



AEROSPACE RECOMMENDED PRACTICE	ARP5305™	REV. B
	Issued 2010-06 Revised 2026-01	
	Superseding ARP5305A	
Structural Design and Construction Considerations for Enclosed Turbofan/Turbojet Engine Test Cells		

RATIONALE

Add language regarding vibration isolation between test cell and adjacent structure, and noise/vibration dampening over distance. Add discussion on post-installed anchor testing.

FOREWORD

This document discusses the structural design and construction considerations for design of structures used for testing turbofan and turbojet engines. The document presents general design and construction information along with information for limiting damage and injuries from projectiles.

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1. SCOPE

This SAE Aerospace Recommended Practice (ARP) is written for individuals associated with the ground-level testing of large and small gas turbine engines and particularly for those who might be interested in constructing new or adding to existing engine test cell facilities.

1.1 Purpose

The purpose of this document is to provide general guidelines for the design and construction of concrete test cell structures that will resist the effects of normal engine operating loads, dynamic loads due to engine failure, over pressures and cell depression loads, acoustic and environmental loads, and engine projectiles.

2. REFERENCES

2.1 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.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 1-877-606-7323 (U.S. and Canada only) or 1-724-776-4970 (outside U.S. and Canada), www.sae.org.

2.1.1.1 AIR4869, Design Considerations for Enclosed Turbofan/Turbojet Engine Test Cells

2.1.1.2 AS567, Safety Cable, Safety Wire, Key Washers, and Cotter Pins for Propulsion Systems, General Practices for Use of

2.1.2 AIA Publications

Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, www.aia-aerospace.org.

2.1.2.1 NASM33540, Safety Wiring, Safety Cabling, Cotter Pinning, General Practices for

2.1.2.2 NASM21045, Nut, Self-locking, Hexagon, Regular Height, 450 °F, 125 ksi Ftu

2.1.3 AISC Publications

Available from American Institute of Steel Construction, 130 East Randolph, Suite 2000, Chicago, IL, 60601, Tel: 800-644-2400, www.aisc.org.

2.1.3.1 Code of Standard Practice for Steel Buildings and Bridges (AISC/ANSI 303)

2.1.3.2 Steel Construction Manual (AISC/ANSI 325)

2.1.3.3 Specification for Structural Steel Buildings (AISC/ANSI 360)

2.1.4 AWS Publications

Available from American Welding Society, 8669 NW 36 Street, #130, Miami, FL 33166-6672, Tel: 1-800-443-9353 or 305-443-9353, www.aws.org.

2.1.4.1 Structural Welding Code - Steel, (AWS D1.1)

2.1.4.2 Structural Welding Code - Sheet Steel, (AWS D1.3)

2.1.4.3 Structural Welding Code - Reinforcing Steel, (AWS D1.4)

2.1.4.4 Structural Welding Code - Stainless Steel, (AWS D1.6)

2.1.5 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

2.1.5.1 DOT/FAA/AR-99/71, Full-Scale Tests of Lightweight Fragment Barriers on Commercial Aircraft

2.1.5.2 DOT/FAA/AR-99/8, I, Improved Barriers to Turbine Engine Fragments: Interim Report I

2.1.5.3 DOT/FAA/AR-99/8, II, Improved Barriers to Turbine Engine Fragments: Interim Report II

2.1.5.4 DOT/FAA/AR-99/8, III, Improved Barriers to Turbine Engine Fragments: Interim Report III

2.1.5.5 DOT/FAA/AR-99/8, IV, Improved Barriers to Turbine Engine Fragments: Interim Report IV

2.1.5.6 DOT/FAA/AR-99/8, V, Improved Barriers to Turbine Engine Fragments: Interim Report V

2.1.5.7 DOT/FAA/AR-98/22, T53-L-13L Turbine Fragment Containment Test

2.1.6 NFPA Publications

Available from National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471, Tel: +1 800-344-3555 (U.S. and Canada) or 1 617-770-3000 (International), www.nfpa.org.

