U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Obsolete

Subject: MEASUREMENT, CONSTRUCTION, AND MAINTENANCE OF SKID-RESISTANT AIRPORT PAVEMENT SURFACES

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Initiated by: AAS-200

AC No: 150/5320-12B
Change:

1. **PURPOSE.** This advisory circular (AC) contains guidelines and procedures for the design and construction of skid-resistant pavement; pavement evaluation, without or with friction equipment; and maintenance of high skid-resistant pavements.

2. **CANCELLATION.** AC 150/5320-12A, Measurement, Construction, and Maintenance of Skid-Resistant Airport Pavement Surfaces, dated July 11, 1986, is cancelled.

3. **RELATED READING MATERIAL.** Appendix 2 contains a listing of documents containing supplemental material relating to the subject. Information on ordering these documents is also provided.

4. **APPLICATION.** The guidelines and standards contained herein are recommended by the Federal Aviation Administration (FAA) for applications involving runway friction measurement, construction, and maintenance. For airport projects funded under Federal grant assistance programs, the standards identified by BOLDFACE CAPITALS in Chapter 2, section IV, paragraphs 26 and 27 and appendix 4 are mandatory.

5. **BACKGROUND.** With the introduction of turbojet aircraft, braking performance on pavement surfaces became more critical. Under certain conditions, hydroplaning or unacceptable loss of friction can occur, resulting in poor braking performance and possible loss of directional control. To address this concern, a number of research programs were conducted by the National Aeronautics and Space Administration (NASA), FAA, United States Air Force (USAF), and various foreign governments. These efforts concentrated in two major areas: high skid-resistant pavement surface design and evaluation and application of proper maintenance techniques and procedures. Guidelines are provided to airport operators in this circular on how to locate and restore areas on the pavement surface where friction has deteriorated below acceptable levels for aircraft braking performance. The material contained in this circular summarizes the findings of these research efforts.

6. **METRIC UNITS.** To promote an orderly transition to metric (SI) units, this circular contains both English and metric dimsinsions. The metric conversions may not be exact equivalents and, until there is an official changeover to the metric system, the English dimensions will govern.

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CHAPTER 1. OVERVIEW

1. Purpose - This advisory circular provides guidelines for designing, constructing, and 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 FAA Advisory Circular 150-5200-30, Airport Winter Safety and Operations.

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 by FAA, NASA, and the U.S. Air Force, as well as those performed by foreign governments, have been directed basically 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.

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, which would allow rain water to escape from beneath tires of landing aircraft. Other research conducted both in the United Kingdom and the United States determined that an open graded, thin asphaltic concrete surface course called "porous friction course" (PFC) also could achieve good results. This permits rain water to permeate through the course and drain off transversely to the side of the runway, preventing water buildup on the surface and creating a relatively dry pavement condition during rainfall. The FAA Technical Center study demonstrated that a high level of friction was maintained on PFC overlays for the entire runway length.

In addition, a number of studies were carried out, and are continuing, on basic skid-resistant behaviors of pavement surfaces, both asphalt and portland cement concrete. These have led to other noteworthy surface treatments that improve pavement surface texture such as asphaltic chip and aggregate slurry seals. For concrete pavements, wire combing the surface, while the concrete is still in the plastic condition, notably improves pavement surface texture.

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 issues, and other factors. In addition to ordinary mechanical wear and tear from aircraft tires, contaminants can collect on runway pavement surfaces to decrease their friction properties. Contaminants such as rubber deposits, dust particles, jet fuel, oil spillage, water, snow, ice, and slush all cause friction loss on runway pavement surfaces. Rubber deposits occur at the touchdown areas on runways and can be quite extensive. Heavy rubber deposits can completely cover the pavement surface texture; thereby, 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 was given to airport owners so that they could take proper corrective measures to eliminate runway pavement deficiencies.

5. Friction Measuring Equipment Research - Beginning in the early 1970's, NASA, FAA, and the U.S. Air Force 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 engineering and 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 1 summarizes research on qualification and correlation of friction measuring equipment.

6. Additional Background and Information - Appendix 2 contains a bibliography of pertinent reading material on pavement friction design and measurement.

CHAPTER 2 - DESIGN AND CONSTRUCTION OF SKID-RESISTANT PAVEMENT

Section I. Basic Design Considerations

7. General - In building new runways, major reconstruction, or adding overlays, the design engineer must choose either asphalt concrete (AC) or portland cement concrete (PCC) as the basic paving component. The selection is usually based on economics, local preference, or other design factors. These considerations, as well as basic pavement structural design, are covered in Advisory Circular 150/5320-6, Airport Pavement Design and Evaluation. This chapter is limited to discussion only of the surface of the airport pavement, literally "where the rubber meets the runway." All of the techniques discussed in this chapter may be applied during original construction (or reconstruction), and some may be applied to existing pavement to restore or create good friction characteristics.

8. 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 microtexture and macrotexture. Microtexture refers to the fine-scale roughness contributed by small individual asperities of aggregate particles on pavement surfaces which are not discernible to the eye but are apparent to the touch, i.e., the feel of fine sandpaper. Macrotexture refers to visible roughness of the pavement surface as a whole. Microtexture provides frictional properties for aircraft operating at low speeds and macrotexture provides frictional properties for aircraft operating at high speeds. Together they provide adequate frictional properties for aircraft throughout their landing/takeoff speed range. The primary function of macrotexture 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 microtexture 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 providing 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 under traffic wear; 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, is not necessarily slippery due to good microtextural 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. The maximum allowable transverse slope for category "C" and "D" runways should be 1½ percent for the most effective drainage (reference Advisory Circular 150/5300-13, Airport Design).

Section 2. Asphalt Concrete (AC) Pavement

9. Construction Techniques for AC Pavement - The surface texture of newly constructed AC pavements is usually quite smooth. This is due to the rolling done during construction to achieve the required compaction and density. Nevertheless, several methods are available to improve surface texture and friction in AC pavements. These include proper mix design, porous friction course, chip seals, and aggregate slurry seals. Saw cut grooves made after final compaction are highly effective. This chapter gives guidance for providing these surface treatments. The construction specification for AC pavement is contained in Advisory Circular 150/5370-10, Standards for Specifying Construction of Airports.

10. AC Pavement Mixtures - Several factors concern the pavement designer in selecting the appropriate design mix. These factors include the blending of aggregate sources, aggregate size and gradation, the relationship between aggregates and binder, and the construction methods to obtain the required surface properties which meet all other requirements.

a. Blending Aggregates. When superior quality aggregates are in limited supply or processing costs are prohibitive, natural aggregates can be combined with synthetic aggregates.

b. Aggregate Size and Gradation. The maximum size aggregate, as well as the mix gradation, may be varied by the pavement designer to produce the desired surface texture and strength. For AC pavement, the size and properties of the coarse aggregate are critical for good macrotexture. Generally, the larger size aggregates in AC pavement mixtures provide greater skid resistance than the smaller ones.

c. Aggregate Characteristics. After size and gradation, the most frequently considered characteristics for skid-resistant aggregates are resistance to polish and wear, texture, and shape of particles.

1. Resistance to Polish and Wear. The ability of an aggregate to resist the polish and wear action of aircraft traffic has long been recognized as the most important characteristic. Certain aggregates in pavements are more susceptible to wear and polish effects than others, becoming extremely slippery when wet. The presence of coarse grain sized and gross differences in grain hardness appear to combine and lead to differential wear and breaking off of grains resulting in a constantly renewed abrasive surface. Rocks high in silica content are the most satisfactory performers. Generally, high carbonate rocks are poor performers. Petrographically, rocks that are generally acceptable and unweathered crushed quartzite, quartz diorite, granodiorite, and granite.

2. Texture. The surface textures of individual aggregates are governed by the size of the individual mineral grains and the matrix in which they are cemented. For an aggregate to exhibit satisfactory skid-resistant properties, it should contain at least two mineral constituents of different hardness cemented in a matrix that will wear differentially, thus continually exposing new surfaces.

3. Shape. The shape of an aggregate particle, which is determined by crushing, significantly affects its skid-resistant properties. Aggregate shape depends on many of the same factors that influence texture. The angularity of an aggregate contributes to its skid-resistant quality. Flat, elongated particles are poor performers.

d. Asphalt Cement. The characteristics and percentages of the asphalt cement used should be in accordance with standard AC pavement design practice.

11. Porous Friction Course (PFC) - One method used to improve runway pavement skid resistance and mitigate hydroplaning is a thin asphaltic concrete surface course overlay that ranges from 3/4 inch to 1½ inches (25 mm to 38 mm) thick, characterized by its open-graded matrix.

a. Pavement Suitability for PFC. Prior to constructing this type of surface course, the existing pavement surface should be evaluated to determine its structural integrity. Strengthening of the existing pavement, if needed, should be accomplished before laying the PFC. Also, the pavement should be in good condition; that is, have proper longitudinal and transverse grades, a good watertight surface that is free of major cracks or any significant depressions, or any other surface irregularities. For minor cracks, normal maintenance procedures should be followed as given in Advisory Circular 150/5380-6, Guidelines and Procedures for Maintenance of Airport Pavements. If there are rubber deposits on the runway pavement surface, these areas should be cleaned prior to constructing the PFC overlay. The PFC should be constructed only on asphaltic concrete pavements. It has been shown that a longer life, as well as better adhesion and bond, can be achieved by adding rubber particles during the preparation of the mix. The specification for the PFC is given in Advisory Circular 150/5370-10. Figure 2-1 shows an edge view of a typical PFC overlay.

b. Restrictions to PFC Construction. On PFC constructed runway surfaces that have high aircraft traffic operations, rubber accumulation can become a serious problem if not closely monitored. If the rubber deposits are not removed before they completely cover the pavement surface and plug up the void spaces in the matrix of the overlay, water can no longer drain internally through the structure of the overlay. When this condition occurs, it is impossible to remove the latex without causing serious damage to the structural integrity of the overlay. Therefore, the FAA recommends that PFC overlays not be constructed on airport runways that have high aircraft traffic operations (over 91 turbojet arrivals per day per runway end).

12. Chip Seal - Temporary improvement of surface friction can be achieved by constructing a chip seal. Latex added to the chip seal extends its life and provides better bond and adhesion to the existing pavement surface. A fog seal added on top of the chip seal will help minimize loose chips and prevent aircraft damage.

13. 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 Advisory Circular 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 2-2 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 III. Portland Cement Concrete (PCC) Pavement

14. Construction Techniques for PCC Pavement - Several methods are available to the paving contractor for constructing skid-resistant PCC pavement surfaces. When Portland cement concrete is still in the plastic condition, it is strongly recommended that some type of textural finish be constructed in the pavement surface prior to grooving. Such texturing can be accomplished by using either a brush or broom finish or a heavy burlap drag finish. Wire comb or wire tined construction provides an excellent textural finish to the surface. Plastic grooves can also be constructed in the pavement before it has hardened. For PCC pavements that have hardened, grooves can be saw cut in the pavement. The textural and grooving construction techniques are briefly described in the following paragraphs. The basic construction specifications for PCC pavement are given in Advisory Circular 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.

15. Timing and Curing - Timing in applying the curing compound is as important as timing the final finishing operations to assure long lasting, nonskid pavement surface texture. The timing of the texturing operation is critical because PCC pavements rarely lose surface moisture evenly or set at a uniform rate, especially during warm weather paving operations. The best time to texture a PCC pavement during construction is when the water spots have dried enough to reasonably hold the texture but before the drier spots have dried too much to texture at all. This is one of the toughest decisions the paving contractor has to make. After texturing of the pavement surface has been completed, immediate application of the curing compound assures that the pavement surface will not lose water and cure too rapidly. If the pavement cures too quickly, the ridges of mortar left by the finishing technique will not set properly and their durability will be greatly reduced, resulting in a faster rate of diminishing skid resistance. Therefore, extreme care must be taken in this process to assure an effective cure.

