SAE Aerospace
An SAE International Group

AEROSPACE RECOMMENDED PRACTICE

SAE ARP5533

Issued 2005-02
Reaffirmed 2013-05

Stationary Runway Weather Information System (In-Pavement)

RATIONALE

ARP5533 has been reaffirmed to comply with the SAE five-year review policy.

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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 three 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 connected by wire, fiber optic or wireless 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.

3. Central Computer to disseminate the above information to users using industry standard computer networks and protocols. The central computer shall also have the ability to support remote access to the information via computer networks and using standard dial telephone lines. Information displays from the central computer shall be in tabular text and graphic formats using industry standard World Wide Web based browsers.

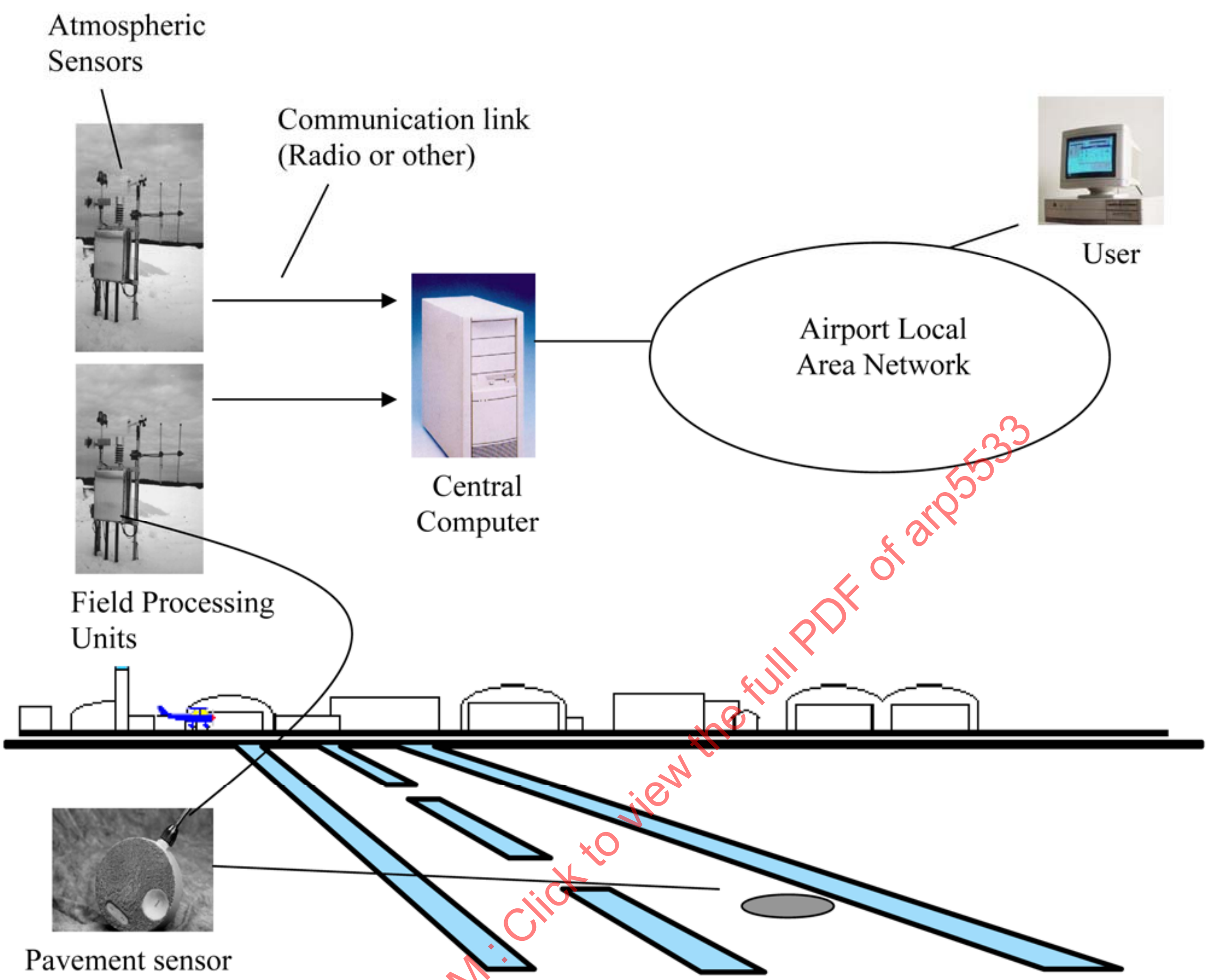

FIGURE 1 - System Components

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 freeze point.

