Hotplate™ TOTAL PRECIPITATION SENSOR MODEL TPS-3100

BULLETIN TPS-3100

Description

The Model TPS-3100 provides real time snow and liquid precipitation rates at remote automated weather stations. It represents the first fundamental breakthrough in basic precipitation measurement in several decades, and is ideal for mission-critical meteorological and transportation applications. Unlike conventional weighing and tipping bucket precipitation gauges that have moving parts and require anti-freeze treatments, the TPS-3100 provides exceptional accuracy and reliability over the entire ±50°C operating range.

About five inches in diameter, the sensor head consists of two isolated plates warmed by electrical heaters. During storms, it measures the rate of rain or snow by how much power is needed to evaporate precipitation on the upper plate and keep its surface temperature constant. The second plate, positioned directly under the evaporating plate and heated to the same temperature as the top, is used to factor out cooling from the wind.

Transportation agencies charged with public safety have traditionally relied on snow gauges with collection buckets that have open orifices. Windshields must be set up around these legacy gauges to increase collection efficiency, particularly of snow. These legacy gauges usually require troublesome anti-freeze additives with oil skim overlays. The action of wind coupled with snow sticking to the sides of open collection vessels tends to bias collection efficiency. Further, some legacy gauges require manually emptying during storm events.

With no moving parts, the all-electronic TPS-3100 sensor avoids problems associated with traditional volumetric or weighing rain gauges. It works equally well in snow and rain conditions. Liquid equivalent rates are calculated from real time measurements and output in real time.

Features

- No moving parts maintenance-free design
- Reliable solid-state technology
- No wind shield or anti-freeze required
- Microprocessor-managed “smart sensor” with RS-232 diagnostic output
- Integrates with Vaisala’s WSDDM weather system.

TPS-3100 Hotplate™ precipitation sensor

Statistically, precipitation rate can be highly variable in both time and space, and a single measurement only reflects a limited space-time domain. The measurement of liquid equivalent rate (LER) of precipitation, especially mixed/frozen precipitation, is fundamental to disciplines as diverse as transportation safety and global climate change research. The TPS-3100 has the unique ability to provide real time histograms of precipitation *rate*.

Applications

Reliable real time performance under any weather conditions makes the TPS-3100 ideal for:

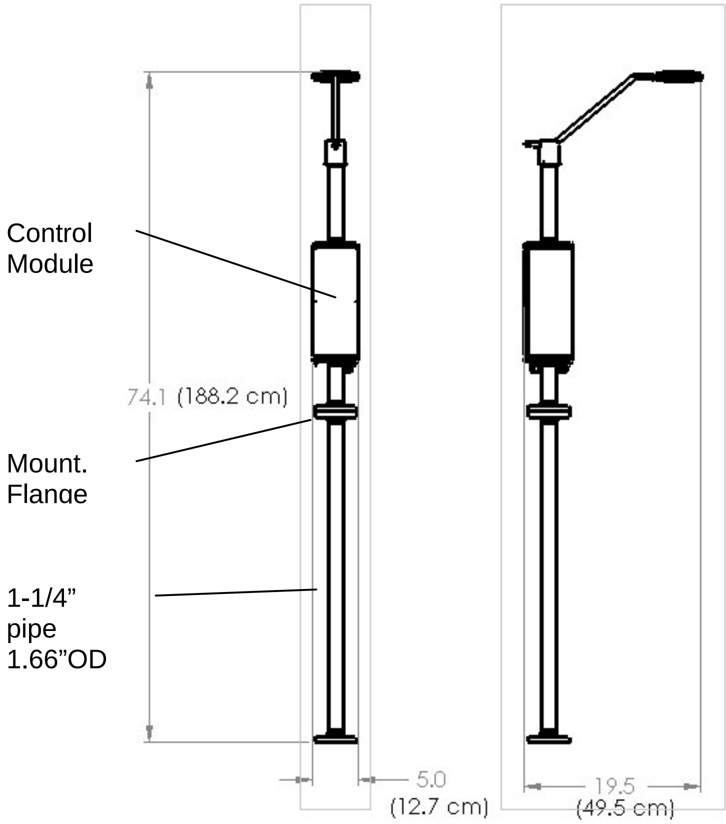
- Professional grade meteorological stations
- Roadway weather information systems
- Calibration of other precipitation gauges
- Weather and global climate change research

Benefits

The TPS-3100 can be placed in difficult-to-access areas and will provide accurate readings of snowfall rates precisely at locations where vehicles are most at risk of experiencing dangerous snow and ice build-up. Snow removal operators are then able to optimize coverage during storm periods. Increased efficiency during snow and ice removal operations improves public safety and saves money. Beyond de-icing applications, the precise knowledge of precipitation rates is fundamental to better understanding the Earth's climatic mechanisms.

Hotplate (TM)

YANKEE ENVIRONMENTAL SYSTEMS, INC.



