U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

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

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Change:

1. PURPOSE. This advisory circular (AC) contains guidance on determining runway surface friction characteristics, specifications for friction measuring equipment, and procedures for the construction and maintenance of skid resistant airport pavement surfaces.

2. CANCELLATION. AC 150/5320-12, Methods for the Design, Construction, and Maintenance of Skid Resistant Airport Pavement Surfaces, dated June 30, 1975, is cancelled.

3. 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 projects funded under Federal grant assistance programs for airports, the standards specified herein are mandatory. These standards are identified by **BOLDFACE CAPITALS**.

4. BACKGROUND. With the introduction of turbojet aircraft, braking performance of aircraft on wet runway pavement surfaces became more critical. Under certain situations hydroplaning occurs resulting in a loss of aircraft braking and directional control. To determine the physical causes for hydroplaning and means of preventing its occurrence, several research programs were jointly conducted by the FAA, the National Aeronautics and Space Administration (NASA), and the United States Air Force (USAF). Although much more work is needed in this area, this AC contains the latest state-of-the-art methods on how to measure runway friction and provides information on the design, construction, and maintenance of pavement surfaces with improved friction characteristics.

5. RELATED READING MATERIAL. Appendix 1 lists publications which contain additional information on the subject matter.

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

Leonard E. Mudd
LEONARD E. MUDD
Director, Office of Airport Standards

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CHAPTER 1. MEASUREMENT OF PAVEMENT SURFACE CHARACTERISTICS

1. GENERAL. This chapter covers two methods for determining the condition of runway pavement surfaces as to their friction characteristics. The first method, as explained in Section 1, is for those airports which do not have friction measuring equipment and the pavement condition is determined by a visual survey. Section 2 covers procedures to be followed for airports having a friction measuring device. Specifications for friction measuring devices are given in Section 3.

SECTION 1. FRICTION SURVEY PROCEDURES.

2. PAVEMENT SURFACE TEXTURE WEAR. Over time, the normal operation of aircraft tires rolling and braking on pavement surfaces wears down the original constructed surface texture until it becomes worn and smooth. The airport owner should periodically measure the textural properties of runway pavements to determine the amount of deterioration that has occurred.

3. PAVEMENT SURFACE TEXTURES. 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, e.g., the feel of very fine sandpaper. Macrotexture refers to roughness of the pavement surface as a whole. For concrete pavements, it is developed by a texturing method that develops ridges of fine mortar and aggregate. When these ridges penetrate above a thin water film, skid resistance and water drainage are improved. Coarse and fine aggregates in asphaltic concrete pavements exposed at the surface provide micro/macrotexture appearance. However, due to the "smoothing" effect of rolling equipment, the coarse aggregates rarely penetrate above a thin water film.

4. FREQUENCY OF FRICTION SURVEYS. Periodic friction surveys should be conducted to assure that wet runway pavement surfaces do not deteriorate below recommended minimum levels (see paragraph 6). Table 1-1 gives the suggested frequency for conducting friction surveys based on the number of daily aircraft operations.

Table 1-1. Suggested Schedule For Conducting Friction Surveys

Number of turbojet aircraft landing daily at airport	Frequency of conducting friction surveys	
	Ungrooved pavements (no surface treatment)	Grooved or porous friction course pavements (including wire combed treated)
Less than 50	every 12 months	every 12 months
51 to 250	every 6 months	every 9 months
251 to 450	every 4 months	every 6 months
451 to 700	every 3 months	every 4 months
701 and above	every 2 months	every 3 months

5. VISUAL INSPECTION OF RUNWAY PAVEMENT SURFACE CONDITION. When conducting friction surveys on runways, a record of the pavement surface condition should be taken to note the extent and amount of rubber accumulation on the surface; type and condition of pavement texture; evidence of drainage problems; surface treatment condition; and any evidence of pavement structural deficiencies. The extent and degree of rubber accumulation should be rated on a scale from zero to nine (no rubber accumulation to pavement texture completely covered). Experience has shown that visual observations alone are insufficient for estimating the degree of rubber accumulation. The pavement surface itself must be touched by the hand to feel the amount of exposed texture left on the rubber coated surface. Table 1-2 contains a method for classifying the degree of rubber accumulation; table 1-3 a method for coding condition of grooves in pavements; and table 1-4 a method for coding pavement surface type.

Table 1-2. Alpha Numeric Coding For Rubber Accumulation

Pavement surface condition	Alpha code	Numerical coding with description
Rubber accumulation	R	0-none 1-rubber covers 10% of texture 2-20% 3-30% 4-40% 5-50% 6-60% 7-70% • 8-80% 9-rubber completely covers texture

Table 1-3. Alpha Numeric Coding For Grooving Condition

Pavement surface treatment	Alpha code	Numerical coding with description
Groove type	H	0-none 1-sawed grooves 2-plastic grooves (includes C-5 to C-8)
Groove condition	G	0-uniform depth across pavement 1-10% 2-20% 3-30% 4-40% 5-50% • 6-60% 7-70% 8-80% 9-grooves not effective

• When these levels are reached, corrective action should be taken.

Table 1-4. Alpha Numeric Coding For Pavement Surface Type

Pavement surface type	Alpha code	Numerical coding with description
Asphalt concrete pavement	A	0-slurry seal coat 1-new, aggregate covered with asphalt, black color 2-microtexture, 75% fine aggregate, color of aggregate 3-mixed-texture, 50-50 fine, coarse aggregate, color of aggregate 4-macrotexture, 75-100% coarse aggregate 5-worn surface, coarse aggregate protrudes and/or abraided out 6-open-graded surface course, PFC 7-chip seal 8-rubberized chip seal 9-other
Portland cement concrete pavement	C	0-belt finished 1-microtexture, predominately fine aggregate 2-macrotexture, predominately coarse aggregate 3-worn surface, coarse aggregate protrudes and/or abraided out 4-burlap dragged 5-broomed or brushed 6-wire comb 7-wire tined 8-float grooved 9-other

6. MEASUREMENT OF PAVEMENT SURFACE TEXTURE. The following procedure is effective for measuring the macrotextural depth of pavements but it will not measure the microtextural properties of the pavement surface. The texture depth along the length of the runway should average at least 0.025 inches (0.25 mm) for good skid resistant properties. To obtain an average texture depth, representative samples should be taken over the entire runway surface. The number of samples required will depend on variations in the surface texture. Descriptions of equipment, method of measurement, and computations involved in this technique are as follows;

a. Equipment. The equipment required is limited to that shown in figure 1-1. On the left in figure 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 is 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 1-2 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.

