U.S. Department
of Transportation
Federal Aviation
Administration

Advisory Circular

Subject: Measurement and Maintenance of Skid-Resistant Airport Pavement Surfaces

Date: DRAFT
Initiated by: AAS-100

AC No: 150/5320-12D

1. What is the purpose of this Advisory Circular (AC)?

This AC contains guidelines and procedures for pavement evaluation with friction measuring equipment, and maintenance of high skid-resistant pavements.

2. Does this AC cancel any prior ACs?

This AC cancels AC 150/5320-12C, Measurement, Construction, and Maintenance of Skid-Resistant Airport Pavement Surfaces, dated March 18, 1997.

3. To whom does this AC apply?

The FAA recommends that guidelines and standards contained herein for applications involving runway friction measurement and maintenance.

4. What are the principal changes in this AC?

a. The Neubert Aero Corp. (NAC) Dynamic Friction Tester has been added as an approved Continuous Friction Measuring Equipment (CFME).

b. The Halliday Technologies RT3 has been added as an approved Continuous Friction Measuring Equipment (CFME).

c. The Traction Watcher One (TWO) has been added as an approved CFME.

d. Guidance for the design and construction of skid-resistant pavements is now contained in AC 150/5370-10, Standards for Specifying Construction of Airports.

e. Recommended texture measuring techniques have been revised.

f. Contact information for approved CFME has been updated.

5. How are metrics represented?

Throughout this AC, customary English units are used followed with “soft” (rounded) conversion to metric units. The English units govern.

6. How can I acquire this AC, other FAA publications, and related reading material?

You can view a list of all ACs at http://www.faa.gov/regulations_policies/advisory_circulars/. You can view the Federal Aviation Regulations at http://www.faa.gov/regulations_policies/faa_regulations/.

APPENDIX B contains a listing of documents containing supplemental material relating to the subject. Information on ordering these documents is also provided.

7. How can I provide comments or suggestions for improvements to this AC?

You can provide comments or suggestions for improvements to this AC to:

Manager, Airport Engineering Division
Federal Aviation Administration
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Table of Contents

List of Figures

List of Tables

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CHAPTER 1. OVERVIEW

1-1. PURPOSE. This AC provides guidelines for maintaining skid-resistant airport pavement surfaces and for conducting evaluations and surveys of runway friction for pavement maintenance purposes. It also contains performance specifications for friction measuring equipment. Guidance on pavement friction measurement for aircraft operational purposes during winter weather and performance standards for decelerometers are found in AC 150/5200-30, Airport Winter Safety and Operations.

1-2. BACKGROUND. Since the advent of turbojet aircraft with their greater weight and high landing speeds, braking performance on runway surfaces, particularly when wet, has become a significant safety consideration. A number of research programs sponsored by FAA, NASA, and USAF, as well as those performed by foreign governments, have been directed in two major areas: original pavement surface design to maximize skid resistance with proper materials and construction techniques; and effective evaluation and maintenance techniques to detect deterioration of skid-resistance and to restore it to acceptable levels.

1-3. PAVEMENT DESIGN RESEARCH. Pavement grooving was the first major step in achieving safer pavement surfaces for aircraft operations in wet weather conditions. These studies were completed by NASA at the Langley Research Center, Langley, Virginia, in 1968. The FAA, through its Technical Center in Atlantic City, New Jersey, directed a test program on pavement surface treatments at the Naval Air Engineering Center, Lakehurst, New Jersey. The study was completed in 1983. Both the NASA Langley and the FAA Technical Center studies showed that a high level of friction could be achieved on wet pavement by forming or cutting closely spaced transverse grooves on the runway surface to allow rain water to escape from beneath tires of landing aircraft.

In addition, a number of studies were carried out, and are continuing, on basic skid-resistant behaviors of pavement surfaces, both HMA and Portland cement concrete (PCC). See AC 150/5370-10, Standards for Specifying Construction of Airports, for guidance on designing and constructing skid-resistant pavements.

1-4. PAVEMENT MAINTENANCE AND EVALUATION RESEARCH. Regardless of pavement type or surface treatment, runway friction characteristics will change over time, depending on type and frequency of aircraft activity, weather, environmental effects, and other factors. Pavements are subject to ordinary mechanical wear and tear from aircraft tires. In addition, contaminants such as rubber deposits, dust particles, jet fuel, oil spillage, water, snow, ice, and slush can collect on runway pavement surfaces and cause a decrease in friction. Rubber is deposited in the touchdown areas on runways by the skidding of airplane tires spinning up on landing. Such deposits can completely cover the pavement surface texture, causing loss of aircraft braking capability and directional control when runways are wet.

In October 1978, the FAA embarked on a 2-year program to conduct friction and pavement evaluation surveys at 268 airports (491 runways) within the contiguous United States. The information obtained represented a very broad collection of data on the friction characteristics of runways at airports that have turbojet aircraft operations. Field observations of the runway pavement surface conditions and analysis of the friction test data identified those areas on the runway pavement which were below the minimum acceptable friction level. Test data and surface condition information obtained during this program were given to airport owners so that they could take proper corrective measures to eliminate runway pavement deficiencies.

1-5. FRICTION MEASURING EQUIPMENT RESEARCH. Beginning in the early 1970's, NASA, FAA, and USAF conducted runway traction studies to determine the correlation between various types of aircraft and friction measuring equipment. These studies showed a fair correlation between some of the friction measuring devices, but the tests on correlation between the friction devices and aircraft were inconclusive. The tests did show, however, that friction measuring devices were effective when used to evaluate pavement surface friction properties for maintenance purposes.

In March of 1990, FAA concluded a test program to evaluate the performance of different tires on approved friction measuring devices and to develop correlation data in order to ensure that devices of different manufacture and design would give comparable results in field use. APPENDIX A summarizes research on qualification and correlation of friction measuring equipment.

CHAPTER 2. QUALITIES OF SKID-RESISTANT PAVEMENTS

Section 1. Basic Design Considerations

2-1. GENERAL. In building new runways, major reconstruction, or adding overlays, the design engineer must choose either HMA or PCC as the basic paving component. The selection is usually based on economics, local preference, and other design factors. These considerations, as well as basic pavement structural design, are covered in AC 150/5320-6, Airport Pavement Design and Evaluation. This AC is limited to discussion only of the surface of the airport pavement, literally "where the rubber meets the runway."

2-2. SURFACE TEXTURE AND DRAINAGE. In discussing the effects of pavement texture on friction and hydroplaning, two terms commonly used to describe the pavement surface are micro-texture and macro-texture. Micro-texture refers to the fine scale roughness contributed by small individual aggregate particles on pavement surfaces which are not readily discernible to the eye but are apparent to the touch, i.e., the feel of fine sandpaper. Macro-texture refers to visible roughness of the pavement surface as a whole. Micro-texture provides frictional properties for aircraft operating at low speeds and macro-texture provides frictional properties for aircraft operating at high speeds. Together they provide adequate frictional properties for aircraft throughout their landing/takeoff speed ranges.

The primary function of macro-texture is to provide paths for water to escape from beneath the aircraft tires. This drainage property becomes more important as the aircraft speed increases, tire tread depth decreases, and water depth increases. All three of these factors contribute to hydroplaning. Good micro-texture provides a degree of "sharpness" necessary for the tire to break through the residual water film that remains after the bulk water has run off. Both properties are essential in maintaining skid-resistant pavement surfaces.

Textural appearances, however, can be deceiving. A rough looking surface could provide adequate drainage channels for the water to escape, but the fine aggregate in the pavement may consist of rounded or uncrushed mineral grains that are subject to polishing by traffic, thereby causing the pavement surface to become slippery when wet. Likewise, a less rough looking surface, that may even have a shiny appearance when wet, will not necessarily be slippery if it has good micro-textural properties.

All paving should, of course, be constructed with appropriate transverse slope for basic drainage and must have adequate provision for prompt removal of storm runoff. AC 150/5300-13, Airport Design, provides guidance in this area.

2-3. PAINTED AREAS ON PAVEMENT SURFACES. Painted areas of wet runway pavement surfaces can be very slippery. In addition, an aircraft with one main gear on a painted surface, and the other on an unpainted surface, may experience differential braking. It is important to keep the skid-resistance properties of painted surfaces as close to that of unpainted surfaces as possible. Usually this means adding a small amount of silica sand to the paint mix to increase the friction properties of the painted surface. Glass beads, while used primarily to increase conspicuity of markings, have been shown to increase friction levels, also.

Section 2. Hot-Mix Asphalt (HMA) Pavement

2-4. CONSTRUCTION TECHNIQUES FOR HMA PAVEMENT. The construction specification for HMA pavement is contained in AC 150/5370-10, Standards for Specifying Construction of Airports.

