National Aeronautics and
Space Administration

CxP 72169

BASELINE (DRAFT)

RELEASE DATE: MONTH XX, XXXX

Draft Maturity 10%
July 27, 2007

ARES I VIBROACOUSTIC AND SHOCK ENVIRONMENTS DATA BOOK

REVISION AND HISTORY PAGE

Status	Revision No.	Change No.	Description	Release Date
Draft	-		Draft Maturity 10%	06/29/07
Draft			Draft Maturity 10%	7/27/07
Baseline	-		Baseline (Reference CxCBD –TBD)	Ares I PDR

NOTE: Updates to this document, as released by numbered changes (Change XXX), are identified by a black bar on the right margin.

Document No: CxP 72169
Ares I Vibroacoustic and Shock Environments Data Book

Submitted by ______________________________ date ___________
Christy Gattis
NASA MSFC, EI13

Reviewed by ______________________________ date ___________
Phil Harrison
NASA MSFC, EV 42

______________________________ date ___________
S. Rusty Jones
NASA MSFC, EV 31/ Upper Stage

______________________________ date ___________
Joe Dutson
ATK

______________________________ date ___________
Nancy Tengler
Lockheed Martin

______________________________ date ___________
Karen Oliver, Loads Panel Chairman
NASA MSFC, EV31

Approved by ______________________________ date ___________
Pravin K. Aggarwal
(AST, AEROSPACE FLIGHT SYSTEMS)
NASA MSFC, EV30

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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this document is to provide the random vibration, internal acoustic, and shock environments induced into the Ares I vehicle during the liftoff, flight, and re-entry events.

These environments will also be documented at the stage level. However, this document serves to ensure that the integrated vehicle configuration was considered in the stage-level analyses. This document also serves as a pointer/collector to the stage-level analyses for better configuration control.

The environments provided within this document are the maximum predicted environments (MPE) at the designated locations.

1.2 SCOPE

This document covers the environments induced by ignition, hold-down nut separation, combustion, stage/fairing separation, aeroacoustic, main engine cutoff (MECO) and re-entry, including chute shock and impact, events. Abort events are not covered, except those which are design drivers for the Crew Exploration Vehicle (CEV) and Launch Abort System (LAS). Transportation environments are also not covered.

This document provides environments for the vehicle only. Environments induced into the mobile launcher (ML) or main propulsion test article (MPTA) will not be covered by this document.

As noted above, this document provides MPE only. No test and verification requirements are levied by this document. The Constellation Environmental Qualification and Acceptance Test Requirements (CEQATR) document defines the test and verification program for the vehicle and references test levels with respect to the MPE contained herein.

1.3 MATURITY

This version of this databook is intended as a draft ready for technical use (RFTU). It should be used for pre-preliminary design review (PDR) analyses. The environments provided in this version should be considered very conservative. An updated draft will be available in December 2007.

These random vibration environments will be updated and extended as the external acoustic environments are updated in the future and as the design configuration matures. Additionally, the vehicle may also be modeled using statistical energy analysis (SEA). The environments resulting from these SEA models will be compared to the environments calculated from the empirical scaling method. By conducting these additional statistical energy analyses, there will be some basis for comparing and checking results from the empirical scaling method. This should provide useful insight into the differences in results from these two methods. After future comparisons to measured flight data, the empirical scaling method and SEA can be evaluated to determine where each method can better predict environments for future Constellation Program projects, including Ares V.

For the shock environments, this version includes several assumptions with regard to type of separation mechanisms used and will be refined as the design matures. Conservatisms in structural and joint attenuation will be removed as further data becomes available. Correlation/supplementation of this data with math model data will be also be included as the models mature. It should also be noted that this version only includes shock generated by separation events; all other events will be included in the December 2007 update.

This version of this document only provides environments for Upper Stage. The CEV and First Stage vibroacoustic and shock environments will be included in the December 2007 update.

This document will be baselined at PDR.

1.4 CHANGE AUTHORITY/RESPONSIBILITY

Proposed changes to this document shall be submitted by a Constellation Program Change Request (CR) to the appropriate Level II Constellation Control Board for consideration and disposition. All such requests will adhere to the Constellation Program Configuration Management Change Process.

The appropriate NASA Office of Primary Responsibility (OPR) identified for this document is EV31.

2.0 DOCUMENTS

2.1 APPLICABLE DOCUMENTS

The following documents include specifications, models, standards, guidelines, handbooks, and other special publications. The documents listed in this paragraph are applicable to the extent specified herein.

CxP 72067	Ares-I Structural Dynamics, Loads, and Models Data Book
CxP 72164	Ares-I Acoustic Environments Data Book
CxP 70143	Induced Environments Design Specification
TBD	CEV Vibroacoustic and Shock Environments
TBD	First Stage Vibroacoustic and Shock Environments

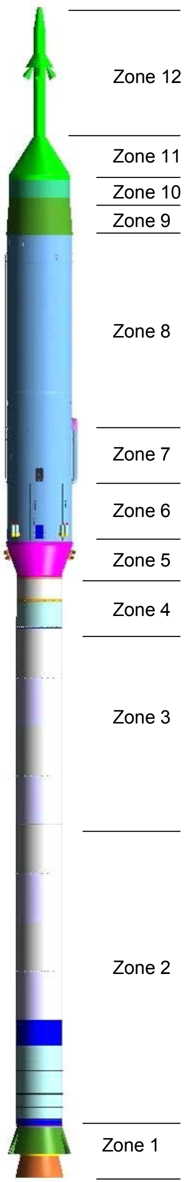
2.2 REFERENCE DOCUMENTS

The following documents contain supplemental information to guide the user in the application of this document.

NASA TN D-1836	Techniques for Predicting Localized Vibratory Environments of Rocket Vehicles by Barrett, R. E.
NASA TN D-2158	Statistical techniques for describing localized vibratory environments of rocket vehicles by Barrett, R. E.
NASA TN D-7159	Development and application of vibroacoustic structural data banks in predicting vibration design and test criteria for rocket vehicle structures by Bandgren, H. J.; Smith, W. C.
NASA-CR-116406, Contract NAS5-15208, March 1970	Martin Marietta Aerospace Systems Pyrotechnic Shock Design Guidelines Manual
Lockheed Martin Document #809-2087 (Contract NAS8-36200)	Orthogrid Acoustic Test Report, Prepared for NASA, Marshall Space Flight Center

3.0 ELEMENT VIBROACOUSTIC AND SHOCK ENVIRONMENTS

For this version of this document, the Ares I vibroacoustic and shock environments will be defined in accordance with the vehicle acoustic environment zones in a DAC2 configuration, as shown in Figure 1. In some cases, further definition may be given within a zone.



Ares 1 Environment Zone Definitions		
Zone Number	Zone Description	X-Station Location (in.)
Zone 12	CEV - LAS	152 to 597.5
Zone 11	CEV - Crew Module	597.5 to 785.7
Zone 10	CEV - Spacecraft Module	787.5 to 880
Zone 9	CEV - Spacecraft Adapter	880 to 1000
Zone 8-4	Instrumentation Ring [US]	1000 to 1089
Zone 8-3	Upper Third LH2 Tank [US]	1089 to 1274.3
Zone 8-2	Middle Third LH2 Tank [US]	1274.3 to 1459.6
Zone 8-1	Lower Third LH2 Tank [US]	1459.6 to 1645
Zone 7-2	Upper Stage – LOX Tank	1645 to 1724
Zone 7-1	Upper Stage – LOX Tank Skirt	1724 to 1780
	Separation Joint 1 – Upper Stage/Interstage	1783
Zone 6-2	Upper Stage -Interstage Upper	1780 to 1905
Zone 6-1	Upper Stage -Interstage Lower	1905 to 2004
Zone 5	First Stage - Frustrum	2004 to 2125
	Separation Joint 2 – (Frustum/Forward Skirt Extension)	2120
Zone 4	First Stage - Forward Skirt and Forward Skirt Extension	2125 to 2289
	Separation Joint 3 – Forward Skirt Extension/Forward Skirt)	2194
Zone 3	First Stage –Upper Motor Segments	2289 to 2929
Zone 2	First Stage – Lower Motor Segments	2929 to 3917
Zone 1	Aft Skirt & Nozzle Extension	3917 to 4087

FIGURE 1 DEFINITION OF ZONES FOR ARES I ENVIRONMENTS
Source: Houston, Janice, "Ares I Liftoff acoustic Environments," ESTSG-FY07-00331, Jacobs Engineering, NASA Marshall Space Flight Center, April 2007

3.1 RANDOM VIBRATION ENVIRONMENTS

The random vibration environment is derived from two main input sources. One source is the direct structural transmission of vibratory energy from the operating rocket engines and/or motors of the launch vehicle, from other onboard equipment such as turbo machinery, pumps, etc., and through the mechanical interfaces with adjacent vehicle elements. The other source of input is the vibratory energy generated by acoustic loading of the external and internal vehicle surfaces.

For structures that have a relatively low ratio of mass to surface-area (i.e. skin panels), pressure fluctuations due to liftoff rocket engine noise and ascent aero-acoustics are the primary drivers of vibration. For structures with more mass per surface area (i.e. beams, struts), the structural transmission of vibrations from the rocket motors is the primary driver of vibration.

The envelope of the liftoff acoustic and aeroacoustic environments is defined in the Ares-I Acoustic Environments Data Book, CxP 72164. For this version of this data book, the random vibration environments have been derived via empirical scaling of measured data from similar structures. This method is documented in NASA TN's D-1836, D-2158 and D-7159, by R. E. Barrett, H. J. Bandgren, and W. C. Smith and scales for differences between the reference test data and the data for this vehicle, as defined by the CxP 72164.

In addition, a component weight attenuation factor incorporates the effect of mounting additional mass (i.e. a component) on the vehicle structure. This version of this databook provides weighted random environments for components mounted in each zone. The environment provided in this document is the maximum predicted environment (MPE) for that zone in any direction.

3.1.1 CEV

3.1.1.1 Zone 12, LAS

The random vibration environment is TBD, pending delivery of this data from the Orion project (estimated delivery December 2007).

3.1.1.2 Zone 11, Crew Module

The random vibration environment is TBD, pending delivery of this data from the Orion project (estimated delivery December 2007).

3.1.1.3 Zone 10, Spacecraft Module

The random vibration environment is TBD, pending delivery of this data from the Orion project (estimated delivery December 2007).

3.1.1.4 Zone 9, Spacecraft Adapter

The random vibration environment is TBD, pending delivery of this data from the Orion project (estimated delivery December 2007).

3.1.2 Upper Stage

3.1.2.1 Zone 8-4, Instrument Unit

In this zone, the highest amplitude acoustic pressure levels are mostly experienced during ascent; therefore, the referenced vibration spectrum was also during ascent. The vehicle structure is composed of Aluminum-Lithium alloy 2195-T8. The referenced structure is an aluminum orthogrid barrel section of the shuttle external tank. Figure 2 defines the random vibration environment for this zone. Table 1 defines the weighted random environment for components located in this zone.

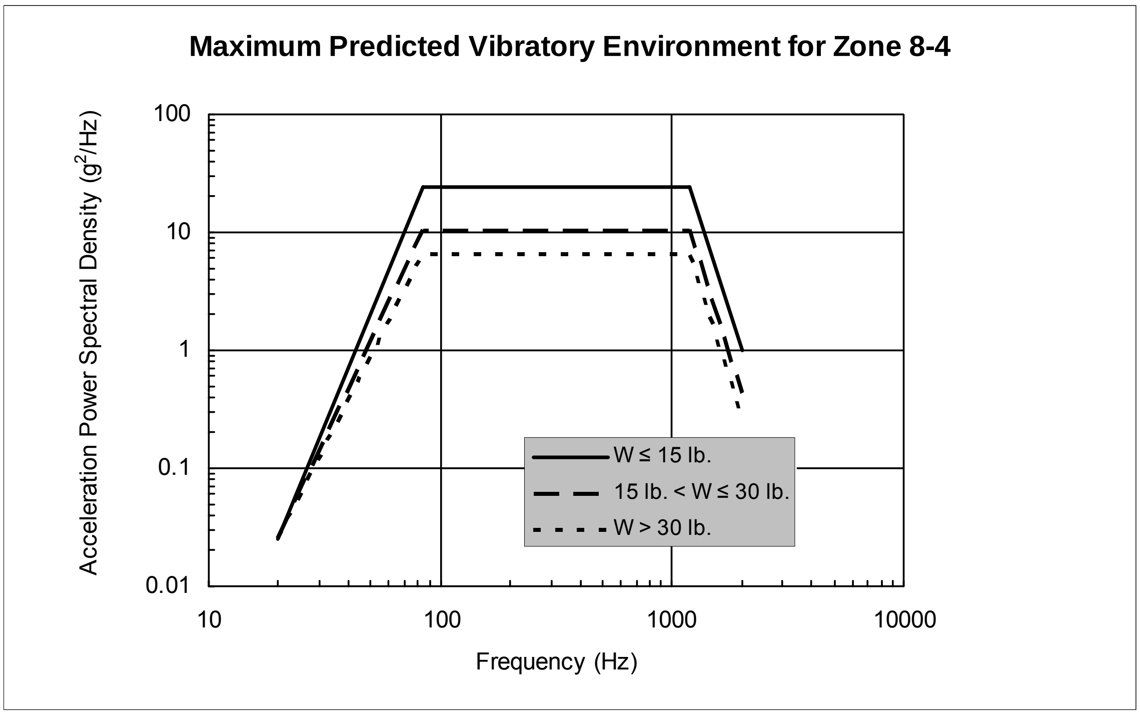


FIGURE 2. RANDOM VIBRATION ENVIRONMENT FOR ZONE 8-4, INSTRUMENT UNIT

TABLE 1. WEIGHTED RANDOM ENVIRONMENT FOR COMPONENTS, ZONE 8-4

Frequency	Power Spectral Density		
	W ≤ 15 lb.	15 lb. < W ≤ 30 lb.	W > 30 lb.
[dB]	[g^2/Hz]	[g^2/Hz]	[g^2/Hz]
20	0.025	0.025	0.025
84	24	10.2	6.5
1200	24	10.2	6.5
2000	1.0	0.42	0.27
Composite G_{RMS}	179.6	117.1	93.3

3.1.2.2 Zone 8-3, LH2 Tank (Upper Third)

In this zone, the highest amplitude acoustic pressure levels are mostly experienced during ascent; therefore, the referenced vibration spectrum was also during ascent. The vehicle structure is composed of Aluminum-Lithium alloy 2195-T8. The referenced structure is an aluminum orthogrid barrel section of the shuttle external tank. Figure 3 defines the random vibration environment for this zone. Table 2 defines the weighted random environment for components located in this zone.