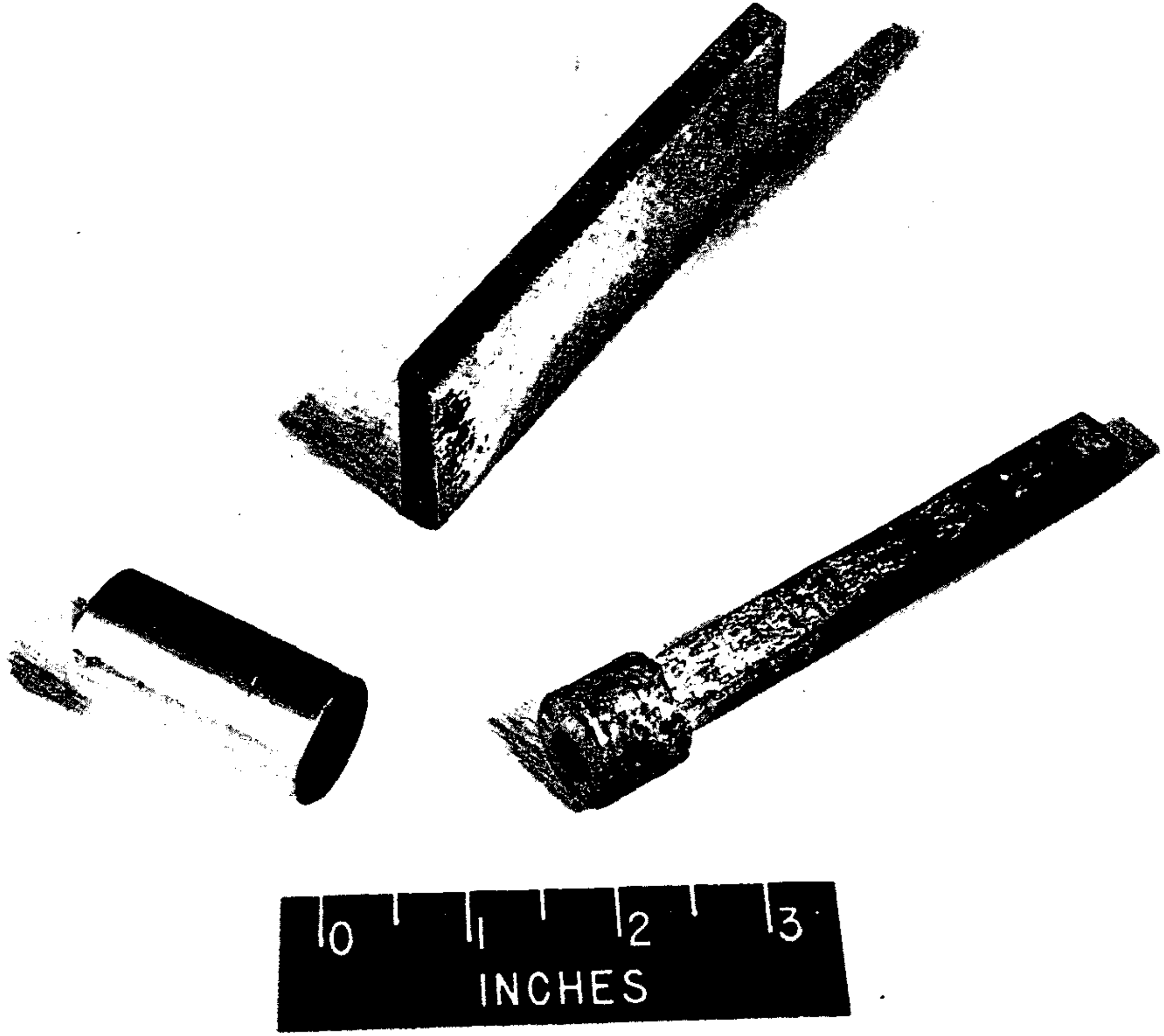

FIGURE 1-1. GREASE-VOLUME MEASURING TUBE, PLUNGER, AND RUBBER SQEEGEE

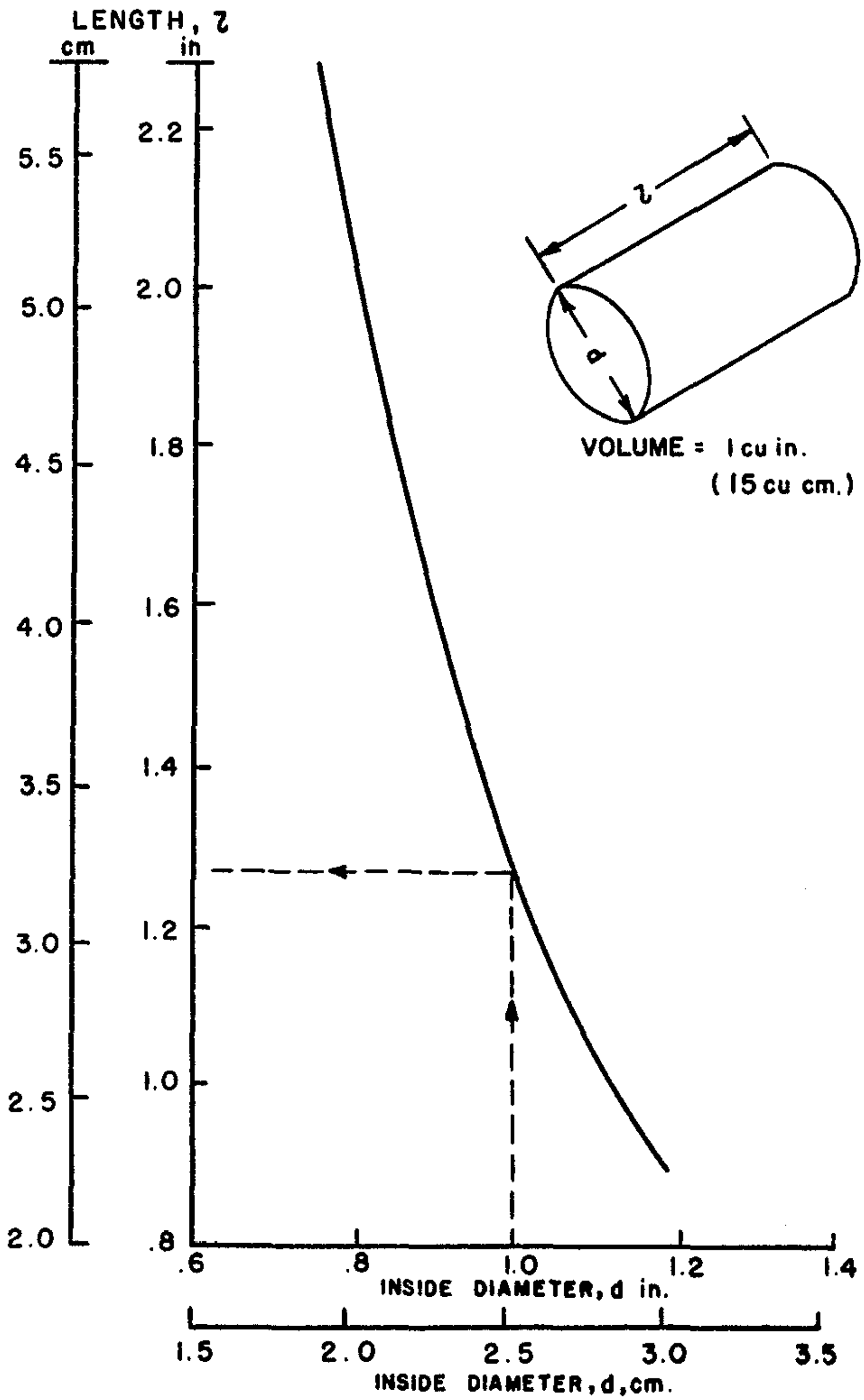

FIGURE 1-2. MEASURING TUBE DIMENSIONS TO MEASURE ONE INCH OR FIFTEEN CUBIC CENTIMETERS

b. Measurement. The tube for measuring the known volume of grease is packed full with a simple tool such as a putty knife, being careful to avoid entrapped air, and the ends are squared off as shown in figure 1-3. A general view of the texture measurement procedure is shown in figure 1-4. 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, being careful 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 computed, the following equations are used to calculate the texture depth.

(1) $\text{Texture depth (inches)} = \dfrac{\text{volume of grease (cu. in.)}}{\text{area covered by grease (sq. in.)}}$

(2) $\text{Average texture depth} = \dfrac{\text{sum of individual tests}}{\text{total tests}}$

7. CONTAMINANTS. Contaminants that collect over a period of time on runway pavement surfaces decrease the friction properties of the pavement when wet. 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.

SECTION 2. FRICTION MEASUREMENT PROCEDURES

8. BACKGROUND. In 1960, NASA began research on aircraft braking performance on dry and wet runway pavements of various textural and groove configurations. In the early 1970's, NASA, FAA, and the 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 and further tests in this area need to conducted. The tests did show, however, that friction measuring devices are effective when used to evaluate pavement surface friction properties for engineering and maintenance purposes.

a. National Runway Friction Measurement Program. 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 air carrier served airports. 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

