Runway Surface Condition Assessment and Reporting

History Behind FAA Friction Level Classifications

Presented to: Symposium Attendees

By: Raymond Zee, PE, Civil Engineer

Office of Safety and Standards

Airport Engineering

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Overview

- Period from 1970's to the present.
- Initially used to establish operational characteristics of pavements particularly on contaminated runways.
- The development and increased use of turbojet aircraft necessitated the use of friction monitoring techniques to detect the presence of rubber contaminants and/or polished aggregates.
- The Mu meter was the first CFME described.

First There Was Mu

1972 – AC 150/5320-9 Use of Friction Measuring Device in Engineering and Maintenance of Airport Pavement Surface:

- **Based research and development in techniques and equipment by the FAA, USAF, NASA, and United Kingdom.**
- **Guidance was based on ICAO Annex 14**
- **Interesting to note that the mu readings described were "relative friction values."**
- **Not a means to predict aircraft stopping distances.**

Based on Contaminants

ICE AND SNOW

Coefficients of Friction	Description
0.40 & above	Good
0.39 - 0.36	Medium to Good
0.35 - 0.30	Medium
0.29 - 0.26	Medium to Poor
0.25 & below	Poor

Based on Contaminants

WATER AND SLUSH

Coefficients of Friction	Description
0.40 & above	Good
0.30 - 0.39	Medium
0.29 & below	Poor

Then in 1975…

The concept of texture (NASA grease smear method) was introduced:

(1) When the AVERAGE TEXTURE DEPTH is equal to or less than 0.020 inches for more than 50 percent of the runway surface, improvements should be made to increase the surface texture to an acceptable level of at least 0.050 inches. Suggested methods for improving texture are given in Chapter 3 and include grooving, porous friction course, and aggregate seal coats. Average texture depths for pavements can be measured by using the NASA grease-smear method. For explanation of the method, see Appendix 2.

(2) When the AVERAGE TEXTURE DEPTH is equal to or greater than 0.050 inches, no further texturing effort is required.

1975 Continued:

The handling of mu and as a result of contaminants was better defined:

(1) When the AVERAGED MU VALUE within the contaminated area is 0.49 or less, for a distance of 500 feet or more, the entire contaminated area should be cleaned.

(2) When the AVERAGED MU VALUE within the contaminated area is 0.29 or less, for a distance of 250 feet or more, the entire contaminated area should be cleaned.

(3) When the DIFFERENCE IN MU VALUES either between the uncontaminated and contaminated areas or within the contaminated surface itself is 0.25 or greater, for a distance of 250 feet or less, the entire contaminated area should be cleaned.

Paint Marking Areas Considered:

(1) When the MINIMUM MU VALUE over the length of the runway marking is 0.25 or less and/or DIFFERENCE IN MU VALUES between the unpainted and painted surfaces is 0.25 or greater, the painted areas should be completely removed and repainted (without glass beads) in a striated pattern. Markings should be striated as shown in Figure 2-2, Appendix 1, of AC 150/5340-1, Marking of Paved Areas on Airports.

As Well as Pavement Abnormalities (Ponding):

(1) When the DIFFERENCE IN MU VALUES between the flooded depressed areas and the surrounding pavement surface is 0.25 or greater for distances exceeding 100 feet, or if there is a repetition of ponded areas, corrective action should be taken. Depending on the extent and circumstances of the depressed areas, minimal normal maintenance to a completely new overlay may be required.

And the First Appearance of the "Minimal Average Friction" Requirement:

Minimal Average Friction Requirement for Runway Pavements. After the runway has been cleared of contaminants, the AVERAGE WET MU VALUE should not be less than 0.50 for each 1,000 foot increments of the runway length. If any increment does not meet this requirement, the entire runway should be corrected according to the suggested methods given in Chapter 3.

