



DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

14 FEB 2007

FROM: HQ AFCESA/CESC
139 Barnes Drive, Suite 1
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SUBJECT: Engineering Technical Letter (ETL) 07-3: Jet Engine Thrust Standoff Requirements for Airfield Asphalt Edge Pavements

1. Purpose. This ETL presents the standoff distances from jet aircraft during engine run-up required to prevent uplift forces from causing catastrophic failure of asphalt edge pavements.

This ETL supersedes ETL 01-5, *Jet Engine Thrust Standoff Requirements for Airfield Asphalt Edge Pavements*.

2. Summary of Revisions: This ETL is substantially revised and must be completely reviewed.

3. Application. The requirements of this ETL are mandatory.

3.1. Authority: Air Force policy directive (AFPD) 32-10, *Air Force Installations and Facilities*, and Air Force instruction (AFI) 32-1023, *Design and Construction Standards and Execution of Facility Construction Projects*.

3.2. Coordination: Major command (MAJCOM) pavement engineers.

3.3. Effective Date: Immediately.

3.4. Intended Users:

- Air Force MAJCOM engineers.
- Base civil engineers (BCE), RED HORSE (Rapid Engineers Deployable - Heavy Operations Repair Squadron Engineers) squadrons, and other units responsible for design, construction, maintenance, and repair of airfield pavements.
- U.S. Army Corps of Engineers (USACE) and Navy offices responsible for Air Force design and construction.

4. Referenced Publications:

4.1. Air Force:

- AFPD 32-10, *Air Force Installations and Facilities*, 27 March 1995, available at <http://www.e-publishing.af.mil/>

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- AFI 32-1023, *Design and Construction Standards and Execution of Facility Construction Projects*, 19 July 1994, available at <http://www.e-publishing.af.mil/>
- AFI 32-1042, *Standards for Marking Airfields*, 27 October 2005, available at <http://www.e-publishing.af.mil/>
- ETL 04-2, *Standard Airfield Pavement Marking Schemes*, 19 July 2004, available at <http://www.afcesa.af.mil/library/etl.asp?Category=Engineering%20Technical%20Letters>

4.2. Army:

- USACE ETL 1110-3-394, *Engineering and Design - Aircraft Characteristics for Airfield-Heliport Design and Evaluation*, 27 September 1991, available at <http://www.usace.army.mil/publications/eng-tech-ltrs/etl1110-3-394/toc.htm>

4.3. Joint:

- Unified Facilities Criteria (UFC) 3-260-01, *Airfield and Heliport Planning and Design*, 1 November 2001, available at http://www.wbdg.org/ccb/browse_cat.php?o=29&c=4

4.4. Industry:

- Boeing Document D6-58329 Rev C, *777 200/300 Airplane Characteristics for Airport Planning*, July 2002, available at <http://www.boeing.com/commercial/airports/777.htm>

5. Acronyms and Terms:

°R	- degree Rankine
AFPD	- Air Force policy directive
AFI	- Air Force instruction
ETL	- engineering technical letter
Fps	- foot per second
ft	- foot
ft-lb/lb	- foot-pound per pound
kph	- kilometers per hour
m	- meter
MAJCOM	- major command
mph	- miles per hour
PCC	- portland cement concrete
psia	- pound per square inch absolute
psf	- pounds per square foot
USACE	- U.S. Army Corps of Engineers

6. Background. Catastrophic failure of airfield edge pavement due to uplift forces from jet engine thrust has occurred at multiple locations, resulting in damage to aircraft, vehicles, and real property. The criteria in this ETL are being issued due to tangible life

safety and financial concerns. This phenomenon has been observed and studied in the past. In 1988, the Air Force Engineering and Services Center (AFESC) responded to MAJCOMs' requests for engineering data on this subject by providing safe standoff distances to edge pavements for numerous aircraft. This ETL encompasses and updates previous guidance.

7. Analysis. Past guidance was based on both mechanistic air velocity–air pressure relationships, as defined by the Bernoulli equation, and empirical observation. Based on the following Bernoulli model, the critical air velocity would be limited to 218 kilometers per hour (kph) (136 miles per hour [mph] or 199.8 feet per second [fps]):

$$V = \sqrt{\frac{2g\Delta p}{\rho}}$$

$$\rho = \frac{P}{RT}$$

where:

V = velocity

Δp = 1197 pascals (25 pounds per square foot [psf]) (51-millimeter [2-inch] thick asphalt mass)

g = 9.81 meters (32.2 feet) per second•second

ρ = 101.3 kilopascals (14.7 pounds per square inch absolute [psia]) at sea level

R (gas constant, air) = 53.3 (ft-lb/lb) / °Rankine (°R)

T = 985 °R (typical exhaust temperature at expected velocity and distance of interest)

However, empirical observation has indicated that the typical 51-millimeter (2-inch) -thick edge pavement can withstand velocities up to 362 kph (225 mph). This higher observed velocity was accepted as a valid basis for criteria development because the simple Bernoulli model ignored other forces which are difficult to model, such as friction, shear, and adhesion. Without being able to further refine the mechanistic model, guidance was issued based on empirical observations, with a safety factor of two applied. The active uplift force is a function of the velocity squared. Dividing the observed velocity of 362 kph (225 mph) by the square root of this safety factor yielded a threshold velocity of 257 kph (160 mph). This velocity was issued as criteria for establishing standoff distances.

8. Standoff Distances. Aircraft should be positioned so that jet blast velocities are below 257 kph (160 mph) at the edge of a typical 51-mm (2-in) -thick asphalt shoulder pavement. Table 1 lists the standoff distance aft of the aircraft tail where data indicates the engine exhaust velocity is reduced to 257 kph (160 mph). Where data indicates that

the actual velocity would be lower than this threshold velocity value, a minimum standoff distance of 8 meters (m) (25 feet [ft]) is recommended.