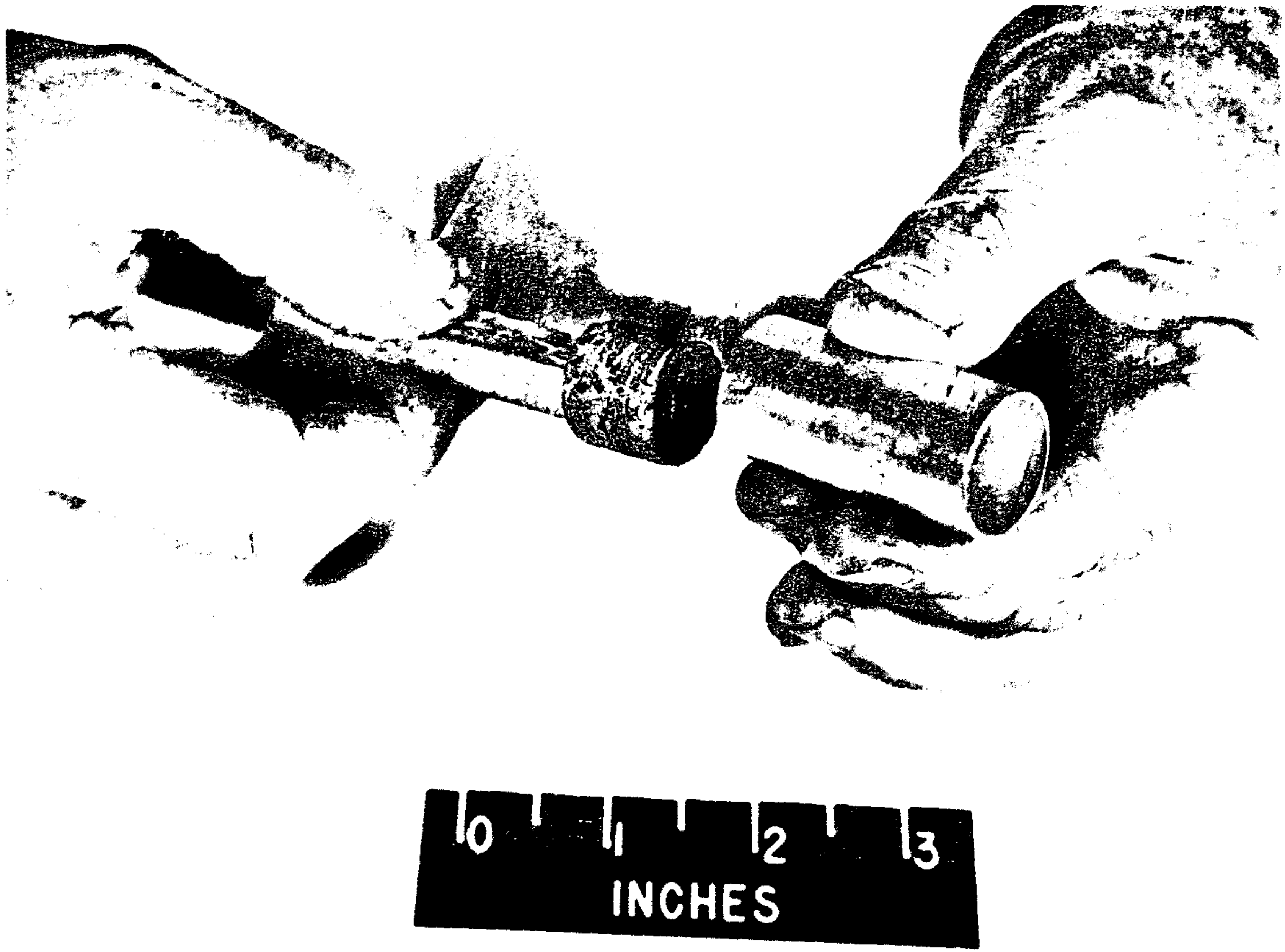

FIGURE 1-3. MEASURING TUBE FILLED WITH GREASE

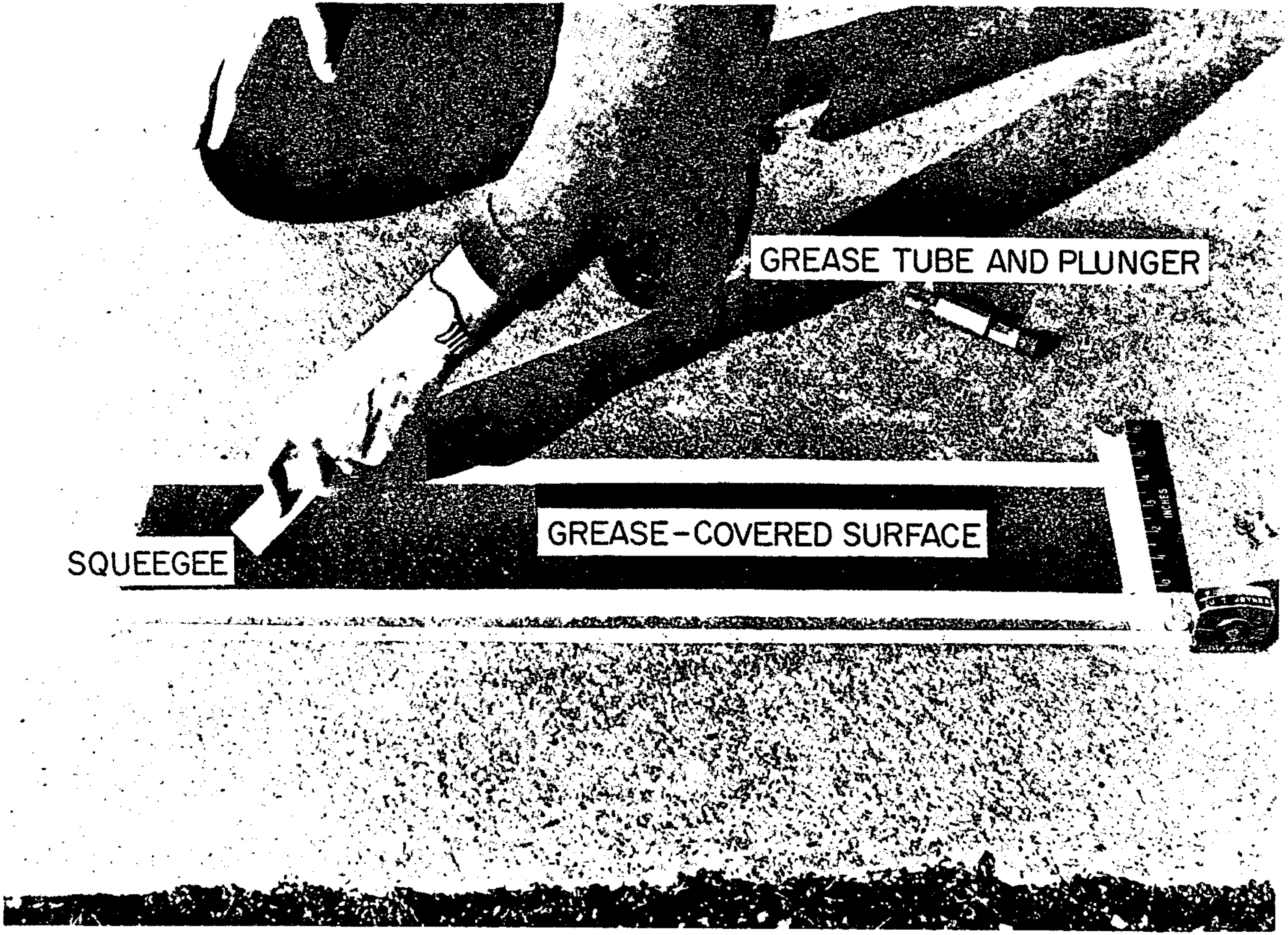

FIGURE 1-4. ILLUSTRATION OF APPARATUS USED IN GREASE APPLICATION TECHNIQUE FOR MEASURING RUNWAY SURFACE TEXTURE DEPTH

program was given to airport owners so that they could take proper corrective measures to eliminate their runway pavement deficiencies.

b. Friction Equipment Evaluation Program. In 1982-1985, the FAA conducted a series of tests to evaluate the performance, reliability and correlation of the Mu Meter with the Saab Friction Tester, Skiddometer, and the Runway Friction Tester under self-wetting conditions. The results, which were repeatable and correlated satisfactorily within the limitations exercised in the test program, indicated that these friction measuring devices were reliable. The evaluation established correlation values for the Saab Friction Tester, the Runway Friction Tester, the Skiddometer, and the Mu Meter.

c. Winter Test Program. A multi-year study was initiated during the 1983-84 winter season to evaluate the effectiveness of several friction measuring devices at several airports to determine the correlation of the friction equipment with various types of aircraft on snow and/or ice covered runways. Pilot braking action reports were used to compare with values obtained by the friction measuring devices. Preliminary results are inconclusive and further testing will be needed to determine if such devices can be used effectively for this purpose.

9. OPERATION AND MAINTENANCE OF FRICTION EQUIPMENT. The success of friction measurements depends heavily on the personnel who are responsible for operating the equipment. Adequate professional training on the operation, maintenance, and procedures for conducting friction measurements is essential to insure reliable friction data. Also, periodic instruction is necessary to review, update, and certify that the operator maintains a high level of proficiency. Experience has shown that unless this is done, personnel lose touch with new developments on calibration, maintenance, and operating techniques. All friction equipment should be checked for calibration within tolerances given by the manufacturer before conducting friction measurements. Friction equipment 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 each vehicle test speed used.

10. APPROVED FRICTION EQUIPMENT. Friction measuring devices that have been approved by the FAA are listed in AC 150/5345-1, Approved Airport Equipment.

11. PROCEDURES FOR CONDUCTING FRICTION MEASUREMENTS.

a. Frequency. Friction measurements should be conducted periodically in accordance with table 1-1.

b. Visual Inspection. Friction measurement surveys should include a visual inspection of the pavement surface condition according to the procedures given in paragraph 5. This information is used to supplement the data obtained from the friction measurements.

c. Data Recording. The following information should be recorded each time a survey is conducted.

(1) Runway number
(2) Distance from runway centerline at which friction survey conducted
(3) Survey time and date
(4) Names of personnel conducting friction survey
(5) Ambient temperature during friction survey
(6) Type of test (calibration, dry, wet)
(7) Weather conditions

d. Location on Runway for Conducting Friction Measurements. Friction measurements are conducted by measuring the friction along the entire length of the runway, in both directions, and 10 feet (3m) to the right of the runway centerline.

e. Vehicle Speed for Conducting Friction Measurements. The standard speed for conducting friction surveys is 40 mi/hr (65 km/hr). A higher speed of 60 mi/hr (97 km/hr), is needed to identify those pavements that have smooth surfaces (texture not apparent to the eye). Pavements with smooth surfaces are not easily identified at slower speeds and are known to be a problem for aircraft operating at high speeds (see paragraph 12d).

f. Conducting Friction Measurements on Dry Runway Pavement Surface. Friction measurements are conducted on dry runway pavements to establish the maximum available friction for aircraft braking performance. Any deterioration from this level is usually due to contaminants or poor microtexture and/or drainage problems. Over a period of time, when conducting friction surveys using the friction equipment self-water systems, the rate of deterioration can be determined based on the drop in friction level from the dry friction values. After the rate of deterioration has been established, the airport operator can project when maintenance will be required to bring the surface back to the original dry friction level. This will provide the airport operator with information that can be used in the airport budgetary planning process. The dry friction surveys should be conducted at least once annually on all runways at the airport that serve turbojet aircraft operations. The dry friction surveys should be completed before conducting friction surveys with the self watering equipment.

g. Conducting Friction Measurements on Dry Runway Pavement Surface Using Self-Watering Equipment. Most friction devices are equipped with self-watering systems to simulate a wet pavement surface by providing a uniform depth of water in front of the friction measuring wheel(s). This water depth will produce friction values that will help the airport operator to identify those areas of runway pavements that are smooth due to poor microtexture, excessive wear by aircraft traffic, aggregates subject to polishing, and contaminants such as rubber deposits or oil and fuel spillages.

h. Conducting Friction Measurements 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 considerably exceed 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 mm), 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.

i. Evaluation of Paint Areas on Runway Pavement Surface. Experience has shown that painted areas on runway pavement surfaces lose friction when wet. These areas should be measured by a friction device under dry and wet conditions to check the magnitude of change in friction values. When the average Mu value is 40 (value obtained by the Mu Meter) or less for 100 ft (30 m), corrective action should be taken. Usually this means adding a small amount of sand to the paint mix to increase the friction properties to an acceptable level.

12. FRICTION SURVEY MEASUREMENT PARAMETERS. The following parameters are based on friction values given by the Mu Meter. Friction values for other devices are given in table 1-5 and were determined from correlation tests conducted at NASA Wallops Flight Center, Wallops Island, Virginia. These guidelines are applicable only for use as a maintenance tool to determine the need for corrective action to improve friction characteristics of a wet runway and do not apply to ice or snow covered runways. Further tests are being conducted to determine the feasibility of using friction devices for the latter case.

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

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

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

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

e. Minimum Friction for Newly Constructed Runway Pavements. For newly constructed runway pavement surfaces 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 ft (152 m) should be no less than 70.

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

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

SECTION 3. SPECIFICATIONS FOR FRICTION MEASURING EQUIPMENT

13. FAA STANDARD. THE CONTENTS OF THIS SECTION ARE FAA STANDARDS.

14. PERFORMANCE REQUIREMENTS. 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.

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 meters) 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 meters). The scale shall be within a tolerance of ± 20 feet (6 meters).

(5) Shall be furnished with measuring tires which are designed for use in conducting friction surveys and which meet ASTM E 670, Standard Test Method for "Side Force Friction on Paved Surfaces Using the Mu Meter, Annex A1, Specification for the Mu Meter 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 equipment manufacturer shall assure supply of the tires will be maintained and at competitive market price levels. The equipment manufacturer shall also guarantee that the performance of the tire is met by statistical methods conducted on each batch produced by the tire manufacturer.

(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 meters) segment located on the pavement surface must be within a confidence level of 95.5%, or two standard deviations of ± 5 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) (may be located on the tow vehicle). The manufacturer shall provide documentation to prove that the flow rate in within a tolerance of ± 10% for both test speeds given in paragraph 14.a.(8).

(8) Shall be able to conduct friction surveys at speeds of 40 and 60 miles per hour (65 and 97 kilometers per hour), within a tolerance of ± 3 miles per hour (± 5 kilometers per hour).

(9) Shall include a complete set of operation and maintenance manuals including guidelines for training airport personnel.

(10) Shall have electronic instrumentation (solid-state electronics) 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, 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 meters) increment of the runway length so easy reference can be made by the operator in identifying specific areas on the runway pavement surface, friction averages for either 500 foot (152 meters) or one-third segments of the runway length as preselected by the operator and average vehicle speed for that segment.

(11) 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 (current edition).

b. The vehicle;

(1) Shall be able to conduct friction surveys at speeds of 40 and 60 miles per hour (65 and 97 kilometers per hour), within a tolerance of ± 3 miles per hour (± 5 kilometers per hour). The vehicle when fully loaded with the prescribed quantity of water shall be capable of accelerating to these speeds within 500 and 1000 feet (152 and 305 meters), respectively, from starting position.

(2) Shall have cruise control to lock in the test speed.

(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 (current edition), 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 fiberglass or reinforced plastic. In addition, the water tank shall have the capacity to complete a friction survey on a 14,000 foot (4,267 meters) 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. In the case 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.

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 meters) either side of the friction measuring device and not less than 5 feet (2 meters) in front of and behind the friction measuring device.

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

15. EQUIPMENT QUALIFICATION PROCEDURES. Procedures for obtaining qualification approval for friction measuring equipment are contained in Appendix 1 of AC 150/5345-1, Approved Airport Equipment.

CHAPTER 2. DESIGN AND CONSTRUCTION OF SKID RESISTANT PAVEMENTS

SECTION 1. GENERAL DESIGN CONSIDERATIONS

16. BACKGROUND. The FAA has conducted many studies concerning pavement surface properties and their effect on aircraft performance when runway pavement surfaces are wet. Grooving and PFC surface treatments both significantly reduce the possibility of hydroplaning. Other noteworthy surface treatments developed through research activities that improve pavement surface texture are 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.

17. GROOVING. Pavement grooving was the first big 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 FAA Technical Center studies showed that a high level of friction was maintained when the saw-cut groove configuration in the runway pavement was constructed at 1/4 inch x 1/4 inch x 1-1/2 inches (6 mm x 6 mm x 38 mm), width, depth and center to center spacing. This is the standard groove configuration recommended by the FAA. Additionally, observations at the Technical Center indicated that grooves do not have to extend to the runway edge to provide adequate drainage after rainfall.