As Researched Continued…

- NASA Flight Center Wallops Flight Facility, Virginia
- NASA Langley Research Center, Virginia
- 12A was published and Minimum Friction requirements were based on mu.

a. Friction Deterioration Below Minimum for 500 Feet. When the averaged Mu value on the wet runway pavement surface is less than 50 but above 40 for a distance of 500 ft (152 m), and the adjacent 500 ft (152 m) segments are above 50, no corrective action is required. These readings indicate that friction is approaching the minimum desired value of 50 and the area in question should be monitored closely by conducting periodic friction surveys to establish the rate and extent of the friction deterioration.

b. Friction Deterioration Below Minimum for 1000 Feet. When the averaged Mu value on the wet runway pavement surface is less than 50 for a distance of 1000 ft (305 m) or more, the airport owner should conduct an extensive evaluation into the cause and extent of the friction deterioration and take corrective action to eliminate the situation.

c. Friction Deterioration Below Minimum for 1500 Feet. When the averaged Mu value on the wet runway pavement surface is less than 40 for a distance of 500 ft (152 m), and the adjacent segments are below 50, corrective action should be taken immediately after determining the cause(s) of the friction deterioration. The overall condition of the entire runway pavement surface should be evaluated with respect to the deficient area before undertaking corrective measures.

c. <u>Friction Deterioration Below Minimum for 1500 Feet.</u> When the averaged Mu value on the wet runway pavement surface is less than 40 for a distance of 500 ft (152 m), and the adjacent segments are below 50, corrective action should be taken immediately after determining the cause(s) of the friction deterioration. The overall condition of the entire runway pavement surface should be evaluated with respect to the deficient area before undertaking corrective measures.

d. <u>Friction Deterioration at Higher Speeds.</u> When the difference between the averaged mu values over a distance of 500 feet (152 m) for speeds of 40 mph (65 kmh) and 60 mph (97 kmh) is greater than 10, the airport owner should conduct an extensive evaluation into the cause and extent of the friction deterioration and take corrective action to eliminate the situation.

Introduction of “Other” Friction Testers (For newly constructed pavements):

Table 1-5. Correlation of Mu Values for Friction Measuring Devices Under Self-wetting Conditions at 40 mph

Mu Meter Mark IV	Saab Friction Tester	Runway Friction Tester	Skiddometer BV-11
40	45	47	51
50	62	60	67
70	97	84	98

1991 - 12B

- **Added the following table:**

TABLE 3-2 CORRECTIVE ACTION BASED ON VISUAL ESTIMATION OF RUBBER DEPOSITS ACCUMULATED ON RUNWAY

DESCRIPTION OF RUBBER COVERING PAVEMENT TEXTURE IN TOUCHDOWN ZONE OF RUNWAY AS OBSERVED BY EVALUATOR	CLASSIFICATION OF RUBBER DEPOSIT ACCUMULATION LEVELS	ESTIMATED RANGE OF MU VALUES AVERAGED 500 FOOT SEGMENTS IN TOUCHDOWN ZONE	SUGGESTED LEVEL OF ACTION TO BE TAKEN BY AIRPORT AUTHORITY
Intermittant individual tire tracks. 95 % of surface texture exposed	VERY LIGHT	0.65 or greater	None
Individual tire tracks begin to overlap. 80 % to 94 % surface texture exposed	LIGHT	0.55 to 0.64	None
Central 20 foot traffic area covered. 60 % to 79 % surface texture exposed	LIGHT TO MEDIUM	0.50 to 0.54	Monitor deterioration closely.
Central 40 foot traffic area covered. 40 % to 59 % surface texture exposed	MEDIUM	0.40 to 0.49	Schedule rubber removal within 120 days.
Central 50 foot traffic area covered. 30 % to 69 % of rubber vulcanized and bonded to pavement surface. 20 % to 39 % surface texture exposed	MEDIUM TO DENSE	0.30 to 0.39	Schedule rubber removal within 90 days.
70 % to 95 % of rubber vulcanized and bonded to pavement surface. Will be difficult to remove. Rubber has glossy or sheen look. 5 % to 19 % surface texture exposed	DENSE	0.20 to 0.29	Schedule rubber removal within 60 days.
Rubber completely vulcanized and bonded to surface. Will be very difficult to remove. Rubber has striations and glossy or sheen look. 0 % to 4 % surface texture exposed	VERY DENSE	Less than 0.19	Schedule rubber removal within 30 days or as soon as possible.

