inflator Thermal Shock Resistance Test:

Purpose: To evaluate performance effect on Inflator components due to rapid temperature changes.

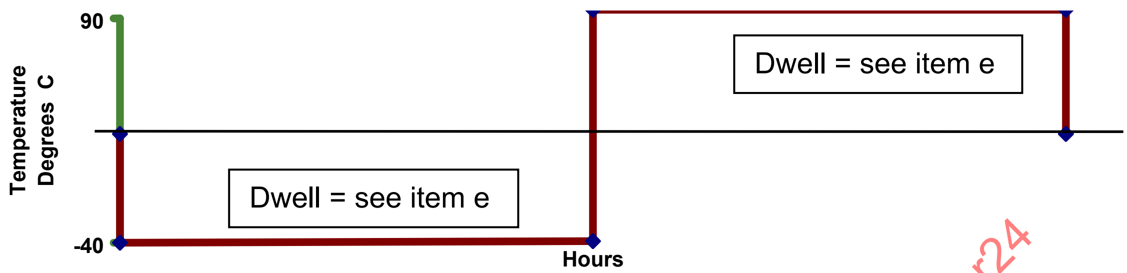
Test Fixtures and Equipment:

Closed tank fixture
Temperature chamber, capable of maintaining -40°C to 90°C

Test Procedure:

1. Beginning and Ending at 23 C Apply 200 temperature cycles, see figure below. One temperature cycle consists of the sequence illustrated in the figure.

Temperature Cycle
Inflator core temperature shall reach the specified conditioning temp
Duration of a cycle may vary with inflator size (see note e)



a- Place Inflator into -40°C chamber within 120 seconds.
b- Condition Inflator at -40°C.
c- Place Inflator into 90°C chamber within 120 seconds.
d- Condition Inflator at 90°C.
e- Hours of dwell shall be four (4) or 125% of the time the core temperature of all inflators require to equilibrate in the test chamber, using the actual mounting method and quantity of inflators under test.
Note: Temperature overshoot of up to 10C with a worst case instrumented control inflator is acceptable.

Evaluation and Results:

Perform visual inspection of the Inflator. All discrepancies shall be documented and reported to the responsible Vehicle Engineering Organizations.

Inspect Inflator for gas leaks (pressure vessel type Inflator).

Optional: Verify Inflator terminal-to-terminal resistance.

5.2.4.8.2 Dynamic Shock Test:

Purpose: To evaluate the effects of mechanical shocks such as pot holes, steering wheel adjustment (25 g), and high impacts (60 g) on Inflator performance.

Test Fixtures and Equipment:

Rigid fixture to mount Inflator
Shaker

Test procedure:

1. Complete Section 5.2.4.8.1, Inflator Thermal Shock Resistance Test.

2. Complete dynamic shock test per the schedule in the following table.

LOW g Test ***Inflators from*** Group D1	***HIGH g Test*** ***Inflators from*** Group D2
Acceleration: Minimum of 25 g Nominal Shock Duration: 6 ms Nominal Shock Shape: Half Sine Number of Shocks Per Axis: 3 (18 total) 3 axis (X, Y, Z) in both positive and negative directions **Test Method:** 1. Apply 25 g, 3 times 2. Change axis and repeat step 1 3. Continue step 1 and step 2 until all 6 axes are tested	Acceleration: Minimum of 60 g Nominal Shock Duration: 11 ms Nominal Shock Shape: Half Sine Number of Shocks Per Axis: (18 total) 3 axis (X, Y, Z) both positive and negative directions **Test Method:** 1. Apply 60 g, 3 times 2. Change axis and repeat step 1 3. Continue step 1 and step 2 until all 6 axes are tested

Evaluation and Results:

Perform visual inspection of the Inflator. All discrepancies shall be documented and reported to the responsible Vehicle Engineering Organizations.

Inspect Inflator for gas leaks (pressure vessel type Inflator).

Optional: Verify Inflator terminal-to-terminal resistance.

5.2.4.8.3 Vibration - Temperature Cycle Test:

Purpose: To evaluate the effect of vibration and temperature on Inflator performance.

Test Fixtures and Equipment:

Temperature chamber, capable of maintaining -40°C to +90°C.
Rigid fixture to mount Inflator
Shaker

Test procedure:

1. Complete Section 5.2.4.8.2, Dynamic Shock Test.

2. Condition Inflator at 23°C per Section 5.2.3.7.1, Conditioning of Inflators, of this document.

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

Table 5.2.4.7.3.A

Frequency range: 5 - 1000 Hz		*Driver Inflators*	*Passenger / Side Inflators*
PSD Level at:	5 Hz	$20\ m^2/s^3 = 0.21\ g^2/Hz$	$8.7\ m^2/s^3 = 0.09\ g^2/Hz$
	30 Hz	$20\ m^2/s^3 = 0.21\ g^2/Hz$	$8.7\ m^2/s^3 = 0.09\ g^2/Hz$
	200 Hz	$0.5\ m^2/s^3 = 0.0052\ g^2/Hz$	$1.1\ m^2/s^3 = 0.011\ g^2/Hz$
	1 kHz	$0.1\ m^2/s^3 = 0.001\ g^2/Hz$	$0.22\ m^2/s^3 = 0.0023\ g^2/Hz$
Maximum acceleration:		$33\ m/s^2 = 3.365$ g RMS	$30\ m/s^2 = 3.053$ g RMS

4. 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 inflator for a minimum of 270 ± 5 minutes at -40°C
   - Raise temperature to 90°C at the rate of 2°C / minute
   - Condition inflator for a minimum of 270 ± 5 minutes at 90°C.
   - Bring inflators to 23°C at the rate of 2°C / minute

5. Optional: Verify Inflator terminal-to-terminal resistance.

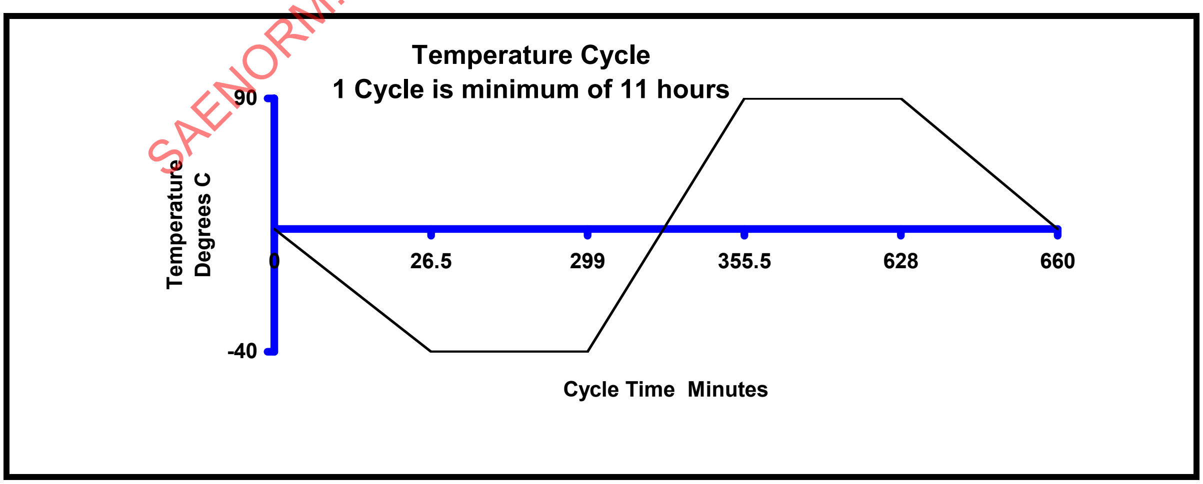
6. Condition Inflator at 23°C per Section 5.2.3.7.1, Conditioning of Inflators, of this document. Change vibration direction to Y-axis (Inflator's axis) repeat steps 3 and 4.

