CHAPTER 6

ENVIRONMENTAL CONDITIONS

6.1 Summary

This chapter introduces the natural environment of launch site, thermal environment during Payload operation, thermal environments, mechanical environments (vibration, shock & noise) and electromagnetic environment during launch preparation and LV flight.

6.2 Pre-launch Environments

6.2.1 Natural Environment

The natural environmental data in JSLC and XSLC such as temperature, ground wind, humidity and winds aloft are concluded by long-term statistic research as listed below.

A. Jiuquan Satellite Launch Center (JSLC)

(1) Temperature statistic result for each month at launch site.

Month	Highest (°C)	Lowest (°C)	Mean (°C)
January	14.20	-32.40	-11.20
February	17.70	-33.10	-6.20
March	24.10	-21.90	1.90
April	31.60	-13.60	11.10
May	38.10	-5.60	19.10
June	40.90	5.00	24.60
July	***42.80***	9.70	26.50
August	*40.60*	7.70	24.60
September	36.40	-4.60	17.60
October	30.10	-14.50	8.30
November	22.10	-27.50	-1.70
December	16.00	***-34.00***	-9.60

(2) The relative humidity at launch site is 35~55%. The dry season is all over the year, the average annual rainfall is 44mm.

(3) The winds aloft used for LV design is an integrated vector profile, see **Figure 6-1**.

(TO BE ISSUED)

Figure 6-1 Wind Aloft Statistics Results in Jiuquan Area (TO BE ISSUED)

B. Xichang Satellite Launch Center
(1) Temperature statistic result for each month at launch site.

Month	Highest (°C)	Lowest (°C)	Mean (°C)
January	7.9	***4.5***	5.9
February	10.4	5.0	8.0
March	14.5	9.7	11.7
April	17.5	13.1	15.0
May	20.2	15.6	17.7
June	21.1	17.7	19.1
July	***21.3***	19.3	20.0
August	***21.3***	18.5	19.8
September	19.3	16.2	17.2
October	16.4	13.2	14.1
November	12.3	8.4	10.0
December	8.9	4.6	6.5

(2) The relative humidity at launch site:

Maximum: 100% at rain season;

Minimum: 6% at dry season.

(3) The winds aloft used for LV design is an integrated vector profile, see **Figure 6-2**, where the altitude is relative to the sea level. The local height above the sea level is 1800 m.

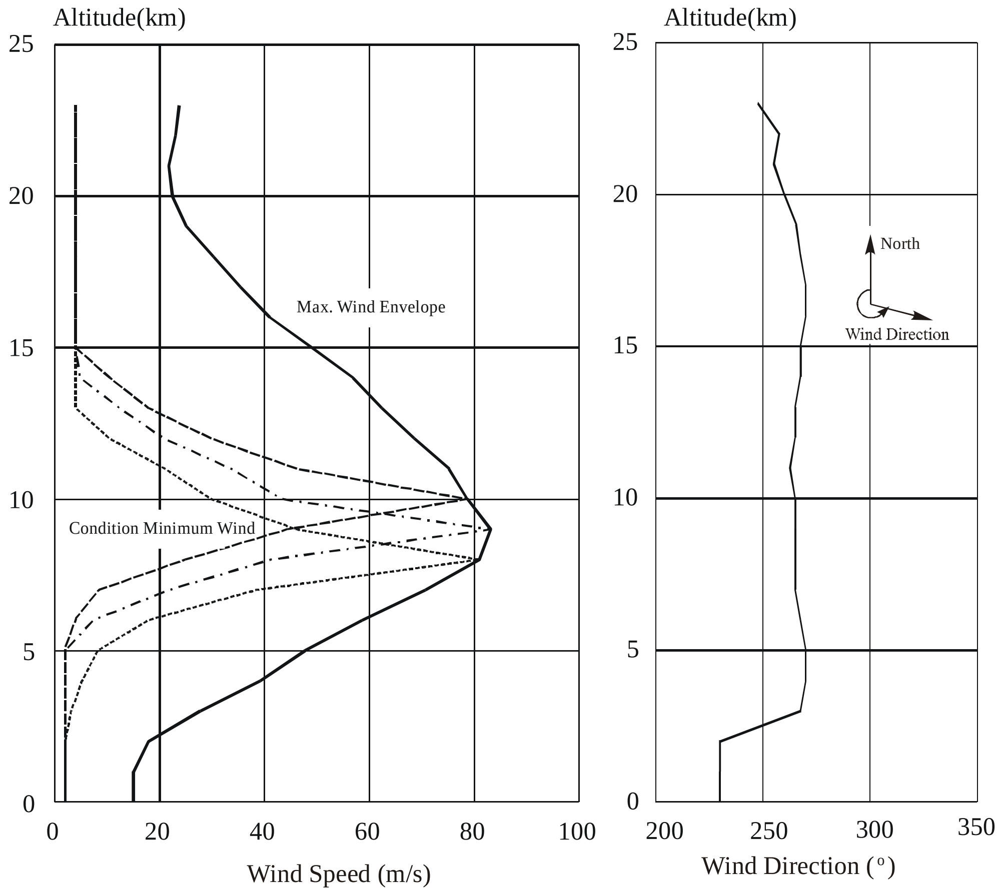


Figure 6-2 Wind Aloft Statistics Results in Xichang Area

6.2.2 Payload Processing Environment

A. Payload Processing Environment in JSLC

In JSLC, the environment impacting Payload includes 6 phases: (1) Processing in BS2; (2) transportation from BS2 to BS3; (3) Processing in BS3; (4) Transportation from BS3 to BLS; (5) Processing in BLS; (6) Transportation from BLS to the Umbilical Tower.

B. Payload Processing Environment in XSLC

In XSLC, Payload will be checked, tested in Payload Processing Buildings (BS2 and BS3) and then transported to the launch pad for launch. The environment impacting Payload includes 3 phases: (1) Processing in BS2 and BS3; (2) Transportation from BS3 to launch pad; (3) preparation on launch tower.

Refer to **Chapter 7**.

6.2.2.1 Environment of Payload in BS2

The environmental parameters in BS2 and BS3, either at JSLC or XSLC, are as follows:

Temperature:	15°C~25°C
Relative humidity:	33%~55%
Cleanliness:	100,000 level

6.2.2.2 Environment of Payload during Transportation to Umbilical Tower

A. In JSLC
The environment for Payload during transportation can be assured by temperature-control measures and/or selecting transportation time (e.g. in morning).

B. In XSLC
Before transportation to launch pad, the Payload will be put into the fairing in BS3 and then loaded onto the transfer vehicle.