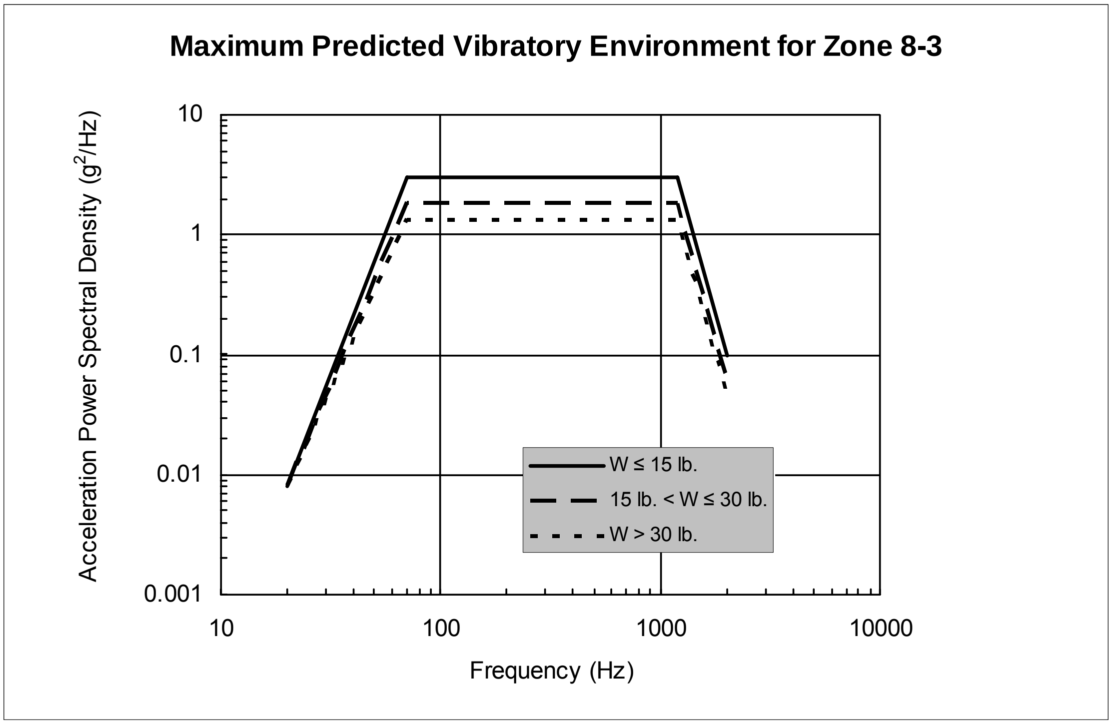


FIGURE 3. RANDOM VIBRATION ENVIRONMENT FOR ZONE 8-3, LH2 TANK (UPPER THIRD)

TABLE 2. WEIGHTED RANDOM ENVIRONMENT FOR COMPONENTS, ZONE 8-3

Frequency	Power Spectral Density		
	W ≤ 15 lb.	15 lb. < W ≤ 30 lb.	W > 30 lb.
[dB]	[g^2/Hz]	[g^2/Hz]	[g^2/Hz]
20	0.008	0.008	0.008
70	3	1.9	1.4
1200	3	1.9	1.4
2000	0.1	0.06	0.05
Composite G_{RMS}	63.5	50.0	42.6

3.1.2.3 Zone 8-2, LH2 Tank (Middle Third)

In this zone, the highest amplitude acoustic pressure levels are mostly experienced during liftoff; therefore, the referenced vibration spectrum was also during liftoff. The vehicle structure is composed of Aluminum-Lithium alloy 2195-T8. The referenced structure is an aluminum orthogrid barrel section of the shuttle external. Figure 4 defines the random vibration environment for this zone. Table 3 defines the weighted random environment for components located in this zone.

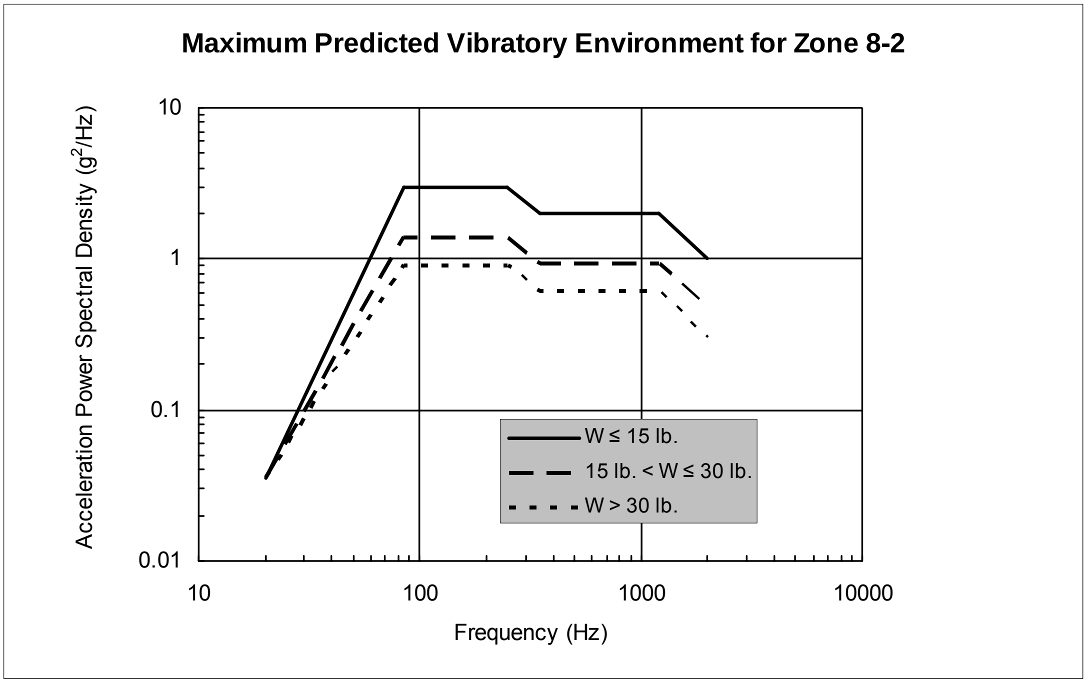


FIGURE 4. RANDOM VIBRATION ENVIRONMENT FOR ZONE 8-2, LH2 TANK (MIDDLE THIRD)

TABLE 3. WEIGHTED RANDOM ENVIRONMENT FOR COMPONENTS, ZONE 8-2

Frequency	Power Spectral Density		
	W ≤ 15 lb.	15 lb. < W ≤ 30 lb.	W > 30 lb.
[dB]	[g^2/Hz]	[g^2/Hz]	[g^2/Hz]
20	0.035	0.035	0.035
84	3	1.4	0.9
250	3	1.4	0.9
350	2	0.9	0.6
1200	2	0.9	0.6
2000	1	0.46	0.30
Composite G_{RMS}	60.2	41.1	33.2

3.1.2.4 Zone 8-1, LH2 Tank (Lower Third)

In this zone, the highest amplitude acoustic pressure levels are mostly experienced during liftoff; therefore, the referenced vibration spectrum was also during liftoff. The vehicle structure is composed of Aluminum-Lithium alloy 2195-T8. The referenced structure is an aluminum orthogrid barrel section of the shuttle external tank. Figure 5 defines the random vibration environment for this zone. Table 4 defines the weighted random environment for components located in this zone.

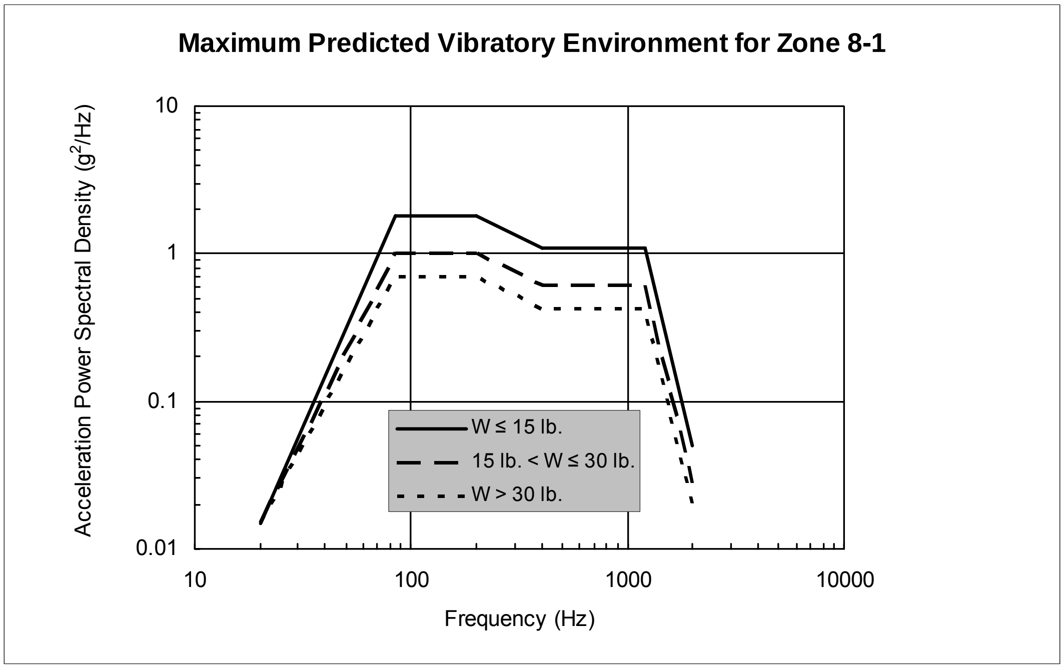


FIGURE 5. RANDOM VIBRATION ENVIRONMENT FOR ZONE 8-1, LH2 TANK (LOWER THIRD)

TABLE 4. WEIGHTED RANDOM ENVIRONMENT FOR COMPONENTS, ZONE 8-1

Frequency	Power Spectral Density		
	W ≤ 15 lb.	15 lb. < W ≤ 30 lb.	W > 30 lb.
[dB]	[g^2/Hz]	[g^2/Hz]	[g^2/Hz]
20	0.015	0.015	0.015
84	1.8	1.0	0.7
200	1.8	1.0	0.7
400	1.1	0.6	0.4
1200	1.1	0.6	0.4
2000	0.05	0.03	0.02
Composite G_{RMS}	40.5	30.2	25.2

3.1.2.5 Zone 7-2, LOX Tank

In this zone, the highest amplitude acoustic pressure levels are mostly experienced during liftoff. The vehicle structure is composed of Aluminum-Lithium alloy 2195-T8. The referenced structure is an aluminum orthogrid barrel section of the shuttle external tank. Figure 6 defines the random vibration environment for this zone. Table 5 defines the weighted random environment for components located in this zone.

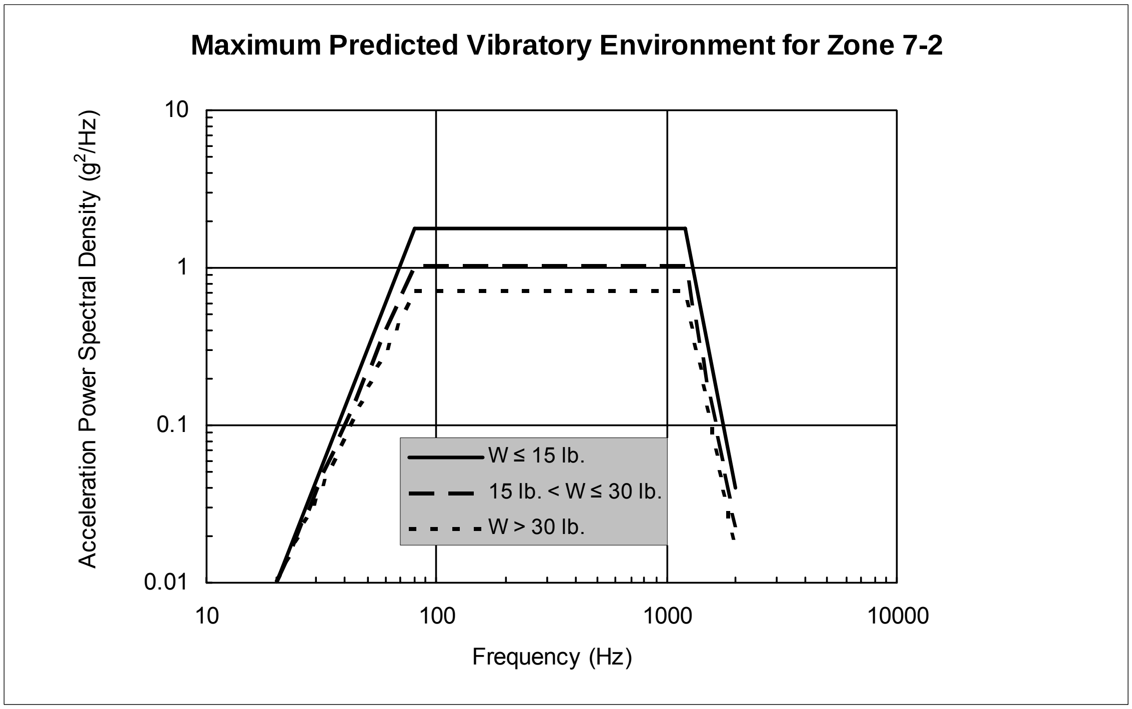


FIGURE 6. RANDOM VIBRATION ENVIRONMENT FOR ZONE 7-2, LOX TANK

TABLE 5. WEIGHTED RANDOM ENVIRONMENT FOR COMPONENTS, ZONE 7-2

Frequency	Power Spectral Density		
	W ≤ 15 lb.	15 lb. < W ≤ 30 lb.	W > 30 lb.
[dB]	[g^2/Hz]	[g^2/Hz]	[g^2/Hz]
20	0.01	0.01	0.01
80	1.8	1.0	0.7
1200	1.8	1.0	0.7
2000	0.04	0.02	0.02
Composite G_{RMS}	48.7	36.5	30.5

3.1.2.6 Zone 7-1, LOX Tank Skirt

In this zone, the highest amplitude acoustic pressure levels are mostly experienced during liftoff; therefore, the referenced set of vibroacoustic data was also taken during liftoff. The vehicle structure is composed of Aluminum-Lithium alloy 2195-T8. The referenced structure is an aluminum orthogrid barrel section of the shuttle external tank. Figure 7 defines the random vibration environment for this zone. Table 6 defines the weighted random environment for components located in this zone.

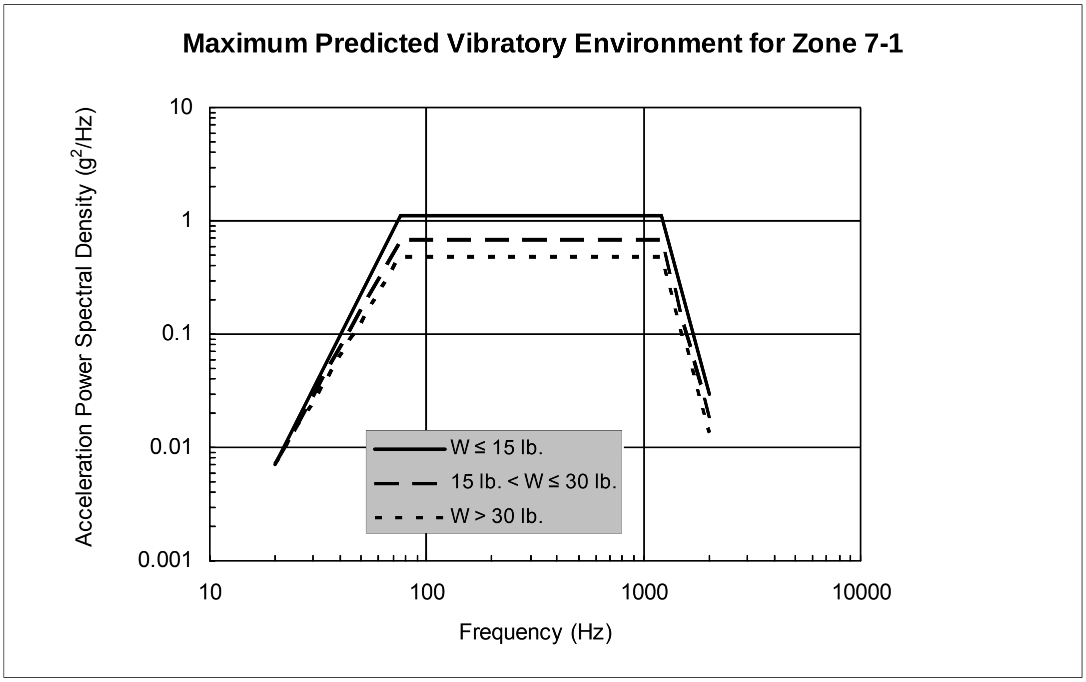


FIGURE 7. RANDOM VIBRATION ENVIRONMENT FOR ZONE 7-1, LOX TANK SKIRT

TABLE 6. WEIGHTED RANDOM ENVIRONMENT FOR COMPONENTS, ZONE 7-1

Frequency	Power Spectral Density		
	W ≤ 15 lb.	15 lb. < W ≤ 30 lb.	W > 30 lb.
[dB]	[g^2/Hz]	[g^2/Hz]	[g^2/Hz]
20	0.007	0.007	0.007
75	1.1	0.7	0.5
1200	1.1	0.7	0.5
2000	0.03	0.02	0.01
Composite G_{RMS}	38.2	29.9	25.4

3.1.2.7 Zone 6-2, Interstage (Upper), Including Thrust Cone

In this zone, the vehicle structure is composed of a composite material with an aluminum honeycomb core; therefore, the referenced vibroacoustic data is from a composite structure with a honeycomb aluminum core. Figure 8 defines the random vibration environment for this zone. Table 7 defines the weighted random environment for components located in this zone.