7. Condition Inflator at 23°C per Section 5.2.3.7.1, Conditioning of Inflators, of this document. Change vibration direction to Z-axis (Inflator's axis), repeat step 3 and 4.

Note: *For symmetrical Inflators, the vibration-temperature cycle can be performed on two axes. However, the vibration duration shall be increased to 33 hours per axis.*

The temperature profile is shown in the following figure.

Figure 5.2.4.7.3.B



Evaluation and Results:

Perform visual and audio inspection of the Inflator during and after the conditioning procedure. All visual and audio discrepancies shall be documented and reported to the Responsible Vehicle Engineering Organization.

Inspect Inflator for gas leaks (pressure vessel type Inflators).

Optional: Verify Inflator terminal-to-terminal resistance.

5.2.4.8.4 Humidity Resistance Test:

Purpose: To evaluate the effect of humidity on Inflator performance

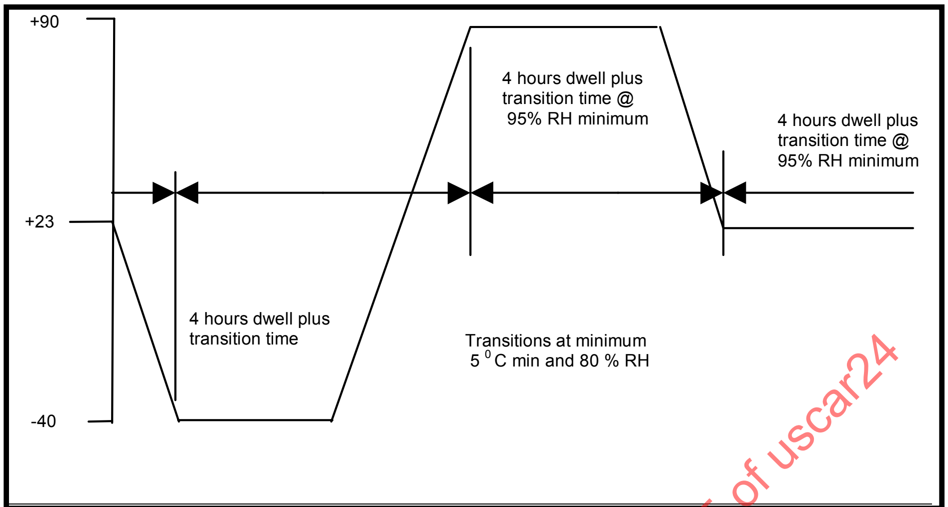
Test Fixtures and Equipment:

Temperature chambers, capable of maintaining -40°C and 90°C, and up to 95% RH.

Test Procedure:

1. Complete Section 5.2.4.8.3, Vibration Temperature Cycle Test
2. Condition Inflator for a minimum of 288 hours with temperatures of -40°C, 23°C, and 90°C and with 95% minimum RH according to Figure 5.2.4.8.4.A, Humidity/Thermal Cycle.
3. Inflator shall complete 24 cycles of conditioning, as shown in Figure 5.2.4.8.4.A, Humidity/Thermal Cycle, the relative humidity shall be at least 95% except during the temperature transitions when the minimum RH level shall be 80% where the temperature is above freezing.
4. The transition shall be at a minimum 5°C/minute, and maintain a minimum of 80% RH where the temperature is above freezing.

Figure 5.2.4.8.4.A Humidity/Thermal Cycle



Evaluation and Results:

Perform visual inspection of the Inflator. All visual damage shall be documented and reviewed with the Responsible Vehicle Engineering Organization.

5.2.4.8.5 Salt Spray Test:

Purpose: To evaluate the corrosion resistance of the Inflator

Test Fixtures and Equipment:

Chamber capable of maintaining 23 C while providing 5% salt solution spray to all surfaces of the inflator.

Test Procedure:

1. Complete Section 5.2.4.8.4, Humidity Resistance Test
2. Optional: Verify Inflator terminal-to-terminal resistance.
3. Condition Inflators at 23°C, per Section 5.2.3.7.1, Conditioning of Inflators of this document.
4. Condition Inflators for minimum of 24 hours in a salt spray at 5% solution and +23C per ASTM B117.
5. Rinse all residual salt solution with clean water and air dry inflators prior to continuing test sequence or storing inflators. Cleaning to enhance ballistic performance is not acceptable.

Evaluation and Results:

Perform visual inspection of the Inflator. The Inflator serial number shall be identifiable (enhancing by scraping, chemical washing, etc. is acceptable). All discrepancies shall be documented and reported to the Responsible Vehicle Engineering Organization.

Note: Corrosion of the components is acceptable, unless the corrosion impacts the Inflator ability to meet functional requirements stated in Section 3.2.7, Inflator Performance and Variability Limits

5.2.4.8.6 Drop Test:

Purpose: To evaluate the effects of drop impacts on the Inflator performance.

Test Fixtures and Equipment:

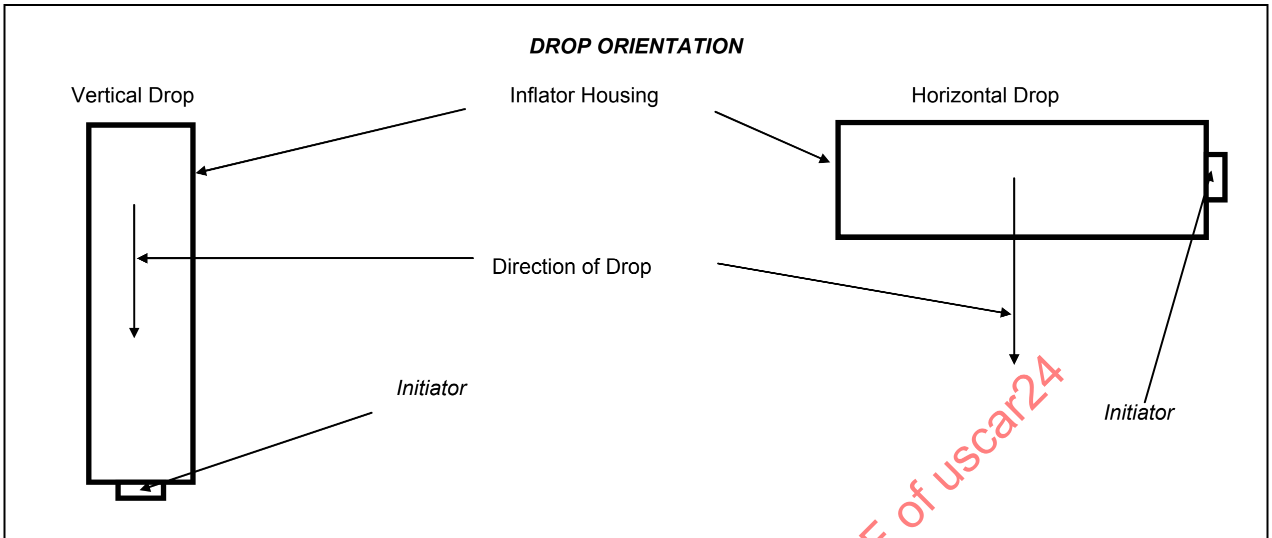
Fixtures to drop Inflators from 1.2 meters.

