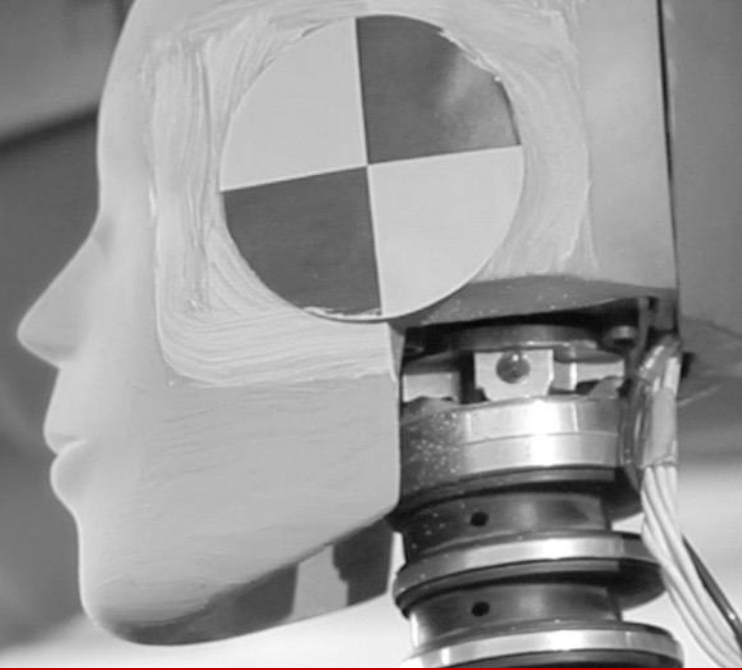


# Shock/Vibration/ Thermal Cycling



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# Objective/Purpose

The purpose of the testing is to stress a rechargeable energy storage system (REESS) from both an electrical and mechanical standpoint to verify that there are no safety issues that arise from mechanical shock, vibration and temperature excursions in real world applications.

# Risk areas and Safety needs

During a normal operation of a vehicle, vehicle's components are subjected to extreme environments such as vibration, shock and temperature. The REESS is susceptible to such environments which could develop internal mechanical failures resulting in a safety event such as thermal runaway. This requirement evaluates the performance of the REESS by subjecting it to a series of shock tests and vibration under extreme temperature cycling.

# Performance criteria

- The REESS is subjected to the following sequential tests:
  - Step 1 Sine Sweep
  - Step 2 Mechanical Shock Test
  - Step 3 Sine Sweep (repeated)
  - Step 4 Random Vibration Test/Thermal Cycling
  - Step 5 Sine Sweep (repeated)
- After Mechanical shock and random vibration/thermal cycling the RESS is evaluated

# Sine Sweep

- The purpose of this test is to find any resonances in the DUT which could lead to potential mechanical failure under normal operating vibration conditions.
- A resonance point is any excitation of the DUT over two times the input excitation from the Vibration stand.

## Sine Sweep Profile

Tolerance bands:  $\pm 6$ dB

Amplitude:	1 G
Frequency Range:	10-1000 Hz.
Sweep Rate:	1 Octave/min

# Mechanical Shock Test

- The purpose of this test is to subject the DUT to shock levels to ensure proper isolation measures between the energy cells, DUT enclosure, and any other devices placed within DUT.
- The Mechanical Shock profile is to be run in three orthogonal axes, referred to as X, Y, Z.

## Mechanical shock profile

Tolerance of +/- 5G (20% of peak acceleration) within the 15ms nominal pulse duration.

Acceleration	Du ration	Pulse Type	Number of P ulses
G	mS		
25	15	Half Sine	3/axis both positive and negative directions for a total of 18

# Random Vibration Test & Thermal Cycling

- The purpose of this test is to subject the DUT to a level of vibration to ensure that the DUT can be considered safe for use in a typical light vehicle transportation scenario. Temperature profile is to be run in conjunction with the Random Vibration test.
- The Random Vibration profile is to be run in three orthogonal axes, referred to as X, Y, Z.

Random Vibration Profile

X axis		Y axis		Z axis	
Hz.	g <sup>2</sup> /Hz.	Hz.	g <sup>2</sup> /Hz.	Hz.	g <sup>2</sup> /Hz.
10	0.065	10	0.065	10	0.07
15	0.065	15	0.065	20	0.08
25	0.029	25	0.029	35	0.037
80	0.012	80	0.012	45	0.037
130	0.006	130	0.006	80	0.02
200	0.006	200	0.006	170	0.005
250	0.001	250	0.001	200	0.005
1000	0.00003	1000	0.00003	250	0.0007
				1000	0.0001

G rms: 1.7                      G rms: 1.7                      Grms: 2.0

Temperature Profile

Segment Length	Elapsed Time	Temperature (°C)	Humidity (%RH)
0	0	25	NA
1 Hour	1 hour	-40	NA
ST+1 Hour	2+ hours	-40	NA
1 Hour	3+ hours	85	4 5
ST+1 Hour	4+ hours	85	4 5
1 Hour	5+ hours	50	8 5
ST+1 Hour	6+ hours	50	8 5
1 Hour	7+ hours	25	NA

# Pass/fail criteria

1. Isolation Resistance: 0.5 Mohm or greater
2. Temperature: Any rise in temperature greater than 10°C
3. Voltage Drift (change in the state of charge): Any change in the state of charge greater than 5% over the course of the test. This can be up to complete loss of potential.
4. Structural Damage: Any abnormal deformations, cracks, or any other signs of physical damage to the DUT which can be found through visual examination methods. Any shifts mechanical resonances found between pre and post test may indicate structural damage and thus any difference greater than 10% in frequency or amplitude level of found resonance points from sine sweep test performed pre and post random vibration and mechanical shock tests shall require internal inspection of the device under test.
5. Functional Charge/Discharge Sequence: A change in capacity/discharge duration or charging duration, greater than 10% when compared to pre-test values shall signify that test criteria is not met.



# Test Procedures

- Detailed test procedures are included in EVS-06-37.