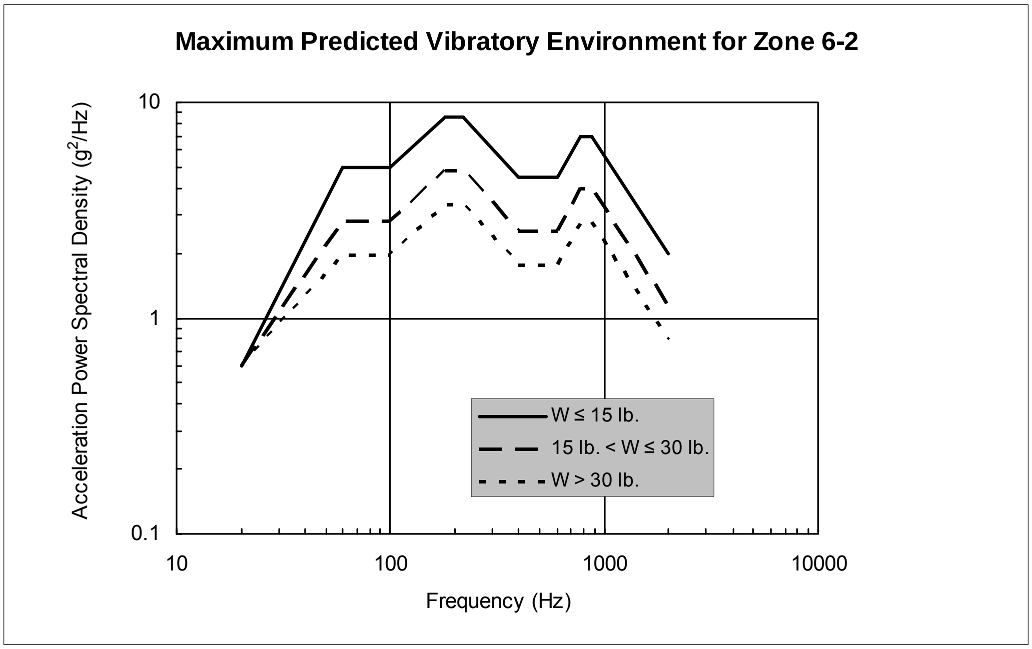


FIGURE 8. RANDOM VIBRATION ENVIRONMENT FOR ZONE 6-2, INTERSTAGE (UPPER HALF)

TABLE 7. WEIGHTED RANDOM ENVIRONMENT FOR COMPONENTS, ZONE 6-2

Frequency	Power Spectral Density		
	W ≤ 15 lb.	15 lb. < W ≤ 30 lb.	W > 30 lb.
[dB]	[g^2/Hz]	[g^2/Hz]	[g^2/Hz]
20	0.6	0.6	0.6
60	5	2.8	2.0
100	5	2.8	2.0
180	8.5	4.8	3.3
220	8.5	4.8	3.3
400	4.5	2.5	1.8
600	4.5	2.5	1.8
780	7	4.0	2.8
880	7	4.0	2.8
2000	2	1.1	0.8
Composite G_{RMS}	94.9	71.4	59.7

The structure of the thrust cone is composed of Aluminum-Lithium alloy 2195-T8, whose density is very similar to aluminum; therefore, the referenced vibroacoustic data is from an isogrid aluminum structure of the Saturn V. The acoustic environment impinging on the thrust cone is the calculated internal acoustic environment of the interstage, as defined in Section 3.3.2.7. The vibratory environment of the thrust cone at the gimbal joint interface, where the J2-X engine is mounted, is negligible. Figure 9 defines the random vibration environment for this zone. Table 8 defines the weighted random environment for components located in this zone.

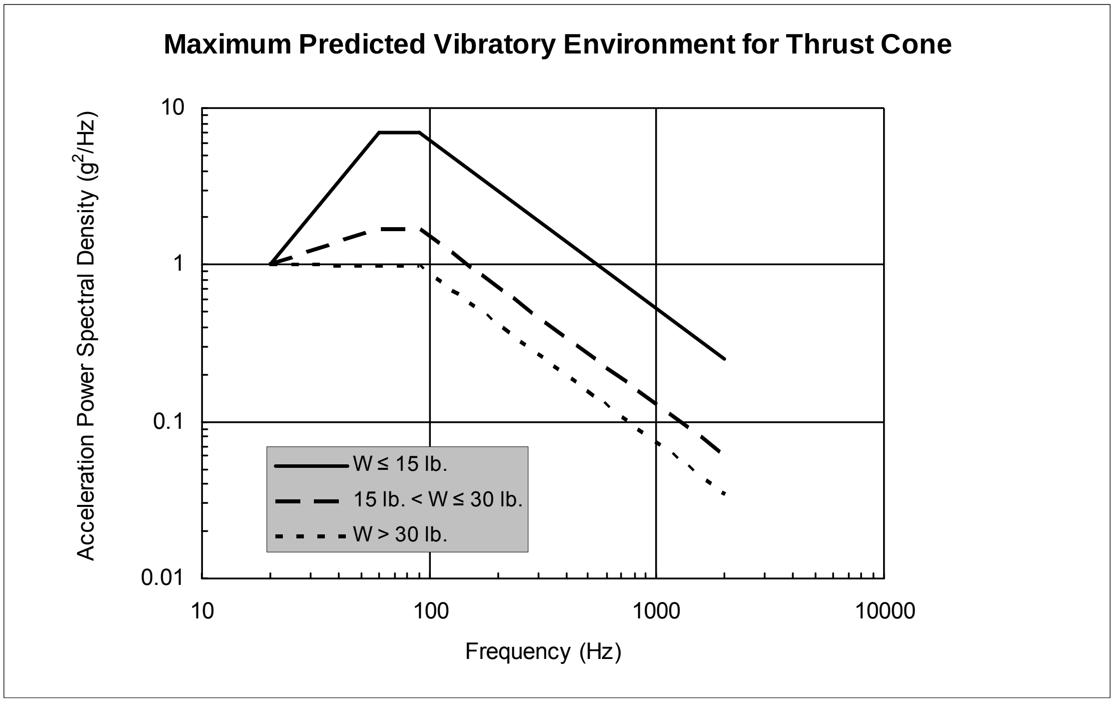


FIGURE 9. RANDOM VIBRATION ENVIRONMENT FOR ZONE 6-2, THRUST CONE

TABLE 8. WEIGHTED RANDOM ENVIRONMENT FOR COMPONENTS, THRUST CONE

Frequency	Power Spectral Density		
	W ≤ 15 lb.	15 lb. < W ≤ 30 lb.	W > 30 lb.
[dB]	[g^2/Hz]	[g^2/Hz]	[g^2/Hz]
20	1	1	1
60	7	1.7	1.0
90	7	1.7	1.0
2000	0.25	0.06	0.03
Composite G_{RMS}	45.8	23.1	17.6

3.1.2.8 Zone 6-1, Interstage (Lower)

In this zone, the vehicle structure is composed of a composite material with an aluminum honeycomb core; therefore, the referenced vibroacoustic data is from a composite structure with a honeycomb aluminum core. Figure 10 defines the random vibration environment for this zone. Table 9 defines the weighted random environment for components located in this zone.

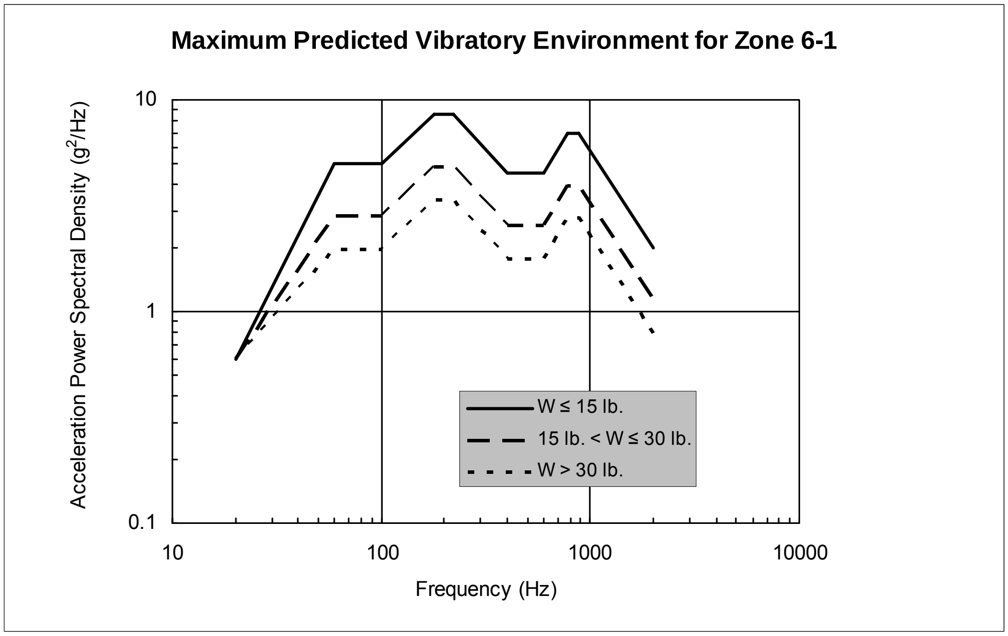


FIGURE 10. RANDOM VIBRATION ENVIRONMENT FOR ZONE 6-1, INTERSTAGE (LOWER HALF)

TABLE 9. WEIGHTED RANDOM ENVIRONMENT FOR COMPONENTS, ZONE 6-1

Frequency	Power Spectral Density		
	W ≤ 15 lb.	15 lb. < W ≤ 30 lb.	W > 30 lb.
[dB]	[g^2/Hz]	[g^2/Hz]	[g^2/Hz]
20	0.6	0.6	0.6
60	5	2.8	2.0
100	5	2.8	2.0
180	8.5	4.8	3.3
220	8.5	4.8	3.3
400	4.5	2.5	1.8
600	4.5	2.5	1.8
780	7	4.0	2.8
880	7	4.0	2.8
2000	2	1.1	0.8
Composite G_{RMS}	94.9	71.4	59.7

3.1.3 First Stage

3.1.3.1 Zone 5, Frustum

The random vibration environment is TBD, pending delivery of this data from the First Stage prime contractor (estimated delivery December 2007).

3.1.3.2 Zone 4, Forward Skirt and Extension

The random vibration environment is TBD, pending delivery of this data from the First Stage prime contractor (estimated delivery December 2007).

3.1.3.3 Zone 3, Upper Motor Segments

The random vibration environment is TBD, pending delivery of this data from the First Stage prime contractor (estimated delivery December 2007).

3.1.3.4 Zone 2, Lower Motor Segments

The random vibration environment is TBD, pending delivery of this data from the First Stage prime contractor (estimated delivery December 2007).

3.1.3.5 Zone 1, Aft Skirt and Nozzle Extension

The random vibration environment is TBD, pending delivery of this data from the First Stage prime contractor (estimated delivery December 2007).

3.2 SHOCK ENVIRONMENTS

The shock environment encompasses all high-frequency transient acceleration events, including both pyrotechnic shock and other mechanical shock events. Pyrotechnic shock or pyroshock is the transient response of structural elements, components, assemblies, subsystems and/or systems to loading induced by the activation of pyrotechnic (explosive or propellant-activated) devices incorporated into or attached to the structure. Other shock events may be induced mechanically, such as in the cases of chute opening and landing/impact.

In both cases, shock is often characterized by its high peak acceleration (up to 300,000 g), high frequency content (up to 1 MHz), and short duration (less than 20 ms). The structural response to shock input is largely dependent on the source type and size or strength, intervening structural path characteristics, and distance from the source to the response point of interest. In this databook, shock response levels below 1000 g peak will be considered negligible; zones where peak shock is below 1000 g will be reported to have no shock environment.

For this version of this data book, the pyroshock environments have been derived from the Martin Marietta Aerospace Systems Pyrotechnic Shock Design Guidelines Manual (NASA-

CR-116406, Contract NAS5-15208, March 1970). This manual provides guidelines for estimating the pyroshock environment, based on certain assumptions about the shock source and vehicle structure. This method is based on multiple test and flight programs, providing suggested environments produced by various types of pyrotechnic devices, attenuation curves for a variety of structures, and effects of structural interfaces. The environment provided in this document is the maximum predicted environment (MPE) for that zone in any direction.

It should be noted that the shock environments contained in this databook are defined at the base structure of the designated zone. The effect of mounting hardware should be considered in deriving environments for components or subsystems attached to the vehicle within these zones.

3.2.1 CEV

3.2.1.1 Zone 12, LAS

The shock environment is TBD, pending delivery of this data from the Orion project (estimated delivery December 2007).

3.2.1.2 Zone 11, Crew Module

The shock environment is TBD, pending delivery of this data from the Orion project (estimated delivery December 2007).

3.2.1.3 Zone 10, Spacecraft Module

The shock environment is TBD, pending delivery of this data from the Orion project (estimated delivery December 2007).

3.2.1.4 Zone 9, Spacecraft Adapter

The shock environment is TBD, pending delivery of this data from the Orion project (estimated delivery December 2007).

3.2.2 Upper Stage

3.2.2.1 Zone 8-4, Instrument Unit

The shock environment in this zone is dominated by the shock produced by the CEV to CLV separation joint. For this version of this databook, the source shock response spectrum (SRS) represents a 20 grain per foot (gpf) linear shaped charge (LSC) as the separation system. Table 10 shows the peak shock at various locations within this zone. Figures 11 through 15 define the full shock environment for this zone due to the defined input. Tables 11 through 15, respectively, represent the break points of these spectra.

