AEROSPACE RECOMMENDED PRACTICE

ARP5533™ **REV. B**

Issued	2005-02
Reaffirmed	2013-05
Revised	2015-09
Stabilized	2023-02

Superseding ARP5533A

Stationary Runway Weather Information System (In-Pavement)

RATIONALE

This technical report is being stabilized because it covers technology, products, or processes which are mature and not likely to change in the foreseeable future.

STABILIZED NOTICE

This document has been declared “STABILIZED” by SAE G-15 Airport Snow and Ice Control Equipment Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

For more information on this standard, visit
https://www.sae.org/standards/content/ARP5533B/

TABLE OF CONTENTS

1. SCOPE

This SAE Aerospace Recommended Practice (ARP) covers the requirements for a Stationary Runway Weather Information System (referred to as the system) to monitor the surface conditions of airfield operational areas to ensure safer ground operations of aircraft. The system provides (1) temperature and condition information of runway, taxiway, and ramp pavements and (2) atmospheric weather conditions that assist airport personnel to maintain safer and more efficient airport operations. The system can be either a wired system or a wireless system.

2. APPLICABLE DOCUMENTS

FAA Advisory Circular 150/5300-13, Airport Design

3. TECHNICAL REQUIREMENTS

3.1 General Description

The basic system shall consist of four primary components (Figure 1).

1. Sensors, in-pavement surface sensor(s), subsurface probe(s), and atmospheric sensors, to monitor pavement surface conditions and atmospheric conditions at specific locations around the airfield. These sensors shall be connected by wire or fiber optic means to a field processing unit that will, in turn, pre-process the monitored conditions.

2. Field Processing Unit to report the measured information to a central computer (CC) at a central monitoring location on the airport using wire or wireless data transmission means or a hosted service using cellular, wireless or wired communications.

3. Central Computer or hosted service to disseminate the above information to users using industry standard computer networks and protocols. The central computer/hosted service shall have the ability to support remote access to the information via standard network communications.

4. Data Display to display all sensor data.

   In-Pavement Runway Weather Information shall be displayed on a map, in tabular text and graphical formats using industry standard World Wide Web based browsers*. Some vendors may offer additional applications specific to displaying the information from the system that may include supporting mobile devices or tablets.

3.2 In-Pavement Sensors

3.2.1 Performance

The pavement sensor shall sense and electronically transmit primary surface information to the rest of the system for processing and dissemination. The sensor shall report pavement temperature, pavement status, chemical concentration, ice condition, and calculated freeze point of surface taking into account the applied deicing agent (if available). Passive sensor technology will require the field processing unit to be configured correctly for the chemical type of deicing agent that is being used.

NOTE: Some newer sensing technologies may not report a freeze point temperature but an alternative to let the user know of current surface condition.

If an active sensor is used, pavement status (wet/dry) and a freeze point of solution shall be reported.

