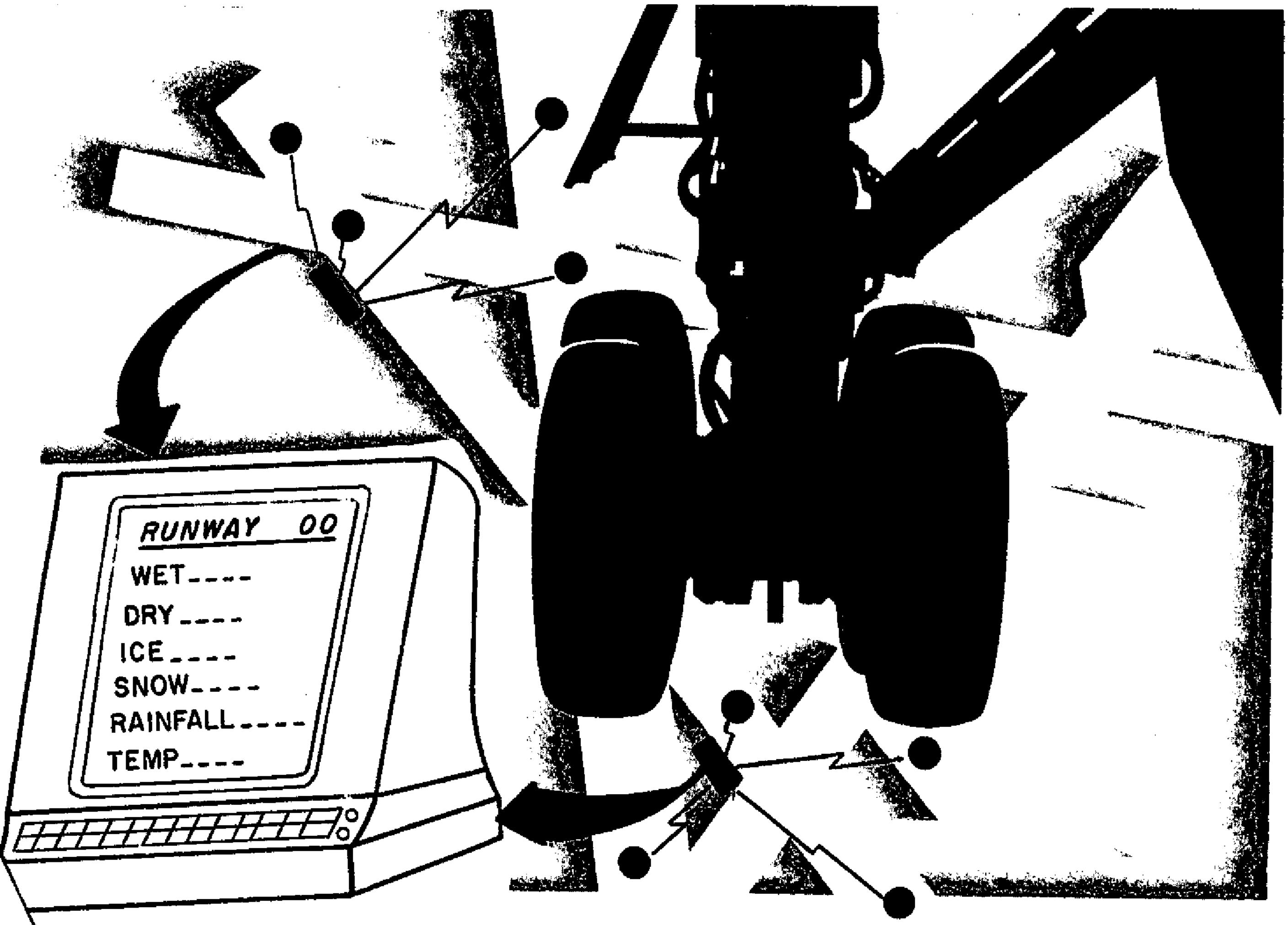
U.S. Department of Transportation
Federal Aviation Administration

Runway Surface Condition Sensor
Specification Guide

AC: 150/5220-13A
Date:

Advisory Circular



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Advisory Circular

Subject: RUNWAY SURFACE CONDITION SENSOR SPECIFICATION GUIDE

Date: 4/22/83

Initiated by: AAS-100

AC No: 150/5220-13A

Change:

1. PURPOSE. This advisory circular (AC) provides guidance on electronic systems which monitor runway surface conditions. The guidance is intended for use by airport operators, engineers and planners.

