TOTAL MET SENSOR
MODEL TPS-3100

BULLETIN TPS-3100

Description

The Model TPS-3100 is the world's first no moving parts thermodynamic weather sensor. Ideal for remote unattended sites in cold climates, it measures real time snow/liquid precipitation rates, wind speed, solar, infrared, and PTU. It represents the first fundamental breakthrough in precipitation measurement in decades, and is ideal for mission-critical transportation weather. Unlike conventional weighing and tipping bucket precipitation gauges requiring anti-freeze treatments, it provides reliable sensitivity and accuracy over a range of ±50°C.

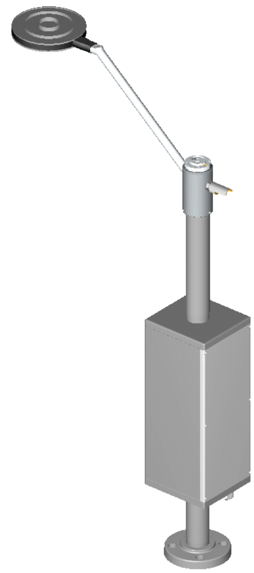
The all metal sensor head consists of two isolated plates warmed by electrical heaters maintained at a constant temperature. The liquid equivalent rate (LER) of precipitation is determined by measuring the power difference of evaporating precipitation on the upper plate while the lower plate, positioned directly underneath, is maintained at the same temperature. The lower plate enables measuring the wind speed as both are affected equally.

Meteorological agencies charged with public safety have traditionally relied on snow gauges with collection buckets with open orifices. Windshields are necessary around legacy gauges to increase collection efficiency, requiring troublesome anti-freeze with oil skim overlays. The action of wind coupled with snow sticking to the sides of open collection vessels tends to bias collection efficiency downward, and some gauges require manually emptying during storm events.

With no moving parts, the electronic TPS-3100 meteorological sensor avoids problems associated with traditional weighing rain gauges and anemometers, especially in colder conditions. Parameters such as Liquid Equivalent Rates are calculated and output in real time.

Features

- Reliable maintenance-free design
- Measures precip, solar/IR, PTU and winds
- No wind shields or anti-freeze are necessary
- Microprocessor-managed "smart sensor" with RS-232 diagnostic outputs



TPS-3100 precipitation sensor

Statistically, precipitation rates are highly variable in both time and space, and a single measurement only reflects a limited space-time domain. The measurement of LER of especially mixed/frozen precipitation, is fundamental to disciplines as diverse as transportation safety and global climate change research. Because it detects down to 0.1mm/hr rates within 60 seconds, it enables rapid response to early storm event precipitation.

Applications

Reliable and accurate measurements in all weather conditions makes it 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 where vehicles are most at risk of experiencing dangerous conditions. Snow and ice removal operations can be optimized, and such efficiency gains improve public safety while saving money. Scientifically, knowledge of precipitation rates is fundamental to better understanding of climate change.