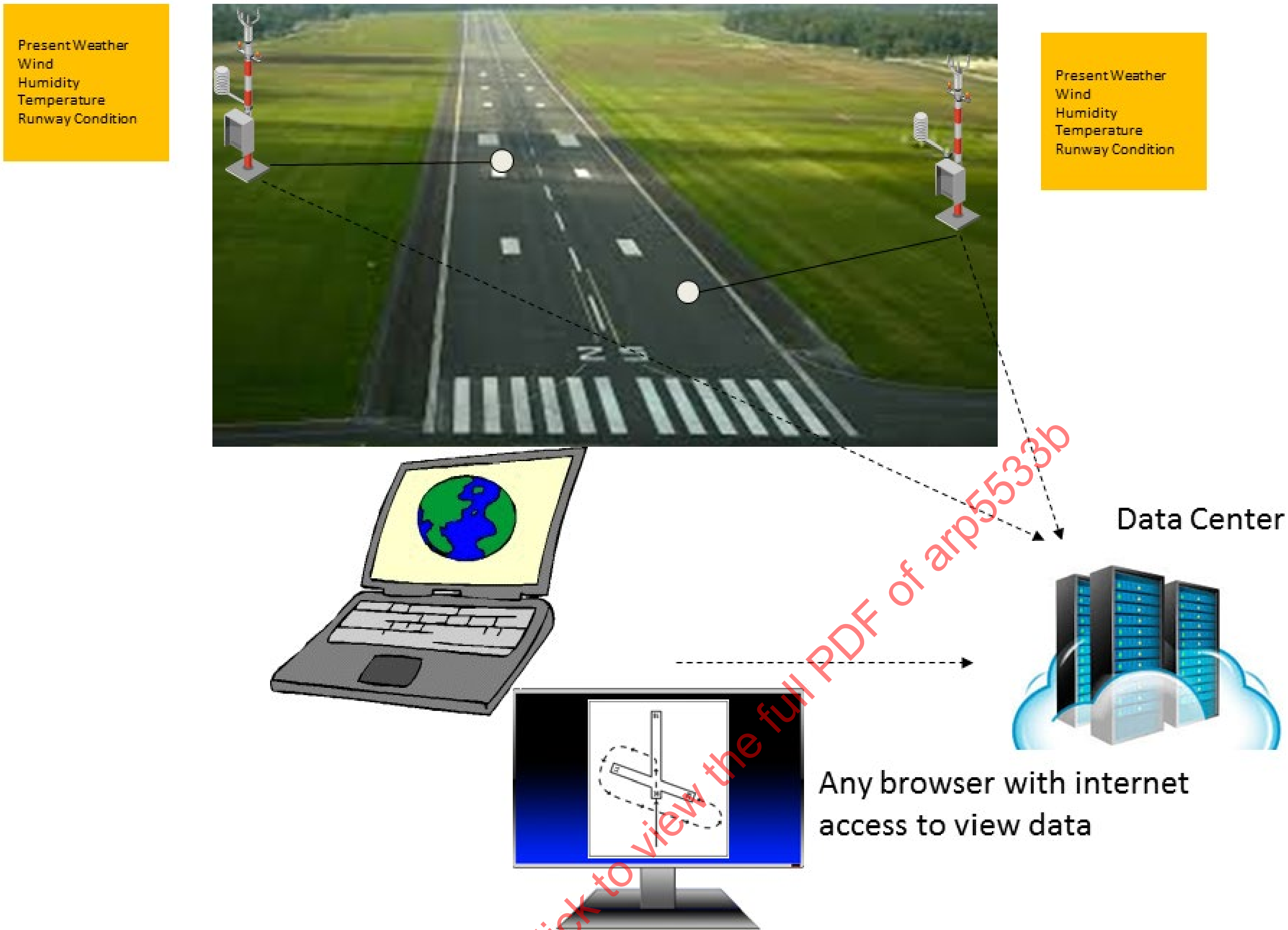

Figure 1 - System components

3.2.2 Design

Passive In-Pavement surface sensors shall be solid state in design without relays, tubes or other electromechanical devices. The pavement sensor shall be factory adjusted, and no adjustment in the pavement sensor device itself shall be required by airport users.

Active surface sensors are also available, these require additional information to be provided by the vendor to ensure reliability and any maintenance requirements that are not covered in this document.

3.2.2.1 Operating Temperature Requirements

The head of the sensor shall have sufficient durability to function over a range of pavement surface and/or air temperatures from -40 to 176 °F (-40 to 80 °C).

The sensor shall contain a temperature-sensing device to measure the temperature of the sensor surface. The temperature measurements shall have an accuracy of at least ±0.9 °F (±0.5 °C). The accuracy of the temperature measurements shall be maintained over a temperature range of -40 to 176 °F (-40 to 80 °C). Documentation confirming that the temperature measurements meet the stated temperature accuracy must be submitted with the system.

The sensor shall be of such design to permit the measurement of freeze point, chemical concentration of a water and ice control chemical solution (runway deicer) for commercially available runway deicers.

As new chemical solutions (runway deicers) come into use, the system should permit easy upgrade to measure these. Airports and end-users should work with system providers to enable the use of new chemical solutions (runway deicers) as they become available.

3.2.2.2 Surface Head Requirements

The head component of the sensor shall be a thermally neutral device, fabricated of a non-corrosive material, with a thermal conductivity closely approximating the surrounding airport pavement material. It shall be closely matched on a site-specific basis to simulate the actual neighboring pavement heat emission and absorption of solar radiation.