Test Procedure:

1. Complete Section 5.2.4.8.5, Salt Spray Test

2. Condition Inflator at 23°C per Section 5.2.3.7.1, Conditioning of Inflators, of this document.

3. Perform all drops at 23°C, from 1.2 meters (lowest point of the Inflator at a 1.2 meter height) on to a steel plate. *Dimension of the plate shall be greater than the Inflator size.* Drop each unit six times, twice with the initiator up, twice with the initiator down and twice on the axis perpendicular to the axis of the previous two orientations. For dual stage inflators with initiators located at opposite ends of the inflator, perform drop twice with each initiator in down position. The third orientation shall be dropped twice in the direction perpendicular to the axis of the both initiators (center pin to center pin) for a total of 6 drops for all orientations.



Drop distance is from 1.2 m ± 0.05 m above a rigid steel plate. Dimension of the plate shall be greater than the Inflator size. One drop shall be in the direction of the initiator (initiator shall hit the ground first).

Evaluation and Results

Inspect for visual damage of the Inflator, electrical connector and lead wire. All visual damage shall be documented and reviewed with the Responsible Vehicle Engineering Organization.

Inspect Inflator for gas leaks (pressure vessel type Inflator).

5.2.4.8.7 Temperature Conditioning and Deployment:

1. Complete Section 5.2.4.8.6, Drop Test.
2. Required: Verify Inflator terminal-to-terminal resistance.
3. Inspect Inflator for gas leaks (pressure vessel type Inflator).
4. Randomly select 3 inflators (2 from low g group and 1 from high g group) for live dissection. Refer to Appendix B for requirements after live dissection.
5. Perform closed tank test per Section 5.2.3.7 Closed Tank Test of this document on the remaining inflators.
6. Perform tank wash requirements as indicated in the Appendix B, DV/PV Validation Test Matrix, and Section 3.2.3.3 Inflator Particulate (Tank wash derived)

Evaluation and Results:

The Inflator shall meet the functional requirements specified in Section 3.2.7, Inflator Performance and Variability Limits

5.2.4.9 Flaming Test:

Purpose: To evaluate Inflator flaming characteristics

Test Fixtures and Equipment:

Temperature chamber, capable of maintaining 85°C.
Camera with a minimum speed of 1000 frames per second.
Note: Film can be color, black and white or high speed video for deployment flaming analysis.
Real time video for post deployment flaming analysis with external flame source.

Test Procedure:

1. Condition 6 Inflators with deflectors, diffusers, shrouds, housings, etc as allowed by Section 3.2.4 Inflator Flaming at 85 C and 23 C per Section 5.2.3.7.1, Conditioning of Inflators.

2. Remove Inflator from the chamber and actuate, using the setup per Appendix G Shadowgraph Procedure, Inflator Flaming Testing (or approved equivalent), in the open air with a minimum RH of 50% per Section 5.2.3.6 Open Air Test, of this document. Actuate the inflator using the Minimum "All-Fire" current at the conditioning temperature. Deploy the Inflators per Section 4.5.1.2 Allowable Time Period for Ballistic Test. Photograph nozzle area(s) of the inflator with a minimum 1000 frame/second camera during deployment in a draft free area against a dark background.

3. Provide external ignition source (flame) using charcoal grill lighter or equivalent all around the Inflator (at gas exhaust port) within 15 seconds after deployment and maintain the flame for 5 seconds. Re-apply the flame for 5 seconds every 30 seconds until a total of 1.5 minutes has elapsed. Photograph nozzle area of inflator with real time video camera following deployment when external flame source is applied.

4. Measure and record flame length and duration (if any) and highlight any burning particles using film analysis.

Evaluation and Results:

The Inflator Shall meet the requirements specified in Section 3.2.4, Inflator Flaming.

Supplier shall provide a VHS videotape (1000 frame/sec for deployment and standard speed for post-deployment flames) showing the actual during-deployment and post-deployment flaming tests.

5.2.4.10 Pressure Cycle Durability Test (pressurized inflation devices):

Purpose: Evaluate integrity of pressurized inflation devices under a pressure cycles.

Test Fixtures and Equipment:

The fixture(s) shall be able to provide required pressure using only dry air or water. (However, water may not be used for carbon steel inflator due to corrosion concerns unless corrosion inhibitor is used in the water. Supplier shall provide the name and amount of corrosion inhibitor used in this test.)

Test Procedure:

1. Determine maximum and minimum stored pressure inside the inflator at extreme temperatures. Use equations and gas property methods (such as Van der Waal's, Redlich-Kwong, NIST Mixture Property Database, or any equivalent method) to determine P_{max} and P_{min}.

$$P_{max} = (P_{nominal} + P_{tolerance}) \text{ at } 85°C$$
$$P_{min} = (P_{nominal} - P_{tolerance}) \text{ at } -40°C$$

2. Condition all Inflators at 23°C per Section 5.2.3.7.1, Conditioning of Inflators, of this document.

3. Perform 4500 pressure cycles on all Inflators. One pressure cycle consists of pressure fluctuation between the pressure extremes (P_{max} -to - P_{min} -to - P_{max}) in 7 seconds ± 2 seconds. The Inflator burst disk(s), Inflator body, and all welds under high pressure shall be evaluated under this pressure cycle test.

   Note: For dual level Inflators, conduct pressure cycle test for each unit separately where applicable.

4. Inspect Inflator body, all welds, and burst disk(s) if possible for any cracks, fractures, or mechanical failures. All findings shall be recorded and provided to the Responsible Vehicle Engineering Organization.

5. Clean the Inflator thoroughly.

6. Fill the inflator with the nominal gas charge including the normal pressure proofed test.

7. Determine the Helium leak for the Inflator. The Inflator shall remain in a gas-spectrometer for a minimum of 10 minutes in order to determine the equilibrium gas leak rate. Time duration in a gas-spectrometer is supplier specific and shall be approved by the Responsible Vehicle Engineering Organization.

Evaluation and Results:

The Inflator shall not have a leak rate, greater than the maximum allowable rate specified in Section 3.2.9.2, Pressurized Inflators.

Inflator body, all welds, and burst disk(s) shall remain intact with no mechanical failures.

Record actual leak rate for each Inflator.

APPENDIX A
PRE-SOURCE QUALIFICATION (QFS) OR BOOKSHELVING REQUIREMENTS

I. INTRODUCTION:

Qualified for Sourcing (QFS)
The QFS process provides a consistent method for evaluating the maturity of new airbag inflators prior to sourcing. The QFS process is intended to assess the inflator technology's ability to meet the requirements of the full specification with a limited amount of testing. Inflators will receive QFS approval only if judged capable of meeting all performance criteria of the full specification.

Production Considerations
For those inflators in production prior to QFS approval, all related design and production control documents shall be made available as requested by the Responsible Vehicle Engineering Organization.

The QFS Process

1. (Optional) Informational Review (including underlined items in the Review Outline below) with the Responsible Vehicle Engineering Organization.
2. (Mandatory) Compile the informational requirements per Section 3.1.6, Informational Requirements and submit the information to the Responsible Vehicle Engineering Organization. For a checklist of the information required for QFS refer to the end of this appendix.
3. Successful Completion of Section IV Performance Requirements or
4. Successful Completion of Section IV items G, H, and I of the Performance Requirements, and successfully completing a DV or PV to the requirements of this full specification.
5. Close all Action Item Requests from the Response Vehicle Engineering Organization.

Note: The tests as outlined here represent the minimum required. Suppliers are encouraged to supply additional data where possible.

Note: Human Exposure testing may be required in addition to the above listed testing. A determination will be made by the criteria outlined in Appendix H: Human Exposure Requirements and Procedure.