2-5. CHIP SEAL. Recent advances in polymer technology have demonstrated the ability for durable, long term improvement of runway surface friction through the use of polymer-based chip seals. Sound engineering judgment should be exercised in the selection of a product when considering the use of polymer-based chip seals for longer term improvements. This technology has not been demonstrated to be compatible with grooved surfaces. A fog seal must be applied on top of the chip seal to minimize loose chips and tire damage. Chips should have a maximum size of 4.75mm (No. 4 sieve) to further minimize aircraft and tire damage.

2-6. AGGREGATE SLURRY SEAL. Temporary improvement of skid-resistance for pavement surfaces can be gained by constructing an aggregate slurry seal, either gradation type II or type III, as given in the specification in AC 150/5370-10. Aggregate slurry seals are recommended only as an interim measure until an overlay is constructed. This type of construction is usually adequate for 2 to 5 years. Figure 2-1 shows a typical type II aggregate slurry seal. Experience has shown that slurry seals do not hold up well in cold climates where snow removal occurs. A life cycle cost analysis should be conducted to determine the long term benefits.

Section 3. Portland Cement Concrete (PCC) Pavement

2-7. CONSTRUCTION TECHNIQUES FOR PCC PAVEMENT. The basic construction specifications for PCC pavement are given in AC 150/5370-10. Quality concrete is a prerequisite to the retention of pavement skid-resistance. The physical properties of the fine aggregates and effectiveness of curing are important factors in improving wear resistance.

2-8. SUITABILITY OF EXISTING PAVEMENTS FOR GROOVING. Existing pavements may have surfaces that are not suitable for sawing grooves. A survey should be conducted to determine if an overlay or rehabilitation of the pavement surface is required before grooving.

a. Reconnaissance. A thorough survey should be made of the entire width and length of the runway. Bumps, depressed areas, bad or faulted joints, and badly cracked and/or spalled areas in the pavement should not be grooved until such areas are adequately repaired or replaced. To verify the structural condition of the pavement, tests should be taken in support of the visual observations.

b. Tests. The strength and condition of the runway pavement should be evaluated and tested according to the procedures specified in ACs 150/5320-6 and 150/5370-10. Future aircraft loads and activity levels should be considered when making the evaluation. Core samples should be taken in HMA pavement to determine stability. The American Society for Testing and Materials (ASTM) Standard D 1559, Standard Test Method for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus, provides methods for testing the resistance to plastic flow of HMA pavements. Engineering judgment should be exercised when employing these methods in determining the stability readings. These tests are recommended to be used for guidance only.

Other factors should be considered in determining how long grooves will remain effective in HMA pavements, such as maximum operational pavement surface temperature, effective tire pressure, frequency of braking action in given areas, mix composition, and aggregate properties. If, in the judgment of the person evaluating the existing pavement, any of the above conditions are not met, the pavement should not be grooved.

2-9. OVERLAYS. If the evaluation shows that the existing pavement is not suitable, either because of surface defects or from a strength standpoint, an overlay, flexible or rigid, will be required. The new overlay may then be grooved according to the instructions given in the following paragraphs:

2-10. PAVEMENT GROOVING. Construction specifications for grooving are given in AC 150/5370-10.

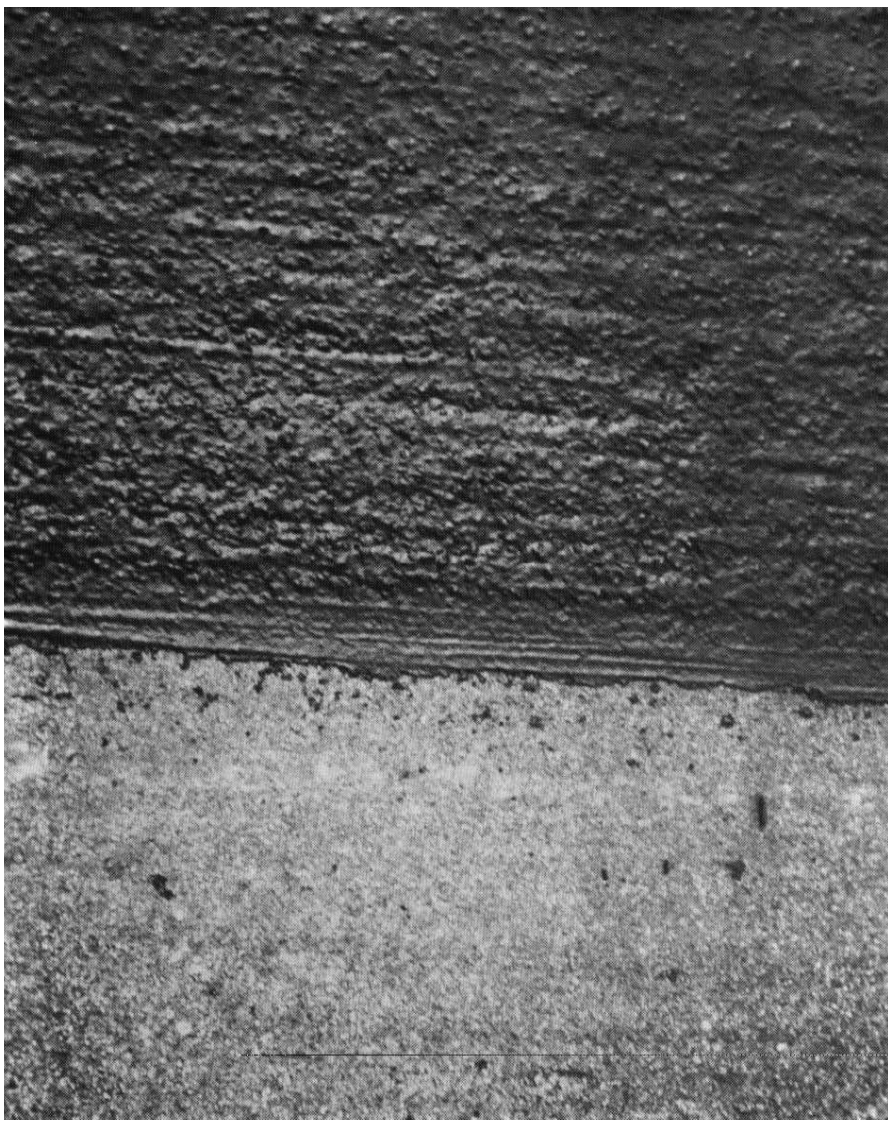

Figure 2-1**. AGGREGATE SLURRY SEAL**

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CHAPTER 3. PAVEMENT EVALUATION

Section 1. Need for and Frequency of Evaluation

3-1. FRICTION DETERIORATION. Over time, the skid-resistance of runway pavement deteriorates due to a number of factors, the primary ones being mechanical wear and polishing action from aircraft tires rolling or braking on the pavement, and the accumulation of contaminants, chiefly rubber, on the pavement surface. The effect of these two factors is directly dependent upon the volume and type of aircraft traffic. Other influences on the rate of deterioration are local weather conditions, the type of pavement (HMA or PCC), the materials used in original construction, any subsequent surface treatment, and airport maintenance practices.

Structural pavement failure such as rutting, raveling, cracking, joint failure, settling, or other indicators of distressed pavement can also contribute to runway friction losses. Prompt repair of these problems should be undertaken as appropriate. Guidance on corrective action may be found in CHAPTER 2 and AC 150/5380-6.

Contaminants, such as rubber deposits, dust particles, jet fuel, oil spillage, water, snow, ice, and slush, all cause friction loss on runway pavement surfaces. Removal and runway treatment for snow, ice, and slush are covered in AC 150/5200-30. The most persistent contaminant problem is deposit of rubber from tires of landing jet aircraft. Rubber deposits occur at the touchdown areas on runways and can be quite extensive. Heavy rubber deposits can completely cover the pavement surface texture causing loss of aircraft braking capability and directional control, particularly when runways are wet.

3-2. SCHEDULING PAVEMENT EVALUATIONS. The operator of any airport with significant jet aircraft traffic should schedule periodic friction evaluations of each runway that accommodates jet aircraft. These evaluations should be carried out in accordance with the procedures outlined in either CHAPTER 3. Section 2 or Section 3 of this chapter, depending upon the availability to the airport operator of CFME. Every runway for jet aircraft should be evaluated at least once each year. Depending on the volume and type (weight) of traffic on the runways, evaluations will be needed more frequently, with the most heavily used runways needing evaluation as often as weekly, as rubber deposits build up. Runway friction measurements take time, and while tests are being conducted, the runway will be unusable by aircraft. Since this testing is not time critical, a period should be selected which minimizes disruption of air traffic. Airport operations management should work closely with air traffic control, fixed base operators, and/or airlines.