18. POROUS FRICTION COURSE. Research conducted both in the United Kingdom and the United States resulted in a specification for an open graded, thin asphaltic concrete overlay called "Porous Friction Course" (PFC). The overlay was designed with no fines, leaving voids throughout the 1 inch to 1-1/2 inches (25 mm to 38 mm) thick course. This permits rain water to permeate throughout the course and drain off transversely to the side of the runway, preventing water buildup on the surface and creating a "dry" pavement condition during rainfall. The FAA Technical Center study demonstrated that a high level of friction was maintained on the PFC. Porous friction course overlays showed consistently high Mu values for the entire runway length. However, on PFC runways that have a high number of aircraft 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 empty spaces in the overlay, water can no longer drain internally through the structure of the overlay. When this condition occurs, it is impossible to remove the rubber without causing serious damage to the overlay. Therefore, the FAA recommends that PFC overlays not be constructed on runways that have high aircraft traffic operations (over 450 operations per day at the airport).

19. FACTORS THAT INFLUENCE THE TEXTURING OF PAVEMENTS. Several factors influence the texturing of pavements including texture depth, microtexture and macrotexture, timing and finishing, construction techniques when concrete is in a plastic condition and after it has cured, construction techniques for asphaltic concrete pavements, wear, drainage, and contaminants.

a. Texture Depth. The engineer, when designing a pavement, should consider wear-resistant aggregates in a proper mix design and choose a finishing method that will provide the desired textural depth. Experience has shown that newly constructed portland cement concrete pavement surfaces having an average texture depth of 0.025 inches (1/4 mm) provide adequate frictional surfaces. A method for measuring texture depth is given in paragraph 6.

b. Microtexture and Macrotexture. The design of a pavement surface should include both micro/macrotextural properties. 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.

c. Timing and Finishing. Timing in applying the curing compound is as important as the rate of application in the final finishing operations to assure long lasting, nonskid, portland cement concrete pavement surface texture. The timing of the texturing operation is critical because portland cement concrete pavements rarely lose surface moisture evenly or set at a uniform rate, especially during warm weather paving operations. The best time to texture a portland cement concrete 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 up 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 is attained.

d. Construction Techniques When Portland Cement Concrete is in the Plastic Condition. Research and experience has shown that pavements constructed with initial texturing as well as wire combing or grooving, or both, are superior in terms of skid resistance. Texture can be constructed into the portland cement concrete surface while it is in the plastic condition by using a broom, heavy burlap drag, or various types of wire brushes. The final finish will give the overall appearance of a rough surface that is gritty to the touch. It will have irregular, small channels for drainage. Wire or tine comb construction provides a groove-like quality that improves friction and drainage characteristics.

e. Construction Techniques after Portland Cement Concrete has Cured. Saw-cut grooves in cured portland cement concrete pavements provide channels deep enough to remove bulk water from under aircraft tires to mitigate the potential for aircraft hydroplaning.

f. Construction Techniques for Asphaltic Concrete Pavement. The surface texture of newly constructed asphaltic concrete pavements are 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 asphaltic concrete pavements. These include saw-cut grooves, porous friction course, chip seals, and aggregate slurry seals. This chapter gives guidance for constructing these surface treatments. Construction specifications for these treatments are given in AC 150/5370-10.

g. Wear. Over time, the normal operation of aircraft tires rolling and braking on pavement surfaces wears down the original constructed surface texture until it becomes worn and smooth. The airport owner should periodically measure the friction and textural properties of runway pavements to determine the amount of deterioration that has occurred since the previous measurement. The fact that most of the texture above the general plane of the pavement surface has less strength and abrasion resistance than the mass of the pavement slab means it will wear down more rapidly. Abrasive wear on asphaltic concrete pavements depends primarily on the abrasive resistance and hardness of the aggregates. Softer aggregates will wear more rapidly, causing slippery pavements when wet due to the polishing action of aircraft tires. 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 slowing wear resistance.

h. Drainage. The primary function of macrotexture is to provide paths for water to escape from beneath the aircraft wheels. 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. Water runoff on runway pavement surfaces is improved when the surface is textured transversely to the landing/takeoff direction. Microtexture plays an important function also in that it 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. However, textural appearance 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. It is recommended that transverse slopes on runways be at least 1-1/2 percent for effective drainage.

i. Contaminants. Several contaminants can collect on runway pavement surfaces to decrease their friction properties when wet. 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.

20. AGGREGATE CHARACTERISTICS. The most frequently considered characteristics for skid resistant aggregates are resistance to polish and wear, texture, shape, and size of particles.

a. 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 sizes 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 are unweathered crushed quartzite, quartz diorite, granodiorite, and granite.

b. 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 constitutents of different hardness cemented in a matrix that will wear differentially, thus continually exposing new surfaces.

c. 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. Aggregate Size and Gradation. Generally, the larger size aggregates in asphaltic concrete pavement mixtures provide greater skid resistance than the smaller ones. For portland cement concrete pavements, the sand aggregate provides the skid resistance of the pavement surface.

21. 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 (Marshall or gyratory, bituminous mix design, or concrete mix design standards).

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 portland cement concrete pavements, the surface texture will be controlled by the fine aggregate and for asphaltic concrete pavements, the coarse aggregate will be the primary control.

c. Binder. The binder percentage depends on the design criteria.

22. CONSTRUCTION METHODS. For asphaltic concrete pavements, assuming that normal quality control methods are employed, there is little that can be done during construction to improve the texture of the pavement surface. For portland cement concrete pavements, several techniques can be employed during the finishing phase of the paving operation that can improve the surface texture.

23. ASPHALTIC CONCRETE PAVEMENT. For high quality, dense-graded asphaltic concrete pavements, the essential design requirements for stability and durability

of the pavement require high compaction during construction. This may result in substandard water drainage and skid resistance due to a lack of micro and macro-textural surface properties. Water drainage and skid resistance for asphaltic concrete pavements can be improved by constructing a PFC or saw-cut grooves.

a. One method used to improve runway pavement skid resistance and mitigate hydroplaning is a thin asphaltic concrete surface course overlay that ranges from 1 inch to 1-1/2 inches (25 mm to 38 mm) thick, characterized by its open-graded matrix. 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, and 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 AC 150/5380-6. 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 AC 150/5370-10. Figure 2-1 shows a typical PFC overlay constructed on an airport runway. PFC is not recommended for runways at airports which are subjected to more than 450 daily operations by turbojet aircraft. Experience gained from the National Runway Friction Measurement Program and a research study completed by the FAA has shown that once rubber fills the voids in the matrix of the PFC, it is impossible to remove by any known cleaning method without seriously damaging the structural integrity of the PFC.

b. Saw-Cut Grooves. Construction details for asphaltic concrete pavements are given in section 2. The grooving contractor should not proceed with the work until the asphalt concrete pavement has sufficiently cured to prevent displacement of the aggregate (usually 30 days). Figure 2-2 shows a sawed-groove asphaltic concrete pavement surface. Rubber deposits are easily removed from portland cement concrete pavements with saw-cut grooves, but they are more difficult to remove from asphaltic concrete 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.

c. Chip Seal. Temporary improvement of surface friction can be achieved by constructing a chip seal. Rubber added to the chip seal extends its life and provides better bond and adhesion to the existing pavement surface.

d. 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 2-4 shows a typical Type II aggregate slurry seal.

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

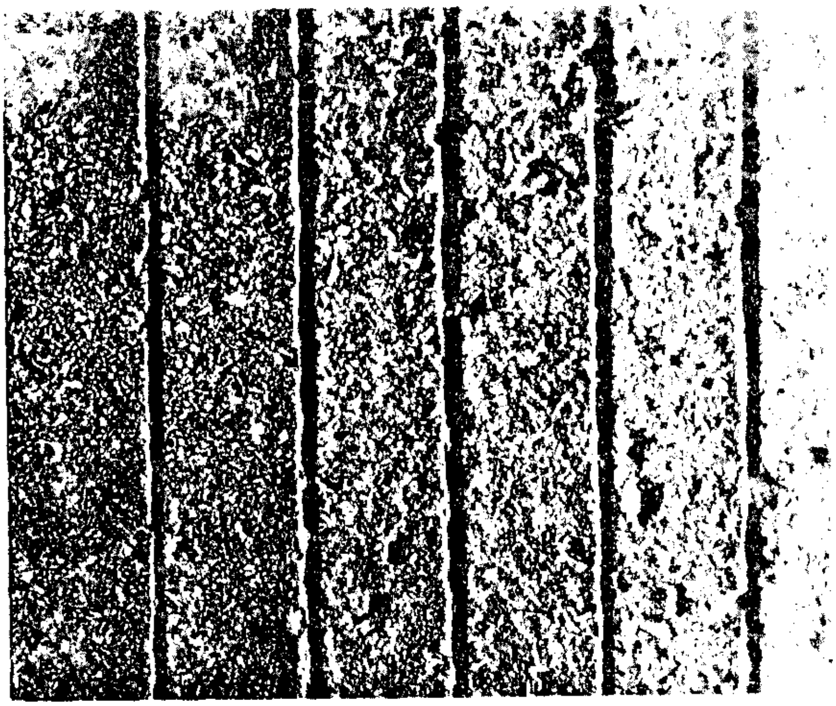

FIGURE 2-2. SAWED GROOVES IN ASPHALTIC CONCRETE PAVEMENT

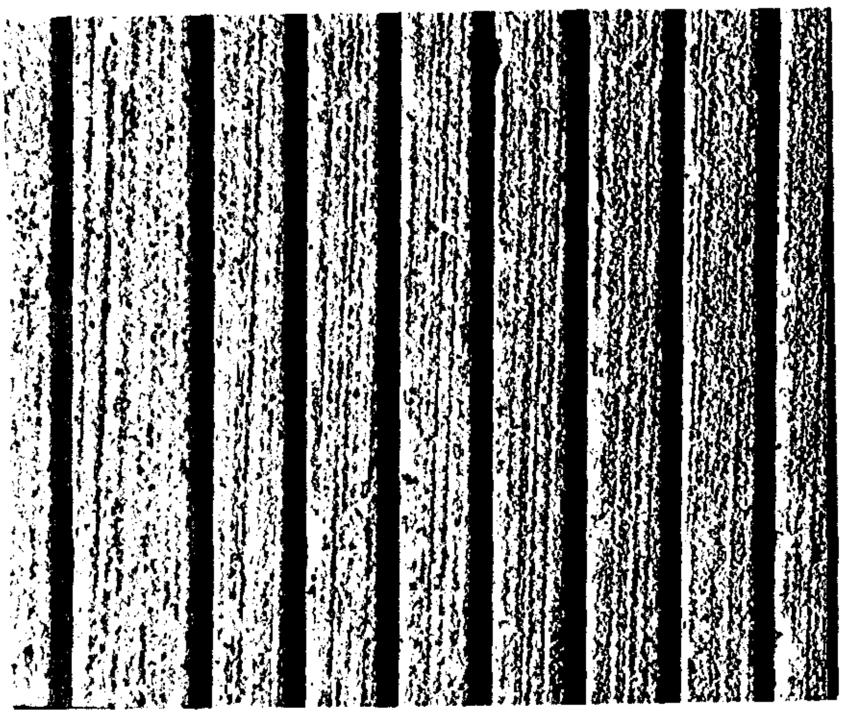

FIGURE 2-3. SAWED GROOVES IN PORTLAND CEMENT CONCRETE PAVEMENT

24. PORTLAND CEMENT CONCRETE PAVEMENT. Several methods are available to the paving contractor for constructing skid resistant, portland cement concrete pavement surfaces. It is strongly recommended that when the portland cement concrete is still in the plastic condition, some type of finishing operation should be constructed before grooving. Such texturing can be accomplished by using either transverse brushing or brooming, or heavy burlap drag in the longitudinal direction. For new portland cement concrete pavements that have hardened, grooves can be saw-cut in the pavement. A brief description for each of these methods follows.