II. GUIDELINES:

Complete the testing according to the following:

a) Use production design intent parts (production tooling not required) from one lot with maximum (worst case, or most difficult to achieve) ballistic output and slope.
You will not be approved for sourcing above the tested output!

b) Perform validation tests according to test procedures from the body of this specification

c) For dual stage inflators a ratio in the range of 30/70 to 40/60 shall be used for any testing where the ratio is not specifically called out.

III. INFORMATIONAL REVIEW REQUIREMENTS:

Review Outline:

III A	Inflator Cutaway Model (if available)	
III B	General Inflator Information Labeled Cutaway Drawing (top and side views) Vital statistics i.e. Size, Weight, dimensions, etc. Standard output chart(s) or curves Envelop Drawing with intended mounting flanges General Information and Description of all features	
III C	Standard Deployment Sequence	
III D	Auto Ignition Sequence	Section 3.2.5 Autoignition…
III E	Dual Stage deployments including: normal full power, second stage only, second stage delay series, reverse order firing (second stage with first stage delay) and 2nd stage disposal (firing of the second stage after the first stage is complete),	Section 3.2.10 Dual Stage Inflators… And Section IV H of this appendix
III F	Chemistry Information	
	Formulation and quantity of all pyrotechnic materials Standard Toxicity of all pyrotechnic materials (MSDS sheets where applicable) Stored gas composition and specified limits 100 ft^3 Chamber Evaluation	Section 3.2.3 Effluents Section 3.2.3.2 Gasses Section 5.2.3.5 100 ft^3 Tank Effluent Test Procedure
	Tank Wash: Total, Soluble and Insoluble fractions	Section 3.2.3.3 Inflator Particulate (Tank Wash Derived)
	Speciation with mass balance of Tank Wash Particulate (to include metal scan and salt components)	Section 3.2.3.3 Inflator Particulate (Tank Wash Derived) Section 5.2.3.7.4 Sampling Tank Contents …Procedure
	Any component materials expected to be consumed by the inflator deployment (coatings, polymers, etc)	
	Note: A determination will be made by the Responsible Vehicle Engineering Organization on the requirement for Human Testing.	Section 3.2.4 Human Exposure Test Criteria
III G	Performance Data Baseline Tank Tests including the following analysis and information: 1. gas conversion percentage 2. gas composition 3. total moles of gas	Section 3.1.6.3 Inflator Performance Envelope and Characteristics
	Structural Evaluation/Safety Factor Calculations	Section 3.2.2.1 Inflator Burst Safety Factor
	Conditioned deployment results (see QFS or DV test matrix) *Note: All conditioned inflator data is not required for a Formal Review.*	
	Safety test data of all pyrotechnic materials. Minimum tests to include ESD, Friction, Impact and Cap Sensitivity of non-aged and aged samples.	Section 3.2.8 Propellant Stability
	Provide mechanical stability data for all propellants containing Ammonium Nitrate Including:	Section 3.2.8 Propellant Stability
	1. DSC traces	Section 3.2.8 Propellant Stability

	2. Dimensional, pellet strength and ballistic evaluation after extended dwell/ramp thermal cycling per 3.2.6.1 Inflator Thermal Shock Resistance using the following profile: 2 hours dwell at 100C, 4 hours dwell at -40C, 4 hour transition time (approximately 35 C/hour ramp rate), 40 cycles minimum)	Section 3.2.8 Propellant Stability
	3. Literature to support stabilization method Mass Flow of Primary Stage (for dual level) and Full output (computation should be done by MTA (MADYMO Tank Analysis) and include Avg. Temperature of gas assumption, Time to 95% of mass flow and be presented in a format consistent with Appendix F *Ballistic Examples*)	Section 3.2.8 Propellant Stability
	Vented Tank, Tunability, and max/min ratio Tests per Sections IV-H and VI- I	Section 3.1.6.3 Inflator Performance Envelope and Characteristics Section 3.2.10 Dual Stage Inflators…
	Note: Present all closed tank data as chart, scatter plot and mean/±3 sigma/±10% plots *Note: Include TTFG on all charted data*	
III H	Specifications List all component materials and material specifications	Section 3.1.5 Heavy Metals….
	Indentured Parts List Differences between the Test Configuration and intended Production Configuration	
	Shipping Classification Competent Authority or equivalent	Section 3.1.6.4 Shipping Classification
III I	DFMEA Top Ten RPNs All 10 Severity List of all Margin Test Series completed, in process and/or identified	
III J	Manufacturing Processes Proposed Process Flow Chart with Quality Checks identified Proposed Traceability System	

IV PERFORMANCE REQUIREMENTS:

IV A. Per Section 5.2.4.1, Inflator Baseline Test

Deploy 8 @ -40°C (tankwash and internal pressures required on all 8)
Deploy 8 @ +23°C (tankwash and internal pressures required on all 8)
Deploy 8 @ +85°C (tankwash and internal pressures required on all 8)
Dissect 3 inflators and evaluate all aspects of the assembly (i.e. propellant or filter crush, position tolerance, etc.)

Note: Measure inflator's internal pressure (using pressure transducer) for all baseline deployments. For dual stage inflators measure internal pressure on only full output deployments. Where the measurement of internal pressures could affect the baseline performance, a separate series of inflators can be utilized for baseline deployments and internal pressure measurements.

Dual Stage Added Requirement:

See Guidelines II, Item c for ratio requirements
Deploy above inflators at 0 offset.
Deploy 3 Offset @ +23°C (Driver @ 10 ms offset, Passenger @ 20 ms offset)
Deploy 3 Primary only deployments @ 23°C

Requirement: The inflators shall meet the functional requirements of Section 3.2.7, Inflator Performance and Variability Limits.

IV B. Per Section 5.2.4.8.1, Inflator Thermal Shock Resistance Test

Condition 7 through Thermal Shock environment.

Deploy 3 @ -40°C (tankwash required on all 3) per Section 5.2.3.7, Closed Tank Test.
Deploy 3 @ +85°C (tankwash required on all 3) per Section 5.2.3.7, Closed Tank Test.

Dual Stage Requirement:

None
Deploy above inflators @ 0 ms offset

Requirement: The inflators shall meet the functional requirements of Section 3.2.6.1 Inflator Thermal Shock Resistance including Section 3.2.7, Inflator Performance and Variability Limits.

IV C. Per Section 5.2.4.6, Accelerated Heat Aging Test

Condition 6 through Heat Age environment

Deploy 3 in USDOT bonfire.
Deploy 3 @ 23°C per Section 5.2.3.7, Closed Tank Test.

Dual Stage Requirement:

None
Deploy above inflators @ 0 ms offset

Requirement: Inflators shall meet the requirements of Section 3.2.5, Autoignition, High Temperature Oven Performance/Autoignition of Heat Aged Inflators including Section 3.2.7, Inflator Performance and Variability Limits.

IV D. Per Section 5.2.4.8, Inflator Sequential/Environmental Test

Condition 12 inflators sequentially through the following environments:
Drop per Section 5.2.4.8.6 Drop Test, Dynamic Shock (6 or 9 (as noted above) low g, 3 high g) per Section 5.2.4.8.2 Dynamic Shock Test, Vibration/Temperature per Section 5.2.4.8.3, Vibration – Temperature Cycle Test, and Humidity per Section 5.2.4.8.4, Humidity Resistance Test.

