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

MAY 24 2001

FROM: HQ AFCESA/CESC
139 Barnes Drive, Suite 1
Tyndall AFB FL 32403-5319

SUBJECT: **Engineering Technical Letter** (**ETL) 01-5: 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.

2. Application. The requirements of this ETL are optional.

2.1. Authority: AFPD 32-10, *Air Force Installations and Facilities*, and AFI 32-1023, *Design and Construction Standards and Execution of Facility Construction Projects*.

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

2.3. Effective Date: Immediately.

2.4. Ultimate Recipients:

- Air Force MAJCOM engineers.
- Base civil engineers (BCE), Rapid Engineers Deployable - Heavy Operations Repair Squadron Engineers (RED HORSE) 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.

3. Referenced Publications:

- AFMAN(I) 32-1123, *Airfield and Heliport Planning and Design*, 1 May 1999 (Unified Facilities Criteria [UFC] Index Number 3-260-01)
- USACE ETL 1110-3-394, *Engineering and Design - Aircraft Characteristics for Airfield-Heliport Design and Evaluation*, 27 September 1991
- Boeing Document D6-58329 Rev C*, 777 200/300 Airplane Characteristics for Airport Planning*, July 2000

4. Acronyms and Terms:

AFESC - Air Force Engineering and Services Center
BCE - base civil engineer
ETL - engineering technical letter

ft	- foot
kph	- kilometers per hour
m	- meter
MAJCOM	- major command
mph	- miles per hour
psf	- pounds per square foot
RED HORSE	- Rapid Engineers Deployable – Heavy Operations Repair Squadron Engineers
TRT	- takeoff rated thrust
UFC	- Unified Facilities Criteria
USACE	- U.S. Army Corps of Engineers

5. 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 is 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 this previous guidance.

6. 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]):

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

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

where:

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
p = 101.3 kilopascals (14.7 pounds per square inch absolute [psia]) at sea level
R(gas constant, air) = 53.3
T = 985 °Rankine (typical exhaust temperature at expected velocity and distance of interest)

However, empirical observation indicated that the typical 51-millimeter-thick edge pavement could 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 by the square root of this safety factor yielded threshold velocity of 257 kph (160 mph). This velocity was issued as criteria for establishing standoff distances.

7. Standoff Distances. It is recommended that the distance aft of the engine exhaust nozzle at which thrust velocities at ground level drop below 257 kph can be used as general criteria for determining safe standoff distances to asphalt edge pavements. Table 1 presents distances and related thrust levels.

Table 1. Safe Standoff Distances Aft of Engine

Aircraft	Power	Distance	Remarks
KC-10	N1 (100%)	53.3 m (175 ft)	
KC-10	N1 (100%)	67 m (220 ft)	3 engines
B-52H	Maximum	25.9 m (85 ft)	
KC-135A	Full	21.3 m (70 ft)	
KC-135R	Takeoff rated thrust (TRT)	45.7 m (150 ft)	
B-1B	Augmentor	103.6 m (340 ft)	
Boeing 747	Takeoff	45.7 m (150 ft)	4 engines
Boeing 777	Takeoff	106.6 m (350 ft)	
C-5A/B	Takeoff	64 m (210 ft)	
C-17	Takeoff	45.7 m (150 ft)	
C-141A/B	Maximum thrust	35 m (115 ft)	

8. Remedies. If airfield geometry precludes maintaining or establishing safe standoff distances, it is recommended to either install blast deflectors or replace the 51-millimeter-thick asphalt edge pavement with thicker asphalt edge pavement. The equation presented in paragraph 6 can be used to calculate a conservative required thickness.

9. 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, Attention: Capt Anthony Davit, DSN 523-6340, commercial (850) 283-6340, Internet anthony.davit@tyndall.af.mil; or Mr Jim Greene, DSN 523-6334, commercial (850) 283-6334, FAX DSN 523-6219, Internet james.greene@tyndall.af.mil.

MICHAEL J. COOK, Colonel, USAF
Technical Director

1 Atch
1. Distribution List

DISTRIBUTION LIST

DEPARTMENT OF DEFENSE

Defense Commissary Service (1)
Director of Facilities
Bldg 8400
Lackland AFB TX 78236-5000

Defense Technical Information Center (1)
ATTN: DTIC-FDA
Alexandria VA 22034-6145

AAFES/ATTN: CFE (1)
PO Box 660320
Dallas TX 75266-0320

SPECIAL INTEREST ORGANIZATIONS

IHS (A.A. DeSimone) (1)
1990 M Street NW, Suite 400
Washington DC 20036

Construction Criteria Database (1)
National Institute of Bldg Sciences
1201 L Street NW, Suite 400
Washington DC 20005