2. SAFETY INFORMATION DISSEMINATION. Runway surface condition monitoring devices have the capability of automatically providing on remote monitors current information on the condition of the runway surface at multiple locations. This capability may be used to improve the airport operator's dissemination of information about airport conditions, but the airport operator is still responsible for accessing and reporting conditions on the runway or its vicinity which may affect aircraft safety.

3. CANCELLATION. AC 150/5220-13, Runway Surface Condition Sensor Interim Specification Guide, dated 11/6/78, is cancelled.

Leonard E. Mudd

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Director, Office of Airport Standards

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CHAPTER 1. INTRODUCTION

1. OVERVIEW. Ice begins to form on pavements when the pavement surface is at the freezing temperature of the water solution on it. Remote runway surface condition sensors which will predict and detect the formation of ice on airport pavements will enhance runway safety while reducing airport equipment, manpower, and chemical costs.

The use of air temperatures exclusively to predict the occurrence of ice on a pavement is not reliable enough, primarily because the temperature differences between pavement surface and ambient air vary so greatly. Factors such as runway surface color and composition, wind patterns, surface water quantity, ice-control chemical residue, atmospheric moisture content, traffic, amount of sunlight as well as air temperature all influence ice formation.

Since ice prevention is more desirable in terms of safety, time savings and cost than ice removal, primary emphasis should be placed on predicting ice before it actually occurs. Runway sensors thus are a primary tool in developing an effective ice prevention program.

2. ICE-CONTROL TECHNIQUES. Airport maintenance personnel apply ice-control chemicals in these modes:

a. Anti-icing. Chemicals are applied prior to the formation of ice. Since no chemical is required to melt through ice and dissolve the bond between the ice and the pavement, much less chemicals are required. Ice prevention is the most effective method of airport ice control.

(1) Safety. Application of chemicals prior to ice formation prevents ice from reducing surface friction below that of a wet runway.

(2) Cost. Ice prevention requires between 30 to 75 percent less chemicals than de-icing operations.

(3) Operational Downtime. Ice prevention requires less airport operational area downtime because the chemicals are effective from the moment of application and no waiting period is required while the ice melts.

b. De-icing. Chemicals are applied after the formation of ice. Usually large amounts of chemicals are needed to lower the water's freezing point and to dissolve the bond between ice and pavement. When liquid chemicals are used, the liquid can float on top of the ice, creating a more slippery surface than prior to chemical application.

c. Spot Application. Chemicals are applied only where ice is observed or anticipated. Patchy ice formation is often caused by the varying temperatures and surface states that exist on larger airports. In general, the difficulty in detecting these patchy areas causes portions of the spots to be missed altogether or excessive amounts of material applied beyond the ice area.

CHAPTER 2. EQUIPMENT SPECIFICATION REQUIREMENTS

3. GENERAL REQUIREMENTS. Measurable changes on a pavement surface occur sequentially, with each event (such as the formation of ice) having a definite beginning or end. A system meeting the requirements of this section shall be able to detect the beginning and end of a given surface event.

4. COMPONENTS. The pavement condition detection system contains four basic functional elements: remote, flush-mounted, in-pavement sensors; power supply/signal processor field units; terminal data processing units; data display units/printers (see figure 2-1).

5. MATERIALS. Materials shall conform to the specifications described herein. When not specifically listed, materials shall be of the best quality used for the purpose in commercial practice. Materials and components shall be free from all defects and imperfections that might affect the system's function.

6. DESIGN AND CONSTRUCTION. The design of the equipment shall be in accordance with the most current engineering practices. The entire system shall be designed to minimize complexity. The equipment design and installation shall permit accessibility for use, maintenance, and servicing. All components and assemblies shall be free of protrusions, sharp edges, cracks, and the potential for electrical shock or other hazards which might cause injury to personnel or equipment. Maximum use shall be made of solid-state electronic devices and standard commercially available equipment such as display modules. The system shall be constructed so that no internal part will be exposed during normal operations. System components shall be built to withstand the climatic conditions at airports: rain, snow, frost, ice, sleet, temperature variations, hail, lightning, sand, dust, and high winds. They also must be built to withstand the strains, jars and vibrations of aircraft landings, taxiing and takeoffs.