1991 - 12B

- Mu ranges are based are from a fixed brake (slip) CFME.
- Correlation tests were made based on testing in 1989 at Wallops.
- Tire performance per ASTM E 670 or ASTM ES 17.
- Distance Criteria:
  - 1000' below MPFL – evaluate
  - 500' below MFL and adjacent 500' below MPFL – corrective action

TABLE 3-3 FRICTION LEVEL CLASSIFICATION FOR RUNWAY PAVEMENT SURFACES

TYPE OF FRICTION EQUIPMENT	MOUNTED WITH DICO TIRE: MARK 4 MU METER TRAILER		MOUNTED WITH McCREARY TIRE: M 6800 RUNWAY FRICTION TESTER		MOUNTED WITH McCREARY TIRE: BV-11 SKIDDOMETER TRAILER	MOUNTED WITH McCREARY TIRE: MARK 2 SAAB FRICTION TESTER
RUNWAY SURFACE FRICTION LEVEL CLASSIFICATION	FRICTION SURVEY SPEED		FRICTION SURVEY SPEED		FRICTION SURVEY SPEED	
	40 MPH	60 MPH	40 MPH	60 MPH	40 MPH	60 MPH
	FRICTION VALUES		FRICTION VALUES		FRICTION VALUES	
MINIMUM	42	26	50	41	50	34
MAINTENANCE PLANNING	52	38	60	54	60	47
NEW DESIGN/ CONSTRUCTION	72	66	82	72	82	74

1997 – 12C

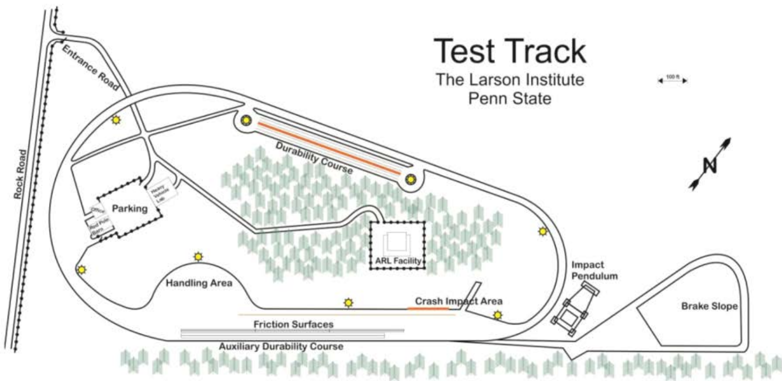
TABLE 3-2. FRICTION LEVEL CLASSIFICATION FOR RUNWAY PAVEMENT SURFACES

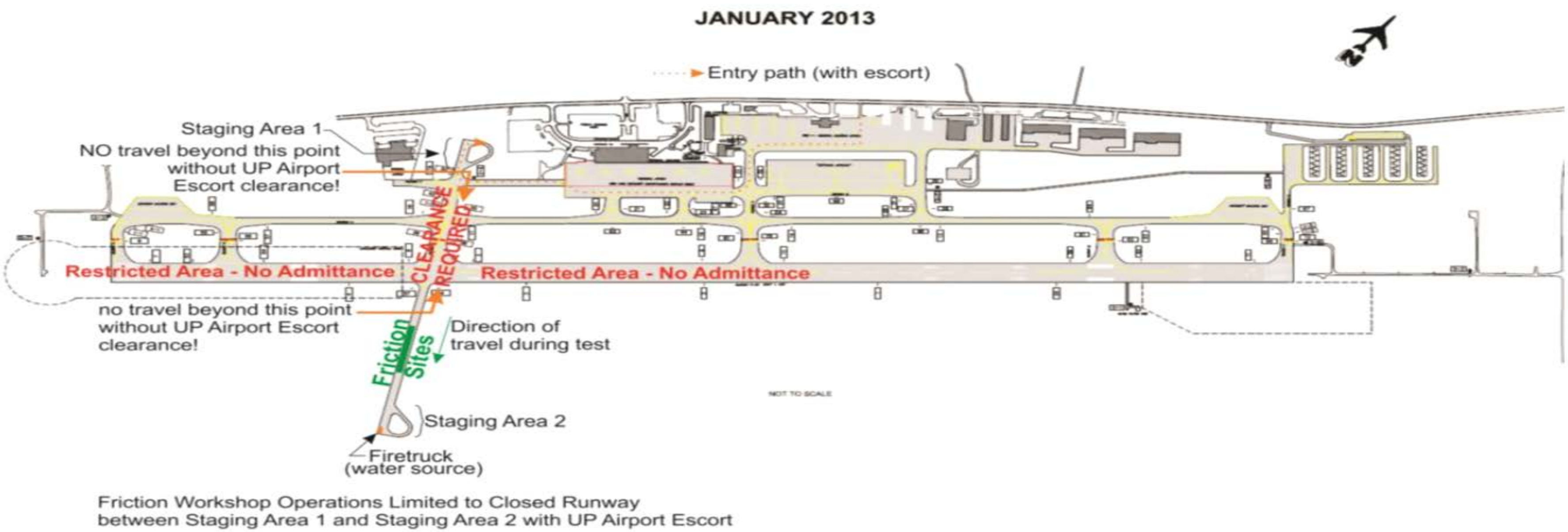
	40 mph			60 mph		
	Minimum	Maintenance Planning	New Design/ Construction	Minimum	Maintenance Planning	New Design/ Construction
Mu Meter	.42	.52	.72	.26	.38	.66
Dynatest Consulting, Inc. Runway Friction Tester	.50	.60	.82	.41	.54	.72
Airport Equipment Co. Skiddometer	.50	.60	.82	.34	.47	.74
Airport Surface Friction Tester	.50	.60	.82	.34	.47	.74
Airport Technology USA Safegate Friction Tester	.50	.60	.82	.34	.47	.74
Findlay, Irvine, Ltd. Griptester Friction Meter	.43	.53	.74	.24	.36	.64
Tatra Friction Tester	.48	.57	.76	.42	.52	.67
Norsemeter RUNAR (operated at fixed 16% slip)	.45	.52	.69	.32	.42	.63