3-3. MINIMUM FRICTION SURVEY FREQUENCY. Table 3-1 should be used as guidance for the initial scheduling of runway friction surveys. This table is based on an average mix of turbojet aircraft operating on any particular runway. Most aircraft landing on the runway are narrow body, such as the DC-9, BAC-111, B-727, B-737, etc. A few wide body aircraft were included in the mix. When any runway end has 20 percent or more wide body aircraft (L-1011, B-747, DC- 10, MD-11, C-5, etc.) of the total aircraft mix, it is recommended that the airport operator should select the next higher level of aircraft operations in Table 3-1 to determine the minimum survey frequency. As airport operators accumulate data on the rate of change of runway friction under various traffic conditions, the scheduling of friction surveys should be adjusted to a frequency that is adequate to ensure evaluators will detect and predict marginal friction conditions in time to take corrective actions.

3-4. SURVEYS WITHOUT CFME. Research has shown that visual evaluations of pavement friction are not reliable. An operator of an airport that does not support turbojet operations who suspects that a runway may have inadequate friction characteristics should arrange for testing by CFME. Visual inspections are essential, however, to note other surface condition inadequacies such as drainage problems, including ponding and groove deterioration, and structural deficiencies.

3-5. GROOVE DETERIORATION. Periodically, the airport operator should measure the depth and width of a runway's grooves to check for wear and damage. When 40 percent of the grooves in the runway are equal to or less than 1/8 inch (3 mm) in depth and/or width for a distance of 1,500 feet (457 m), the grooves' effectiveness for preventing hydroplaning has been considerably reduced. The airport operator should take immediate corrective action to reinstate the 1/4 inch (6 mm) groove depth and/or width.

Table 3-1. FRICTION SURVEY FREQUENCY

NUMBER OF DAILY MINIMUM TURBOJET AIRCRAFT LANDINGS PER RUNWAY END	MINIMUM FRICTION SURVEY FREQUENCY
LESS THAN 15	1 YEAR
16 TO 30	6 MONTHS
31 TO 90	3 MONTHS
91 TO 150	1 MONTH
151 TO 210	2 WEEKS
GREATER THAN 210	1 WEEK

NOTE: Each runway end should be evaluated separately, e.g., Runway 18 and Runway 36.

3-6. MEASUREMENT OF PAVEMENT SURFACE TEXTURE. When a friction test identifies a pavement surface with inadequate friction characteristics, the cause, such as rubber accumulation, is often obvious. When the cause is not obvious, the following guidance may be helpful in determining if the deficiency is a result of deterioration in surface texture depth. Such deterioration may be caused by weather influences, wear/polishing effects of aircraft traffic, and contaminants including but not limited to rubber deposits. Visual inspections cannot be relied upon to identify pavement surfaces with poor texture. Pavement texture depths can only be determined by direct measurements. Even direct measurements may be affected by the operator of the equipment, so they should be used as only part of an overall pavement friction evaluation.

Section 2. CFME - General

3-7. GENERAL REQUIREMENTS FOR CFME. All airports with turbojet traffic should own or have access to CFME. Not only is it an effective tool for scheduling runway maintenance, it can also be used in winter weather to enhance operational safety (see AC 150/5200-30). Airports that have few turbojet traffic operations may be able to borrow the CFME from nearby airports for maintenance use, share ownership with a pool of neighboring airports, or hire a qualified contractor.

3-8. FAA PERFORMANCE STANDARDS FOR CFME. APPENDIX C contains the performance specifications for CFME. These standards should be used by airport operators in procuring CFME and replacement tires for the equipment.

3-9. FAA QUALIFIED PRODUCT LIST. The equipment listed in APPENDIX D has been tested and meets the FAA standards for CFME for use in conducting maintenance friction tests.

3-10. USE OF DECELEROMETER. Since decelerometers are not capable of providing continuous friction measurements, and do not give reliable results on wet pavement surfaces, they are not approved for conducting runway maintenance surveys as discussed in this AC. However, the devices are approved for conducting friction surveys on runways during winter operations (reference AC 150/5200-30).

3-11. FEDERAL FUNDING OF CFME. The Airport and Airway Improvement Act of 1982 (AAIA) includes friction measuring equipment as an eligible item for airport development. However, before programming or procuring this equipment, airport operators should contact their FAA Airports Regional or District Office for guidance.

3-12. TRAINING OF PERSONNEL. The success of friction measurement in delivering reliable friction data depends heavily on the personnel who are responsible for operating the equipment. Adequate professional training on the operation, maintenance, and procedures for conducting friction measurement should be provided either as part of the procurement package or as a separate contract with the manufacturer. Also, recurrent training is necessary for review and update to ensure that the operator maintains a high level of proficiency. Experience has shown that unless this is done, personnel lose touch with new developments on equipment calibration, maintenance, and operating techniques. A suggested training outline for the manufacturers is given in APPENDIX E. Airport personnel should be trained not only in the operation and maintenance of the CFME but also on the procedures for conducting friction surveys. These procedures are provided in Section 3 below. At airports where friction tests are performed less frequently than quarterly, and CFME is not used for winter operations, consideration should be given to hiring a qualified contractor to perform tests.

3-13. CALIBRATION. All CFME should be checked for calibration within tolerances given by the manufacturer before conducting friction surveys. CFME furnished with self-wetting systems should be calibrated periodically to ensure that the water flow rate and distribution is correct for all test speeds.

Section 3. Conducting Friction Evaluations with CFME

3-14. PRELIMINARY STEPS. Friction measurement operations should be preceded by a thorough visual inspection of the pavement to identify deficiencies as outlined in paragraphs 3-1 and 3-4. Careful and complete notes should be taken not only of the CFME data but of the visual inspection as well. The airport operator should ensure that appropriate communications equipment and frequencies are provided on all vehicles used in conducting friction surveys and that all personnel are fully cognizant of airport safety procedures. Personnel operating the equipment should be fully trained and current in all procedures. The CFME should be checked for accurate calibration and the vehicle checked for adequate braking ability.

3-15. LOCATION OF FRICTION SURVEYS ON THE RUNWAY. The airport operator, when conducting friction surveys on runways at 40 mph (65 km/h), should begin recording the data 500 feet (150 m) from the threshold end to allow for adequate acceleration distance. The friction survey should be terminated approximately 500 feet (150 m) from the opposite end of the runway to allow for adequate distance to safely decelerate the vehicle. When conducting friction surveys at 60 mph (95 km/h), the airport operator should start recording the survey 1,000 feet (300 km) from the threshold end and terminate the survey approximately 1,000 feet (300 km) from the opposite end of the runway. Where travel beyond the end of the runway could result in equipment damage or personal injury, additional runway length should be allowed for stopping. Unless surface conditions are noticeably different on either side of the runway centerline, a test on one side of the centerline in the same direction the aircraft lands should be sufficient. However, friction surveys should be conducted in both directions, as rubber deposits often result in different friction values based on direction.

The lateral location on the runway for performing friction surveys is based on the type and/or mix of aircraft operating on the runway:

a. Runways Serving Only Narrow Body Aircraft. Friction surveys should be conducted 10 feet (3 m) to the right of the runway centerline.

b. Runways Serving Narrow Body and Wide Body Aircraft. Friction surveys should be conducted 10 and 20 feet (3 and 6 m) to the right of the runway centerline to determine the worst case condition. If the worst case condition is found to be consistently limited to one track, future surveys may be limited to this track. Care should be exercised, however, to account for any future and/or seasonal changes in aircraft mix.

3-16. VEHICLE SPEED FOR CONDUCTING SURVEYS. All of the approved CFME in APPENDIX E can be used at either 40 mph (65 km/h) or 60 mph (95 km/h). The lower speed provides an indication of the overall microtexture/contaminant/drainage condition of the pavement surface. The higher speed provides an indication of the condition of the surface's macrotexture. A complete survey should include tests at both speeds.

3-17. USE OF CFME SELF-WETTING SYSTEM. Since wet pavement always yields the lowest friction measurements, CFME should routinely be used on wet pavement which gives the "worst case" condition. CFME is equipped with a self-wetting system to simulate rain-induced wet pavement surface conditions and provide the operator with a continuous record of friction values along the length of the runway. The attached nozzle(s) are designed to provide a uniform water depth of 1 mm (0.04 inch) in front of the friction measuring tire(s). This wetted surface produces friction values that are most meaningful in determining whether or not corrective action is required.

