U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Change 1 to AIRPORT WINTER SAFETY AND OPERATIONS

Date: 11/22/91
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Change: 1

1. PURPOSE. This change allows the use of fluid potassium acetate and solid compound runway deicers/anti-icers on aircraft operational areas that meet the potassium acetate specification or the generic solid specification.

Affected pages carry the change number and effective date on the top. The typing character "|" located on the left margin identifies revised, added or deleted portions.

PAGE CONTROL CHART

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(7) Movement areas where aircraft will operate at high speeds such as turnoffs should receive the same snow and ice control attention as runways. Areas of low speed operation such as taxiways and ramps can also be critical under some conditions. Directional control and braking action should be maintained under all conditions.

(8) Airports with joint military operations may have arresting barriers located near the end of the active runway or the beginning of the overrun area. Great care should be taken in clearing snow from the barriers. Barriers located on the runway should be deactivated and pendants removed prior to snow removal operations. Snow should be removed to the distance required for effective runout of the arresting system. Snow removal involving arresting barriers should be coordinated with the military tenant prior to the snow removal season.

(9) In heavy snow areas it is helpful to place flags on flexible stakes extending 1 or 2 feet above the edge lights. Visibility is enhanced by using international orange flags. Although these are primarily to assist snow removal equipment operators in avoiding striking the lights while plowing near them, pilots also report that they are useful. Time and effort in clearing snow from around the lights is minimized by plowing as close as possible to them. The remaining snow can be blown away using a truck-mounted airblast unit, the airblast from a broom, or by spraying with liquid deicing chemical. In some cases, edge lights may be raised. As a last resort, hand shoveling may be necessary.

(10) The face of all signs and all lights should be kept clear of snow and in good repair at all times with priority given to lights and signs associated with holdlines and ILS.

(11) Centerline and touchdown zone (TDZ) lights inset in the pavement tend to form "igloos" of ice or compacted snow surrounding them. Heat from the lamps will melt even cold dry snow which will refreeze and adhere to the pavement and then accumulate around the lights. One method of control or removal is described in paragraph 24. To prevent damage to these lights, use rubber or plastic cutting edges or shoes and casters on plow moldboards and the front of rotary plows.

(12) Striated pavement markings are useful in reducing ice buildup.

22. **SNOW DISPOSAL.** Some means of disposing of snow must be provided when there is insufficient space for storage adjacent to cleared areas. This will entail loading trucks and hauling to a disposal site, pushing the snow into melting pits sited near the areas being cleared, or portable melting pits set up over catch basins. Although melting pits eliminate long hauls and may reduce truck traffic in the ramp area, an economic analysis should be made to determine the benefit of constructing and operating them. Calculation of the thermal energy required is based on the heat of fusion of ice, 144 Btu/lb (335 kJ/kg) and the specific heat of ice, 0.5 Btu/lb (2.1 kJ/kg). Submerged combustion burners have been developed and are commercially available. A typical 10 x 8 x 8 ft (3 x 2.4 x 2.4 m) deep melting pit containing two burners can melt 120 tons of snow per hour (30 kg/s) consuming 60 gal. (227 liters) of No. 2 fuel oil per burner.

23. **MECHANICAL METHODS FOR CONTROLLING ICE.** Ice near the freezing point is soft and may be scraped off the pavement. Cold, hard ice bonds much more tenaciously and is difficult to remove by mechanical means. Scraping is not very effective, and attempts to lift the ice from the pavement by penetration with a wedge parallel to the pavement, have only been partially successful. Cutting edges attached to plow moldboards can be operated in contact with the pavement in the attempt to remove ice. At plowing speeds above about 10 mph (16 km/hr), front-mounted plows tend to bounce and leave ice on the pavement. Slower speeds, heavier plows, or plows which can be downloaded can reduce this "porpoising" or bouncing. Application of downward force also helps to penetrate and scrape the ice. Although down pressure can be applied by hydraulic cylinders on front-mounted plows, underbody blades can apply greater pressure without reducing steering control. All blades or cutting edges or the moldboards to which they are attached should have trip mechanisms to release the blade upon striking an obstacle in order to prevent damage to the blade, truck, pavement insert, or pavement. Carbon steel cutting edges run in contact with the pavement wear rapidly and require frequent replacement. Tungsten carbide cutting edges are extremely tough and can last for thousands of miles. They are brittle, however, and can chip upon striking metal or other very hard projections. Serrated cutting edges which cut grooves in hard ice are sometimes used and will facilitate retention of chemicals and abrasives which might otherwise be blown off. Centerline or flush lights should not be plowed with metal cutting edges contacting the pavement; rubber or polymer cutting edges will help prevent damage to the lights. Slush or very soft ice can also be removed effectively by rubber cutting edges which squeegee the pavement.

24. **ANTI-ICING VS. DEICING.** The most difficult task in winter maintenance occurs when snow or ice bond to the pavement. Thus the primary effort should be directed at bond prevention. Though dry snow will not readily form a strong bond even under heavy and frequent wheel passes, wet snow and ice will develop such a strong bond that mechanical removal is either difficult, slow, or damaging to the pavement. Ice removal after formation is called deicing; preventing the bond from forming is called anti-icing or bond prevention. Anti-icing, which is recommended over deicing whenever possible, is accomplished by concentrating either thermal or chemical energy at the pavement surface. Because of the high cost of installing pavement heating systems and the large amounts of energy required to maintain the surface above freezing prior to the onset of precipitation, anti-icing/deicing with approved airside chemicals is generally more economical. Chemical application is in either solid (includes pre-wetted) or liquid form. Chemicals in liquid form are most effective for uniform anti-icing treatment of pavements. All deicing/anti-icing chemicals should be applied based on pavement temperature rather than air temperature (see AC 150/5220-13A, Runway Surface Condition Sensor-Specification Guide).

a. **Deicing Chemicals.** Deicing chemicals should be applied on ice 1/16 inch (1.5 mm) or less in thickness. Thicker layers of ice require an extended period of time to obtain ice-free pavement. However, solar radiation from even a cloudy sky enhances melting action to such an extent that elimination of ice thicknesses greater than 1/16 inch (1.5 mm) are possible.

b. **Anti-Icing Chemicals.** The recommended chemical form for anti-icing is liquid, although solid chemicals can also be effective in this application. A dry solid chemical has the disadvantage that if applied to a cold dry surface it may not adhere and therefore, may be windblown or scattered by aircraft movements. However, certain physical properties of a solid, such as its bulk density, particle shape, etc., may reduce these tendencies. Regardless, wetting a dry anti-icing chemical, either during distribution or before or after loading into the application vehicle, improves the ability to achieve uniform distribution and improved adhesion.

25. **CHEMICALS.** Any water-soluble substance will lower the freezing point of water and thus, promote the melting of ice. Theoretically, the lower the molecular weight and the more individual particles (ions) the substance disassociates into, the more effective the product is as an ice control chemical, assuming its solubility still remains high at the freezing temperature. For the purpose of shared information, airport operators should inform the airlines before introducing a new chemical on the airside.

a. **Approved Airside Chemicals.** The FAA either establishes approval specifications or, upon recognition, references the specifications of professional associations such as, the Society of Automotive Engineers (SAE) through Aerospace Material Specifications (AMS) and the United States military (MIL-SPEC). The approved airside chemicals for nonaircraft applications are two fluids and those solid compounds meeting either the generic SAE specification or the specific SAE, MIL specification. These specifications require vendors to provide the airport operator a material safety data sheet (MSDS) and certification that the chemical conforms to the applicable specification. With the increased accountability placed on airport operators to manage deicing/anti-icing chemical runoff, they should request vendors to provide certain environmental data. These data consists of pollutants that the Environmental Protection Agency and the State Department of Natural Resources require of the airport operator in their discharge reporting. Typical information includes: percent product biodegradability, biological oxygen demand (BOD_5), chemical oxygen demand (COD), pH, presence of toxic or hazardous components, if any, and remaining inert elements after application. Related to the environment, MSDSs provide measures on how to secure large product spills and a 24-hour 800 emergency phone number. While these fluid and solid specifications cover technical requirements for deicing/anti-icing compounds, they do not address the compatibility issue of combining products during operations. Airport operators should query manufacturers about the safe and proper use of concurrently applying <u>multiple</u> deicers/anti-icers. The FAA approved airside chemical specifications are as follows:

(1) **Fluids.**

(i) **Glycol-base Fluids.** The approved specifications are SAE AMS 1426B, Fluid, Deicing/Anti-Icing-Runways and Taxiways, and MIL-D-83411A, Deicer/Anti-icer Fluid (for Runways and Taxiways). Composition of proprietary solutions meeting these specifications varies with the manufacturer, though the glycol-base content is approximately 50 percent. Application rates range from 1-2 gal/1000 ft^2 for deicing and from 0.2-0.5 gal/1000 ft^2 for anti-icing. While the specifications only require a eutectic temperature of -10°F (-23°C) or less, proprietary products are available with eutectic temperatures as low as -75°F (-59°C). Ethylene glycol, $(CH_2)(OH)(CH_2)(OH)$, has a eutectic temperature of approximately -58°F (-50°C) for an aqueous solution of 58-78 weight percent of ethylene glycol and a freezing point of approximately 8.6°F (-13°C) for the pure fluid. Propylene glycol, $(CH_2)(OH)(CH)(OH)(CH_3)$, has a eutectic temperature of approximately -75°F (-59°C) for an aqueous solution of 60 weight percent of propylene glycol. Propylene glycol in its pure form does not have a freezing point per se, but sets to glass below -60°F (-51°C).

(ii) **Potassium Acetate-base Fluids.** The approved specification is SAE AMS 1432, Fluid, Deicing/Anti-icing - Runways and Taxiways, Potassium Acetate Base. Application rates range from 1-2 gal/1000 ft^2 for deicing and from 0.3-0.5 gal/1000 ft^2 for anti-icing. While the specification requires a eutectic temperature of -10°F (-23°C) or less, proprietary products are available with eutectic temperatures as low as -76° F (-60° C).

(2) **Solid Compound Deicer/Anti-icer.**

(i) **Generic Specification.** The approved specification is SAE AMS 1431A, Compound, Solid Runway and Taxiway Deicing/Anti-icing. Approved solid compounds include airside urea, calcium magnesium acetate (CMA), and sodium formate. The specification requires a phase diagram relating product dilution to freeze point. The delivered product is effective within +7° F (+4° C) of the preproduction temperature value established by the manufacturer. Application rates for a specific product are based on manufacturer recommendations.

(ii) **Airside Urea (also called carbamide).** The approved specifications are SAE AMS 1431A, Compound, Solid Runway and Taxiway Deicing/Anti-icing and MIL SPEC DOD-U-10866D, Urea-Technical. Agricultural grade urea that meets any of these specifications, termed airside urea, is acceptable. Production of this nontoxic solid white chemical, chemical formula $(NH_2)_2CO$, is in either powder or "shotted" ("prilled") form. The latter form's shape is small spheres of about 1/16 inch (1.5 mm) diameter. Both forms are primarily for deicing where powdered urea is frequently mixed with sand. Hot mixtures of powder or "shotted" urea and sand serve two purposes: (1) immediate increase in braking action and; (2) retention of chemical over the pavement area until it initially dissolves some of the ice and then melts the remainder. The urea deicing function is practical only at temperatures above approximately 15° F (-10° C) because of the decreasing

Application Rate of Urea (lb/ft^2) [kg/m^2]

Ice Thickness	Temperature Degrees F (°C)		
inch (cm)	30° (-1.1°)	25° (-3.9°)	20° (-6.7°)
less than 1/32 (.08)	.016 (.078)	.023 (0.11)	.06 (0.29)
1/32 (.08) up to but not including 1/8 (.32)	.03 (0.15)	.06 (0.29)	.125 (0.61)
1/8 - 1/4 (.32-.64)	.125 (0.61)	.175 (0.86)	.275 (1.34)

melting rates below this temperature value. The decreasing melting rate is a result of urea's eutectic temperature, defined in paragraph 2(f), which is approximately 11.3° F (-11.5° C). However, the presence of solar radiation assists urea in the melting action. Pavement surface temperature and ice thickness determine the urea application rate.

b. **Landside Chemicals.** The most effective landside chemicals used for deicing/anti-icing based on both cost and freezing point depression are from the chloride family, e.g., sodium chloride (rock salt), calcium chloride, and lithium chloride. Unfortunately, these chemicals are known to be corrosive to aircraft and therefore are prohibited from use on aircraft operational areas. Although classified as salts, CMA, sodium formate, and potassium acetate are approved for airside use because they comply with an SAE specification. When any corrosive chemical is used, precautions should be taken to ensure that vehicles do not track these products onto the aircraft operational areas.

26. **ENVIRONMENTAL ASPECTS OF DEICING CHEMICALS.** All freezing point depressants may cause scaling of portland cement concrete (PCC) by physical action related to the chemical concentration gradient in the pavement. Deleterious effects on PCC can be reduced by ensuring sufficient cover over reinforcing steel (minimum of 2 inches (5 cm)), using air-entraining additives, and avoiding applications of chemicals for a year after placement. Concrete meeting the compressive strength outlined in ASTM C 672, Scale Resistance of Concrete Surfaces Exposed to Deicing Chemicals, will perform well when subjected to chemical deicers. No surface degradation of asphalt concrete has been observed due to approved chemicals. Deicing/anti-icing chemicals commonly used on airfields, e.g., airside urea, CMA, sodium formate, glycols, and potassium acetate, rapidly biodegrade in the environment although biological oxygen demand for some products may be high under certain cases. Low temperatures and dilution from heavy runoff during periods of use tend to minimize this. Urea decomposes to ammonia which may be quickly dissipated.

27. **RUNWAY FRICTION IMPROVEMENT.** Since snow and ice degrade the coefficient of friction between rubber tires and pavement and could pose an unsafe condition for aircraft, it is important to clear to bare pavement whenever possible. There are situations where complete removal is difficult or impossible to achieve within a required span of time; at temperatures approaching the eutectic temperature of a deicing chemical, for instance, it may require an hour or more for the chemical to go into solution and melt the ice. There are two techniques for modifying the frictional coefficient of a pavement covered with ice or compacted snow, one by building in a texture on the surface and the other by surface treatment of the ice or snow. It should be emphasized, however, that an abrasive is not a deicing chemical and will not remove ice or compacted snow--in fact, heavy applications of abrasives can insulate the ice and prolong its presence.

a. **Pavement Surface Modification.** Surface texture and surface treatment modifications by themselves will not increase the coefficient of friction of ice formed on the surface but both will enhance the response of chemical treatment.

(1) **Pavement Grooving.** Grooves cut into the pavement will trap deicing chemical, reduce loss, and prolong its action. Grooves also assist in draining melt water and avoiding its refreezing. There is empirical evidence that grooves and porous friction courses modify the thermal characteristics of a pavement surface, probably by reducing the radiant heat loss, and delay the formation of ice. There do not appear to be any negative effects from grooved pavements.

(2) **Porous Friction Course (PFC).** PFC has generally the same benefits as grooving. Open graded asphalt concrete is less effective in improving coefficient of friction under icing conditions because the open spaces will fill with compacted snow, and to a lesser extent with ice in the case of freezing rain. Most maintenance personnel have found that chemical treatment rates may need to be increased on this type of pavement compared to dense graded asphalt concrete because of drainage of the chemical. The drainage characteristics also change as abrasives accumulate in the voids and plug them.

b. **Surface Treatment.** This is the approach taken to rapidly increase the frictional coefficient of an ice surface. Two methods are available: application of coarse granular material ("abrasives") and scarifying the ice surface with a serrated blade. A friction value measured below 27 (MU equivalent), as discussed in paragraph 13, indicates that surface treatment should be initiated.

(1) **Abrasives.** Granular material provides a roughened surface on ice and thereby improves aircraft directional control and braking performance. Use of abrasives should be controlled carefully on

turbojet movement areas to reduce engine erosion. If the granules do not embed or adhere to the ice, not only are they likely to be ingested in engines but they can be blown away by wind or scattered by traffic action and serve no useful function. This is particularly the case when ice or compacted snow is at temperatures below about 20° F (-6.7° C) since no water film exists on the surface to act as an adhesive. There are three approaches to reducing loss of abrasives: (a) they can be heated to enhance embedding into the cold surface; (b) the granules can be coated with an approved deicing chemical in the stockpile or in the distributing truck hopper; or (c) dilute deicing chemical can be sprayed on the granules or the pavement at the time of spreading. If stockpiles are kept in a heated enclosure and spread promptly after truck loading, sufficient heat may remain for embedding without the necessity for any further treatment. One method of setting the sand, though difficult to implement, is to apply heat after the sand has been spread by using weed burners or other open flame sources. Maintenance personnel should make a test on an unused pavement covered with ice or compacted snow to determine if bonding is adequate to prevent loss. When the slippery condition giving rise to the requirement for abrasives has passed, treated pavements should be swept to remove the residue to prevent engine damage. Abrasives should be used when the friction measurement, as discussed in paragraph 13, is below 27 (MU equivalent). Other factors to consider when deciding to apply abrasives are pavement and air temperatures and frequency of operations.

(2) **Ice Scarifying.** Directional control of vehicles on an ice or compacted snow surface can be improved dramatically by cutting longitudinal grooves in the ice. However, no improvement in braking effectiveness results from grooving, so this approach is only an expedient to be employed when very low temperatures prevent rapid chemical action or mechanical removal. The grooves trap abrasives or chemicals and hence contribute to improving the surface friction characteristics and melting action.

28. **ABRASIVES.**

a. **Materials.** The airlines should be consulted about the material used on the runways. *The following is the standard for abrasives.* Friction improving materials applied to airport movement surfaces shall consist of washed granular particles free of stones, clay, debris, and chloride salts or other corrosive substances. The pH of the water solution containing the material shall be approximately neutral (pH 7). Material shall meet the following gradation using U.S.A. Standard Sieves conforming to ASTM E 11-81.

Sieve Designation	Percent by Weight Passing
4	100
8	97-100
16	30-60
50	0-10
80	0-2

b. **Application.** Sharp, hard silica sand provides the greatest increase in traction and remains effective the longest when compared to softer materials because of its resistance to fracturing and rounding. It is also very abrasive. Limestone is softer and may be used where available if abrasion needs to be reduced. Tests have shown that application rates of 0.1-0.2 lb/ft^2 (0.49-0.98 kg/m^2) of sand will substantially increase friction coefficient. The greater amount is required at temperatures approaching 32°F (0°C), the amount decreasing as the temperature drops.

c. **Chemically-treated Abrasives.** Granular particles are treated with approved chemicals or heated to make them adhere to ice thereby preventing loss of material. At temperatures above 15°F (-9.4°C) a solution of airside urea may be used; below this temperature glycol or potassium acetate will be more effective. Approximately 8-10 gallons (30-38 liters) of fluid chemical are required to coat one ton of sand. The most effective method of applying the chemical is to spray it on granules as they drop onto the spinner mechanism of a material spreader since wetting is more thorough than when the chemical is poured onto the stockpile or the hopper load. Below 0°F (-17.8°C), heated sand can be more effective because of more rapid adhesion of the granules to ice.

g. The glide slope snow clearance area for the "capture-effect" antenna configuration should be evaluated by the crew chief and cleared as shown on figure A2-3. Contact should be made with the airway facilities manager or his designee at 887-6532 and the air traffic control tower at 887-8765 before moving equipment into the ground plane area.