TABLE 10. PEAK SHOCKS FOR ZONE 8-4, INSTRUMENT UNIT

Peak Shock	Location	Station
9,130 g	10" Aft of CEV Sep Joint	1010
8,400 g	17" Aft of CEV Sep Joint	1017
5,220 g	41" Aft of CEV Sep Joint	1041
3,560 g	65" Aft of CEV Sep Joint	1065
2,130 g	IU to LH2 Tank Interface	1089

FIGURE 11. SHOCK ENVIRONMENT FOR ZONE 8-4, 10" AFT OF CEV SEP JOINT

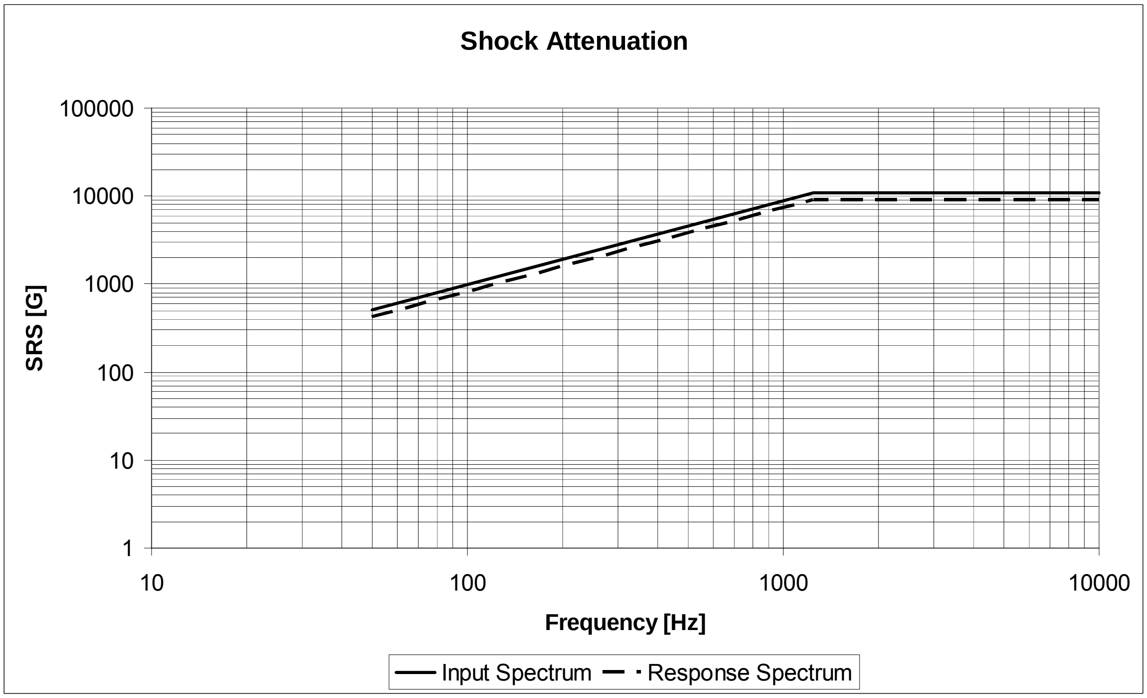


TABLE 11. SHOCK ENVIRONMENT FOR ZONE 8-4, 10" AFT OF CEV SEP JOINT (BREAK POINTS)

Frequency	SRS Response
50 Hz	425 g
1,250 Hz	9,130 g
10,000 Hz	9,130 g

FIGURE 12. SHOCK ENVIRONMENT FOR ZONE 8-4, 17" AFT OF CEV SEP JOINT

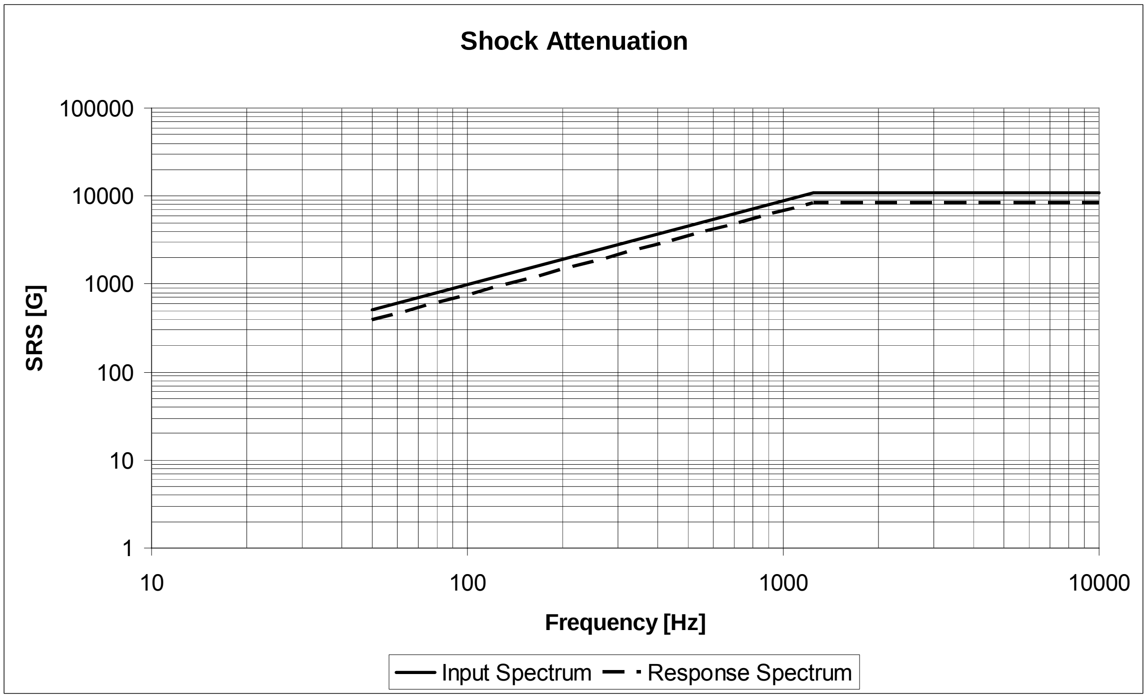


TABLE 12. SHOCK ENVIRONMENT FOR ZONE 8-4, 17" AFT OF CEV SEP JOINT (BREAK POINTS)

Frequency	SRS Response
50 Hz	390 g
1,250 Hz	8,400 g
10,000 Hz	8,400 g

FIGURE 13. SHOCK ENVIRONMENT FOR ZONE 8-4, 41" AFT OF CEV SEP JOINT

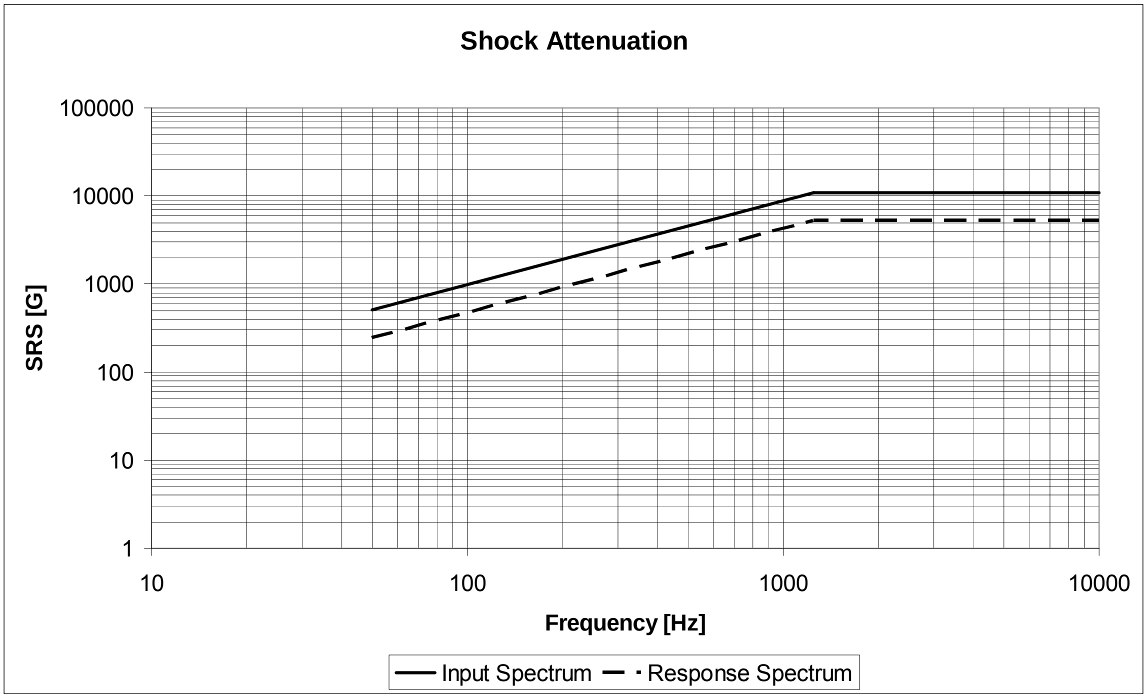


TABLE 13. SHOCK ENVIRONMENT FOR ZONE 8-4, 41" AFT OF CEV SEP JOINT (BREAK POINTS)

Frequency	SRS Response
50 Hz	245 g
1,250 Hz	5,220 g
10,000 Hz	5,220 g

FIGURE 14. SHOCK ENVIRONMENT FOR ZONE 8-4, 65" AFT OF CEV SEP JOINT

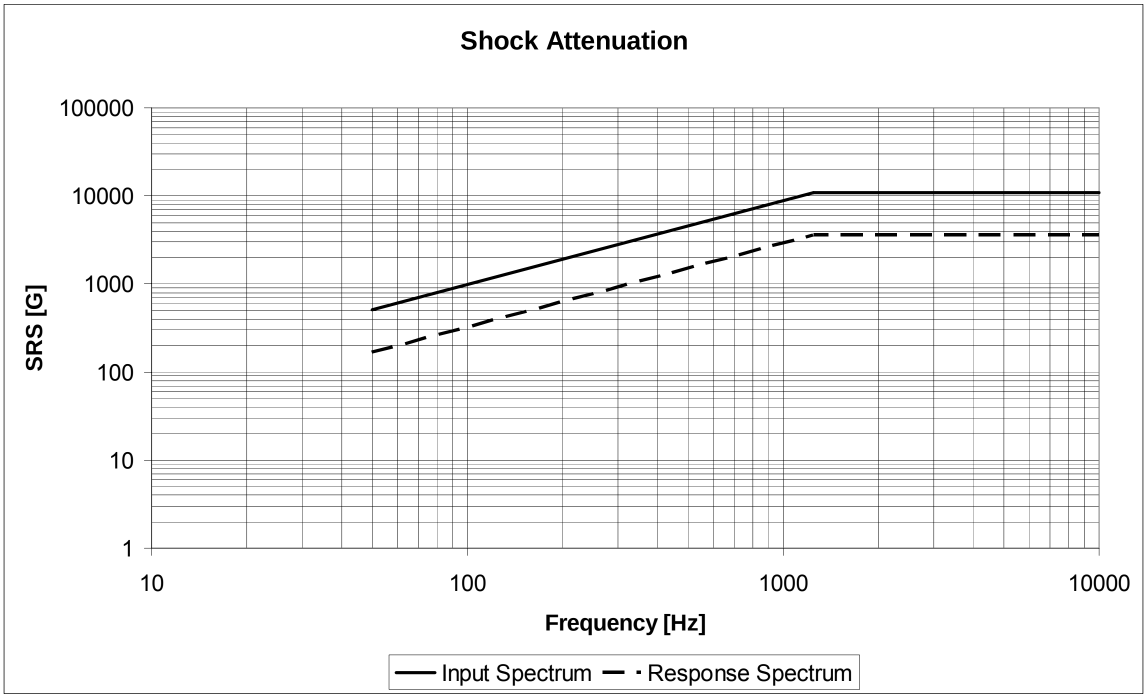


TABLE 14. SHOCK ENVIRONMENT FOR ZONE 8-4, 65" AFT OF CEV SEP JOINT (BREAK POINTS)

Frequency	SRS Response
50 Hz	165 g
1,250 Hz	3,560 g
10,000 Hz	3,560 g

FIGURE 15. SHOCK ENVIRONMENT FOR ZONE 8-4, AT LH2 TANK INTERFACE

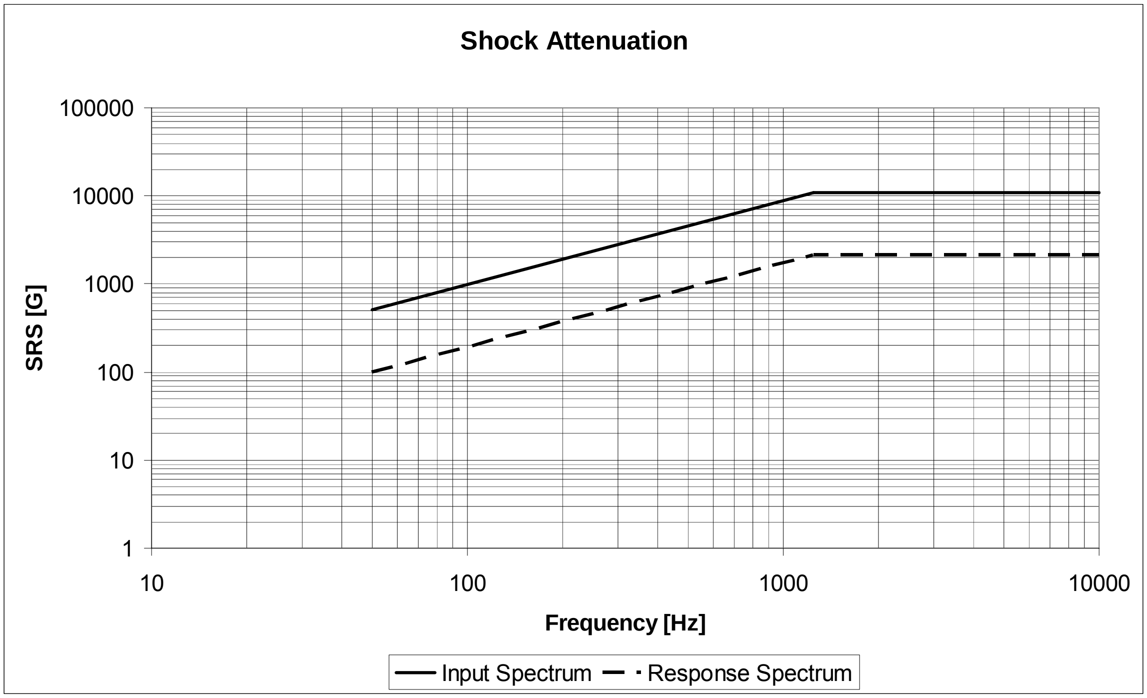


TABLE 15. SHOCK ENVIRONMENT FOR ZONE 8-4, AT LH2 TANK INTERFACE (BREAK POINTS)

Frequency	SRS Response
50 Hz	100 g
1,250 Hz	2,130 g
10,000 Hz	2,130 g

3.2.2.2 Zone 8-3, LH2 Tank (Upper Third)

The shock environment in this zone is dominated by the shock produced by the CEV to CLV separation joint. For this version of this databook, the source SRS represents a 20 gpf LSC as the separation system. Table 16 defines the shock environment for this zone due to the defined input. Figures 16 and 17 define the full shock environment for this zone due to the defined input. Tables 17 and 18, respectively, represent the break points of these spectra.