The transfer vehicle at XSLC equipped with Air-conditioning system which can keep the environment as that in BS3. It will take 30 minutes from BS3 to launch pad and 40 minutes to mate to the second stage of Launch Vehicle. The Air Conditioning system will be cut off during the mating. Refer to **Chapter 7** and **Chapter 8**.

6.2.2.3 Air-conditioning inside Fairing at Launch Pad

The fairing air-conditioning system is shown in **Figure 6-3**. The air-conditioning parameters inside the fairing are as follows:

Temperature:	15°C~25°C
Relative Humidity:	33%~55%
Cleanliness:	100,000 level
Air Speed inside Fairing:	≤2m/s
Noise inside Fairing:	≤90dB
Max. Air Flow Rate:	3000~4000m^3/hour

The air-conditioning is shut off at L-45 minutes and would be recovered in 40 minutes if the launch aborted.

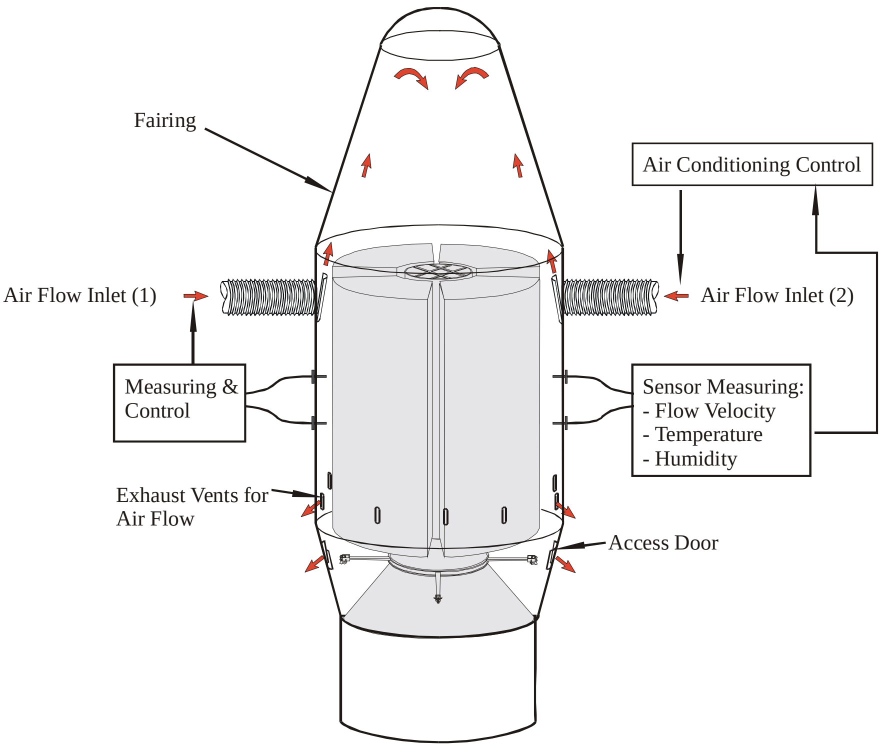


Figure 6-3 Fairing Air-conditioning on the Launch Tower

6.2.3 Electromagnetic Environment

6.2.3.1 Radio Equipment onboard LM-2E and Ground Test Equipment

Characteristics of on-board radio equipment and ground test equipment are shown below:

	EQUIPMENT	FREQUENCY (MHz)	POWER (W)	susceptibility	Polarization	Antenna position
LAUNCH VEHICLE	Telemetry Transmitter 1	2200~2300	10		linear	Stage-1 Inter-tank section
	Telemetry Transmitter 2	2200~2300	10		linear	Stage-2 Inter-tank section
	Transponder 1	Rec.5860~5910 Tra.4210~4250	2	≤-120dBW (14.77dBuv/m)	linear	Stage -2 Inter-tank section
	Transponder 2	Rec.5580~5620 Tra.5580~5620	300(max) 0.8~1.0μs 800Hz P_{av}<300 mW	≤-90dBW (44.77dBuv/m)	linear	Stage -2 Inter-tank section
	Beacon	2730~2770	2		linear	VEB
	Telemetry command Receiver	550~750		≤-128dBW (4.77dBuv/m)	linear	Stage-2 Inter-tank section
GROUND	Tester for Transponder 1	5840~5890	0.5			Tracking & safety system ground test room at launch center
	Tester for Transponder 2	5870~5910	0.5			
	Tester for Transponder 3	5570~5620	100W(peak)			
	Telemetry Command Transmitter	550~750	1W			

6.2.3.2 RF Equipment and Radiation Strength at XSLC and JSLC

	XSLC	**JSLC**
Working frequency	5577~5617 MHz	TBD
Antenna diameter	4.2m	TBD
Impulse power	<1500 kW	TBD
Impulse width	0.0008ms	TBD
Min. pulse duration	1.25ms	TBD
Mean power	<1.2kW	TBD

6.2.3.3 LV Electromagnetic Radiation and Susceptibility

The energy levels of launch vehicle electromagnetic radiation and susceptibility are measured at 1m above VEB. They are shown in **Figure 6-4** to **Figure 6-6**.

6.2.3.4 EMC Analysis among Payload, LV and Launch Site

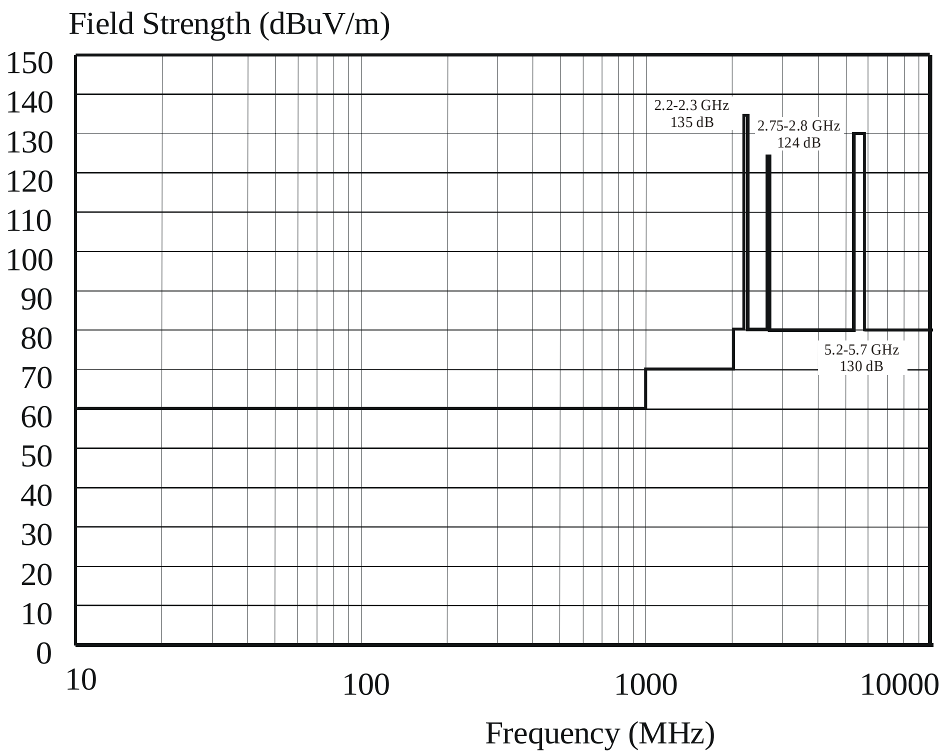
To conduct the EMC analysis among Payload, LV and launch site, both Payload and LV sides should provide related information to each other. The information provided by CALT are indicated in the figures in this chapter**,** while the information provided by SC side are as follows:

