AEROSPACE INFORMATION REPORT	**AIR4951™**	
	Issued 2011-06 Reaffirmed 2017-02	
	Test Cell Thrust Measurement	

SAE INTERNATIONAL®

RATIONALE

AIR4951 has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE

Thrust measurement systems come in many sizes and shapes, with varying degrees of complexity, accuracy and cost. For the purposes of this information report, the discussions of thrust measurement will be limited to axial thrust in single-axis test systems.

1.1 Purpose

There are several purposes served by this information report:

a. To provide guidelines for the specification of thrust measurement systems.

b. To address the major factors which can influence thrust measurement uncertainty.

c. To consider the operational characteristics and the effects on system performance.

2. REFERENCES

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 the 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 Applicable Documents

2.1.1 ASME Publications

Available from American Society of Mechanical Engineers, 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007-2900, Tel: 973-882-1170, www.asme.org.

ASME 86-WA-DE-3   Evaluating and Testing of Turbofan Jet Engines, miller, T.M., 1986

ASME PTC 19.1-2006   Test Uncertainty

TO PLACE A DOCUMENT ORDER:	Tel:	877-606-7323 (inside USA and Canada)
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2.1.2   ISO Publications

Available from International Organization for Standardization, 1, rue de Varembe, Case postale 56, CH-1211 Geneva 20, Switzerland, Tel: +41-22-749-01-11, www.iso.org.

ISO/IEC Guide 98-1-2009   Uncertainty of measurement - Part 1: Introduction to the expression of uncertainty in measurement

ISO/IEC Guide 98-3:2008   Uncertainty of measurement - Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)

2.1.3   Other Publications

Covert, E.: "Thrust and Drag: Its Prediction and Verification", Volume 98, Progress in Astronautics and Aeronautics, American Institute of Aeronautics and Astronautics, 1985.

Ashwood, P.F. et al.: "Operation and Performance Measurements on Engines in Sea Level Test Facilities", AGARD Lecture Series No. 132 (AGARD-LS-132), Advisory Group for Aerospace Research and Development, North Atlantic Treaty Organization, Neuilly-sur-Seine, France, 1984.

Stroud, J.F.: "Propulsion System Testing Requirements for a Commercial Transport", AGARD CP-293, 1981.

Roberts, J.H., et al.: "Engine Thrust Measurement Uncertainty", AIAA 85-1404, 1985.

MacWhorter, R.F.: "F404-GE-400 NARF Engine Test Cell Mount System Vibration Test", General Electric Component Development Laboratory, TN4759, 1981.

2.2   Definitions

ANGULAR LOAD, CONCENTRIC: A load applied concentric with the primary axis at the point of application and at some angle with respect to the primary axis.

ANGULAR LOAD, ECCENTRIC: A load applied eccentric with the primary axis at the point of application and at some angle with respect to the primary axis.

AXIAL LOAD: A load applied along or parallel to and concentric with the primary axis.

CALIBRATION: The comparison of thrust frame output to a standard load. A calibration curve is obtained by performing a calibration at a number of increasing and decreasing load points.

COMBINED ERROR: The maximum deviation of output from a straight line drawn between the no-load and rated load outputs expressed as a percentage of the rated output and measured on both increasing and decreasing loads.

COMPENSATION: The use of supplementary devices, materials, or processes to minimize known sources of error.

CREEP: The change in load cell output occurring with time while under a constant load condition and with all environmental conditions remaining constant. Usually measured at the rated load and expressed as a percentage of the rated load over a specific period of time.

DEFLECTION: The change in length along the primary axis of the load cells between no-load and rated load conditions.

ERROR FACTORS: Systematic and random differences between the measured and true value of the parameter being measured, the combination of which comprise the measurement uncertainty.

EXCITATION, ELECTRICAL: The voltage or current applied to the terminals of the load cell.

FLEXURE: A plate or cylinder incorporating two areas of reduced thickness (webs) which act as pivots. Each pivot allows a rotation or pivoting action as the result of elastic deformation in the areas of reduced thickness.

GROUND FRAME: The part of the thrust frame structure which is rigidly attached to the building feature such as the roof or a foundation. It is also referred to as the fixed frame.

HYSTERESIS: The maximum difference between output readings for the same applied load, one reading being obtained by increasing the load from zero, and the other by decreasing the load from the rated load. It is usually measured at 50% of the rated load and expressed as a percentage of the rated load.

LIVE FRAME: The part of the thrust frame structure which is suspended from the ground frame by the flexures. It is also referred to as the floating frame.

LOAD: The force applied to the load cell.

LOAD CELL: A device which produces an electrical signal proportional to the force applied to it.

MEASUREMENT UNCERTAINTY: The difference between the measured value of a physical quantity and the true value of the same physical quantity.

NON-LINEARITY: The maximum deviation of the calibration curve from a straight line drawn between the no-load, and rated load outputs, expressed as a percentage of the rated load, and measured on increasing load only.

OVERLOAD RATING, SAFE: The maximum load, in percent of rated capacity, which can be safely applied without producing a permanent shift in the performance characteristics beyond those specified.

PRIMARY AXIS: The axis along which the load cell is designed to be loaded; normally its geographic centerline.

RATED LOAD: The maximum thrust the thrust frame is designed to measure. Also referred to as rated capacity.

REPEATABILITY: The maximum difference between individual thrust frame output readings for repeated loadings under identical load and environmental conditions.

RESOLUTION: The smallest change in load input which results in a detectable change in output.

SENSITIVITY: The ratio of the change in output to the change in mechanical input.

SHUNT CALIBRATION: The electrical simulation of load cell output by known shunt resistors between appropriate points within the circuitry.

SIDE LOAD: Any load acting perpendicular to the primary axis at the point of the load application.

TEMPERATURE RANGE COMPENSATED: The range of temperature within which the load cell is compensated to maintain rated output and zero balance within specific limits.

TEMPERATURE COEFFICIENT: The change in load cell output per unit change in temperature at a constant load condition and with all other environmental conditions remaining constant. Usually specified as effect on sensitivity in % of reading $/\Delta T$ and effect on zero in % of rated output$/\Delta T$.

THRUST STAND: Test cell fixture used to support and interface with the engine adapter. Consists of ground and live frames and contains the thrust measurement and in-frame calibration system components. Sometimes referred to thrust frame or test stand.

ZERO BALANCE: The output signal of the load cell with rated excitation and with no-load applied, usually expressed in percent of rated output.

ZERO SHIFT: A change in the no-load output.