OBTAINING LOADS FOR DESIGN SIMULATION AND QUALIFICATION TESTING OF VIBRATING EQUIPMENT ON AIRCRAFT

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ABSTRACT

All aircraft vibrate and all components are designed, tested and certified to survive these vibration levels over their entire service life. Design standards like MIL-STD-810F, DEF-STAN-0035 or RTCA DO-160E, are often used to derive the vibration loads; but what is the safety margin? How many hours do they represent on real aircraft? Can the equipment life be extended for aircraft with less damaging usage profiles? Can I use 'read-across' evidence from one aircraft to another? This paper discusses the latest approaches to the analysis of shock and vibration and shows how vibration tests can be tailored based on measured flight spectra, how different tests can be compared, and how the life of equipment can be adjusted based on operational experience.

New techniques discussed in this paper provide a means of comparing shock and vibration-induced damage across different vibration tests and different aircraft platforms. This enables us to use test and service evidence obtained on one aircraft platform to qualify equipment on a new platform. This 'read-across' evidence has been successfully used to qualify equipment without the need for any additional vibration testing. It offers considerable cost savings and also enables a rapid path for the deployment of mission-critical equipment in military operations.

New techniques, which derive tailored vibration tests based on measured flight load data, are also discussed. Accelerometers record the vibration levels at a number of positions on the aircraft while flying a prescribed sequence of manoeuvres. The fatigue damage dosage for each manoeuvre is calculated using a Fatigue Damage Spectrum (FDS), which effectively plots damage vs. frequency. The damage from each manoeuvre is summed over the usage profile of the aircraft to determine the whole-life damage dosage. From this profile we determine a statistically representative vibration test which contains at least the same damage content as the whole-life, but over a much shorter test period. This facilitates the provision for 'Test Tailoring', as specified in Annex A of MIL-STD-810F.

Techniques are described for calculating the FDS from measured accelerometer data, as well as a number of traditional sign-off tests including PSD random, sine-on-random, sine sweep and sine dwell test profiles. Case studies are presented to describe how the analysis was used by AgustaWestland for tailoring vibration tests for its latest aircraft. Studies also describe how the techniques have been used to provide 'read-across' evidence to support flight clearance for urgently needed equipment in military operations. These include clearance for helicopter avionics and opto-electrical equipment, as well as external stores and missiles on fixed-wing fighter aircraft. Studies also describe how cases for limited type approval (i.e. restricted flight envelope or service life), or experimental flight approval are assessed quantitatively using these techniques. The paper concludes by describing how the technique can be used to provide quantitative evidence to support equipment life extensions based on Operational Loads Monitoring (OLM) and Health and Usage Monitoring System (HUMS) data.

Key words:

Vibration Qualification, Vibration Test, Vibration Flight Clearance, Test Tailoring