a. Payload RF system configuration, characteristics, working period, antenna position and direction, etc.
b. Values and curves of the narrow-band electric field of intentional and parasitic radiation generated by Payload RF system at Payload/LV separation plane and values and curves of the electromagnetic susceptibility accepted by Payload.

CALT will perform the preliminary EMC analysis based on the information provided by SC side, and both sides will determine whether it is necessary to request further information according to the analysis result.

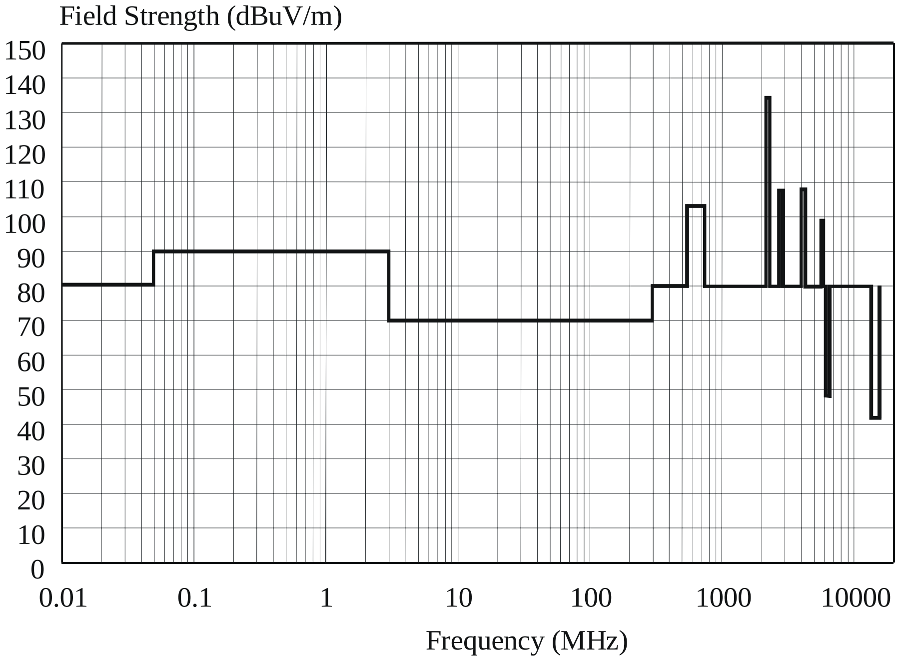
6.2.4 Contamination Control

The molecule deposition on Payload surface is less than $2mg/m^2$/week. The total mass loss is less than 1%. The volatile of condensable material is less than 0.1%.



Frequency (MHz)	Field Strength (dBμV/m)
2255.5 - 2265.5	134
2273.5 - 2283.5	130
2750 - 2760	126
5308 - 5333	120
5388 - 5408	120
5566 - 5626	134
5725 - 5750	100
5805 - 5825	100

Figure 6-4a Intentional Radiation from LM-2E and Launch Site (In JSLC)



Frequency (MHz)	Field Strength (dBμV/m)
0.01-0.05	80
0.05-3	90
3-300	70
300-550	80
550-750	103
750-2200	80
2200-2300	134
2300-2730	80
2730-2770	107
2770-4200	80
4200-4250	107
4250-5580	80
5580-5620	99
5620-6000	80
6000-6500	48
6500-13500	80
13500-15000	42
15000-	80

Figure 6-4b Intentional Radiation from LM-2E and Launch Site (In XSLC)

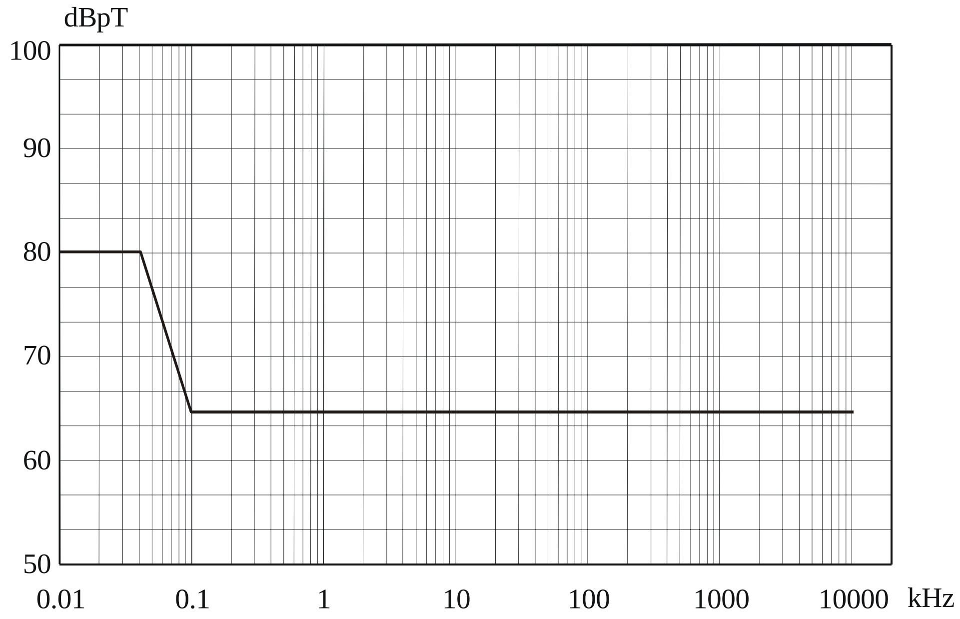
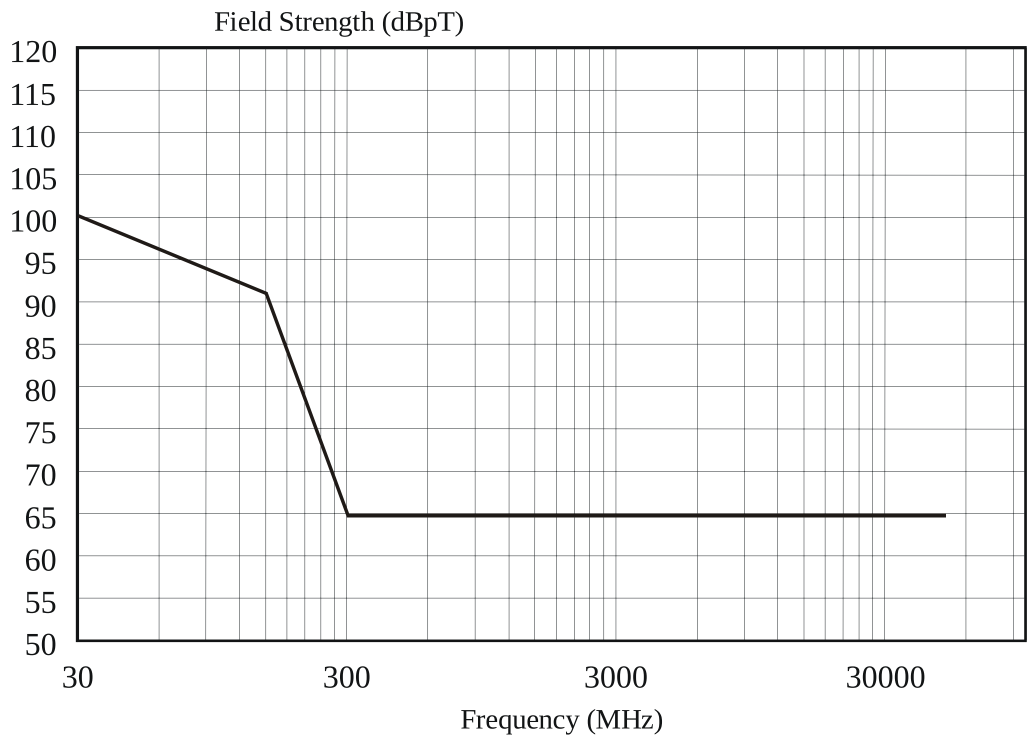