4. **Ice Control.** Icing conditions occur most frequently at air temperatures between 28 and 34°F (-2 and 1°C), though there have been instances as low as 5°F (-15°C) and as high as 40°F (4.4°C). Frequent contact should be made by operations staff with the National Weather Service or the contract weather service when the air temperature falls in the most probable icing range. Runway sensors which are monitored by operations division employees are important tools in determining when icing conditions may occur.

a. **Runways, Taxiways and Ramps.** It is the policy of this airport to apply X-7V liquid deicing chemical meeting SAE specification AMS 1426B to all priority 1 movement areas as soon as the pavement surfaces become wet and the temperature is close to 32°F (0°C) as an anti-icing treatment. In the event that ice forms on movement areas, the standard procedure will be to apply prilled (solid) urea at the rate of 0.1 lb/ft^2 (.49 kg/m^2) when the temperature is above 20°F (-6.7°C) and sand wetted with X-7V at temperatures below this. Absolutely no chloride salts or other corrosive chemicals are to be used on aircraft movement areas.

b. **Access Roads and Parking Areas.** Sodium chloride and calcium chloride are permissible on automobile roadways. Sand used in these areas may be treated with these chemicals to assist in adhering to the ice and to prevent stockpiles from freezing. Bridges must receive special attention since icing frequently occurs on those surfaces prior to the adjoining pavement because of cooling from underneath.

5. **Cleanup.** All snow windrows must be removed as soon as possible after a storm ends. Sand will be removed from runways as soon as the surface is dry and braking action has been restored. The crew chief and/or operations staff will ensure that this is done. The airfield should be checked for broken or damaged lights and signs and repairs should be made.

NOTE: It is useful to append lists of personnel with their phone numbers, maps showing routing of equipment teams, radio frequencies or channels assigned to snow and ice control equipment, and other special local conditions affecting operations.

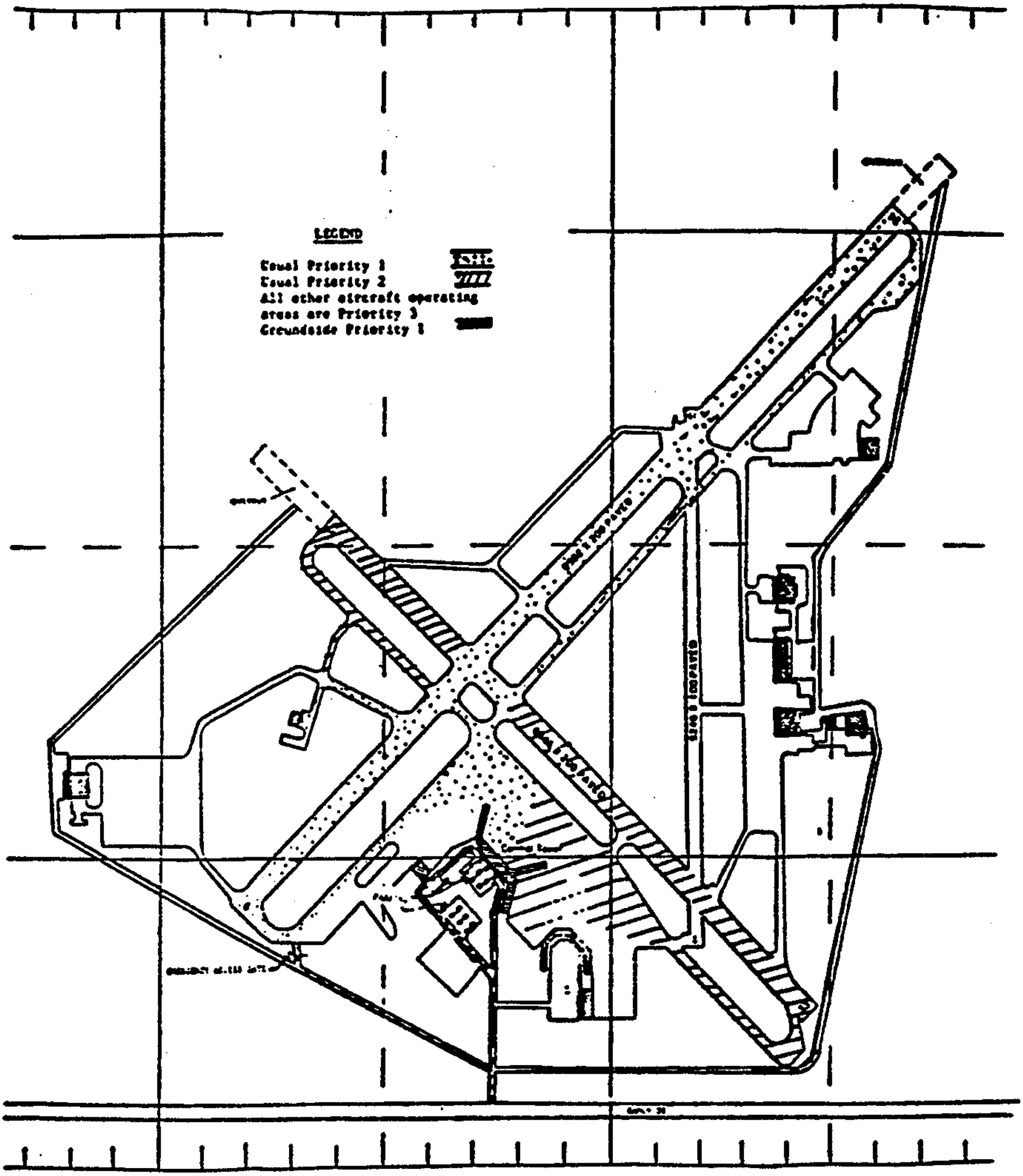

Figure A2-1 Priority Areas for Snow Control at Muncho Airport

APPENDIX 4 - FAA-APPROVED MANUFACTURERS OF FRICTION EQUIPMENT

CONTINUOUS FRICTION MEASURING EQUIPMENT

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 (H) 46 (758) 51589 Post Office Box 20079 BROMMA, SWEDEN S-161 20 (8)-29 5070 (O) **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**

DECELEROMETER FRICTION EQUIPMENT

MANUFACTURER/SALES REPRESENTATIVE
BOWMONK SALES President 50 Tiffield Road UNIT #10 Scarborough, Ontario CANADA M1V 5B7 FAX (416) 609-0827 (416) 609-0858 **BOWMONK DECELEROMETER**
TAPLEY SALES (CANADA) President 100 Palmer Circle R.R. No. 2 Bolton, Ontario CANADA L7E 5R8 FAX (416) 231-9121 (416) 880-0858 **TAPLEY DECELEROMETER**

APPENDIX 5 - PERFORMANCE STANDARDS FOR DECELEROMETERS

1. **Scope.** This appendix describes the procedures for establishing the reliability, performance, and consistency of decelerometers.

2. **Certification (General).** The manufacturer will certify that the electronic or mechanical decelerometers:

a. Are portable, rugged, and reliable.

b. Are capable of being fitted to vehicles qualified by the requirements given in this specification. Minimal vehicle modifications will be necessary to accommodate the mounting plates and electrical connections. Vehicles are qualified according to their size, braking and suspension system, shock absorber capabilities, and tire performance. The vehicle shall:

(1) Be either large sedans, station wagons, intermediate or full size automobiles, or utility and passenger-cargo trucks. Vehicles can be powered by either front-wheel, rear-wheel, or four-wheel drive.

(2) Be equipped with either standard disc and/or drum brakes as long as they are maintained according to the manufacturer's performance requirements. They can also qualify if they have a single sensor ABS (anti-lock braking system) installed on the rear axle.

(3) Be equipped with heavy-duty suspension and shock absorbers to minimize the rocking or pitching motion during the application of brakes. The weight should be distributed equally to the front and rear axle of the vehicle. Ballast can be added to achieve and maintain this distribution.

(4) Have tires made from the same construction, composition, and tread configuration. Inflation pressure shall be maintained according to the vehicle manufacturer's specifications. When tread wear is excessive on any one tire on the vehicle and/or exceeds 75 percent of the original tread, all four tires on the vehicle shall be replaced with new tires.

c. Shall be capable of measuring the deceleration of the vehicle from speeds greater than or equal to 15 mph (24 km/h) to an accuracy of $\pm$ 0.02 g.

d. Shall be capable of providing deceleration values upon request of the operator.

e. Shall be capable of consistently repeating friction averages throughout the friction range on all types of compacted snow and/or ice-covered runway pavement surfaces.

f. Shall not be affected by changes in vehicle velocity.

g. Shall not be affected by change in personnel or their performance in brake-applied decelerations.

h. Shall be capable of providing the vehicle operator with a readily visible deceleration reading.

i. Shall be capable of providing the deceleration values in recorded order enabling the average friction value for any length of runway to be either electronically or manually calculated.

j. Shall be capable of providing average deceleration values for touchdown, midpoint, and rollout zones of the runway and the average friction value for the entire runway tested. These averages shall be automatically calculated by the decelerometers, thus eliminating potential human error when calculated manually.

3. **Certification (electronic only).** The manufacturer will certify that the electronic decelerometer:

a. Shall be capable of storing a minimum of 21 deceleration values via the internal microprocessor memory.

b. Shall be capable of providing a hard copy printout of stored deceleration values at the end of the testing period. The printout will record a minimum of:

(1) Providing the date.

(2) Providing the time.

(3) Providing the runway designation or heading.

c. Shall be capable of providing further information, which may be recorded at the manufacturers discretion, e.g., make of decelerometer, ambient/pavement temperature, airport name and location, and operator identification.

4. **Decelerometer Calibration.** The decelerometer shall be calibrated by the manufacturer before shipping to the airport authority. The manufacturer shall provide the airport authority with a certificate of calibration, including test results of the calibration. The manufacturer shall provide a 1 year warranty for the decelerometer.

The decelerometer shall be returned to the manufacturer for servicing and recalibration every 2 years.

5. **Training.** The manufacturer shall provide the airport authority with training manuals and/or videos of all relevant data concerning friction measuring recording and reporting, including:

a. An outline of the principles involved in the operation of the decelerometer-type friction measuring device.

b. Copies of pertinent advisory circulars.

c. Procedures for reporting results of the friction tests in NOTAM format.

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Federal Aviation Administration

Airport Winter Safety and Operations

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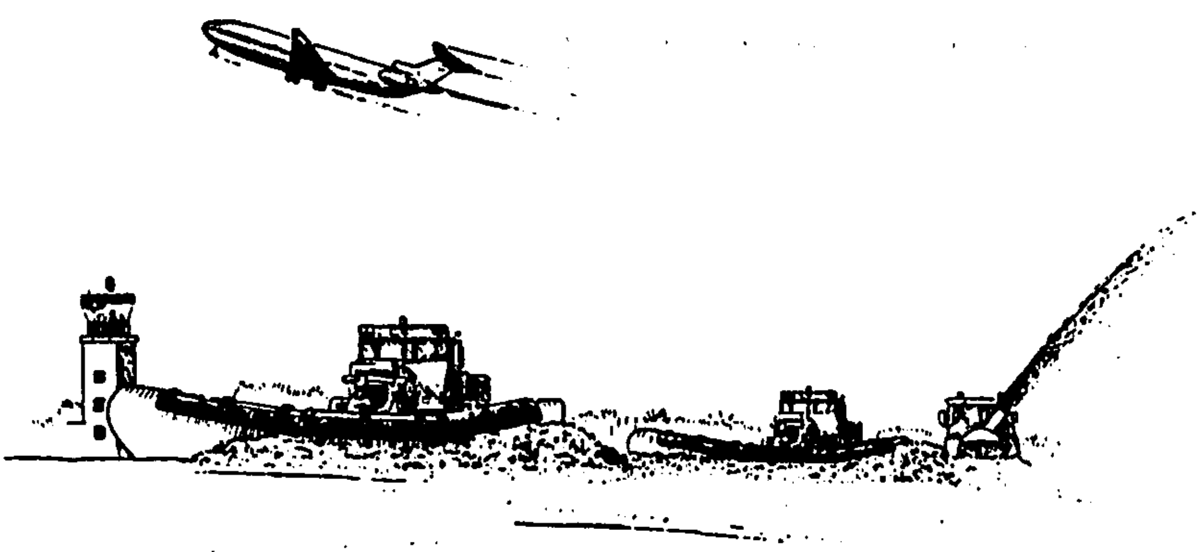
Advisory Circular

INCORPORATES CHANGE 1



AAS-100

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: AIRPORT WINTER SAFETY AND OPERATIONS
Date: 10/1/91
Initiated by: AAS-100
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Change:

1. **PURPOSE.** The purpose of this advisory circular (AC) is to provide guidance to assist airport owners/operators in the development of an acceptable airport snow and ice control program and to provide guidance on appropriate field condition reporting procedures.

2. **CANCELLATION.** AC 150/5200-30 dated 4/20/88 is cancelled.

3. **APPLICATION.** The guidance and standards contained in this advisory circular are recommended by the Federal Aviation Administration for winter operations at all civil airports. Guidance is also provided on information which could be included in the Snow and Ice Control Plan required by Federal Aviation Regulations (FAR) Part 139 for certificated airports and for procedures to conduct friction surveys during winter operations at airports. At certificated airports, standards for the use of deicing/anti-icing chemicals and abrasives described in paragraphs 25 and 28 provide an acceptable means of compliance with FAR Part 139.

4. **METRIC UNITS.** To promote an orderly transition to metric (SI) units, this AC contains both English and metric dimensions. The metric conversions may not be exact, and pending an official changeover to this system, the English system governs.

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CHAPTER 1. INTRODUCTION

1. **BACKGROUND.** Snow, ice, drifting snow, and reduced visibility at airports in areas subject to below freezing temperatures can severely affect wintertime operational safety. The presence of snow, ice, or slush on airport movement surfaces frequently causes hazardous conditions which contribute to aircraft accidents, incidents, and reduced traffic volumes, resulting in delays, diversions, and flight cancellations. Airport management's approach to snow and ice control procedures will largely determine the extent to which these effects can be minimized. Timely assessment of runway braking conditions during winter weather and providing accurate and real-time information to pilots will further enhance operations.

2. **DEFINITIONS.**

a. **Ice.** The solid form of water consisting of a characteristic hexagonal symmetry of water molecules. Density of pure ice is 57 lb/ft^3 (913 kg/m^3), which is 9 percent less dense than water. Compacted snow becomes ice when the air passages become discontinuous at a density of about 50 lb/ft^3 (800 kg/m^3).

b. **Slush.** Snow which has a water content exceeding its freely drained condition such that it takes on fluid properties (e.g., flowing and splashing). Water will drain from slush when a handful is picked up.

c. **Snow.** A porous, permeable aggregate of ice grains which can be predominately single crystals or close groupings of several crystals.

(1) **Dry Snow.** Snow which has insufficient free water to cause cohesion between individual particles; generally occurs at temperatures well below 32^0 F (0^0 C). An operational test is to make a snowball; if this is futile because it falls apart, the snow is dry.

(2) **Wet Snow.** Snow which has grains coated with liquid water which bonds the mass together but has no excess water in the pore spaces. A well-compacted solid snowball can be made, but water will not squeeze out.

d. **Patchy Conditions.** Areas of bare pavement showing through snow and/or ice covered pavements. Patches normally show up first along the centerline in the central portion of the runway in the touchdown areas.

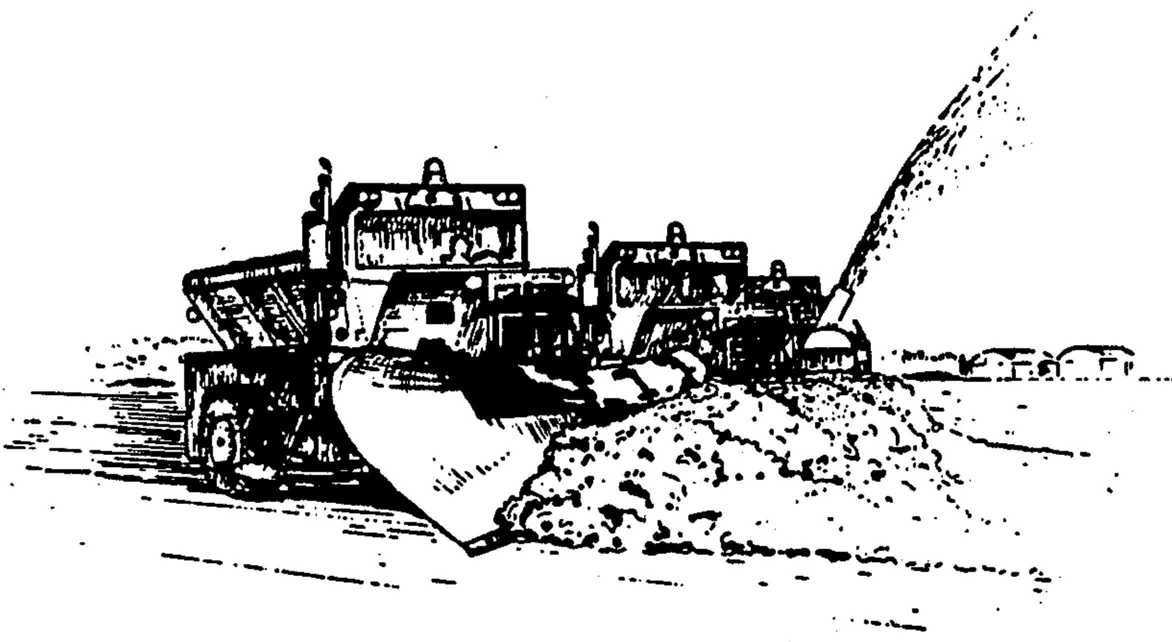
e. **Deiced.** Ice on runway has been coated with chemicals.

f. **Eutectic Temperature/Composition.** A deicing chemical melts ice by lowering the freezing point. The extent of this freezing point depression depends on the chemical and the proportions of chemical and water in the system. The limit of freezing point depression, equivalent to saying the lowest temperature that the chemical will melt ice, occurs with a specific amount of chemical. This temperature is called the eutectic temperature and the amount of chemical is the eutectic composition. Collectively, it is referred to as the eutectic point.

g. **Coefficient of Friction.** The ratio of the tangential force needed to maintain uniform relative motion between two contacting surfaces (aircraft tires to the pavement surface) to the perpendicular force holding them in contact (distributed aircraft weight to the aircraft tire area). The coefficient is often denoted by the Greek letter MU. It is a simple means used to quantify the relative slipperiness of pavement surfaces. Friction values range from 0 to 100 where zero is the lowest friction value and 100 is the maximum frictional value obtainable.

3. - 6. **RESERVED.**

Chapter 2
Winter Operations on Airports



CHAPTER 2. WINTER OPERATIONS ON AIRPORTS

7. **SAFETY REQUIREMENTS.** Snow, ice, and slush should be removed as expeditiously as possible to maintain runways, high-speed turnoffs, and taxiways in a "no worse than wet" condition. Surface friction can be improved by application of abrasive material when unusual conditions prevent prompt and complete removal of slush, snow, or ice. Operations of snow removal equipment and support vehicles must be conducted to prevent interference and conflict with aircraft operations. This responsibility is shared by both airport personnel and aircraft operators. The reduced hours of daylight during the winter and frequent low visibility conditions, resulting from fog, blowing snow, or precipitation, require extra care during field operations and greater attention to enhancing visibility of equipment performing winter maintenance (i.e., snow removal, friction enhancement, etc.).

a. **Airport Operator.** An operator has a major duty to ensure the safety of operations at his facility. This involves performance according to accepted principles, ensuring a high standard of care, and providing state-of-the-art standards in equipment and techniques. Care should be taken that the snow and ice removal plan in the airport's certification manual is current, complete, and customized to the local conditions. All airport leases and agreements should be clear and specific and cover the duties and responsibilities of lessees to carry out their snow and ice control duties. Airport operators, however, have the duty to warn of any change in published procedure or change in the physical facility. As an example, an operator should give timely or proper notice of pavement or visual aids which may have been damaged by a snow plow. Complete documentation of compliance with the certification manual should be kept.

b. **Snow and Ice Control Contractors.** The principles of ensuring safety of operations also apply to contractors. In particular, agreements should be clear and specific regarding duties, procedures for snow and ice control, responsibilities for communications and control, and contingencies. Contractors should be given a copy of the airport certification manual as well as the snow plan.

c. **Airman's Information Manual (AIM).** The procedures for pilot braking action reporting and runway friction reporting are given in the AIM. These procedures cover how pilots report aircraft braking action to ATC and how ATC reports friction numbers obtained from airport management to pilots during winter operations.