The Transition

- Correlations based on Friction Workshop at Wallops.
- Last Friction Workshop held in 2008.
- Workshop moved to Penn State University/ The Larson Institute in 2009.

A New Direction





A New Direction

- Annual Penn State Friction Workshop
- Federal Aviation Administration and Federal Highway Administration Sponsorship
- Vendor Sponsorship
- ASTM support
- 8 surfaces at the University Test Track
- 5 surfaces at the University Park Airport
- Banked University test track became issues for some CFMEs

A New Direction

A final look at the lack of harmonization:

- **Operator Training**
- **Calibrations:**

  Force (Load) – independent verification that the equipment is reading the load on the wheel.

  Speed – easy to verify – radar gun.

  Water (1mm) – how do we know that the system is putting down 1mm of water in front of the test tire?

  Slip – is the assumed slip the actual slip?

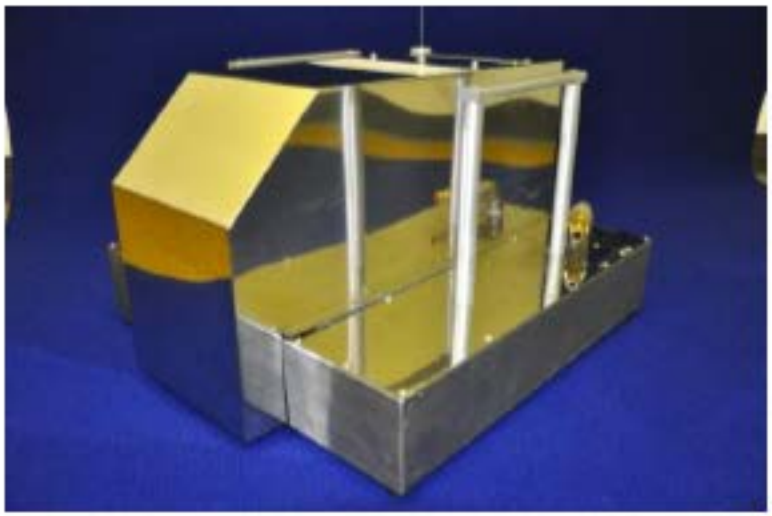
Operator Training

- **Workshop providing some training.**
- **Advisory Circular provides training requirements as well.**
- **ASTM may offer as well.**
- **Other third parties.**
- **Lack of training standards – dependent on CFME.**

Performance Based Requirements

- **Test Surface mu based on correlation to texture equipment.**

CTM



DFT

Force Calibration (w/tire on plate)

- Vertical load on the plate should match load recorded on the CFME.
- Horizontal loads (longitudinal and lateral) should match forces recorded on the CFME.