Deploy 2 low g and 1 high g @ -40°C (tankwash required on all 3) per Section 5.2.3.7, Closed Tank Test.
Deploy 2 low g and 1 high g @ +23°C (tankwash required on all 3) per Section 5.2.3.7, Closed Tank Test.
Deploy 2 low g and 1 high g @ +85°C (tankwash required on all 3) per Section 5.2.3.7, Closed Tank Test.

Dual Stage Added Requirement:

Condition an additional 6 inflators (for total of 18)
See Guidelines II, Item c for ratio requirements
Deploy above inflators at 0 offset.
Deploy 3 inflators conditioned through sequential with low g @ +23°C (Driver 10 ms offset, Passenger 20 ms offset)
Deploy 3 inflators conditioned through sequential with low g @ +23°C Primary Output stage only.

Requirement: The inflators shall meet the functional requirements of Section 3.2.6, Sequential Test Series including Section 3.2.7, Inflator Performance and Variability Limits.

IV E. Per Section 5.2.4.2, Structural Burst Test

Burst 9 inflators and calculate the Burst Safety Factor using MEOP data from Baseline Ballistic Tank Tests.

Dual Stage Added Requirement:

See Guidelines II, Item c for ratio requirements
Burst 9 inflators for each structural chamber and calculate structural safety margin on each Structural Unit separately. Use MEOP from worst case firing of Primary stage first, Secondary stage first, 0 offset firing at hot, cold or ambient.

Requirement: The inflators shall meet the requirements of Section 3.2.2.1, Inflator Burst Safety Factor.

IV F. Per Section 5.2.4.10, Pressure Cycle Durability Test (pressurized inflators only)

Condition 3 through Pressure Cycle Durability and then inspect.

Dual Stage Requirement:

No additional requirement

Requirement: The inflators shall meet the requirements of Section 3.2.9, Hermiticity.

IV G. Per Section 5.2.3.5, 100ft^3 Tank[3] Effluent Tests

Deploy 3 inflators (in representative vented bag modules: see Table IV G 1, **Standard Module Configurations**) in a 100ft^3 tank and measure airborne particulate and gaseous effluents per SAE Recommended Practice J1794.

Dual Stage Added Requirement:

See Guidelines II, Item c for ratio requirements
Deploy above inflators 0 ms offset
Deploy 6 additional inflators:

1. Deploy 3 inflators, primary stage only
2. Deploy 3 inflators @ 100 ms offset

Requirement: The airborne particulate and gaseous effluent levels shall meet the requirements of Section 3.2.3, Effluents

[3] Note: These tests to be performed by a laboratory approved by the Responsible Vehicle Engineering Organization or Certified per Section 4, VALIDATION.

Table IV G -1, Standard Module Configurations

Type	Bag Size	Vent Size	Inflator Output
Passenger	120-140 l	1 X 42 mm	550-650 KPa (60 l tank)
Driver	55-65 l	2 X 25 mm	180-220 KPa (60 l tank)
Curtain	25-30 l	none	200-250 KPa (1 ft^3 tank)
Side Impact	18-22 l	1 X 20 mm	180-200 KPa (1 ft^3 tank)

IV H. Tailorability and Hot/Cold Spread Ballistic Tank Tests

Deploy an additional 12 inflators according to the following table:

Table IV H-1, Tunability Matrix

Temp.	Min. Ballistic Output & Slope (Closed Tank)	Nom. Ballistic Output & Slope (Closed Tank)	Max. Ballistic Output & Slope[4] (Closed Tank)
-40°C	3	0	(8)
+23°C	3	3	(8)
+85°C	3	0	(8)

[4] Note: These are the Baseline Ballistic Tank tests.

Dual Stage Added Requirement(s):

Deploy **Table IV H-1, *Tunability Matrix*** with 0 offset
Deploy 5 inflators of maximum output, with a ratio between 70/30 to 60/40 @ +23°C with 0, 5, 10, 20, and 30 ms offset. (Provide curves on a single graph)
Deploy an additional 2 inflators of maximum ballistic output and slope @ +23°C, secondary Stage only.
Deploy an additional 2 inflators of maximum ballistic output and slope @ +23 °C in reverse order (i.e. second stage first) with 10 ms offset. (if previous 2 second stage only deployments ignite the primary stage in <10 ms this test need not be run)
Deploy an additional 12 inflators, @ +23°C, one each at 0, 10 and 30 ms offset, according to the following table:

Configurations that match those included in **Table IV H-1, *Tunability Matrix,*** are not required to be retested.

Table IV H-2 Dual Stage Output Definitions for Tunability Matrix

Inflator Configuration	Combination of Stored Gas (where applicable) and propellant to provide: Primary Stage	Secondary Stage
3@ Min/Max Ratio	Minimum Output	Maximum Output
3@ Max/Min Ratio	Maximum Output	Minimum Output
3@ Max/Max Ratio	Maximum Output	Maximum Output
3@ Min/Min Ratio	Minimum Output	Minimum Output

Requirement: The inflators shall meet the functional requirements of the body of this specification. The inflators shall not fail structurally.

Note: Clearly state ratio, output of each stage and total output of each configuration on the ballistic plots

IV I. Equivalence Data and Vented Tank Tests

Note: *Equivalence Data and Vented Tank Tests are optional unless requested by the Responsible Vehicle Engineering Organization. The Responsible Engineering Organization will specify the tank size to be used based on the comparative data available.*

Supply gas conversion percentage, gas composition, total moles of gas, gas temperature (at inflator nozzle), and millisecond by millisecond mass flow data of the following tests.

Deploy an additional 6 according to the following table:

Table IV I-1

Temperature	Min. Ballistic Output & Slope (Vented Tank)	Nom. Ballistic Output & Slope (Vented Tank)	Max. Ballistic Output & Slope (Vented Tank)
+23°C	3	0	3

Requirement: The inflators shall meet the functional requirements of the body of this specification. Otherwise, data is for informational purposes only.

Dual Stage Requirement: No additional inflators required. Deploy the 6 inflators detailed above at 0 ms offset.

Table IV I-2

Tank Size	Vent Size
100l	2 X 2 inch NPT
60 l	2 X 1 1/2 inch NPT
1 ft^3	2 X 1 inch NPT

IV J. per Section 3.2.4 Inflator Flaming

Deploy 2 inflators at 23 C and 2 inflators at 85 C per Section 5.2.4.9 Flaming Test and Appendix G Shadowbox **Procedure.** Evaluate and record, and provide video documentation of the results. Note the use of any, deflectors, diffusers, shrouds, housings, etc. , used as a standard component for applications of the inflator to redirect gasses, minimize bag damage and/or modify system performance.

Dual Stage Added Requirement(s):

None

Requirement: The inflators shall meet the functional requirements of the body of this specification.

