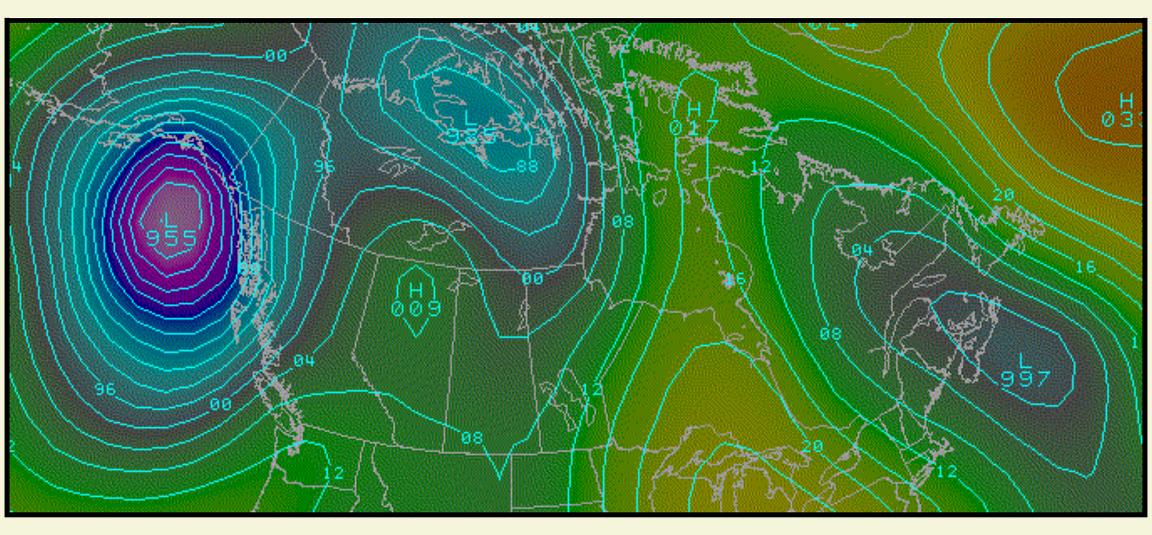
ASOS Pressure Sensor



AWIPS display of sea-level pressure in contour and image formats

1. Introduction.

The most important surface weather element for aircraft operations is probably atmospheric pressure because it is used to determine the height of an aircraft above the ground. It is the only element that cannot be directly observed or qualitatively sensed by the observer or pilot. Because of its importance, pressure is carefully measured and the sensor routinely compared to some reference standard.

The atmospheric pressure is defined to be the pressure exerted by the atmosphere as a consequence of gravitational attraction upon a column of air lying directly above the point or area of interest. The pressure can be expressed in terms of :

a. Altimeter setting - Pressure value to which an aircraft altimeter scale is set so that it will indicate the altitude above MSL of an aircraft on the ground at the location for which the value was determined.

b. Barometric pressure - The atmospheric pressure measured by a barometer.