TABLE 16. PEAK SHOCKS FOR ZONE 8-3, LH2 TANK (UPPER THIRD)

Peak Shock	Location	Station
1,705 g	89" Aft of CEV Sep Joint	1089
1,006	108" Aft of CEV Sep Joint	1108

FIGURE 16. SHOCK ENVIRONMENT FOR ZONE 8-3, 89" AFT OF CEV SEP JOINT

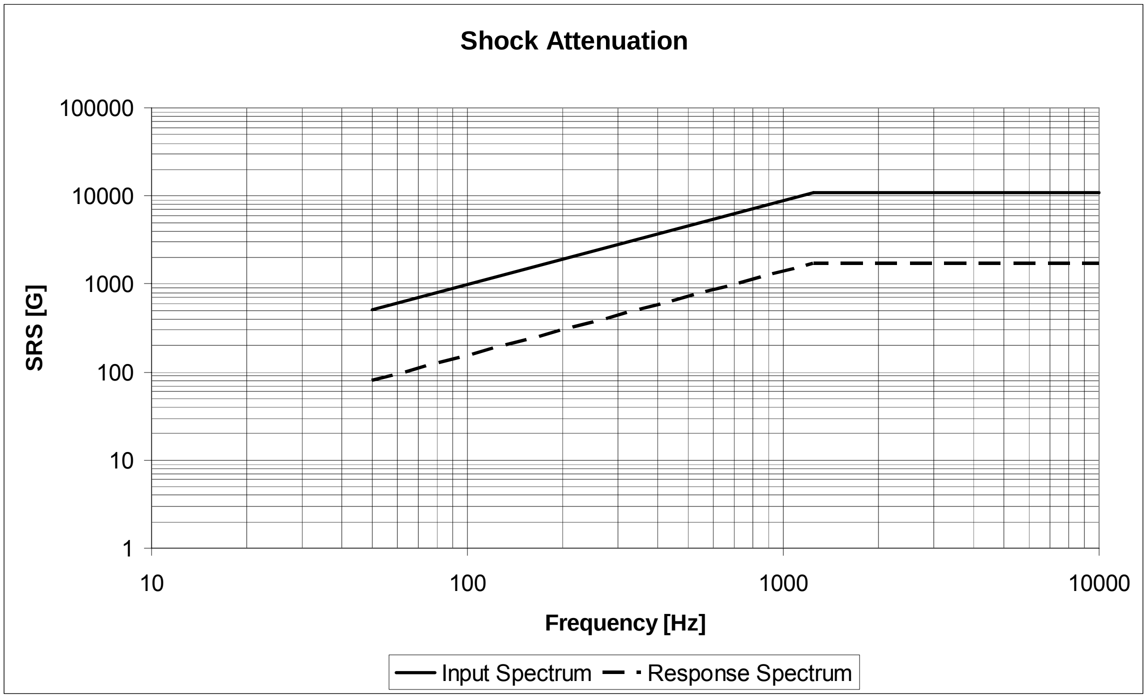


TABLE 17. SHOCK ENVIRONMENT FOR ZONE 8-3, 89" AFT OF CEV SEP JOINT (BREAK POINTS)

Frequency	SRS Response
50 Hz	80 g
1,250 Hz	1,705 g
10,000 Hz	1,705 g

FIGURE 17. SHOCK ENVIRONMENT FOR ZONE 8-3, 108" AFT OF CEV SEP JOINT

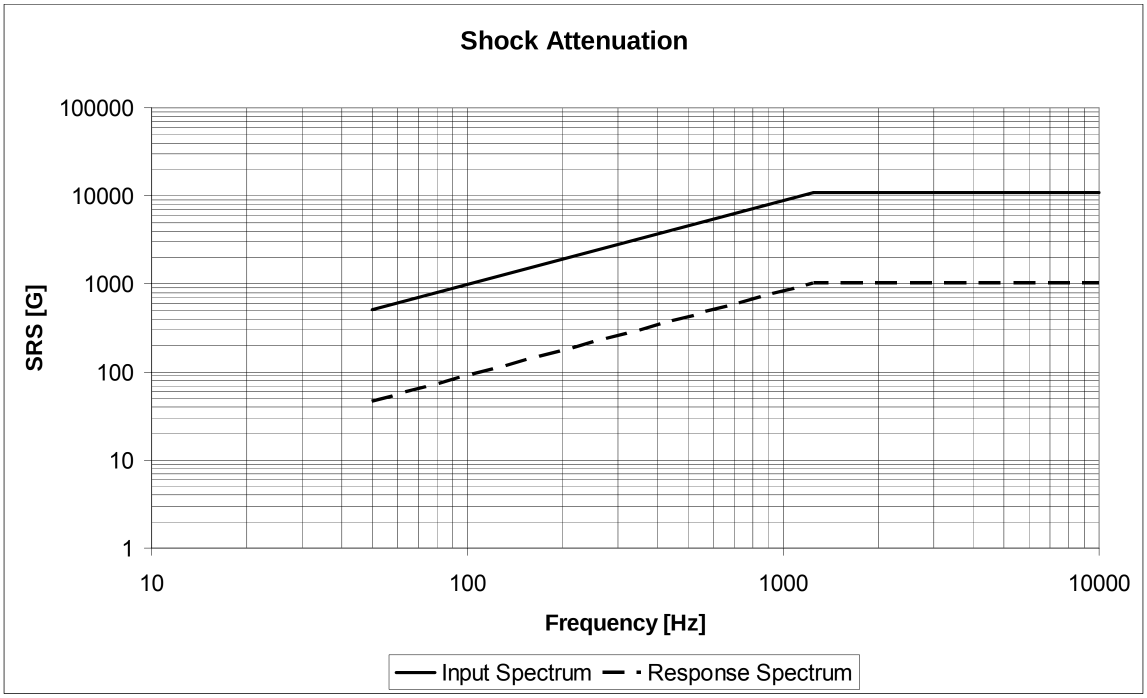


TABLE 18. SHOCK ENVIRONMENT FOR ZONE 8-3, 108" AFT OF CEV SEP JOINT (BREAK POINTS)

Frequency	SRS Response
50 Hz	50 g
1,250 Hz	1,010 g
10,000 Hz	1,010 g

3.2.2.3 Zone 8-2, LH2 Tank (Middle Third)

There is no shock environment in this zone.

3.2.2.4 Zone 8-1, LH2 Tank (Lower Third)

There is no shock environment in this zone.

3.2.2.5 Zone 7-2, LOX Tank

The shock environment in this zone is dominated by the shock produced by separation joint 1. For this version of this databook, the source SRS envelope represents a 30 gpf LSC. Table 19 defines the shock environment for this zone due to the defined input. Figures 18 and 19 define the full shock environment for this zone due to the defined input. Tables 20 and 21, respectively, represent the break points of these spectra.

TABLE 19. PEAK SHOCKS FOR ZONE 7-2, LOX TANK

Peak Shock	Location	Station
2,400 g	59” Forward of Sep Joint 1	1724
1,008 g	88” Forward of Sep Joint 1	1695

FIGURE 18. SHOCK ENVIRONMENT FOR ZONE 7-2, 59” FORWARD OF SEP JOINT 1

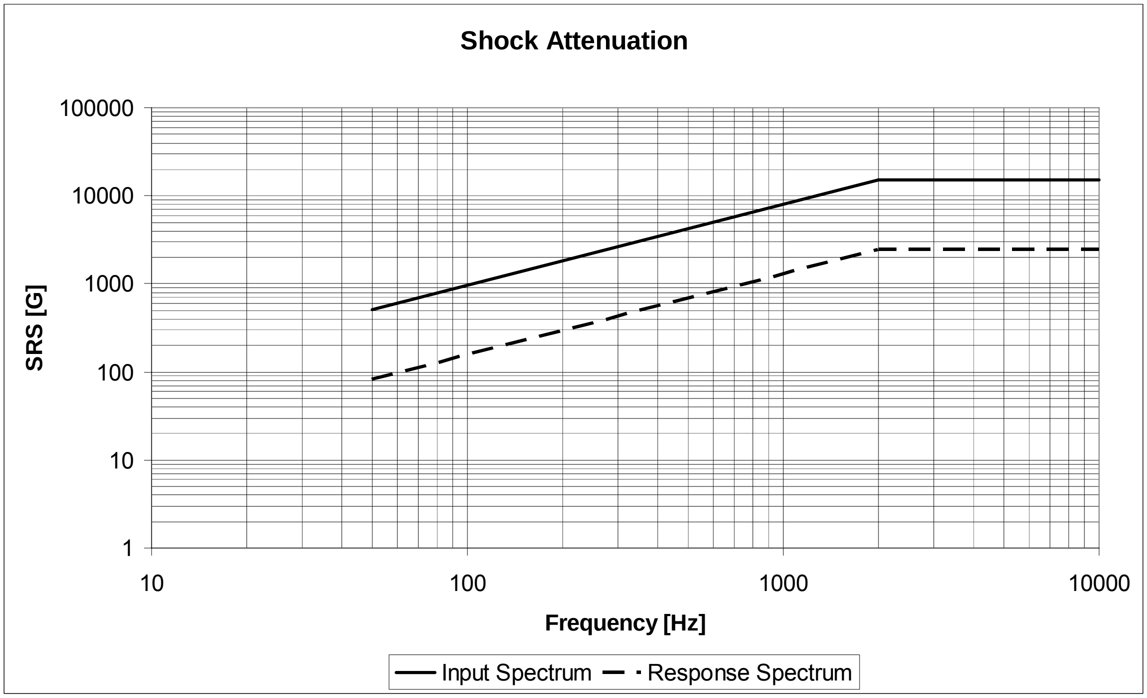


TABLE 20. SHOCK ENVIRONMENT FOR ZONE 7-2, 59” FORWARD OF SEP JOINT 1 (BREAK POINTS)

Frequency	SRS Response
50 Hz	85 g
1,250 Hz	2,400 g
10,000 Hz	2,400 g

FIGURE 19. SHOCK ENVIRONMENT FOR ZONE 7-2, 88" FORWARD OF SEP JOINT 1

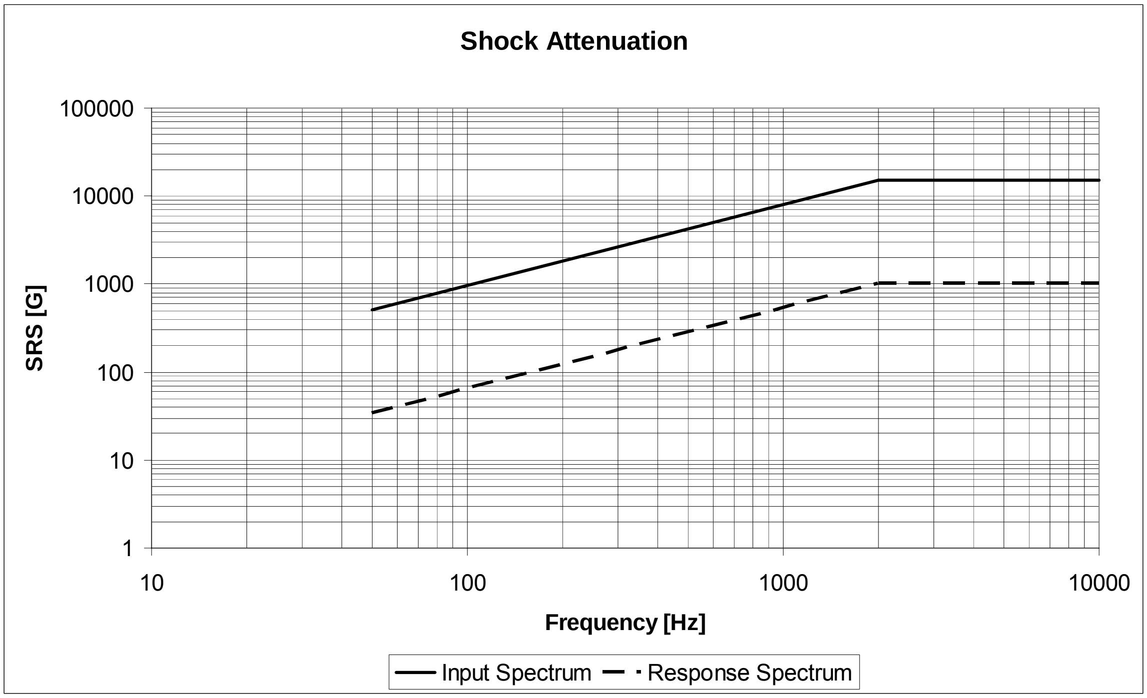


TABLE 21. SHOCK ENVIRONMENT FOR ZONE 7-2, 88" FORWARD OF SEP JOINT 1 (BREAK POINTS)

Frequency	SRS Response
50 Hz	34 g
1,250 Hz	1,008 g
10,000 Hz	1,008 g

3.2.2.6 Zone 7-1, LOX Tank Skirt

The shock environment in this zone is dominated by the shock produced by separation joint 1. For this version of this databook, the source SRS envelope represents a 30 gpf LSC. Table 22 defines the shock environment for this zone due to the defined input. Figures 20 through 22 define the full shock environment for this zone due to the defined input. Tables 23 through 25, respectively, represent the break points of these spectra.

TABLE 22. PEAK SHOCKS FOR ZONE 7-1, LOX TANK SKIRT

Peak Shock	Location	Station
12,000 g	10” Forward of Sep Joint 1	1773
6,750 g	25” Forward of Sep Joint 1	1758
3,000 g	Skirt to LOX Tank Interface	1724

FIGURE 20. SHOCK ENVIRONMENT FOR ZONE 7-1, 10” FORWARD OF SEP JOINT 1

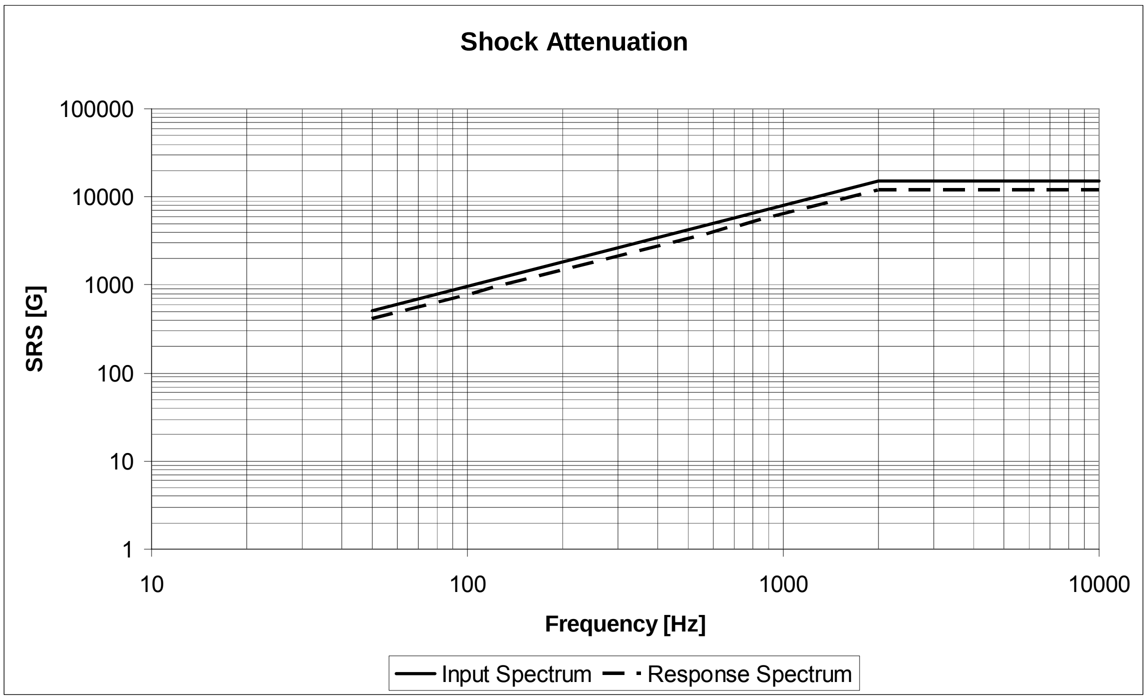


TABLE 23. SHOCK ENVIRONMENT FOR ZONE 7-1, 10” FORWARD OF SEP JOINT 1 (BREAK POINTS)