2.1.6.1 NFPA 68, Technical Committee on Explosion Protection Systems, Guide for Venting of Deflagrations

2.1.6.2 NFPA 423, Technical Committee on Airport Facilities, Standard for Construction and Protection of Aircraft Engine Test Facilities

2.1.6.3 NFPA 220, Technical Committee on Building Construction, Standard on Types of Building Construction

2.1.7 U.S. Government Publications

Copies of these documents are available online.

2.1.7.1 ARMY TM 5-1300, Structures to Resist the Effects of Accidental Explosions - out of print. Available online at: https://www.wbdg.org/FFC/ARMYCOE/COETM/ARCHIVES/tm_5_1300_1990.pdf.

2.1.7.2 UFC 3-340-02, Structures to Resist the Effects of Accidental Explosions, with Change 2 [superseded Army TM 5-1300]. Available online at: https://www.wbdg.org/FFC/DOD/UFC/ufc_3_340_02_2008_c2.pdf.

2.1.8 Other Publications

- 2.1.8.1 American Concrete Institute (ACI), Building Code Requirements for Reinforced Concrete (ACI 318-14) and Commentary (ACI 318R-14), ACI Committee 318, 2014.
- 2.1.8.2 American Concrete Institute (ACI), Code Requirements for Nuclear Safety Related Concrete Structures, Special Provisions for Impulsive and Impactive Effects, ACI Committee 349, Appendix F, 2013.
- 2.1.8.3 American Society of Civil Engineers (ASCE), Design of Blast Resistant Buildings in Petrochemical Facilities, Task Committee on Blast Resistant Design of the Petrochemical Committee of the Energy Division of ASCE, 1998.
- 2.1.8.4 Smith, P.D., and Hetherington, J.G. (1994). *Blast and ballistic loading of structures*. Butterworth-Heinemann.
- 2.1.8.5 Samara, M.F. (1998). Nonstructural considerations in design of blast-resistant buildings. *Practice Periodical on Structural Design and Construction*, 3(4). [https://doi.org/10.1061/\(ASCE\)1084-0680\(1998\)3:4\(172\)](https://doi.org/10.1061/(ASCE)1084-0680(1998)3:4(172)).
- 2.1.8.6 Mays, G.C., and Smith, P.D. (Eds.). (1995). *Blast effects on buildings*. Thomas Telford.
- 2.1.8.7 Kar, A.K. (1978). Local effects of tornado-generated missiles. *Journal of the Structural Division*, 104(5). <https://doi.org/10.1061/JSDEAG.0004915>.
- 2.1.8.8 American Concrete Institute (ACI), Environmental Engineering Concrete Structures (ACI 350), ACI Committee 350, 2006.
- 2.1.8.9 American Concrete Institute (ACI), Report for the Design of Concrete Structures for Blast Effects, ACI Committee 370, (ACI 370R-14).
- 2.1.8.10 American Concrete Institute (ACI), Report on Fiber Reinforced Concrete (ACI 544.1R), ACI Committee 544, 2009.
- 2.1.8.11 American Concrete Institute (ACI), Measurement of Properties of Fiber Reinforced Concrete (ACI 544.2R), ACI Committee 544, 2009.
- 2.1.8.12 Shockey, D.A., Erlich, D.C., and Simons, J.W. (1999, November 15-19). *Lightweight fragment barriers for commercial aircraft* [Conference paper]. 18th International Symposium on Ballistics, San Antonio, Texas, United States.
- 2.1.8.13 American Society of Civil Engineers (ASCE), Minimum Design Loads for Buildings and Other Structures, ANSI/ASCE 7.
- 2.1.8.14 Federal Emergency Management Agency (FEMA), Taking Shelter from the Storm: Building a Safe Room for Your Home or Small Business (P-320).
- 2.1.8.15 Federal Emergency Management Agency (FEMA), Safe Rooms for Tornadoes and Hurricanes (P-361).
- 2.1.8.16 International Code Council (ICC), International Building Code (IBC).
- 2.1.8.17 International Code Council (ICC), Standard for the Design and Construction of Storm Shelters (ICC-500).
- 2.1.8.18 Research Council on Structural Connections (RCSC), Specification for Structural Joints Using High-Strength Bolts.
- 2.1.8.19 "Considerations for Design of Concrete Structures Subjected to Fatigue Loading" (ACI 215R-74) Reported by ACI Committee 215; reapproved 1997.
- 2.1.8.20 Ahsan, R. (2013). *Fatigue in concrete structures*. BSMR Seminar on Fatigue Properties of Constructional Steel.
- 2.1.8.21 The Aberdeen Group. (1971). *Effect of high temperature on hardened concrete* (Publication #C710477).
- 2.1.8.22 The Aberdeen Group. (1962). *Some notes on concrete fatigue* (Publication #C620295).