Figure 6-5a Magnetic Field Radiation from LV and Launch Site (In JSLC)



Frequency (MHz)	Field Strength (dBpT)
30-150	100-91 (linear)
150-300	91-65 (linear)
300-50000	65

Figure 6-5b Magnetic Field Radiation from LV and Launch Site (In XSLC)

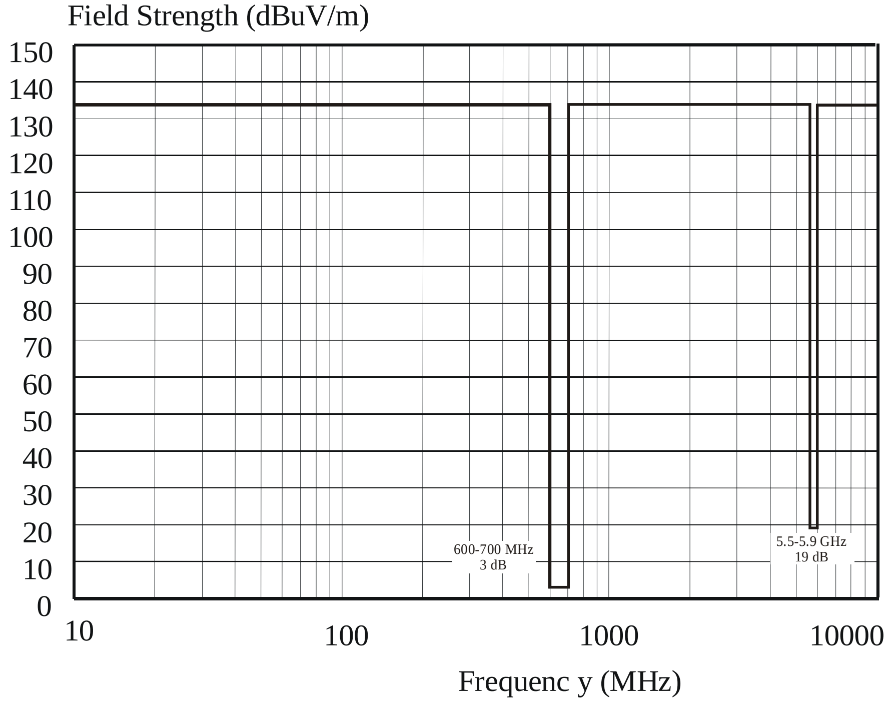
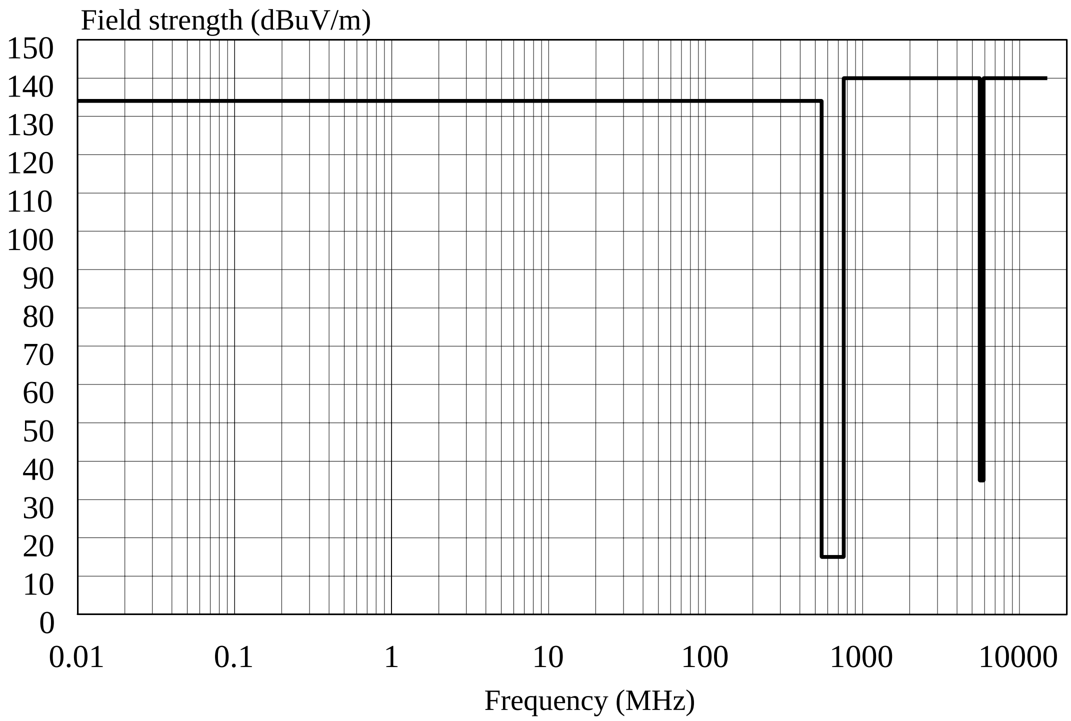


Figure 6-6a LV Electromagnetic Radiation Susceptibility (In JSLC)



Frequency (MHz)	Field Strength (dBμV/m)
0.01-550	134
550-760	15
5580-5910	35

Figure 6-6b LV Electromagnetic Radiation Susceptibility (In XSLC)

6.3 Flight Environment

The mechanical environment for payload is at Payload/LV interface. The pressure environment and thermal environment is just for typical fairing.