Frequency	SRS Response
50 Hz	410 g
1,250 Hz	12,000 g
10,000 Hz	12,000 g

FIGURE 21. SHOCK ENVIRONMENT FOR ZONE 7-1, 25" FORWARD OF SEP JOINT 1

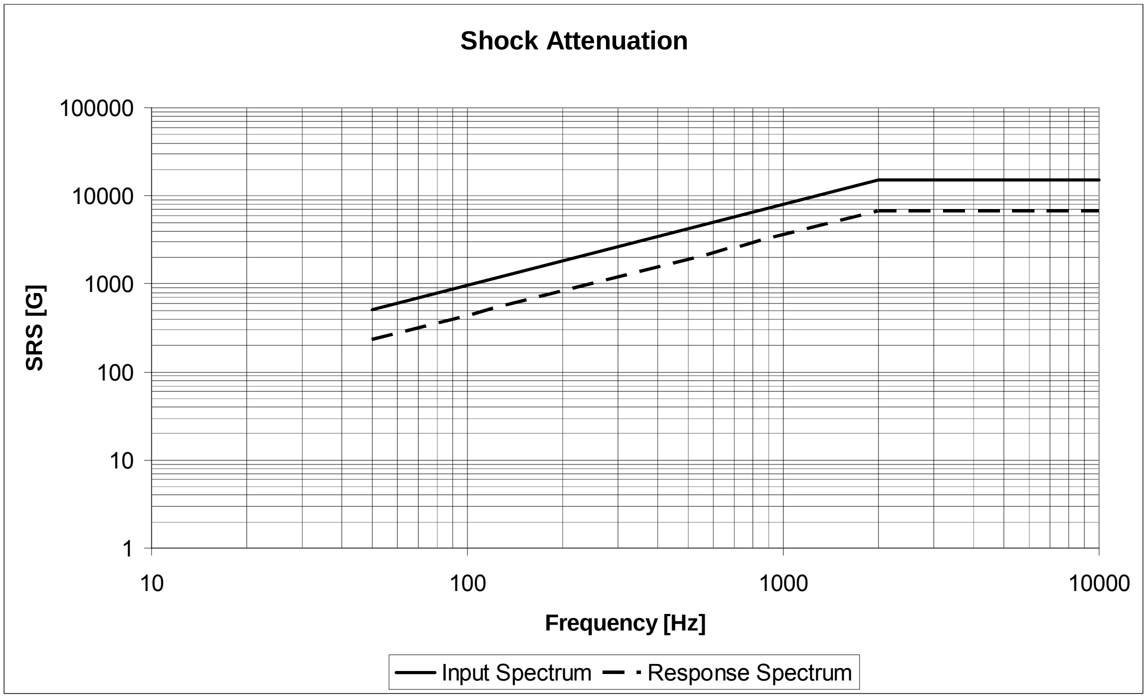


TABLE 24. SHOCK ENVIRONMENT FOR ZONE 7-1, 25" FORWARD OF SEP JOINT 1 (BREAK POINTS)

Frequency	SRS Response
50 Hz	230 g
1,250 Hz	6,750 g
10,000 Hz	6,750 g

FIGURE 22. SHOCK ENVIRONMENT FOR ZONE 7-1, SKIRT TO LOX TANK INTERFACE

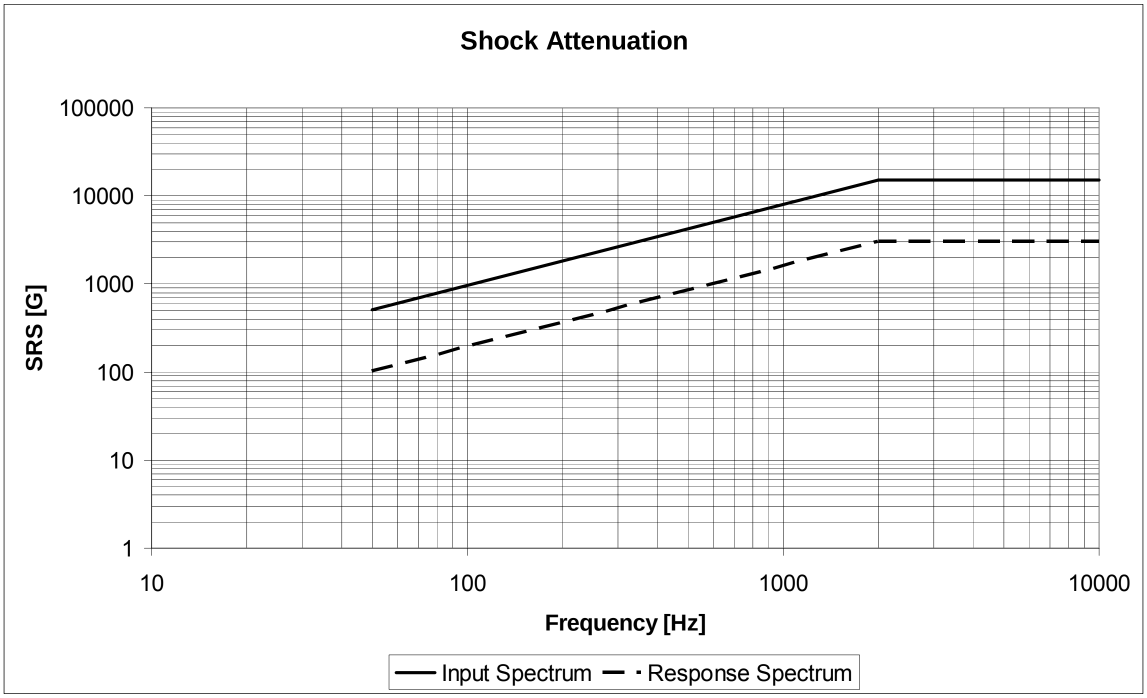


TABLE 25. SHOCK ENVIRONMENT FOR ZONE 7-1, SKIRT TO LOX TANK INTERFACE (BREAK POINTS)

Frequency	SRS Response
50 Hz	105 g
1,250 Hz	3,000 g
10,000 Hz	3,000 g

3.2.2.7 Zone 6-2, Interstage (Upper)

The shock environment in this zone is dominated by the shock produced by separation joint 1. For this version of this databook, the source SRS envelope represents a 30 gpf LSC. Table 26 defines the shock environment for this zone due to the defined input. Figures 23 through 27 define the full shock environment for this zone due to the defined input. Tables 27 through 31, respectively, represent the break points of these spectra.

TABLE 26. PEAK SHOCKS FOR ZONE 6-2, INTERSTAGE (UPPER)

Peak Shock	Location	Station
12,750 g	25" Aft of Sep Joint 1	1808
10,200 g	50" Aft of Sep Joint 1	1833
8,250 g	75" Aft of Sep Joint 1	1858
6,750 g	100" Aft of Sep Joint 1	1883
1,000 g	45" Above Thrust Cone to LOX Dome Interface	N/A

FIGURE 23. SHOCK ENVIRONMENT FOR ZONE 6-2, 25" AFT OF SEP JOINT 1

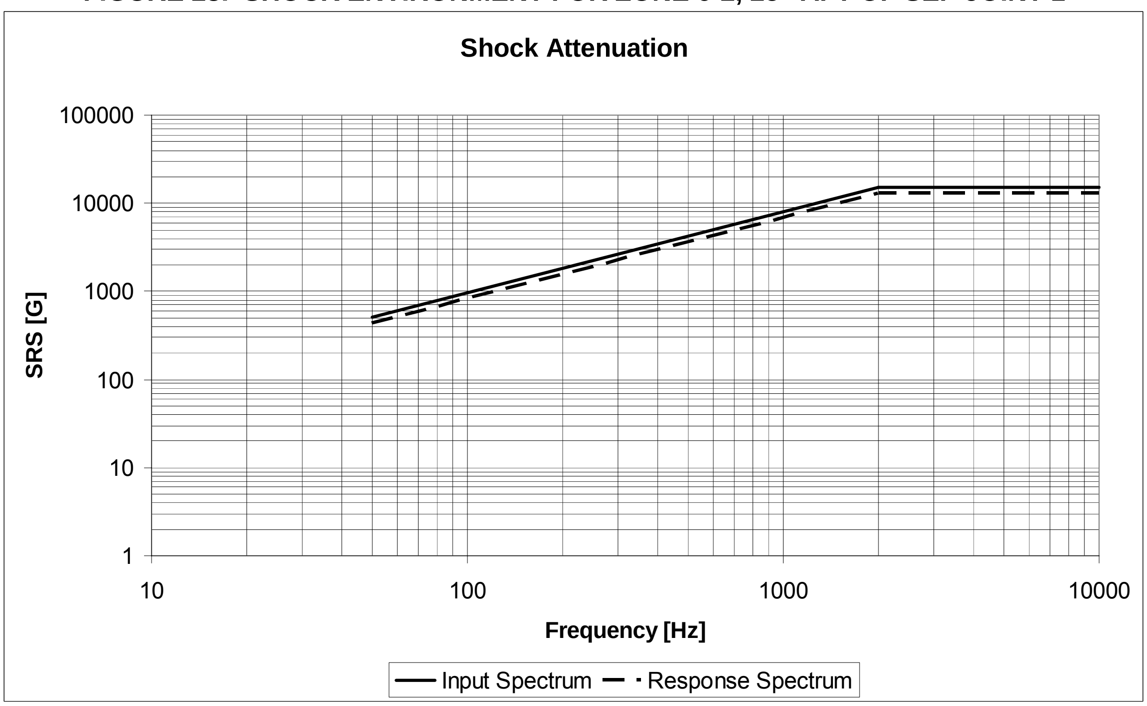


TABLE 27. SHOCK ENVIRONMENT FOR ZONE 6-2, 25" AFT OF SEP JOINT 1 (BREAK POINTS)

Frequency	SRS Response
50 Hz	435 g
1,250 Hz	12,750 g
10,000 Hz	12,750 g

FIGURE 24. SHOCK ENVIRONMENT FOR ZONE 6-2, 50" AFT OF SEP JOINT 1

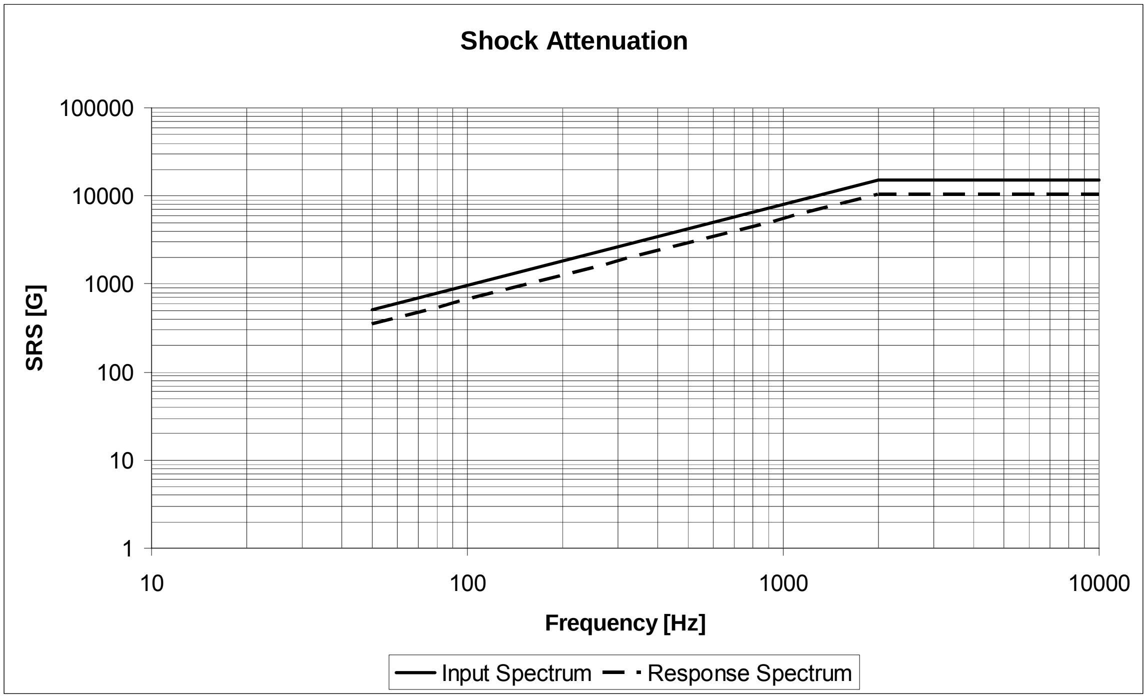


TABLE 28. SHOCK ENVIRONMENT FOR ZONE 6-2, 50" AFT OF SEP JOINT 1 (BREAK POINTS)

Frequency	SRS Response
50 Hz	350 g
1,250 Hz	10,200 g
10,000 Hz	10,200 g

FIGURE 25. SHOCK ENVIRONMENT FOR ZONE 6-2, 75" AFT OF SEP JOINT 1

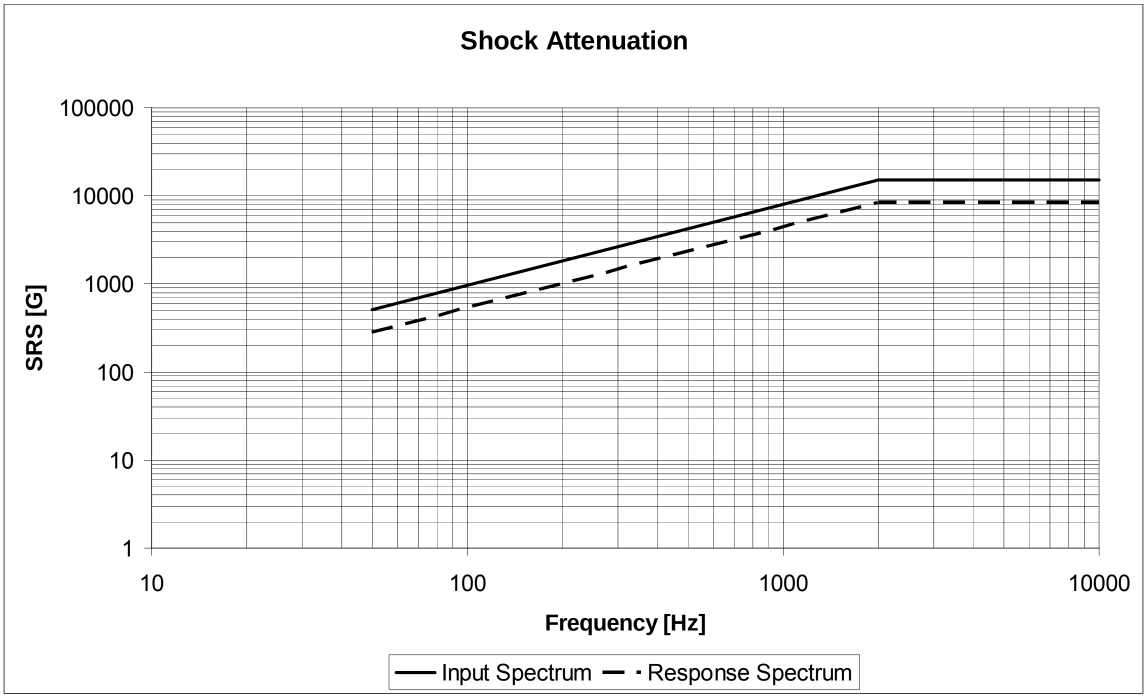


TABLE 29. SHOCK ENVIRONMENT FOR ZONE 6-2, 75" AFT OF SEP JOINT 1 (BREAK POINTS)