7. PERFORMANCE SPECIFICATIONS.

a. The system shall continuously sample, in real time, runway surface conditions. In addition, it must be nondestructive to pavement, nondegrading to the environment, and nonhazardous to personnnel. When activated, the system shall continuously transmit data, with a time lag no greater than 3 minutes, to a remote display console unit. Transmitted data shall be displayed in a clear, concise and easily understandable, digital format. The system shall measure and display information about the following conditions on the runway surface:

(1) Runway surface temperature, i.e., actual temperature of pavement at sampling site in degrees C^o (Celsius) or F^o (Fahrenheit) to accuracies of $\pm$ 1/2 degree F^o.

(2) Dry pavement—no perceptible moisture;

(3) Wet pavement—visible moisture on surface;

(4) Pre-ice conditions—advance alert of incipient ice formation, i.e., pre-ice condition is indicated by the in-pavement sensor head just prior to actual formation on pavement, thereby providing advance warning time dependent on air/pavement temperature drop rate;

SYSTEM COMPONENT DESIGN

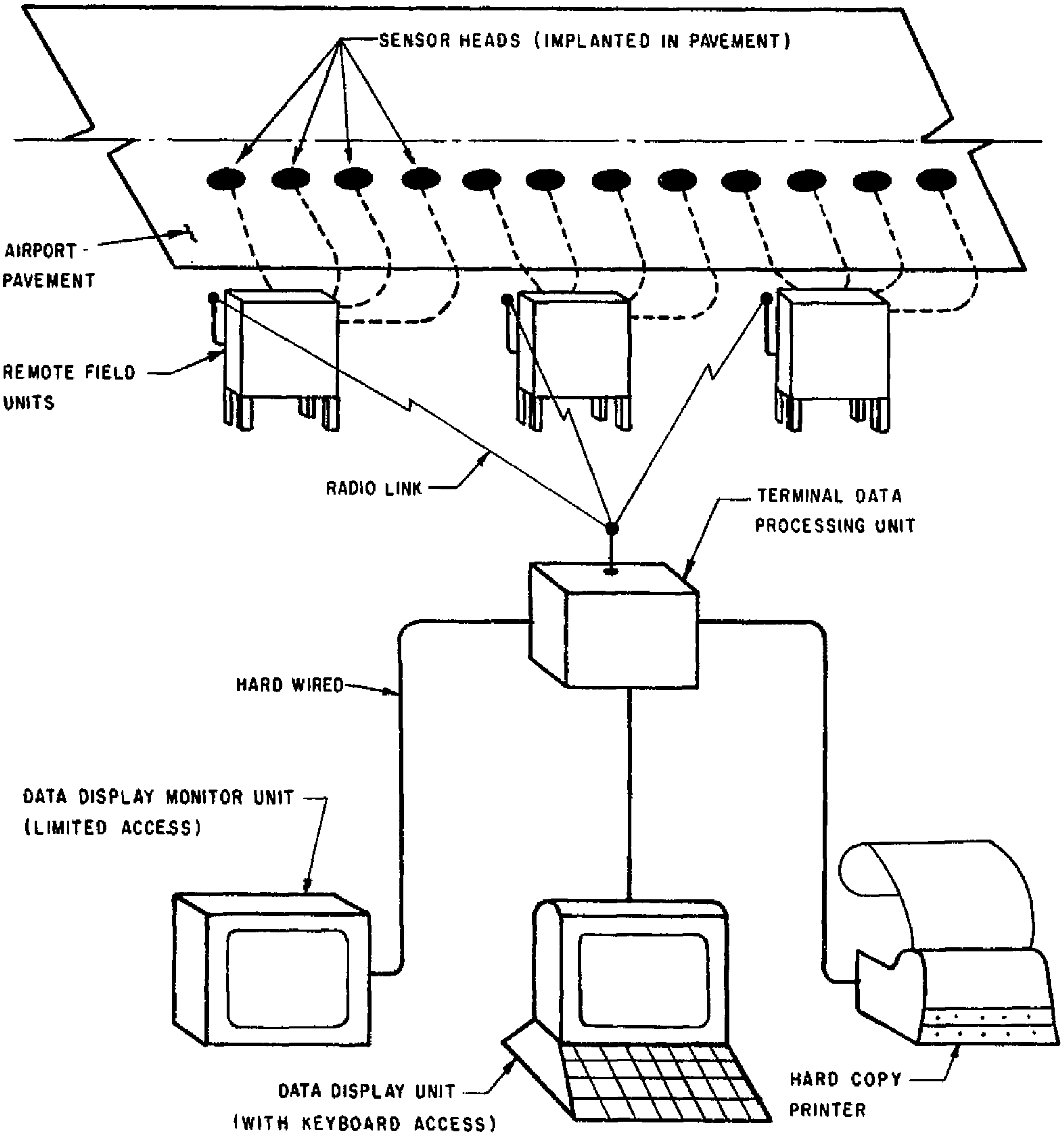

Figure 2-1. System Component Design

(5) Actual ice—visible or otherwise detectable ice on pavement; and

(6) Ambient air temperature at ground level in the vicinity of the runway.

b. The in-pavement sensor head shall be capable of transmitting the above data, in a stable mode, to the display unit by buried cable or a radio transmission link. Equipment shall operate using conventional power sources available on the airport and shall be protected against lightning. The system shall function as described above without constant servicing or adjustment.

8. PRIMARY SYSTEM COMPONENTS. This section describes requirements for each element of the system.

a. Pavement Condition Input Device. The most critical element of the system, due to the difficulty of servicing or replacing it, is the in-pavement sensor, i.e., pavement condition input device. This component is designed to be installed directly in the pavement, flush and in the plane of the pavement surface. The sensor head senses and electronically transmits primary surface information to the rest of the system for further processing. The sensor head shall conform to the following design criteria:

(1) Internal components shall be of a solid-state electronic design without relays, tubes, or other electro-mechanical devices. The head shall be factory adjusted and require no further adjustment in the field.

(2) All electronic components shall be permanently potted and sealed against shock, moisture, and vibration. The cable shall be permanently molded and sealed to the head in a leakproof design. An additional waterproof seal may be installed on the cable/head interface to ensure against moisture wicking.

(3) The head shall be a thermally neutral device, fabricated of a non-corrosive material, with a thermal conductivity closely approximating airport pavement material. It shall be color matched on a site specific basis to each pavement surface to simulate actual pavement heat emission and absorption of solar radiation.

(4) Head surface texture shall be similar to that of the pavement surface to approximate the water flow and pooling characteristics which will occur on the surrounding pavement.

(5) Head design and configuration shall require a pavement installation procedure of no greater complexity than for a standard in-pavement lighting fixture, i.e., a single core and cable-way saw cut for each sensor head.

(6) The power/data transmission cable shall be of sufficient length and capacity to extend to a signal processing site a minimum of 2000 feet (608 m) from the head.

(7) The head shall have sufficient durability to function over a range of surface or air temperatures from +175° F (+80°C) to -20°F (-29°C).

b. Power Supply/Signal Processor Units.

(1) Remote Field Unit. This component provides power to the in-pavement sensor head, processes raw surface condition input data, and transmits the processed data to the terminal data processing unit. The remote field unit shall be designed to be mounted aboveground on frangible couplings. The height of the enclosure and the distance from the runway or taxiway will be governed by factors such as opportunities to co-locate the equipment with or on existing airport navigation facilities. The unit's waterproof enclosure shall be a standard National Electrical Manufacturer's Association (NEMA) type 4 or equivalent. The recommended data transmission method to the terminal unit is by radio telemetry using standard Federal Communication Commission (FCC) approved transmitters operating in the frequency range of 170-176 MHZ. An alternate transmission method may be by use of multi-conductor buried cables.