8. **ISSUES.** Snow, ice, and slush on aircraft movement surfaces can degrade the coefficient of friction and reduce aircraft braking and directional control.

a. **Runway Operations.** Snow, ice, slush, and standing water impede aircraft acceleration. Although acceptable limits vary by aircraft, most jet aircraft flight manuals limit the aircraft to landing with 1 inch or less of slush or standing water on the runway and to taking off with one-half inch or less of slush or standing water on the runway. AC 91-6A, Water, Slush, and Snow on the Runway, provides additional information concerning the operation of turbojet aircraft when water, slush, and snow are on the runway.

b. **General Aircraft Surface Operations.** Other winter safety concerns include:

(1) **Obscured Visual Aids.** In-pavement and edge lights, taxiway lights, runway markings, airport guidance signs, and visual approach slope indicators need to be maintained free of snow and ice.

(2) **Obstructions.** Hazardous snow banks, drifts, windrows, and ice ridges, which could come into contact with any of the aircraft wing or nacelle surfaces, should be prevented or eliminated.

(3) **Navigational Aids.** Any snow or ice which affects the signal of electronic navigation aids must be removed.

c. **Parking Ramp Operations.** Snow, ice, and slush accumulations on ramps and parking or holding areas create safety hazards. Three effects of such accumulations are:

(1) **Slick Surfaces.** Equipment and personnel operating on a slick or icy pavement surface may not have sufficient traction to start, stop, or even remain in place when encountering exhaust blast from other aircraft. Maintaining directional control under these conditions is also a very real problem.

(2) **Power Runup.** Pilots of parked or holding aircraft (especially turbojet aircraft) must apply increased power to break away, maneuver, and taxi under adverse surface conditions. The resultant blast may damage other aircraft or ramp support equipment and could even injure ramp personnel.

(3) **Obscured Visual Aids.** The absence of visible painted markings or obliterated sign messages could make maneuvering on ramp areas difficult. Pilots, unable to see these visual aids, are hard pressed to judge direction and obstacle clearances.

9. CONTROL.

a. **Snow Committee.** All airports subject to annual snowfall of several inches or more or icing conditions should have a snow committee. The committee size and function will vary depending on the frequency and amount of anticipated snowfall and the size of the airport. The formally constituted snow committee expedites decisionmaking, reduces the response time for keeping runways, taxiways, and ramp areas operational, and improves the safety evaluation process which determines when or if a runway should be closed. A committee may be composed of representatives of airport management and operational staffs, airline flight operations departments and/or fixed-base operators, the air traffic control tower (ATC), the flight service station, airway facilities (AF), the National Weather Service, other meteorological services, and any other interested or concerned parties. Airlines normally provide information on aircraft operational limitations and assist in evaluating pavement surface conditions. Snow committees are generally chaired by the airport manager or his representative. Committees have proved useful, not only in day-to-day operations (because communications are enabled), but in identifying long-range equipment needs and selecting and applying ice control chemicals. Snow committees normally critique past season's activities. Many snow committees also critique responses after each storm event.

b. **Snow Control Center.** Airports in frequent or heavy snowfall areas should set up a special facility for all snow and ice control activities (i.e., a "Snow Desk" or "Snow Control Center"). The snow desk or snow control center will normally inform air carriers and the ATC of expected runway opening and closing times and serve as a prime source of field condition information. The size and complexity of this facility will depend on the size of the airport, local climate conditions, and the personnel available. Communication between the ATC tower, snow and ice control equipment and/or supervisors' vehicles, and other support elements need to be provided. Status boards are often used for displaying the type, identification number, status, and location of each piece of equipment. A status board is also useful for recording the condition and inspections of airport surfaces and visual aids. The snow control center can keep an equipment checklist to supplement the status board and a visual inspection to ensure that all equipment has cleared runways prior to resumption of aircraft operations.

c. **Snow Removal Plan.** Every airport where snowfall is likely should have a written plan which states the procedures, equipment, and materials to be used by the airport in removing snow and ice. It should set out maintenance objectives and the priorities assigned to the airport movement areas, establish and define areas of responsibility (including who can close a runway), establish operational requirements and procedures, and define relationships with contractors if used. The plan should also address any unique environmental, climatic, and physical conditions affecting the airport. Elements that should be in this plan are preseason preparation, snow committee composition, snow desk or snow control center location, equipment, personnel training, weather reports, field condition reports, clearance criteria, clearance priorities, supervision, and communications. The snow plan should be flexible enough to allow snow and ice removal operations to change with changing weather and operational procedures. The snow committee at the airport can be charged with helping the airport operator keep the snow plan up to date. The sophistication or detail included in a snow plan will necessarily increase with the increasing size and complexity of the airport. A typical snow plan is included in appendix 2.

10. SNOW REMOVAL PRINCIPLES. Certain principles or objectives form the basis for a snow removal plan. These are discussed below:

a. **Snow Removal.** Snow impedes the passage of wheels by absorbing energy in compaction and displacement. The resulting drag increases as the water content of the snow increases. Wet snow and, in particular, slush will accumulate on all exposed surfaces subject to splashing from the landing gear, degrading flight control effectiveness or possibly preventing retraction of landing gear. Engine flameout can also be caused by wet snow. Even dry snow will accumulate on the landing gear and underside of the fuselage because of engine heat and the use of reverse thrust. A slush-covered pavement will reduce friction coefficient and can also cause hydroplaning. It is, therefore, necessary to remove snow from Priority 1 (active) runways as soon as possible after snowfall begins. Dry snow falling on a cold dry pavement will generally not adhere and may be blown off by wind or aircraft operations. Under these circumstances, only brooming may be needed to prevent compacted snow tracks from forming. Wet snow cannot blow off the pavement and will readily compact and bond to it upon the passage of wheels.

b. **Height of Snow on Shoulders.** Snow plowed off the runways must be reduced in height, sufficient to provide clearance for wings, engines, and propellers [see chapter 3, paragraph 21b(6)]. Eliminating windrows at the runway edge will also reduce the formation of drifts onto the runway. These drifts, often called finger drifts, frequently take the form of long, intermittent, and possibly narrow snow projections which taper in width and height and can cause loss of aircraft directional control. Furthermore, snow cleared from the runways should not be deposited within a navigational aid (NAVAID) critical area, especially a reflecting plane area (see figures 3-6a and 3-6b).

c. **Ice and Bonded Snow Prevention.** Proper application of approved chemicals on the pavement prior to or during the very early stages of a snowfall will reduce the likelihood of compacted snow bonding to the pavement. Prompt treatment will also reduce the effort needed by either mechanical or chemical means of removing the snow. Additionally, chemicals should not be used where their melting abilities may cause dry blowing snow to accumulate on pavement surfaces in the form of slush.

d. **Response to Freezing Rain.** Freezing rain will bond to a cold pavement surface and will require special treatment depending on the pavement surface temperature. If the pavement surface temperature is below freezing, chemical application may be the most effective control measure. On the other hand, if the pavement surface temperature is above freezing and a frozen rain (slush) develops, a more effective method of control would be brooming.

e. **Effect of Chemicals on Friction.**

(1) Deicing chemicals may initially degrade the frictional level of a pavement surface upon application because of the concentrated chemical film that will occur on the surface area. This is especially true with liquid chemicals. However, after a short period of time, the frictional quality of the pavement surface should recover if the microtecture of the pavement surface is sound.

(2) During anti-icing, pavements in otherwise good condition will not experience an unsafe drop in friction levels when chemicals are applied at the manufacturers' recommended rates. On the other hand, pavements with poor microtexture due to wear or contamination by rubber deposits may become slippery [Effects of Runway Anti-Icing Chemicals on Traction (DOT/FAA/CT-TN 90/53), Nov. 1990].

(3) After the threat of inclement weather has passed, prompt cleanup measures should be initiated to remove surface contaminants prior to aircraft operations. When equipment is available, friction measurements should be made prior to reopening the runway (see paragraphs 13 and 14).

f. **Communications Equipment.** Two-way radios provide the primary communication between snow and ice control elements, i.e., snow control center, supervisory vehicles, and often times with snowplows, brooms, and other equipment. All units operating on runways and taxiways should be able to communicate on the appropriate airport advisory frequency or be under the control of a radio-equipped vehicle. Methods of signaling to indicate to the operators the necessity for clearing the runway or changing the removal plan should be worked out in advance. Some airports use a flashing beacon on supervisory vehicles as a signal. This signal beacon is separate and distinct from the flashing beacon that should be operating whenever vehicles are in an aircraft movement area. High noise levels in snow and ice control equipment may justify the installation of radios equipped with headsets and noise-cancelling microphones.

g. **Clearance around NAVAID's.**

(1) Snow removal around FAA localizers, glide slope installations, transmissometers, etc., should commence in conjunction with runway/taxiway/ramp snow control based upon the snow plan and the Instrument Landing System (ILS) snow depth criteria agreed to with the FAA airway facilities sector manager or designee. Prior to starting removal and after finishing removal, the air traffic control tower, flight service station, UNICOM, or appropriate facilities should be contacted. No equipment should be moved into the NAVAID areas until all aircraft

approaches are completed. In addition, the local AF office should be contacted before beginning removal actions unless the glide slope has been Notices to Airmen (NOTAMED) out of service. Clearance around non-Federal NAVAID's should be accomplished according to the facility's operations/maintenance manual.

(2) Snow fences can also minimize snow accumulation around NAVAID's and other sensitive facilities. The nearest AF office should be contacted prior to erection of any snow fence for technical guidance and determination of the effect such structures will have on the proper functioning of the NAVAID's. Failure to remove the snow in areas adjacent to the NAVAID may result in the restriction or shutdown of the facility. The airport sponsor should have an agreement with AF related to the conditions for which snow removal must be undertaken and the limits of the required snow removal to preclude restriction of the facility.

11. **PRESEASON PREPARATIONS.** Preparation for the next winter season should begin as soon as the previous winter season ends. A review of the past winter's experiences and problems should be made as soon as possible while the experience is still fresh in mind.

a. **Equipment and Supplies.** The condition of the airport snow control equipment should be determined, repairs scheduled, and replacement parts not in stock ordered. Ice control chemicals and abrasives should be ordered to ensure their being on hand before the first snowfall of the following winter season. Chemical and abrasive spreading equipment should be calibrated to ensure application of a known, controlled amount of material. The correct spread rate should be based on the prevailing conditions and the guidance provided in chapter 3.

b. **Training and Communications.** Crews should be trained in the operation of the equipment, and practice runs should be made with the equipment in typical operational scenarios. Also, the crews should be taught general maintenance and repair techniques for the vehicles and be trained in communication procedures and terminology, as well as be completely familiarized with airport layout, marking, signs, and lighting. A complete check of communication equipment should be made. Operator training on the use and repair of specific pieces of equipment is extremely important as it allows more efficient use of the equipment and less likelihood of breakdowns during operation.

c. **Installation of Snow Fences.** Immediately prior to the onset of a winter season, snow fences should be installed at locations where prior observation has shown they will be effective in minimizing accumulation (see paragraphs 10g(2) and 21a(2)).

d. **Identification of Disposal Areas.** If there is insufficient storage space for snow near the areas to be cleared and no melting or flushing means are available, hauling to a disposal site may be necessary. In that case, a site should be selected before winter in an area where the snow pile will not interfere with aircraft operations, will be readily accessible, and will not interfere with the airports' NAVAID's. The disposal site selection should be coordinated with the local AF Sector Office. Careful consideration must be given to drainage in selecting a land disposal site as the ground will remain snow-covered or wet long after all other snow has melted and seasonal vegetative growth will be delayed. If large quantities of snow must be handled, a tracked bulldozer may be necessary to push the snow from the truck dumping point into a pile. This will reduce the area occupied by the snow and prevent haul trucks from becoming stuck in the dumped snow. Debris remaining after the spring melt will need to be cleaned up. Disposal by use of melting devices is discussed in chapter 3.

12. **AIRFIELD CONDITION ASSESSMENT**

a. **Weather Reports.** Appropriate response to a snow or ice removal event depends on accurate information about an approaching storm and the likely effect of precipitation on airport surfaces. The snow or ice removal task can be reduced and costs lessened by a prompt, effective response to a storm warning; in addition, unnecessary callouts and other mobilization costs can be eliminated by responding appropriately to accurate storm forecasts. In many areas, good forecasts can be obtained from the National Weather Service. Where these are very general, both with regard to geographic area and time of the precipitation event, contract weather services are also available and can provide local specific forecasts and short-time warnings. Some airports have installed color weather radar monitors on which views of precipitation cells can be called up from local or distant radars. Another option may be procurement of a weather radar system including x-band radar (designed specifically for snow and low-level precipitation conditions like "lake effect storms"). At smaller airports, a telephone network with outlying areas (possibly county or State highway offices) can be used to track approaching storms.

b. **Pavement Surface Condition Sensors.** Sensors embedded in the pavement to measure surface conditions serve two functions: (1) they provide a precise measure of the pavement temperature and they indicate the presence of water, ice, or other contaminant; and (2) they transmit this information to the snow control center to provide an important part of the information necessary for selecting the most appropriate snow and ice control strategy. Many factors influence pavement temperature: surface color and composition, wind, humidity, solar radiation, traffic, and the presence of residual deicing chemicals or other contaminants. Since pavement temperature lags behind air temperature, use of air temperature to infer the condition of the pavement surface is imprecise and can be very misleading. Ice will not form unless the pavement temperature reaches the freezing point; therefore, knowledge of the direction and rate of change of pavement temperature will provide a predictive capability for the formation of ice. Sensors are particularly valuable in the timing of anti-icing applications of chemicals (see Chapter 3). If ice or compacted snow has accumulated on pavements, knowledge of the pavement temperature will guide selection of chemical and application rate to achieve clearance within a specified time with the minimum amount of material.

c. **Field Condition Assessment.** The snow control center must be aware of the surface conditions of all movement areas in order to plan and carry out appropriate maintenance actions. Runway condition reports received from pilot reports, "snow team" personnel, friction measurements (paragraph 13), or pavement condition sensors can be used to assess the surface state. This same information forms the basis for field condition reports. In addition to the usefulness for efficient snow and ice removal, field condition reports can enhance aircraft safety when provided to pilots during winter operations. Therefore, when the airport has appropriate equipment and trained personnel, these reports should be prepared and promulgated in accordance with procedures and formats set forth in paragraphs 13 and 14.

13. OPERATIONAL RUNWAY FRICTION TESTING. Airports serving turbojet aircraft operations during winter conditions should have trained personnel and approved equipment to carry out runway friction testing. Under certain conditions, difficulties in stopping and controlling the aircraft on snow or ice-covered runways can occur with potentially serious results. Pilot braking action reports have been found to vary significantly and are sometimes not representative of the actual runway braking condition. For this reason, many airports use runway friction measuring equipment to provide an indication of the existing friction on runways contaminated by snow or ice during aircraft operations and during snow removal operations. Pavement condition reports should be prepared and issued on a real-time basis to pilots using the airport during appropriate periods as specified below. Further guidance on runway friction measurement may also be found in Advisory Circular 150/5320-12, Measurement, Construction, and Maintenance of Skid-Resistant Airport Pavement Surfaces.

a. **When to Conduct Friction Testing.** In general, friction tests should be conducted on a periodic basis during any time that airfield pavement is contaminated with snow, ice or slush. The interval between tests can vary from every hour during rapidly changing weather conditions to every 8 hours if the weather is stable. If pilots report consistent favorable braking conditions, this interval may be extended. In addition, certain other conditions and events may trigger a need for testing. The following circumstances call for friction testing of runways:

(1) When runway contaminants exist. In this case, the runway should be tested before the first flight of the day. Typical conditions requiring periodic testing are:

(a) Ice or compacted snow, either bare or covered with water, chemicals or sand;

(b) Loose snow; or

(c) Slush;

(d) Patches of bare pavement, wet or dry, fully or partially covered with or devoid of chemicals and/or sand; or

(e) Any combination of the above.

(2) When any major weather or pavement condition changes occur. Typical examples of these changes are rapidly accumulating snow or freezing precipitation, snow changing to freezing rain, or a rapid drop or rise in ambient temperature through the freezing point. If pavement sensors are available in the runway, they should be used in lieu of ambient temperatures. Testing should continue every hour until the friction stabilizes.

(3) Before the runway is reopened following snow or ice removal by plowing or sweeping, anti-icing, deicing, or sanding operations.

(4) After pilot braking report of "Nil" or after several pilot braking reports of ""Poor".

(5) Any time after an aircraft incident/accident.

(6) Any other time airport management believes friction measurement data would be useful, either for aircraft operational use or for airport maintenance purposes.

b. **Friction Measuring Equipment.** Two basic types of friction measuring equipment may be used for conducting runway surveys during winter operations - decelerometers and continuous friction measuring equipment. FAA has approved a number of manufactured devices of each type as meeting FAA requirements. Appendix 5 lists the approved equipment. Continuous friction measuring equipment may also be used for pavement condition evaluation for maintenance and repair purposes. Decelerometers do not provide a continuous record of pavement friction, do not give reliable results on wet pavement, and are thus approved only for winter operational runway surveys. Neither type of device will give usable data if operated on more than 2 inches (5cm) of loose snow or 1/2 inch (13mm) of slush.

(1) **Continuous Friction Measuring Equipment (CFME).** CFME devices are preferred equipment used to measure friction on runway surfaces. They may be either self-contained or towed. Performance specifications for CFME may be found in AC 150/5320-12, "Measurement, Construction and Maintenance of Skid Resistant Airport Pavement Surfaces." CFME's are recommended for use at any airport with significant turbojet aircraft operations.

(2) **Decelerometers.** These devices may be either electronic or mechanical. Performance standards for decelerometers are in appendix 6.

(a) **Electronic Decelerometers.** At airports that do not have CFME, electronic decelerometers are acceptable for use at any airport with significant turbojet aircraft operations. The electronic decelerometers eliminate potential human error by automatically recording friction averages for each one-third zone of the runway and also provide a printed record of the friction survey results.

(b) **Mechanical Decelerometers.** Mechanical decelerometers are acceptable for use only at airports having runway ends with less than 31 daily turbojet aircraft arrivals. Mechanical decelerometers do not provide automatic friction averages or a printed copy and, consequently, require a larger runway downtime to complete the survey. Busier airports who currently own mechanical decelerometers should plan to replace them with the electronic versions as soon as practicable.

(3) **Communication Equipment.** The airport operator should furnish appropriate communications equipment and frequencies on all vehicles used in conducting friction surveys. This will assure that airport operations personnel at both controlled and uncontrolled facilities can monitor appropriate ground control and/or airport advisory frequencies.

c. **Friction Measuring Procedures.** Runway friction measurements take time, and while the tests are being conducted, the runway will be unusable for air traffic. Airport operations management should work closely with air traffic control, if available, fixed base operators, and/or airlines to minimize interruption to normal traffic flow. Close coordination among all parties concerned is necessary if personnel safety, traffic management, and timely friction measurement objectives are to be met. The airport operator should coordinate with the tower and ask for a 3-minute period (or other apprpropriate period) of time to check the runway. At a high activity airport, friction measurements may have to be made in segments to reduce runway down times. Upon request, ATC personnel generally can plan a break in arrival and departure traffic to permit a friction measurement test run. Through such planning, the friction measurement team can be in position adjacent to the runway when ATC gives the go-ahead. In this way, disruptions to traffic flow can be minimized. A letter of agreement between the airport operator and the ATC facility should identify the means and responsibilities for coordination and for reporting runway conditions.