Mechanical Interface: 72"H x 22"W

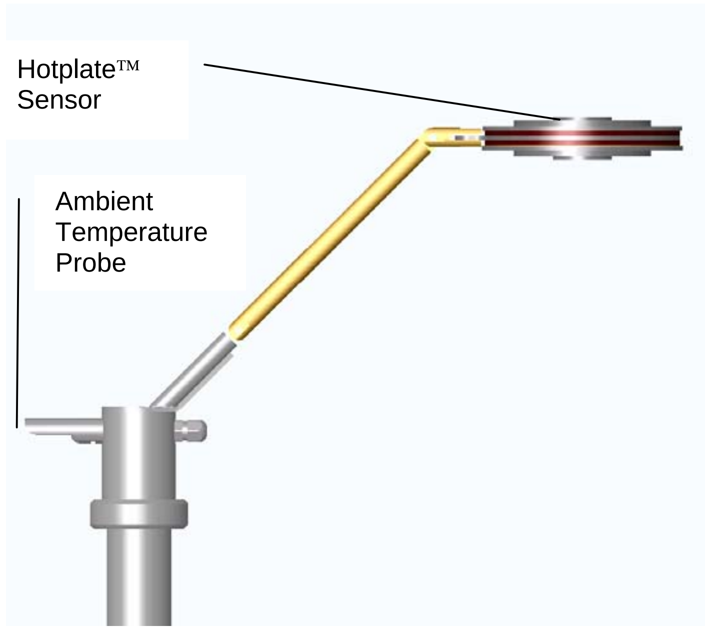
Mechanical Configuration

The aluminum weatherproof electronics enclosure and sensor heads provide long life. Electrical and components are designed to operate over a temperature span of ±50°C. The sensing head is typically mounted at least two meters above the ground mated to a customer-supplied flange, and the temperature sensor is aimed away form the equator to shade it from direct solar radiation.

Internal CPU Operation

The TPS-3100 Hotplate™ sensor is controlled by an embedded CPU that serves several functions:

- At power up, the processor initiates heating to maintain an operating temperature of ≈90°C.
- Once operating temperature is reached, power is adjusted to the top and bottom plates to maintain the plates at the temperature setpoint.
- The serial port is monitored for commands; upon receipt of the query command, the CPU outputs a single data record. Streaming is also supported.
- Continuous measurements of the plate power and ambient temperature are made by the ADC.
- Differences between the plate power indicate incident precipitation, and the rate is calculated.
- The CPU performs digital filtering of the data to minimize measurement noise.



Side view of TPS-3100 Hotplate™ sensor.

Electrical Connections

Separate AC and communications conduit ports are located on the bottom of the electronics enclosure. Cabling between the sensing head and the enclosure is encased within the support arm. Inside the system electronics enclosure, a DB-9 female RS-232 connector provides digital interface (3 wire no handshaking), while a terminal strip provides AC input termination. Typically, two flexible conduits are used to connect power and serial data communications to a user-provided junction box.

Digital Output Data Format

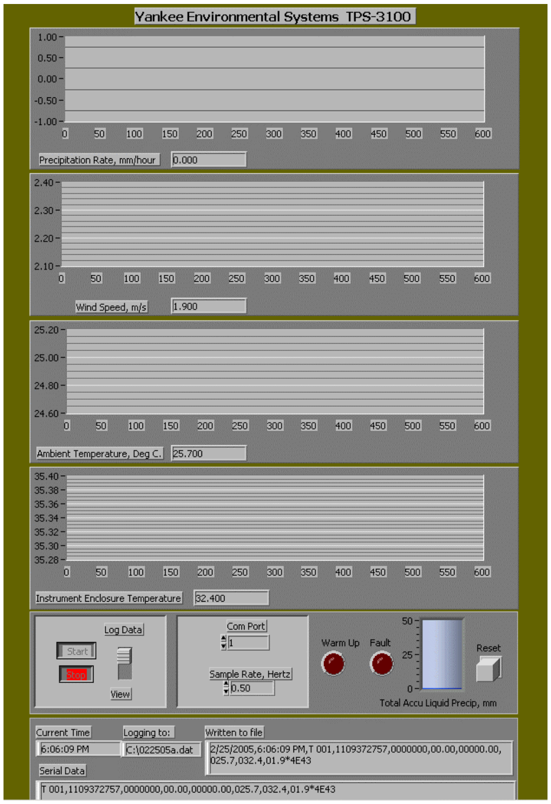
The serial port output can be streamed or respond to a "T" string. It produces a record consisting of the measured precipitation rate in mm hr^{-1}, power to the top and bottom plates in Watts, ambient temperature in °C, calculated wind speed in ms^{-1}, and system status, as well as a CRC check. The system outputs fixed length output records which can feed your data management system or optional WSDM software.

Available Options

- Dual version for detection of blowing snow
- WSDDM Software
- Dialup Telco Modem for POTS telephone lines
- Ethernet 802.3 10/100BaseT for LANs

Hotplate (TM)

YANKEE ENVIRONMENTAL SYSTEMS, INC.



Real time data display software for MS-Windows.