16. Brush or Broom Finish - If the pavement surface texture is to be a type of brush or broom finish, it should be applied when the water sheen has practically disappeared. The equipment should operate transversely across the pavement surface, providing corrugations that are uniform in appearance and approximately 1/16 inch (1½ mm) deep. It is important that the texturing equipment not tear or unduly roughen the pavement surface during the operation. Any imperfections resulting from the texturing operation should be corrected immediately after application before the concrete becomes too stiff to work. Figure 2-3 shows the texture formed by the broom finish.

17. Burlap Drag Finish - A burlap drag finish used to texture the pavement surface should be at least 15 oz/square yard (355 gm/square m). To produce a rough textured surface, the transverse threads of the burlap should be removed from approximately 1 foot (0.3 m) of the trailing edge and grout allowed to buildup and harden on the trailing burlap threads. A heavy buildup of grout on the burlap threads produces the desired wide sweeping longitudinal striations on the pavement surface. The aggregate particles form the corrugations which should be uniform in appearance and approximately 1/16 inch (1½ mm) deep. A runway pavement constructed with a burlap drag finish is shown in figure 2-4.

18. Wire Combing - The wire comb technique uses rigid steel wires to form a deep texture in the plastic concrete pavement. An excellent example of this method is the one constructed at Patrick Henry Airport in Virginia, where the spacing of the ridges was approximately ½ inch (13 mm) center to center (see figure 2-5). The spring steel wires which were used had an exposed length of 4 inches (100 mm), 0.028 inch (0.7 mm) thick and 0.08 inch (2 mm) wide. The wire comb equipment should provide grooves that are approximately 1/8 inch x 1/8 inch (3 mm x 3 mm) spaced ½ inch (13 mm) center to center. It is not necessary to provide preliminary texturing before constructing the wire comb texture. Because of the closeness of the spaced grooves, the preliminary

texturing of the remaining land areas would not be effective. The wire comb technique should be constructed over the full pavement width. This technique is not to be confused with saw cut or plastic-grooved runway pavements. Wire combing is a texturing technique and cannot be substituted for saw cut or plastic grooves because it does not prevent aircraft from hydroplaning.

19. Wire Tined - Flexible steel wires are used to form deep texture in the plastic concrete pavement. The flexible steel bands are 5 inches (125 mm) long and approximately ¼ inch (6 mm) wide, spaced ½ inch (13 mm) apart. The appearance of this technique is quite similar to the wire comb method. This technique is not to be confused with saw cut or plastic-grooved runway pavements. Wire tining is a texturing technique and cannot be substituted for saw cut or plastic-grooved because it does not prevent aircraft from hydroplaning.

Section IV Runway Grooving

20. General Grooving Techniques - Cutting or forming grooves in existing or new pavement is a proven and effective technique for providing skid resistance and prevention of hydroplaning during wet weather. In existing pavement, both AC and PCC, grooves must be saw cut; in new PCC pavement, grooves may be formed while the concrete is still plastic. Grooves in AC pavement must be saw cut whether new or existing pavement is to be treated.

21. Determining Need for Grooving - Grooving of all runways, serving or expected to serve turbojet aircraft, should be considered high priority safety work and accomplished during initial construction. Such existing runways without grooving should be programmed as soon as practicable. For other runways, the following factors should be considered:

a. Historical review of aircraft accidents/incidents related to hydroplaning at the airport.

b. Wetness frequency (review of annual rainfall rates and intensity).

c. Transverse and longitudinal grades, flat areas, depressions, mounds, or any other surface abnormalities that may impede water runoff.

d. Surface texture quality as to slipperiness under dry or wet conditions. Polishing of aggregate, improper seal coating, inadequate micro-macrotexture, and contaminant buildup are some examples of conditions that may cause the loss of surface friction.

e. Terrain limitations such as dropoffs at the ends of the runway safety areas.

f. Adequacy of number and length of available runways.

g. Crosswind effects, particularly when low friction factors prevail at the airport.

h. The strength and condition of the runway pavements at the facility.

22. 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 Advisory Circulars 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 AC pavement to determine stability. ASTM Standard D 1559 or Military Standard 620A provides methods for testing the resistance to plastic flow of asphaltic concrete pavements. Experienced 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 AC 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.

23. Overlays - If the evaluation shows that the existing pavement is not suitable because of either 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:

24. AC Pavement Grooving - Construction specifications for grooving are given in paragraph 26. Grooving should not commence until the AC pavement has sufficiently cured to prevent displacement of the aggregate (usually 30 days). Figure 2-6 shows a sawed-groove asphaltic concrete pavement surface.

25. PCC Pavement Grooving - There are two acceptable methods for grooving PCC pavements: plastic grooving and saw-cut grooving.

a. **Plastic Grooving.** One method to form grooves in the concrete while in the plastic state uses a vibrating ribbed plate attached to the bridge that spans across the pavement slab. The plate is vibrated to help redistribute the aggregate in the concrete. This prevents tearing and shearing as the plate proceeds transversely across the pavement slab. The grooves formed in the pavement are approximately ¼ inch x ¼ inch (6 mm x 6 mm) width and depth, spaced 1½ inch (38 mm) center to center. Figure 2-8 shows the grooving operations.

Another method uses a roller with protrusions or ribs which form the grooves in the plastic concrete. This method does not give the same finish as the method using the vibrating ribbed plate. The roller is not vibrated and, therefore, does not consistently penetrate to the required depth of 1/4 inch (6 mm). Figure 2-9 shows the results of this technique.

b. **Sawed Grooves.** For existing or new PCC pavements that have hardened, transverse grooves can be saw cut in the pavement. The timing should be as directed by the engineer. Construction specifications for providing sawed grooves in PCC pavements are given in paragraph 26. Figure 2-7 shows a sawed-groove PCC pavement surface.

26. FAA Specifications for Runway Grooving

a. THE FAA STANDARD GROOVE CONFIGURATION IS ¼ INCH (± 1/16 INCH) IN DEPTH BY ¼ INCH (+ 1/16 INCH, - 0 INCH) IN WIDTH BY 1½ INCH (± 1/8 INCH) CENTER TO CENTER SPACING).

THE FAA STANDARD GROOVE CONFIGURATION IN METRICS IS 6 MM (± 1.6 MM) IN DEPTH BY 6 MM (+ 1.6 MM, - 0 MM) IN WIDTH BY 38 MM (± 3 MM) CENTER TO CENTER SPACING).

b. THE DEPTH OF 60 PERCENT OR MORE OF THE GROOVES SHALL NOT BE LESS THAN ¼ INCH (6 MM).

c. THE GROOVES SHALL BE CONTINUOUS FOR THE ENTIRE RUNWAY LENGTH AND TRANSVERSE (PERPENDICULAR) TO THE DIRECTION OF AIRCRAFT LANDING AND TAKEOFF OPERATIONS.

d. THE GROOVES SHALL BE TERMINATED WITHIN 10 FEET (3 M) OF THE RUNWAY PAVEMENT EDGE TO ALLOW ADEQUATE SPACE FOR OPERATION OF THE GROOVING EQUIPMENT.

e. THE GROOVES SHALL NOT VARY MORE THAN 3 INCHES (8 CM) IN ALIGNMENT FOR 75 FEET (23 M), ALLOWING FOR REALIGNMENT EVERY 500 FEET (152 M).

f. GROOVES SHALL NOT BE CLOSER THAN 3 INCHES (8 CM) OR MORE THAN 9 INCHES (23 CM) FROM TRANSVERSE JOINTS IN CONCRETE PAVEMENTS.

g. GROOVING THROUGH LONGITUDINAL OR DIAGONAL SAW KERFS WHERE LIGHTING CABLES ARE INSTALLED SHALL BE AVOIDED. Grooves may be continued through longitudinal construction joints.

h. Extreme care must be exercised when grooving near inpavement light fixtures and subsurface wiring. GROOVES SHALL BE SAWED NO CLOSER THAN 6 INCHES (15 CM) AND NO MORE THAN 18 INCHES (46 CM) FROM INPAVEMENT LIGHT FIXTURES.

i. Bidding should be based on the square yard of the grooved area, using the two-dimensional method of measure with no deduction for areas skipped next to joints and fixtures as specified.

j. Cleanup is extremely important and should be continuous throughout the grooving operations. The waste material collected during the grooving operation must be disposed of -- either by flushing with water, by sweeping, or by vacuuming. If waste material is flushed, the specifications should state the following:

(1) Whether or not the airport owner or contractor is responsible for furnishing water for cleanup operations.

(2) The waste material should not be flushed into the storm or sanitary sewer system.

(3) The waste material should not be allowed to drain onto the grass shoulders adjacent to the runway or left on the runway surface. Failure to remove the material from all paved and shoulder areas can create conditions hazardous to aircraft operations.

27. Grooving Runway Intersections and Angled Exit Taxiways

a. **IN ALL CASES, THE ENTIRE LENGTH OF THE PRIMARY RUNWAY WILL BE GROOVED. THE SECONDARY RUNWAY INTERSECTING THE PRIMARY RUNWAY SHALL BE SAW CUT IN A STEP PATTERN AS SHOWN IN FIGURE 2-10.**

b. **HIGH SPEED OR ANGLED EXIT TAXIWAYS SHALL BE SAW CUT IN A STEP PATTERN AS SHOWN IN FIGURE 2-11.** Since the grooving machine varies in cutting width, it is suggested that the step pattern width start at the projecting pavement edge, not exceeding 40 inches (102 cm) nor less than 18 inches (46 cm) in width.