6.3.1 Pressure Environment

When the launch vehicle flies in the atmosphere, the fairing air-depressurization is provided by 12 vents (total venting area 230cm^2) opened on the lower cylindrical section. The typical design range of fairing internal pressure is presented in **Figure 6-7a** and **Figure 6-7b**. The maximum depressurization rate inside fairing will not exceed 6.9 kPa/sec.

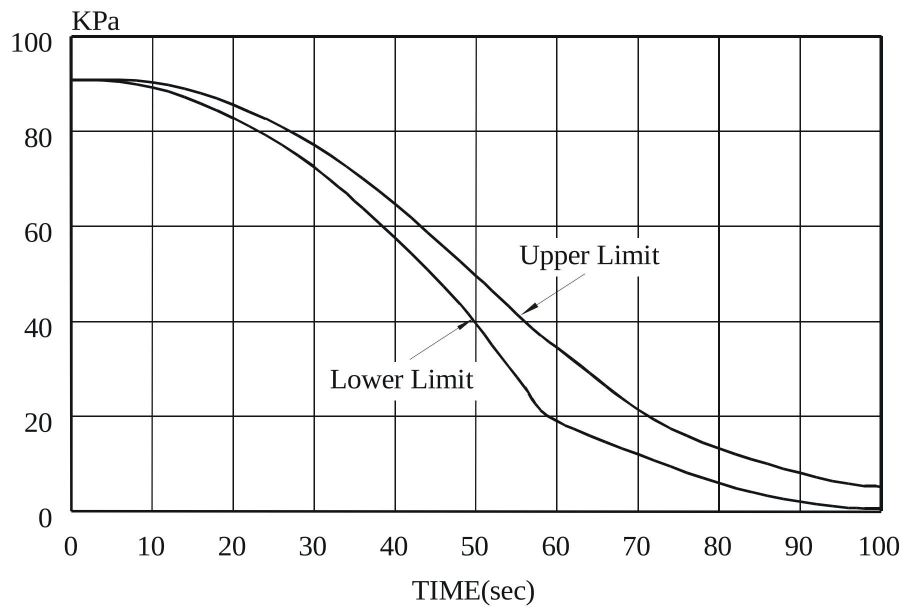


Figure 6-7a Fairing Internal Pressure vs. Flight Time (from JSLC)

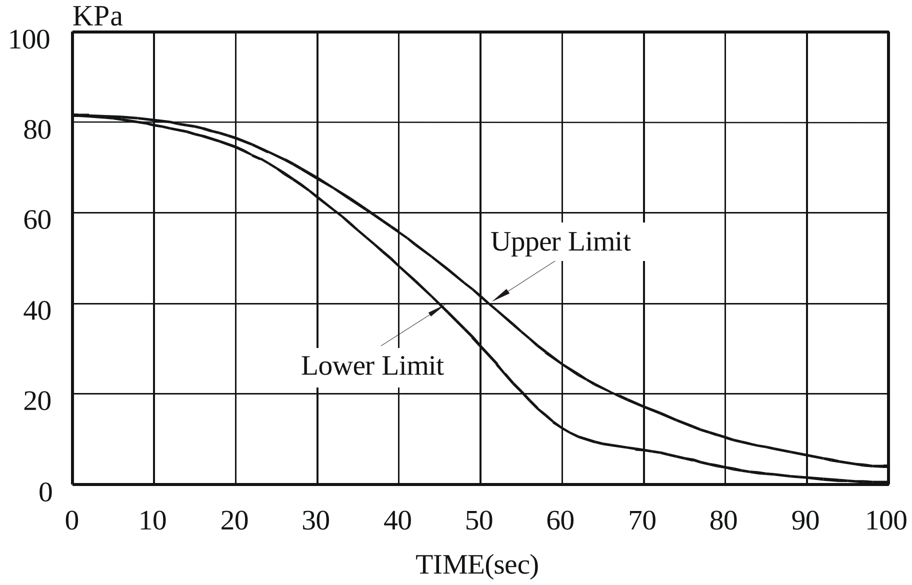


Figure 6-7b Fairing Internal Pressure vs. Flight Time (from XSLC)

6.3.2 Thermal environment

The radiation heat flux density and radiant rate from the inner surface of the fairing is shown in **Figure 6-8**.

The free molecular heating flux at fairing jettisoning shall be lower than 1135W/m^2 (See **Figure 6-9**). After fairing jettisoning, the thermal effects caused by the sun radiation, Earth infrared radiation and albedo will also be considered. The specific affects will be determined through the Payload/LV thermal coupling analysis by CALT.

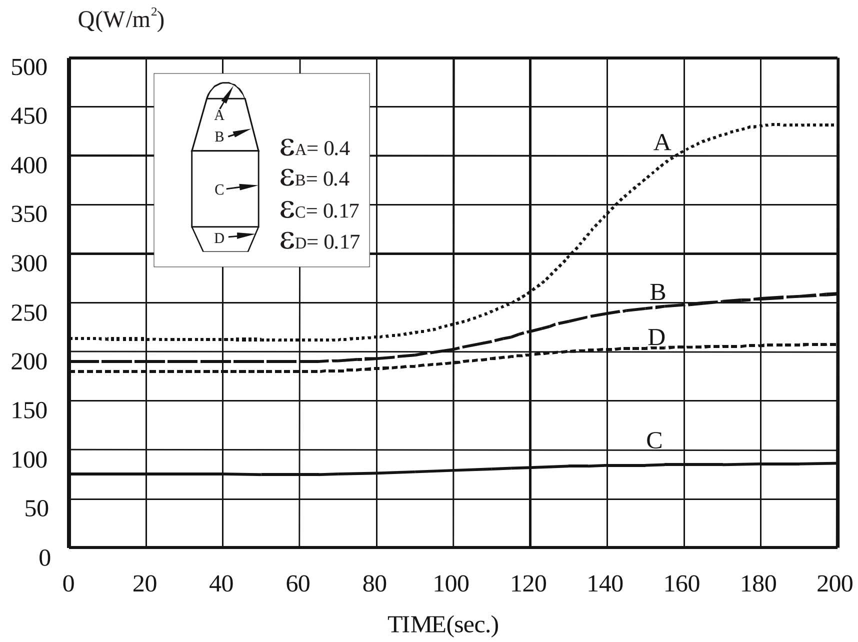


Figure 6-8 Radiation Heat Flux Density and Radiant Rate on the Inner Surface of Each Section of the Fairing

