TSPWG 3-260-02.07-3
26 April 2019

TRI-SERVICE PAVEMENTS WORKING GROUP (TSPWG) MANUAL

JET ENGINE THRUST STANDOFF FOR AIRFIELD ASPHALT EDGE PAVEMENTS

TRI-SERVICE PAVEMENTS WORKING GROUP MANUAL (TSPWG M)

JET ENGINE THRUST STANDOFF FOR AIRFIELD ASPHALT EDGE PAVEMENTS

Indicate the preparing activity beside the Service responsible for preparing the document.

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND

AIR FORCE CIVIL ENGINEER CENTER (Preparing Activity)

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	Date	Location

This TSPWG Manual supersedes Air Force ETL 07-3, dated 14 February 2007.

FOREWORD

This Tri-Service Pavements Working Group (TSPWG) Manual supplements guidance found in other Unified Facilities Criteria, Unified Facilities Guide Specifications, Defense Logistics Agency Specifications, and Service-specific publications. All construction outside of the United States is also governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA) and, in some instances, Bilateral Infrastructure Agreements (BIA). Therefore, the acquisition team must ensure compliance with the most stringent of the UFCs referencing this TSPWG Manual, the SOFA, the HNFA, and the BIA, as applicable. This TSPWG Manual provides information on jet engine thrust standoff distances for airfield asphalt edge pavements. The information in this TSPWG Manual is referenced in technical publications found on the Whole Building Design Guide. This TSPWG Manual is not intended to take the place of Service-specific doctrine, technical orders (T.O.), field manuals, technical manuals, handbooks, Tactics, Techniques, and Procedures (TTPs), or contract specifications, but is used along with these to help ensure pavements meet mission requirements.

TSPWG Manuals are living documents and will be periodically reviewed, updated, and made available to users as part of the Services' responsibility for providing technical criteria for military construction, maintenance, repair, or operations. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Command (NAVFAC), and the Air Force Civil Engineer Center (AFCEC) are responsible for administration of this document. Technical content of this TSPWG Manual is the responsibility of the Tri-Service Pavements Working Group (TSPWG). Defense agencies should contact the preparing activity for document interpretation. Send recommended changes with supporting rationale to the respective Service TSPWG member.

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TRI-SERVICE PAVEMENTS WORKING GROUP MANUAL (TSPWG M)
NEW SUMMARY SHEET

Document: TSPWG Manual 3-260-02.07-3, *Jet Engine Thrust Standoff for Airfield Asphalt Edge Pavements*

Superseding: This TSPWG Manual supersedes Air Force ETL 07-3, *Jet Engine Thrust Standoff Requirements for Airfield Asphalt Edge Pavements*, dated 14 February 2007.

Description: This TSPWG presents supplemental technical guidance for minimum standoff distances from jet aircraft during engine run-up to prevent uplift forces causing catastrophic failure of asphalt edge pavements.

Reasons for Document: To ensure the material is available to all Services.

Impact: There is no cost impact. The following benefits should be realized.

- The life-cycle cost for a typical 2-inch (51-millimeter) -thick asphalt shoulder pavement will improve by minimizing the damage from uplift forces created by jet engine thrust that cause premature deterioration of edge asphalt pavement requiring additional maintenance and early replacement.
- The damage to aircraft, vehicles, and real property is reduced by minimizing FOD created by jet engine thrust on asphalt shoulders.
- Supplemental information on the operation, maintenance, and repair of airfield asphalt edge pavements as well as airfield damage repair will be available to all Services.
- Maintenance and upgrading of this supplemental information will include inputs from all Services.

Unification Issues: None

Note: The use of the name or mark of any specific manufacturer, commercial product, commodity, or service in this publication does not imply endorsement by the Department of Defense (DoD).

CHAPTER 1 INTRODUCTION

1-1 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 Tri-Service Pavements Working Group (TSPWG) Manual is being issued due to tangible life safety and financial concerns. This phenomenon has been observed and studied in the past.

1-2 PURPOSE AND SCOPE.

This TSPWG Manual presents supplemental technical guidance for minimum standoff distances from jet aircraft during engine run-up to prevent uplift forces causing catastrophic failure of asphalt edge pavements.

Applicability.