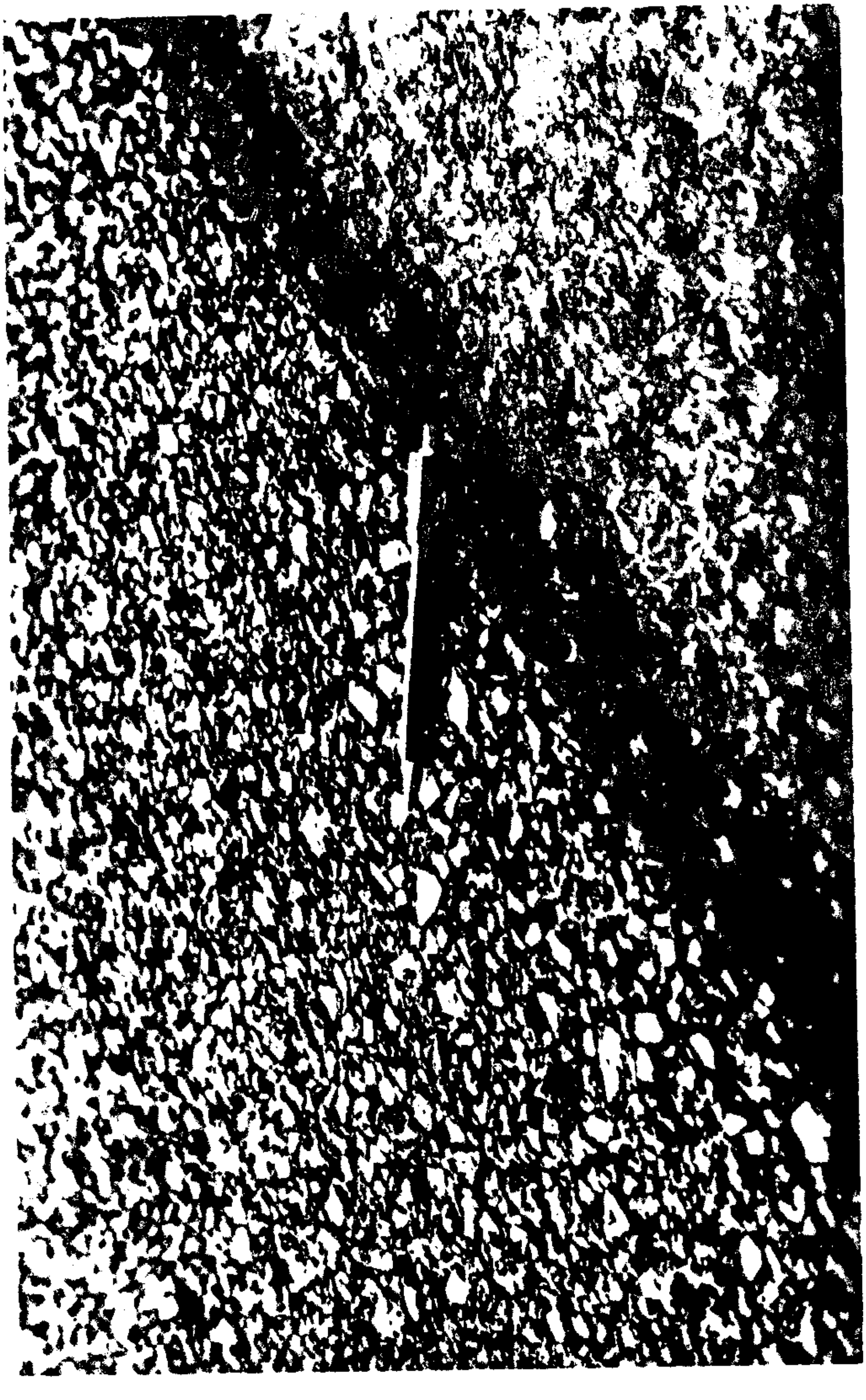

FIGURE 2-1. EDGE VIEW OF POROUS FRICTION COURSE OVERLAY

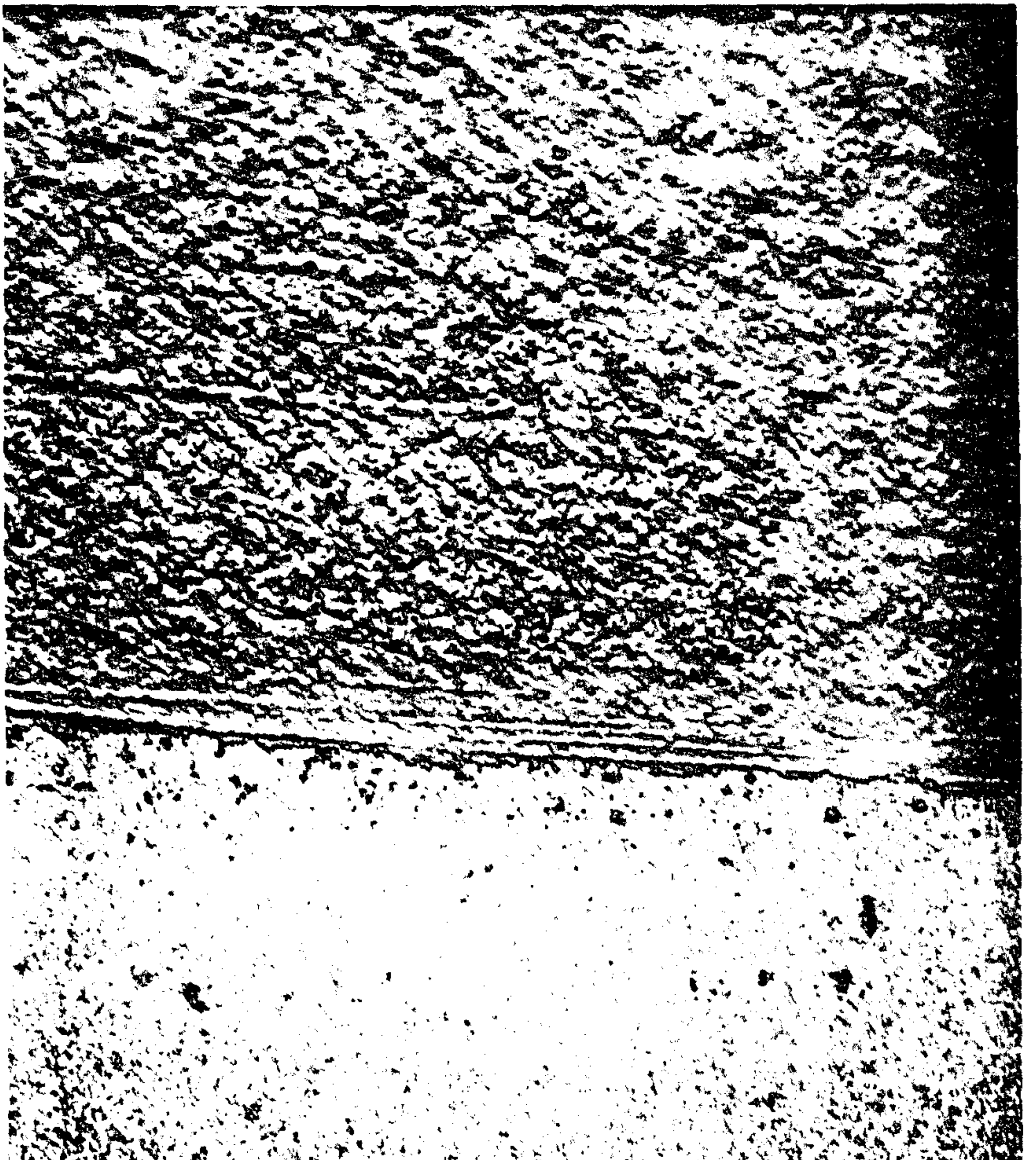

FIGURE 2-2. AGGREGATE SLURRY SEAL

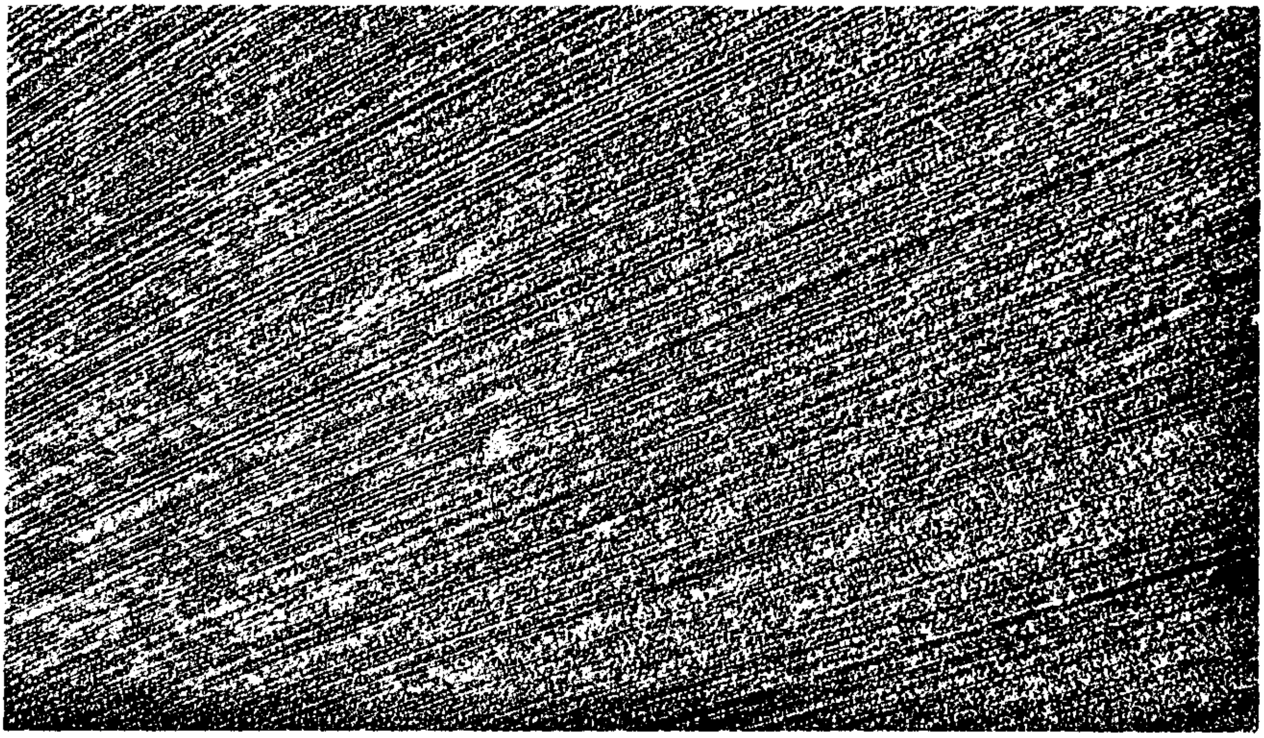

FIGURE 2-3. HEAVY PAVING BROOM FINISH

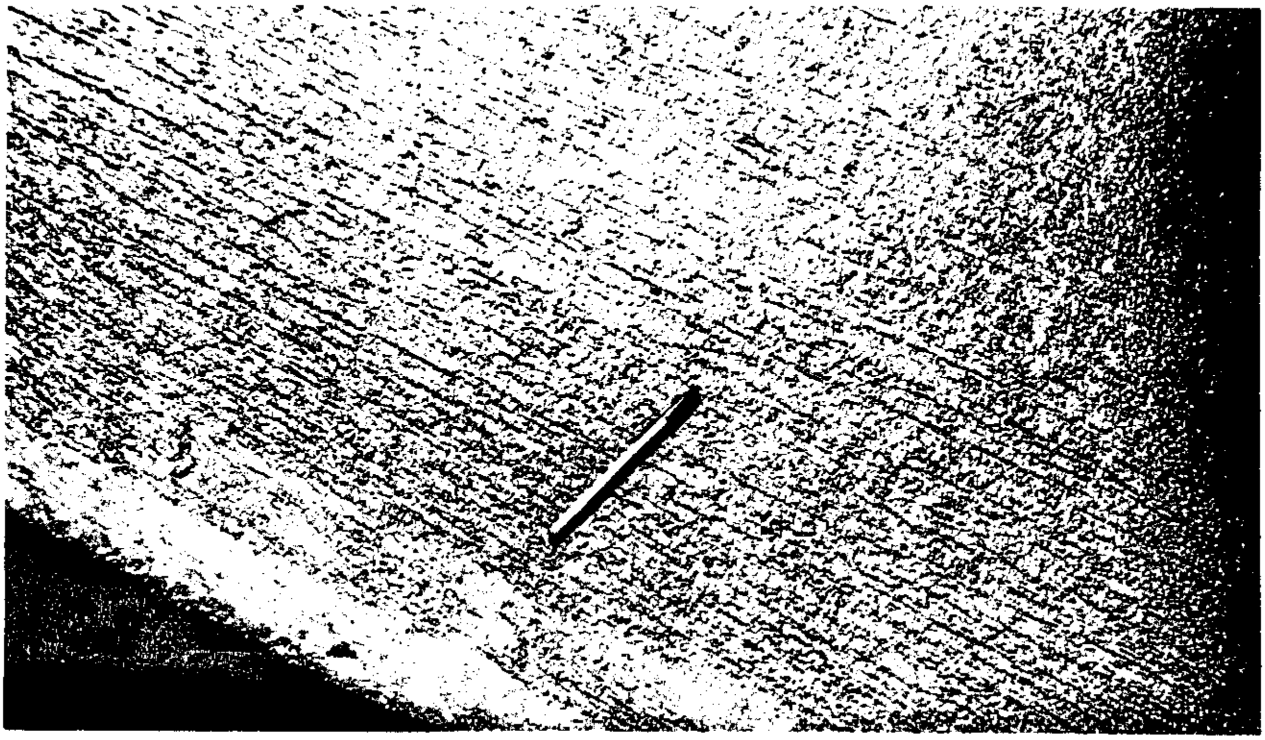

FIGURE 2-4. HEAVY BURLAP DRAG FINISH

FIGURE 2-5. WIRE COMB TECHNIQUE CONSTRUCTED AT PATRICK HENRY AIRPORT, VIRGINIA, USING A 1/8" X 1/8" X 1/2" CONFIGURATION

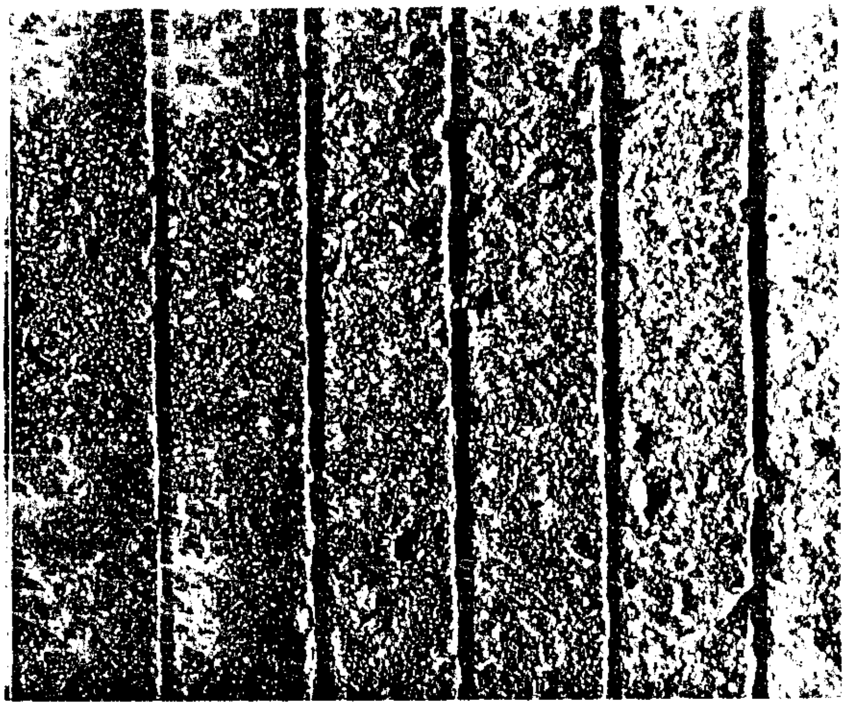

FIGURE 2-6. SAWED GROOVES IN ASPHALTIC CONCRETE PAVEMENT

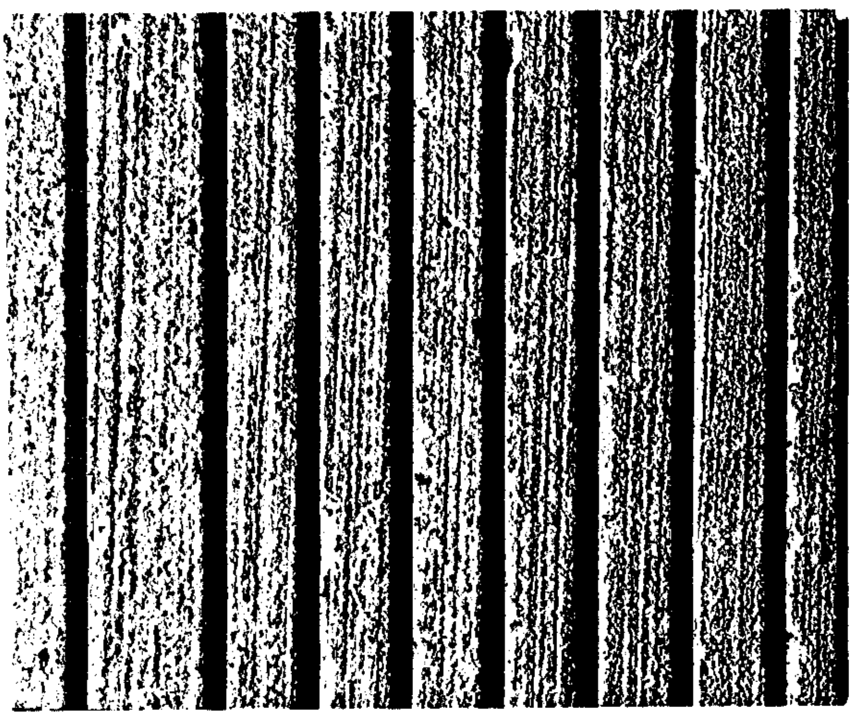

FIGURE 2-7. SAWED GROOVES IN PORTLAND CEMENT CONCRETE PAVEMENT

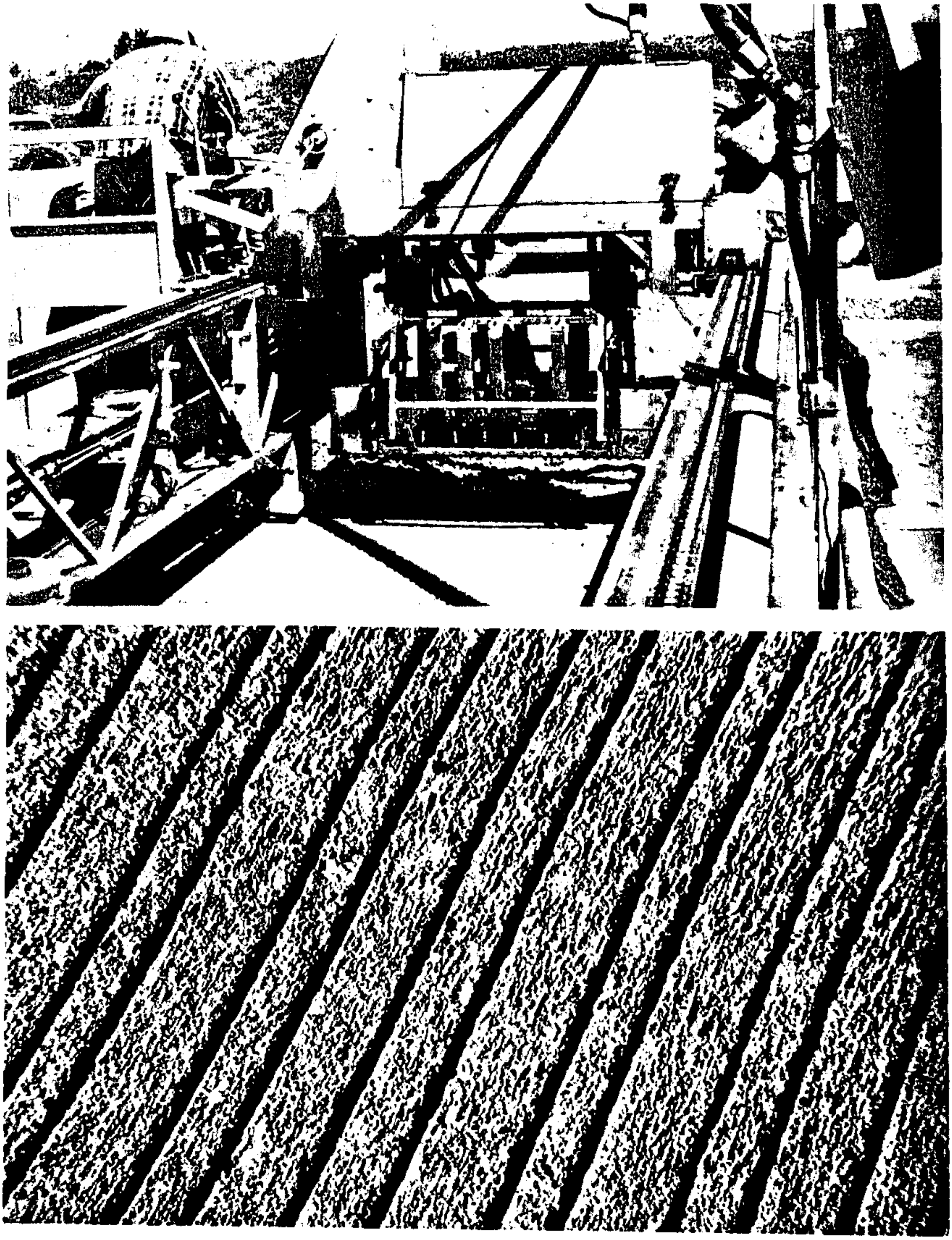

FIGURE 2-8. PLASTIC GROOVING TECHNIQUE USING A VIBRATING RIBBED PLATE

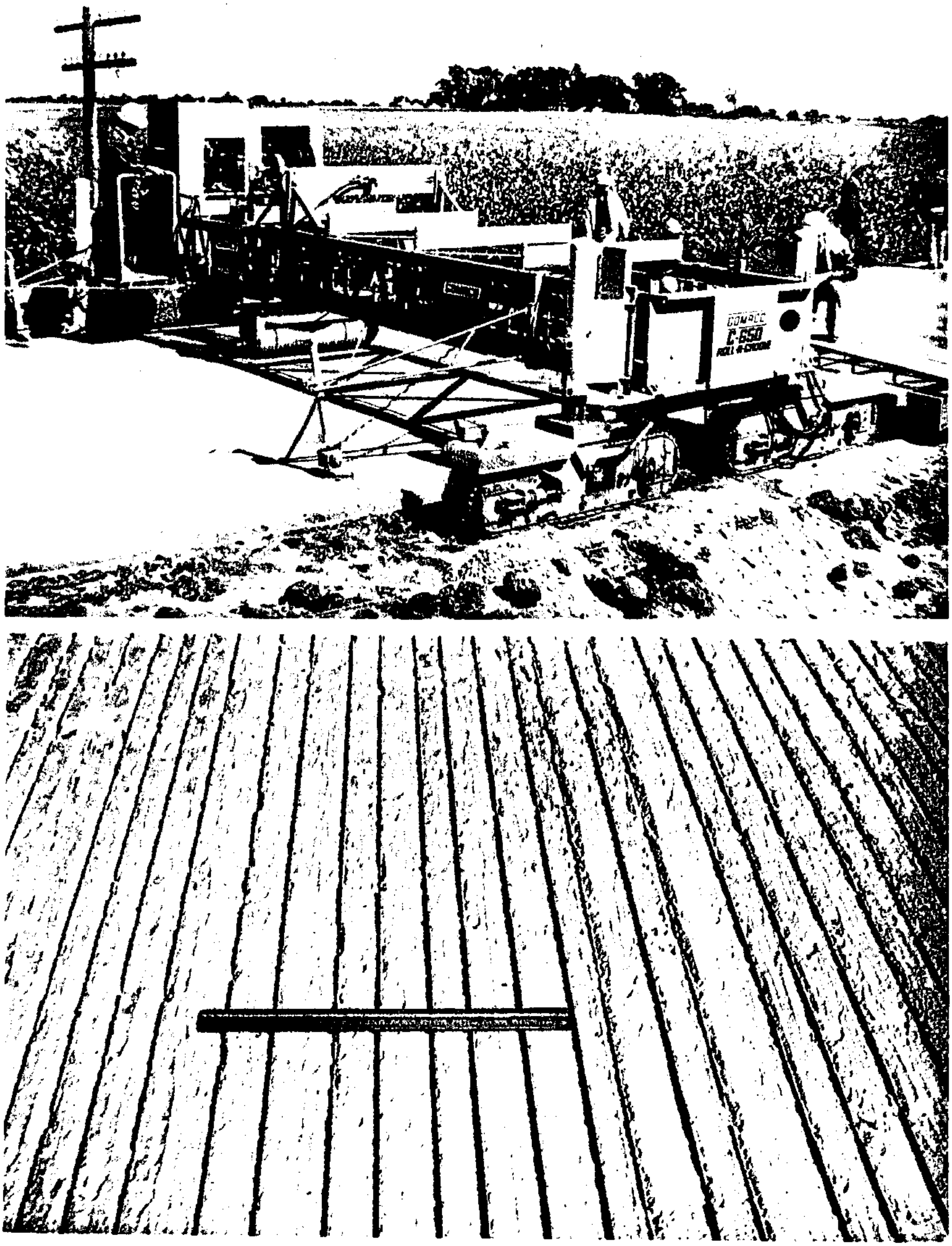

FIGURE 2-9. PLASTIC GROOVING TECHNIQUE USING A RIBBED ROLLER TUBE

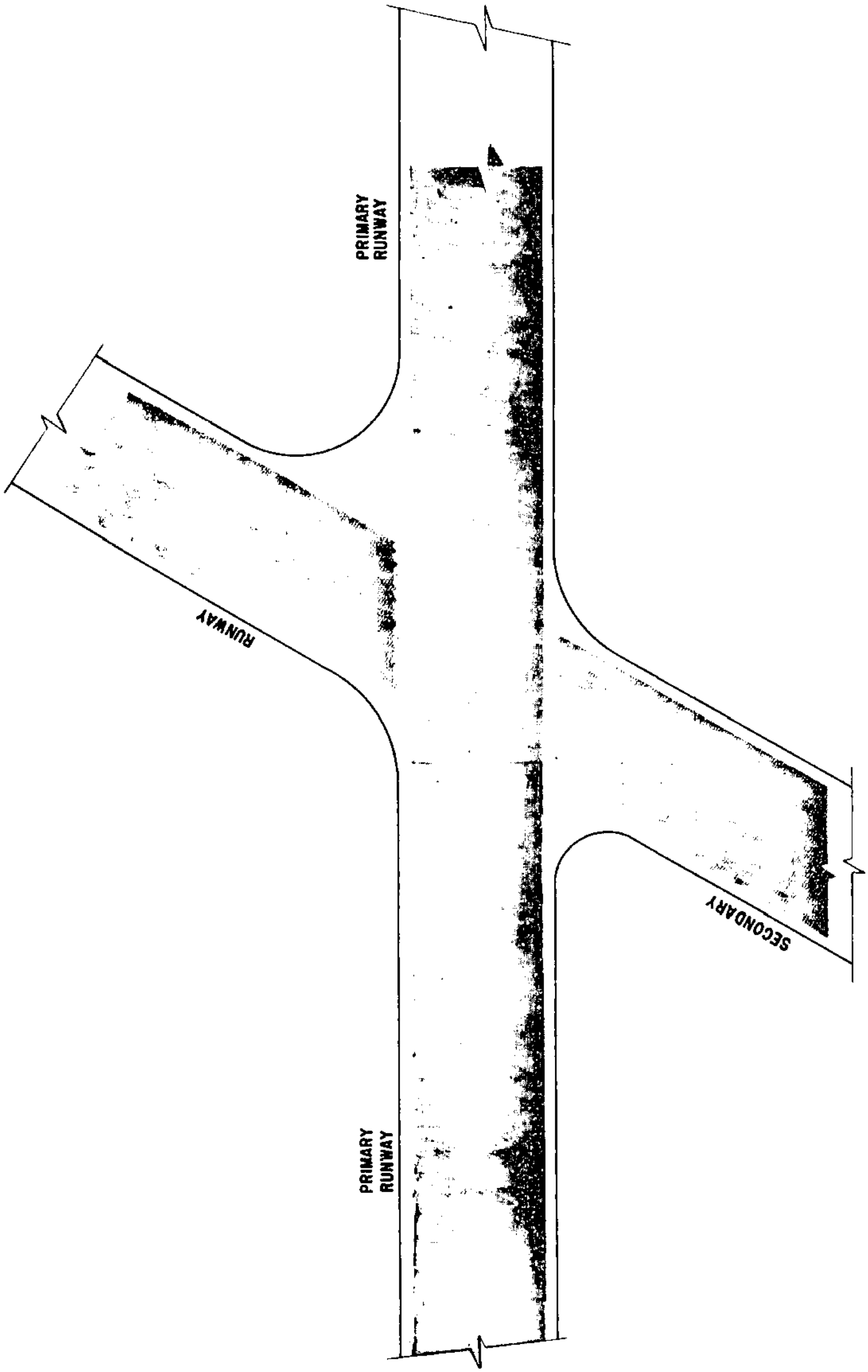

FIGURE 2-10. GROOVING INTERSECTIONS OF PRIMARY AND SECONDARY RUNWAYS

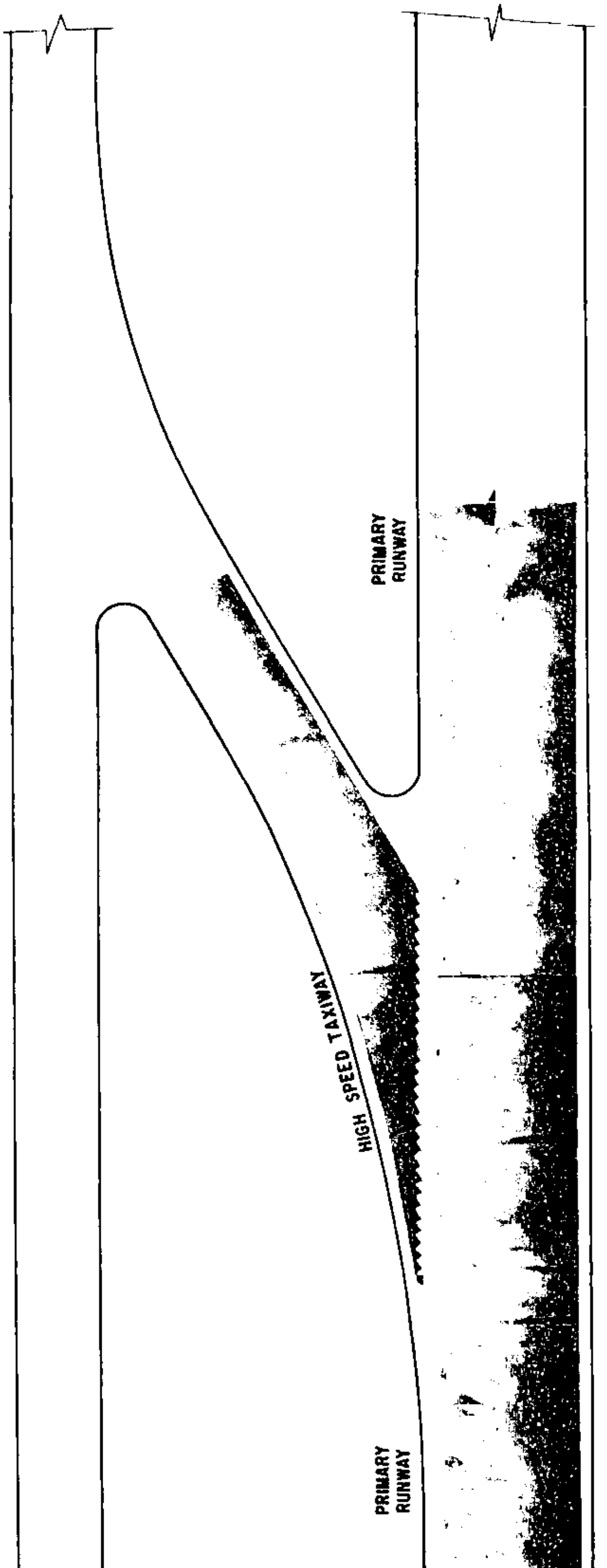

FIGURE 2-11. GROOVING OF HIGH SPEED OR ANGLED EXIT TAXIWAYS

CHAPTER 3 - PAVEMENT EVALUATION

Section I. Need For and Frequency Of Evaluation

28. 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 impact 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 (AC 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 in Advisory Circular 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 Advisory Circular 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, thereby, causing loss of aircraft braking capability and directional control, particularly when runways are wet.

29. Scheduling Pavement Evaluations - The operator of any airport with significant jet aircraft traffic should schedule periodic friction evaluations of each runway which accommodates jet aircraft. These evaluations should be carried out in accordance with the procedures outlined in either section II or III of this chapter, depending upon the availability to the airport operator of continuous friction measuring equipment (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 accumulation builds up. Runway friction measurements take time, whether CFME is used or not, 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, if available, fixed base operations, and/or airlines.