Appendix 1: Pre-source Single Stage Inflator Matrix and Post Deployment Plan

Test Sequence	Spec. Section	Qty A	Qty B	Qty C	Qty D	Qty E	Qty F	Qty G	Qty H	Qty I	Qty J	
Document Part #, Serial #		27	9	7	12	9	3	3	12	6	6	94 inflators total
Leak Test	3.2.9	27	9	7	12	9	3	3	12	6	6	(6 optional*)
Weight Inspection		27	9	7	12	9	3	3	12	6	6	
Visual Inspection		27	9	7	12	9	3	3	12	6	6	
Electrical Checks		27	9	7	12	9	3	3	12	6	6	
Accelerated Aging (Qty B)	5.2.4.6		9									
Accelerated Aging with High Temp…	5.2.4.3		3									
Accelerated Aging with Bonfire	5.2.4.4		3									
Inflator Thermal Shock Resistance (Qty C)	5.2.4.8.1			7								
Inflator Sequential/Environments (Qty D)	5.2.4.8				12							
Dynamic Shock Test	5.2.4.8.2				12							
Vibration - Temperature Cycle Test	5.2.4.8.3				12							
Humidity Resistance Test	5.2.4.8.4				12							
Drop Test	5.2.4.8.6				12							
Structural Burst (Qty E)	5.2.4.2					9						
Pressure Cycle (Qty F)	5.2.4.10						3					
Leak Test	5.2.3.1		3	7	12		3					
Weight Inspection			3	7	12							
Visual Inspection			3	7	12							
Electrical Checks			3	7	12							
Flaming	5.2.4.9											
Flaming +23											3	
Flaming +85											3	
Live Dissection	5.2.3.8	3		1	3							
Closed Tank Tests	5.2.3.7											
-40 C		8		3	3							
+23 C		8	3		3							
+85 C		8		3	3							
100 ft^3 Tank Tests	5.2.3.5							3				
Tunability Matrix	Appendix A Section IV-H								12			
Vented Tank (Optional)*	Appendix A Section IV-I									6*		
Sampling Tank Content (Tank Wash)	5.2.3.7.4											
-40 C		3										
+23 C		3										
+85 C		3										
Tank Effluents sampling and Chemical analysis	5.2.3.7.5	9										
Tank Wash Chemical Speciation	5.2.3.7.6											
+23 C		2										
Post Deployment Internal Inspection												
+85 C		3										
Visual Inspection Post Test Documentation		27	9	6	9	9	3	3	12	6	6	

Appendix 1: Pre-source Dual Stage Inflator Matrix and Post Deployment Plan

Test Sequence	Spec. Section	Qty A	Qty B	Qty C	Qty D	Qty E	Qty F	Qty G	Qty H	Qty I	Qty J	133 total inflators
Document Part #, Serial #		33	9	7	18	9	3	9	33	6	6	(6 optn'l)**
Leak Test	3.2.9	33	9	7	18	9	3	9	33	6	6	
Weight Inspection		33	9	7	18	9	3	9	33	6	6	
Visual Inspection		33	9	7	18	9	3	9	33	6	6	
Electrical Checks		33	9	7	18	9	3	9	33	6	6	
Accelerated Aging (Qty B)	5.2.4.6		9									
Accelerated Aging with High Temp…	5.2.4.3		3									
Accelerated Aging with Bonfire	5.2.4.4		3									
Inflator Thermal Shock Resistance (Qty C)	5.2.4.8.1			7								
Inflator Sequential/Environments (Qty D)	5.2.4.8				18							
Dynamic Shock Test	5.2.4.8.2				18							
Vibration - Temperature Cycle Test	5.2.4.8.3				18							
Humidity Resistance Test	5.2.4.8.4				18							
Drop Test	5.2.4.8.6				18							
Structural Burst (Qty E)	5.2.4.2					9						
Pressure Cycle (Qty F)	5.2.4.10						3					
Leak Test	5.2.3.1		3	7	18		3					
Weight Inspection			3	7	18							
Visual Inspection			3	7	18							
Electrical Checks			3	7	18							
Flaming (Qty J)	5.2.4.9											
Flaming +23											3	
Flaming +85											3	
Live Dissection	5.2.3.8	3		1	3							
Closed Tank Tests	5.2.3.7											
Full Output -40 C		8		3	3							
Full Output +23 C		8	3		3							
Full Output +85 C		8		3	3							
Primary Only Output +23 C		3			3							
Staged Deployment +23 C		3			3							
Second Stage Deploy Only									2			
Reverse Firing Order Tests	Appendix A Section IVH								2			
100 ft^3 Tank Tests (Qty G)	5.2.3.5							9				
Tunability Matrix (Qty H)	Appendix A Section IV-H								27*			
Vented Tank (Qty I) (Optional)**	Appendix A Section IV-I									6**		
Sampling Tank Content (Tank Wash)	5.2.3.7.4											
Full Output -40 C		3										
Full Output +23 C		3										
Full Output +85 C		3										
Tank Effluents sampling and Chemical analysis	5.2.3.7.5	9										
Tank Wash Chemical Speciation	5.2.3.7.6											
Full Output +23 C		2										

Post Deployment Internal Inspection												
Full Output +85 C		3										
Primary Output +85 C		3										
Visual Inspection Post Test Documentation		32	9	6	15	9	3	9	33	6	6	

*This number assumes 0 offset, Max/Max and Min/Min match tunability matrix

Appendix 2: QFS Checklist

Inflator Name	Status	Output(s)	Date
Review Status			
Open Issues Status			
Information Section			
General			
Inflator Cutaway and hardware			
Inflator Cutaway Drawings (plan and side view)			
Size, Wt, moles, gas mass and Output Chart			
Envelope Drawing with mounting flange			
General Description			
Standard Deployment Sequence			
Autoignition Sequence			
Chemistry			
Formulation with gas yield and percentages			
Toxicity			
Stored Gas Composition			
100 ft3 Chamber evaluation			
Tank Particulate soluble/insoluble %			
Tank wash Speciation			
Part Coatings Etc.			
Generant Hazard Testing (Before Aging)			
Generant Hazard Testing (After Aging)			
Specifications			
Indented Parts List (with Drawing Rev. #)			
Component and Materials List (with Spec #'s)			
Differences of QFS to Production			
Shipping Classification (or Schedule)			
DFMEA			
Top ten			
All 10 PNs			
Margin Test Listing re: DFMEA (or Schedule)			
Manufacturing			
Process Flow Chart			
Redundant Checks of all actions			
Poke yoke (error proofing)			
Production Status (schedule)			
Traceability System Description			
Initial Bar Code application			
Station to Station part tracking			
Lot control at each station			
Lot Control in plant			
Performance Data and/or Test Matrix		To be submitted as scatter plots with +/- 3 sigma, +/- 10%, mean plots or, USCAR windows	
Baseline			
Conditioned Deployments			
Thermal Shock			
Heat Age			
Bonfire			
Sequential			
Structural Margin			
Pressure Cycle			
Tunability			
Vented Tank (if required)			
Human Testing (if Required)			
Mass Flow			
Gas Temperature			
Dual Stage Specific			
Full Power			

Primary Only		
Secondary Only		
Second Stage Disposal		
Delay Series (0,5,10,20,30, primary only)		
Max/Min Ratio Demonstration		

APPENDIX B
DV/PV TEST MATRIX

DV Matrix and Post Deployment Plan - Dual Stage (see following table)
The test matrix shall be a minimum set of tests and maximum quantity sample size for the Design Validation (DV) of dual stage inflators. It shall be the supplier's responsibility to evaluate this plan and allow for additional testing based on the inflator design's unique characteristics. This table shall not replace the supplier's responsibility, based on the DFMEA and PFMEA to define and complete appropriate margin testing to establish a final robust design. Any deviations from this test matrix shall be reviewed and approved by the Responsible Vehicle Engineering Group.

Note: Where Pre-source (QFS) testing has not been completed, testing from Appendix A sections IV-H shall be provided with the DV report. Testing from Appendix A, section IV-I shall be provided with the DV report where specifically requested by the Responsible Engineering Organization.

PV Matrix and Post Deployment Plan - Dual Stage (see following table)
The test matrix shall be a minimum set of tests and maximum quantity sample size for the Production Validation (PV) of dual stage inflators. It shall be the supplier's responsibility to evaluate this plan and allow for additional testing based on the inflator design's unique characteristics. This table shall not replace the supplier's responsibility, based on the DFMEA and PFMEA to define and complete appropriate margin testing to establish a final robust design. Any deviations from this test matrix shall be reviewed and approved by the Responsible Vehicle Engineering Group. Subscript refers to Lot a, b, and c equally divided among tests.