3-18. FRICTION SURVEYS DURING RAINFALL. One limitation in using the self-wetting system on a friction measuring device is that it cannot by itself indicate the potential for hydroplaning. Some runways have depressed areas that pond during periods of moderate to heavy rainfall. These areas may exceed considerably the water depth used by the self-wetting system of the friction measuring device. Therefore, the airport operator should periodically conduct visual checks of the runway surface during rainfall, noting the location, average water depth, and approximate dimensions of the ponded areas. If the average water depth exceeds 1/8 inch (3 mm) over a longitudinal distance of 500 feet (150 m), the depressed area should be corrected to the standard transverse slope. If possible, the airport operator should conduct periodic friction surveys during rainfall through the ponded areas.

3-19. FRICTION LEVEL CLASSIFICATION. In physics, friction is defined as the ratio of the force moving a surface parallel to another surface to the force perpendicular to those surfaces. It is represented by the Greek letter μ (pronounced "myew," and spelled "Mu" in English). Since friction is dependent on both surfaces, it is incorrect to refer to a pavement's friction value without stating the method (device) by which the value is obtained. Mu values measured by CFME can be used as guidelines for evaluating the surface friction deterioration of runway pavements and for identifying appropriate corrective actions required for safe aircraft operations. Table 3-2 depicts the friction values for three classification levels for FAA qualified CFME operated at 40 and 60 mph (65 and 95 km/h) test speeds. This table was developed from qualification and correlation tests conducted at NASA's Wallops Flight Facility.

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

	40 mph (65 km/h)			60 mph (95 km/h)		
	Mini-mum	Maint-enance Planning		Mini-mum	Maint-enance Planning	
Airport Surface Friction Tester	.50	.60		.34	.47	
Airport Technology USA Safegate Friction Tester	.50	.60		.34	.47	
Dynatest Consulting, Inc. Dynatest Runway Friction Tester	.50	.60		.41	.54	
Findlay, Irvine, Ltd. Griptester Friction Meter	.43	.53		.24	.36	
Halliday Technologies RT3	.45	.55		.42	.52	
Moventor Oy Inc. BV-11 Skiddometer	.50	.60		.34	.47	
Mu Meter	.42	.52		.26	.38	
NAC Dynamic Friction Tester	42	52		28	38	
Norsemeter RUNAR (operated at fixed 16% slip)	.45	.52		.32	.42	
Tatra Friction Tester	.48	.57		.42	.52	

3-20. EVALUATION AND MAINTENANCE GUIDELINES. The following evaluation and maintenance guidelines are recommended based on the friction levels classified in Table 3-2. These guidelines take into account that poor friction conditions for short distances on the runway do not pose a safety problem to aircraft, but long stretches of slippery pavement are of serious concern and require prompt remedial action.

a. Friction Deterioration Below the Maintenance Planning Friction Level (500 ft, 150 m). When the average Mu value on the wet runway pavement surface is less than the Maintenance Planning Friction Level but above the Minimum Friction Level in Table 3-2 for a distance of 500 feet (150 m), and the adjacent 500 foot (150 m) segments are at or above the Maintenance Planning Friction Level, no corrective action is required. These readings indicate that the pavement friction is deteriorating but the situation is still within an acceptable overall condition. The airport operator should monitor the situation closely by conducting periodic friction surveys to establish the rate and extent of the friction deterioration.

b. Friction Deterioration Below the Maintenance Planning Friction Level (1000 ft, 300 m). When the averaged Mu value on the wet runway pavement surface is less than the Maintenance Planning Friction Level in Table 3-2 for a distance of 1000 feet (300 m) or more, the airport operator should conduct extensive evaluation into the cause(s) and extent of the friction deterioration and take appropriate corrective action.

c. Friction Deterioration Below the Minimum Friction Level. When the averaged Mu value on the wet pavement surface is below the Minimum Friction Level in Table 3-2 for a distance of 500 feet (150 m), and the adjacent 500 foot (150 m) segments are below the Maintenance Planning Friction Level, a NOTAM should be issued which states the runway is "Slippery when wet" and corrective action should be taken immediately after determining the cause(s) of the friction deterioration. Before undertaking corrective measures, the airport operator should investigate the overall condition of the entire runway pavement surface to determine if other deficiencies exist that may require additional corrective action.

Section 4. Conducting Texture Depth Measurements

3-21. RECOMMENDED TESTING. When friction values meet the criteria in paragraphs 3-20.a, 3-20.b, and 3-20.c, no texture depth measurements are necessary. When friction values do not meet these criteria and the cause is not obvious (e.g. rubber deposits), the airport operator should perform texture depth measurements.

3-22. RECOMMENDED TEXTURE DEPTHS.

a. Existing Pavements. For the purposes of texture evaluation, the runway is divided into thirds lengthwise.

(1) When the average texture depth measurement in any third of the runway falls below 0.045 inch (1.14 mm), the airport operator should conduct texture depth measurements each time a runway friction survey is conducted.

(2) When the average texture depth measurement in any third of the runway is below 0.030 inch (0.76 mm) but above 0.016 inch (0.40 mm), the airport operator should initiate plans to correct the pavement texture deficiency within a year.

(3) When the average texture depth measurement in any third of the runway falls below 0.010 inch (0.25 mm), the airport operator should correct the pavement texture deficiency within 2 months.

b. Retexturing. Retexturing of the pavement surface should improve the average texture depth to a minimum of 0.030 inch (0.76 mm).

3-23. LOCATION OF MEASUREMENTS. Groove depths are never included in texture depth measurements. For grooved runway pavements, texture depth measurements should always be located in non-grooved areas, such as near transverse joints or light fixtures, but as close as possible to heavily trafficked areas.

3-24. TEST METHODS. A minimum of four texture depth measurements should be taken in any area noted as deficient. More measurements should be taken when obvious textural changes in the pavement surface are observed. An average texture depth should be computed for each area. Three different macro-texture measurement methods are recommended for the determination of commonly used macro-texture descriptors. Descriptions of these methods and necessary equipment and the computations involved in determining texture depths are as follows:

3-25. TEST METHOD 1 - ASTM E 965 – 96, STANDARD TEST METHOD FOR MEASURING PAVEMENT MACRO-TEXTURE DEPTH USING A VOLUMETRIC TECHNIQUE.

a. Equipment. Another low-cost method is the standard macro-texture measurement test method: ASTM E 965 – 96: Standard Test Method for Measuring Pavement Macro-texture Depth Using a Volumetric Technique[1] This method cannot be used to evaluate the pavement micro-texture. The basic tools of the ASTM apparatus are depicted in Figure 3-. The minimal set of tools contains the following material and equipment:

(1) Solid glass spheres (high quality sand). The gradation and quality requirements are detailed in the ASTM D 1155 glass beads standard.

(2) A suitable container of a precise volume of 1.5 cubic in. (25 000 mm3).

(3) A flat, hard cylindrical shaped hard rubber disc approximately 1 in. (25 mm) thick and 2.5 to 3.0 in. (60 to 75 mm) in diameter. (An ice hockey puck is considered suitable.)

(4) A stiff wire brush and a soft bristle brush.

[1] This test method is under the jurisdiction of ASTM Committee E17 on Vehicle-Pavement Systems and is the direct responsibility of Subcommittee E17.23 on Surface Characteristics Related to Tire–Pavement Slip Resistance. Current edition approved Aug. 1, 2006. Published August 2006. Originally approved in 1983. Last previous edition approved in 2001 as E 965 – 96 (2001).

(5) A suitable wind protection device.

b. Measurement. The following is a brief description of the procedures. The detailed description of the measurements is given in the ASTM standard. A dry and relatively homogeneous surface area with no surface discontinuities of distress (crack, joint etc.) is cleaned. If necessary, the wind screening device is put around the selected surface area. The known volume container is filled with the glass sand and poured onto the surface, preferably in small cone shaped pile. The sand is spread into a circular patch with the disk tool. The diameter of the sand-patch is measured at four equally spaced locations around the circumference. The average of the measured diameters gives the patch diameter that is used to compute the macro-texture depth using the formula given in paragraph 3-25.c.

