



AEROSPACE STANDARD

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Standard Test Method for Measuring Impact Forces and Pressures of a Soft Projectile on an Inclined Rigid Flat Surface

RATIONALE

Measurement of impact forces by soft projectiles is important in understanding how soft projectiles respond and how the forces are transmitted into the impacted structure in highly dynamic impact events. This method is recommended for recording force and pressure data to characterize the projectile response on inclined surfaces. Data captured can be used to compare the response of physical simulants, proposed to replace real birds in bird strike testing, to real bird impact responses. This method is also useful for generation of data for validation of computational material models for soft or frangible objects such as ice, soft polymers, and materials used to simulate birds for aircraft bird strike testing.

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1. SCOPE

This document describes methods for measuring dynamic forces, pressures, and projectile fragment distribution patterns during an impact between a soft or frangible projectile and a rigid flat inclined surface. It also describes the hardware, setup, and instrumentation required.

In this test method, a soft body projectile impacts a rigid plate inclined at a specified angle to the direction of flight. The rigid target plate is backed up by a rigid structure, and sandwiched between the plate and the structure are force sensors to record reaction loads. Optionally, pressure transducers may be embedded in the target plate to record the pressure-time history of the impact. The target plate shall be sufficiently large so that the projectile flows across the surface without passing behind the plane of the plate impact surface, therefore capturing all of the impact load. A projectile fragment collector system for capturing projectile fragments is also described, along with a method for characterizing the projectile dispersion pattern after impact.

This test is intended for measuring the transient forces and pressures generated by the projectile when it impacts the plate. Projectile breakup pattern data may also be captured during this test. The projectile material shall be low modulus and low strength (soft) compared with the target plate material. Impact stresses generated in the plate must be lower than the yield strength of the plate material so that all deformations in the plate are elastic.

The values stated in either SI units or inch-pound units are considered separate standards. The values stated in each system may not be exactly equivalent; therefore, each system must be considered as independent.

This standard does not address all of the safety concerns associated with its use. It is the responsibility of each user of this standard to ensure that any safety issues are properly addressed.

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM F330-21 Standard Test Method for Bird Impact Testing of Aerospace Transparent Enclosures

2.2 Other Publications

Barber, J., Taylor, H., and Wilbeck, J. (1975). *Characterization of Bird Impacts on a Rigid Plate: Part 1* (AFFDL-TR-75-5). Air Force Flight Dynamics Laboratory.

3. TERMINOLOGY

3.1 Definition of Terms Specific to this Standard

For terms that represent a physical quantity, analytical dimensions are stated immediately following the term (or letter symbol) in fundamental dimension form, using the following SAE standard symbology for fundamental dimensions, shown within square brackets: [M] for mass, [L] for length, [T] for time, [θ] for thermodynamic temperature, and [nd] for non-dimensional quantities. Use of these symbols is restricted to analytical dimensions when used with square brackets, as the terms may have other definitions when used without the brackets.

3.1.1 X-DIRECTION, n

The direction parallel to the axis of the launcher. The positive direction is in the direction of flight.

3.1.2 Y-DIRECTION, n

The direction of a horizontal vector perpendicular to the launcher axis pointed to the right when facing from the launcher to the target plate.

3.1.3 Z-DIRECTION, n

The direction of a vertical vector in the plane of the front face of the target plate pointed downward when facing from the launcher to the target plate.

3.1.4 LONG AXIS OF THE PROJECTILE, n

A line extending from the center of the rear of the projectile to the center of the front of the projectile. The angle of this line may change during flight.

3.1.5 IMPACT VELOCITY, V_i [LT^{-1}], n

Velocity of the projectile in the direction of projectile travel just before impact.

3.1.6 PITCH ANGLE, n

Angle of the long axis of the projectile about the Y-direction.

3.1.7 YAW ANGLE, n

Angle of the projectile about the Z-direction.

3.1.8 IMPACT ANGLE, n

The incline angle of the target plate relative to the Y-axis.

3.1.9 IMPACT FORCE, F [MLT^{-2}], n

The force transmitted through the target plate, normal to the target plate face, generated by the impact of the projectile.

3.1.10 IMPACT PRESSURE, P [$ML^{-1}T^{-2}$], n

Pressure generated by the impact of the projectile against the target plate, normal to the plate surface.

4. SUMMARY OF TEST METHOD

An impact test is performed by accelerating a soft projectile to a specified velocity, typically with the use of a single-stage gas gun, into an inclined rigid plate. The stiffness and strength of the projectile are small compared to those of the target plate. The relative angle between the plate and the projectile direction of flight (gun axis) shall be specified by the test requestor. The length and width of the target plate shall be a minimum of four times the diameter of the projectile so that after impact, the projectile material flows across the surface of the target plate without portions flowing past the plane of the impacted face. Force sensors sandwiched between the target plate and the target plate support structure shall be used to record the impact force history on the target plate. Optional piezoelectric pressure sensors may be embedded in the target plate around the targeted impact site to record the impact pressure history, if required by the test requestor. Refer to AFFDL-TR-75-5, which employed pressure transducers to compare impact pressures of various soft projectile materials.