- All pavement 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 design and construction of airfield pavements
- All designers and construction contractors building airfield pavements

1-3 GLOSSARY.

Appendix B contains acronyms, abbreviations, and terms.

1-4 REFERENCES.

Appendix C contains a list of references used in this document. The publication date of the code or standard is not included in this document. Unless otherwise specified, the most recent edition of the referenced publication applies.

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CHAPTER 2 ANALYSIS

2-1 PAST GUIDANCE.

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 136.2 miles per hour (mph) or 199.8 feet per second (fps) (219.2 kilometers per hour [kph] or 60.87 meters per second [mps]):

Equation 2-1. Bernoulli Equation (Velocity of Air)

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

Equation 2-2. Density of Dry Air

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

where:

V = *velocity = fps (mps)*

∆p = *pressure change reading = 25 pounds per square foot [psf] (1.197 kilopascals [kPa]) for a 2-inch [in.] (51-milimeter [mm]) -thick asphalt mass*

g = *standard acceleration due to gravity = 32.2 fps (9.81 mps)*

p = *air pressure = pounds per square inch [psi] (Pascal [Pa])*

ρ = *density of moving air = 14.7 pounds per square inch absolute [psia] (101.4 kPa) at sea level*

R = *gas constant air = 53.3 pound-force foot per pound °Rankine [ft-lb/lb °R] (286.7 Joules per kilogram Celsius [J/(kg °C)])*

T = *air temperature = °Rankine [°R] - 985°R (274.07 °Celsius [°C]) (typical exhaust temperature at expected velocity and distance of interest) (274.07 °Celsius [C°])*

However, empirical observation has indicated that the typical 2-in. (51-mm) -thick edge pavement can withstand velocities up to 225 mph (362 kph). This higher observed velocity was accepted as a valid basis for criteria development because the simple Bernoulli model ignored other forces that 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 225 mph (362 kph) by the square root of this safety factor yielded a threshold velocity of 160 mph (257 kph). This velocity is issued as criteria for establishing standoff distances.

2-2 STANDOFF DISTANCES.

Position aircraft so jet blast velocities are below 160 mph (257 kph) at the edge of a typical 2-in. (51.mm) -thick asphalt shoulder pavement to avoid damage to the asphalt shoulder pavement. Table 2-1 lists the standoff distance aft of the aircraft engine exhaust nozzle where data indicates the engine exhaust velocity is reduced to 160 mph (257 kph). Where data indicates that the actual velocity would be lower than this threshold velocity value, a minimum standoff distance of 25 feet (ft) (8 meters [m]) is recommended.

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

Aircraft	Aircraft Tail Standoff Distance	Jet Blast Velocity Data Source	Remarks
B-1B	290 ft (88 m)	TSC Report 13-2	
B-52H	25 ft (8 m)	TSC Report 13-2	See note 3
C-5A/B	75 ft (23 m)	TSC Report 13-2	
C-9A	65 ft (20 m)	TSC Report 13-2	
C-17	60 ft (18 m)	TSC Report 13-2	
C-20B	60 ft (18 m)	TSC Report 13-2	See note 6
C-21A	30 ft (9 m)	TSC Report 13-2	
C-32 (Boeing 757-200)	180 ft (55 m)	TSC Report 13-2	
C-37A	60 ft (18 m)	TSC Report 13-2	See note 6
C-40 (Boeing 737-700)	85 ft (26 m)	Boeing	
C-130	25 ft (8 m)	TSC Report 13-2	See note 3
C-141A/B	30 ft (9 m)	TSC Report 13-2	
KC-10A	200 ft (61 m)	TSC Report 13-2	3 engines
KC-135E/R EC-135A/G/L RC-135	105 ft (32 m)	TSC Report 13-2	
VC-25A (B747-200)	85 ft (26 m)	Boeing	
Boeing 707	115 ft (35 m)	Boeing	
Boeing 727	110 ft (34 m)	Boeing	