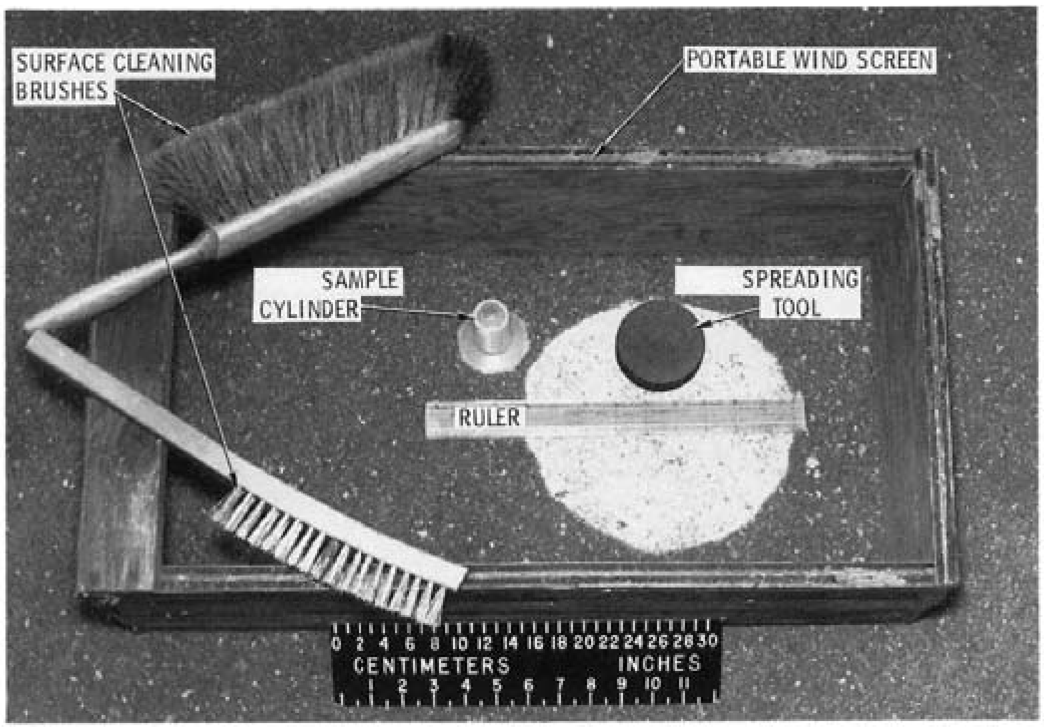

Figure 3-1. APPARATUS FOR MEASURING SURFACE MACRO-TEXTURE DEPTH (With permission of ASTM copied from E 965 – 96 (2006))

c. Computation. After the area is completed, the following equations are used to calculate the average texture depth of the pavement surface:

$$\text{Average Texture Dept} = \frac{4 \times \text{Volume of Glass Sand}}{\pi \times \text{Diameter}^2}$$

The same operator should perform the four measurements. The average of the four individual macro-texture depth values is the average macro-texture depth of the tested pavement surface. A measurement taken according to ASTM E 965 – 96 standard is depicted in Figure 3-.

Figure 3-2. MEASUREMENT OF MACRO TEXTURE DEPTH USING ASTM E 965 – 96.

3-26. TEST METHOD 2 - ASTM E 2157 – 01 (2005), STANDARD TEST METHOD FOR MEASURING PAVEMENT MACRO-TEXTURE PROPERTIES USING THE CIRCULAR TRACK METER.

a. Equipment. A high-technology method is the standard macro-texture measurement test method: ASTM E 2157 – 01 (2005): Standard Test Method for Measuring Pavement Macrotexture Properties Using the Circular Track Meter.[2] This method cannot be used to evaluate the pavement micro-texture. The basic tools of the ASTM apparatus are depicted in Figure 3-. The minimal set of tools contains the following material and equipment:

1. The Circular Track Texture Meter (CTM) measurement equipment.
2. Notebook computer for control and data storage and analyses.
3. A DC Power supply providing a minimum of 24W power at 12V-DC.

[2] This test method is under the jurisdiction of ASTM Committee E17 on Vehicle-Pavement Systems and is the direct responsibility of Subcommittee E17.23 on Surface Characteristics Related to Tire Pavement Slip Resistance. Current edition approved Oct. 1, 2005. Published December 2005. Originally approved in 2001. Last previous edition approved in 2001 as E 2157 – 01.

b. Measurement. The following is a brief description of the procedures. The detailed description of the measurements is given in the ASTM standard. A flat, dry, and relatively homogeneous surface area with no surface discontinuities of distress (crack, joint etc.) is cleaned. The CTM is placed on the surface. Using the notebook computer connected to the CTM for control, the mean profile depth (MPD) option is selected for texture depth computation. This measurement is directly correlated to the sand-patch average texture depth measurements. The four measurements are recorded and stored on the notebook computer. The average of the four MPD measurements is the average Mean Predicted Texture Depth.

c. Computation. The following equations are used to calculate the average texture depth of the pavement surface:

$$\text{Average Texture Depth} = 0.947 \times \text{MPD} + 0.069$$

when Average Texture Depth and MPD are expressed in millimeters,

or:

$$\text{Average Texture Depth} = 0.947 \times \text{MPD} + 0.0027$$

when Average Texture Depth and MPD are expressed in inches.

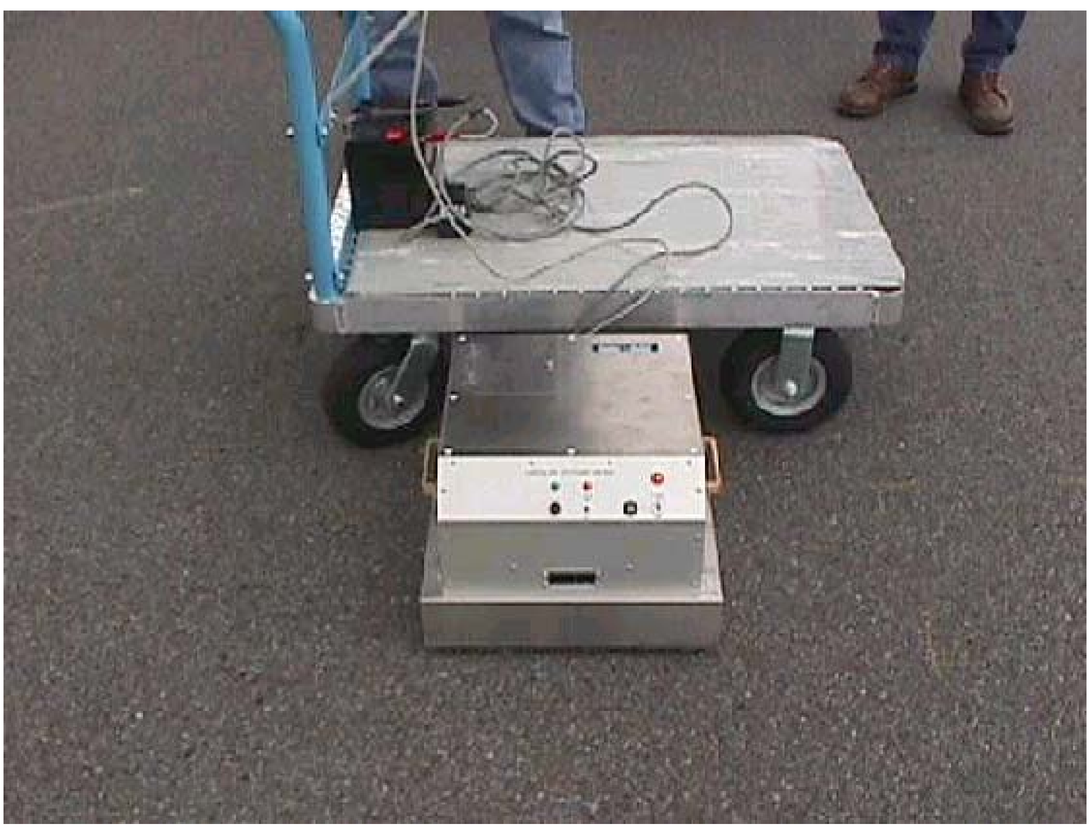

Figure 3-3. APPARATUS FOR MEASURING SURFACE MACRO-TEXTURE DEPTH

CHAPTER 4. MAINTAINING HIGH SKID-RESISTANCE

Section 1. Maintenance Considerations

4-1. NEED FOR MAINTENANCE. As traffic wears down micro-texture and macro-texture, and as contaminants build up on runway pavements, friction may decrease to a point where safety is affected. At joint use airports where high numbers of military aircraft operations occur, the venting of excess fuel can lead to serious loss of friction due to contaminants on the pavement. Also, fog seal treatment of HMA surfaces can substantially reduce the pavement's coefficient of friction during the first year after application. Surfaces which already have marginally acceptable friction can become unacceptable when given this type of surface treatment.

Table 4-1 may be used as an initial planning tool for budgeting for and scheduling timely removal of rubber deposits and restoration of good friction characteristics. As stated in CHAPTER 3, the average aircraft mix is based on mostly narrow body aircraft with a few wide body aircraft operations included. Rubber accumulation is dependent on the type and frequency of aircraft landing operations; e.g., weight of aircraft, the number of wheels that touchdown on the surface, climate, runway length, and runway composition. When more than 20 percent of the total aircraft mix landing on any one runway end are wide body aircraft, it is recommended that the airport operator select the next higher level of aircraft operations in Table 4-1 to determine the rubber removal frequency. Experience and the use of CFME will allow the airport operator to develop a schedule specific to each runway.