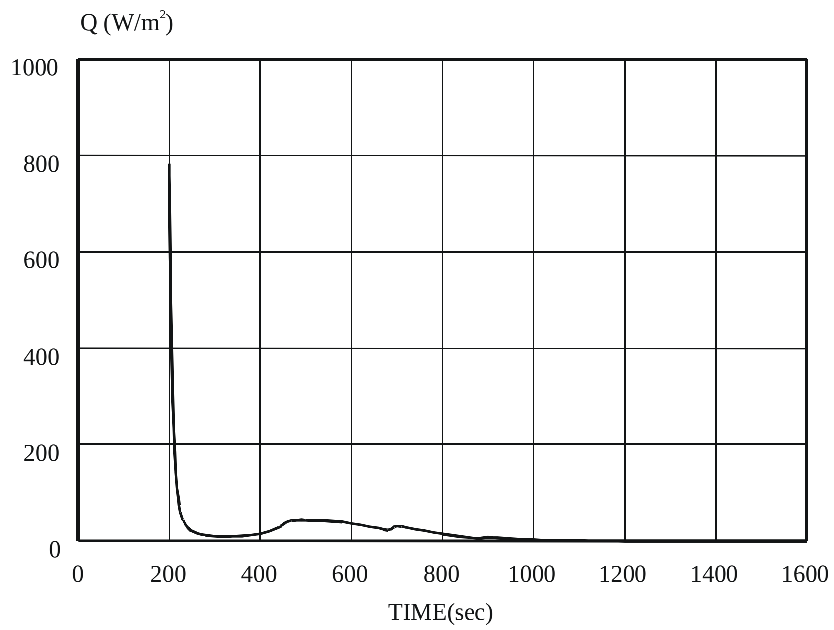


Figure 6-9 Typical Free Molecular Heating Flux

6.3.3 Static Acceleration

The maximum longitudinal acceleration during LV flight will not exceed 5.6g. The maximum lateral acceleration will not exceed 0.4g.

6.3.4 Vibration Environment

A. Sinusoidal Vibration

The sinusoidal vibration mainly occurs in the processes of engine ignition and shut-off, transonic flight and stage separations. The sinusoidal vibration (zero-peak value) at Payload/LV interface is shown below.

Direction	Frequency Range (Hz)	Amplitude or Acceleration
Longitudinal	5 - 10 10 - 100	2.5 mm 1.0g
Lateral	2-5 5 - 10 10 - 100	0.2g 2.0 mm 0.8 g

B. Random Vibration

The Payload random vibration is mainly generated by noise and reaches the maximum at the lift-off and transonic flight periods.

The random vibration Power Spectral Density and the total Root-Mean-Square (RMS) value at Payload/LV separation plane in three directions are given in the table below.

Frequency Range (Hz)	Power Spectral Density	Total RMS Value
20 - 150	+3dB/octave.	7.63 g
150 - 800	$0.04\ g^2/Hz$	
800 - 2000	-3 dB/octave.	

6.3.5 Acoustic Noise

The flight noise mainly includes the engine noise and aerodynamic noise. The maximum acoustic noise Payload suffers occurs at the moment of lift-off and during the transonic flight phase. The values in the table below are the maximum noise levels in fairing.

Central Frequency of Octave Bandwidth (Hz)	Acoustic Pressure Level (dB)
31.5	122
63	128
125	134
250	139
500	135
1000	130
2000	125
4000	120
8000	116
Total Acoustic Pressure Level	142

0 dB referenced to 2×10^{-5} Pa.

6.3.6 Shock Environment

The maximum shock Payload suffers occurs at the Payload/LV separation. The shock response spectrum at Payload/LV separation plane is shown bellow.

Frequency Range (Hz)	Response Acceleration (Q=10)
100-1500	+9.0 dB/octave.
1500-4000	4000 g

6.4 Load Conditions for Payload Design

6.4.1 Frequency Requirement

To avoid the Payload resonance with LM-2E launch vehicle, the primary frequency of Payload structure should meet the following requirement (under the condition that the Payload is rigidly mounted on the LV separation plane.):

The frequency of the lateral main mode>8Hz

The frequency of the longitudinal main mode >25Hz

6.4.2 Loads Applied for Payload Structure Design

The maximum lateral load occurs at the transonic phase or Maximum Dynamic Pressure phase. The maximum axial static load occurs prior to the boosters' separation. The maximum axial dynamic load occurs after the first and second stage separation. Therefore, the following limit loads corresponding to different conditions in flight are recommended for Payload design consideration.

Flight Condition		Max. lateral load status	Max. Axial static load	Max. Axial dynamic load
Longitudinal Acceleration(g)	Static	+2.0	+5.6	+0.8
	Dynamic	±0.6	±0.6	±2.0
	Combined	+2.6/+1.4	+6.2/+5.0	+2.8/-1.2
Lateral Acceleration(g)	Combined	2.2	1.0	2.0

Notes:

❶ The loads are acting on the C.G of Payload.

❷ The direction of the longitudinal loads is the same as the LV longitudinal axis.

❸ The lateral load means the load acting in any direction perpendicular to the longitudinal axis.

❹ Lateral and longitudinal loads occur simultaneously.

❺ Usage of the above table:

Payload design loads = **Limit loads** × **Safety factor***

***** The safety factor is determined by the Payload designer.(What CALT suggests ≥1.25)

6.4.3 Coupled Load Analysis

The Payload manufacturer should provide the Payload mathematical model to CALT for Coupled Loads Analysis (CLA). CALT will predict the Payload maximum dynamic response by coupled load analysis. The Payload manufacturer should confirm that the Payload could survive from the predicted environment and has adequate safety margin. (CALT requires that the safety factor is equal to or greater than 1.25.)

6.5 Payload Qualification and Acceptance Test Specifications

6.5.1 Static Test (Qualification)

The main Payload structure must pass static qualification tests without damage. The test level must be not lower than Payload design load required in Paragraph 6.4.2.