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

3.2.2 Design: 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.

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. Should new non-conductive chemical solutions (runway deicers) become available, active sensor technology should be used to ensure accurate measurements.

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.

3.2.3 Installation: 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, if not a wireless type, 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 area as defined by *FAA Advisory Circular 150/5300-13, Airport Design,* available on http://www.faa.gov/arp/150acs.htm.

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.

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.

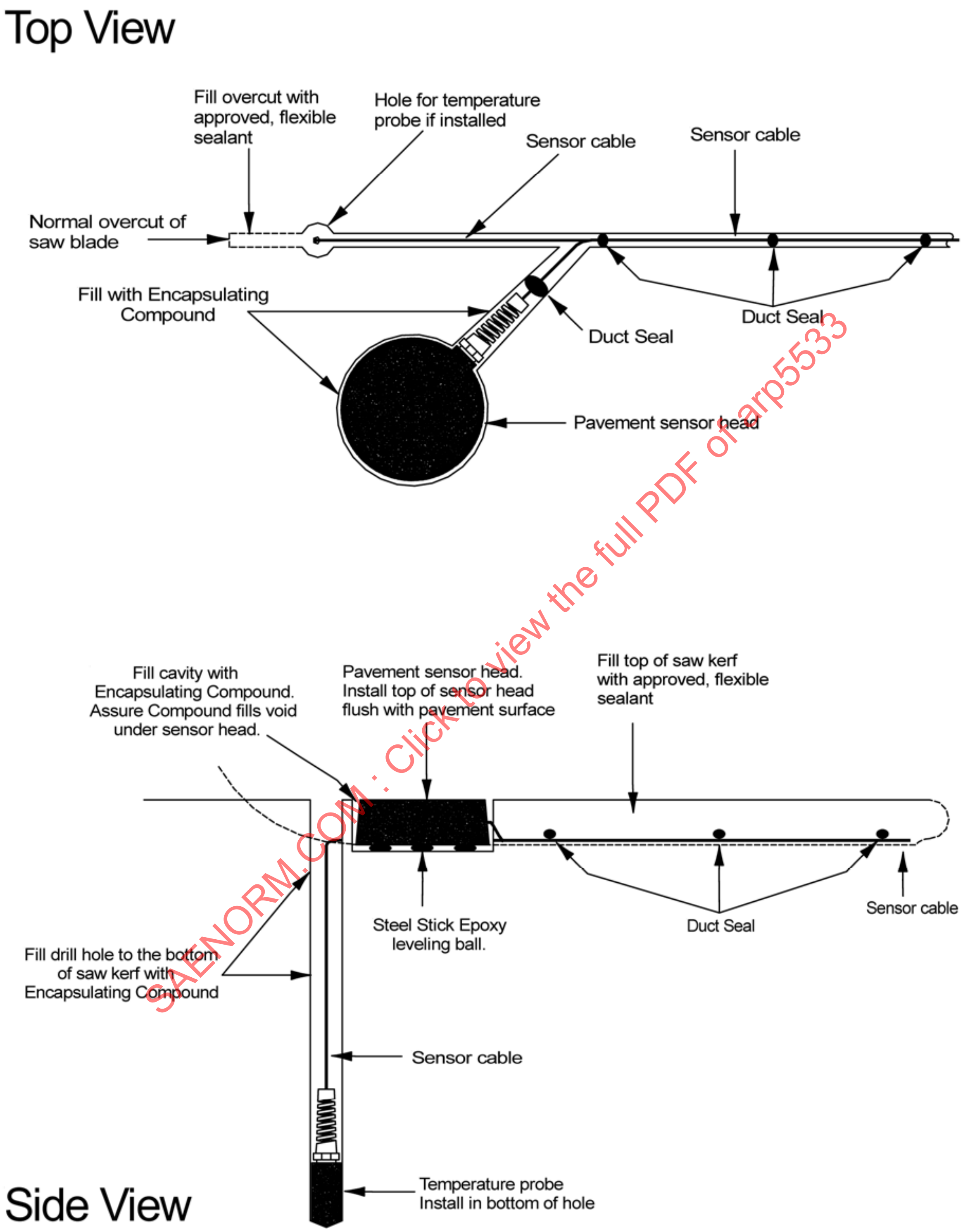

FIGURE 2 - Typical Sensor Installation Cuts

Cross Section View

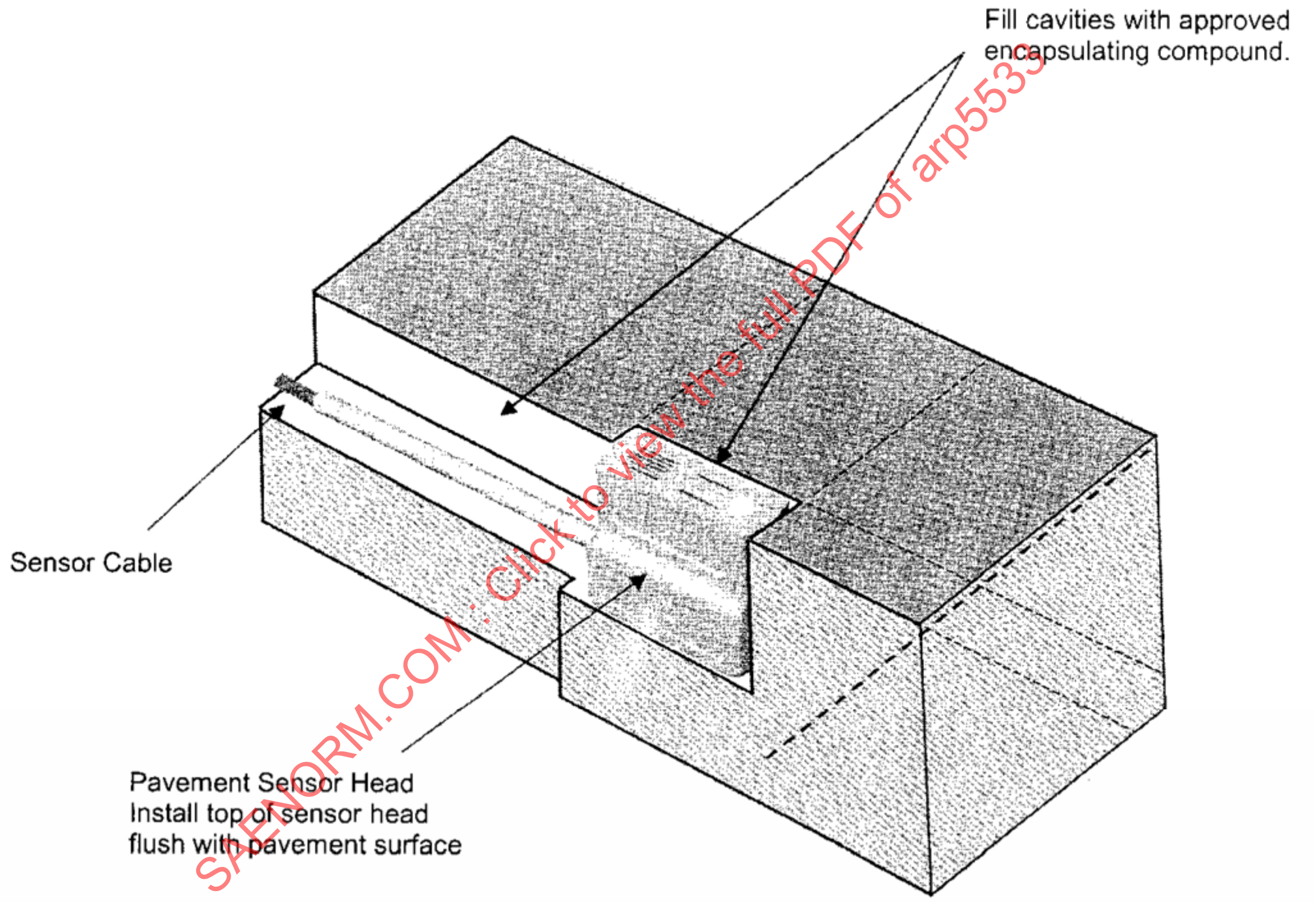

FIGURE 3 - Alternate Typical Sensor Installation Cuts

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 snow in geographic zones of normally temperate 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 (3000 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 when the buyer will be receiving pavement specific weather forecasting.

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, if not of a wireless type, shall be of the design to permit proper operation at a minimum of 2000 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 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 17 inches (43 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, if not of a wireless type, 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°).

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 -30 to 60 °C (-22 to 140 °F).