Table 4-1. RUBBER DEPOSIT REMOVAL FREQUENCY

NUMBER OR DAILY TURBOJET AIRCRAFT LANDING PER RUNWAY END	SUGGESTED RUBBER DEPOSIT REMOVAL FREQUENCY
LESS THAN 15	2 YEARS
16 TO 30	1 YEAR
31 TO 90	6 MONTHS
91 TO 150	4 MONTHS
151 TO 210	3 MONTHS
GREATER THAN 210	2 MONTHS

Section 2. Methods for Removing Contaminants

4-2. RECOMMENDED CONTAMINANT REMOVAL TECHNIQUES. Several methods are available for cleaning rubber deposits, other contaminants, and paint markings from runway surfaces. They include high pressure water, chemical, high velocity impact, and mechanical grinding. After the contaminants have been removed from the runway surface by any of these methods, the airport operator should conduct friction measurements to ensure the Mu values have been restored to within 10 percent of those on the uncontaminated center portion of the runway, and that both measurements are well within the acceptable friction levels for safe aircraft operations. The effectiveness of rubber deposit removal procedures cannot be evaluated by visual inspection. It is highly recommended that rubber deposit removal contracts base payments on final tests by CFME. A brief description follows for each of the contaminant removal techniques. None of the techniques should be used unless the runway is free of standing water, snow, slush, and/or ice. Also, chemical or water impact removal methods should not be used if there is a danger of the fluids freezing.

The ultimate success of any method will depend on the expertise of the equipment operator. Results can vary from completely ineffective to a situation where all rubber deposits are removed, but the underlying pavement is significantly damaged. It is recommended that airport operators require that a test section be cleaned by the contractor to demonstrate that rubber deposits will be removed without damage to the underlying pavement.

a. Removal by High Pressure Water. A series of high pressure water jets is aimed at the pavement to blast the contaminants from the surface, allowing the water to transport the rubber particles to the edge of the runway. The technique is economical and removes deposits from the pavement surface with minimal downtime to the airport operator. High-pressure water blasting also may be used to improve the surface texture of smooth pavements. Water pressures used vary significantly. There are so many other parameters that vary from one contractor's equipment to another, however, that the pressure of the water used is not a good indication of the potential for either effectiveness or pavement damage. The airport operator should rely on the contractor's experience, demonstrated expertise, and references.

b. Removal by Chemicals. Chemical solvents have been used successfully for removal of contaminants on both PCC and HMA runways. Any chemicals used on runways must meet federal, state, and local environmental requirements. For removal of rubber deposits on PCC runways, chemicals that have a base of cresylic acid and a blend of benzene are used, with a synthetic detergent for a wetting agent. For removal of rubber deposits on HMA runways, alkaline chemicals are generally used. Because of the volatile and toxic nature of such chemicals, extreme care must be exercised during and after application. If the chemicals remain on the pavement too long, the painted areas on the runway, and possibly the surface itself, could be damaged. It is also very important to dilute the chemical solvent that is washed off the pavement surface so that the effluent will not harm surrounding vegetation or drainage systems, or pollute nearby streams and wildlife habitats. Detergents made of metasilicate and resin soap can be used effectively to remove oil and grease from PCC runway surfaces. For HMA pavements, an absorbent or blotting material such as sawdust or sand combined with a rubber alkaline degreaser may be used.

c. High Velocity Impact Removal. This method employs the principle of throwing abrasive particles at a very high velocity at the runway pavement surface, thus blasting the contaminants from the surface. Additionally, the machine that performs this operation can be adjusted to produce the desired surface texture, if so required. The abrasive is propelled mechanically from the peripheral tips of radial blades in a high speed, fan like wheel. The entire operation is environmentally clean in that it is self-contained; it collects the abrasive particles, loose contaminants, and dust from the runway surface; it separates and removes the contaminants and dust from the abrasive; and it recycles the abrasive particles for repetitive use. The machine is very mobile and can be removed rapidly from the runway if required by aircraft operations.

d. Mechanical Removal. Mechanical grinding that employs the corrugating technique has been successfully used to remove heavy rubber deposits from both PCC and HMA runways. It has also been used to remove high areas such as bumps on pavement surfaces or at joints where slabs have shifted or faulted. This method greatly improves the pavement surface friction characteristics. Pavement surfaces that are either contaminated (rubber buildup or bleeding) or worn can have their surface friction coefficient greatly increased by a thin milling operation. This technique removes a surface layer between 1/8 and 3/16 inch (3.2 and 4.8 mm) in depth

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APPENDIX A. QUALIFICATION PROCESS FOR CFME

A-1. FRICTION EQUIPMENT CORRELATION PROGRAM. From 1982 through 1985, the FAA conducted a series of tests to determine the correlation of the Mu Meter, Saab Friction Tester, Skiddometer, and the Runway Friction Tester, using equipment-provided self-wetting systems on dry pavement surfaces at NASA's Wallops Flight Facility. Correlation values were established for each device. Reference Report No. DOT/FAA/AS-90-1, which shows the results of the correlation trials conducted at NASA’s Wallops Flight Facility in August 1989. As trials at Wallops ceased in 2008, research continued on performance based requirements at the Annual Friction Workshop at Penn States’ Larson Institute and University Park Airport. Additional devices that have since been found to meet FAA specifications. All devices found to meet FAA specifications as of the date of this AC are listed in APPENDIX D.

A-2. FRICTION/SPEED RELATIONSHIPS FOR PAVEMENT SURFACES. The relationship of speed to friction has a profound influence on aircraft braking performance when pavements have little or no microtextural properties. According to the Unified Mechanism of Rubber/Pavement Friction, the adhesion component of friction, which is governed mainly by the shear force between the tire and the pavement surface, is high at lower speeds of up to about 100 mph (165 km/h). The rubber couples well with a good micro-textured surface to provide high friction at the lower speeds. At speeds over 100 mph (165 km/h), the hysteresis component of friction governs. This component is the effect of damping or reacting elastic pressure of rubber when deformed around aggregate particles. The deformation is produced best by good macro-textured surfaces. In essence, the Unified Mechanism simply states that a good macro/micro-texture surface will provide relatively high friction and flat friction speed gradient on wet pavement surfaces. As speed increases, macro-textured surfaces will provide good drainage to keep the hydrodynamic pressure low and the tire in contact with the pavement surface for a low friction/speed gradient. However, a poor macro-textured pavement surface cannot provide sufficient drainage for good tire/pavement contact. Thus, the friction speed gradient decreases rapidly.

The relationship of the friction/speed gradient was determined at NASA's Wallops Flight Facility by conducting friction surveys on several types of pavement surfaces that represented a wide range of friction values at speeds of 20, 40, 60, and 80 mph (33, 65, 95, and 133 km/h). Testing operational runways at 20 mph is not practicable, since a test of a 10,000' runway would take approximately six minutes. Likewise, the distance required to accelerate to and decelerate from 80 mph would preclude testing most of a typical touchdown zone. Therefore, a compromise is made and tests are conducted at only two speeds, 40 and 60 mph (65 and 95 km/h). These two speeds will provide an adequate representation of the friction/speed gradient for the various textured pavement surfaces encountered.

A-3. DEVELOPMENT OF PERFORMANCE SPECIFICATION FOR FRICTION EQUIPMENT. The following paragraphs discuss the qualification process used to develop the performance specification for the friction equipment and friction measuring tires.

a. Development of the Friction Equipment Performance Specification. For friction measuring equipment to qualify for federal funding, performance standards are necessary. Testing was conducted at NASA's Wallops Flight Facility to develop performance standards for friction measuring equipment. The standards were developed to assure the airport operator that the friction measuring equipment would perform with reliability and consistency on all types of pavement surface conditions.

b. Development of the Tire Performance Specification. Prior to 1989, only one friction measuring tire was available for friction measuring devices. During 1988, the E-17 committee of ASTM requested the FAA to conduct tire performance tests on two tires manufactured according to two ASTM specifications — E-524, Specification for Standard Smooth Tire for Pavement Skid-Resistance Tests; and E-670, Standard Test Method for Side Force Friction on Paved Surfaces — and to use the Mu-Meter to compare these tires with the performance of the then FAA standard tire. Test tire specifications were developed and adopted by ASTM as E1551, Standard Specification for Special Purpose, Smooth–Tread Tire, Operated on Fixed Braking Slip Continuous Friction Measuring Equipment and E1844 Standard Specification for A Size 10 & 4–5 Smooth-Tread Friction Test Tire. The tires are manufactured in the United States by:

Specialty Tires of America Inc.
1600 Washington Street
Indiana, PA 15701.