The surface texture of the pavement sensor head shall be designed to approximate the flow and pooling characteristics of water on the surrounding pavement.

If an active sensor is used, following requirements must be used:

The active surface sensor shall be a single solid-state electronic device that is installed in the pavement. The sensor shall be thermally active using a Peltier thermo-electric element to measure the freeze point temperature of solution on the pavement. At the point when the liquid/moisture changes state from liquid to solid, the temperature of the cell shall be measured and reported as the freeze point to the field processing unit.

Additional data should be provided from the vendor to ensure that no part of the sensor can become detached which could cause a FOD (Foreign Object Debris) issue.

3.2.3 Installation

In-pavement sensors shall be designed to be installed flush with the plane of the pavement surface to prevent interference with or damage from snow removal equipment and aircraft operations. Figures 2 and 3 show a typical in-pavement sensor installation.

All electronic components shall be permanently potted and sealed against shock, moisture, and vibration. The cable attached to the pavement sensor shall be permanently molded and sealed to the head in a leak-proof design. An additional waterproof seal shall be installed on the cable/head interface or cable connection to ensure against moisture wicking. Cables should be resistant to degradation affects by runway deicers.

The sensor 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/or cable-way saw cut for each sensor head.

The sensor, power/data transmission cable, shall be of the design to permit proper operation at a minimum of 2000 feet (608 m) (cable distance) from the field-processing unit. It is recommended that the cable have the ability to transmit information to field processing units which are to be located outside of the runway safety areas as defined by FAA Advisory Circular 150/5300-13, Airport Design, available on http://www.faa.gov/arp/150acs.htm, or outside of the graded portion of the runway strip under ICAO Annex 14, Volume 1, Design and Operations of Aerodromes

3.2.4 Location and Number of Sensors

In general, pavement surface conditions that can adversely affect aircraft transitioning from flight, turning off runways, and taxiing to apron parking should be monitored. Areas of special interest include aircraft braking area and taxiway bridges.