System sensitivity and alignment or adjustment shall be controlled from this unit and shall require no special service equipment or tools. All components requiring change or adjustment shall be located to minimize servicing difficulty, with all circuit boards/cards designed for plug-in installation, removal and service. The enclosure shall be designed so that necessary service can be accomplished with minimum exposure to the critical elements of the system. The unit shall be capable of supplying power to, and processing data output from, a minimum of four in-pavement sensor heads.

(2) Terminal Data Processing Unit. This unit receives primary data from all remote field units in the system, stores and proceses all input information, and transmits this processed data to display and printer units. This unit shall have the ability to process data from up to 120 in-pavement sensor heads. This unit shall be of solid-state electronic construction and have appropriate micro-processor design for the system requirements. The system shall be designed for operation in a sheltered environment and shall provide stable operation at temperatures from 30°F (0°C) to 120°F (50°C). The unit shall have provision for additional plug-in devices to expand memory and output capabilities. The terminal processing unit shall connect with the rest of the field system by radio link, phone lines, or automatic telephone dialing.

c. Data Display Unit. This unit receives both real time input information from the terminal data processor as well as additional data manually inserted by keyboard or automatically transmitted to the display unit by other means. The unit shall display data by cathode ray tube (CRT) and/or a hard copy printer. The information displayed shall include all the data set forth in paragraph 7 as well as other data dictated by operational needs at the airport. The information format shall be flexible enough to satisfy the data display needs of the airport in a clear, easily understood format. The display unit shall be a conventional off-the-shelf design requiring no special hardware to operate or install. The display unit electronics shall be primarily solid-state. Software/hardware packages which can improve the basic capabilities of the standard system are:

(1) Graphics. Graphs of trends showing the history and probable event sequence.

(2) Information Highlight. Information of a critical nature enhanced by a color contrast on the display.

(3) Additional Information. Additional aeronautical operation information displayed separate from sensor data using a display format tailored to the operator's needs.

(4) Additional Monitor Units. These shall display information at any remote site needing the pavement surface information by connecting additional display monitors to the master data display unit. These additional monitor units shall have manual entry keyboards when needed to supplement automatic weather data entry.

(5) Acoustical Alarm. An audible alert that can be triggered by a particular condition such as the incipient formation of ice.

(6) Remote Signalling. The ability to page or telephone operations personnel.

(7) Chemical Detection. The ability to detect chemicals on the runway surface and to approximate the percentage of chemicals in runway surface water.

(8) Atmospheric Condition Detection. The ability to gather and sort atmospheric measurements of wind direction, wind speed, dew point, and relative humidity.

The system shall be designed to permit incorporation of these additional capabilities either during initial installation or at a later date.

9. REQUIRED PROTECTION AND SYSTEM STANDARDIZATION.

a. Circuit Protection Devices. The system shall be grounded, and lightning and power-surge protected, using standard protection devices.

b. Power Supply System. The system shall use standard relays, circuit devices, and other components of power supplies.

10. ANCILLARY EQUIPMENT. Depending on the system selected, equipment necessary for the operation of the system may include an FCC approved, single-frequency radio telemetry system conforming to FCC frequency limits for nonaeronautical use on airports. (See paragraph 8b(1) for frequency guidelines.)

11. ELECTRICAL POWER REQUIREMENTS. The equipment should be designed to minimize power requirements and should have the following maximum power requirement or ranges:

a. Sensor head--.5 watts.

b. Power supply (when transmitter equipped)--up to 200 watts, ± 50 watts.

c. Output monitor--700 watts, ± 100 watts.

d. Voltage requirements for complete system shall be standard 110-130 VAC at 50/60 HZ or 220-260 VAC at 50/60 HZ.

12. MANUFACTURER CERTIFICATION. The manufacturer shall submit with his/her bid, in writing, the results of tests or installations establishing compliance with the applicable specifications. In addition, the manufacturer shall supply a written warranty which guarantees that the manufacturer will correct by repair or replacement any defect in design, material, or workmanship which occurs during normal use in the first year of operation after installation, provided the installation was in accordance with Federal Aviation Administration (FAA) and manufacturers' specifications. The manufacturer shall also agree to maintain a testing/evaluation/quality control program for all the system components. Particular emphasis shall be placed on quality control and climatic/reliability testing of the in-pavement sensor head.