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 3000 mm/hour (0.005 to 118 in per hour). It shall measure rain accumulation from 0.1 to 999.999 mm (0.005 to 39 in), with a rain accumulation accuracy of 5%.

The sensor shall have a snow dynamic range of 0.01to 300 mm/hour water equivalent (0.0004 to 11.8 in/hour). It shall measure snow accumulation from 0.001 to 999.999 mm water equivalent (0.00004 to 39 in), with a snow accumulation accuracy of 10%.

3.7.1 (Continued):

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 -40 to 50 °C (-40 to 122 °F). 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 UL1449.

Lightning and over-voltage protection filters shall be provided for all sensors connected to the field processing unit's serial ports, digital ports, and analog ports. Optical isolation may be used in place of over-voltage protection.

The field processing unit shall provide stable operation over the temperature range of -30 to 70 °C (-22 to 158 °F).

3.8.2 (Continued):

The field processing unit shall be housed in waterproof enclosures meeting the National Electrical Manufacturer's Association (NEMA) for type 4 or equivalent (UL 508 Type 4, Type 4X and Type 12; NEMA/EEMAC Type 4, Type 4X, Type 12, and Type 13; CSA Type 4, Type 4X and Type 12 VDE IP66). The enclosure shall be designed so that service can be performed with minimum exposure to the critical elements of the system.

The field processing unit shall be capable of utilizing the NTCIP-ESS the Intelligent Transportation System (ITS) standard data communication protocol for data communication between the field processors and the central computer.

The field processing unit should be expandable to provide a minimum of four dry contact closure signal outputs for controlling external field devices and systems, such as lights and anti-icing spray systems. The activation of the dry contact closure signal outputs shall be from instructions received from the display units and/or the central computer.