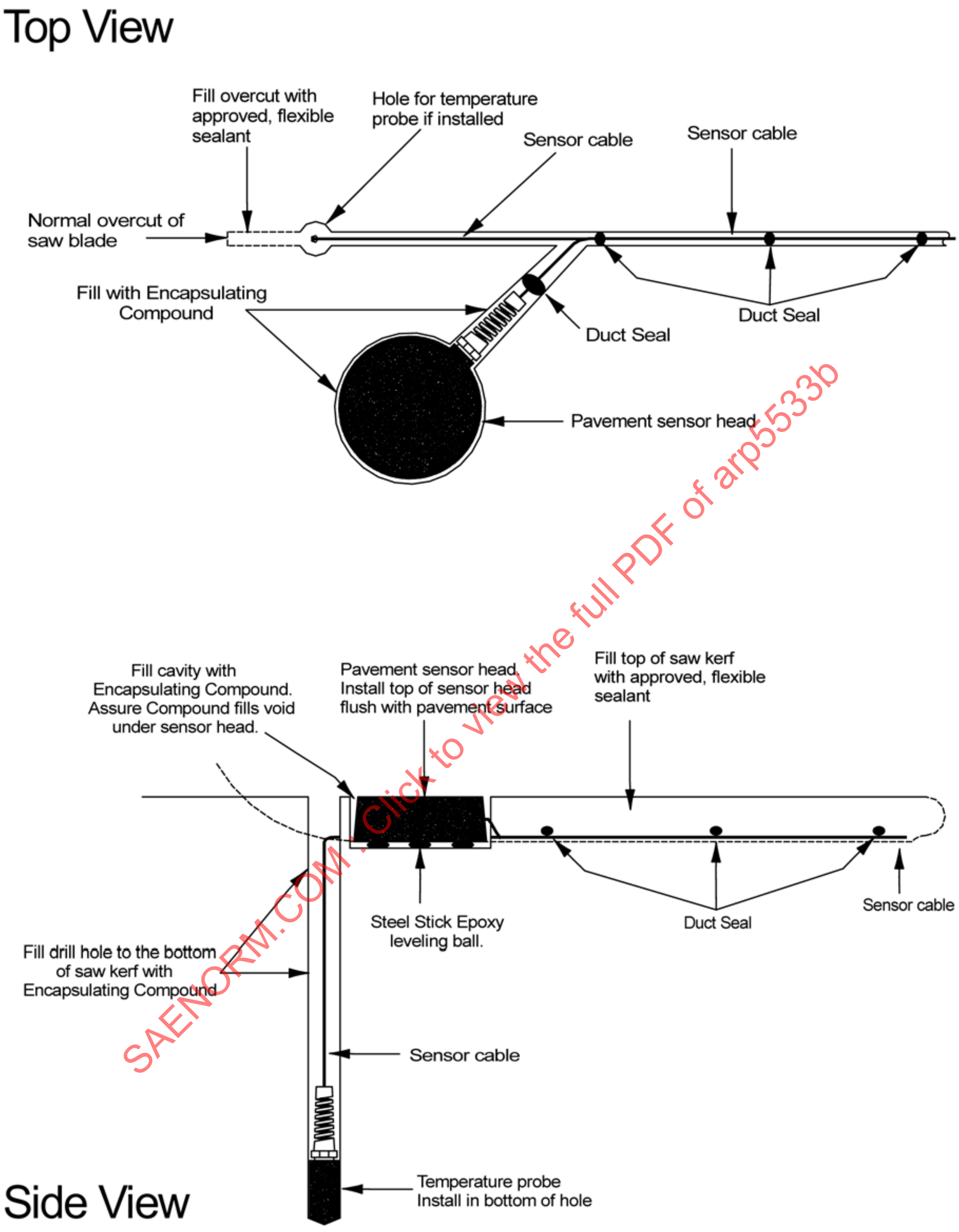

Figure 2 - Typical sensor installation cuts

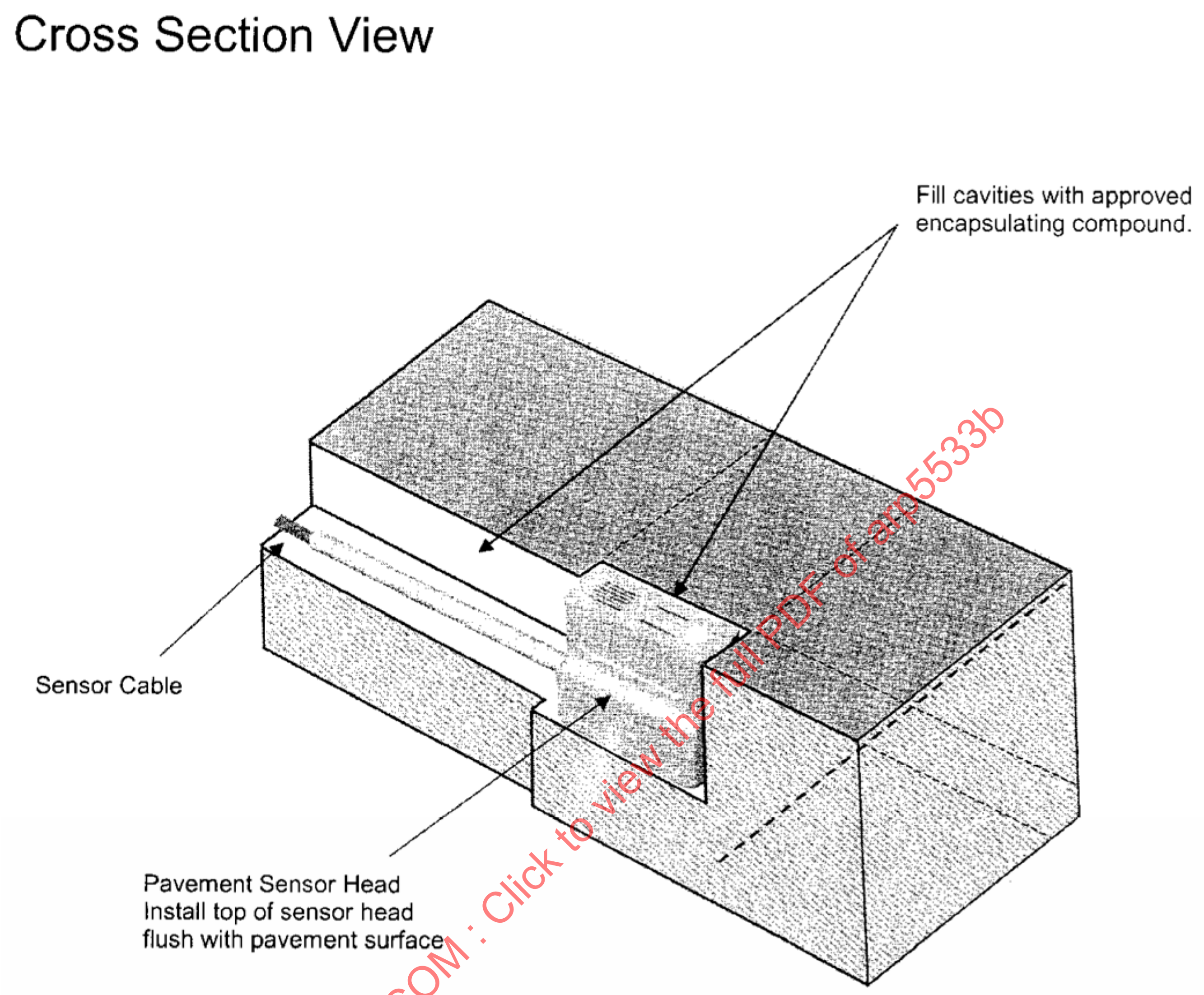

Figure 3 - Alternate typical sensor installation cuts

3.2.4.1 Minimum Number

There shall be a minimum of three in-pavement sensors per runway (items a, b, and c), located as noted below. Item d shall be included for taxiway routes and apron areas deemed by airport authorities as necessary to maintain safe aircraft taxiing operations.

a. Touchdown Zone: To monitor surface conditions affecting initial directional control and stability of landing aircraft, and then aircraft braking ability.

b. Mid-runway: To monitor surface conditions affecting the region of maximum aircraft braking effort and turnoffs onto taxiways.

c. Runway Exit at rollout end: To monitor surface conditions affecting low speed aircraft braking and the turnoffs onto taxiways.

d. Taxiways and Aprons: To monitor surface conditions affecting low speed aircraft maneuvering and parking operations.

3.2.4.2 Additional Sensors

Factors that may require additional sensors for the runway, supporting taxiway(s), and ramp area(s) are:

a. Various Pavement Materials and Crown: Differences in pavement types affect the emission and absorption rates of heat and sunlight; thus, the melting rate of ice and snow. Light pavements (concrete) will generally freeze before darker pavements (asphalt) and are candidates for additional sensors. Areas of reduced pavement crown, such as in large apron areas, can result in slower runoff of water, increasing the possibility of ice formation. These areas are also candidates for additional sensors.

b. Type of Winter Storms: Ice formation is much more common than show in geographic zones of normally temperature winter weather. To provide more timely alerts for airport operators to implement airport ice prevention measures, additional sensors are significant in these zones.

c. Various Subsurface Materials and Conditions: As a result of variations in subsurface materials and/or conditions, some pavement areas will have colder surface temperatures than the surrounding pavements and are prone to form ice earlier or more persistently. Temperature variations will result not only from differences in subgrade materials but from variations in the angle of incidence between the surface and the rays of the sun at the transition to and from bridge decking, and, as a result of varying wind direction, ground water tables, culverts, and other phenomena.

d. Large and Complex Airports: The pavement area needed for aircraft operations increases, at complex airport configurations. In these cases, the physical difficulty of monitoring the pavement surface conditions by manual inspection increases and the number of sensors should be increased. As a general rule, the need for sensors will range from a minimum of 3 for a shorter runway with no unusual local conditions up to 8 or more sensors for a 10,000-foot (3,000 m) runway with varying surface and subsurface conditions. Furthermore, airport operator experience can provide insight into unusual needs for the required additional number and location of sensors.

