Vibro-Engineering with Air-Borne Defence Stores

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Extended Abstract

Aircrafts, Helicopters and Unmanned Aerial Vehicles (UAV) are airborne platforms, which carry defence stores for offensive as well defensive applications. As these airborne platforms vibrate in course of take-off, maneuver, acrobats, climbing, turning, pitching, yawing, rolling and landing, the carried defence stores like missiles, bombs, guns, flares and chaffs are subjected to severe vibrations levels in course of carriage sorties, before actual deployment or dispensation. During design, development and testing of these airborne defence stores, qualification in respect of vibration is kept as basic requirements. The ill-effects of vibration like leakage, loosening, fatigue, cracking, rupture, electrical malfunctioning, etc are monitored on ground, before these stores are given air-worthiness certificates. The qualification of these stores for vibration levels in sinusoidal as well as random mode are carried out as per standards and the same is elaborated in this paper.

As Airborne-platforms vibrates, the carried stores are naturally subjected to those vibration levels. The airborne platforms have mainly three source of vibration – Buffet, noise and flutter. Buffet is observed while moving through turbulent environment, noise is generated during take-off or landing, and flutter is movement of wings due to air-flow. Vibration testing is carried out on ground to ascertain the vibration frequencies and modes, so that the same can be implemented on airborne defence stores [1], [2], [3]. In fact each section of aircraft like fuselage, wings, cockpit, engine, rudder, vibrates with different amplitude and frequencies and depending on the mounting locations, the associated vibrations must be applied on the carried defence stores [4]. For example, missiles and bombs are carried on pylon or hard-points, flares and chaffs are mounted in fuselage at different positions. After installing vibration sensors, these stores are actually flown and actual vibration recorded are observed after the flight of the aircraft. The vibration resulting from all sources has been evaluated as a set based on flight test

and laboratory work. This is the basis of the tailored criteria and test methodology contained in MIL-STD-810 and STANAG-4370 covering jet and propeller conventional fixed wing airplanes and helicopters. MIL-STD-8591 provides a considerable database and vibration prediction methodology based on several modern U.S. combat aircraft, including a vertical takeoff and landing (VTOL) aircraft.

The Airborne defence stores are subjected to sinusoidal as well as Random vibration in the frequency range varying from 20 Hz to 2000 Hz. For high performance aircraft in random mode ground test, the cycle starts from 15 Hz onward at 0.04 g^2/Hz, followed by a ramp up of +4 dB/octave till 300 Hz. This is followed by a constant power spectral density value till 1000 Hz, again a decline at the rate of -6 dB/octave till 2000 Hz is applied. The higher constant power spectral density value is dependent on type of vibration induction mechanism and depending on power-plant induced and aerodynamic induced vibrations, the values may vary. For external stores carried on Jet aircrafts, two constant power spectral density values separated by +3 dB/octave ramp-up in the frequency range of +20 Hz to 2000 Hz is applied. For a typical missile, the applied vibration levels are given as Figure 1. For fitted store on aircraft, sinusoidal vibration is applied between 5 Hz to 70 Hz such that constant peak to peak displacement of 12 mm in the beginning followed by constant peak acceleration of 3g is applied. the sweep rate of 1 octave/min for 75 minute per axis is considered adequate. For Random vibration, between 100 Hz to 1000 Hz, 0.04 g^2/Hz is applied with both sides $\pm$3 dB/octave ramp is applied between 20 Hz to 2000 Hz (Figure 2).

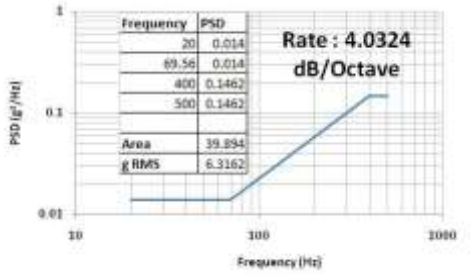

Figure 1. Random Vibration for a Typical Airborne Missile

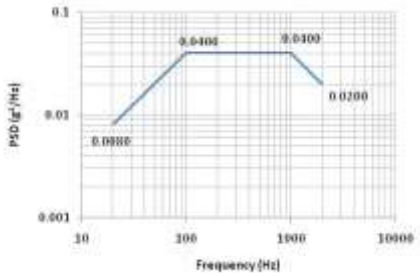

Figure 2. Random Vibration on Mounted Airborne Store

All vibration tests are conducted on all three axes for adequate duration and after undergoing these ground vibration trials, the stores must function satisfactorily in form, fitment, efficacy and performance.

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