(1) **Preliminary Steps.**

(a) **Calibration.** The equipment operator should ensure that the device is correctly calibrated in accordance with operations manuals and that all ancillary systems (recording devices, vehicles, two-way radios, etc.) are operating properly. For CFME's, the airport operator should check the electronic calibration each time the equipment is used. A recalibration check of the instrument by the manufacturer should be scheduled every 3 years or as often as required for the life of the instrument. A recalibration check of decelerometers by the manufacturer should be scheduled every 2 years or as often as required for the life of the instrument. The operator should not try to adjust the calibration of decelerometers. If it is suspected of being out of calibration, the airport operator should contact the manufacturer for repair. Recalibration should be scheduled during the spring-summer season to ensure that the equipment will be ready for the next winter's friction surveys.

(b) **Advance Coordination with ATC.** To assure that safe and efficient air traffic operations are maintained at all times, the following coordination procedures should be followed by the airport operator and ATC when setting up friction surveys on runways:

(i) The airport operator should provide as much advanced notification as possible to ATC, commensurate with major weather or pavement condition changes to minimize disruptions to aircraft operations at the facility. Notification should include the estimated runway occupancy time required to complete the friction survey.

(ii) ATC should then provide to the airport operator, as soon as possible, the estimated time for scheduling the friction survey on the runway, based on prior coordination and air traffic commitments.

(c) **ATC Clearance.** Before proceeding with testing vehicle runs at controlled airports, the operator must contact ATC for runway clearance in accordance with standard procedures and remain in radio communication during the entire period of testing on active runways. ATC should provide appropriate clearances on and off the runways to permit the airport operator access to conduct friction surveys. At uncontrolled airports, operations personnel must be alert for aircraft and advise any air traffic on advisory frequencies before, during, and after completion of the friction measurement survey. In this situation , more coordination is needed between the area ATC, the airport operator, and other parties involved to assure safe and efficient aircraft operations are maintained at all times.

(2) **Location of Friction Surveys.** The 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.

(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 6.1 m) to the right of the runway centerline to determine the worst case condition.

(c) **Runway Zones.** The runway length should be divided by three to obtain the touchdown, midpoint, and rollout zones, according to aircraft landing direction. Testing is to be conducted for each zone.

(d) **Non-runway Areas.** Airport operators may consider use of friction measuring equipment to determine necessary treatment of non-runway areas, such as high speed taxiways.

(3) **Testing with Decelerometers.** Conduct at least three braking tests in each zone. Determine the average MU for each zone. If there is an erratic value in any one zone (when the measured MU number exceeds 10 percent of the other two averaged MU numbers), repeat the test to confirm. The vehicle speed for conducting friction surveys should be 20 mph (32 km/h). Decelerometers are not recommended for use on wet runway pavement surfaces because they do not provide consistent and reliable results, nor should they be used on loose snow over 2 inches (5 cm) or slush over 1/2 inch (13 mm) deep.

(4) **Testing with Continuous Friction Measuring Equipment.** Conduct friction tests and determine the average MU number for each zone. These devices provide a continuous graphic record of MU values for each 500-foot (152 m) zone of each zone. The vehicle speed for conducting friction surveys should be 40 mph (65km/h) or less as conditions dictate. Towed devices can become unstable when operated at the speed of 40 mph (65km/h) on pavement that has areas of (a) ice covered with water, (b) ice covered with liquid chemicals, and (c) slush on ice. However, they can

provide reliable data when the speed is reduced to 20 mph (32km/h) on these surfaces. Friction tests should not be made on loose snow over 2 inches (5cm) or slush over 1/2 inch (13mm) deep.

(5) **Recording Test Data.** A record of the conditions under which surveys are made as well as the testing results can be valuable data for airport operators in assessing effectiveness of runway treatments, in accident or incident investigation, for making long-term correlations of local weather patterns with airfield pavement slipperiness or for other purposes. Figure 2-1 is a suggested form which includes a block for recording each item of appropriate data. The Remarks column should be used to note, for example, pilot reports received (and aircraft type) or any unusual conditions existing when the tests are made. The continuous electronic friction measuring devices and electronic decelerometers provide their own records. These may be used to augment the form as appropriate. Records should be kept until they are no longer useful to the airport operator.

(6) **ATC Notification After Testing.** The airport operator should notify ATC immediately upon completion of the friction survey and report the status of the runway in accordance with paragraph 13.

(7) **Out-of-Service Friction Measuring Equipment.** For details on the management of out-of-service friction equipment, reference AC 150/5320-12. During winter operations, if friction measuring readings have been issued on a regular basis and equipment used to obtain these readings becomes unserviceable, a NOTAM should be issued until the equipment is restored to service. Meanwhile, runway advisories may be issued using other means of observation (e.g., pilot reports). If another approved friction measuring device is available at the airport, it should be used until the primary device has been repaired.

14. PAVEMENT CONDITION REPORTING. Generally, the condition of the pavement should be reported by the airport operator whenever there is a change in the runway condition that is not reflected in the current information available to airport users. Time is of the essence in pavement condition reporting.

a. **When Reports Should Be Made.**

(1) Whenever there is a significant change in the runway surface because of snow or ice conditions.

(2) Whenever MU values drop below 40 on any zone of any active runway.

(3) When MU values rise above 40 on all zones of any active runway previously showing a MU below 40.

(4) When a runway is closed or scheduled to close for friction testing or snow or ice removal or treatment.

(5) When any other condition exists or changes occur which may affect operational safety of the airport.

(6) Routine periodic reports confirming current status as required by agreement with ATC.

b. **Report Contents.** The pavement condition report should identify the runway, the time of measurement and MU numbers for each zone, and the contaminant conditions, e.g., wet snow, dry snow, slush, deicing chemicals, etc.

c. **Reporting Procedures.** The procedure for transmitting reports to ATC to disseminate information to pilots may vary from airport to airport. The letter of agreement between the airport operator and ATC should spell out the procedures and formats for each type of event - runway closure, friction testing results, runway treatment, etc. For example, certain friction equipment manufacturers offer the airport operator an optional data link system that provides direct transmission of the friction measuring equipment data to airport operators, or ATC, or both. Reports may also be furnished to local operators, airlines, or other users. In the absence of a control tower on the airport, the report should be supplied to the ATC facility that provides approach control service or to an appropriate flight service station (FSS), fixed-base operator (FBO), or other authority to broadcast on the UNICOM/COMMON TRAFFIC Advisory Frequency (CTAF).

15. NOTAMS. Airport operators are responsible for issuing NOTAMS. AC 150/5200-28, Notices to Airman (NOTAMS) for Airport Operators, provides details of format and abbreviations for use in reporting winter conditions on aircraft movement areas. See appendix 1 for examples of NOTAM snow reports.

AIRPORT NAME ______________________________

DATE OF SURVEY	TIME	RUNWAY-TAXIWAY DESIGNATOR	DESCRIPTION OF SURFACE CONDITION	CONTAMINANT REMOVAL		TEMPERATURE	
				METHOD(S) EMPLOYED	TIME	AMBIENT	PAVEMENT

TYPE OF FRICTION MEASURING DEVICE USED AT AIRPORT	DATE LAST CALIBRATED	VEHICLE SPEED (MPH)	LOCATION OF TEST RUN FROM RUNWAY CENTERLINE (FEET)	AVERAGED MU NUMBERS--EACH ZONE			REMARKS
				TOUCHDOWN ZONE	MIDPOINT ZONE	ROLLOUT ZONE	

Figure 2-1 Runway Friction Survey Record

16. **CLEARANCE PRIORITIES.** Since all aircraft movement surfaces cannot be cleared simultaneously, the most critical areas should be attended to first with other areas taken care of in their order of importance. Airport operators should identify and prioritize all areas to be cleared of snow and ice based on safety requirements, flight schedules, and operational routes of traffic. Priority 1 areas normally include the primary instrument runway, its principal taxiways and high-speed turnoffs, designated ramp areas, emergency roads or firefighters' access routes, and NAVAID's (see subparagraph 10g) for the active instrument runway(s). Priority 2 areas generally include secondary runways and taxiways, other NAVAID's, and ramp areas not otherwise classified. Priority 3 areas may include refueling areas and perimeter roads. The face of all signs and all runway lights should be kept clear of snow at all times, and they should be checked frequently during the snow removal operation to ensure that they are both cleared of snow and operational. Roads to the passenger terminal should be considered in a separate category since different equipment and techniques may be employed and timely access and departure by the public rather than operational safety is the objective.

17. **CLEARANCE TIMES.** The number of pieces of equipment normally required to accomplish the clearance priorities outlined in paragraph 16 can be determined based on individual equipment performance specifications. For example, the speed of operation of a snow removal team is generally controlled by the capacity and speed of the rotary plows assigned to it. Once the number and type of rotary plows are determined, the number of displacement plows, brooms, etc., can be determined.

a. **Commercial Service Airports.** Commercial service airports should have sufficient equipment to clear 1 inch (2.54 cm) of snow weighing up to 25 lb/ft^3 (400 kg/m^3) from the primary instrument runway, one or two principal taxiways to the ramp area, emergency or firefighters' access roads, and sufficient ramp area to accommodate anticipated aircraft operations within the times shown below. If parallel runways typically have simultaneous operations during the winter months, the areas for both runways and associated principal taxiways should be included:

Annual operations	Clearance time (hour)
40,000 or more	1/2
10,000-40,000	1
6,000-10,000	1-1/2
6,000 or less	2

b. **Other than Commercial Service Airports.** All other airports should have sufficient equipment to clear 1 inch (2.54 cm) of snow weighing up to 25 lb/ft^3 (400 kg/m^3) from the primary instrument runway or that runway providing the maximum wind coverage, the principal taxiway to the ramp area, and sufficient ramp area to accommodate anticipated aircraft operations within the times shown below:

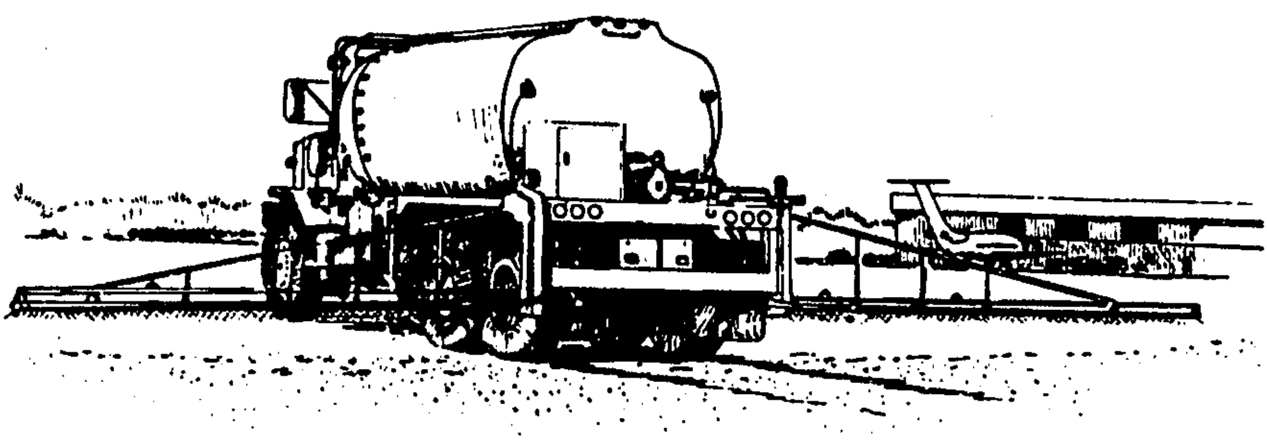
Annual operations	Clearance time hour)
40,000 or more	2
10,000-40,000	3
6,000-10,000	4
6,000 or less	6

18. **STORAGE OF ICE CONTROL MATERIALS.** Enclosed shelters are recommended for storing ice control materials. Storage of deicing/anti-icing chemicals reduces the prospect of product degradation due to environmental effects while storage of abrasives reduces the potential for leaching of chemicals that lower the abrasive's freezing point. Storage prevents absorption of moisture which may freeze the stockpile during cold weather. Storage also permits preheating an abrasive prior to application. AC 150/5220-18, Buildings for Storage and Maintenance of Airport Snow and Ice Control Equipment and Materials, provides typical layouts and other recommendations for the storage of ice control materials.

19. **EQUIPMENT MAINTENANCE AND STORAGE.** Whenever possible, snow and ice control equipment should be housed in heated garages during the winter to prolong the useful life of the equipment and to enable rapid response to operational needs. Repair facilities should be available for onsite equipment maintenance and repair during the winter season. Equipment should be inspected after each use to determine whether additional maintenance or repair is appropriate. AC 150/5220-18 provides typical layouts and other recommendations for the storage of equipment.

20. **RESERVED.**

Chapter 3
Snow and Ice Removal Procedures



CHAPTER 3. SNOW AND ICE REMOVAL PROCEDURES

21. **SNOW CONTROL PROCEDURES.** Close coordination should be maintained between the snow control center, air traffic control facility, FSS or UNICOM, and airport management to ensure a prompt response to snow and ice control urgencies. Alternate access to the runway by snow and ice control equipment, friction measuring equipment, and aircraft is necessary to keep movement areas operational to the extent practical.

a. **Control of Snow Drifting.** Preventing drifting snow from reaching operational areas will reduce the clearance effort.

(1) **Operational Procedures.** If possible, move the snow to the prevailing downwind side of the runway to reduce drifting. Plan on the prevailing winds and the likelihood that they will change with frontal passage. Another aid to help reduce drifting snow early in the season is to have all vegetation on the pavement edges mowed as short as possible.

(2) **Snow Fences.** Snow fences, if properly designed and located, can reduce the drifting of windblown snow. Snow fences should not be placed so that they penetrate any critical surfaces, and they should be outside of the runway safety area. Studies with snow fences have shown that optimum retention is obtained with a fence having 50 percent porosity, and the fence should be located upwind of the area to be protected a distance of at least thirty times the height of the fence. Studies by the United States Department of Agriculture, Forest Service aided in the development of the "Wyoming" snow fence which has proven very effective. It has horizontal slats with 50 percent porosity, a gap of 12-18 inches (30-46 cm) at the bottom, an angle of 15 degrees toward the leeward side, and is set perpendicular to the prevailing wind. A 12-foot (3.7 m) height was generally most effective in their studies, though a shorter height can be used and is usually necessary on airports.

(3) **Snow Trenches.** An expedient involves cutting a trench in the snow which has been cleared off the edges of the runway to act as a trap (see figure 3-1). Care must be taken in digging the trenches to ensure that the surface of the safety area is not damaged (i.e., ruts, humps, or bumps are created). Multiple trenches spaced about 10 feet (3 m) apart can store more snow. The closest to the runway that a trench should be excavated is 50 feet (15 m).

b. **Snow Removal Principles.** While conditions at individual airports vary widely and may require special removal methods or techniques, there is general criteria that should be followed as closely as possible. In general, airport users should be promptly notified, and a NOTAM should be issued immediately, advising of unusual airport conditions.

(1) Start snow and ice control operations on priority 1 areas as defined in paragraph 16, beginning with the primary instrument runway or active runway, as soon as snow or frozen precipitation begins to fall. Sweepers, if available, should be used to keep the center bare. As soon as snow has accumulated to a depth that cannot efficiently be handled by the sweepers, displacement plows and rotary plows should be dispatched to remove the windrows. If the pavement is warm enough for snow to compact and bond or if freezing rain is forecast, anti-icing chemicals should be applied prior to the start of precipitation or as soon after its start as possible. When snow has melted or begins to accumulate, or any ice that has formed has been disbonded from the pavement by the chemical, sweepers should remove this residue.

(2) The severity of a snowstorm will determine the extent of the area to be cleared initially. The objective should be to clear the entire priority 1 area; but should snowfall be too heavy to accomplish this, operations should be reduced to keeping the center of the priority 1 runway and its taxiways open. If the full width of the runway cannot be cleared, this situation should be reported in a NOTAM giving details of the cleared width to allow each operator to judge the suitability of conducting operations since aircraft requirements differ. If this width will not meet minimum operational requirements, operations should be reduced further or curtailed, and efforts should be concentrated on satisfying those requirements.

(3) Clearance of snow from the runway is accomplished most effectively by operating a plow team in echelon, figures 3-2 and 3-3, using a number of displacement plows to move the snow with a minimum of rehandling into a windrow which can then be cast beyond the edge lights by a rotary plow.

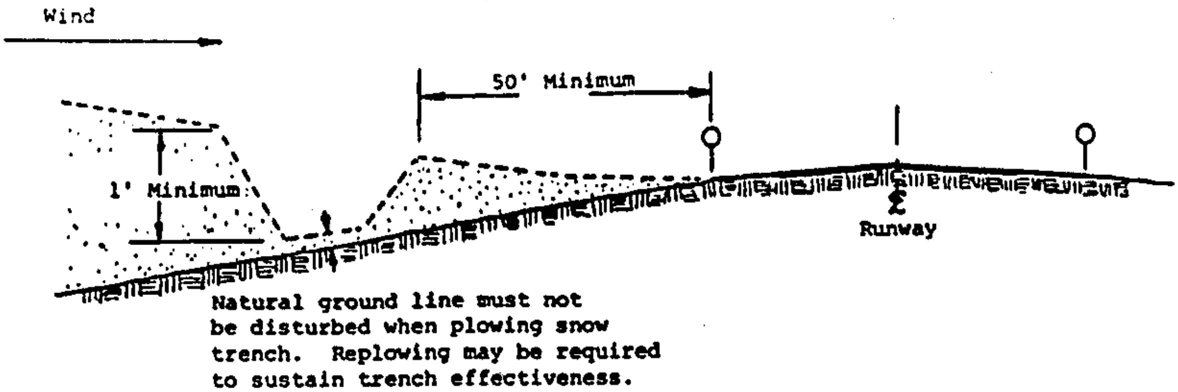


Figure 3-1. Typical Snow Trench.

The number of displacement plows to be used should be based on the volume of snow handled and the capacity of the rotary plow. Blades should not be dropped onto the pavement until the equipment is in motion in order to avoid damage to pavement and equipment. A safe distance should be maintained between vehicles operating in a team to avoid accidents resulting from loss of visibility. If visibility suddenly drops to near zero while plowing operations are in progress, equipment should stop immediately and radio its position to the supervisor or snow desk. No further movement should be attempted until visibility improves.

(4) If no wind is blowing, snow can be cleared to either side of the runway. Selection of casting direction can then be based on storage capacity of the field adjacent to the runway; visibility considerations, avoidance of structures, NAVAID's or other devices; and least effort clearance. If a wind is blowing, however, free choice of clearance direction may not be possible because movement of snow into the wind will result in considerable drifting back onto the cleared areas and will reduce the operator's visibility. In the case of a cross wind, clearance is best accomplished by plowing and casting with the wind, figure 3-4, regardless of the situation on the side of the runway where the snow will be deposited (except make sure clearances are in tolerance with figures 3-5, 3-6a, and 3-6b).

(5) Equipment movements must be carefully timed and coordinated to ensure an orderly turnaround and safe reentry at the start of the return pass. Close liaison must be maintained between the control tower, snow control center, and supervisory personnel. The control tower should be in contact with the snow control monitoring network whenever equipment is operating on movement areas.