APPENDIX B. RELATED READING MATERIAL

B-1. The latest issues of the following free publications may be obtained from the U.S. Department of Transportation, Warehousing and Subsequent Distribution Section, SVC-121.23, Washington, DC 20590. AC 00-2, *Advisory Circular Checklist*, current edition, contains the listing of all current issues of circulars and changes thereto.

a. AC 150/5200-28, *Notices to Airman (NOTAMS) for Airport Operators*.

b. AC 150/5200-30, *Airport Winter Safety and Operation*.

c. AC 150/5320-6, *Airport Pavement Design and Evaluation*.

B-2. Copies of the following publications may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Send check or money order with your request made payable to the Superintendent of Documents in the amount stated. No C.O.D. orders are accepted.

a. AC 150/5300-13, *Airport Design*.

b. AC 150/5370-10, *Standards for Specifying Construction of Airports*, current edition ($18.00).

c. AC 150/5380-6, *Guidelines and Procedures for Maintenance of Airport Pavements* ($7.00).

B-3. Copies of ASTM Standards ‘Volume 04.03 Road and Paving Materials; Vehicle-Pavement Systems,’ may be obtained from the American Society For Testing and Materials, 100 Barr Harbor Drive; Conshohochen, PA 19428.

B-4. Copies of the following publications may be obtained from the National Technical Information Service, Springfield, Virginia 22151.

a. *Pavement Grooving and Traction Studies*, Report No. NASA SP-5073, 1969.

b. *A Comparison of Aircraft and Ground Vehicle Stopping Performance on Dry, Wet, Flooded, Slush, and Ice-covered Runways*, Report No. NASA TN D-6098, November 1970.

c. *Runway Friction Data for 10 Civil Airports as Measured with a Mu Meter and Diagonal Braked Vehicle*, Report No. FAA-RD-72-61, July 1972.

d. *Effects of Pavement Texture on Wet Runway Braking Performance*, Report No. NASA TN D-4323, January 1969.

e. *Porous Friction Surface Courses*, Report No. FAA-RD-73-197, February 1975.

f. *Laboratory Method for Evaluating Effect of Runway Grooving on Aircraft Tires*, Report No. FAARD-74-12, March 1974.

g. *Investigation of the Effects of Runway Grooves on Wheel Spin-up and Tire Degradation*, Report No. FAA-RD-71-2, April 1971.

h. *Environmental Effects on Airport Pavement Groove Patterns*, Report No. FAA-RD-69-37, June 1969.

i. *The Braking Performance of an Aircraft Tire on Grooved Portland Cement Concrete Surfaces*, Report No. FAA-RD-80-78, January 1981.

j. *Braking of an Aircraft Tire on Grooved and Porous Asphaltic Concrete,* Report No. DOT-FAARD-82-77, January 1983.

k. *Analytical and Experimental Study of Grooved Pavement Runoff*, Report No. DOT-FAA-PM83/84, August 1983.

l. *Surveys of Grooves in Nineteen Bituminous Runways*, Report No. FAA-RD-79-28, February 1979.

m. *Modified Reflex-Percussive Grooves for Runways*, Report No. DOT-FAA-PM-82-8, March 1984.

n. *Reliability and Performance of Friction Measuring Tires and Friction Equipment Correlation*, Report No. DOT/FAA/AS-90-1, March 1990.

B-5. Copies of *MS-16, Asphalt in Pavement Maintenance*, may be obtained from the Asphalt Institute Building, College Park, Maryland 20740.

B-6. Copies of *Maintenance Practices for Concrete Pavements*, may be obtained from the Portland Cement Association, Old Orchard Road, Skokie, Illinois 60076.

B-7. Copies of the following publications may be obtained from the Highway Research Board, National Academy of Sciences, 2101 Constitution Avenue, Washington, D.C. 20418.

a. *Skid-resistance, National Cooperative Highway Research Program (NCHRP) Synthesis of Highway Practice 14*, 1972.

b. *Pavement Rehabilitation - Materials and Techniques, National Cooperative Highway Research Program (NCHRP) Synthesis of Highway Practice 9*, 1972.

c. *Factors Affecting Skid-resistance and Safety of Concrete Pavements*, Special Report No. 101, 1969.

d. *Road Surface Texture and the Slipperiness of Wet Roads*, Record No. 214, 1968.

e. *Pilot Field Study of Concrete Pavement Texturing Methods*, Record No. 389, 1972.

f. *Prediction of Skid-resistance Gradient and Drainage Characteristics of Pavements*, Record No. 131, 1966.

g. *Standard Nomenclature and Definitions for Pavement Components and Deficiencies*, Special Report No. 113, 1970.

h. *Development of Specifications for Skid-Resistant Asphalt Concrete*, Record No. 396, 1972.

i. *Skid-resistance of Screenings for Seal Coats*, Record No. 296, 1968.

B-8. Copies of the following technical bulletins may be purchased from the American Concrete Paving Association, Suite 490, 3800 N. Wilke Rd., Arlington Heights, Illinois, 60004-1268.

a. *Texturing of Concrete Pavements*, Bulletin No. 1.

b. *Interim Recommendations for the Construction of Skid-Resistant Concrete Pavement*, Bulletin No. 6.

c. *Guideline for Texturing of Portland Cement Concrete Highway Pavements*, Bulletin No. 19.

B-9. Copies of *Evaluation of Two Transport Aircraft and Several Ground Test Vehicle Friction Measurements Obtained for Various Runway Surface Types and Conditions*, NASA Technical Paper 2917, February 1990, may be obtained from NASA, under the Code NTT-4, Washington, DC 20546-0001.

B-10. Copies of ASTM Specifications can be obtained from ASTM, 1916 Race Street, Philadelphia, Pennsylvania 19103.

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APPENDIX C. PERFORMANCE SPECIFICATIONS FOR CFME

C-1. FRICTION EQUIPMENT PERFORMANCE STANDARD. The friction measuring equipment may be self-contained or towed. If towed, the tow vehicle will be considered an integral part of the device. The vehicles and/or trailers must meet all applicable Federal and state laws and/or regulations for vehicles and/or trailers for use on public highways. The side force friction measuring device, the Mu Meter, must meet the Standard Test Method given in ASTM E 670. The fixed brake slip CFME must meet the Standard Test method specifications given in ASTM E2340.

a. The Friction Measuring Equipment must do the following:

(1) provide fast, continuous, accurate, and reliable friction measurements for the entire length of the runway, less the differences required for accelerating and decelerating the vehicle at the runway ends.

(2) be designed to sustain rough usage, still function properly, and provide efficient and reliable methods of equipment calibration.

(3) be capable of automatically providing the operator with a selection of average friction values for both a 500 foot (150 m) and one-third segment of runway length. In addition, it must be capable of providing data, whereby, the average friction value for any length of runway can be manually calculated.

(4) be capable of producing a permanent trace of friction measurements versus pavement length at a scale of at least one inch (25 mm) equals 300 feet (90 m).

(5) be capable of consistently repeating friction averages throughout the friction range on all types of pavement surfaces. Friction averages for each 500 foot (150 m) segment located on the pavement surface must be within a confidence level of 95.5 percent, or two standard deviations of ±.06 Mu numbers.

(6) contain a self-wetting system that distributes water in front of the friction measuring wheel(s) at a uniform depth of 0.04 inch (1 mm). Water must be applied to the test surface just ahead of the test tire so as to provide the chosen nominal water film thickness across the full width of the test tire at any test speed. Regulation of rate of water flow must be within ±10 %.

(7) be able to conduct friction surveys at speeds of 40 and 60 mph (65 and 95 km/hr), within a tolerance of ±3 mph (±5 km/hr).

(8) include a complete set of the latest operation and maintenance manuals, including guidelines for training airport personnel. The training manuals must include the current copy of this AC.

(9) have electronic instrumentation (solid-state electronics), including a keyboard for data entry, that will enhance the information gathering and analysis capability of the equipment, and provide the operator more convenience in equipment operation and performance. The information gathered must be stored electronically for easy retrieval and be readily visible to the operator of the vehicle. Each printout of the chart produced by the system electronics must include the following recorded information: runway designation and date; time of friction survey; a continuous trace of the friction values obtained for the entire runway length minus the acceleration/deceleration distances; printed marks depicting each 100 foot (30 m) increment of the runway length so easy reference can be made by the operator in identifying specific areas on the runway pavement surface; average friction value for 500 foot (150 m) and one-third segments of the runway length as preselected by the operator; and average vehicle speed for that segment.

b. The vehicle must:

(1) be able to conduct friction surveys at speeds of 40 and 60 mph (65 and 95 km/hr), within a tolerance of ±3 mph (±5 km/hr). The vehicle, when fully loaded with water, must be capable of accelerating to these speeds within 500 and 1000 feet (150 and 300 m) from the starting position, respectively.