30. Minimum Friction Survey Frequency - Table 3-1 should be used as guidance for scheduling 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 may be adjusted to ensure that evaluators will detect and predict marginal friction conditions in time to take corrective actions.

TABLE 3-1. FRICTION SURVEY FREQUENCY

NUMBER OF DAILY TURBOJET AIRCRAFT LANDINGS PER RUNWAY END	MINIMUM FRICTION SURVEY FREQUENCY
LESS THAN 15	ANNUALLY
16 TO 30	6 MO
31 TO 90	3 MO
91 TO 150	MONTHLY
151 TO 210	2 WKS
GREATER THAN 210	WEEKLY

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

Section II. Conducting Friction Evaluations Without Continuous Friction Measuring Equipment (CFME)

31. Surveys Without CFME - The FAA recommends that all airports serving a significant number of turbojet aircraft use CFME in accordance with section III of this chapter. CFME may be owned solely by the airport, borrowed from a nearby airport as needed, or owned by a pool for use at a number of airports. However, if CFME is not available, there are two basic methods of evaluating runway friction an airport operator should use to determine need for corrective action. These two methods, systematic visual inspection of pavement surfaces and pavement texture measurement, are outlined in the following paragraphs: The frequency of conducting these surveys should be determined by reference to table 3-1 for each runway end.

32. Systematic Visual Inspection Procedure - All survey personnel should be fully briefed on and follow safe operational procedures on active airport surfaces and should have appropriate communication equipment for monitoring ground control or airport advisory frequencies.

The touchdown zone should be separated into 500-foot (152 m) segments and each segment evaluated separately.