Aircraft	Aircraft Tail Standoff Distance	Jet Blast Velocity Data Source	Remarks
Boeing 737	85 ft (26 m)	Boeing	
Boeing 747	115 ft (35 m)	Boeing	
Boeing 757	160 ft (49 m)	Boeing	
Boeing 767	150 ft (46 m)	Boeing	
Boeing 777	310 ft (94 m)	Boeing	
DC-9	75 ft (23 m)	Boeing	
DC-10	240 ft (73 m)	Boeing	
MD-80	120 ft (37 m)	Boeing	
Airbus A300F4-600	100 ft (30 m)	Airbus	
Airbus A318-100	40 ft (12 m)	Airbus	
Airbus A319	25 ft (8 m)	Airbus	See note 3
Airbus A320	85 ft (26 m)	Airbus	
Airbus A321	25 ft (8 m)	Airbus	See note 3
Airbus A330	250 ft (76 m)	Airbus	
Airbus A340	No jet blast data available for >102 mph (164 kph)		
Airbus A380	350 ft (107 m)	Airbus	
AN-124	No jet blast data available		
IL-76	No jet blast data available		

Notes:

1. If the design aircraft is not listed in Table 2-1, bases should contact the Pavements Discipline Working Group (DWG) or their designated representative 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. When data indicate jet blast velocities are less than 160 mph (257 kph) at the back of the aircraft tail, it is recommended that a minimum 25-ft (8-m) standoff 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.

2-3 RUN-UP PAD DESIGN.

The following presents supplemental technical guidance when designing new or checking existing engine run-up pads for minimum standoff distances from jet aircraft during engine run-up to prevent uplift forces causing catastrophic failure of asphalt edge pavements.

2-3.1 New and Existing Run-up Pads.

Design or modify new and existing run-up pads to provide the full standoff distance behind the tail of the aircraft, as listed in Table 2-1.

2-3.2 Minimum Distances.

When it is not possible or practical to meet the distances listed in Table 2-1, provide a minimum 25 ft (8 m) of portland cement concrete (PCC) pavement 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.

2-3.3 Other Objects in Jet Blast Wake.

Give consideration to other objects in the jet blast wake, such as roads, walkways, parking lots, hangars, lights, cargo. Take precautions to eliminate the potential for damage caused by flying debris.

2-4 RUN-UP PAD MARKINGS.

Proper marking of engine run-up pads is critical to ensure aircraft positioning meet minimum standoff distances from jet aircraft during engine run-up to prevent uplift forces causing catastrophic failure of asphalt edge pavements. All markings must comply with UFC 3-260-04, *Airfield and Heliport Marking*. The following additional information is provided on current and future run-up pad locations.

2-4.1 Centerline Marking.

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

2-4.2 Nose Wheel Stop-Block Marking.

Provide a nose wheel stop-block marking for the primary assigned aircraft that use 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, but do not park aircraft on nose wheel stop-block markings that provide less standoff distance.

2-4.3 Nose Wheel Label.

Label each nose wheel stop-block marking for each aircraft intended to use the run-up pad. Per UFC 3-260-01, *Airfield and Heliport Planning and Design*, and UFC 3-260-04, provide only stop-block markings for primary assigned aircraft. Transient aircraft using the run-up pad are evaluated on a case-by-case basis.

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APPENDIX A BEST PRACTICES

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APPENDIX B GLOSSARY

°C	Degree Celsius
°R	Degree Rankine
DWG	Design Working Group
ETL	Engineering Technical Letter
fps	Foot Per Second
ft	Foot
in.	Inch
kPa	Kilopascal
kph	Kilometer Per Hour
m	Meter
mm	Millimeter
mph	Mile Per Hour
mps	Meter Per Second
psf	Pound per Square Foot
TSC	[USACE] Transportation Systems Center

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APPENDIX C REFERENCES

DOD

UFC 3-260-01, *Airfield and Heliport Planning and Design*, https://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc

UFC 3-260-04, *Airfield and Heliport Marking*, https://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc

ARMY

TSC Report 13-2*, Aircraft Characteristics* for *Airfield Pavement Design and Evaluation*. **This document is FOUO.** Request copies from the Transportation Systems Center: https://transportation.erdc.dren.mil/triservice/Default.aspx

BOEING

Airplane Characteristics for Airport Planning, https://www.boeing.com/commercial/airports/plan_manuals.page

AIRBUS

Aircraft Characteristics - Airport Operations & Tech Data, https://www.airbus.com/aircraft/support-services/airport-operations-and-technical-data/aircraft-characteristics.html