(6) The height of a snowbank on an area adjacent to a runway, taxiway, or apron should be reduced to provide wing overhang clearance and preclude operational problems caused by ingestion of ice into turbine engines or propellers striking the banks prior to the area being reopened to aircraft operations. Figure 3-5 shows the desired maximum snow height profile which generally should be obtained. This profile should be checked for the most demanding airplanes used at the airport to ensure that props, wing tips, etc., do not touch the snow with a wheel at the edge of the full-strength pavement. When conditions permit, the profile height should be reduced to facilitate future removal operations and to reduce the possibility of snow ingestion into jet engines. Figures 3-6a and 3-6b provides a graphic presentation of the glide slope (ground plane) area to be kept clear. Snowbanks should not be allowed between this area and the runway.

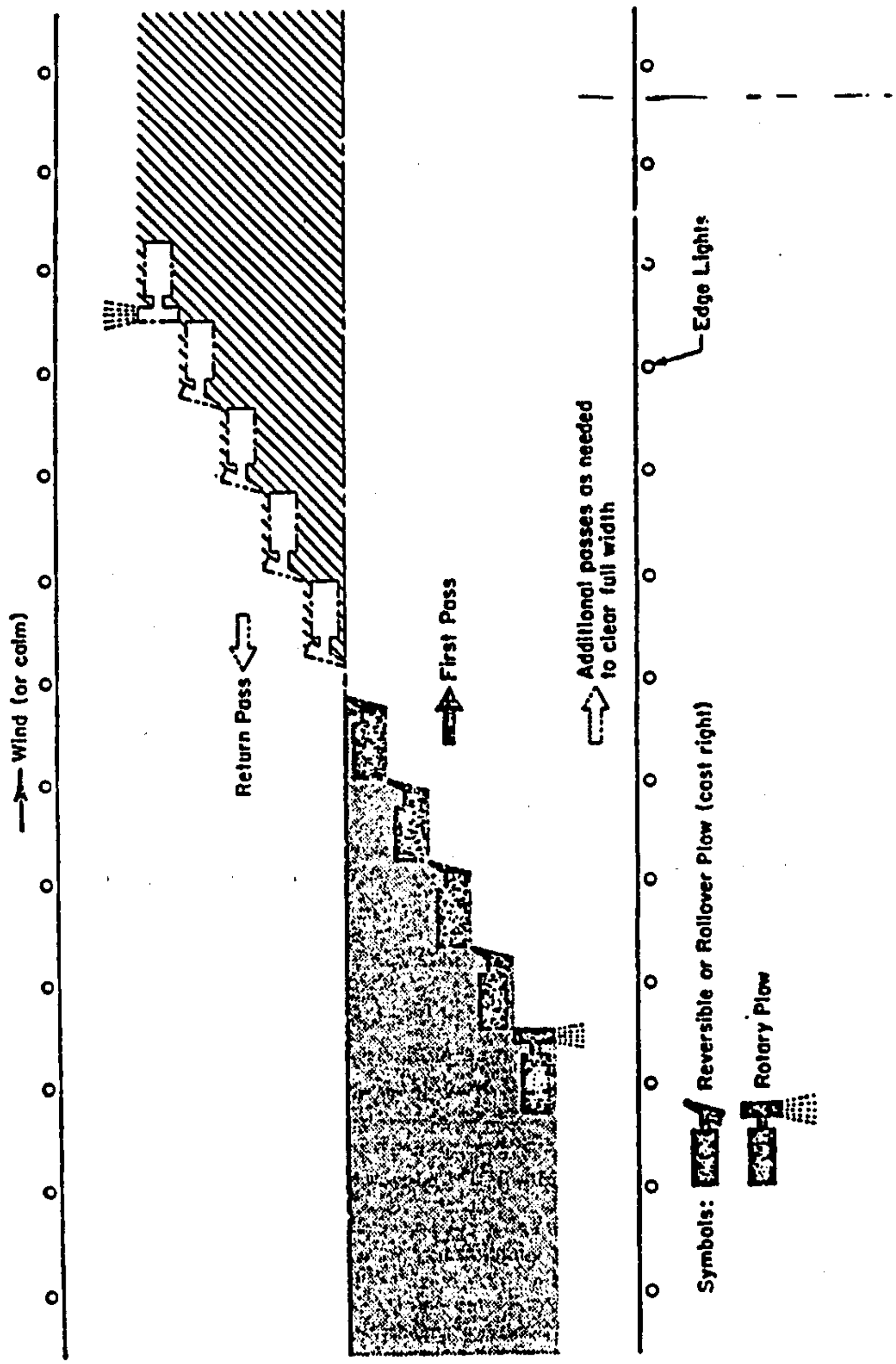


Figure 3-2 Possible Team Configuration During Light Snowfall with Parallel or Calm Wind Situations

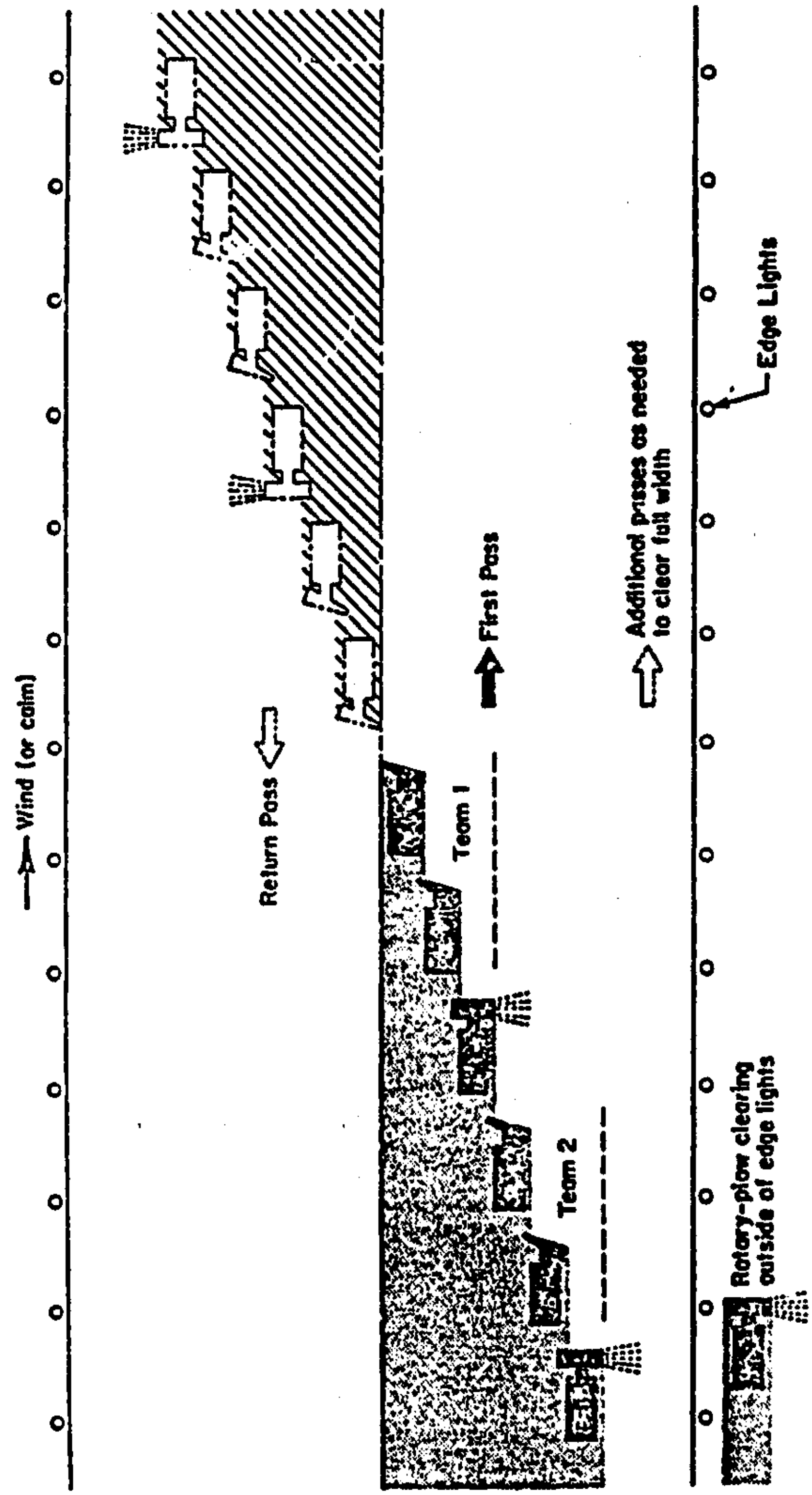


Figure 3-3 Possible Team Configuration with Parrallel or Calm Wind. Rotary Plow Can be Used Outside of Edge Lights if Suitable Paved Shoulder is Available.

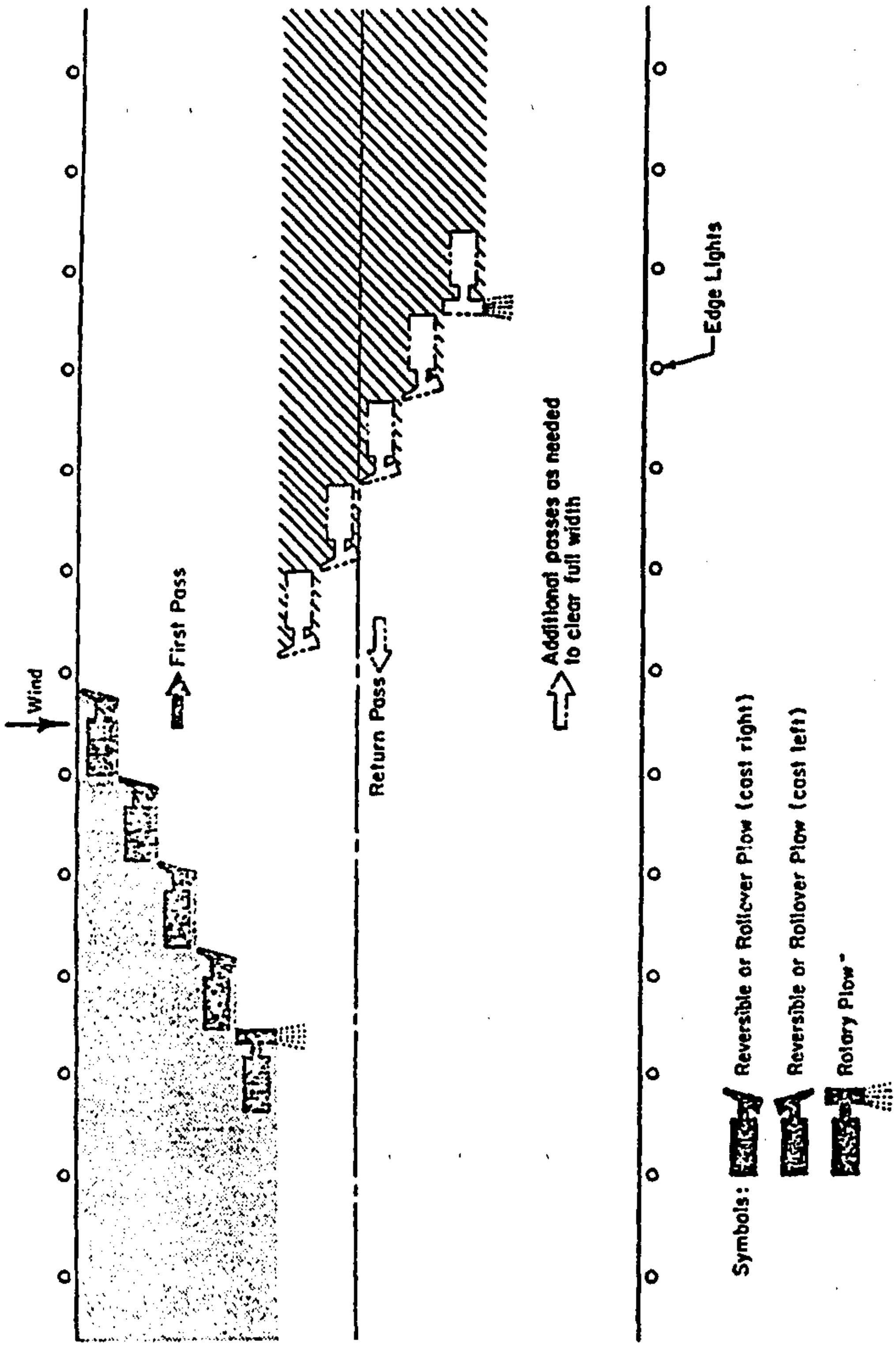


Figure 3-4 Possible Team Configuration with Perpendicular Wind.
(Dependent upon Capacity of the Rotary Plow)

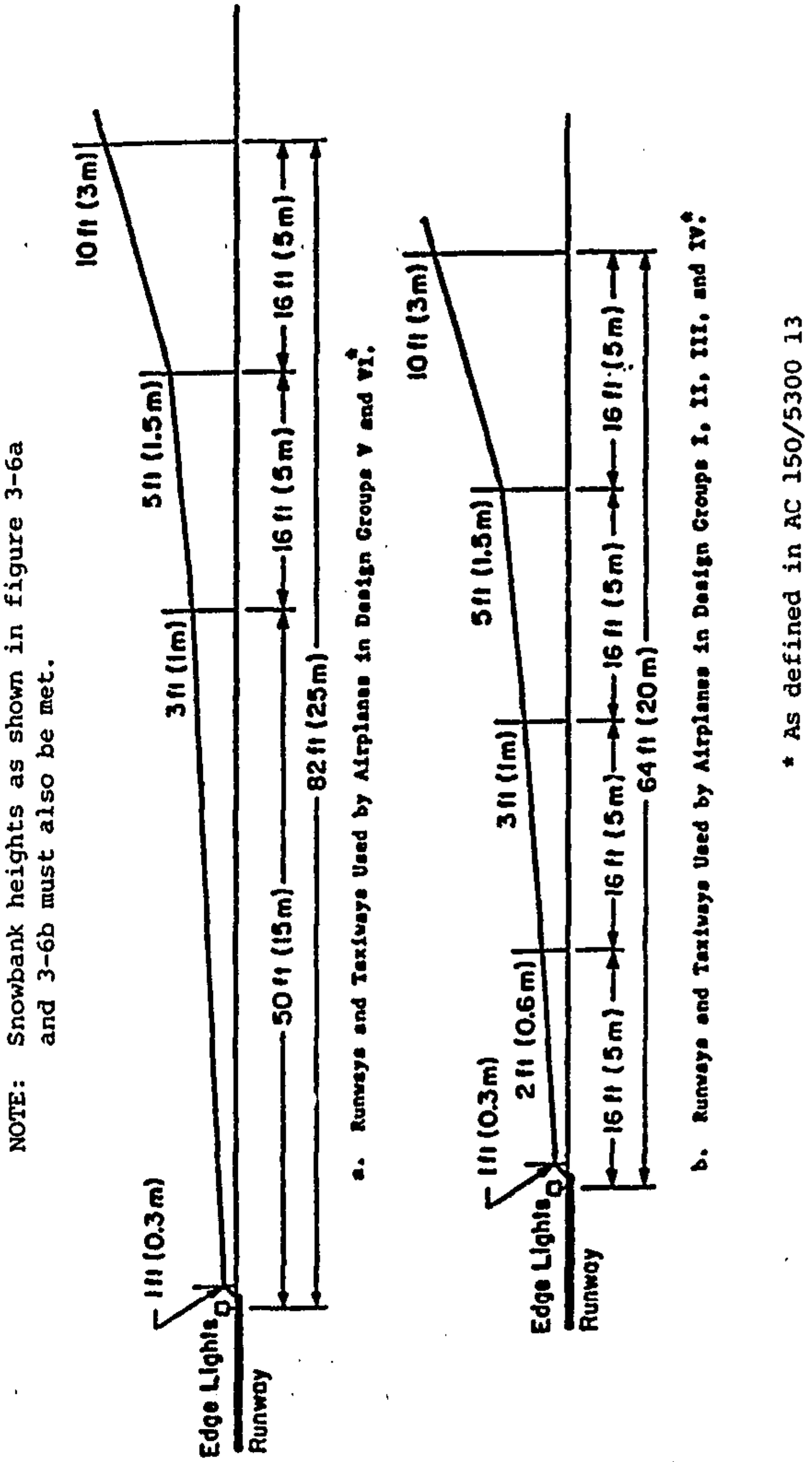
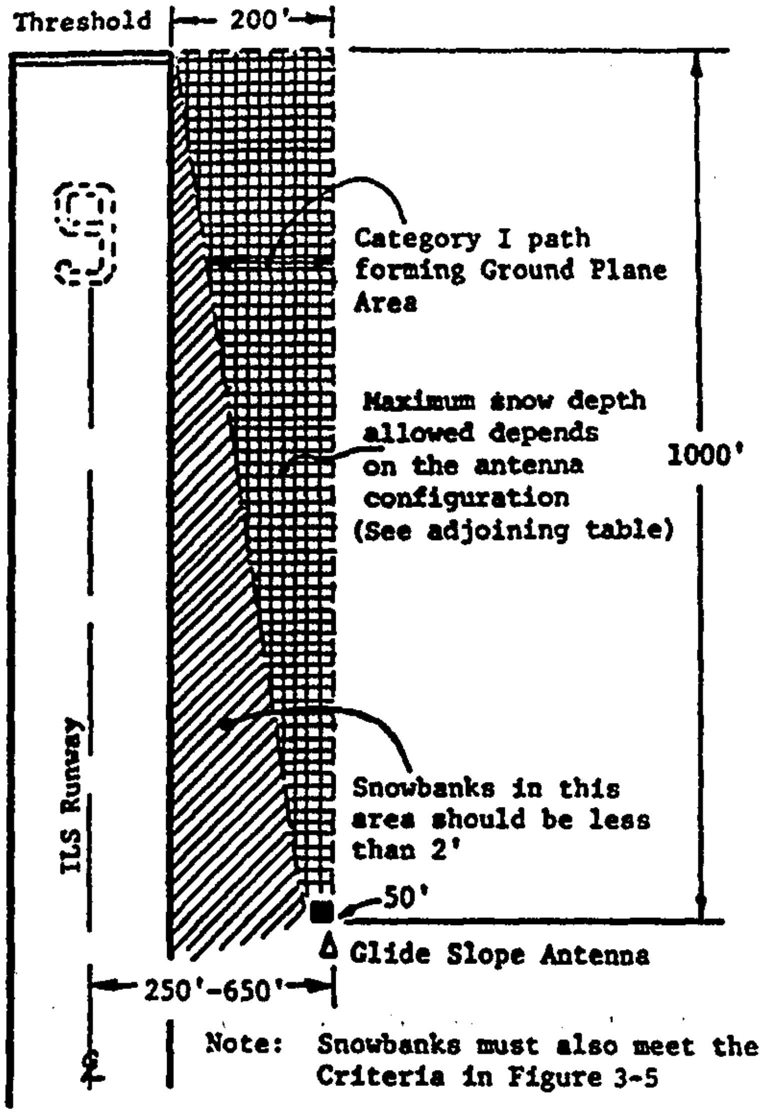


Figure 3-5 Snowbank Heights Generally Acceptable to Clear Engines and Wingtips With the Airplane Wheels on Full Strength Pavement