Frequency	SRS Response
50 Hz	280 g
1,250 Hz	8,250 g
10,000 Hz	8,250 g

FIGURE 26. SHOCK ENVIRONMENT FOR ZONE 6-2, 100" AFT OF SEP JOINT 1

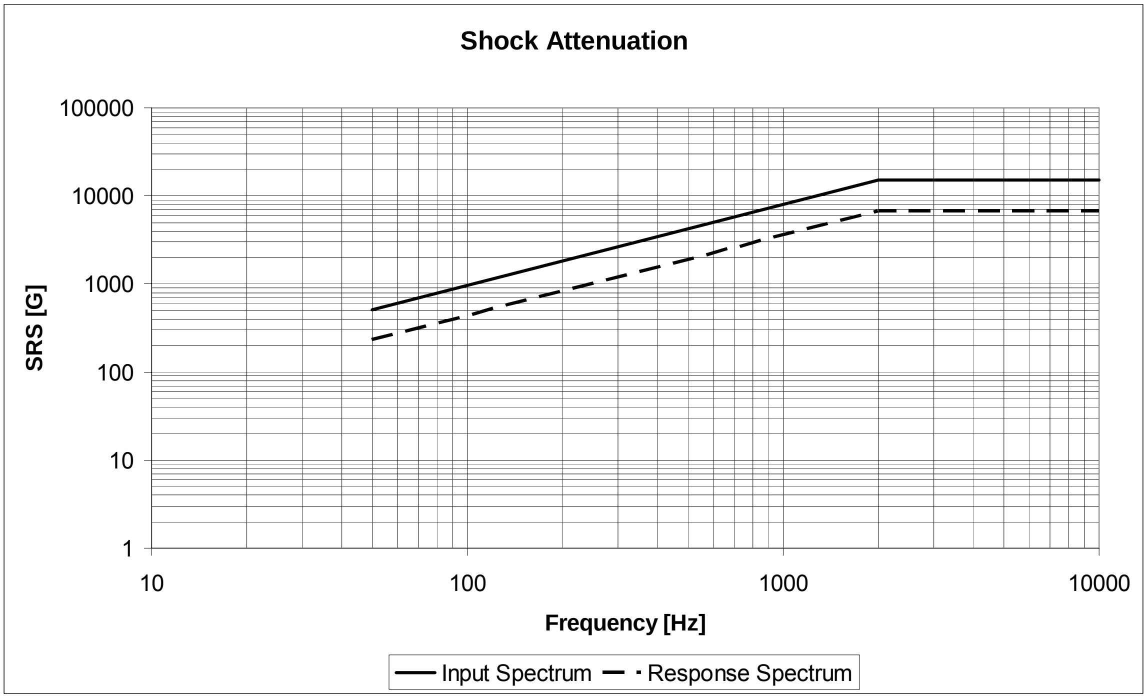


TABLE 30. SHOCK ENVIRONMENT FOR ZONE 6-2, 100" AFT OF SEP JOINT 1 (BREAK POINTS)

Frequency	SRS Response
50 Hz	230 g
1,250 Hz	6,750 g
10,000 Hz	6,750 g

FIGURE 27. SHOCK ENVIRONMENT FOR ZONE 6-2, 45" ABOVE THRUST CONE TO LOX DOME INTERFACE

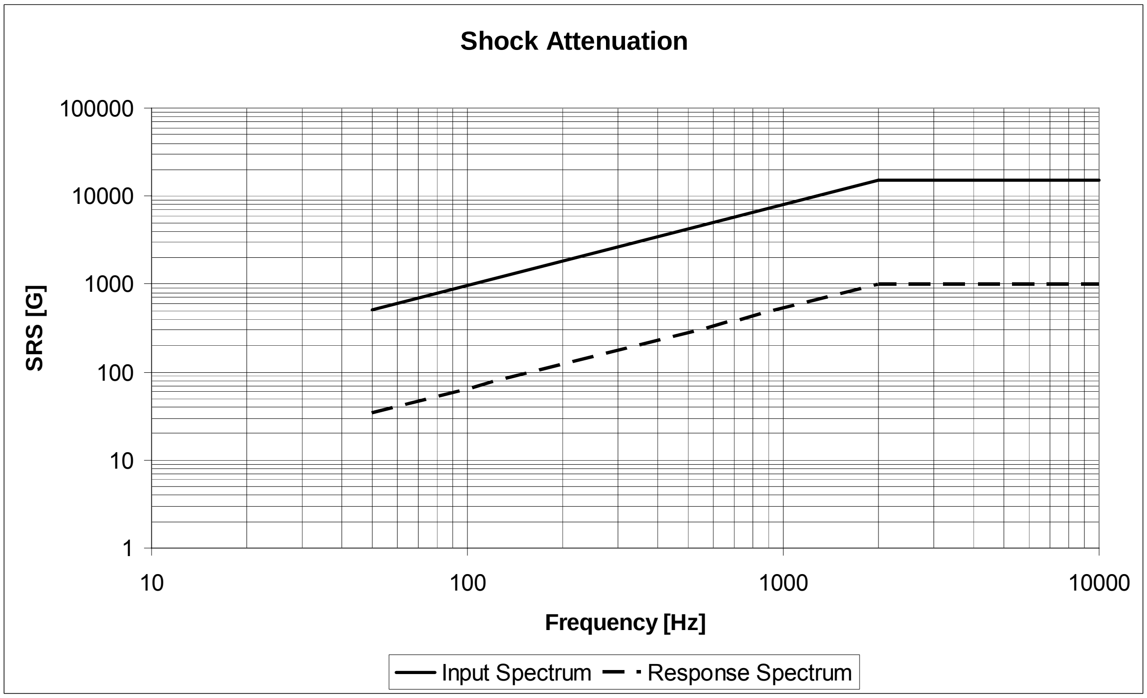


TABLE 31. SHOCK ENVIRONMENT FOR ZONE 6-2, 45" ABOVE THRUST CONE TO LOX DOME INTERFACE (BREAK POINTS)

Frequency	SRS Response
50 Hz	34 g
1,250 Hz	1000 g
10,000 Hz	1000 g

3.2.2.8 Zone 6-1, Interstage (Lower)

The shock environment in this zone is dominated by the shock produced by separation joint 1. For this version of this databook, the source SRS envelope represents a 30 gpf LSC. Table 32 defines the shock environment for this zone due to the defined input. Figures 28 through 32 define the full shock environment for this zone due to the defined input. Tables 33 through 37, respectively, represent the break points of these spectra.

TABLE 32. SHOCK ENVIRONMENT FOR ZONE 6-1, INTERSTAGE (LOWER)

Peak Shock	Location	Station
4,880 g	20" Aft of Upper Interstage	1925
4,100 g	40" Aft of Upper Interstage	1945
3,440 g	60" Aft of Upper Interstage	1965
2,940 g	At BDM and RCS Locations	1984
2,500 g	At Frustum Interface	2004

FIGURE 28. SHOCK ENVIRONMENT FOR ZONE 6-1, 20" AFT OF UPPER INTERSTAGE

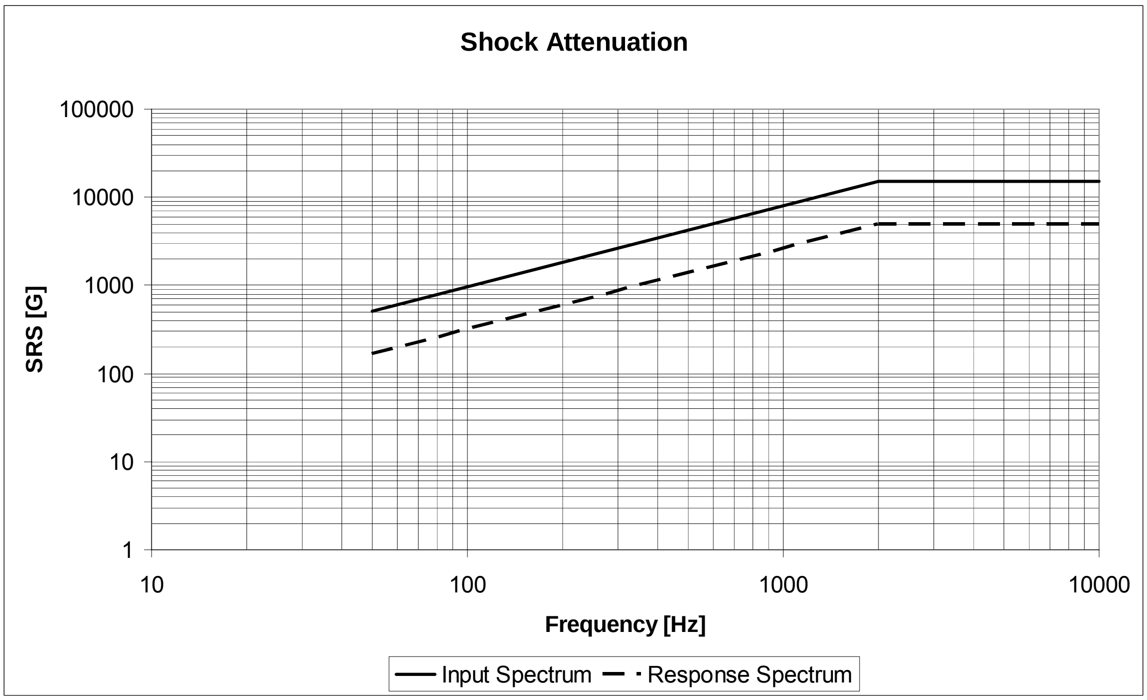


TABLE 33. SHOCK ENVIRONMENT FOR ZONE 6-1, 20" AFT OF UPPER INTERSTAGE (BREAK POINTS)

Frequency	SRS Response
50 Hz	165 g
1,250 Hz	4,880 g
10,000 Hz	4,880 g

FIGURE 29. SHOCK ENVIRONMENT FOR ZONE 6-1, 40" AFT OF UPPER INTERSTAGE

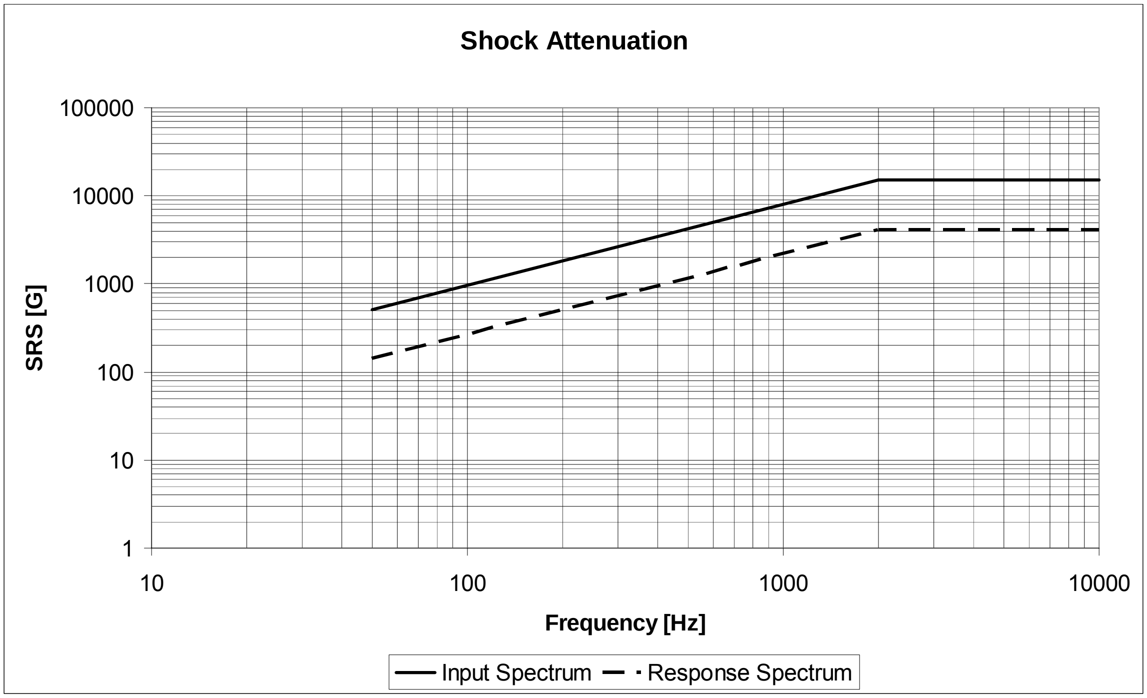


TABLE 34. SHOCK ENVIRONMENT FOR ZONE 6-1, 40" AFT OF UPPER INTERSTAGE (BREAK POINTS)

Frequency	SRS Response
50 Hz	140 g
1,250 Hz	4,100 g
10,000 Hz	4,100 g

FIGURE 30. SHOCK ENVIRONMENT FOR ZONE 6-1, 60" AFT OF UPPER INTERSTAGE

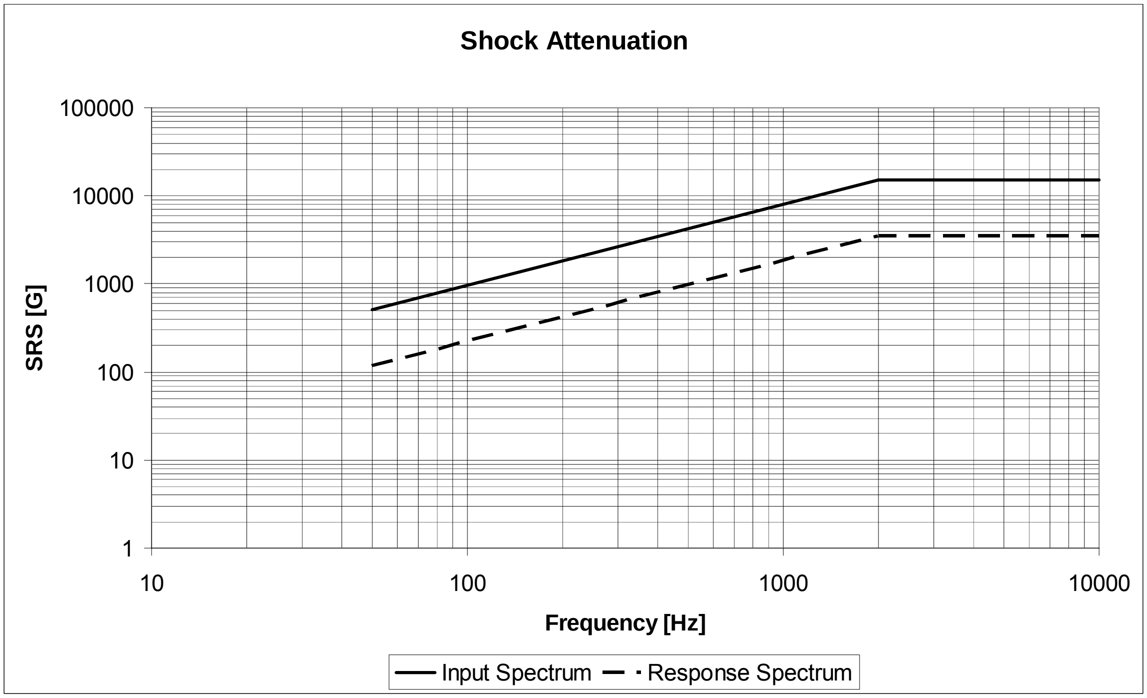


TABLE 35. SHOCK ENVIRONMENT FOR ZONE 6-1, 60" AFT OF UPPER INTERSTAGE (BREAK POINTS)