CHAPTER 3. NUMBER AND LOCATION OF SENSORS

13. LOCATION OF SENSORS. The typical aircraft landing transition path from flight to taxi needs to be monitored at several locations. The primary sensor head locations are:

a. Touchdown Zone. Sensors monitor conditions affecting aircraft braking and initial directional control and stability.

b. Middle Runway. Sensors monitor conditions affecting the region of maximum aircraft braking effort and the capability to turn onto taxiways.

c. Runway End or Turnoff. Sensors monitor conditions affecting low speed aircraft braking and capability to make low speed turns.

d. Taxiways and Aprons. Sensors monitor conditions affecting low speed manuvering and parking.

14. NUMBER OF SENSORS. There shall be a minimum of three sensor heads per runway. Local conditions, however, may require additional sensors. (See figure 3-1.) Typical factors which may require additional sensors for the runway, associated taxiways, and ramp areas are:

a. Color and Crown. Differences in pavement color affect the emission and absorption rates of heat and sunlight, and thus the melting rate of ice and snow. Therefore, when all other conditions are equal, light pavements (concrete) will generally freeze before darker pavements (asphalt) and hence are prime candidates for additional sensors. Areas of reduced pavement crown can result in slow water runoff, increasing the possibility of water ponding and ice formation. These sites are also prime candidates for additional sensors.

b. Temperature Differences on Pavement. Some pavement areas have colder surface temperatures than the surrounding pavements and thus form ice earlier or more persistently. The temperature variations depend on factors such as differences in subgrade, exposed runways/taxiways, bridge decking, wind direction, ground water table, culverts, and other phenomena. Areas subject to colder temperatures are good candidates for additional sensors.

15. SENSOR PLACEMENT AS FUNCTION OF COMPLEX AIRPORT CONFIGURATION. As an airport's operational pavement area increases, not only does the physical difficulty of monitoring surface conditions by manual inspection increase, but the number of sensor head locations must be increased to maintain coverage. While there is no formula for the exact number of sensors required, as a general rule the number of sensors will range from a minimum of 3 for a 3,000 foot (900 m) runway with no unusual local conditions, to 12 or more sensor heads for a 10,000 foot (3000 m) runway with difficult local conditions. Local operator experience with ice and snow control will provide valuable insight into the required number and location of sensors.

16. GEOGRAPHIC LOCATION. Ice formation is much more common than snow in geographic zones of normally temperate winter weather; thus, the need for airport ice prevention, with the aid of pavement condition detection systems, is greater in such zones than for snow removal capabilities.