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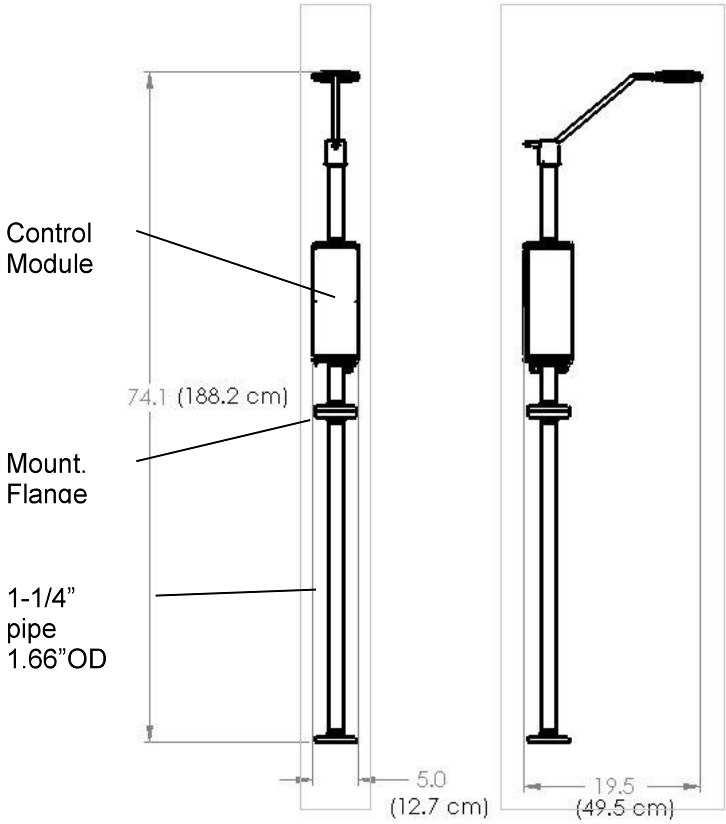


Mechanical Interface: 72"H x 22"W

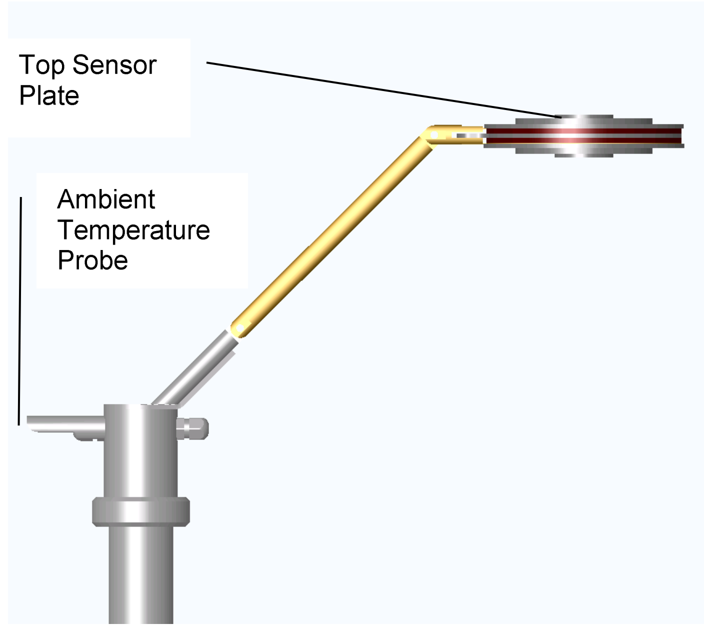
Mechanical Configuration

The aluminum weatherproof electronics enclosure and sensor head provide long life. Components are designed to operate over a temperature span of ±50°C. The sensing head is mounted level at least two meters above the ground, mated to a customer-supplied vertical pipe flange. A temperature sensor is shaded from solar radiation.

Internal CPU Operation

The 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
- Continuous measurements of plate power and ambient temperature are made by the ADC
- Differences between the plate power indicate incident precipitation, and the rate is calculated after measurement noise is minimized via filtering
- The serial port is monitored for commands; upon receipt of the query command; an on demand single data record or stream are provided



Side view of sensor head assembly.

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 with CRC check. The system outputs fixed length output records to drive your data management or decision support system.