Field processing units shall be expandable to permit the easy integration of additional sensing or monitoring devices including color still frame video.

3.8.3 Number of Units: The system shall have at least one field processing unit.

3.8.4 Location and Installation: Configuration of the field processing unit and alignment of attached sensors shall be controlled from the field processing unit. No special service equipment or tools shall be required to perform configuration/alignment.

All field processing units shall be mounted/housed on a corrosion resistant structure, such as stainless steel or aluminum. The field processing unit structure shall be installed above ground, utilize frangible couplings, and contain obstruction lighting.

The location of a field processing unit is somewhat determined by function. Where practical, these units should be co-located with air navigational aids within the runway object-free area (OFA), but outside the runway safety area (RSA) and beneath the runway obstacle-free zone (ROFZ) (See FAA AC 150/5300-13 for object clearing criteria clarification).

To protect the field processing unit from lightning, the installation of the airport tower structure must include proper grounding. To accomplish appropriate grounding, multiple ground wires leading from the airport tower structure (field processing unit cabinet) must be installed and connected to ground rods. The ground wire must be solid or woven with an outside diameter equal to or larger than 6 mm (0.25 in). Multiple grounds rods (at least 2 per leg for a total of 4) spaced at a radial distance of 0.91 m (3 ft) and 3 m (10 ft) shall be installed in series from each airport tower structure leg. Rods shall be copper-clad steel or approved equal, with at least a 12 mm (0.5 in) diameter, and a minimum of 3 m (10 ft) in length.