Factors Affecting Sensor Location

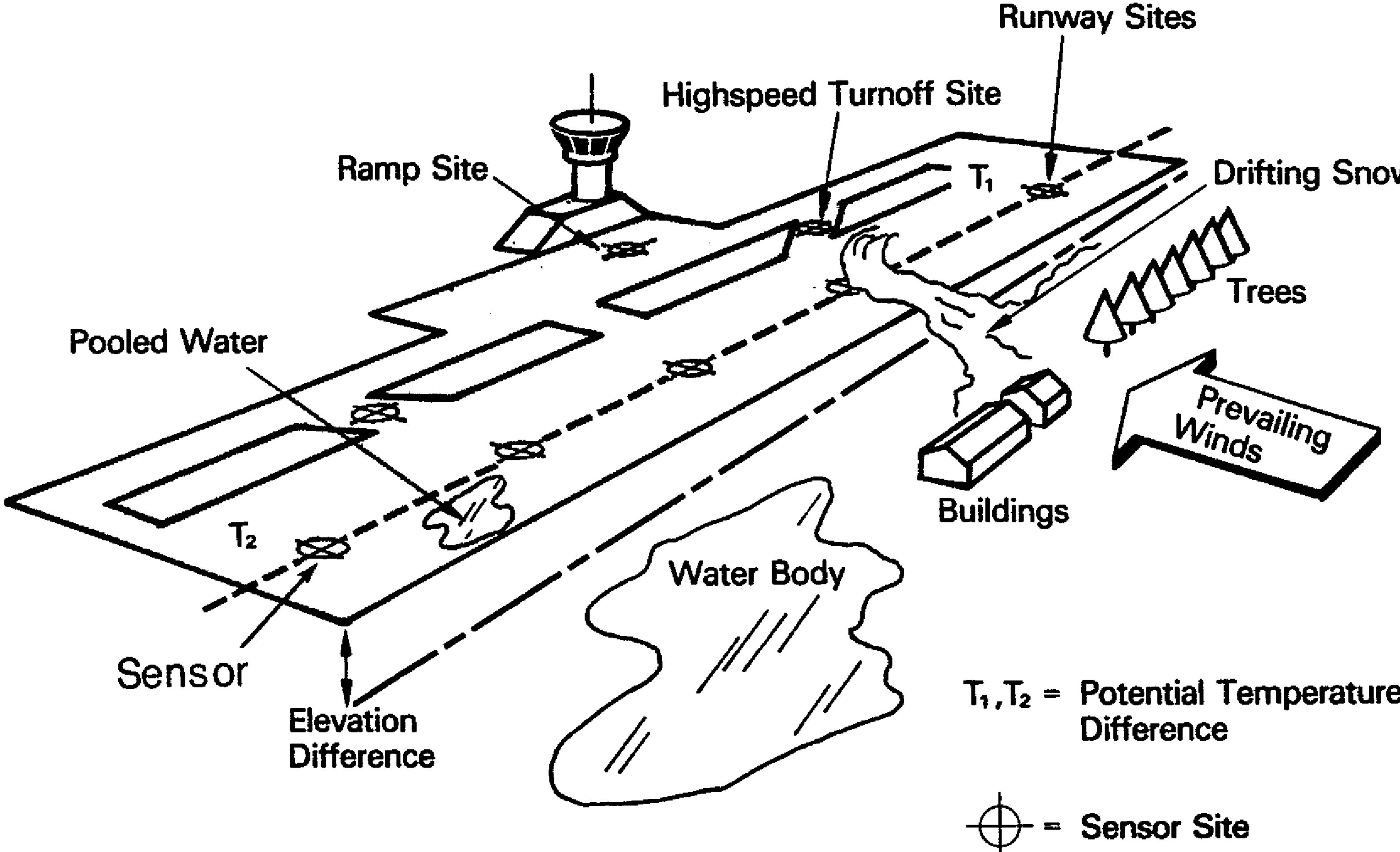

Figure 3-1. Factors Affecting Sensor Location

CHAPTER 4. INSTALLATION CRITERIA

17. GENERAL. The procedure for installing the in-pavement sensor head is the same for all pavement types. (See figure 4-1.) Specific details can be found in the manufacturers' installation specifications.

18. PAVEMENT DRILLING AND SAWING. Holes are drilled in the pavement to accommodate the sensor head. Kerfs for the cables are sawed in the pavement running from the drill hole to the pavement edge. The sides and bottom of the drill hole and cable kerf are then cleaned (sandblasting may be necessary) and flushed with a high velocity air jet or wiped dry to ensure a good bond with the sealing agent.

19. INSTALLATION OF IN-PAVEMENT SENSOR HEAD. It is essential the installer ensure correct orientation of the sensor head with respect to aircraft traffic for proper self-cleaning of the sensor head conductive probes. Sensor heads must be flush with the top surface and in the plane of the pavement surface. When filling the kerf and drill hole, the installer shall make sure that the bonding agent fills the cavity and does not exude over the sensor head. The installer shall anchor the cables in bottom of the cleaned kerf cut with wedges or similar devices before filling in the kerf with the manufacturer's recommended bonding agent.

See AC 150/5340-19, Taxiway Centerline Lighting System (paragraph 7), and AC 150/5340-4C, Installation Details for Runway Centerline and Touchdown Zone Lighting Systems (paragraph 5), current editions, for additional installation recommendations.

20. CONNECTION/INSPECTION AND TEST. Connections from in-pavement sensor heads to the remote field unit and connections from the field unit to the airport power supply shall be made in accordance with manufacturers' instructions and the FAA advisory circulars referenced in paragraph 19. The installer shall check and align the complete system during installation since in-pavement components are not accessible for corrective action after installation. A complete check for all sensor functions shall be accomplished prior to project completion. All test equipment and adjustments required at a particular site shall be supplied by the system manufacturer. All elements of the sensor electric power supply sytem, including materials, components, and designs, shall conform to national, state, local, and FAA accepted practices or codes for the installation of systems with similar electrical power requirements and placements. This requirement covers cable, cable burial, electrical tie-ins, and other equipment necessary for system operation.