Available Options

- Dual systems mounted at 2m and 10m can detect blowing snow

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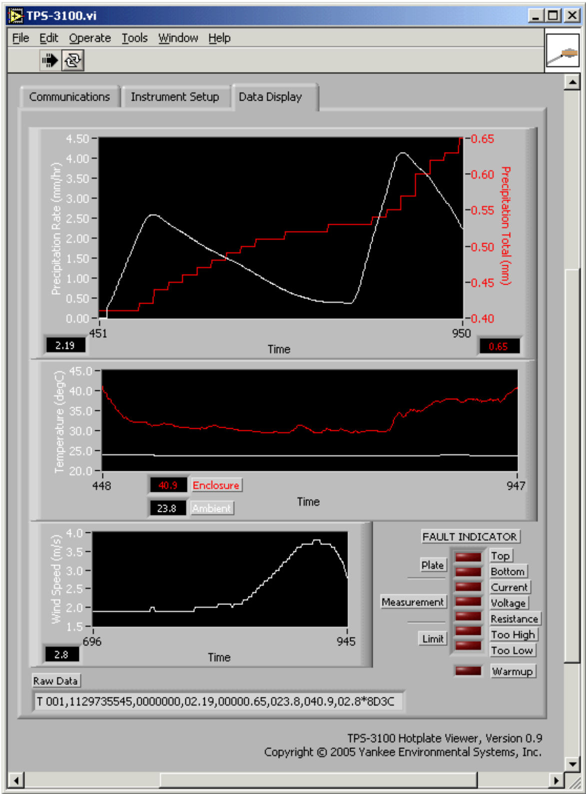

Real time data display software for MS-Windows.

Why it's Better

Many techniques have been developed over the years to measure precipitation, commonly described as weighing or tipping bucket gauges. All involve essentially measuring either the weight or the volume of collected water. The problem is that water is a polar molecule that freezes in complex ways. Unlike many compounds, water 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 collection 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 air temperature can vary dramatically through a 12-hour period, often by up to 40°F. Tending a rain gauge in the colder months with chemicals is tedious and labor-intensive. The TPS has no moving parts and eliminates complexity using thermal techniques to maintain precipitation in the liquid state; it's *zero-maintenance!*

A second advantage is its *catch-efficiency*. Any precipitation gauge attempts to quantify a mass flow of water across an aperture opening. In traditional rain gauges, a vertical pipe serves as this orifice. During precipitation events it's often wind and because the bottom of the collection vessel is closed (i.e. like an organ pipe), in light or blowing snow conditions, there tends to be a pressure buildup inside that precludes snow from entering ballistically. Further, blowing snow can adhere itself to the inside side of the vessel and then sublime directly into water vapor, never reaching the bottom of the vessel where it was supposed to be weighed.

While rain is better than snow in this regard, the windier the conditions are, the more challenging it becomes to catch all precipitation faithfully. The literature is full of examples of various types of windshields (e.g., Alter, Wisconsin, etc.) developed over the years to block wind around rain gauges.

As snow hits the upper heated plate it is immediately vaporized. As there is no need for mechanical shielding, a TPS has unsurpassed *catch efficiency*, leading to state-of-the-art measurement accuracy.

Finally, the system provides accurate rate measurements *immediately*. As a *real time* measurement, data are presented within a minute of the start of a snow or rain event. Whereas a tipping bucket gauge can also measure as low as 0.1mm per hour, it can take a *full hour* to accumulate that drop and obtain a measurement. During that period, it's likely the rain or snow may evaporate before the tip occurs! This measurement error can be a matter of life and death in some applications.

Historically, manual snow measurement techniques as simple as a ruler against a vertical wooden board have been used for measuring snowfall depth. However, in colder climates, direct measurement of liquid equivalent rate using weighing or volumetric gauges has been problematic, as sensors often freeze up and fail. The traditional use of oil-covered antifreeze in liquid precipitation gauges have plagued their reliability and long term accuracy because human labor is required.

Development History

The original thermodynamic sensing technology was funded by the National Science Foundation and Federal Aviation Administration for improving public transportation safety in adverse weather conditions.

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/ RJ45 802.3 Ethernet 6’ (1.8m), AC to int. terminal strip
Power Required:	100-250 Vac, 50/60Hz, 1Φ 600W max 100W nominal (low wind/no precip)	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

R&D testing at Denver, Colorado, USA in 2005

UAF field site Alaska, USA (double-fenced gauge at rear)

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