Note: Where Pre-source (QFS) testing has not been completed, testing from Appendix A sections IV-H shall be provided with the DV report. Testing from Appendix A, section IV-I shall be provided with the PV report where specifically requested by the Responsible Engineering Organization.

DV Matrix and Post Deployment Plan - Single Stage (see following table)
The test matrix shall be a minimum set of tests and maximum quantity sample size for the Design Validation (DV) of single stage inflators. It shall be the supplier's responsibility to evaluate this plan and allow for additional testing based on the inflator design's unique characteristics. This table shall not replace the supplier's responsibility, based on the DFMEA and PFMEA to define and complete appropriate margin testing to establish a final robust design. Any deviations from this test matrix shall be reviewed and approved by the Responsible Vehicle Engineering Group.

Note: Where Pre-source (QFS) testing has not been completed, testing from Appendix A sections IV-H shall be provided with the DV report. Testing from Appendix A, section IV-I shall be provided with the DV report where specifically requested by the Responsible Engineering Organization.

PV Matrix and Post Deployment Plan - Single Stage (see following table)

The test matrix shall be a minimum set of tests and maximum quantity sample size for the Production Validation (PV) of single stage inflators. It shall be the supplier's responsibility to evaluate this plan and allow for additional testing based on the inflator design's unique characteristics. This table shall not replace the supplier's responsibility, based on the DFMEA and PFMEA to define and complete appropriate margin testing to establish a final robust design. Any deviations from this test matrix shall be reviewed and approved by the Responsible Vehicle Engineering Group. Subscript refers to Lot a, b, and c equally divided among tests.

Note: Where Pre-source (QFS) testing has not been completed, testing from Appendix A sections IV-H shall be provided with the DV report. Testing from Appendix A, section IV-I shall be provided with the PV report where specifically requested by the Responsible Engineering Organization.

DV Matrix and Post Deployment Plan - Dual Stage

Test Sequence	Section	Qty A	Qty B	Qty C	Qty D1	Qty D2	Qty E	Qty F	Qty G	Notes
Document Part #, Serial #		75	15	30,45	36	33	15	8	12	269 inflators total
Leak Test	5.2.3.1	75	15	30,45	36	33	15	8	12	
Weight Inspection	5.2.3.2	75	15	30,45	36	33	15	8	12	
Visual Inspection	5.2.3.3	75	15	30,45	36	33	15	8	12	
Electrical Checks	5.2.3.4	75	15	30,45	36	33	15	8	12	
High Humidity/Heat Age Test	5.2.4.7			30						30 units of quantity C
Accelerated Aging	5.2.4.6			45						45 units of quantity C
High Temperature Oven Test	5.2.4.3 5.2.4.6.1		3	3						
Autoignition/Bonfire	5.2.4.4 5.2.4.6.2		6	6						
Slow Heat/Autoignition	5.2.4.5 5.2.4.6.3		6	6						
Sequential Environments	5.2.4.8				36	33				
Thermal Shock	5.2.4.8.1				36	33				
Dynamic Shock Low G	5.2.4.8.2				36					
Dynamic Shock High G	5.2.4.8.2					33				
Vibration - Temperature Cycle	5.2.4.8.3				36	33				
Humidity Resistance	5.2.4.8.4				36	33				
Salt Spray	5.2.4.8.5				36	33				
1.2 Meter Drop	5.2.4.8.6				36	33				
Structural Burst	5.2.4.2						15			
Pressure Cycle	5.2.4.10							8		
Flaming	5.2.4.9									
Flaming +23									6	
Flaming +85									6	
Leak Test	5.2.3.1			30,30	36	33		8		
Weight Inspection				30,30	36	33				
Visual Inspection				30,30	36	33				
Electrical Checks				30,30	36	33				
Live Dissection	5.2.3.8	3			2	1				
Closed Tank Tests	5.2.3.7									
Full Output -40 C		10		10,6	5	5				
Full Output +23 C		10		10,6	5	5				
Full Output +85 C		10		10,6	5	5				
Primary Only Output -40 C		5			5	5				
Primary Only Output +23 C		5		6	5	5				
Primary Only Output +85 C		5			5	5				
Staged Deployment -40 C		5								10 ms delay for
Staged Deployment +23 C		5		6	4	2				Driver
Staged Deployment +85 C		5								20 ms delay for Pass.
100ft3 Tank Effluent Test	5.2.3.5									
Full Output +23 C		6								
Primary Only Output +23 C		3								
100 ms Offset Deployment		3								
Supplemental Evaluations of Tank Tests										
Sampling Tank Content (Tank Wash)	5.2.3.7.4									
Full Output -40 C	5.2.3.7.5	5		3	3	3				Evaluation of Tank
Full Output +23 C	5.2.3.7.5	10		6	5	3				Wash required
Full Output +85 C	5.2.3.7.5	10		6	5	3				per 5.2.3.7.5
Tank Wash Chemical Speciation	5.2.3.7.6									Evaluation of Tank
Full Output -40 C										Wash required
Full Output +23 C		3								per 5.2.3.7.6
Full Output +85 C										
Tank Effluents (gas analysis)										For informational
Full Output +23 C		5								purposes only

Primary Output Only +23 C		5								
Post Deployment Internal Inspection										
Full Output +85 C		5			5					
Primary Output +85 C		5								
Visual Inspection Post Test Documentation	5.2.3.3	72	15	30,45	34	32	15	8	12	

PV Matrix and Post Deployment Plan - Dual Stage

Test Sequence	Section	Qty $A_{a,b,c}$	Qty B_a	Qty C_a	Qty $D1_{a,b}$	Qty $D2_c$	Qty E_a	Qty F_a	Qt G_a	Notes
Document Part #, Serial #		123	15	30,45	66	33	15	8	12	347 inflators total
Leak Test	5.2.3.1	123	15	30,45	66	33	15	8	12	
Weight Inspection	5.2.3.2	123	15	30,45	66	33	15	8	12	
Visual Inspection	5.2.3.3	123	15	30,45	66	33	15	8	12	
Electrical Checks	5.2.3.4	123	15	30,45	66	33	15	8	12	
High Humidity/Heat Age Test	5.2.4.7			30						30 units of quantity C
Accelerated Aging	5.2.4.6			45						45 units of quantity C
High Temperature Oven Test	5.2.4.3 5.2.4.6.1		3	3						
Autoignition/Bonfire	5.2.4.4 5.2.4.6.2		6	6						
Slow Heat/Autoignition	5.2.4.5 5.2.4.6.3		6	6						
Sequential Environments	5.2.4.8				66	33				
Thermal Shock	5.2.4.8.1				66	33				
Dynamic Shock Low G	5.2.4.8.2				66					
Dynamic Shock High G	5.2.4.8.2					33				
Vibration - Temperature Cycle	5.2.4.8.3				66	33				
Humidity Resistance	5.2.4.8.4				66	33				
Salt Spray	5.2.4.8.5				66	33				
1.2 Meter Drop	5.2.4.8.6				66	33				
Structural Burst	5.2.4.2						15			
Pressure Cycle	5.2.4.10							8		
Flaming	5.2.4.9									
Flaming +23									6	
Flaming +85									6	
Leak Test	5.2.3.1			30,30	66	33		8		
Weight Inspection				30,30	66	33				
Visual Inspection				30,30	66	33				
Electrical Checks				30,30	66	33				
Live Dissection	5.2.3.8	3			2	1				
Closed Tank Tests	5.2.3.7									
Full Output -40 C		15		10,6	10	5				
Full Output +23 C		15		10,6	10	5				
Full Output +85 C		15		10,6	10	5				
Primary Only Output -40 C		15			10	5				
Primary Only Output +23 C		15		6	10	5				
Primary Only Output +85 C		15			10	5				
Staged Deployment -40 C		6								10 ms delay
Staged Deployment +23 C		6		6	4	2				for Driver20
Staged Deployment +85 C		6								ms delay for Pass.
100ft3 Tank Effluent Test	5.2.3.5									
Full Output +23 C		6								
Primary Only Output +23 C		3								
100 ms Offset Deployment		3								
Supplemental Evaluations of Tank Tests										
Sampling Tank Content	5.2.3.7.4									
Full Output -40 C	5.2.3.7.5	6		3	3	3				Evaluation of Tank
Full Output +23 C	5.2.3.7.5	15		6	5	3				Wash required
Full Output +85 C	5.2.3.7.5	15		6	5	3				per 5.2.3.7.5
Tank Wash Chemical Speciation	5.2.3.7.6									
Full Output -40 C										Evaluation of Tank
Full Output +23 C		3								Wash required
Full Output +85 C										Per 5.2.3.7.6
Tank Effluents (gas analysis)										For informational
Full Output +2 C		6								Purposes only