During the conduct of visual inspection surveys, a record of the pavement surface conditions should be taken to note the extent and condition of pavement texture; evidence of drainage problems; surface treatment condition; and any evidence of pavement structural deficiencies. Sample forms are provided in appendix 3 for recording the visual pavement inspection surveys.

As an aid in estimating the percentage of rubber deposits covering the pavement texture, the evaluator should stroke the pavement surface by hand at several locations in the touchdown zone. Careful and complete notes taken during the periodic surveys should be maintained as long-term records can be used to forecast the rate of deterioration and to evaluate the effectiveness and longevity of treatments to restore skid resistance.

In technical discussions of friction, the term MU is often used. It is a quantitative number expressing the relative resistance to slipping of two surfaces bearing on one another, e.g., rubber tire on pavement. The higher the number, the more resistant the pavement is to slipping.

Table 3-2 gives simulated MU values obtained with a fixed-brake CFME operating over pavement with conditions similar to those noted. Table 3-2 may also be used as a guide for planning and scheduling rubber removal. The last column indicates the frequency that rubber removal could be expected for the air traffic operations at the airport. However, unique conditions at the airport, e.g., weather, pavement type and condition, traffic mix, etc., may cause variance from that norm. The actual results of the evaluations made in accordance with section(s) II or III in chapter 3 should be used to schedule contaminant removal according to the recommendations given in table 4-1 in chapter 4. Other factors that can cause pavement deterioration are: age of the pavement; excessive wear by the rolling, turning and braking action of aircraft tires; climatic influences; number of wide-body aircraft that operate on the runway; and length of runways. Accordingly, the recommended level of action may vary according to conditions encountered at the airport.

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.