a. Sawed Grooves. For existing or new portland cement concrete pavements that have hardened, transverse grooves can be saw-cut in the pavement. The timing should be as directed by the engineer. Construction details for providing sawed grooves in portland cement concrete pavements are given in Section 2. Figure 2-3 shows a sawed-groove, portland cement concrete pavement surface.

b. Finishing New Portland Cement Concrete Pavement in Plastic Condition Prior to Grooving. The timing of the finishing operations is critical. If the portland cement concrete is too fluid, the paving materials will flow into the newly formed indentations, partially filling them. If the finishing is delayed too long, the portland cement concrete will stiffen and it will be difficult to form the indentations. Experience has shown that proper care of the texturing equipment (brushes, brooms, etc.) is required during the finishing operations. The equipment should be cleaned regularly to remove any excess grout buildup, otherwise the finished surface will not be uniform.

c. 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 (1-1/2 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 2-5 shows the texture formed by the broom finish.

d. Burlap Drag Finish. If a burlap drag is used to texture the pavement surface, it should be at least 15 oz/yard^2 (355 gm/m^2). To produce a rough textured surface, the transverse threads of the burlap should be removed from approximately 1 ft (0.3 m) of the trailing edge and grout allowed to build up and harden on the trailing burlap threads. A heavy build-up 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 (1-1/2 mm) deep. A runway pavement constructed with a burlap drag finish is shown in figure 2-6.

e. Plastic Grooving. A method used in the United Kingdom forms grooves in the concrete while in the plastic state by a vibrating ribbed plate attached to the bridge that spans across the pavement slab. The plate is vibrated to help to redistribute the aggregate in the concrete to prevent tearing and shearing as the