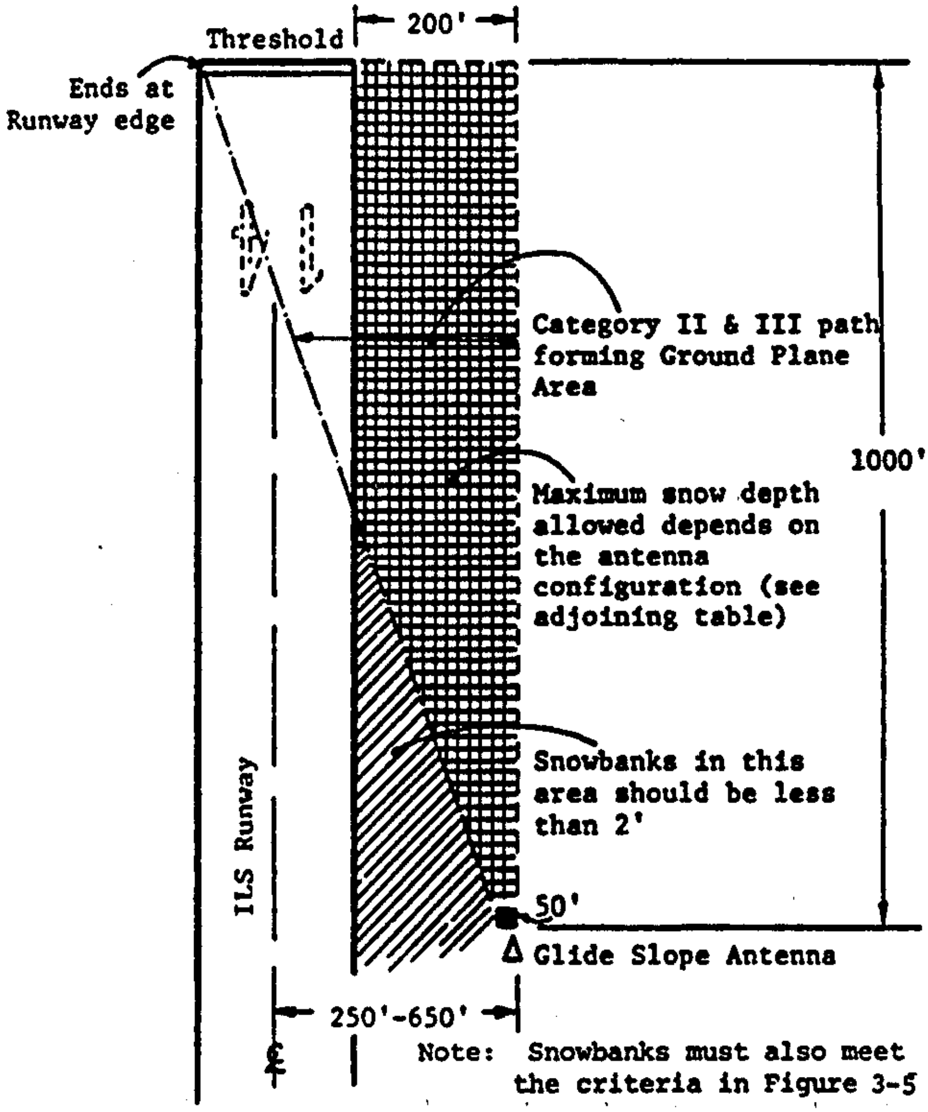


SNOW DEPTH

ACTION TAKEN	SBR < 6 in NR, CEGS < 18 in	SBR 6 - 8 in NR, CEGS 18 - 24 in	SBR > 8 in NR, CEGS > 24 in
Snow is removed	Removal not required. Full CAT I service.	Remove snow 50 ft wide at mast widening to 200 ft wide at 1000 ft towards middle marker.	
Snow is not removed	Full CAT I service.	Category D aircraft minima raised to localizer only.	CAT I approach restricted to localizer only minima.

Antenna configurations: SBR sideband reference
NR null reference
CEGS capture-effect glide slope

Figure 3-6a CAT I Snow Critical Areas to be Kept Clear of Snow Accumulation



SNOW DEPTH

ACTION TAKEN	SBR < 6 in NR,CEGS < 18 in	SBR 6 - 8 in NR,CEGS 18 - 24 in	SBR > 8 in NR,CEGS > 24 in
Snow is removed	Removal not required. Full CAT II & III services.	Remove snow 50 ft wide at mast widening to 200 ft wide at 1000 ft towards middle marker plus widen the area to include the line from the mast to the far edge of the runway threshold.	
Snow is not removed	Full CAT II & III services.	Both CAT II & III restore to CAT I service. Category D aircraft minima raised to localizer only.	Landing minima raised to localizer only minima.

Antenna configurations: SBR sideband reference
NR null reference
CEGS capture-effect glide slope

Figure 3-6b CAT II & III Snow Critical Areas to be Kept Clear of Snow Accumulation

(7) Movement areas where aircraft will operate at high speeds such as turnoffs should receive the same snow and ice control attention as runways. Areas of low speed operation such as taxiways and ramps can also be critical under some conditions. Directional control and braking action should be maintained under all conditions.

(8) Airports with joint military operations may have arresting barriers located near the end of the active runway or the beginning of the overrun area. Great care should be taken in clearing snow from the barriers. Barriers located on the runway should be deactivated and pendants removed prior to snow removal operations. Snow should be removed to the distance required for effective runout of the arresting system. Snow removal involving arresting barriers should be coordinated with the military tenant prior to the snow removal season.

(9) In heavy snow areas it is helpful to place flags on flexible stakes extending 1 or 2 feet above the edge lights. Visibility is enhanced by using international orange flags. Although these are primarily to assist snow removal equipment operators in avoiding striking the lights while plowing near them, pilots also report that they are useful. Time and effort in clearing snow from around the lights is minimized by plowing as close as possible to them. The remaining snow can be blown away using a truck-mounted airblast unit, the airblast from a broom, or by spraying with liquid deicing chemical. In some cases, edge lights may be raised. As a last resort, hand shoveling may be necessary.

(10) The face of all signs and all lights should be kept clear of snow and in good repair at all times with priority given to lights and signs associated with holdlines and ILS.

(11) Centerline and touchdown zone (TDZ) lights inset in the pavement tend to form "igloos" of ice or compacted snow surrounding them. Heat from the lamps will melt even cold dry snow which will refreeze and adhere to the pavement and then accumulate around the lights. One method of control or removal is described in paragraph 24. To prevent damage to these lights, use rubber or plastic cutting edges or shoes and casters on plow moldboards and the front of rotary plows.

(12) Striated pavement markings are useful in reducing ice buildup.

22. SNOW DISPOSAL. Some means of disposing of snow must be provided when there is insufficient space for storage adjacent to cleared areas. This will entail loading trucks and hauling to a disposal site, pushing the snow into melting pits sited near the areas being cleared, or portable melting pits set up over catch basins. Although melting pits eliminate long hauls and may reduce truck traffic in the ramp area, an economic analysis should be made to determine the benefit of constructing and operating them. Calculation of the thermal energy required is based on the heat of fusion of ice, 144 Btu/lb (335 kJ/kg) and the specific heat of ice, 0.5 Btu/lb (2.1 kJ/kg). Submerged combustion burners have been developed and are commercially available. A typical 10 x 8 x 8 ft (3 x 2.4 x 2.4 m) deep melting pit containing two burners can melt 120 tons of snow per hour (30 kg/s) consuming 60 gal. (227 liters) of No. 2 fuel oil per burner.

23. MECHANICAL METHODS FOR CONTROLLING ICE. Ice near the freezing point is soft and may be scraped off the pavement. Cold, hard ice bonds much more tenaciously and is difficult to remove by mechanical means. Scraping is not very effective, and attempts to lift the ice from the pavement by penetration with a wedge parallel to the pavement, have only been partially successful. Cutting edges attached to plow moldboards can be operated in contact with the pavement in the attempt to remove ice. At plowing speeds above about 10 mph (16 km/hr), front-mounted plows tend to bounce and leave ice on the pavement. Slower speeds, heavier plows, or plows which can be downloaded can reduce this "porpoising" or bouncing. Application of downward force also helps to penetrate and scrape the ice. Although down pressure can be applied by hydraulic cylinders on front-mounted plows, underbody blades can apply greater pressure without reducing steering control. All blades or cutting edges or the moldboards to which they are attached should have trip mechanisms to release the blade upon striking an obstacle in order to prevent damage to the blade, truck, pavement insert, or pavement. Carbon steel cutting edges run in contact with the pavement wear rapidly and require frequent replacement. Tungsten carbide cutting edges are extremely tough and can last for thousands of miles. They are brittle, however, and can chip upon striking metal or other very hard projections. Serrated cutting edges which cut grooves in hard ice are sometimes used and will facilitate retention of chemicals and abrasives which might otherwise be blown off. Centerline or flush lights should not be plowed with metal cutting edges contacting the pavement; rubber or polymer cutting edges will help prevent damage to the lights. Slush or very soft ice can also be removed effectively by rubber cutting edges which squeegee the pavement.

24. **ANTI-ICING VS. DEICING.** The most difficult task in winter maintenance occurs when snow or ice bond to the pavement. Thus the primary effort should be directed at bond prevention. Though dry snow will not readily form a strong bond even under heavy and frequent wheel passes, wet snow and ice will develop such a strong bond that mechanical removal is either difficult, slow, or damaging to the pavement. Ice removal after formation is called deicing; preventing the bond from forming is called anti-icing or bond prevention. Anti-icing, which is recommended over deicing whenever possible, is accomplished by concentrating either thermal or chemical energy at the pavement surface. Because of the high cost of installing pavement heating systems and the large amounts of energy required to maintain the surface above freezing prior to the onset of precipitation, anti-icing/deicing with approved airside chemicals is generally more economical. Chemical application is in either solid (includes pre-wetted) or liquid form. Chemicals in liquid form are most effective for uniform anti-icing treatment of pavements. All deicing/anti-icing chemicals should be applied based on pavement temperature rather than air temperature (see AC 150/5220-13A, Runway Surface Condition Sensor-Specification Guide).

a. **Deicing Chemicals.** Deicing chemicals should be applied on ice 1/16 inch (1.5 mm) or less in thickness. Thicker layers of ice require an extended period of time to obtain ice-free pavement. However, solar radiation from even a cloudy sky enhances melting action to such an extent that elimination of ice thicknesses greater than 1/16 inch (1.5 mm) are possible.

b. **Anti-Icing Chemicals.** The recommended chemical form for anti-icing is liquid, although solid chemicals can also be effective in this application. A dry solid chemical has the disadvantage that if applied to a cold dry surface it may not adhere and therefore, may be windblown or scattered by aircraft movements. However, certain physical properties of a solid, such as its bulk density, particle shape, etc., may reduce these tendencies. Regardless, wetting a dry anti-icing chemical, either during distribution or before or after loading into the application vehicle, improves the ability to achieve uniform distribution and improved adhesion.

25. **CHEMICALS.** Any water-soluble substance will lower the freezing point of water and thus, promote the melting of ice. Theoretically, the lower the molecular weight and the more individual particles (ions) the substance disassociates into, the more effective the product is as an ice control chemical, assuming its solubility still remains high at the freezing temperature. For the purpose of shared information, airport operators should inform the airlines before introducing a new chemical on the airside.

a. **Approved Airside Chemicals.** The FAA either establishes approval specifications or, upon recognition, references the specifications of professional associations such as, the Society of Automotive Engineers (SAE) through Aerospace Material Specifications (AMS) and the United States military (MIL-SPEC). The approved airside chemicals for nonaircraft applications are two fluids and those solid compounds meeting either the generic SAE specification or the specific SAE, MIL specification. These specifications require vendors to provide the airport operator a material safety data sheet (MSDS) and certification that the chemical conforms to the applicable specification. With the increased accountability placed on airport operators to manage deicing/anti-icing chemical runoff, they should request vendors to provide certain environmental data. These data consists of pollutants that the Environmental Protection Agency and the State Department of Natural Resources require of the airport operator in their discharge reporting. Typical information includes: percent product biodegradability, biological oxygen demand (BOD_5), chemical oxygen demand (COD), pH, presence of toxic or hazardous components, if any, and remaining inert elements after application. Related to the environment, MSDSs provide measures on how to secure large product spills and a 24-hour 800 emergency phone number. While these fluid and solid specifications cover technical requirements for deicing/anti-icing compounds, they do not address the compatibility issue of combining products during operations. Airport operators should query manufacturers about the safe and proper use of concurrently applying multiple deicers/anti-icers. The FAA approved airside chemical specifications are as follows:

(1) **Fluids.**

(i) **Glycol-base Fluids.** The approved specifications are SAE AMS 1426B, Fluid, Deicing/Anti-icing-Runways and Taxiways, and MIL-D-83411A, Deicer/Anti-icer Fluid (for Runways and Taxiways). Composition of proprietary solutions meeting these specifications varies with the manufacturer, though the glycol-base content is approximately 50 percent. Application rates range from 1-2 gal/1000 ft^2 for deicing and from 0.2-0.5 gal/1000 ft^2 for anti-icing. While the specifications only require a eutectic temperature of -10°F (-23°C) or less, proprietary products are available with eutectic temperatures as low as -75°F (-59°C). Ethylene glycol, $(CH_2)(OH)(CH_2)(OH)$, has a eutectic temperature of approximately -58°F (-50°C) for an aqueous solution of 58-78 weight percent of ethylene glycol and a freezing point of approximately 8.6°F (-13°C) for the pure fluid. Propylene glycol, $(CH_2)(OH)(CH)(OH)(CH_3)$, has a eutectic temperature of approximately -75°F (-59°C) for an aqueous solution of 60 weight percent of propylene glycol. Propylene glycol in its pure form does not have a freezing point per se, but sets to glass below -60°F (-51°C).

(ii) **Potassium Acetate-base Fluids.** The approved specification is SAE AMS 1432, Fluid, Deicing/Anti-icing - Runways and Taxiways, Potassium Acetate Base. Application rates range from 1-2 gal/1000 ft^2 for deicing and from 0.3-0.5 gal/1000 ft^2 for anti-icing. While the specification requires a eutectic temperature of -10°F (-23°C) or less, proprietary products are available with eutectic temperatures as low as -76° F (-60° C).

(2) **Solid Compound Deicer/Anti-icer.**

(i) **Generic Specification.** The approved specification is SAE AMS 1431A, Compound, Solid Runway and Taxiway Deicing/Anti-icing. Approved solid compounds include airside urea, calcium magnesium acetate (CMA), and sodium formate. The specification requires a phase diagram relating product dilution to freeze point. The delivered product is effective within +7° F (+4° C) of the preproduction temperature value established by the manufacturer. Application rates for a specific product are based on manufacturer recommendations.

(ii) **Airside Urea (also called carbamide).** The approved specifications are SAE AMS 1431A, Compound, Solid Runway and Taxiway Deicing/Anti-icing and MIL SPEC DOD-U-10866D, Urea-Technical. Agricultural grade urea that meets any of these specifications, termed airside urea, is acceptable. Production of this nontoxic solid white chemical, chemical formula $(NH_2)_2CO$, is in either powder or "shotted" ("prilled") form. The latter form's shape is small spheres of about 1/16 inch (1.5 mm) diameter. Both forms are primarily for deicing where powdered urea is frequently mixed with sand. Hot mixtures of powder or "shotted" urea and sand serve two purposes: (1) immediate increase in braking action and; (2) retention of chemical over the pavement area until it initially dissolves some of the ice and then melts the remainder. The urea deicing function is practical only at temperatures above approximately 15° F (-10° C) because of the decreasing

Application Rate of Urea (lb/ft^2) [kg/m^2]

Ice Thickness	Temperature Degrees F (°C)		
inch (cm)	30° (-1.1°)	25° (-3.9°)	20° (-6.7°)
less than 1/32 (.08)	.016 (.078)	.023 (0.11)	.06 (0.29)
1/32 (.08) up to but not including 1/8 (.32)	.03 (0.15)	.06 (0.29)	.125 (0.61)
1/8 - 1/4 (.32-.64)	.125 (0.61)	.175 (0.86)	.275 (1.34)

melting rates below this temperature value. The decreasing melting rate is a result of urea's eutectic temperature, defined in paragraph 2(f), which is approximately 11.3° F (-11.5° C). However, the presence of solar radiation assists urea in the melting action. Pavement surface temperature and ice thickness determine the urea application rate.

b. **Landside Chemicals.** The most effective landside chemicals used for deicing/anti-icing based on both cost and freezing point depression are from the chloride family, e.g., sodium chloride (rock salt), calcium chloride, and lithium chloride. Unfortunately, these chemicals are known to be corrosive to aircraft and therefore are prohibited from use on aircraft operational areas. Although classified as salts, CMA, sodium formate, and potassium acetate are approved for airside use because they comply with an SAE specification. When any corrosive chemical is used, precautions should be taken to ensure that vehicles do not track these products onto the aircraft operational areas.

26. ENVIRONMENTAL ASPECTS OF DEICING CHEMICALS. All freezing point depressants may cause scaling of portland cement concrete (PCC) by physical action related to the chemical concentration gradient in the pavement. Deleterious effects on PCC can be reduced by ensuring sufficient cover over reinforcing steel (minimum of 2 inches (5 cm)), using air-entraining additives, and avoiding applications of chemicals for a year after placement. Concrete meeting the compressive strength outlined in ASTM C 672, Scale Resistance of Concrete Surfaces Exposed to Deicing Chemicals, will perform well when subjected to chemical deicers. No surface degradation of asphalt concrete has been observed due to approved chemicals. Deicing/anti-icing chemicals commonly used on airfields, e.g., airside urea, CMA, sodium formate, glycols, and potassium acetate, rapidly biodegrade in the environment although biological oxygen demand for some products may be high under certain cases. Low temperatures and dilution from heavy runoff during periods of use tend to minimize this. Urea decomposes to ammonia which may be quickly dissipated.

27. RUNWAY FRICTION IMPROVEMENT. Since snow and ice degrade the coefficient of friction between rubber tires and pavement and could pose an unsafe condition for aircraft, it is important to clear to bare pavement whenever possible. There are situations where complete removal is difficult or impossible to achieve within a required span of time; at temperatures approaching the eutectic temperature of a deicing chemical, for instance, it may require an hour or more for the chemical to go into solution and melt the ice. There are two techniques for modifying the frictional coefficient of a pavement covered with ice or compacted snow, one by building in a texture on the surface and the other by surface treatment of the ice or snow. It should be emphasized, however, that an abrasive is not a deicing chemical and will not remove ice or compacted snow--in fact, heavy applications of abrasives can insulate the ice and prolong its presence.

a. **Pavement Surface Modification.** Surface texture and surface treatment modifications by themselves will not increase the coefficient of friction of ice formed on the surface but both will enhance the response of chemical treatment.

(1) **Pavement Grooving.** Grooves cut into the pavement will trap deicing chemical, reduce loss, and prolong its action. Grooves also assist in draining melt water and avoiding its refreezing. There is empirical evidence that grooves and porous friction courses modify the thermal characteristics of a pavement surface, probably by reducing the radiant heat loss, and delay the formation of ice. There do not appear to be any negative effects from grooved pavements.

(2) **Porous Friction Course (PFC).** PFC has generally the same benefits as grooving. Open graded asphalt concrete is less effective in improving coefficient of friction under icing conditions because the open spaces will fill with compacted snow, and to a lesser extent with ice in the case of freezing rain. Most maintenance personnel have found that chemical treatment rates may need to be increased on this type of pavement compared to dense graded asphalt concrete because of drainage of the chemical. The drainage characteristics also change as abrasives accumulate in the voids and plug them.

b. **Surface Treatment.** This is the approach taken to rapidly increase the frictional coefficient of an ice surface. Two methods are available: application of coarse granular material ("abrasives") and scarifying the ice surface with a serrated blade. A friction value measured below 27 (MU equivalent), as discussed in paragraph 13, indicates that surface treatment should be initiated.