Note: The schedules given in the above table are for a runway end that has medium turbojet aircraft activity, about 31 daily operations. As aircraft activity on a runway increases above 31, especially an increase in the wide-body aircraft activity, the airport operator may have to compress the schedule. The percent of coverage should be estimated only on the central portion of the runway most heavily used at touchdown, about 20 to 30 feet (6 to 9 m) on each side of the runway centerline, not edge to edge of the pavement. The MU ranges given above are from fixed-brake CFME and are representative for each classification level. Though the airport does not have a CFME, these values will indicate to the evaluator the projected level of deterioration in friction over time.

Note: During the evaluation of the rubber deposits on the runway, the airport operator should also measure the depth and width of the 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.

33. Pavement Texture Measurement - Pavement texture measurements should be taken in conjunction with visual inspections, and the results recorded in the inspection records. These measurements determine the average texture depth of the surface, that is the average distance between the peaks and valleys in the surface texture. The measurements may be used to evaluate the textural deterioration of the pavement surface caused by contaminant accumulation and wear/polishing effects of aircraft braking action. On grooved pavements, texture depth measurement should be taken in nongrooved areas, such as near transverse joints or light fixtures. Average texture depth in good skid-resistant pavement will average 0.025 inches (0.625 mm) or more. Less than that indicates a deficiency in macrotexture that will need correction as the surface deteriorates. A minimum of three measurements should be taken in each of the touchdown, midpoint, and rollout zones of the runway. More should be taken if there are evident variations in the paving. An average texture depth should be recorded for each zone. Descriptions of equipment, method of measurement, and computations involved are as follows:

a. **Equipment.** On the left in figure 3-1 is shown the tube which is used to measure the volume of grease, either 15 cubic centimeters or 1 cubic inch. On the right in shown the tight-fitting plunger which is used to expel the grease from the tube, and in the center is shown the rubber squeegee which is used to work the grease into the voids in the runway surface. The sheet rubber on the squeegee is cemented to a piece of aluminum for ease in use. Any general purpose grease can be used. As a convenience in the selection of the length of the measuring tube, figure 3-2 gives the relation between the tube inside diameter and tube length for an internal tube volume of one cubic inch (15 cubic centimeters). The plunger can be made of cork or other resilient material to achieve a tight fit in the measuring tube.

b. **Measurement.** The tube for measuring the known volume of grease is packed full with a simple tool, such as a putty knife, with care to avoid entrapped air, and the ends are squared off as shown in figure 3-3. A general view of the texture measurement procedure is shown in figure 3-4. The lines of masking tape are placed on the pavement surface about four inches (10 centimeters) apart. The grease is then expelled from the measuring tube with the plunger and deposited between the previously placed lines of masking tape. It is then worked into the voids of the runway pavement surface with the rubber squeegee, with care that no grease is left on the masking tape or the squeegee. The distance along the lines of masking tape is then measured and the area that is covered by the grease is computed.

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

$$\text{Texture Depth (inches)} = \frac{\text{Volume of Grease (cu.in.)}}{\text{Area Covered by Grease (sq.in.)}}$$

$$\text{Average Texture Depth} = \frac{\text{Sum of Individual Tests}}{\text{Total Number of Tests}}$$

Section III. Conditions Essential For CFME

34. General Requirements for CFME - All airports with significant turbojet traffic should own or have access to use of 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 Advisory Circular 150/5200-30). Airports that have lesser turbojet traffic operations can either borrow the CFME from nearby airports for maintenance use or share ownership with a pool of neighboring airports.

35. FAA Performance Standards for CFME - Appendix 4 contains the performance specifications for CFME. These standards should be used by airport operators in procuring CFME and replacement tires for the equipment.

36. FAA Qualified Product List - The equipment listed in appendix 5 has been tested and approved by the FAA.

37. 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 Advisory Circular 150/5200-30).

38. 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 field office for guidance.

39. <u>Training and Calibration of CFME</u>

a. **Training.** 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 a separate contract with the manufacturer. Also, follow on instruction 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 6. Airport personnel should be trained not only in the operation and maintenance of the continuous friction measuring equipment but also on the procedures for conducting friction surveys. These procedures are provided in section IV below.

b. **Calibration** - All CFME should be checked for calibration within tolerances given by the manufacturer before conducting friction surveys. CFME furnished with self water systems should be calibrated periodically to assure that the water flow rate is correct and that the amount of water produced for the required water depth is consistent and applied evenly in front of the friction measuring wheel(s) for all test speeds.

<u>Section IV. Conducting Friction Evaluation With CFME</u>

40. <u>Preliminary Steps</u> - Friction measurement operations should be preceded by a thorough visual inspection of the pavement to identify deficiencies as outlined in paragraph 31. Careful and complete notes should be taken not only of the CFME data but of the visual inspection as well. Appendix 3 contains a suggested checklist and data format which may be used for maintaining long-term records. The airport operator should assure 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.

41. <u>Location of Friction Surveys on Runway</u> - The airport operator, when conducting friction surveys on runways at 40 mph (65 km/h), should begin recording the data 500 feet (152 m) from the threshold end to allow for adequate acceleration distance. The friction survey should be terminated approximately 500 feet (152 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 (305 km) from the threshold end and terminate the survey approximately 1,000 feet from the opposite end of the runway. The lateral location on the runway for performing the test is based on the type of aircraft operating on the runway. 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, when both runway ends are to be evaluated, vehicle runs can be made to record data on the return trip (both ways).

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.

42. <u>Vehicle Speed for Conducting Surveys</u> - All of the approved CFME in appendix 6 can be used at either 40 mph (65 km/h) or 60 mph (95 km/h). The lower speed is most often used and determines the overall macrotexture/contaminant/drainage condition of the pavement surface. If the airport operator suspects that the runway has microtexture problems (pavement does not feel "sandpapery" and/or aircraft report skidding only at higher speeds), measurements

should also be made periodically at 60 mph (95 km/h).

43. Wet and Dry Friction Surveys - Since wet pavement *always yields the lowest friction* measurements, CFME should routinely be used on wet pavement - the "worst case" condition.

a. **Wet Pavement Simulation.** CFME is equipped with a self water system to simulate rain-wet pavement surface conditions and provide the operator with a continuous record of friction values for each foot travelled along the length of the runway. The attached nozzle(s) are designed to provide a uniform water depth of 1 mm (0.04 inches) 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.*

b. **Dry Pavement Simulation**. CFME friction is used on dry runway pavements to establish the maximum available friction for aircraft braking performance. In addition, it sets a base line for comparison of existing and newly constructed pavements to determine the deterioration level over time. After the rate of deterioration has been established, the airport operator can project when maintenance should be required to bring the surface back to the original dry friction level.

44. Friction Surveys During Rainfall - One limitation in using the self-water system on a friction measuring device is that it cannot by itself indicate the potential for hydroplaning. Some runways have depressed areas which pond during periods of moderate to heavy rainfall. These areas may exceed considerably the water depth used by the self-water system of the friction measuring device. Therefore, it is recommended that the airport owner 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 0.125 inches (3 mm) over a longitudinal distance of 500 feet (152 m), the depressed area should be corrected to the standard transverse slope. If possible, the airport owner should conduct periodic friction surveys during rainfall through the ponded areas.

45. Friction Level Classification - MU numbers (friction 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 3-3 depicts the friction values for three classification levels for four 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 Wallops Flight Facility in 1989.

TABLE 3-3 FRICTION LEVEL CLASSIFICATION FOR RUNWAY PAVEMENT SURFACES

TYPE OF FRICTION EQUIPMENT	MOUNTED WITH DICO TIRE		MOUNTED WITH McCREARY TIRE			
	MARK 4 MU METER TRAILER		M 6800 RUNWAY FRICTION TESTER		BV-11 SKIDDOMETER TRAILER	MARK 2 SAAB FRICTION TESTER
RUNWAY SURFACE	FRICTION SURVEY SPEED		FRICTION SURVEY SPEED		FRICTION SURVEY SPEED	
FRICTION LEVEL	40 MPH	60 MPH	40 MPH	60 MPH	40 MPH	60 MPH
CLASSIFICATION	*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

46. Evaluation and Maintenance Guidelines - The following evaluation and maintenance guidelines are recommended based on the friction levels classified in table 3-3. In using these guidelines, it should be noted that poor friction conditions for short distances on the runway do not pose a safety problem to aircraft. However, long stretches of slippery pavement are of serious concern and require prompt remedial action.

(a) **Friction Deterioration Below the Maintenance Planning Friction Level for 500 Feet (152 m).** When the averaged MU value on the wet runway pavement surface is less than the **Maintenance Planning Friction Level** but above the **Minimum Friction Level** in table 3-3 for a distance of 500 feet (152 m), and the adjacent 500-foot (152 m) segments are at or above the **Maintenance Planning Friction Level**, no corrective action may be required. These readings indicate that the pavement friction is deteriorating but the situation is not within a nonacceptable 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 for 1000 Feet (305 m).** When the averaged MU value on the wet runway pavement surface is less than the **Maintenance Planning Friction Level** in table 3-3 for a distance of 1000 feet (305 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 3-3 for a distance of 500 feet (152 m), and the adjacent 500-foot (152 m) segments are below the **Maintenance Planning Friction Level**, 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.

(d) **New Design/Construction Friction Level for Runways.** For new constructed runway pavement surfaces serving turbojet aircraft operations that are either saw-cut grooved or have a porous friction course (PFC) overlay, the averaged MU value on the wet runway pavement surface for each 500-foot (152 m) segment should be no less than the **New Design/Construction Friction Level** in table 3-3.

(e) **Evaluation of Paint Areas on Runway.** Paint on wet runway pavement surfaces causes very slippery conditions for aircraft braking operations. Friction surveys should be conducted over painted surfaces at 40 mph (65 km/h), under dry and wet conditions, to check the magnitude of the change in friction values between the unpainted and painted surfaces. When the averaged MU value is at the **Minimum Friction Level** in table 3-3 for 100 feet (30 m) or more and/or the difference between the wet and dry readings is greater than 40, corrective action should be taken. Usually this means adding a small amount of sand to the paint mix to increase the friction properties of the paint to an acceptable level.