SENSOR PLACEMENT

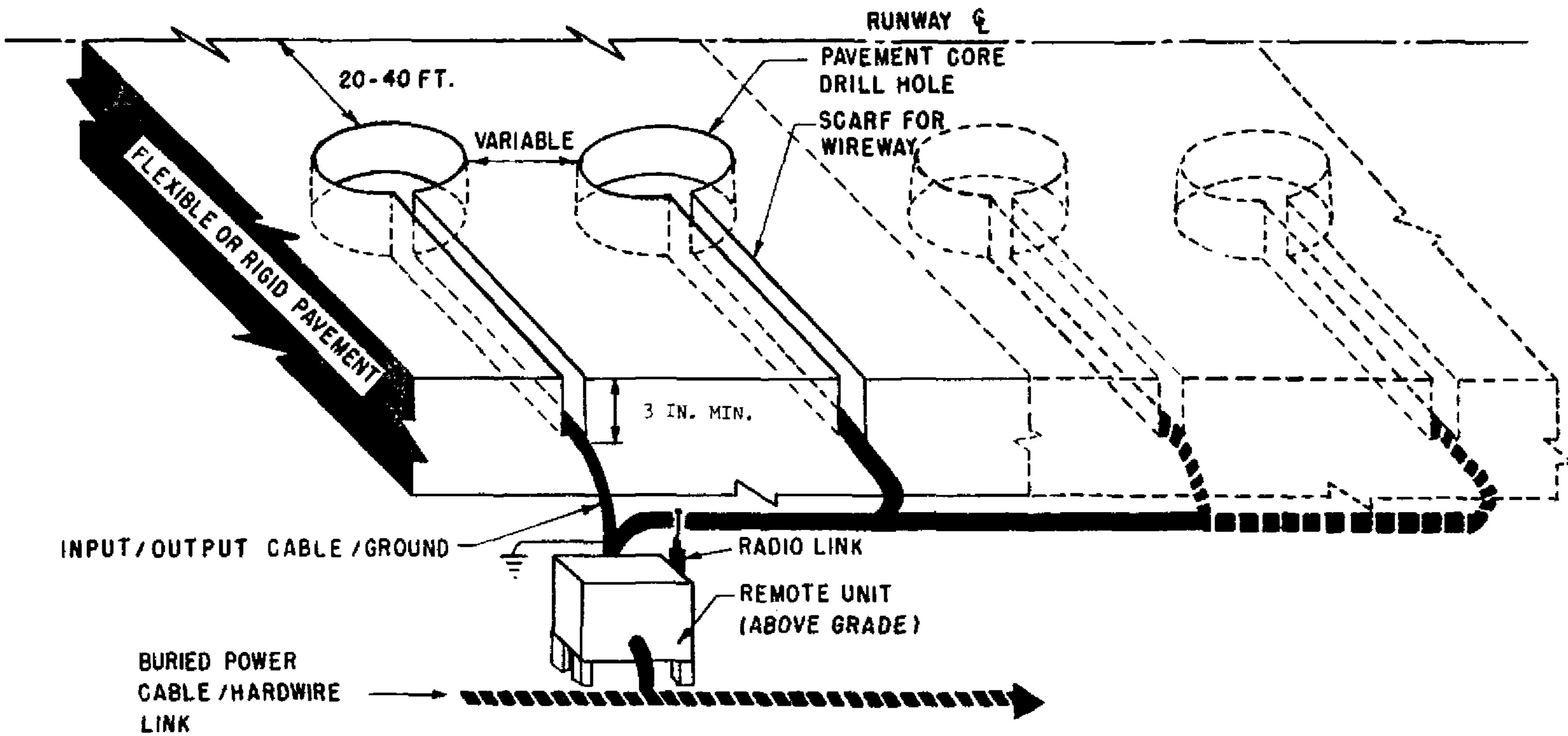

Figure 4-1. Sensor Placement

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