Windblast Testing

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Introduction

Ejection from an aircraft will subject an aircrew to airflow, the velocity of which can vary from 0 knots on one extreme (ejection on ground at 0 knots aircraft speed) to 600 knots at other extreme; the highest velocity at which the modern fighter could be flying at the time of ejection. This sudden exposure to ambient air flow once canopy is jettisoned / removed is known as windblast. Exposure to such high velocity wind can cause petechial haemorrhages, sub-conjunctival haemorrhages, chest injury and flailing of head and extremities. Apart from the spinal injuries due to high catapult force, the windblast injuries can also cripple an aircrew and affect post ejection survival. Restraint systems provide some protection against flailing of limbs. The helmet / visor and oxygen mask provide protection to the head and face. The life preserver unit (aircrew jacket) protects the chest. Windblast testing hence becomes an integral part of the battery of certification tests for helmet, visor, oxygen mask and Life Preservation Unit (LPU).

How is Windblast Testing done?

Wind blast testing is carried out in specially designed test facilities that are different from the standard wind tunnel. The wind tunnel provides laminar flow in which aerodynamic properties of an aerofoil are studied. A wind blast test facility on the contrary provides sudden high speed wind blast to assess its human effects. As of date a wind tunnel facility is available at the National Aerospace Laboratory (NAL) Bangalore but there is no Wind blast test facility in India. The facilities at the specialised labs in France and USA are used for wind blast testing and certification of the indigenous flying clothing under development.

Testing Facility

The typical set up of a Wind blast test facility is shown in figure 1. The main components of the system are as follows:-

High wind speed generator

The windblast facility produces a high velocity

Fig 1: A Windblast Test Facility
(Reproduced from http://www/dtbtest.com/eLibrary/wind-blast-testing.pdf-United States)

air flow field (100-700 knots) similar to the aerodynamic environment during ejection. This is accomplished with a controlled expansion of high pressure compressed air (11 Mega Pascal) which exits through nozzles. The nozzle assembly is arranged to provide uniform airflow. Thus, the broadened windblast airstream more accurately simulates the ejection aerodynamic conditions

Anthropomorphic test dummy (ATD)

Hybrid II/ III anthropomorphic dummies are used to simulate the ejectee. This Mannequin should have a biofidelic instrumented neck. The neck is instrumented to record the forces on exposure to wind blast. The test Mannequin is instrumented to measure the biodynamic neck loads and acceleration experienced by each part of the body. The dummies are available in 3 sizes viz. 95th percentile, 50th percentile and 5th percentile US anthropometry. The selection of size of the dummy does not really affect the test and usually 50th percentile dummy is used. The dummy is suitably clothed with correct sizes of various items of flying clothing viz. helmet (with visors), oxygen mask, LPU and Anti G suit.

Ejection seat

The clothed dummy is placed in a ejection seat placed directly in front of the jet nozzle. The seat is mounted on suitable stand so that the included angle as in the aircraft. The certification of wind blast testing and certification can be done for specific ejection seat for the following reasons:-

(i) The pitch of each seat in aircraft may vary (e.g. Martin Baker Mk 10 seat has pitch of 25°.

(ii) If a visor flies of on exposure to wind blast, the timing of that event with ejection seat sequence (that is specific to each seat) is assessed to see if the flown off visor would affect the ejection sequence in any way.

Data recording equipment

The dummy is instrumented with 3 axis head accelerometers, 2 pressure sensors for the eyes, bending moment and tensile force transducers in the neck (C1 & C7 vertebra). High speed video cameras (500 - 1000 frames/s) are installed to record the wind blast and its effects, which enables to analyse the specific events and assists in failure analysis in time domain.

Objectives of Windblast testing

The wind blast test assesses the following objectives:-

(a) To demonstrate that the Aircrew helmet and visor does not fly away from the head during ejection

(b) To demonstrate the structural integrity of the flying clothing

(c) To demonstrate pilot's facial protection

(d) To measure the helmet induced forces and movements at occipito-atlantic joint, in support of neck injury hazard assessment.

Standards to perform a Windblast Test

Wind blast testing of helmet and visor assembly is carried out in accordance with Mil standards 87174 A and Mil-V-25951/1 (AS). The testing is recommended to be carried out max windblast velocity of 600 ± 60 KEAS. The time of exposure to the maximum velocity should be 300ms ± 50ms, and the rise time to reach peak velocity should be within 125 ± 20ms. The total windblast duration should be at least 3.0s. The testing is recommended to be carried out in Head on position. Additional testing is also recommended with head yawed to left and right and in head pitch up condition.

Post-test activities

After the test a detailed visual inspection of the test items is performed without touching anything. Photographic documentation is done and all findings are recorded. All the test items from the manikin are disassembled and thorough visual inspection is done. The visor is subjected to Photo Elastic inspection method. A raw data is prepared using all the sensor data records. The actual airspeed is calculated and the data sheet is completed.

Pass - Fail Criteria

(a) General pass - fail criteria. There should be no structural damage, which can compromise head and facial protection. This includes breaking / tearing / cracking or loosening of any pilot safety related elements.

(b) Visor pass – fail criterion. The visor is deemed to have failed if any cracks or significant deformation is observed.

(c) Helmet retention pass - fail Criterion. Any loss of helmet, including visor and oxygen mask from the Manikin's head is deemed as a test failure.

(d) Pilot facial protection pass - fail criteria. Max rotation / slipping of helmet assembly with respect to Manikin's head should be such that the gap between visor and mask (Nose Bridge) should not increase by more that ½" from pre-test position. Facial areas, not protected by the helmet or mask, should not be stroked by visor or any helmet component. The oxygen mask should be displaced and the mask – hose junction should remain intact. The Oxygen hose should not flatten / crack.

(e) LPU, Anti G suit, flying overall and gloves pass – fail criteria. The cloth, pockets and stole (in sea version of LPU) should not show any tears. The zip should not open. The gloves should be retained.

Conclusion

Wind blast testing of flying clothing is essential step in certification of flying clothing for fighter aircrew. It is essential to understand the difference between wind tunnel testing and wind blast testing. This teaching note brings out the test methodology and pass – fail criteria. Flying clothing that has passed this stringent test is expected to be retained on the aircrew during an ejection and remain functional even if the ejection were to take place at high speed. The aeromedical significance of this highly technical test lies in the surety that the life support systems would continue to protect the ejectee throughout the ejection and post ejection survival.