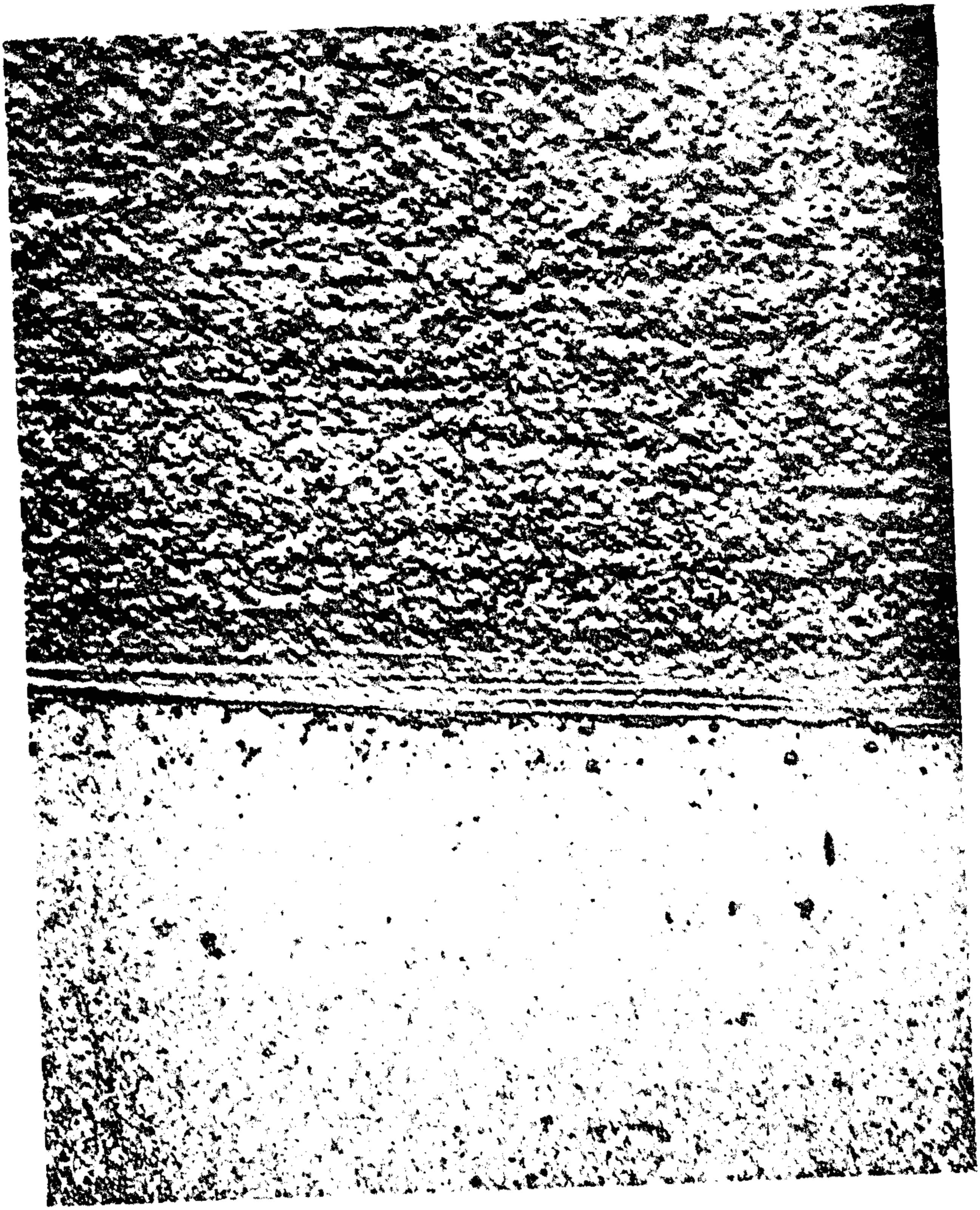

FIGURE 2-4 AGGREGATE SLURRY SEAL

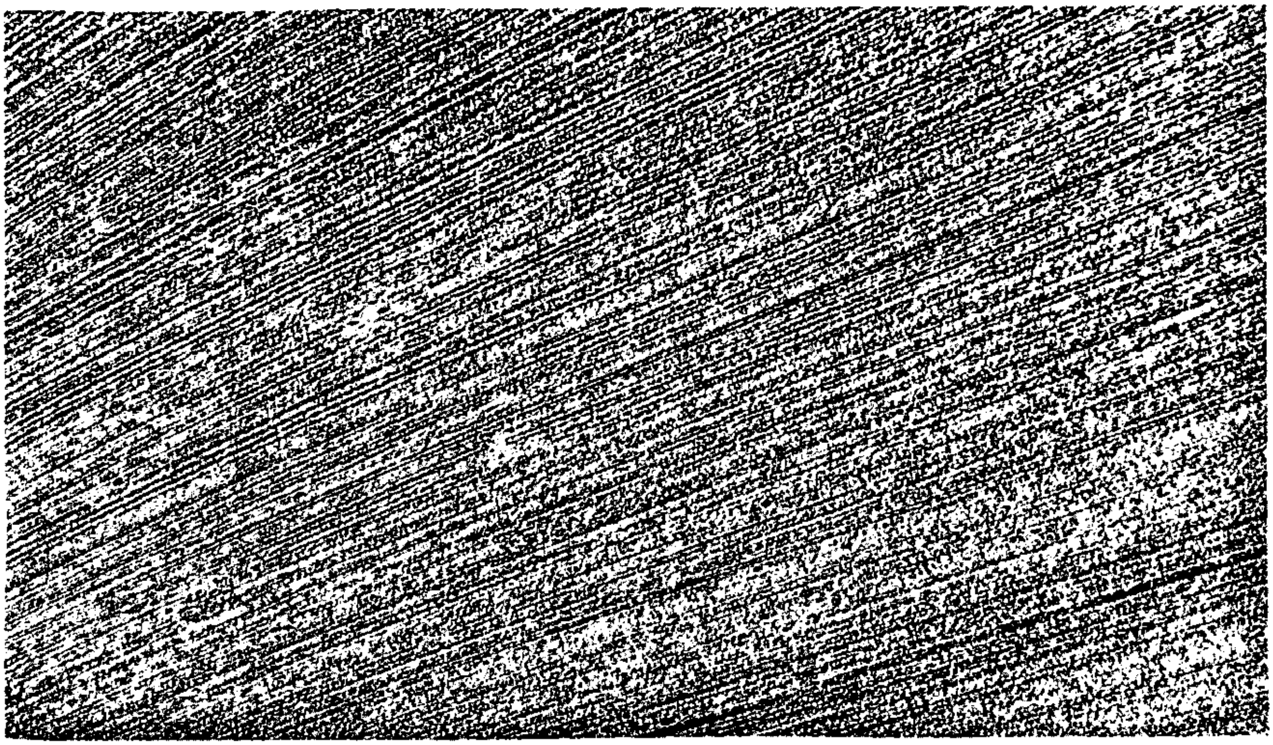

FIGURE 2-5. HEAVY PAVING BROOM FINISH

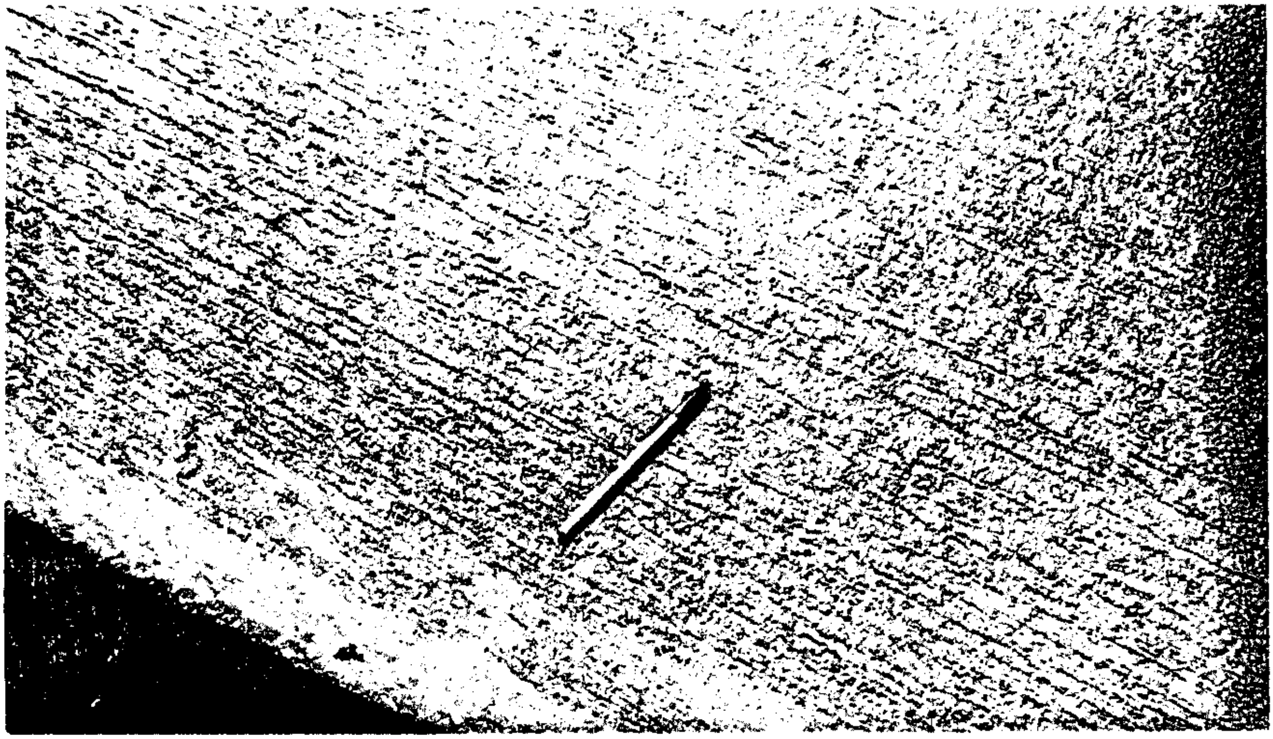

FIGURE 2-6. HEAVY BURLAP DRAG FINISH

plate proceeds transversely across the pavement slab. The grooves formed in the pavement are approximately 1/4 inch x 1/4 inch (6 mm x 6 mm) width and depth, spaced 1 inch (25 mm) center to center. Figure 2-7 shows the paving operation. In the United States, paving contractors use 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 used in the United Kingdom. The roller is not vibrated and therefore does not consistently penetrate to the required depth of 1/4 inch (6 mm). Figure 2-8 shows the results of this technique.

f. Wire Combing. The wire comb technique uses rigid steel wires to form a groove-like 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 1/2 inch (13 mm) center to center (see figure 2-9). 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 1/2 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.

g. Wire Tined. Flexible steel wires are used to form groove-like texture in the plastic concrete pavement. The flexible steel bands are 5 inches (125 mm) long and approximately 1/4 inch (6 mm) wide, spaced 1/2 inch (13 mm) apart. The appearance of this technique is quite similar to the wire comb method.

SECTION 2. GROOVING TECHNIQUES

25. GENERAL. Sawing of grooves in existing or properly cured bituminous concrete or portland cement concrete pavements provides drainage channels of uniform width, depth, and alignment. Runway grooving is the most effective means of removing water from the pavement/tire interface. Moreover, it increases the pavement's skid resistance.

26. FACTORS TO BE CONSIDERED. The following factors should be considered in justifying grooving of airport runways.

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

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.