6.5.2 Vibration Test

A. Sine Vibration Test

During tests, the Payload must be rigidly mounted on the shaker. The table below specifies the vibration acceleration level (zero - peak) of Payload qualification and acceptance tests at Payload/LV interface. (See **Figure 6-10** and **Figure 6-11**).

	Frequency (Hz)	Test Load	
		Acceptance	Qualification
Longitudinal	5-10 8-100	2.5 mm 1.0 g	3.125 mm 1.25 g
Lateral	2-5 5-10 10-100	0.2 g 2.0mm 0.8 g	0.25g 2.5mm 1.0 g
Scan rate (Oct/min)		4	2

Notes:

- Frequency tolerance is allowed to be ±2%
- Amplitude tolerance is allowed to be ±10%
- Acceleration notching is permitted after consultation with CALT and concurred by all parties. Anyway, the notched acceleration should not be lower than the coupled load analysis results on the interface plane.

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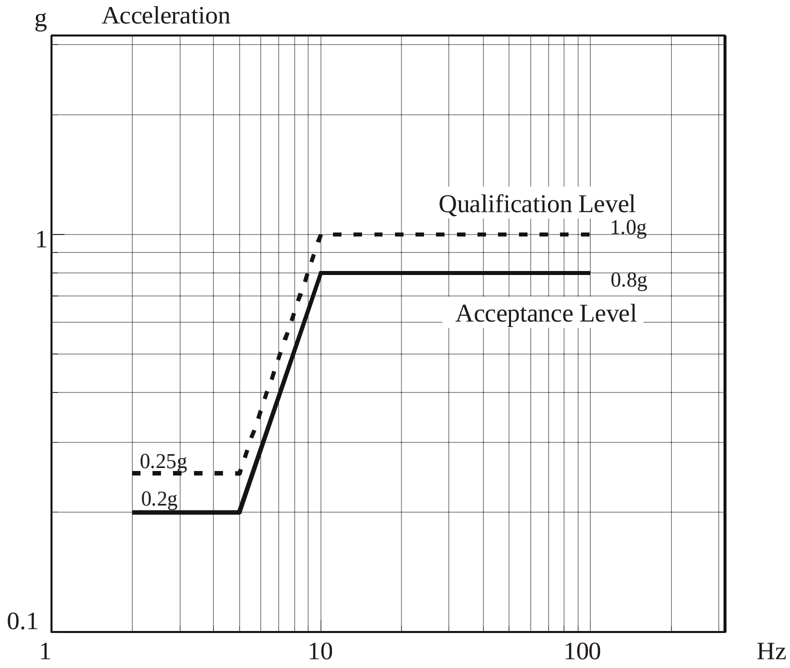


Figure 6-10 Sinusoidal Vibration Test in lateral direction

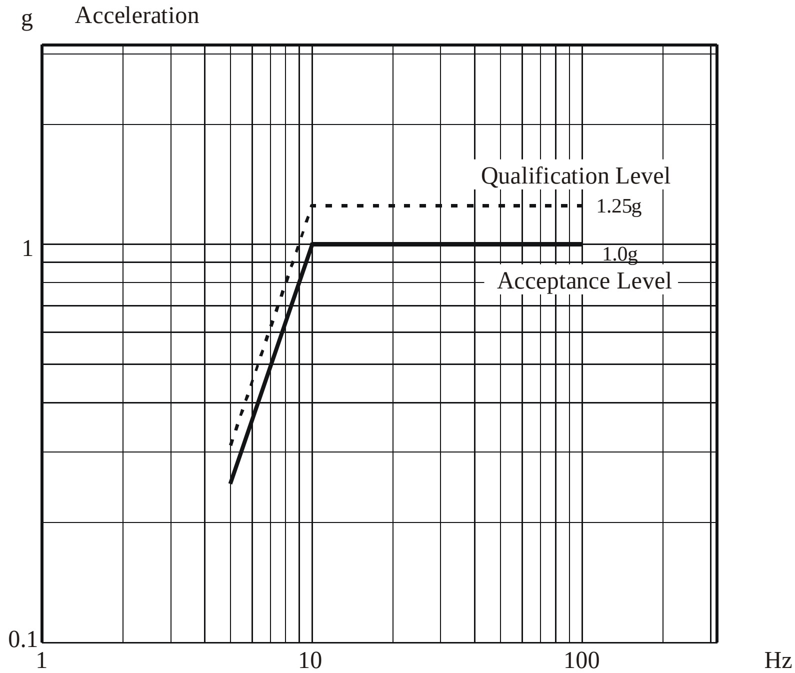


Figure 6-11 Sinusoidal Vibration Test in axial direction

B. Random Vibration Test

During tests, the Payload structure must be rigidly mounted onto the shaker. The table below specifies the Payload qualification and acceptance test levels at Payload/LV interface. (See **Figure 6-12**).

Frequency (Hz)	Acceptance		Qualification	
	Spectrum Density	Total rms (Grms)	Spectrum Density	Total rms (Grms)
20 - 150	+3 dB/octave.	7.63g	+3 dB/octave.	10.79g
150 - 800	0.04 g^2/Hz		0.08 g^2/Hz	
800 - 2000	-3 dB/octave.		-3 dB/octave	
Duration	1min.		2min.	

Notes:

- Tolerances of ±3.0 dB for power spectral density and ±1.5 dB for total rms values are allowed.
- The random test can be replaced by acoustic test.

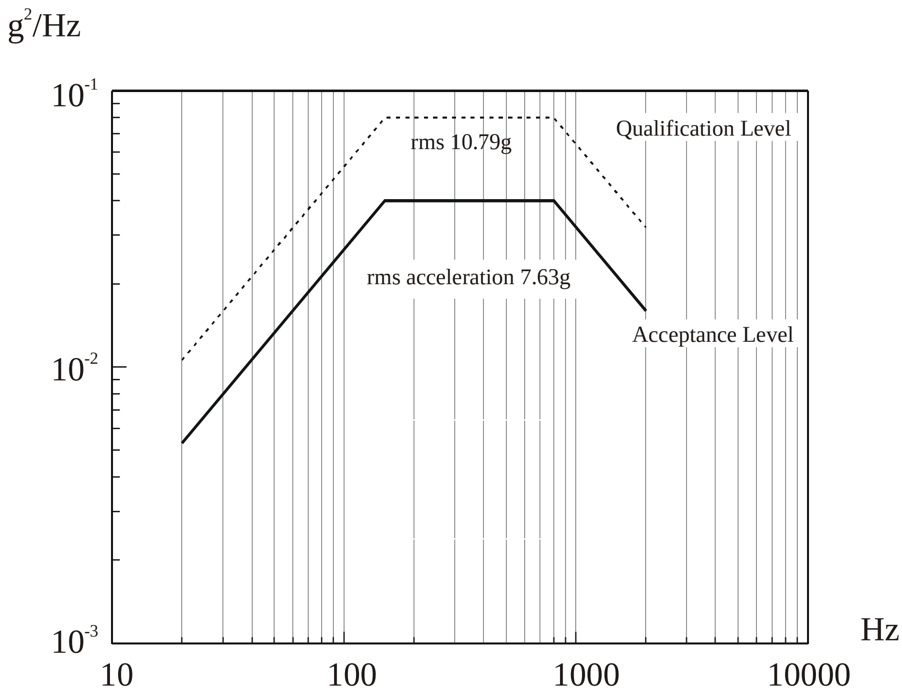


Figure 6-12 Random Vibration Test

6.5.3 Acoustic Test

The acceptance and qualification test levels are given in the following table (also see **Figure 6-13**).