Figure 12. Force Calibration Pit and Platform

Speed Calibration

Figure 17. STALKER radar system and display used for speed calibration station.

Water Calibration

Figure 13. Water calibration station.

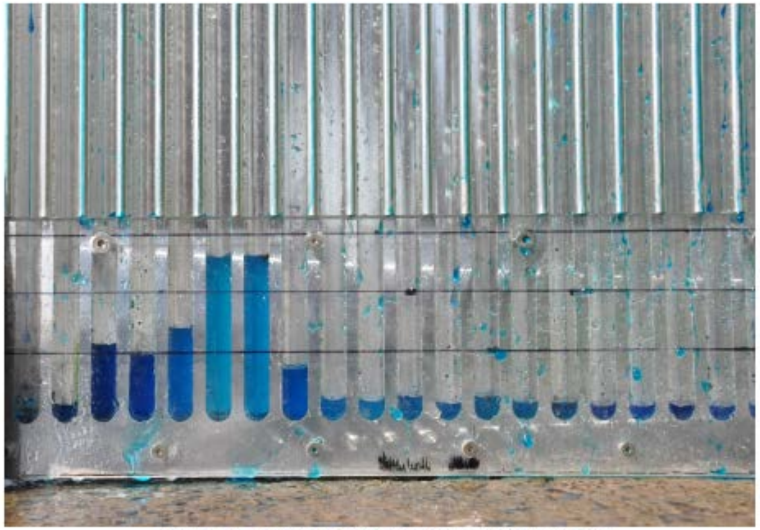


Figure 14. Close-up of one end of the water collection tray.

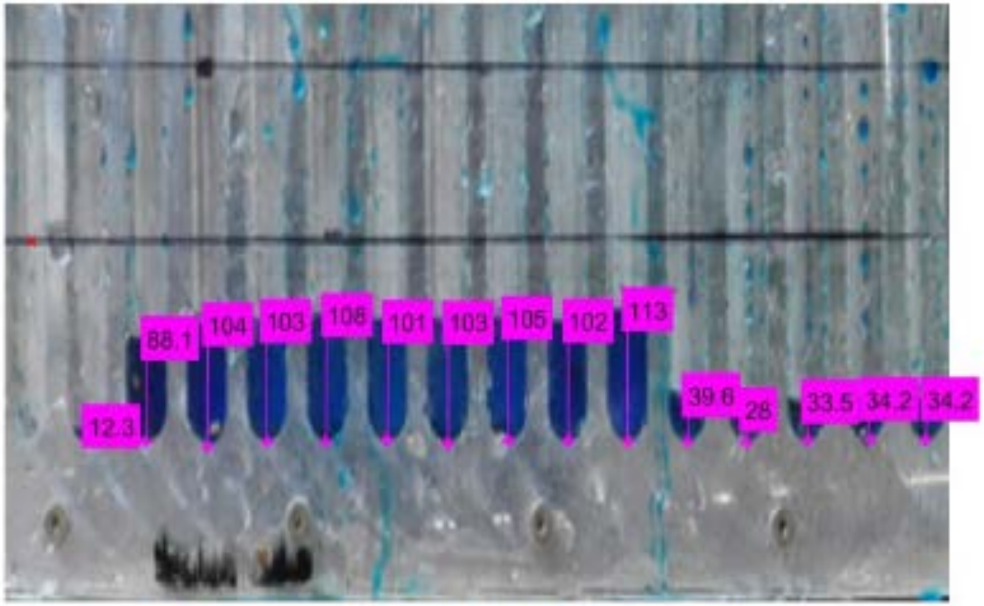


Figure 15. Example picture showing pixel measurement

Slip Calibration

Dev7 TireHysteresis.mp4

Objectives:

- **Pure harmonization of all equipment.**
- **Eventual third party approval or certification of current and new equipment.**

Other Relevant Research

- Shift to aircraft braking mu and braking on contaminants.
- Utilization of data from landing aircraft to provide almost real-time braking mu.
- Investigating the relationships between the aircraft ABS, contaminants, and brake line pressures.
- Nose and main gear instrumented 727 at FAA Tech Center in Atlantic City, NJ.

Application of Manufactured Snow

Manufactured Snow Dual Test Strip

Aircraft Braking Dual Test Strip

Thank You!