Frequency	SRS Response
50 Hz	120 g
1,250 Hz	3,440 g
10,000 Hz	3,440 g

FIGURE 31. SHOCK ENVIRONMENT FOR ZONE 6-1, AT BDM AND RCS LOCATIONS

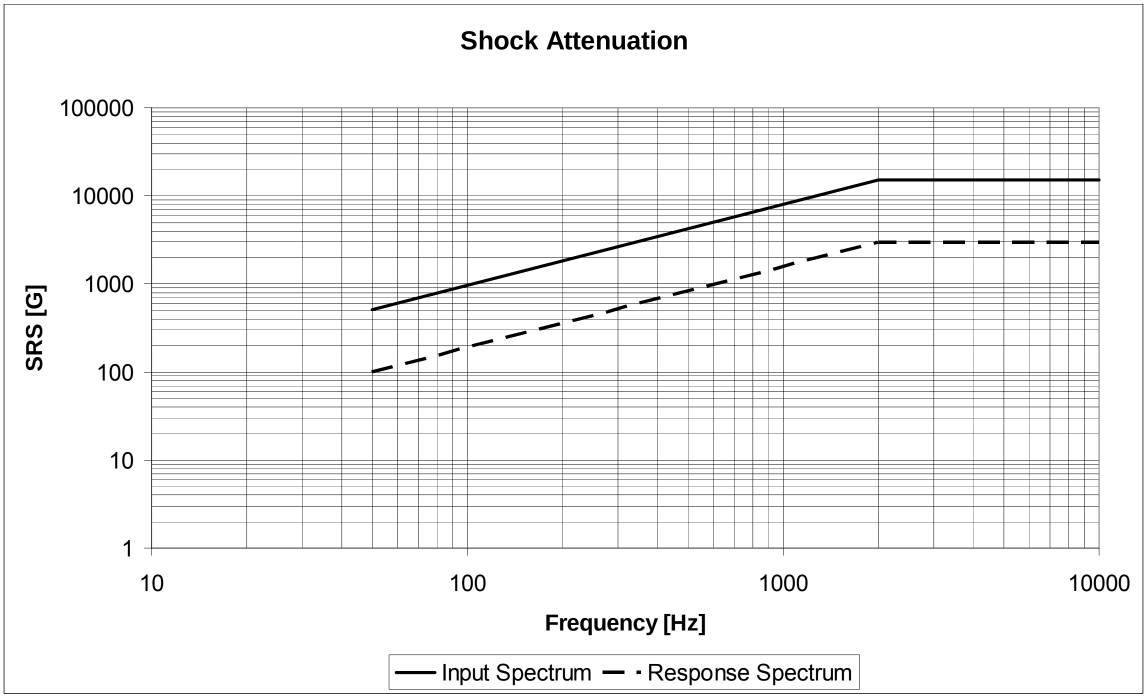


TABLE 36. SHOCK ENVIRONMENT FOR ZONE 6-1, AT BDM AND RCS LOCATIONS (BREAK POINTS)

Frequency	SRS Response
50 Hz	100 g
1,250 Hz	2,940 g
10,000 Hz	2,940 g

FIGURE 32. SHOCK ENVIRONMENT FOR ZONE 6-1, AT FRUSTUM INTERFACE

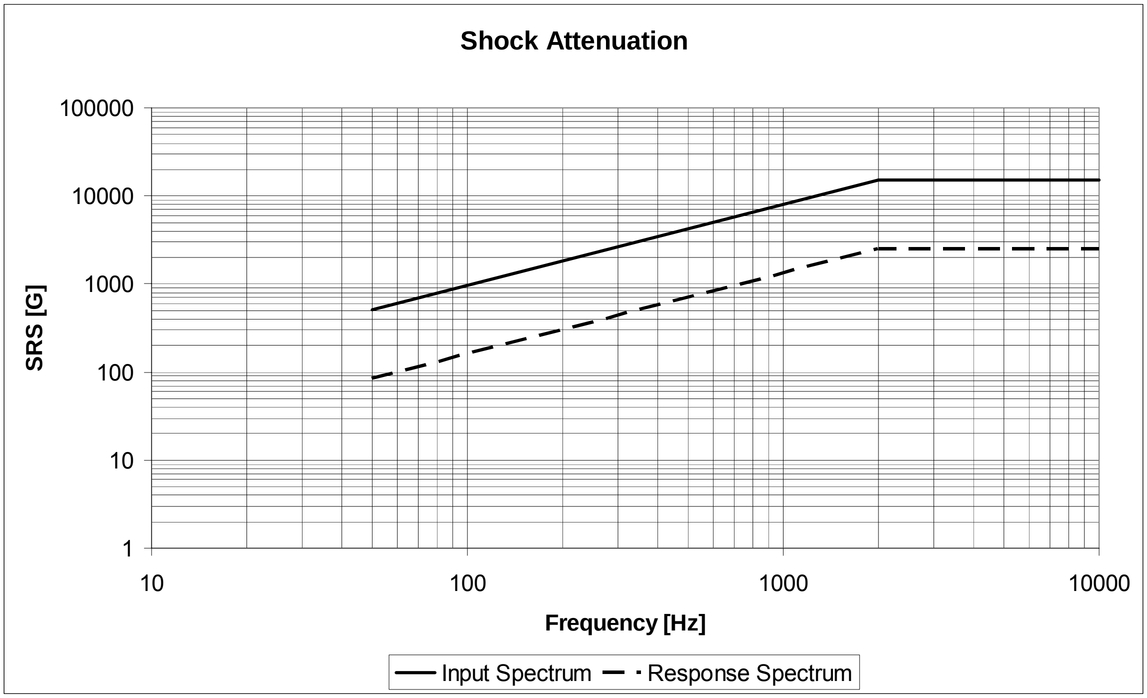


TABLE 37. SHOCK ENVIRONMENT FOR ZONE 6-1, AT FRUSTUM INTERFACE (BREAK POINTS)

Frequency	SRS Response
50 Hz	85 g
1,250 Hz	2,500 g
10,000 Hz	2,500 g

3.2.3 First Stage

3.2.3.1 Zone 5, Frustum

The shock environment is TBD, pending delivery of this data from the First Stage prime contractor (estimated delivery December 2007).

3.2.3.2 Zone 4, Forward Skirt and Extension

The shock environment is TBD, pending delivery of this data from the First Stage prime contractor (estimated delivery December 2007).

3.2.3.3 Zone 3, Upper Motor Segments

The shock environment is TBD, pending delivery of this data from the First Stage prime contractor (estimated delivery December 2007).

3.2.3.4 Zone 2, Lower Motor Segments

The shock environment is TBD, pending delivery of this data from the First Stage prime contractor (estimated delivery December 2007).

3.2.3.5 Zone 1, Aft Skirt and Nozzle Extension

The shock environment is TBD, pending delivery of this data from the First Stage prime contractor (estimated delivery December 2007).

3.3 INTERNAL ACOUSTIC ENVIRONMENTS

The internal acoustic environments for cavities inside the vehicle are calculated by applying a transmission loss to the external acoustic environment impinging on the cavity's surrounding structure. The transmission loss is a function of acoustic frequency and the surrounding structure's configuration and material.

3.3.1 CEV

3.3.1.1 Zone 12, LAS

No internal acoustic environment will be derived for this zone.

3.3.1.2 Zone 11, Crew Module

The internal acoustic environment is TBD, pending delivery of this data from the Orion project (estimated delivery December 2007).

3.3.1.3 Zone 10, Spacecraft Module

The internal acoustic environment is TBD, pending delivery of this data from the Orion project (estimated delivery December 2007).

3.3.1.4 Zone 9, Spacecraft Adapter

The internal acoustic environment is TBD, pending delivery of this data from the Orion project (estimated delivery December 2007).

3.3.2 Upper Stage

3.3.2.1 Zone 8-4, Instrument Unit

The internal acoustic environment is TBD and will be included in the December 2007 update of this databook.

3.3.2.2 Zone 8-3, LH2 Tank (Upper Third)

No internal acoustic environment will be derived for this zone.

3.3.2.3 Zone 8-2, LH2 Tank (Middle Third)

No internal acoustic environment will be derived for this zone.

3.3.2.4 Zone 8-1, LH2 Tank (Lower Third)

No internal acoustic environment will be derived for this zone.

3.3.2.5 Zone 7-2, LOX Tank

No internal acoustic environment will be derived for this zone.

3.3.2.6 Zone 7-1, LOX Tank Skirt

The internal acoustic environment is TBD and will be included in the December 2007 update of this databook.

3.3.2.7 Zone 6-2, Interstage (Upper)

An appropriate transmission loss was applied to the external acoustic environment for LOX tank aft skirt, interstage, and frustum. The resulting internal acoustic environments in each of these three zones were then enveloped. This envelope, shown in Table 38, defines the internal acoustic environment for this zone.

TABLE 38. INTERNAL ACOUSTIC ENVIRONMENT FOR ZONE 6-2, INTERSTAGE (UPPER)

Interstage Internal Acoustics (Upper)	
Frequency	Internal Acoustic Pressure Levels
[Hz]	[dB]
16	136.0
20	138.0
25	139.0
31.5	140.0
40	141.0
50	141.8
63	140.8
80	141.7
100	139.8
125	137.8
160	135.6
200	134.4
250	133.0
315	131.4
400	129.6
500	128.0
630	126.2
800	124.0
1000	123.8
1250	123.4
1600	123.0
2000	122.5
2500	121.9
3150	121.3
4000	120.5
5000	119.7
6300	119.0
8000	118.2
10000	104.6

3.3.2.8 Zone 6-1, Interstage (Lower)

An appropriate transmission loss was applied to the external acoustic environment for LOX tank aft skirt, interstage, and frustum. The resulting internal acoustic environments in each of these three zones were then enveloped. This envelope, shown in Table 39, defines the internal acoustic environment for this zone.

TABLE 39. INTERNAL ACOUSTIC ENVIRONMENT FOR ZONE 6-1, INTERSTAGE (LOWER)

Interstage Internal Acoustics (Lower)	
Frequency	Internal Acoustic Pressure Levels
[Hz]	[dB]
16	136.0
20	138.0
25	139.0
31.5	140.0
40	141.0
50	141.8
63	140.8
80	141.7
100	139.8
125	137.8
160	135.6
200	134.4
250	133.0
315	131.4
400	129.6
500	128.0
630	126.2
800	124.0
1000	123.8
1250	123.4
1600	123.0
2000	122.5
2500	121.9
3150	121.3
4000	120.5
5000	119.7
6300	119.0
8000	118.2
10000	104.6

3.3.3 First Stage

3.3.3.1 Zone 5, Frustum

The internal acoustic environment is TBD, pending delivery of this data from the First Stage prime contractor (estimated delivery December 2007).

3.3.3.2 Zone 4, Forward Skirt and Extension

The internal acoustic environment is TBD, pending delivery of this data from the First Stage prime contractor (estimated delivery December 2007).

3.3.3.3 Zone 3, Upper Motor Segments

No internal acoustic environment will be derived for this zone.

3.3.3.4 Zone 2, Lower Motor Segments

No internal acoustic environment will be derived for this zone.

3.3.3.5 Zone 1, Aft Skirt and Nozzle Extension

The internal acoustic environment is TBD, pending delivery of this data from the First Stage prime contractor (estimated delivery December 2007).

-End-

APPENDIX A
ACRONYMS AND ABBREVIATIONS

CEQATR	Constellation Environmental Qualification and Acceptance Test Requirements
CEV	Crew Exploration Vehicle
CLV	Crew Launch Vehicle
CR	Change Request
dB	Decibel
DRM	Design Reference Mission
DSNE	Design Specification for Natural Environments
gpf	Grains Per Foot
G_{RMS}	G Root-Mean-Squared
Hz	Hertz
IEDS	Integrated Environments Design Specification
LAS	Launch Abort System
LH2	Liquid Hydrogen
LOX	Liquid Oxygen
LSC	Linear Shaped Charge
MECO	Main Engine Cutoff
ML	Mobile Launcher
MPE	Maximum Predicted Environment
MPTA	Main Propulsion Test Article
OPR	Office of Primary Responsibility
PDR	Preliminary Design Review
RFTU	Ready for Technical Use
rms	Root Mean Squared
SEA	Statistical Energy Analysis
SBU	Sensitive But Unclassified
SRS	Shock Response Spectrum
TBD	To Be Determined
TBR	To Be Resolved

APPENDIX B
OPEN WORK

Table B-1 lists the specific To Be Determined (TBD) items in the document that are not yet known. The TBD is inserted as a placeholder wherever the required data is needed and is formatted in bold type within brackets. The TBD item is numbered based on the section where the first occurrence of the item is located as the first digit and a consecutive number as the second digit (i.e., **<TBD 4-1>** is the first undetermined item assigned in Section 4 of the document). As each TBD is solved, the updated text is inserted in each place that the TBD appears in the document and the item is removed from this table. As new TBD items are assigned, they will be added to this list in accordance with the above described numbering scheme. Original TBDs will not be renumbered.

TABLE B-1. TO BE DETERMINED ITEMS

TBD	Section	Description
	RANDOM VIBRATION	
3.1	3.1.1.1	ZONE 12, LAS
3.2	3.1.1.2	ZONE 11, CREW MODULE
3.3	3.1.1.3	ZONE 10, SPACECRAFT MODULE
3.4	3.1.1.4	ZONE 9, SPACECRAFT ADAPTER
3.5	3.1.3.1	ZONE 5, FRUSTUM
3.6	3.1.3.2	ZONE 4, FORWARD SKIRT AND EXTENSION
3.7	3.1.3.3	ZONE 3, UPPER MOTOR SEGMENTS
3.8	3.1.3.4	ZONE 2, LOWER MOTOR SEGMENTS
3.9	3.1.3.5	ZONE 1, AFT SKIRT AND NOZZLE EXTENSION
	SHOCK ENVIRONMENTS	
3.10	3.2.1.1	ZONE 12, LAS
3.11	3.2.1.2	ZONE 11, CREW MODULE
3.12	3.2.1.3	ZONE 10, SPACECRAFT MODULE
3.13	3.2.1.4	ZONE 9, SPACECRAFT ADAPTER
3.14	3.2.3.2	ZONE 4, FORWARD SKIRT AND EXTENSION
3.15	3.2.3.3	ZONE 3, UPPER MOTOR SEGMENTS
3.16	3.2.3.4	ZONE 2, LOWER MOTOR SEGMENTS
3.17	3.2.3.5	ZONE 1, AFT SKIRT AND NOZZLE EXTENSION
	INTERNAL ACOUSTIC ENVIRONMENTS	
3.18	3.3.1.2	ZONE 11, CREW MODULE
3.19	3.3.1.3	ZONE 10, SPACECRAFT MODULE
3.20	3.3.1.4	ZONE 9, SPACECRAFT ADAPTER
3.21	3.3.2.1	ZONE 8-4, INSTRUMENT UNIT
3.22	3.3.2.6	ZONE 7-1, LOX TANK SKIRT
3.23	3.3.3.1	ZONE 5, FRUSTUM
3.24	3.3.3.2	ZONE 4, FORWARD SKIRT AND EXTENSION
3.25	3.3.3.5	ZONE 1, AFT SKIRT AND NOZZLE EXTENSION

Table B-2 lists the specific To Be Resolved (TBR) issues in the document that are not yet known. The TBR is inserted as a placeholder wherever the required data is needed and is formatted in bold type within brackets. The TBR issue is numbered based on the section where the first occurrence of the issue is located as the first digit and a consecutive number as the second digit (i.e., **<TBR 4-1>** is the first unresolved issue assigned in Section 4 of the document). As each TBR is resolved, the updated text is inserted in each place that the TBR appears in the document and the issue is removed from this table. As new TBR issues are assigned, they will be added to this list in accordance with the above described numbering scheme. Original TBRs will not be renumbered.

TABLE B-2 TO BE RESOLVED ISSUES

TBR	Section	Description
None 6/29/07		