Table 1. Safe Standoff Distances Aft of Aircraft Tail (Based on 51-mm [2-in] Asphalt Shoulder Pavement Thickness)

NOTES

1. If the design aircraft is not listed in Table 1, bases should contact their MAJCOM pavement engineer for additional guidance.
2. The information listed in the table is derived from the best information available at the time of publication. However, aircraft models and engines can change, resulting in changes to jet blast characteristics. Therefore, when designing or evaluating a site for a particular aircraft, always check for updated jet blast characteristics.
3. Data indicates jet blast velocities are less than 257 kph (160 mph) at the back of the aircraft tail. In such instances, it is recommended that a minimum 8 m (25 ft) standoff should be applied.
4. All reported distances are for maximum or takeoff engine power settings.
5. Where no specific aircraft model is listed, listed standoff distance is for the aircraft model with highest jet blast velocity.
6. Standoff distance is based on Gulfstream II jet blast data.

Aircraft	Aircraft Tail Standoff Distance	Jet Blast Velocity Data Source	Remarks
B-1B	88 m (290 ft)	ETL 1110-3-394	
B-52H	8 m (25 ft)	ETL 1110-3-394	See note 3
C-5A/B	23 m (75 ft)	ETL 1110-3-394	
C-9A	20 m (65 ft)	ETL 1110-3-394	
C-17	18 m (60 ft)	ETL 1110-3-394	
C-20B	18 m (60 ft)	ETL 1110-3-394	See note 6
C-21A	9 m (30 ft)	ETL 1110-3-394	
C-32 (Boeing 757-200)	55 m (180 ft)	ETL 1110-3-394	
C-37A	18 m (60 ft)	ETL 1110-3-394	See note 6
C-40 (Boeing 737-700)	26 m (85 ft)	Boeing	
C-130	8 m (25 ft)	ETL 1110-3-394	See note 3
C-141A/B	9 m (30 ft)	ETL 1110-3-394	
KC-10A	61 m (200 ft)	ETL 1110-3-394	3 engines
KC-135E/R EC-135A/G/L RC-135	32 m (105 ft)	ETL 1110-3-394	
VC-25A (B747-200)	26 m (85 ft)	Boeing	
Boeing 707	35 m (115 ft)	Boeing	
Boeing 727	34 m (110 ft)	Boeing	
Boeing 737	26 m (85 ft)	Boeing	
Boeing 747	35 m (115 ft)	Boeing	
Boeing 757	49 m (160 ft)	Boeing	

Aircraft	Aircraft Tail Standoff Distance	Jet Blast Velocity Data Source	Remarks
Boeing 767	46 m (150 ft)	Boeing	
Boeing 777	94 m (310 ft)	Boeing	
DC-9	23 m (75 ft)	Boeing	
DC-10	73 m (240 ft)	Boeing	
MD-80	37 m (120 ft)	Boeing	
Airbus A300F4-600	30 m (100 ft)	Airbus	
Airbus A318-100	12 m (40 ft)	Airbus	
Airbus A319	8 m (25 ft)	Airbus	See note 3
Airbus A320	26 m (85 ft)	Airbus	
Airbus A321	8 m (25 ft)	Airbus	See note 3
Airbus A330	76 m (250 ft)	Airbus	
Airbus A340	No jet blast data available for >102 mph.		
Airbus A380	107 m (350 ft)	Airbus	
AN-124	No jet blast data available.		
IL-76	No jet blast data available.		

9. Run-Up Pad Design. When designing new or checking existing engine run-up pads, the following criteria should be applied:

9.1. New and existing run-up pads should be designed/modified to provide the full standoff distance behind the tail of the aircraft, as listed in Table 1.

9.2. When it is not possible or practical to meet the distances listed in Table 1, then a minimum 8 m (25 ft) of portland cement concrete (PCC) pavement must be provided between the tail of the aircraft and the edge of the apron. However, be aware that damage to the asphalt shoulder pavement can be expected. To mitigate damage, PCC may be constructed in lieu of asphalt in the areas affected by jet blast.

9.3. Consideration must be given to other objects in the jet blast wake (e.g., roads, parking lots, hangars, lights, cargo). Precautions should be taken to eliminate the potential for damage caused by flying debris.

10. Run-Up Pad Markings. Proper marking of engine run-up pads is critical to ensure aircraft positioning complies with required standoff distances. All markings should comply with AFI 32-1042, *Standards for Marking Airfields*, and ETL 04-2, *Standard Airfield Pavement Marking Schemes*. The following guidance shall be followed on current and future run-up pad locations:

10.1. Provide a centerline marking that runs parallel to the prevailing wind direction specific to the run-up pad.

10.2. Provide a nose wheel stop-block marking for the primary assigned aircraft that will be using the run-up pad. If several different aircraft are assigned to the installation, provide a nose wheel stop-block marking for the most demanding aircraft. Aircraft may be parked on nose wheel stop-block markings that provide more standoff distance than required. However, aircraft must not be parked on nose wheel stop-block markings that provide less standoff distance.

10.3. Label each nose wheel stop-block marking for the aircraft that are intended to use it. Only mark blocks for primary assigned aircraft. Transient aircraft requiring use of the run-up pad should be evaluated on a case-by-case basis.

11. Contact. Recommendations for improvements to this ETL are encouraged and should be furnished to HQ AFCESA/CESC, 139 Barnes Drive, Suite 1, Tyndall AFB, FL 32408-5319, Pavements Engineer, HQ AFCESA/CESC, DSN 523-6334, commercial (850) 283-6334, internet AFCESAReachBackCenter@tyndall.af.mil.

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