Why the Hotplate is Better

Many techniques have been developed over the years to measure precipitation, including weighing and tipping bucket gauges, but all involve essentially measuring either the weight or the volume of water. The problem is that water freezes in complex and unpredictable ways, and unlike other compounds, it actually expands when it freezes. We can perhaps best summarize the end maintenance nightmare that occurs by quoting directly from a conventional weighing rain gauge manufacturer's instruction manual:

> *"When the gauge is operating below 0°C, an antifreeze blend must be added to the solution in the bucket to melt frozen precipitation and prevent freezing. If the precipitation freezes the ice will rise above the oil and sublimation will occur. It is important to notice that the capacity of the collected precipitation is decreased when antifreeze is added. The antifreeze becomes a part of the total volume collected. Two types of antifreeze are available, Ethylene glycol and the more environmentally friendly Propylene glycol. Methanol is added to both to adjust the density of the antifreeze to prevent stratification. Tables in the following sections show the amount of antifreeze needed to keep the collected precipitation from freezing at various temperatures. "*

The problem of course is that the temperature can vary dramatically through a 12-hour period, often by more that 30 to 40°. If personally tending a rain gauge outside in the colder months with chemicals is your idea of fun, then read no more. The Hotplate™, on the other head, has no moving parts and eliminates this complexity by using thermal techniques that keep the precipitation in the liquid state. It is literally *zero-maintenance*.

A second advantage of the Hotplate™ technology is its *catch-efficiency*. Any precipitation gauge is essentially trying to quantify a mass flow of water across an aperture opening. In most traditional rain gauges, a vertical pipe acts as this orifice. Often it is windy during precipitation events and because the bottom of the collection pipe is closed (like an organ pipe), in very light or blowing snow conditions, there tends to be a pressure buildup inside the pipe that precludes the snow from entering the pipe ballistically. Further, snow often sticks to the inside of the pipe and then sublimes directly into a gas, never reaching the bottom of the pipe where it was supposed to be measured.

While rain does not have as much of a problem as snow, the windier the conditions are, the harder it is to catch all the precipitation faithfully. The literature is full of examples of various types of windshields (e.g., Alter, Wisconsin, etc.) that have been developed over the years to block the wind around traditional rain gauges. On the Hotplate™, as snow hits the heated plate it is immediately vaporized, and there is no need for mechanical shielding. It has a very faithful *catch efficiency*, which implies it is more accurate.

Finally, the Hotplate™ provides accurate rate measurements *immediately*. Whereas a tipping bucket gauge can measure as low as 0.1mm per hour, it takes a full hour to accumulate that drop and get the signal. During that period, you can bet that the rain or snow evaporated before the tip occurred. Meanwhile, the Hotplate™ provides data within a minute of when the snow or rain begins. It is truly a *real time* measurement, which can be a matter of life and death in some applications.

Historically, manual techniques as simple as a ruler against a vertical wooden board have been used for measuring snowfall. Particularly in colder climates, direct measurement of liquid equivalent rate using weighing or volumetric gauges has been problematic as the sensor often freezes up and fails. Problems with the use of oil-covered antifreeze in liquid precipitation gauges drove the development of the Hotplate™ technology.

Development History

The Hotplate™ technology was developed by scientists at the Nation Center for Atmospheric Research (NCAR) and the Desert Research Institute (DRI). funded by the Federal Aviation Administration The NCAR/DRI research effort was aimed at improving public safety in adverse weather conditions. The patented Hotplate™ technology was then licensed for manufacture to YES.

The Hotplate™ technology is protected by U.S. Patent #5,744,711, titled “Winter Precipitation Measuring System,” U.S. Patent #6,546,353 B1 titled “Hotplate Precipitation Measuring System,” and five (5) continuation patent applications filed on February 18, 2003 (serial #s. 10/368,548, 10/368,504, 10/368,506, 10/368,508, 10/368,509).

Specifications

Size: Weight:	72” H; 22”D; 8”W 17 lbs. (8 kg)	Materials:	Aluminum
Power on Delay: Running Average:	10 minutes 5 minutes	Electrical Connections: Data communications: AC line power:	DB9-F RS-232, 6’ (1.8m), AC (to terminal strip)
Power Required:	110/220 Vac, 50/60Hz, 1Φ 600W max 100W nominal	Environmental operating temperature range:	±50°C

PRECIPITATION MEASUREMENT

Measurement range	0-50 mm hr^{-1}
Liquid Equivalent Rate accuracy	±0.5 mm hr^{-1}
Slew rate	1 minute T_c , ≈0.5 mm s^{-1}
Repeatability	±0.25 mm hr^{-1}
Hysteresis	None
Resolution	0.1 mm hr^{-1}
Digital output	RS-232, 9600 baud 8-N-1, ASCII (14-bit 0.01mm/hr resolution)
	Separate pulse output simulates tipping bucket for interface to data loggers with counter inputs

Hotplate™ R&D testing at Denver, Colorado, USA

YANKEE ENVIRONMENTAL SYSTEMS, INC.
Airport Industrial Park
101 Industrial Blvd., Turners Falls, MA 01376 USA
Tel: (413) 863-0200 Fax: (413) 863-0255
E-mail: info@yesinc.com http://www.yesinc.com