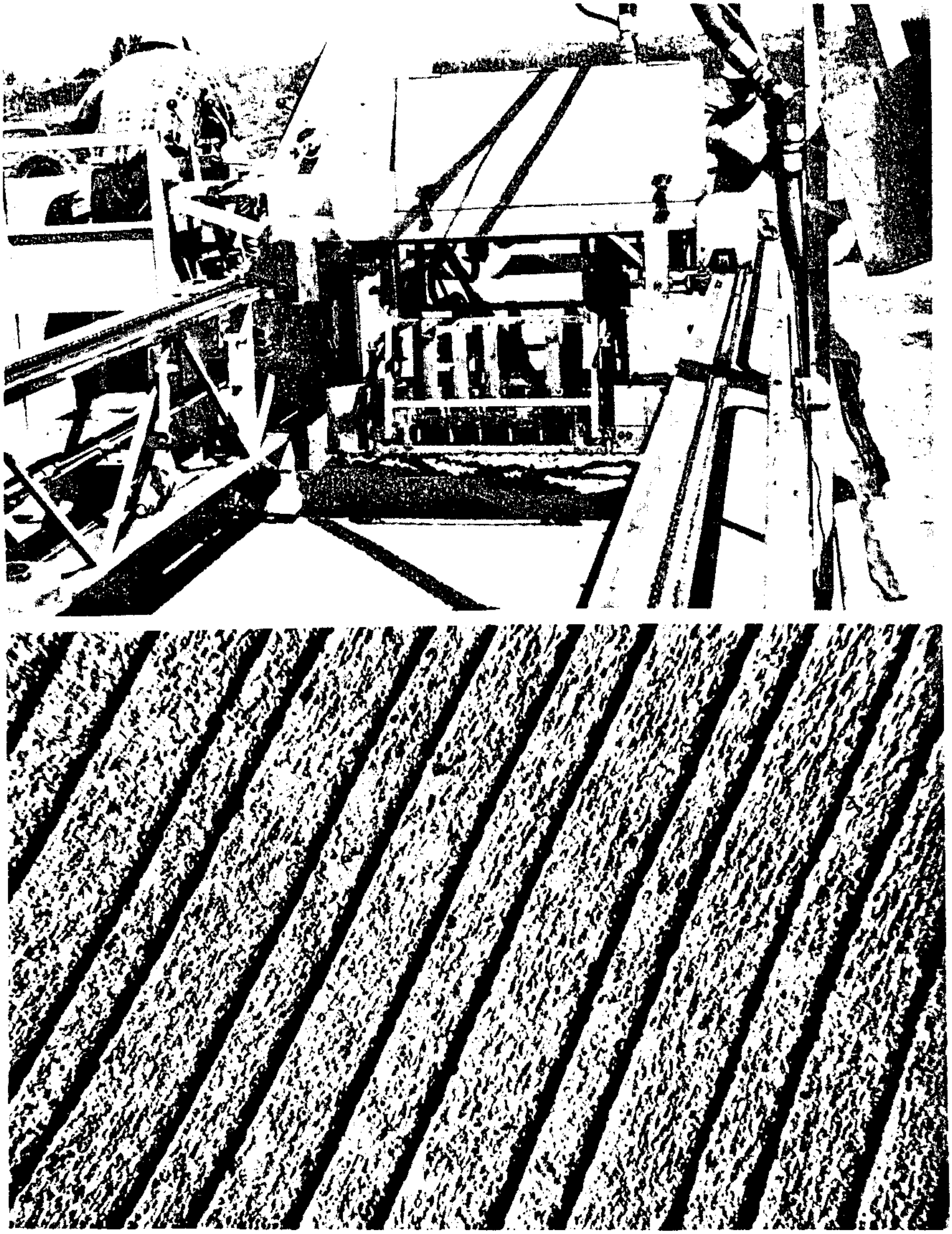

FIGURE 2-7. PLASTIC GROOVING TECHNIQUE USED IN THE UNITED KINGDOM

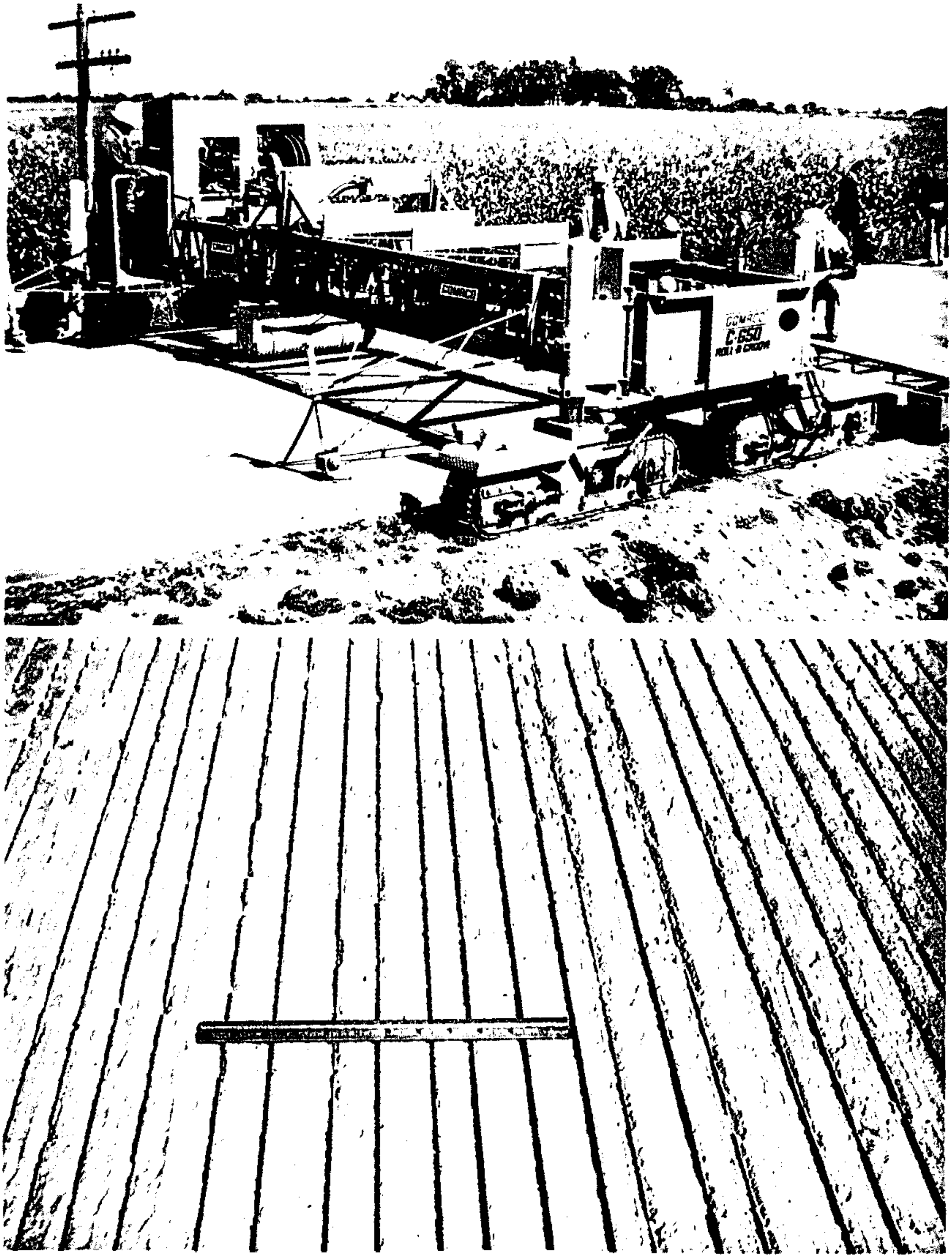

FIGURE 2-8. PLASTIC GROOVING TECHNIQUE USED IN THE UNITED STATES

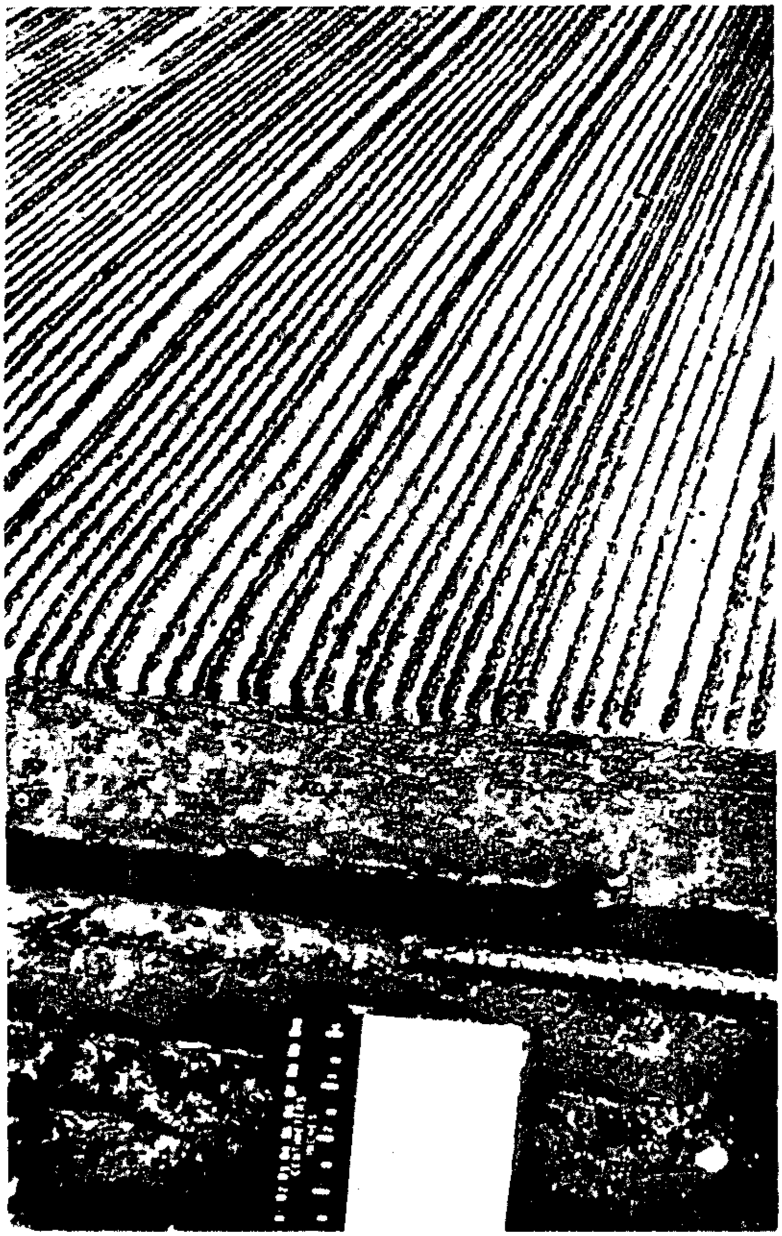

FIGURE 2-9 WIRE COMB TECHNIQUE CONSTRUCTED AT PATRICK HENRY AIRPORT, VIRGINIA, USING A 1/8" x 1/8" x 1/2" CONFIGURATION

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

f. Adequacy of number and length of available runways.

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

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

27. EVALUATION OF EXISTING PAVEMENTS. Existing pavements may or may not have surfaces that are suitable for sawing grooves. A survey should be conducted to determine if an overlay or rehabilitation of the pavement surface is required before grooving operations begin.

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 AC's 150/5370-10 and 150/5320-6, current edition. Future aircraft loads and trafficking should be considered when making the evaluation. Core samples should be taken in asphaltic concrete pavement to determine the stability of the bituminous hot mix. 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 asphaltic concrete pavements. Some of the factors to be considered are maximum operational pavement surface temperature, effective tire pressure, frequency of braking action in given areas, mix composition, and aggregate properties. Core samples must be precisely 4 inches (10 cm) in diameter, as improper seating of the Marshall breaking head during the tests could have variable and substantial effects on the values. 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.

28. OVERLAYS. As stated above, if the survey 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 using the procedures as given in AC 150/5320-6, current edition. The new overlay should be grooved according to the instructions given in the following paragraphs.

29. SAWED GROOVES. The contractor should groove a test section to demonstrate that the equipment will provide the required configuration within the prescribed tolerances. The following conditions should be met for asphalt and concrete pavements:

a. THE FAA STANDARD GROOVE CONFIGURATION IS 1/4 INCH (± 1/16 INCH) IN DEPTH BY 1/4 INCH (± 1/16 inch) IN WIDTH BY 1-1/2 INCH (± 1/8 inch) CENTER TO CENTER SPACING. THE GROOVES SHALL BE CONTINUOUS FOR THE ENTIRE RUNWAY LENGTH AND TRANSVERSE, I.E., PERPENDICULAR TO THE DIRECTION OF AIRCRAFT LANDING AND TAKEOFF OPERATIONS. 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. THE GROOVES SHALL NOT VARY MORE THAN 3 INCHES (8 CM) IN ALIGNMENT FOR 75 FEET (23 M), ALLOWING FOR REALIGNMENT EVERY 500 FEET (150 M).

b. GROOVES SHALL NOT BE CLOSER THAN 3 INCHES (8 CM) OR MORE THAN 9 INCHES (23 CM) FROM TRANSVERSE JOINTS IN CONCRETE PAVEMENTS. GROOVING THROUGH LONGITUDINAL OR DIAGONAL SAW KERFS WHERE LIGHTING CABLES ARE INSTALLED SHALL BE AVOIDED. Grooves may be continued through longitudinal construction joints.

c. 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.

d. 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.

e. Cleanup is extremely important and should be continuous throughout the grooving operation. 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 be flushed into the storm or sanitary sewer system.

(3) The waste material should not be allowed to drain onto to 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.

30. <u>GROOVING RUNWAY INTERSECTIONS AND ANGLED EXIT TAXIWAYS</u>. 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. HIGH SPEED OR ANGLED EXIT TAXIWAYS SHALL BE SAW-CUT IN A STEP PATTERN AS SHOWN ON 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.