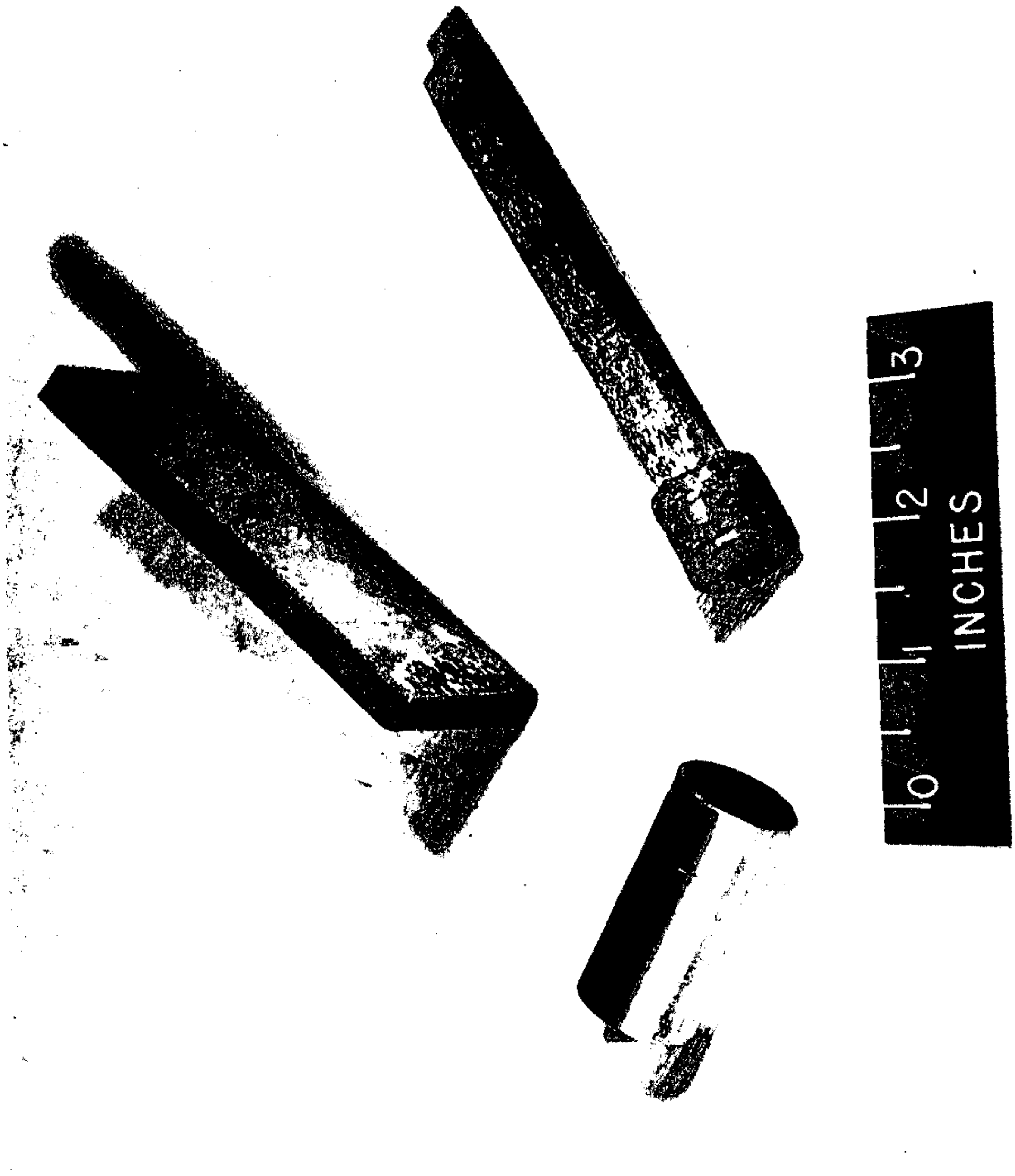

FIGURE 3-1. GREASE-VOLUME MEASURING TUBE, PLUNGER, AND RUBBER SQUEEGEE

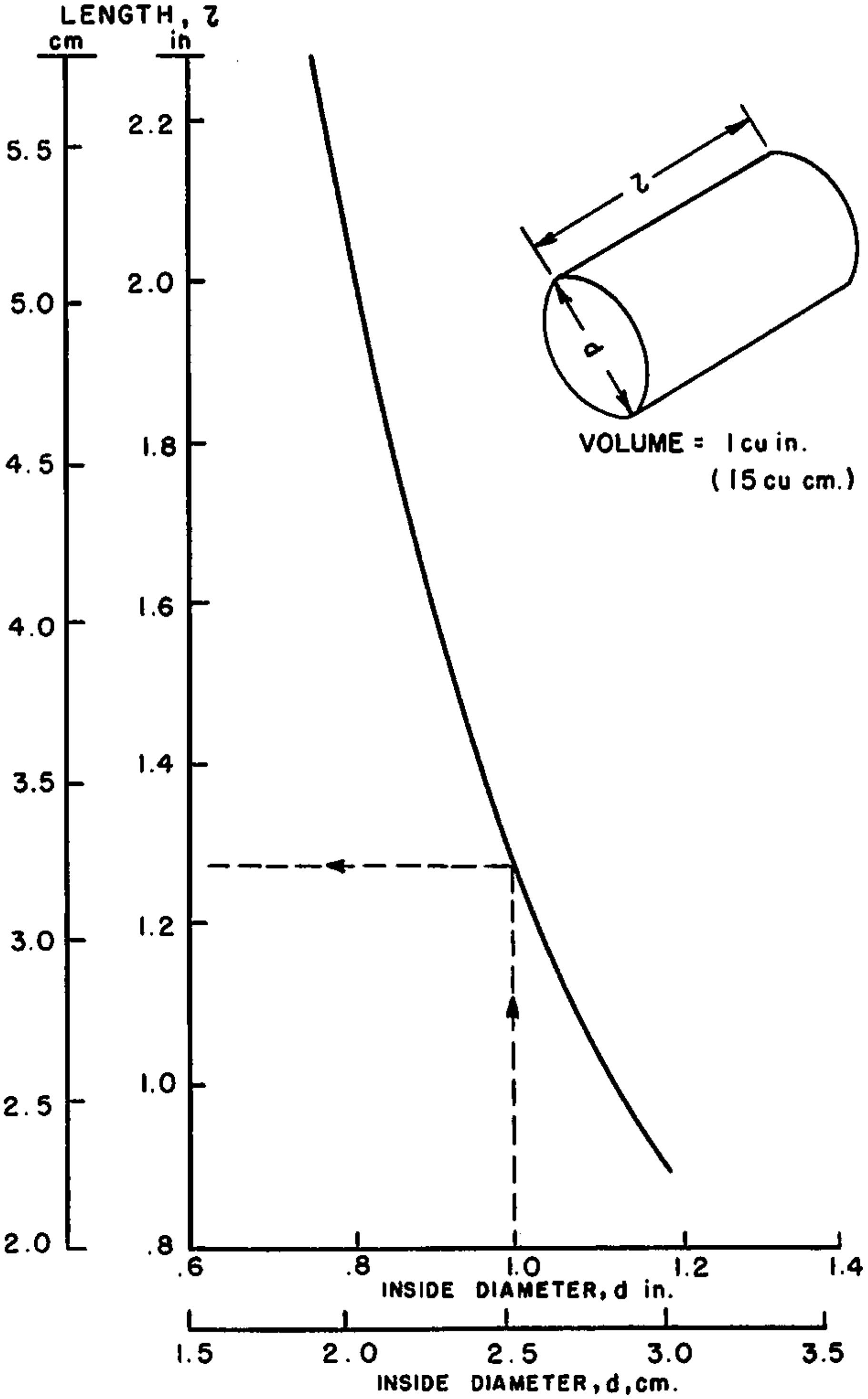

FIGURE 3-2. MEASURING TUBE DIMENSIONS TO MEASURE ONE INCH OR FIFTEEN CUBIC CENTIMETERS

FIGURE 3-3. MEASURING TUBE FILLED WITH GREASE

FIGURE 3-4. ILLUSTRATION OF APPARATUS USED IN GREASE APPLICATION TECHNIQUE FOR MEASURING RUNWAY SURFACE TEXTURE DEPTH

CHAPTER 4 - MAINTAINING HIGH SKID RESISTANCE

Section I. Maintenance Considerations

47. Need for Maintenance - As traffic mechanically wears down microtexture and macrotexture and as contaminants build up on runway pavements, friction will decrease to a point where safety may be diminished. At joint-use airports, where high numbers of military aircraft operations occur, the venting of excess fuel can lead to serious loss of friction by either causing contaminant buildup or an oil film on the pavement surface. Also, fog seal treatment of asphalt concrete surfaces can substantially reduce the pavement's coefficient of friction during the first year after application. Surfaces which already had marginally acceptable friction can become unacceptable when given this type of surface treatment.

When the measured coefficient of friction values approach or drop below the **Maintenance Planning Level** as shown in table 3-3 in chapter 3 or when the visual inspection shows deteriorating friction as noted in table 3-2, the airport operator should schedule appropriate and timely maintenance for removal of contaminants and restoration of good friction characteristics according to the suggested schedule given in table 4-1. As stated in chapter 3, the average aircraft mix was based on mostly narrow-body aircraft, such as the DC-9, BAC-111, B-727, B-737, etc., with a few wide-body aircraft operations included. Rubber accumulation is dependent on the type and frequency of aircraft landing operations; i.e., weight of aircraft and the number of wheels that touchdown on the surface. When more than 20 percent of the total aircraft mix landing on any one runway end are wide-body aircraft, such as the L-1011, B-747, DC-10, MD-11, C-5, etc., it is recommended that the airport operator should select the next higher level of aircraft operations in table 4-1 to determine the rubber removal frequency.

TABLE 4-1 RUBBER REMOVAL FREQUENCY

NUMBER OF DAILY TURBOJET AIRCRAFT LANDINGS PER RUNWAY END	SUGGESTED RUBBER REMOVAL FREQUENCY
LESS THAN 15	2 YRS
16 TO 30	ANNUALLY
31 TO 90	6 MO
91 TO 150	4 MO
151 TO 210	3 MO
GREATER THAN 210	2 MO

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

Section II. Methods for Removing Contaminants

48. 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 assure that 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. 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, or ice; nor should chemical or water impact removal methods be used if the temperature is expected to be below 40 degrees F (5 degrees C).

a. **Removal by High Pressure Water.** A series of high pressure water jets is aimed at the pavement surface to blast the contaminants off, allowing the water to transport the rubber particles to the edge of the runway. The technique is economical, environmentally clean, and effectively removes deposits from the pavement surface with minimal downtime to the airport operator. Most types of equipment used today operate at a water pressure between 5,000-8,000 lb/in^2 (35-55 MPa) and are capable of pressures exceeding 10,000 lb/in^2 (69 MPa). One type is purported to remove rubber successfully with water pressures up to 35,000 lb/in^2 (240 MPa). Rubber deposits are easily removed from PCC pavement having saw-cut grooves, but they are more difficult to remove from AC pavements. The water used at high pressures does remove the rubber, but if pressures are set too high, the water also removes the bitumen and possibly some aggregate within the pavement itself. Generally, the high pressure water technique was found to be the most effective method for removing rubber deposits on asphaltic concrete pavements, however, it must be used with extreme care.

b. **Removal by Chemicals.** Chemical solvents have been used successfully for removal of contaminants on both PCC and AC runways. Any chemicals used on runways must meet the Environmental Protection Agency requirements. For removal of rubber deposits on PCC runways, chemicals are used which have a base of cresylic acid and a blend of benzene, with a synthetic detergent for a wetting agent. For removal of rubber deposits on AC 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 dilutant will not harm surrounding vegetation or drainage systems, or pollute nearby streams and wildlife habitats. Detergents made of metasilicate and resin soap can be effectively used to remove oil and grease from PCC runway surfaces. For AC pavements, an absorbent or blotting material such as sawdust or sand combined with a rubber alkaline degreaser can 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 impact. 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 AC 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 inches (3.2 and 4.8 mm) in depth.

APPENDIX 1 - QUALIFICATION PROCESS FOR CFME

1. FRICTION EQUIPMENT CORRELATION PROGRAM. From 1982 through 1985, the FAA conducted a series of tests to determine the correlation of the Mu Meter with the Saab Friction Tester, Skiddometer, and the Runway Friction Tester, using the equipments' self-water systems on dry pavement surfaces at NASA's Wallops Flight Facility. Correlation values were established for the Saab Friction Tester, the Runway Friction Tester, the Skiddometer, and the Mu Meter. Reference Appendix 2, Report No. DOT/FAA/AS-90-1, which shows the results of the correlation trials conducted at NASA Wallops Flight Facility in August 1989.

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. The rubber couples well with a good microtextured surface to provide high friction at the lower speeds. At speeds over 100 mph, 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 macrotextured surfaces. In essence, this theory simply states that a good macro/microtexture surface will provide relatively high friction and flat friction-speed gradient on wet pavement surfaces. As speed increases, macrotextured 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 macrotextured pavement surface cannot provide sufficient drainage for good tire/pavement contact. Thus, the friction-speed gradient drops off rapidly.

a. NASA Friction/Speed Gradient Research. 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. Because the test vehicle requires over 2,000 feet of the runway length to obtain 80 mph speed and almost 1,000 feet for deceleration of the vehicle, a good portion of the touchdown zones could not be measured. So, a compromise was made to use only two speeds, 40 and 60 mph. It was determined that these two speeds will provide an adequate representation of the friction/speed gradient for the various textured pavement surfaces encountered.