3.3 Sub-Surface Temperature Probe

The sub-surface temperature probe shall be installed to report the temperature below the surface.

3.3.1 Performance

The sub-surface temperature probe shall measure and electronically transmit the sub-surface runway temperatures to the rest of the system for processing.

The probe shall have sufficient durability to function over a range of surface or air temperatures from -40 to 176 °F (-40 to 80 °C).

The probe shall contain a temperature-sensing device to measure the temperature of the sensor surface. The temperature measurements shall have an accuracy of at least ±0.9 °F (±0.5 °C). The accuracy of the temperature measurements shall be maintained over a temperature range of -40 to 176 °F (-40 to 80 °C). Documentation confirming that the temperature measurements meet the stated temperature accuracy must be submitted with the system.

3.3.2 Design

The probe shall be solid state in design without relays, tubes or other electromechanical devices. The probe shall be factory adjusted and no adjustment in the probe itself shall be required.

The probe shall be small, fabricated of a non-corrosive material. All electronic components shall be permanently potted and sealed against shock, moisture, and vibration. The cable attached to the probe for wired systems shall be permanently molded and sealed to the probe in a leak-proof design. An additional waterproof seal shall be installed on the cable/head interface or cable connection to ensure against moisture wicking.

The probe power/data transmission cable, shall be of the design to permit proper operation at a minimum of 2,000 feet (608 m) (cable distance) from the site of the field processing unit.

3.3.3 Number of Probes

The number of probes to be installed shall be 1 at a minimum, for larger airport installations it should be based on the number of installed pavement sensors for which additional pavement specific weather forecasts are desired.

3.3.4 Installation and Location

The probe shall be designed to be installed below the surface and along the pavement surface at a recommended depth of 12 inches (30 cm). Probes may be installed at different depths to provide a profile of the temperature gradient below the pavement surface. The probe 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/or cable-way saw cut for each probe. The probe shall be installed within 18 inches (46 cm) of a pavement sensor. Figure 2 show a typical sub-surface temperature probe installation.

3.4 Air Temperature Sensor

3.4.1 Performance and Design

The air temperature sensor shall measure and electronically transmit the air temperature to the field processing unit. The air temperature and relative humidity sensor output shall be used by the field processing unit to calculate the dew point temperature.

The temperature measurements shall have an accuracy of at least ±0.9 °F (±0.5 °C). The accuracy of the temperature measurements shall be maintained over a temperature range of -40 to 176 °F (-40 to 80 °C). Documentation confirming that the temperature measurements meet the stated temperature accuracy must be submitted with the system.

3.4.2 Number of Sensors

The system shall have one air temperature sensor per field processing unit, unless otherwise specified. While one air temperature sensor per runway may be adequate for small airports, more than one can be specified for airports with long runways.

3.4.3 Installation and Location

The air temperature sensor shall be located at the field processing unit.

The air temperature sensor shall be installed in a solar wind shield to maintain accurate measurements. The sensor should be mounted at a height of approximately 6 feet (2 m) above the ground. The sensor, should be able to properly operate at cable distances up to 150 feet (45 m) from the field processing unit.

The air temperature sensor may be combined in a single solar wind shield with the relative humidity sensor.

3.5 Relative Humidity Sensor

3.5.1 Performance and Design

The relative humidity sensor shall measure and electronically transmit the relative humidity of the air to the field processing unit.

The sensing device shall have a range of 10 to 100% relative humidity, an accuracy of ±5% relative humidity, and shall maintain that accuracy over a temperature range of -31 to 158 °F (-35 to 70 °C).

The relative humidity and air temperature sensor output shall be used by the field processor to calculate the dew point temperature.

3.5.2 Number of Sensors

The system shall have one relative humidity sensor per field processing unit, unless otherwise specified. While one relative humidity sensor per runway may be adequate for small airports, more than one can be specified for airports with long runways.

3.5.3 Location and Installation

The relative humidity sensor shall be located at the field processor.

The relative humidity sensor shall be installed in a solar wind shield to maintain accurate measurements. The sensor should be mounted at a height of approximately 6 feet. The sensor should be able to properly operate at cable distances up to 150 feet from the field processing unit.