(2) be equipped with electronic speed control.

(3) conform to the requirements of AC 150/5210-5, Painting, Marking, and Lighting of Vehicles Used on an Airport, for airfield service vehicles.

(4) be equipped with transceiver(s) necessary for communication with airport operations and air traffic control.

(5) be able to lock the test wheel for calibration purposes. The test wheel shall be placed on a load plate with three dimensional load measurement capabilities (vertical and two dimensions horizontally (longitudinal and transverse). The plate shall have precise levelling capabilities and there shall be a non-slip coating where the test wheel comes in contact with the plate. The load plate shall be calibrated by an ISO 17025 certified organization and tests performed before the plate calibration expiration date. The test wheel shall be placed on the plate and the its vertical forces be verified within 10% of the plate readings. With the wheel locked, horizontal and transverse forces shall be placed on the load plate and the vehicle shall indicate a reading within 10% with the associated readings on the load plate.

(6) be equipped with a water tank constructed of strong lightweight material, of sufficient capacity to complete a friction survey on a 14,000 foot (4,300 m) runway in one direction, and all necessary appurtenances to deliver the required water flow rate to the friction measuring wheel(s).

(7) be equipped with appropriate heavy duty shock absorbers and heavy duty suspension to adequately handle imposed loads. The test/tow vehicle must not exceed the vehicle manufacturer’s given gross vehicle weights and tire loading specifications when fully loaded.

(8) be equipped with internally controlled spotlights on each side of the vehicle. For trailer mounted equipment, the tow vehicle must also be equipped with at least two floodlights mounted such that the friction measuring device and rear portion of the tow vehicle is illuminated to a level of at least 20 foot-candles within an area bounded by lines 5 feet (2 m) on either side of the friction measuring device and 5 feet (2 m) in front of and behind the friction measuring device.

(9) be equipped with an air conditioner when specified by the purchaser.

c. The manufacturer must perform a comparison of the Mu values obtained from its own device to the Mu values obtained under the same conditions from another device in Table 3-2. The manufacturer must use this comparison to determine the Mu value readings of its device that are equivalent to the milestone values listed for the other devices. These values will be used to update Table 3-2.

C-2. TIRE PERFORMANCE STANDARD. The friction measuring equipment must be furnished with measuring tires which are designed for use in conducting friction surveys and which meet ASTM standard E670, E-1551, or E-1844, as appropriate. Non-ribbed (smooth) tire(s) must be used to eliminate the effect of tire tread wear and provide greater sensitivity to variations in pavement surface texture. The tires must be furnished with split rims and the tubes must have curved valve stems. The manufacturer of the friction equipment must provide the airport user with a calibrated dial pressure gauge.

A new test tire must not be used until it has been conditioned by running at fixed slip at the normal tire inflation pressure to obtain a smooth, uniform rubber tread surface free of any curing agents. For tires not conditioned and tested by the supplier, conditioning may typically be carried out by the operator running the tire dry for about 100 ft (30 m) followed by about 1000 ft (300 m) on a wet surface. The operator must be aware that these lengths are typical and, on an aggressive surface, the tire need not be run dry for as much as 30 m and, on a smooth surface, longer conditioning will be required.

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APPENDIX D. FAA-APPROVED CFME

AIRPORT SURFACE FRICTION TESTER INDUSTRIES AB Piledalsv. 51 271 73 Kopingebro Sweden	**AIRPORT SURFACE FRICTION TESTER** +46 0 411 651 00 FAX +46 0 411 190 12 Web site: www.asft.se Email: sales@asft.se
AIRPORT TECHNOLOGY USA NO LONGER AVAILABLE	**SAFEGATE FRICTION TESTER**
DOUGLAS EQUIPMENT LTD Douglas House Village Road Cheltenham Gloucestershire GL51 0AB United Kingdom	**MU METER** + 44 (0)1242 527921 FAX +44 (0) 1242 571667 Web site: www.douglas-equipment.com Email: spd@douglas-equipment.com
DYNATEST CONSULTING, INC., **(FORMERLY K.J. LAW ENGINEERS, INC**.) 38284 Abruzzi Drive Westland, MI 48185	**RUNWAY FRICTION TESTER (6810, 6850 and 6875)** (734) 729-0400 FAX (734) 729-0401 Web site: www.dynatest.com Email: fholt@dynatest.com
FINDLAY, IRVINE, LTD. Bog Road Penicuik Midlothian EH26 9BU Scotland United Kingdom	**GRIPTESTER FRICTION TESTER** + 44 (0) 1968 671 200 FAX + 44 (0) 1968 671 237 Web site: www.findlayirvine.com Email: http://www.findlayirvine.com/contact-us
HALLIDAY TECHNOLOGIES 8525 Rausch Drive Plain City, OH 43064	**RT3** (614) 504 4150 FAX (614) 873 3842 Web site: www.hallidaytech.com Email: info@hallidaytech.com
INTERTECH ENGINEERING NO LONGER AVAILABLE	**TATRA FRICTION TESTER**
MOVENTOR OY INC. Viherkiitäjä 2 33960 Pirkkala Finland	**BV-11 SKIDDOMETER** tel. +358 (0)10 2896100 Web site: www.moventor.com Email: info@moventor.com
NEUBERT AERO CORP. 4105 West De Leon Street Tampa, FL 33609	**NAC DYNAMIC FRICTION TESTER** (727) 538-8744 FAX (727) 538-8765 Web site: www.airportnac.com Email: info@airportnac.com
NORSEMETER P.O.Box 125, Bogstadveien N-0323 Oslo, Norway	**RUNAR RUNWAY ANALYSER AND RECORDER** +47 23 20 1270 FAX +47 23 20 1271 Web site: www.norsemeter.no Email: info@norsemeter.no
Olsense Technology AS Bergstigen 1C 1472 Fjellhamar Norway	**Traction Watcher One (TWO)** **+47 480 28 460** **Web site: www.two-friction.com** **Email: vidar@two-friction.com**
SCANDINAVIAN AIRPORT AND ROAD SYSTEMS AB) Box 31, Sjoviksvagen 4**)** SE 231 21 Trelleborg Sweden	**SARSYS FRICTION TESTER (SFT)** **SARSYS TRAILER FRICTION TESTER (STFT)** **SARSYS SURFACE VOLVO FRICTION TESTER** **(SVFT -VOLVO V70, XC70, SKODA OCTOVIA)** **SARSYS SURFACE TRAILER (STFT)** **SARSYS SURFACE FRICTION TESTER**

US/Canada:. Tradewind Scientific Ltd. Box 3262, Station D Ottawa, Ontario, Canada K1P 6H8	**TRANSPORTER (SFTT – VW TRANSPORTER, VW CARAVELLER, VW MULTIVAN)** **SARSYS SURFACE OPEL FRICTION TESTER (SOFT – OPEL MOKKA, VAUXHAL MOKKA, BUICK ENCORE, CHEVROLET TRAX, HOLDEN TRAX)** +46 410 46 110 FAX +46 410 46 111 Web site: www.sarsys.se Email: info@sarsys.se (613) 238-1246 FAX: (613) 726-0871 Web site: www.tradewind.aero E-mail:support@tradewind.aero

APPENDIX E. TRAINING REQUIREMENTS OUTLINE FOR CFME

E-1. GENERAL DISCUSSION. The following paragraph lists the major items which should be considered in developing a training program for airport personnel responsible for operating and maintaining CFME. Whenever a major change in equipment design occurs, the training and instruction manuals should be revised. A document titled Training and Instruction Manual should always be provided to the airport personnel by the manufacturer and kept updated.

E-2. TRAINING REQUIREMENTS OUTLINE.

a. Classroom Instruction.

(1) Purpose of Training Program.

(2) General Discussion on Pertinent Federal Aviation Regulations.

(3) General Discussion on Pertinent ACs.

(4) General Discussion on Pertinent ASTM Standards.

(5) General Overview of Program.

(6) Review of Requirements in AC 150/5320-12.

(a) Coefficient of Friction Definition.

(b) Factors Affecting Friction Conditions.

(c) ASTM Standards for CFME.

(d) Programming the Computer for FAA and ICAO Formats.

(e) Maintenance of CFME.

(f) Procedures for Reporting Friction Numbers.

(g) Preparation and Dissemination of NOTAMS.

(7) Orientation to the Calibration, Operation, and Maintenance of CFME.

b. Field Experience. Operation and Maintenance of CFME.

c. Testing. Solo Test and Written Examination on All Items Covered in Course.

d. Award of Training Certificate.

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