3. DEVELOPMENT OF PERFORMANCE SPECIFICATIONS 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. To qualify for Federal funds, friction equipment performance standards had to be developed. Friction tests were conducted at NASA's Wallops Flight Facility to develop the performance specification for friction measuring equipment. The specification was 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 the American Society for Testing and Materials (ASTM) requested the FAA to conduct tire performance tests on two tires manufactured according to ASTM specifications E-524 and E-670 and compare these tires with the performance of the present FAA standard tire. A tire performance specification was developed for the test program. The tests were conducted at NASA's Wallops Flight Facility in August 1989. The tires are manufactured in the United States by the McCreary Tire & Rubber Company of Indiana, Pennsylvania and Dico Tire, Inc. of Clinton, Tennessee.

APPENDIX 2 - BIBLIOGRAPHY

1. The latest issuance of the following free publications may be obtained from the U.S. Department of Transportation, Utilization and Storage Section, M-443.2, Washington, DC 20590. The Advisory Circular Checklist, AC 00-2, is updated triannually and contains the listing of all current issuances 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.

2. Copies of the following publications may be obtained from the Superintendent of Document, 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 ($ 15.00).

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

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

3. Copies of Part 15, "Road, Paving, Bituminous Materials, Skid Resistance, and Skid Resistance of Highway Pavements, STP 530," may be obtained from the American Society For Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

4. Copies of "MIL-STD-62OA, Test Methods for Bituminous Paving Materials", may be obtained from the Commanding Officer, Naval Supply Depot, 5901 Tabor Avenue, Philadelphia, Pennsylvania 19120.

5. 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, dated 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, dated 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, dated July 1972.

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

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

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

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

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

i. The Braking Performance of an Aircraft Tire on Grooved Portland Cement Concrete Surfaces, Report No. FAA-RD-8O-78, dated January 1981.

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

k. Analytical and Experimental Study of Grooved Pavement Runoff, Report No. DOT-FAA-PM-83/84, dated August 1983.

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

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

n. The Correlation and Performance Reliability of Several Types of Friction Measuring Devices.

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

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

7. Copies of "Maintenance Practices for Concrete Pavements" may be obtained from the Portland Cement Association, Old Orchard Road, Skokie, Illinois 60076.

8. 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, Report No.14, Synthesis for Highway Practice, dated 1972.

b. Pavement Rehabilitation - Materials and Techniques, Report No. 9, Synthesis of Highway Practice.

c. Factors Affecting Skid Resistance and Safety of Concrete Pavements, Special Report No.101, dated 1969.

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

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

f. Prediction of Skid Resistance Gradient and Drainage Characteristics of Pavements, Record No. 131, dated 1966.

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

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

i. Skid Resistance of Screenings for Seal Coats, Record No. 296, dated 1968.

9. Copies of the following Technical Bulletins may be purchased from the American Concrete Paving Association, 1211 West 22nd.Street, Oak Brook, Illinois.

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.

10. Copies of the following document may be obtained from NASA, under the Code NTT-4, Washington, DC 20546-0001.

a. Evaluation of Two Transport Aircraft and Several Ground Test Vehicle Friction Measurements Obtained for Various Runway Surface Types and Conditions, NASA Technical Paper 2917, dated February 1990.

11. Copies of American Society for Testing and Materials (ASTM) Specifications can be obtained from: ASTM, 1916 Race Street, Philadelphia, Pennsylvania 19103.

DATE OF VISUAL SURVEY	RUNWAY	CONTAMINANTS IN TOUCHDOWN ZONE ON RUNWAY		OTHER CONTAMINANTS OBSERVED ON RUNWAY		ADDIT OBSERV
		CLASSIFICATION OF RUBBER DEPOSIT ACCUMULATION LEVELS	RECOMMENDED ACTION	CLASSIFICATION OF CONTAMINANT(S) AND LOCATION	RECOMMENDED ACTION	

SURFACE TREATMENT CONDITION			PAVEMENT SURFACE TYPE CONDITION		ADDIT OBSERV
SAW-CUT GROOVE	PLASTIC GROOVE	POROUS FRICTION COURSE	ASPHALTIC CONCRETE	PORTLAND CEMENT CONCRETE	

SUGGESTED PAVEMENT DESCRIPTIONS

PAVEMENT SURFACE TYPE	GENERAL PAVEMENT DESCRIPTIONS
ASPHALTIC CONCRETE	Slurry Seal Coat
	New, asphalt-covered aggregate, black color
	Microtexture, 75 % fine aggregate, color of aggregate
	Mixed-texture, 50 - 50 fine, coarse aggregate, color of aggregate
	Macrotextexture, 75 - 100 % coarse aggregate
	Worn surface, coarse aggregate protrudes and/or abraided out
	Open-graded surface course, PFC
	Chip Seal
	Rubberized Chip Seal
	Other
PORTLAND CEMENT CONCRETE	Belt Finished
	Microtextured, predominately fine aggregate
	Macrotextured, predominantly coarse aggregate
	Worn surface, coarse aggregate protrudes and/or abraided out
	Burlap Drag
	Wire Comb
	Wire Tine
	Float Grooved
	Other

APPENDIX 4. PERFORMANCE SPECIFICATIONS FOR CFME

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 shall 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, shall meet the Standard Test Method given in ASTM E 670. The Standard Test Method for the fixed brake slip devices is under preparation by the ASTM Committee.

a. The Friction Measuring Equipment:

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

(3) Shall be capable of automatically providing the operator with a selection of average friction values for both a 500-foot (152 m) and one-third segment of runway length. In addition, it shall be capable of providing data, whereby, the average friction value for any length of runway can be manually calculated.

(4) Shall be capable of producing a permanent trace of friction measurements versus pavement length at a scale of one inch (25 mm) equals 300 feet (90 m). The scale shall be within a tolerance of ± 20 feet (6 m).

(5) Shall be furnished with measuring tires which are designed for use in conducting friction surveys and which meet either ASTM E 670, Standard Test Method for "Side Force Friction on Paved Surfaces Using the Mu Meter or ASTM ES 17, "Standard Specification for Special Purpose, Smooth Tread Standard Tire." Nonribbed (blank) tire(s) shall be used to eliminate the effect of tire tread wear and provide greater sensitivity to variations in pavement surface texture. The tires shall be furnished with split-rims and the tubes shall have curved valve stems. The tire manufacturer(s) must meet the performance criteria as set forth in paragraph 17. The manufacturer of the friction equipment shall provide the airport user with a calibrated pressure dial gauge.

(6) Shall be capable of consistently repeating friction averages throughout the friction range on all types of pavement surfaces. Friction averages for each 500-foot (152 m) segment located on the pavement surface must be within a confidence level of 95.5%, or two standard deviations of ± 6 Mu numbers.

(7) Shall contain a self-watering system that distributes water in front of the friction measuring wheel(s) at a uniform depth of 0.04 inches (1 mm). The manufacturer shall provide documentation to prove that the flow rate is within a tolerance of ± 10 percent for both test speeds.

(8) Shall 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).

(9) Shall include a complete set of the latest operation and maintenance manuals including guidelines for training airport personnel. The training manuals shall include the current copy of advisory circular AC 150/5320-12.

(10) Shall 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 during a friction survey should be stored in an internal microprocessor memory and be readily visible to the operator of the vehicle. This will allow for the examination of data, printouts, and calculation of average friction values over all or any portion of the test run. Each printout of the chart produced by the microprocessor unit shall 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 (152 m) and one-third segments of the runway length as preselected by the operator; and average vehicle speed for that segment.

(11) The CFME trailer shall be painted chrome yellow in accordance with the requirements of AC 150/5210-5, Painting, Marking, and Lighting of Vehicles Used on an Airport.

b. The vehicle;

(1) Shall 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, shall be capable of accelerating to these speeds within 500 and 1000 feet (152 and 305 m) from the starting position, respectively.

(2) Shall have electronic speed control.

(3) Shall have a yellow rotating beacon installed on the top of the vehicle in accordance with the requirements of AC 150/5210-5, Painting, Marking, and Lighting of Vehicles Used on an Airport, and shall be equipped with radio communications with airport operations and ground control.

(4) Shall be equipped with a water tank constructed of strong lightweight material, such as Fiberglas or reinforced plastic. In addition, the water tank shall have the capacity to complete a friction survey on a 14,000-foot (4,267 m) runway in one direction and all necessary appurtenances to deliver the required water flow rate to the friction measuring wheel(s).

(5) Shall have appropriate heavy-duty shock absorbers and heavy-duty suspension to adequately handle imposed loads.

(6) Shall be equipped with a device that will regulate the water flow within the confines of the vehicle near the driver's position. Where flow regulation is automatic, no device is required in the vehicle.

(7) Shall be equipped with mounted spot lights on each side of the vehicle with one controlled from the driver's position and the other from the passenger's position.

(8) Shall be painted chrome yellow in accordance with the requirements of AC 150/5210-5, Painting, Marking, and Lighting of Vehicles Used on an Airport.

c. The Tow Vehicle (If a Separate Tow Vehicle is Used).

(1) Shall be equipped with not fewer than two high wattage halogen floodlights mounted such that the friction measuring device and rear portion of the tow vehicle is illuminated to a level of not less than 20-foot candles within an area bounded by lines not less than 5 feet (2 m) either side of the friction measuring device and not less than 5 feet (2 m) in front of and behind the friction measuring device.

(2) Shall be painted chrome yellow in accordance with the requirements of AC 150/5210-5, Painting, Marking, and Lighting of Vehicles Used on an Airport.

d. Optional Equipment. The tow vehicle may be equipped with an air conditioner when specified by the purchaser.

2. TIRE PERFORMANCE STANDARD. The tire manufacturer shall certify that the friction measuring tires for the CFME meet the requirements given in either ASTM E 670 or ASTM ES 17 specification standards.

APPENDIX 5 - QUALIFIED PRODUCT LIST FOR CFME

MANUFACTURER/SALES REPRESENTATIVE
K. J. LAW ENGINEERS, INC. President Transportation Testing Equipment Division 42300 West Nine Mile Road Novi, Michigan 48375-4103 FAX (313) 347-3343 (M 6800) (313) 347-3300 RUNWAY FRICTION TESTER
BISON INSTRUMENTS, INC. President 5708 West 36th Street Minneapolis, Minnesota 55416 FAX (612) 926-0745 (612) 926-1846 MU METER (Mark 4)
AIRPORT EQUIPMENT COMPANY AB President Post Office Box 20079 BROMMA, SWEDEN S-161 20 ATT 01 46 8 295070 SKIDDOMETER (BV-11)
AIRPORT TECHNOLOGY USA President 6 Landmark Square Suite 400 Stamford, Connecticut 06901 FAX (203) 378-0501 (Mark 2) (203) 359-5730 SURFACE FRICTION TESTER

APPENDIX 6 - TRAINING REQUIREMENTS OUTLINE FOR CFME

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 Training and Instruction Manual should always be provided to the airport personnel by the manufacturer and kept updated.

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 Advisory Circulars.

4. General Discussion on Pertinent ASTM Standards.

5. General Overview of Program.

6. Review of Requirements in Advisory Circular 150/5320-12.

(a) Coefficient of Friction Definition.

(b) Factors Affecting Friction Conditions.

(c) ASTM Standards for CFME.

(d) ASTM Standards for Friction Measuring Tires.

(e) Operation of CFME.

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

(g) Maintainance of CFME.

(h) Procedures for Reporting Friction Numbers.

(i) Preparation and Dissemination of NOTAMS.

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

b. FIELD EXPERIENCE

1. Operation and Maintainance of CFME.

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

c. AWARD OF TRAINING CERTIFICATE.

U.S. Department
of Transportation

**Federal Aviation
Administration**

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