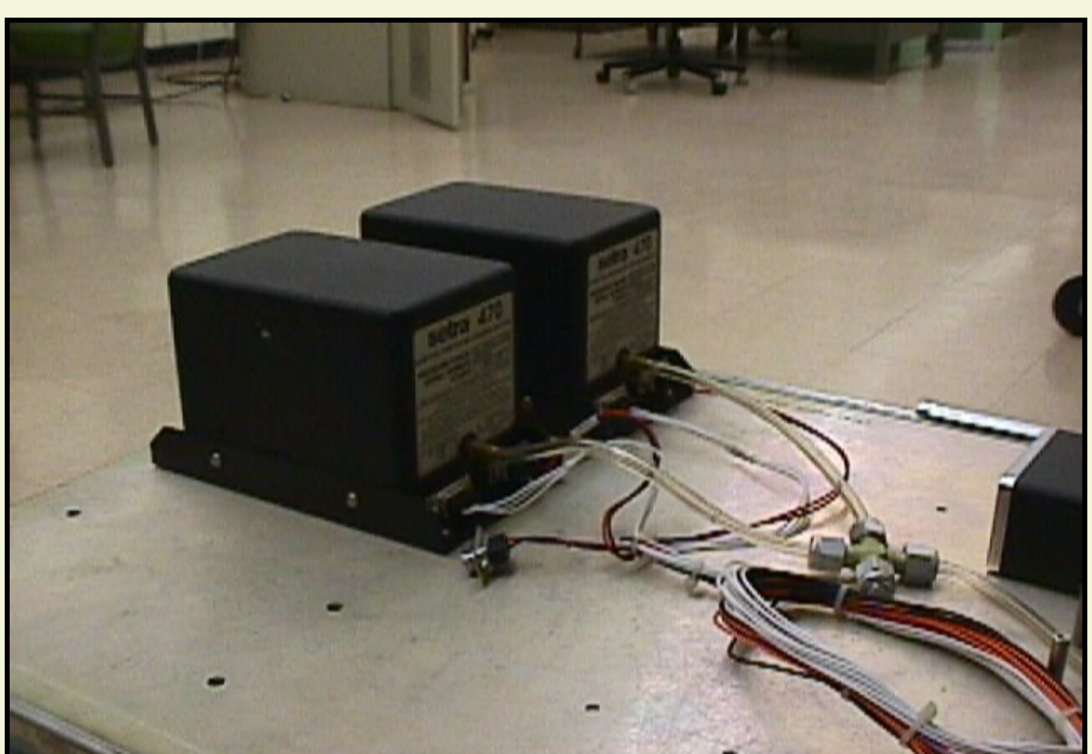
In the past, the pressure was observed from the highest priority pressure-measuring instrument available. These include the general category of precision aneroid (altimeter-setting indicator or microbarograph) and mercury barometer. The observing procedures include the reading of the pressure instrument, then correction, conversion and reduction of pressure to sea-level. Corrections are based on a 12-hour mean temperature and known residual errors obtained from a correction card.

2. Operation of The ASOS Pressure Sensor.

The ASOS pressure sensor is the most reliable and accurate of all ASOS sensors. It is an automatic sensor without controls or indicators, and, since it operates continuously, it produces more pressure remarks than manual observations. Since the ASOS pressure sensor is designed for continuous operation, it remains on dc power at all times.

The ASOS pressure sensor configuration consists of two (Class I system) or three (Class II system) separate model 470 digital pressure transducers, manufactured by Setra Corporation. Each pressure transducer is a highly accurate pressure measurement instrument that uses advanced microcomputer-based electronics and firmware, resulting in a 0.02% full scale accuracy.

The capacitive sensors, which are located on a tray at the bottom of the ASOS computer cabinet (ACU), are permanently evacuated to a vacuum on one side to make each an absolute or barometric pressure sensor. The pressure sensors share a common 3/8-inch tygon sensor tube for sensing barometric pressure (see figure below).



Pressure instruments mounted on shelf inside the ACU.

Since the ambient barometric pressure is input to each pressure transducer through a shared tygon sensor tube, each pressure transducer receives the same barometric pressure input level. This configuration ensures reliable reporting of barometric pressure information. The tygon air tube is routed to the pressure drawer from a pressure port located on the connector panel. At some sites, when the ACU is located in the tower, the pressure port on the connector panel may be connected to an outside pressure vent via additional (copper) tubing. It has been found that in some towers that inside environmental factors (such as heating and air-conditioning systems) affect the barometric pressure readings. Pressure sensor accuracy relies on the tygon tubing from the sensors to the pressure vent inlets. A transducer assembly internal to each unit converts the pressure level into an electrical signal level. This level is then monitored and translated by a microprocessor-based circuit within the pressure sensor to produce a barometric pressure value. During normal operation, ASOS reads the pressure value from each pressure transducer, compares the values to verify the accuracy of the measured data and sends its calculated barometric pressure when polled to the CPU via an RS-232 interface.

Pressure sensors that are installed in Class I ACU cabinets must be equipped with threshold detectors, which may be either internal (built into the sensor) or external. A threshold detector ensures that the pressure sensor resets completely in the event of a dc undervoltage fluctuation (when its power drops below 4.55 vdc). Threshold detectors are not required on Class II systems because the ACU's uninterruptible power supply prevents such fluctuations.