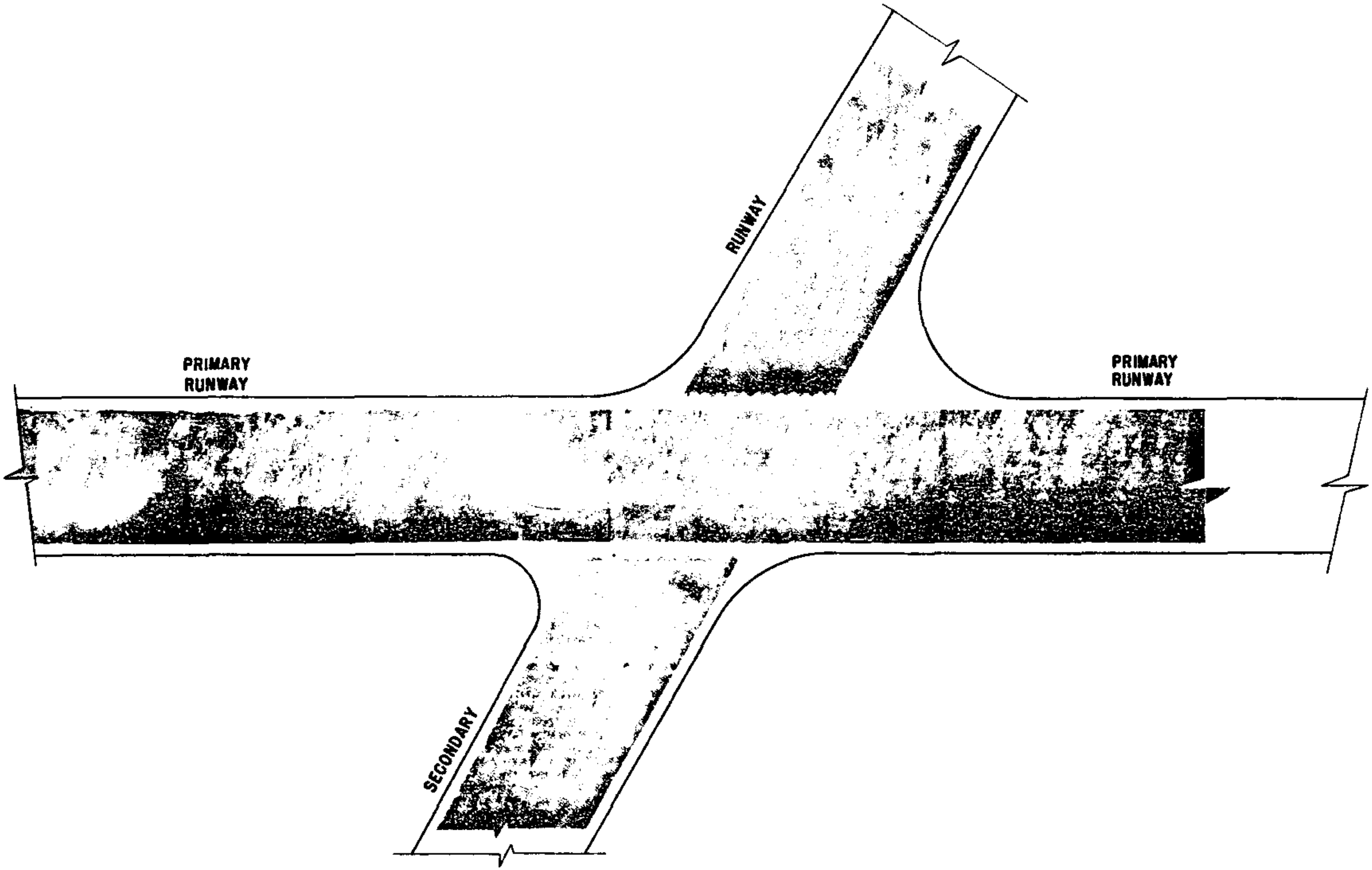

FIGURE 2-10. GROOVING INTERSECTIONS OF PRIMARY AND SECONDARY RUNWAYS

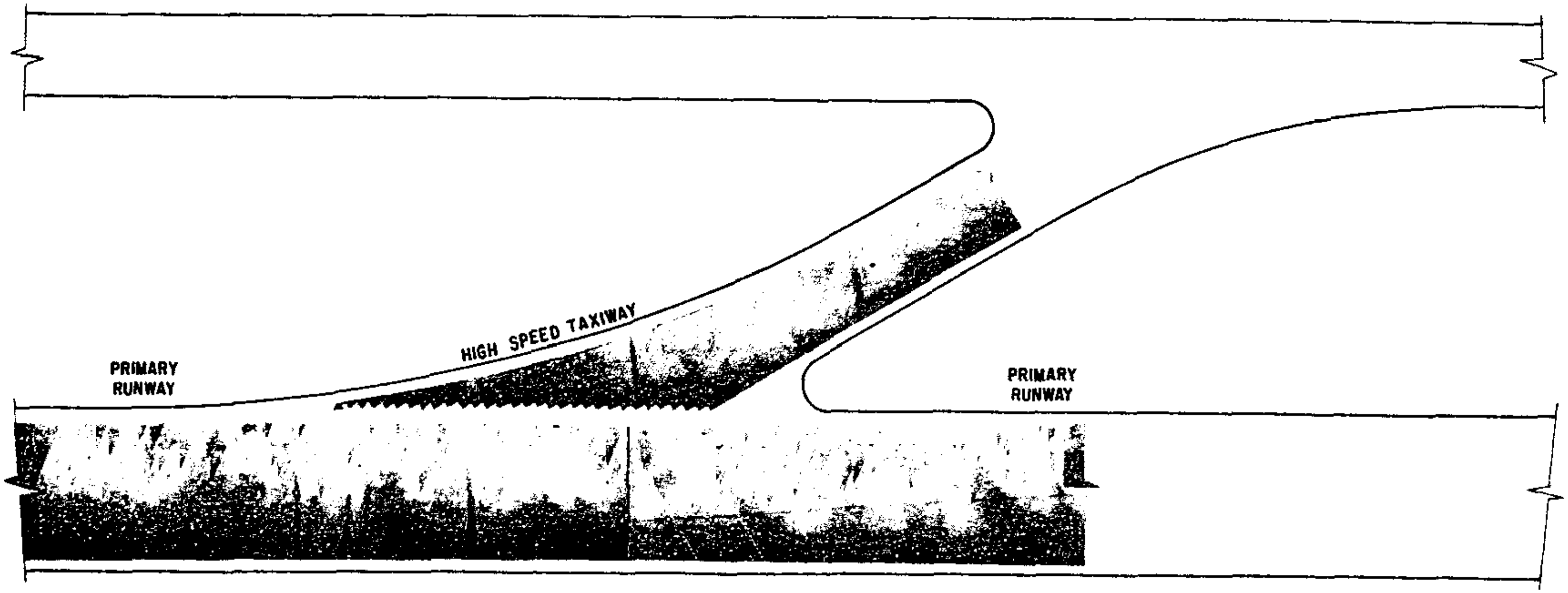

FIGURE 2-11. GROOVING OF HIGH SPEED OR ANGLED EXIT TAXIWAYS

CHAPTER 3. MAINTENANCE OF PAVEMENT SURFACES

32. MAINTENANCE CONSIDERATIONS. Airport personnel should make frequent periodic inspections of runway pavement surface conditions to locate, identify and determine the extent of the deterioration that has developed since the previous survey. Items to look for include contaminants and pavement failures which decrease surface friction. Figure 3-1 depicts particular types of pavement surfaces encountered in the National Runway Friction Measurement Program, and their relationship to annual aircraft landing weight. Although the curves developed are very approximate, they do give an indication of the frequency at which rubber removal should be undertaken. The airport operators should use these curves as guidance when scheduling their cleaning operations. A friction survey should be conducted before and after rubber deposits are removed to verify the effectiveness of the operation.

33. FAILURES IN PAVEMENT SURFACE TEXTURE. Failures which can lead to decreased skid resistance of pavements include depressions along longitudinal or transverse grades and irregularities such as pavement rutting, raveling, cracking, or faulted joints. When maintenance inspections reveal significant changes in pavement surfaces, measurements of surface characteristics should be made as prescribed in chapter 1 to determine what corrections are required. Improvements should be made according to the design and construction methods described in chapter 2.

34. REMOVAL OF CONTAMINANTS. If maintenance inspections reveal significant buildup of contaminants, measurement of surface characteristics should be made as prescribed in chapter 1. If tests indicate a need for removal of contaminants, 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. Experience has shown that a rubber removal technique should be selected on the basis of its compatibility with aircraft components, airport structures, pavement materials, personnel, environment and its cost effectiveness. In selecting a method, its ability to restore the coefficient of friction to an acceptable level and its lasting effect should be considered. A brief description follows for each of the techniques.

a. High Pressure Water. Within the last few years, high pressure water has been used successfully for removing contaminants and weathered paint markings off runway pavement surfaces at airports. The principle of this method is very simple. A series of very high pressure water jets are 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 equipment used today operates at a water pressure between 5,000-8,000 lb/in^2 (35-55 Pa) and is capable of pressures exceeding 10,000 lb/in^2 (69 Pa). Friction and texture depth measurements should be conducted before and after each cleaning operation to determine whether or not any deterioration in friction characteristics has occurred due to the cleaning technique used and to check on the quality of the cleaning operation. The method can be used when temperatures are 40^{o}F (55^{o}C) and rising, but never on snow, ice, or slushed-covered runways.

b. Chemical. Chemical solvents have been used successfully for removal of contaminants on both portland cement concrete and asphaltic concrete runways. Any chemicals used on runways must meet the Environmental Protection Agency requirements. For removal of rubber deposits on concrete 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 asphalt runways, alkaline chemicals are generally used. Because of the volatile and toxic nature of such chemicals, extreme care must be exercised by all personnel during and after application. If the chemicals remain on the pavement too long, the painted areas on the runway and possibily 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 portland cement concrete runway surfaces. For asphaltic concrete pavements, an absorbent or blotting material such as sawdust or sand combined with a rubber alkaline degreaser may be used. Chemicals can be used when temperatures are 40°F (5°C) and rising, but never on snow, ice, or slush-covered runways.

c. High Velocity Impact. 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. The reconditioning operations can be carried out during all temperature conditions and seasons except during rain or when there may be standing water, slush, snow, or ice on the runway surface.

d. Mechanical. Mechanical grinding that employs the corrugating technique has been successfully used to remove heavy rubber deposits from 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.

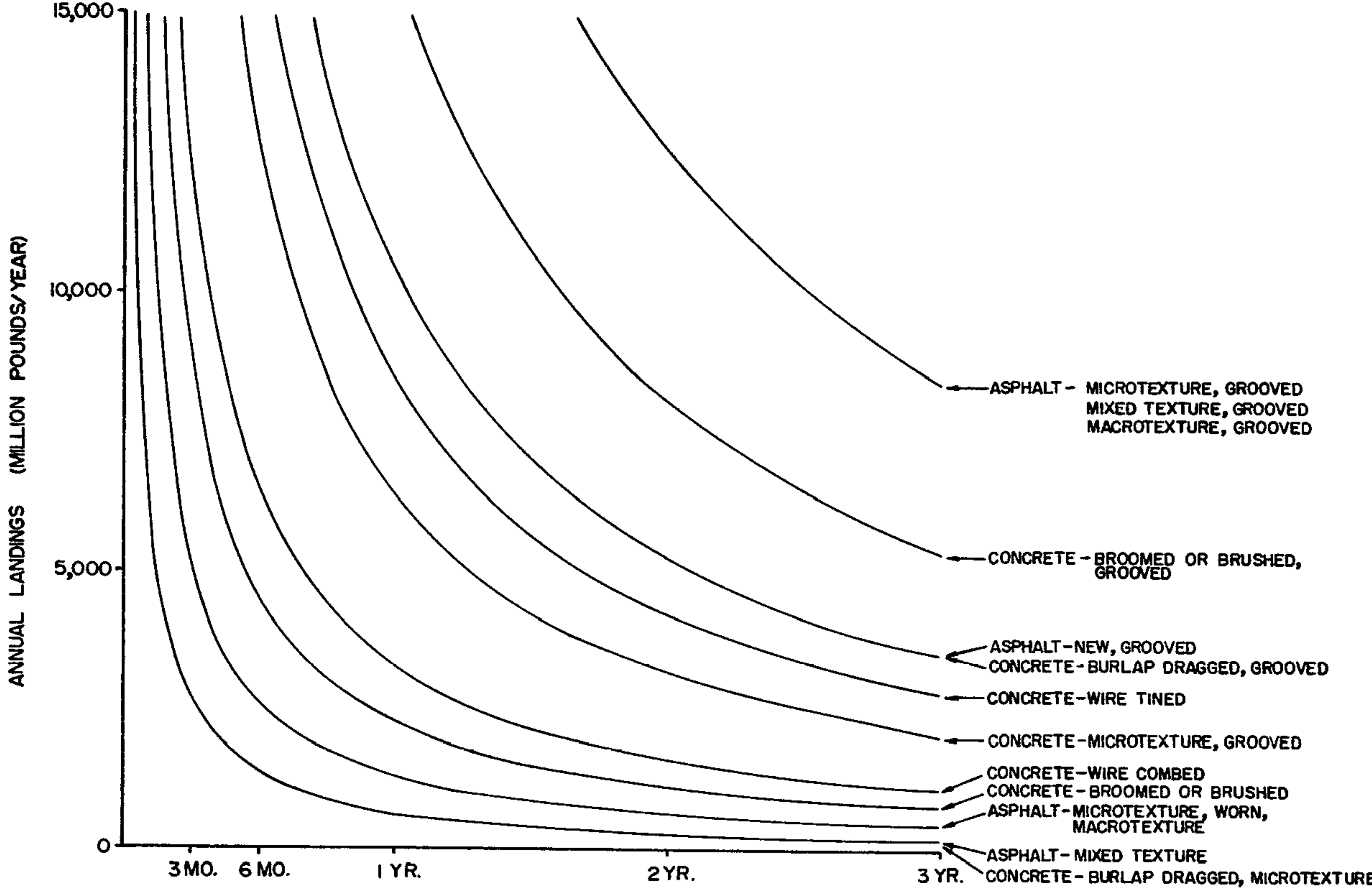

FIGURE 3-1 RUBBER REMOVAL FREQUENCY FOR VARIOUS PAVEMENT TYPES

APPENDIX 1. RELATED READING MATERIAL

1. The following advisory circulars may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402:

a. AC 150/5320-6, Airport Pavement Design and Evaluation, dated December 7, 1978.

b. AC 150/5370-10, Standards for Specifying Construction of Airports, dated May 31, 1977.

c. AC 150/5380-6, Guidelines and Procedures for Maintenance of Airport Pavements, dated December 3, 1982.

2. 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.

3. Copies of MIL-STD-620A, Test Methods for Bituminous Paving Materials, may be obtained from the Commanding Officer, Naval Supply Depot, 5901 Tabor Avenue, Philadelphia, Pennsylvania 19120.

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-507, 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-80-78, 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.

l. 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.

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

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

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, 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.

8. 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.

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