(1) **Abrasives.** Granular material provides a roughened surface on ice and thereby improves aircraft directional control and braking performance. Use of abrasives should be controlled carefully on

turbojet movement areas to reduce engine erosion. If the granules do not embed or adhere to the ice, not only are they likely to be ingested in engines but they can be blown away by wind or scattered by traffic action and serve no useful function. This is particularly the case when ice or compacted snow is at temperatures below about 20° F (-6.7° C) since no water film exists on the surface to act as an adhesive. There are three approaches to reducing loss of abrasives: (a) they can be heated to enhance embedding into the cold surface; (b) the granules can be coated with an approved deicing chemical in the stockpile or in the distributing truck hopper; or (c) dilute deicing chemical can be sprayed on the granules or the pavement at the time of spreading. If stockpiles are kept in a heated enclosure and spread promptly after truck loading, sufficient heat may remain for embedding without the necessity for any further treatment. One method of setting the sand, though difficult to implement, is to apply heat after the sand has been spread by using weed burners or other open flame sources. Maintenance personnel should make a test on an unused pavement covered with ice or compacted snow to determine if bonding is adequate to prevent loss. When the slippery condition giving rise to the requirement for abrasives has passed, treated pavements should be swept to remove the residue to prevent engine damage. Abrasives should be used when the friction measurement, as discussed in paragraph 13, is below 27 (MU equivalent). Other factors to consider when deciding to apply abrasives are pavement and air temperatures and frequency of operations.

(2) **Ice Scarifying.** Directional control of vehicles on an ice or compacted snow surface can be improved dramatically by cutting longitudinal grooves in the ice. However, no improvement in braking effectiveness results from grooving, so this approach is only an expedient to be employed when very low temperatures prevent rapid chemical action or mechanical removal. The grooves trap abrasives or chemicals and hence contribute to improving the surface friction characteristics and melting action.

28. ABRASIVES.

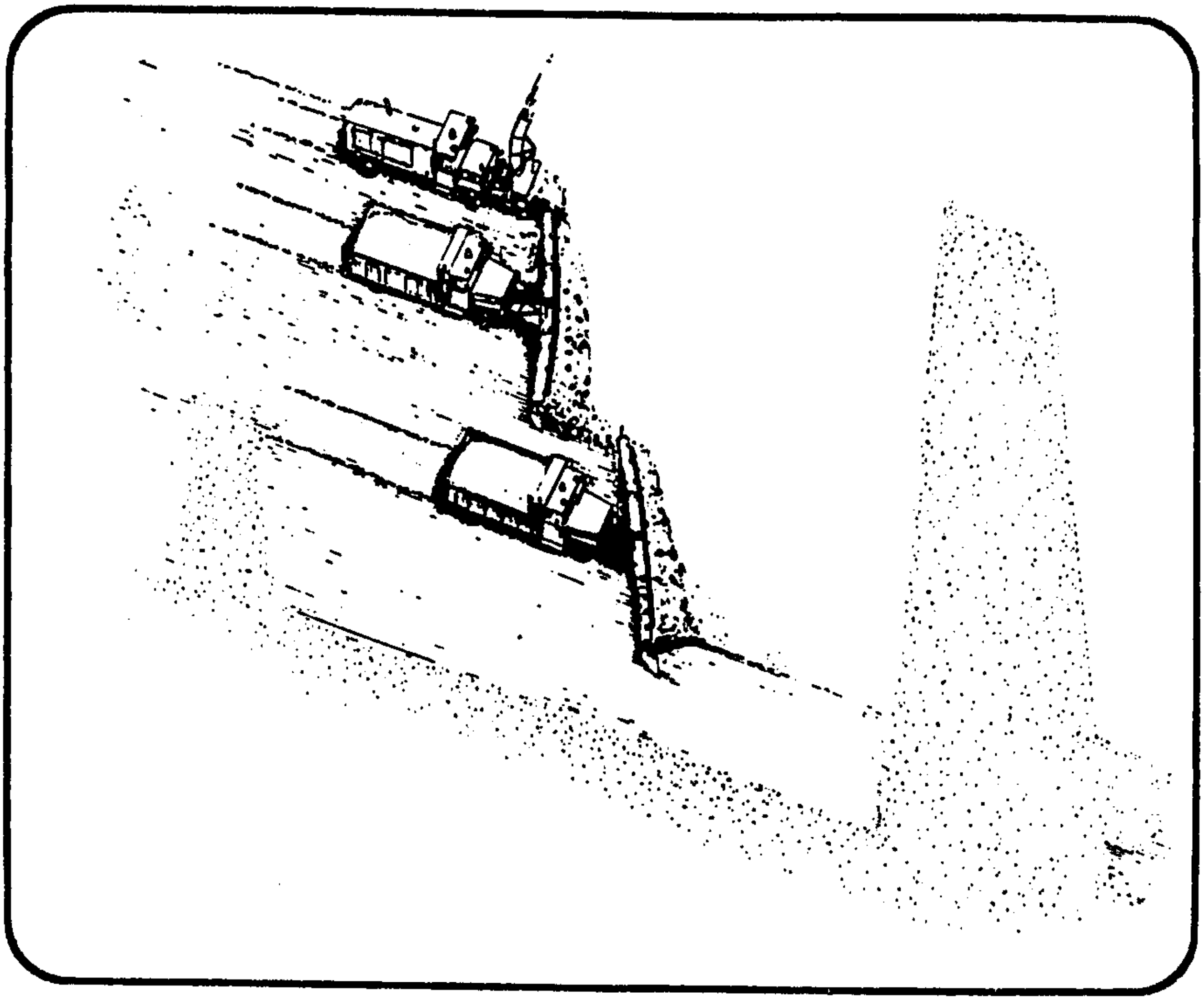
a. **Materials.** The airlines should be consulted about the material used on the runways. *The following is the standard for abrasives.* Friction improving materials applied to airport movement surfaces shall consist of washed granular particles free of stones, clay, debris, and chloride salts or other corrosive substances. The pH of the water solution containing the material shall be approximately neutral (pH 7). Material shall meet the following gradation using U.S.A. Standard Sieves conforming to ASTM E 11-81.

Sieve Designation	Percent by Weight Passing
4	100
8	97-100
16	30-60
50	0-10
80	0-2

b. **Application.** Sharp, hard silica sand provides the greatest increase in traction and remains effective the longest when compared to softer materials because of its resistance to fracturing and rounding. It is also very abrasive. Limestone is softer and may be used where available if abrasion needs to be reduced. Tests have shown that application rates of 0.1-0.2 lb/ft^2 (0.49-0.98 kg/m^2) of sand will substantially increase friction coefficient. The greater amount is required at temperatures approaching 32°F (0°C), the amount decreasing as the temperature drops.

c. **Chemically-treated Abrasives.** Granular particles are treated with approved chemicals or heated to make them adhere to ice thereby preventing loss of material. At temperatures above 15°F (-9.4°C) a solution of airside urea may be used; below this temperature glycol or potassium acetate will be more effective. Approximately 8-10 gallons (30-38 liters) of fluid chemical are required to coat one ton of sand. The most effective method of applying the chemical is to spray it on granules as they drop onto the spinner mechanism of a material spreader since wetting is more thorough than when the chemical is poured onto the stockpile or the hopper load. Below 0°F (-17.8°C), heated sand can be more effective because of more rapid adhesion of the granules to ice.

Appendicies



APPENDIX 1 - EXAMPLES OF SNOW NOTAMS

These examples illustrate snow NOTAM information relating to conditions existing on movement areas during periods of snow and ice and actions taken to maintain operational capability. See AC 150/5200-28, Notices to Airmen (NOTAMS) for Airport Operators, for greater detail.

Contractions:	Meaning:
BRAF	Braking action fair
BRAG	Braking action good
BRAN	Braking action nil
BRAP	Braking action poor
CHM	Chemicals applied on runway
CLSD	Closed
FRZN	Frozen
IR	Ice on runway
IN	Inch(es)
LGT	Light, or lighted
LSR	Loose snow on runway
MAEW	Men and equipment working
MU	A runway friction measuring ratio
OBSC	Obscured
OVR	Over
PSR	Packed snow on runway
SIR	Packed or compacted snow/ice on runway
PTCHY	Patchy
PLW	Plowed
RUF	Rough
RY	Runway
SND	Sand or sanded
SLR	Slush on runway
SNW	Snow
BERM	Snowbank contains earth/gravel (AK only)
DRFT	Snowbanks drifted by wind
SNBNK	Snowbanks, plowed
TWY	Taxiway
WSR	Wet snow on runway
###	(location identifier)

Examples:

9-27 1/2 IN PTCHY SNW PLW 75 WIDE+RY LGT E 2000 OBSC

Explanation: An airport's 8000 ft. (2.4 km) runway has been plowed its entire length but for only part of its width. It has reopened for traffic until it can be closed for further snow removal, but the plowed portion has patches of snow and the edge lights on the eastern fourth of the runway are completely obscured by snow.

9-27 1/2 IN SIR PLW 100 WIDE SND 5500/75 BRAG DC9

Explanation: The center 100 ft. (30 m) of a 150 ft. (46 m) wide runway has been plowed its entire length but only a 75 ft. (23 m) wide strip 5500 ft. (1.7 km) long has been sanded. PLW is used only if a portion of the surface has been plowed. When reporting braking action, the type of vehicle or aircraft from which the report is received should be given.

APPENDIX 2 - TYPICAL SNOW PLAN

The following snow plan provides a guide for preparation of an actural plan. The actual plan should be tailored to the unique requirements and conditions at the airport. See paragraph 16 for a list of items that should be considered for inclusion in a Snow Plan.

MUNCHO AIRPORT

SNOW AND ICE CONTROL PLAN

1. **Responsibilities and Supervision**

a. The airport manager or his designated representative is responsible for the following (include if possible who is authorized to make decisions and their phone numbers):

(1) Determining when snow removal or anti-icing operations shall begin. This will be based on the managers evaluation of existing field conditions and present and forecast weather.

(2) Maintaining a constant check of runway conditions during snow or ice storms to determine presence of snow, ice, or slush and their depth and to determine the coefficient of friction by use of our qualified friction tester.

(3) Keeping all NAVAID snow clearance areas within snow depth limits for the specific type of glide slope antenna configuration and notifying the local airway facilities (AF) sector office at 887-0500 immediately upon engaging the snow removal plan.

(4) Disseminating airport information through the Notice to Airmen (NOTAM) system by calling 887-6532 prior to commencing snow removal or ice control operations, when low friction measurement readings are recorded, when ridges or windrows of snow remain on or adjacent to movement areas, when any hazard to aircraft operations exists, or when conditions change from those reported by a previous NOTAM.

(5) Informing the airport traffic control tower at 887-8765, air carrier operations office (United 887-6565, Delta 887-6546), and other airport users (Joe at 887-1212, etc.) of the current airport surface conditions.

b. All fixed-base operators will be responsible for snow removal and ice control on their designated ramp areas.

c. All supervisors (i.e., Chief Maintenance Engineer) involved in snow removal and ice control are responsible for the efficient operation of snow and ice removal equipment. All equipment must be inspected by supervisors to ensure proper operation. Equipment should be properly sheltered to ensure complete, prompt readiness for use. A 72-hour supply of gasoline and diesel fuel must be kept on hand in the event that a prolonged storm occurs. The equipment must be inspected for damage and/or maintenance needs after each snow and ice removal event.

2. **Vehicles.**

a. All snow removal and ice control vehicles operating on aircraft movement areas must be equipped with a two-way radio or be under the direct control of a vehicle so equipped. Radios must be capable of monitoring the ground control frequency (or such other frequency assigned by the airport traffic control tower) at all times.

b. All outside contractors employed for snow and ice control operations (currently Brittany Construction) will be subject to all airport regulations. They will operate under the supervision of the airport manager or his representative and get clearance from the airport traffic control tower prior to entering movement areas. At no time will contractors be permitted to operate equipment beyond the limits of the ramp areas without being cleared by the appropriate authorities and without being accompanied by a radio-equipped vehicle. All vehicles must be equipped with the necessary lights and warning signals for night operation in accordance with AC 150/5210-5, Painting, Marking and Lighting of Vehicles Used on an Airport.

c. The following airport-owned equipment and authorized operators will be utilized for snow and ice control on movement areas:

Vehicle No.	Type	Plow	Operator	Home Phone
1	4x4 Truck	14 ft Blade	J . Doe	123-4567
2	4x2 Truck	Rotary	R. Jones	999-0001
3	(list continues)			

Another possibility is to list personnel and equipment separately so that there is more flexibility and efficiency---this is a function of airport size and organization. Reference may be made to a list of current personnel kept in specific location at airport.

d. Brittany Construction Company is the contractor for providing equipment and trained personnel for emergency snow removal operations on an as-needed basis. Equipment available from the contractor: three graders, two front-end loaders, and four 4x4 trucks equipped with 12-ft. (3.7 m) reversible plows. The contractor will furnish driver/operators and all maintenance support.

Contacts with Brittany Construction Company

Day: 222-1492
Night: 111-1895 (Sam Foreman)

Requests for contractor support must be approved by the airport manager (Jim) or his representative (operations officer).

3. **Snow Removal Operations.**

The following principles regarding snow removal shall be adhered to in maintaining safe operating conditions on airport movement areas.

Drifted or windrowed snow will be removed completely and promptly from runway, taxiway, and ramp surfaces.

In the event of heavy snow accumulation, the height of snowbanks alongside usable runway, taxiway, and ramp surfaces must be such that: (1) all aircraft propellers, engine pods, rotors and wingtips will clear each snowdrift and snowbank when the aircraft's landing gear traverses any full-strength portion of the movement area, and (2) the permissible snow heights of glide slope clearance areas are maintained.

In the event that the snow removal crew is unable to comply promptly with the requirements stated above, the airport manager or his representative will utilize the Notice to Airmen system to describe the conditions and will promptly notify the air carrier operations offices, airport control tower, and other airport users.

a. Snow removal operations are to commence when snow begins to accumulate on the movement surface. The runway will be closed for aircraft use if it has more than 1/2 inch (1.3 cm) of slush or 2 inches (5.1 cm) of dry snow.

b. The active runway, associated parallel taxiway, and taxiways connecting the active runway to the parking ramp are designated Priority 1. This will usually be the shaded areas in figure A2-1. Standard procedure will consist of:

(1) Dispatching brooms to maintain the centerline clear,

(2) Utilizing displacement plows to move the snow cast by the brooms along the edge lights, and

(3) Displacement plows will be utilized to create a windrow, and rotary plows will be utilized to cast the snow beyond the edge lights.

c. Snow removal operations will commence concurrently on the Aircraft Rescue and Firefighting (ARFF) access roads and/or emergency airport access gates, the aircraft parking ramp, and the crosswind runway and its associated taxiways as shaded in figure 1. While work is progressing on these areas, the condition of the active runway will be monitored by the crew chief. If continuing snowfall requires replowing, work in all other areas will be suspended and all necessary equipment diverted to maintaining the active runway.

d. Maximum allowable snowbank height is defined in the graphic on the next page (Figure A2-2) and should be checked frequently by the crew chief. Snowbank heights should be lower than this if possible.

e. Signs and lights should be frequently checked by the crew chief for visibility and should be cleared as appropriate.

f. Snow removal operations on the airport access roads, auto parking lots, and service areas will receive lowest priority. The equipment dedicated to their maintenance will be used, but they will be plowed only after drivers are available. Because of the importance of the safe movement of passengers and visitors on the airport properties, access roads, parking areas, and sidewalks should be properly plowed and deiced. This requires different pieces of equipment and different chemicals than used on aircraft movement surfaces and will normally be the responsibility of facilities maintenance crews.

g. The glide slope snow clearance area for the "capture-effect" antenna configuration should be evaluated by the crew chief and cleared as shown on figure A2-3. Contact should be made with the airway facilities manager or his designee at 887-6532 and the air traffic control tower at 887-8765 before moving equipment into the ground plane area.

4. **Ice Control.** Icing conditions occur most frequently at air temperatures between 28 and 34°F (-2 and 1°C), though there have been instances as low as 5°F (-15°C) and as high as 40°F (4.4°C). Frequent contact should be made by operations staff with the National Weather Service or the contract weather service when the air temperature falls in the most probable icing range. Runway sensors which are monitored by operations division employees are important tools in determining when icing conditions may occur.

a. **Runways, Taxiways and Ramps.** It is the policy of this airport to apply X-7V liquid deicing chemical meeting SAE specification AMS 1426B to all priority 1 movement areas as soon as the pavement surfaces become wet and the temperature is close to 32°F (0°C) as an anti-icing treatment. In the event that ice forms on movement areas, the standard procedure will be to apply prilled (solid) urea at the rate of 0.1 lb/ft^2 (.49 kg/m^2) when the temperature is above 20°F (-6.7°C) and sand wetted with X-7V at temperatures below this. <u>Absolutely no chloride salts or other corrosive chemicals are to be used on aircraft movement areas.</u>

b. **Access Roads and Parking Areas.** Sodium chloride and calcium chloride are permissible on automobile roadways. Sand used in these areas may be treated with these chemicals to assist in adhering to the ice and to prevent stockpiles from freezing. Bridges must receive special attention since icing frequently occurs on those surfaces prior to the adjoining pavement because of cooling from underneath.

5. **Cleanup.** All snow windrows must be removed as soon as possible after a storm ends. Sand will be removed from runways as soon as the surface is dry and braking action has been restored. The crew chief and/or operations staff will ensure that this is done. The airfield should be checked for broken or damaged lights and signs and repairs should be made.

NOTE: It is useful to append lists of personnel with their phone numbers, maps showing routing of equipment teams, radio frequencies or channels assigned to snow and ice control equipment, and other special local conditions affecting operations.