Primary Output Only +23 C		6								
Post Deployment Internal Inspection										
Full Output +85 C		6			6					
Primary Output +85 C		6								
Visual Inspection Post Test Documentation	5.2.3.3	120	15	30,45	64	32	15	8	12	

DV Matrix and Post Deployment Plan - Single Stage

Test Sequence	Section	Qty A	Qty B	Qty C	Qty D1	Qty D2	Qty E	Qty F	Qty G	Notes
Document Part #, Serial #		39	15	30,33	17	16	15	8	12	185 inflators total
Leak Test	5.2.3.1	39	15	30,33	17	16	15	8	12	
Weight Inspection	5.2.3.2	39	15	30,33	17	16	15	8	12	
Visual Inspection	5.2.3.3	39	15	30,33	17	16	15	8	12	
Electrical Checks	5.2.3.4	39	15	30,33	17	16	15	8	12	
High Humidity/Heat Age Test	5.2.4.7			30						30 units of quantity C
Accelerated Aging	5.2.4.6			33						33 units of quantity C
High Temperature Oven Test	5.2.4.3 5.2.4.6.1		3	3						
Autoignition/Bonfire	5.2.4.4 5.2.4.6.2		6	6						
Slow Heat/Autoignition	5.2.4.5 5.2.4.6.3		6	6						
Sequential Environments	5.2.4.8				17	16				
Thermal Shock	5.2.4.8.1				17	16				
Dynamic Shock Low G	5.2.4.8.2				17					
Dynamic Shock High G	5.2.4.8.2					16				
Vibration - Temperature Cycle	5.2.4.8.3				17	16				
Humidity Resistance	5.2.4.8.4				17	16				
Salt Spray	5.2.4.8.5				17	16				
1.2 Meter Drop	5.2.4.8.6				17	16				
Structural Burst	5.2.4.2						15			
Pressure Cycle	5.2.4.10							8		
Flaming	5.2.4.9									
Flaming +23									6	
Flaming +85									6	
Leak Test	5.2.3.1			30,18	17	16		8		
Weight Inspection				30,18	17	16				
Visual Inspection				30,18	17	16				
Electrical Checks				30,18	17	16				
Live Dissection	5.2.3.8	3			2	1				
Closed Tank Tests	5.2.3.7									
-40 C		10		10,6	5	5				
+23 C		10		10,6	5	5				
+85 C		10		10,6	5	5				
100ft3 Tank Effluent Test	5.2.3.5									
+23 C		6								
Supplemental Evaluations of Tank Tests										
Sampling Tank Content	5.2.3.7.4									
-40 C	5.2.3.7.5	5		3	3					Evaluation of Tank Wash required per 5.2.3.7.5
+23 C	5.2.3.7.5	10		6	5					
+85 C	5.2.3.7.5	10		6	5					
Tank Wash Chemical Speciation	5.2.3.7.6									
-40 C										Evaluation of Tank Wash required per 5.2.3.7.6
+23 C		3								
+85 C										
Tank Effluents (gas analysis)										For informational purposes only
+23 C		5								
Post Deployment Internal Inspection										
+85 C		5			6					
Post Test Documentation	5.2.3.3	36	15	30,33	15	15	15	8	12	

PV Matrix and Post Deployment Plan - Single Stage

Test Sequence	Section	Qty $A_{a,b,c}$	Qty B_a	Qty C_a	Qty $D1_{a,b}$	Qty $D2_c$	Qty E_a	Qty F_a	Qty G_a	Notes
Document Part #, Serial #		54	15	30,33	32	16	15	8	12	215 inflators total
Leak Test	5.2.3.1	54	15	30,33	32	16	15	8	12	
Weight Inspection	5.2.3.2	54	15	30,33	32	16	15	8	12	
Visual Inspection	5.2.3.3	54	15	30,33	32	16	15	8	12	
Electrical Checks	5.2.3.4	54	15	30,33	32	16	15	8	12	
High Humidity/Heat Age Test	5.2.4.7			30						30 units of quantity C
Accelerated Aging	5.2.4.6			33						33 units of quantity C
High Temperature Oven Test	5.2.4.3 5.2.4.6.1		3	3						
Autoignition/Bonfire	5.2.4.4 5.2.4.6.2		6	6						
Slow Heat/Autoignition	5.2.4.5 5.2.4.6.3		6	6						
Sequential Environments	5.2.4.8				32	16				
Thermal Shock	5.2.4.8.1				32	16				
Dynamic Shock Low G	5.2.4.8.2				32					
Dynamic Shock High G	5.2.4.8.2					16				
Vibration - Temperature Cycle	5.2.4.8.3				32	16				
Humidity Resistance	5.2.4.8.4				32	16				
Salt Spray	5.2.4.8.5				32	16				
1.2 Meter Drop	5.2.4.8.6				32	16				
Structural Burst	5.2.4.2						15			
Pressure Cycle	5.2.4.10							8		
Flaming	5.2.4.9									
Flaming +23									6	
Flaming +85									6	
Leak Test	5.2.3.1			30,18	32	16		8		
Weight Inspection				30,18	32	16				
Visual Inspection				30,18	32	16				
Electrical Checks				30,18	32	16				
Live Dissection	5.2.3.8	3			2	1				
Closed Tank Tests	5.2.3.7									
-40 C		15		10,6	10	5				
+23 C		15		10,6	10	5				
+85 C		15		10,6	10	5				
100ft3 Tank Effluent Test	5.2.3.5									
+23 C		6								
Supplemental Evaluations of Tank Tests										
Sampling Tank Content	5.2.3.7.4									
-40 C	5.2.3.7.5	6		3	3					Evaluation of Tank Wash required per 5.2.3.7.5
+23 C	5.2.3.7.5	15		6	6					
+85 C	5.2.3.7.5	15		6	6					
Tank Wash Chemical Speciation	5.2.3.7.6									
-40 C										Evaluation of Tank Wash required per 5.2.3.7.6
+23 C		3								
+85 C										
Tank Effluents (gas analysis)										For informational purposes only
+23 C		6								
Post Deployment Internal Inspection										
+85 C		6			6					
Visual Inspection Post Test Documentation	5.2.3.3	51	15	30,33	32	16	15		12	