Central Octave Frequency (Hz)	Acceptance Sound Pressure Level (dB)	Qualification Sound Pressure Level (dB)	Tolerance (dB)
31.5	122	126	-2/+4
63	128	132	-1/+3
125	134	138	
250	139	143	
500	135	139	
1000	130	134	
2000	125	129	
4000	120	124	-4/+4
8000	116	120	-4/+4
Total Sound Pressure Level	142	146	-1/+3

0 dB is equal to 2×10^{-5} Pa.

Test Duration:

- Acceptance test: 1.0 minute
- Qualification test: 2.0 minutes

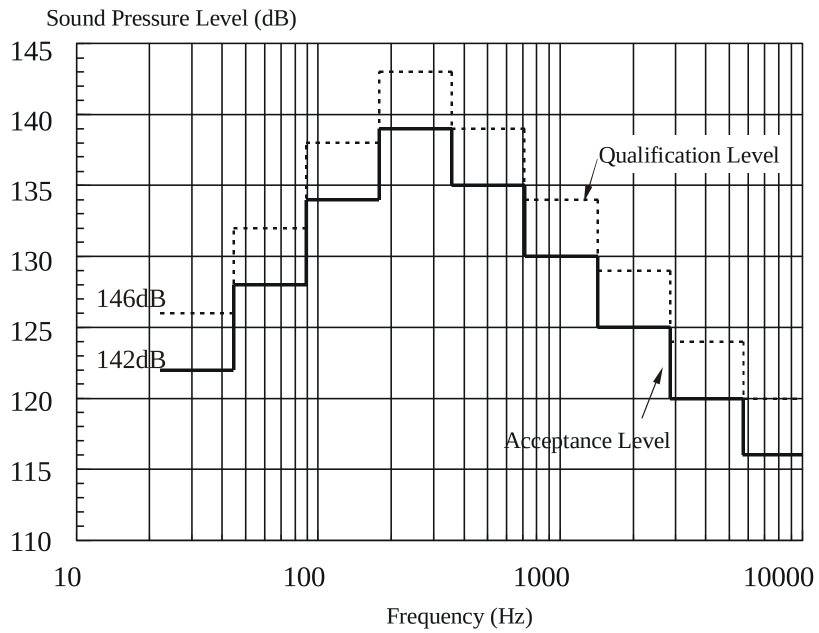
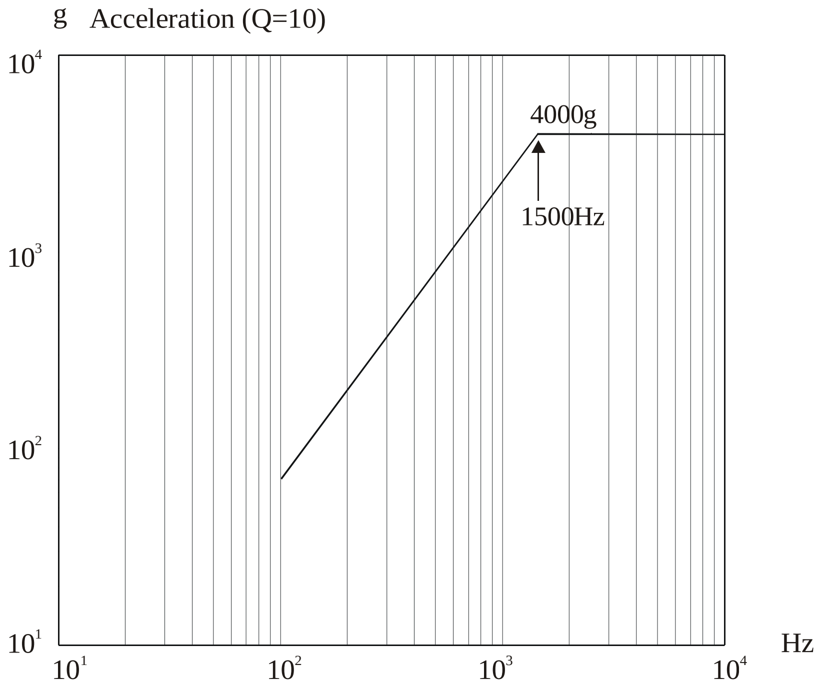


Figure 6-13 Payload Acoustic Test

6.5.4 Shock Test

The shock test level is specified in **Paragraph 6.3.6**. Such test shall be performed once for acceptance, and twice for qualification. A ±6.0 dB tolerance in test specification is allowed. However, the test strength must be applied so that in the shock response spectral analysis over 1/6 octave on the test results, 30% of the response acceleration values at central frequencies shall be greater than or equal to the values of test level. (See **Figure 6-14**)

The shock test can also be performed through Payload/LV separation test by using of flight Payload, payload adapter, and separation system. Such test shall be performed once for acceptance, and twice for qualification.



Frequency Range (Hz)	Shock Response Spectrum (Q=10)
100~1500	9.0dB/octave
1500~4000	4000g

Figure 6-14 Shock Response Spectrum at Payload/LV Separation Plane

6.5.5 Proto-flight Test

The Proto-flight test is suitable for the Payload that is launched by LM-2E for the first time even though it has been launched by other launch vehicles.

The test level for the Proto-flight should be determined by satellite manufacturer and CALT and should be higher than the acceptance level but lower than the qualification level. If the same satellite has been tested in the conditions that are not lower than the qualification test level described in **Paragraph 6.5.2** to **Paragraph 6.5.4**, CALT will suggest the following test conditions:

a. Vibration and acoustic test should be performed according to the qualification level and acceptance test duration or scan rate specified in **Paragraph 6.5.2-6.5.3**.
b. Shock test should be performed once according to the level in **Paragraph 6.5.4**.

6.6 Environment Parameters Measurement

The flight environment is measured during each flight. The measured parameters include temperature and pressure, noises inside the fairing and the vibration parameters at Payload/LV interface.