The relative humidity sensor may be combined in a single solar wind shield with the air temperature sensor.

3.6 Wind Sensor

3.6.1 Performance and Design

The wind sensor shall measure and electronically transmit the direction and speed of the wind to the field processor.

The wind sensor shall be capable of measuring wind speed from 0 to 134 mph, and the azimuth of the wind from any direction (360 degrees).

In areas with high exposure to freezing rain and sleet the wind sensor shall be provided with a heating element to prevent a buildup of ice on the instrument.

3.6.2 Number of Sensors

The system shall have one wind sensor per field processing unit, unless otherwise specified. While wind sensor per runway may be adequate for small airports, more than one can be specified for airports with long runways.

3.6.3 Location and Installation

The wind sensor shall be located at the field processing unit.

The wind sensor shall be mounted at a height of approximately 8 feet (2.45 m) above the ground. The sensor if not wireless, should be able to properly operate at cable distances up to 150 feet (45 m) from the field processing unit.

3.7 Precipitation and Present Weather/Visibility Sensor

3.7.1 Performance and Design

Precipitation Occurrence Sensor:

The precipitation sensor shall measure and electronically transmit the onset and cession of precipitation occurrences. The sensor shall provide the basic Yes/No precipitation information to the field processing unit.

The precipitation sensor shall utilize optical, infrared technology to detect precipitation with beam interruptions by precipitation particles. It shall provide proper operation over a temperature range of -22 to 140 °F (-30 to 60 °C).

Present Weather/Visibility Sensor:

The present weather/visibility sensor shall provide all or a selected combination of the following functionality:

- Precipitation classification, into rain, snow and drizzle classifications
- Intensity of precipitation, classified by the National Weather Service into light, moderate or heavy
- Rate of precipitation, in inches or mm per hour
- Visibility, with a range of from 0.005 to 1 mile

The sensor shall have a rain dynamic range of 0.1 to 200 mm/hour (0.005 to 8 inches/hour). It shall measure rain accumulation from 0.1 to 999.999 mm (0.005 to 39 inches), with a rain accumulation accuracy of 5%.

The sensor shall have a snow dynamic range of 0.01 to 200 mm/hour water equivalent (0.0004 to 8 inches/hour). It shall measure snow accumulation from 0.001 to 999.999 mm water equivalent (0.00004 to 39 inches), with a snow accumulation accuracy of 10%.

Sensor housing shall be all weather and ice-proof with heated optics to prevent ice, dew or frost buildup. Normal operating temperature range shall be from -22 to 140 °F (-30 to 60 °C). The present weather/visibility sensor shall be mounted at the same location as the field processing unit.

Please note that only one each of the Precipitation Occurrence Sensor or the Present Weather/Visibility Sensor should be installed at a field processing unit site.

3.7.2 Number of Sensors

The system shall have one precipitation sensor per field processing unit, unless otherwise specified. While one precipitation sensor per runway may be adequate for small airports, more than one can be specified for airports with long runways.

3.7.3 Installation and Location

The precipitation sensor shall be located at the field processing unit and be installed at a height of 6 to 10 feet (2 to 3 m) above the ground.

3.8 Field Processing Unit

3.8.1 Performance

The field processing unit provides power to all connected sensor types (pavement, subsurface, and atmospheric), processes raw sensor input data and when requested by the central computer, transmits the processed data to the central computer.

The field processing unit shall be capable of being powered from standard 120 VAC commercial power or from a solar/battery power supply. Depending on the complement of sensors connected to field processing unit, the amount of solar charging arrays to provide sufficient power may be of considerable physical size. The physical size, placement and location of the solar charging arrays and batteries in relation to areas of aircraft movement shall be considered to avoid a safety hazard to aircraft operations.

3.8.2 Design

The field processing unit shall be of solid-state design and be microprocessor/computer based. The field processing unit design shall maximize the use of modular circuit cards for ease of maintenance. All circuitry of the RPU, the voltage inputs, the sensor inputs, and the communications ports shall be designed and tested to provide transient and surge protection. Line voltage shall be transient protected to UL 1449.