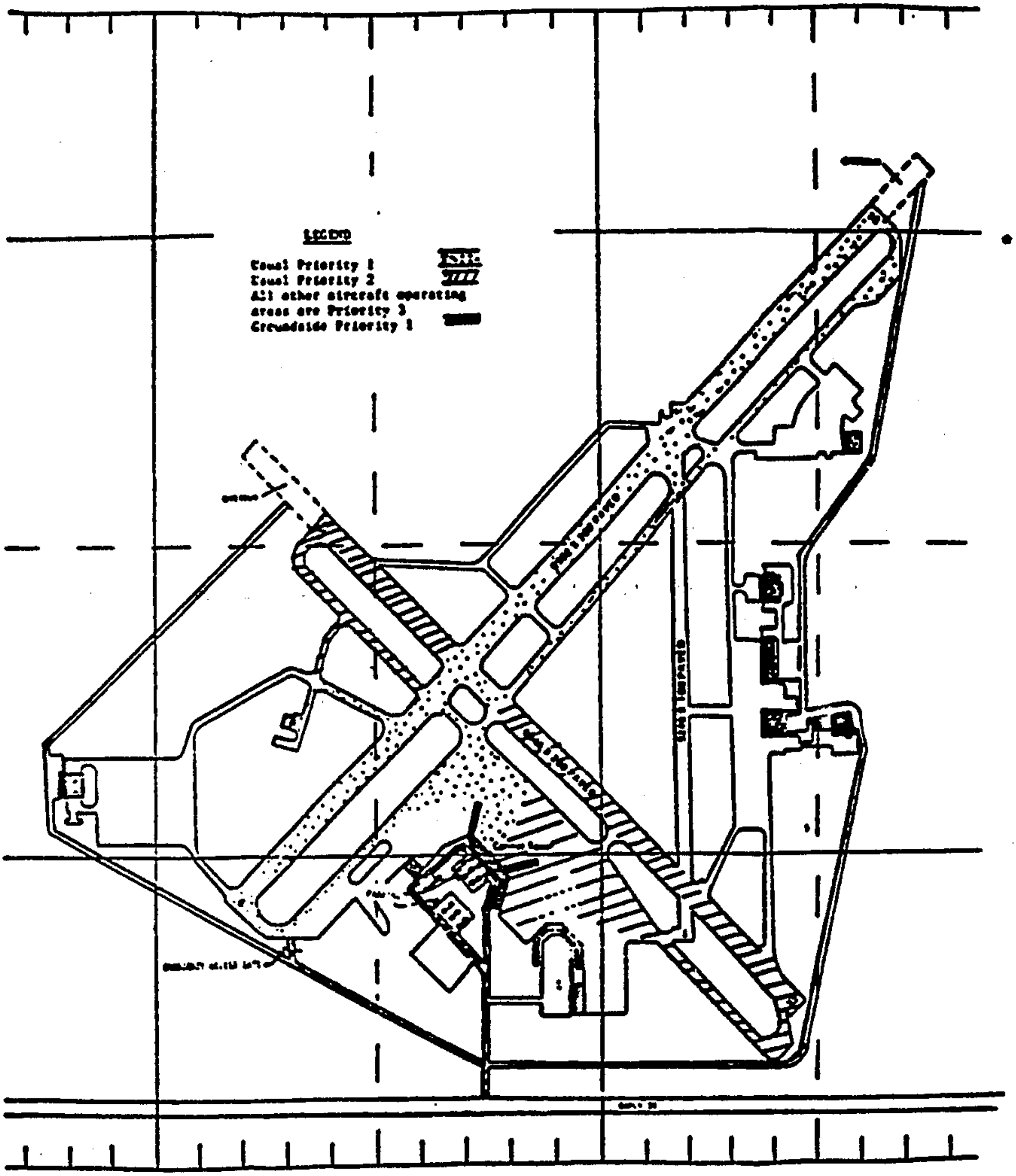
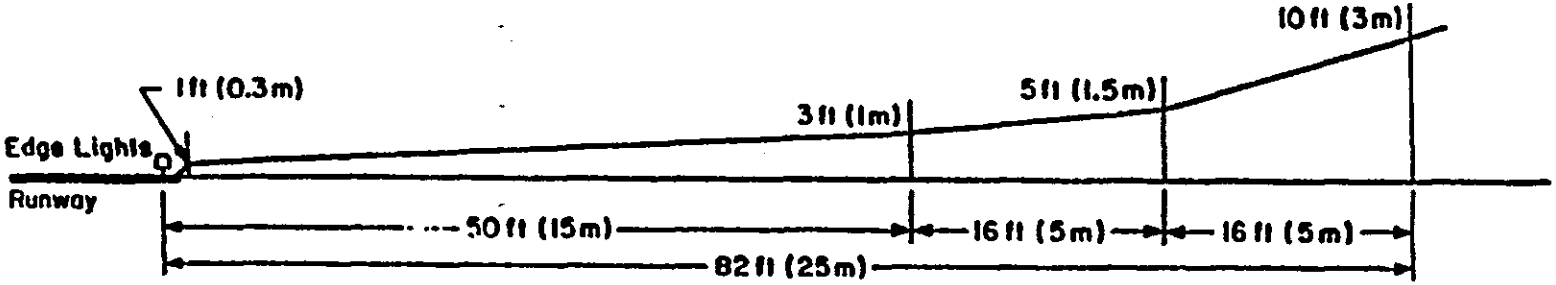
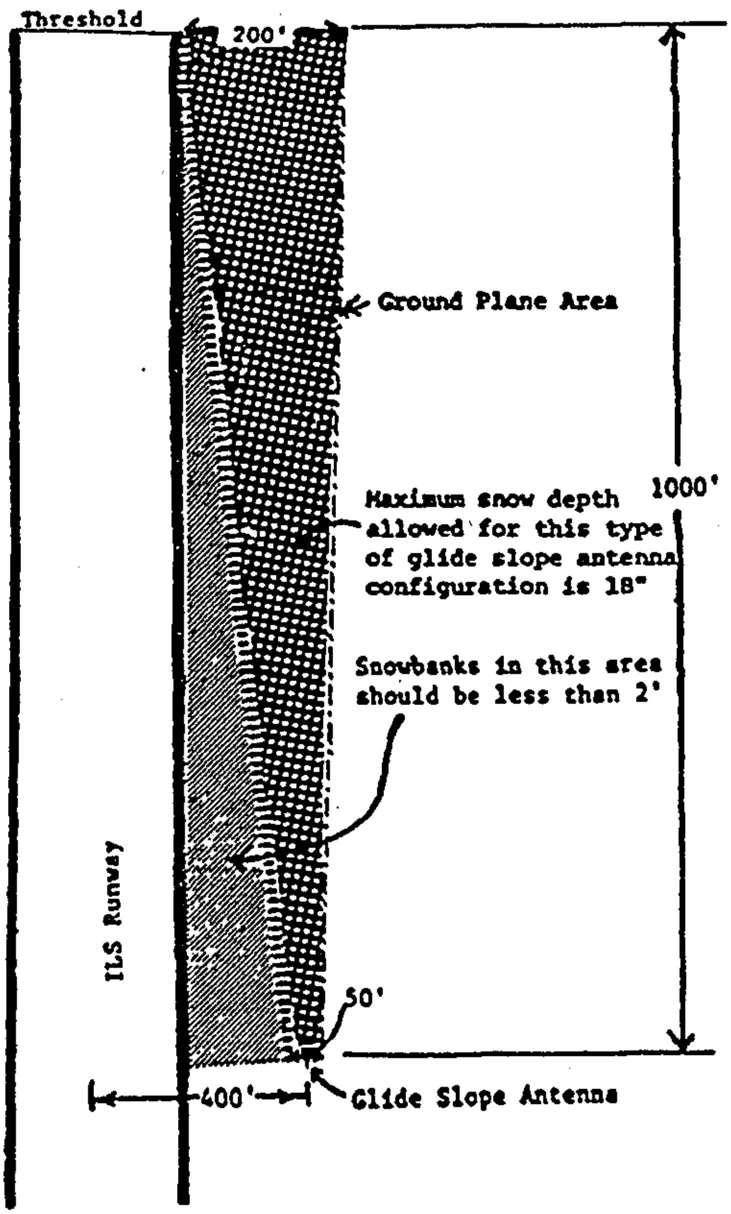


Figure A2-1 Priority Areas for Snow Control at Muncho Airport



NOTE: Figure A2-3 may take precedence near a glide slope antenna. Other glide slope antenna configurations exist that restrict the height of snow even more than this example.

Figure A2-2 Snowbank Profiles Allowed Along Runways and Taxiways



NOTE 1. A Sideband Reference GS requires less than 6 inches in the GS snow clearance area.

NOTE 2. Snowbank heights defined in figure A2-2 must also be met.

Figure A2-3 Snow Critical Areas to be Kept Clear of Snow Accumulation

APPENDIX 3 - SNOW AND ICE CONTROL AS A MATERIALS HANDLING PROBLEM

1. **Introduction.** Snow and ice have many unique properties which distinguish them from other materials commonly handled by mechanized mobile equipment. Earthmoving equipment, for example, is generally not well-adapted to handling snow because the properties of snow are so different from earth and other minerals for which this equipment was designed. Typical of these properties is its unique density, hardness, thermal instability, cohesiveness, and metamorphism (age hardening) of snow under varying winter conditions.

2. **Snow.** Snow is a porous, permeable aggregate of ice grains which can be predominantly single crystals or a close grouping of several crystals. The pores of cold, dry snow are filled with air and water vapor. In wet snow the grains are coated with liquid water.

a. **Density.** This is the mass per unit volume, a measure of how much material there is in a given volume. Values range from very low 3 lb/ft^3 (50 kg/m^3) for low density, new snow) to about 37 lb/ft^3 (600 kg/m^3). Old snow which has not been compacted by vehicles or other loads normally will not exceed a density of 25 lb/ft^3 (400 kg/m^3). When density exceeds 50 lbs/ft^3 (800 kg/m^3), the air passages become discontinuous and the material becomes impermeable; by convention, it is called ice. Uncompacted snow has little bearing capacity, so wheels readily sink into it and encounter rolling resistance. Snow increases in density either by deformation such as trafficking or by a natural aging process (see paragraph e below). Density is measured by weighing a sample of known volume. Though earth will compact to some extent, its density on handling will increase only a few percent. In contrast, snow will easily increase in density over 80 percent during plowing or trafficking.

b. **Hardness.** Hardness or strength depends on the grain structure and temperature. Grain structure, in turn, is dependent on the density of the snow and the degree of bonding between adjacent grains. Snow when it first falls is cohesionless, i.e., individual grains do not stick to one another, but bonds quickly form and grow at grain contacts. As the temperature of the snow approaches the melting point, 32°F (0°C), liquid water begins to coat the snow grains and though density remains the same, the strength will decrease. Conversely, the strength or hardness will increase as temperature drops. Hard snow is difficult to penetrate with a bucket or a blade plow or to disaggregate with a rotary plow. Typical values for unconfined compressive strength of well-bonded snow range from less than 1 lbf/in^2 (6.89 kPa) for new snow with density of 6.2 lb/ft^3 (100 kg/m^3) to 30 lb/in^2 (207 kPa) for well-bonded snow with density of 25 lb/ft^3 (400 kg/m^3). Hardness is sometimes determined by measuring the resistance to penetration. However, since a very good correlation exists between compressive strength and density for cold snow, determination of the density may suffice to indicate the snow hardness. In contrast, the strength of dry, frozen ground is little different from thawed ground. It is only when soil contains water that the strength increases upon freezing; and depending upon the ice content, it will be much like hard, compacted snow or ice in its strength.

c. **Thermal Instability.** Snow exists at temperatures relatively close to its melting point. Most snow properties are dependent on the temperature. Strength, for example, will decrease rapidly when temperature approaches 32°F (0°C) and will increase, though at a slower rate, as temperature is lowered. The thermal instability of snow is particularly important in the case of metamorphism (see paragraph e. below).

d. **Cohesiveness.** Individual snow grains will bond to one another to form a consolidated mass. Although cold, dry snow when initially deposited will lack cohesion, the age hardening process will quickly lead to bond formation and increasing cohesion (see next paragraph). Fine particles of snow produced by a rotary snowplow will adhere to each other on contact and tend to clog cutting and blowing equipment.

e. **Metamorphism.** Metamorphism is also called age hardening. The structure of a snow mass is continually changing by migration of water vapor from small to large grains. The number and extent of grain bonds increases with time even in an uncompacted mass, and, as a consequence, the density and, hence, the strength increases. The rate of change is increased when a natural snow cover is disturbed by wind drifting or by mechanical agitation such as plowing; in either case, the snow is broken into smaller fragments, increasing the surface area and the potential for a greater number of grain contacts. The increase in strength or hardness can be very rapid following plowing, particularly after blowing with a rotary snowplow. Only 2 or 3 hours after plowing, snow may require three times the amount of work to reprocess it. For this reason, it is advisable to clear snow to its final location as promptly as possible in order to minimize the amount of work involved.

3. Ice. Ordinary ice is a solid form of water consisting of a characteristic hexagonal symmetry of the water molecules. Its strength and slipperiness distinguish it from snow both in the action of rubber tires trafficking an icecovered pavement and in the effort involved in its removal.

a. **Methods of Formation.** There are four common methods by which ice will form on a surface: (1) radiation cooling, (2) freezing of cold rain, (3) freeze-thaw of compacted snow, and (4) freezing of ponded or melt water.

(1) **Radiation Cooling.** Any body will radiate energy to another body having a lower temperature. Pavement exposed to the night sky will radiate energy to that nearly perfect blackbody, and if the heat is not replaced as rapidly as it is lost, cooling will result. Pavement temperature can drop below freezing even when the air temperature is above freezing. Water vapor in the air deposits on the cold surface and freezes, the rate and quantity depending on the amount of moisture in the air and the rate at which the heats of condensation and fusion of the water vapor are dissipated. The ice forms in discrete particles and may not cover the pavement completely. Bonding is generally not very strong since particle contact area is small even when the pavement is completely covered, and therefore removal is not difficult. A term applied to this type of ice is surface hoar, or more commonly "hoarfrost". On occasion dew will form, then freeze; because of its greater area of contact, bonding will be very strong. Since the layer of ice so formed will be very thin and nearly invisible, it is sometimes called "black ice". Clouds or fog will usually prevent cooling of pavement by outgoing radiation.

(2) **Freezing of Cold Rain.** Freezing rain is one of the most common methods of ice formation and one of the most difficult to remove. If the pavement is at or below 32°F (0°C), rain falling on it may freeze, depending on a number of factors. Conditions favoring formation of so-called glare ice or glaze, a homogeneous clear ice cover, are a slow rate of freezing, large droplet size, high precipitation rate, and no more than a slight degree of supercooling. The rain has an opportunity to flow over the surface before freezing, forming a smooth, tightly bonded cover. Glaze usually forms at air temperatures between 27 and 32°F (-3 to 0°C), though some cases have been reported as low as -5°F (-20°C) or as high as 37°F (3°C). Because of its intimate contact with the pavement, glaze ice is difficult to remove by mechanical means.

(3) **Freeze-thaw of Compacted snow.** At low temperatures compaction of cold dry snow by passage of wheels will not cause a strong bond to develop between snow and pavement. However, if the snow has a high water content or some melting takes place and the temperature subsequently drops, a bond as strong as that of glaze ice can develop.

(4) **Freezing of Ponded or Melt Water.** These are commonly called icings (or "glaciers" in some regions). Though the term was originally limited to ice formed from groundwater flowing onto a pavement, by extension it applies to water from any source other than directly from rain. Thus, melt water resulting from poor drainage or water impounded by snow windrows can cause icings. This type of ice is usually well bonded to the pavement and, in addition, its thickness may exceed that of the other types described above. This is the easiest kind of ice to avoid; proper maintenance practices will prevent accumulation of water leading to icings.

b. **Adhesion to Surfaces.** The bond between ice and pavement when it is well developed will exceed the tensile strength of ice; and, therefore, when mechanical removal is attempted, failure will occur either within the ice or in the pavement itself.

c. **Density.** Bubble-free ice has a density of 57 lb/ft^3 (917 kg/m^3), though by convention compacted snow which has become impermeable (there are no connected air passages) is called ice. This occurs at a density of about 50 lb/ft^3 (800 kg/m^3). Ice arising from compacted snow will not ordinarily densify beyond this value.

d. **Strength.** Ultimate strengths of ice at 23°F (-5°C) are as follows:

Tension	15 kgf/cm^2	210 lbf/in^2
Compression	35	500
Shear	7	100
Flexure (bending)	17	240

Ice in the vicinity of the melting point has even lower flexural rigidity and, therefore, will not be fractured when a tire rolls over an ice-covered pavement. Ice becomes brittle with increasing rigidity at low temperatures (below 20°F (-6.7°C)). The bond strength also increases as the temperature decreases.

4. **Slush.** Wet snow has liquid water coating the grains. Wet snow is easily deformed since the grains are lubricated and slide easily past one another. If the deposit is freely drained, no excess water beyond that wetting the surface of each grain will be present. If, however, the snow lies on an impermeable surface such as a pavement, water may not drain freely from it. When the amount of excess water reaches about 15 percent (i.e., the amount in excess of the freely drained state), a viscous state is reached and the mass will splash and flow like a thick liquid. Upon impacting a surface, such as the landing gear or underside of an aircraft, the excess water will drain and the snow will compact and frequently bond to the surface. Slush on a runway is a hazard because: (1) it greatly increases drag during the take-off roll, (2) it reduces directional control to a great extent, and (3) it decreases braking effectiveness. It can be removed by use of displacement plows which are preferably fitted with rubber or polymer cutting edges (see paragraph 23).

APPENDIX 4 - FAA-APPROVED MANUFACTURERS OF FRICTION EQUIPMENT

CONTINUOUS FRICTION MEASURING EQUIPMENT

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 (H) 46 (758) 51589 Post Office Box 20079 BROMMA, SWEDEN S-161 20 (8)-29 5070 (O) **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**

DECELEROMETER FRICTION EQUIPMENT

MANUFACTURER/SALES REPRESENTATIVE
BOWMONK SALES President 50 Tiffield Road UNIT #10 Scarborough, Ontario CANADA M1V 5B7 FAX (416) 609-0827 (416) 609-0858 **BOWMONK DECELEROMETER**
TAPLEY SALES (CANADA) President 100 Palmer Circle R.R. No. 2 Bolton, Ontario CANADA L7E 5R8 FAX (416) 231-9121 (416) 880-0858 **TAPLEY DECELEROMETER**

APPENDIX 5 - PERFORMANCE STANDARDS FOR DECELEROMETERS

1. Scope. This appendix describes the procedures for establishing the reliability, performance, and consistency of decelerometers.

2. **Certification (General).** The manufacturer will certify that the electronic or mechanical decelerometers:

a. Are portable, rugged, and reliable.

b. Are capable of being fitted to vehicles qualified by the requirements given in this specification. Minimal vehicle modifications will be necessary to accommodate the mounting plates and electrical connections. Vehicles are qualified according to their size, braking and suspension system, shock absorber capabilities, and tire performance. The vehicle shall:

(1) Be either large sedans, station wagons, intermediate or full size automobiles, or utility and passenger-cargo trucks. Vehicles can be powered by either front-wheel, rear-wheel, or four-wheel drive.

(2) Be equipped with either standard disc and/or drum brakes as long as they are maintained according to the manufacturer's performance requirements. They can also qualify if they have a single sensor ABS (anti-lock braking system) installed on the rear axle.

(3) Be equipped with heavy-duty suspension and shock absorbers to minimize the rocking or pitching motion during the application of brakes. The weight should be distributed equally to the front and rear axle of the vehicle. Ballast can be added to achieve and maintain this distribution.

(4) Have tires made from the same construction, composition, and tread configuration. Inflation pressure shall be maintained according to the vehicle manufacturer's specifications. When tread wear is excessive on any one tire on the vehicle and/or exceeds 75 percent of the original tread, all four tires on the vehicle shall be replaced with new tires.

c. Shall be capable of measuring the deceleration of the vehicle from speeds greater than or equal to 15 mph (24 km/h) to an accuracy of $\pm$ 0.02 g.

d. Shall be capable of providing deceleration values upon request of the operator.

e. Shall be capable of consistently repeating friction averages throughout the friction range on all types of compacted snow and/or ice-covered runway pavement surfaces.

f. Shall not be affected by changes in vehicle velocity.

g. Shall not be affected by change in personnel or their performance in brake-applied decelerations.

h. Shall be capable of providing the vehicle operator with a readily visible deceleration reading.

i. Shall be capable of providing the deceleration values in recorded order enabling the average friction value for any length of runway to be either electronically or manually calculated.

j. Shall be capable of providing average deceleration values for touchdown, midpoint, and rollout zones of the runway and the average friction value for the entire runway tested. These averages shall be automatically calculated by the decelerometers, thus eliminating potential human error when calculated manually.

3. **Certification (electronic only).** The manufacturer will certify that the electronic decelerometer:

a. Shall be capable of storing a minimum of 21 deceleration values via the internal microprocessor memory.

b. Shall be capable of providing a hard copy printout of stored deceleration values at the end of the testing period. The printout will record a minimum of:

(1) Providing the date.

(2) Providing the time.

(3) Providing the runway designation or heading.

c. Shall be capable of providing further information, which may be recorded at the manufacturers discretion, e.g., make of decelerometer, ambient/pavement temperature, airport name and location, and operator identification.

4. **Decelerometer Calibration.** The decelerometer shall be calibrated by the manufacturer before shipping to the airport authority. The manufacturer shall provide the airport authority with a certificate of calibration, including test results of the calibration. The manufacturer shall provide a 1 year warranty for the decelerometer.

The decelerometer shall be returned to the manufacturer for servicing and recalibration every 2 years.

5. **Training.** The manufacturer shall provide the airport authority with training manuals and/or videos of all relevant data concerning friction measuring recording and reporting, including:

a. An outline of the principles involved in the operation of the decelerometer-type friction measuring device.

b. Copies of pertinent advisory circulars.

c. Procedures for reporting results of the friction tests in NOTAM format.

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