2.2 Definitions

AREAL DENSITY: Dry fabric weight, a two-dimensional measure of density.

dBA: A-weighted decibels - the relative loudness of sounds in air as perceived by the human ear, calculated by standardized method.

f'c: f'c is the specified compressive strength of hardened concrete using standard ASTM test procedures, typically cylinders 12 inches tall by 6 inches diameter, at the age of 28 days.

REBAR: Steel reinforcement used in concrete construction.

2.3 Abbreviations

The following terms and abbreviations are used in this report.

ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing Materials
AWS	American Welding Society
cm	centimeter
FOD	Foreign Object Damage - caused by items being ingested into the engine, or Foreign Object Debris - items having the potential of being ingested into the engine
ft	foot or feet
ft-lb	foot-pound, force, a measure of energy
f/s or fps	feet per second
g	gram or grams
IBC	International Building Code
kips	1000 pounds
kN	kilonewton
kPa	kilopascal
lbf	pound or pounds, force
m	meters
m/s	meters per second
mm	millimeters
MPa	megapascal

OSHA	Occupational Safety and Health Administration
Pa	pascal
psf	pounds per square foot
RCSC	Research Council on Structural Steel Connections

3. BACKGROUND

An engine test cell is subjected to varying types and magnitudes of loads which must be considered by the structural engineer. In addition to the usual gravity loads (dead and live loads) and environmental loads (wind, seismic, etc.), test cells are also subject to potential loads arising out of the engine testing activities themselves.

During testing of turbofan and turbojet engines, parts or assemblies may fail. Also, during scientific investigations, sometimes it is necessary to deliberately test parts to failure.

In the case of machinery rotating at very high rates, such as turbofan and turbojet engines, the failure of one part can quickly lead to damage to other parts and to a general failure of the apparatus to withstand circumferential forces. When the failure has progressed that far, rotating parts fly off in various directions with great velocity and great energy. These parts can carry other parts or subassemblies with them. As these projectiles strike other objects, they can create additional projectiles. Due to their high velocity, even small, lightweight projectiles can injure personnel, damage equipment, or even damage the test cell structure itself.

Reference 2.1.8.2 states that projectile loads cause both local effects and overall structural effects. It defines the local effects of penetration, perforation, scabbing (also called backface spalling), spalling, and punching shear.

An expensive solution in preventing structural damage would be to provide shielding for portions of the structure, particularly in the test chamber. But extensive shielding could interfere with operations and is likely to be very expensive. A more reasonable approach is to use good design and construction practices to provide a structure that, although damaged, will be repairable, that will limit further injury to personnel and damage to equipment and that will not collapse.

4. TEST CELL STRUCTURAL DESIGN CONSIDERATIONS

4.1 Structural Loads

4.1.1 Normal Loads

Turbofan and turbojet engines are not supported directly by the building structure. Between the engine and the structure are devices called thrust frames or thrust stands and thrust beams. These devices support the engines and transfer the engine dead load and live load to the structure. The structural engineer must obtain the thrust frame forces and connection details from the thrust frame manufacturer.

Other normal loads include dead loads, live loads, and the environmental loads specific to the facility site. Environmental loads are discussed below.

Each test cell must be designed by a qualified industry professional on a case-by-case basis.