Each pressure sensor is polled for data once every 10 seconds. ASOS software automatically checks the data from each sensor to determine accuracy and to detect for failure of any one of the pressure transducers. If a pressure sensor fails to respond more than once in a 1-minute period or fails to respond more than twice in a 12-hour period, a data quality failure is logged for that sensor. Because corrective maintenance tasks such as troubleshooting or replacing a pressure sensor require longer than 20 seconds, these tasks will typically generate data quality failures. Whenever pressure sensor report processing is off (for any reason), ASOS assumes that the pressure data may not be accurate and therefore should not be used.

Unlike the other ASOS sensors, the pressure sensors, because they are critical to aircraft safety, require the technician to take a positive action to clear a data quality failure and bring the sensor on-line. A data quality failure occurs if the data from one pressure sensor is more than 0.040 in Hg apart from the other(s). In a system with three pressure sensors, the out-of-tolerance sensor is logged as a data quality failure. In a system with two pressure sensors, it is impossible to determine which of the two is out of tolerance, so the system logs both as data quality failures. The first action by the technician is to use a portable pressure standard to verify that the sensor is reporting accurate data. Next, the pressure sensor data quality failure is cleared by deconfiguring and reconfiguring the sensor according to established procedures.

A technician must verify the accuracy of data from the pressure sensors by comparing pressure sensor output data (viewed on the sensor status page at the OID) against a calibrated portable pressure standard. All sensor values must be within 0.020 of the value on the portable pressure standard. Sensors out of tolerance are replaced by the technician. The verification should be performed under the following conditions:

a. Every 90 days

b. Whenever pressure sensor report processing has been turned off.

c. Whenever a pressure sensor data quality failure has occurred.

d. After performing pressure sensor corrective maintenance.

3. Algorithm Calculations.

There are two types of pressure change noted in the observations. There is the short-term pressure change which is appended in the remarks part of the hourly and special observations and there is the pressure change which is recorded every three hours in the 00, 03, 06, 09, 12, 15, 18, and 21 UTC observations. In the manual observation, the 12-hour mean temperature that is used in the sea-level pressure adjustment is calculated from the current ambient temperature and the ambient temperature 12 hours ago. A short-term pressure change remark (PRESRR or PRESFR) is reported if the pressure is rising or falling at a rate of at least .06 inch per hour and the pressure change during the last 20 minutes totals .02 inch or more. The station pressure is determined by adjusting the corrected barometric pressure to compensate for the difference between the height of the barometer and the designated station elevation.

ASOS calculates a 1-minute average pressure once each minute using the six 10-second readings. The station pressure is calculated using the average pressure reading and the average temperature in degrees Rankine. The Rankine temperature scale is in degrees F with the zero point of the Kelvin (K) scale. Thus the ice point is 491.69 degrees R.

First the difference between sensor elevation (H_z) and station elevation (H_p) is determined.

$H_{zp} = (H_z - H_p)$

Then, the average 5-minute temperature (R) and average 1-minute pressure is calculated.

The station pressure is calculated from the following equation:

$P_s = P \times 10^{(0.00813 \times H_{zp}/avgT(R))}$

If the temperature is marked missing and the absolute value of H_{zp} is less than or equal to 100 feet, station pressure is calculated using the following equation:

$P_s = [AS^{0.1903} - (1.313 \times 10^{-5}) \times H_p]^{5.255}$

Where AS is the altimeter setting.

The altimeter setting is calculated using the field pressure (P_a) and field elevation (H_a) using the following equation:

$AS = [P_a^{0.1903} + (1.313 \times 10^{-5}) \times H_a]^{5.255}$

If the field pressure is missing, the average pressure (P) and elevation of the pressure sensor (H_z) are used. Readings are rounded down to the nearest 0.01 inch.

Each minute ASOS checks the remark criteria. Remarks meeting the criteria are included in all observations, including the next hourly. Only the most recent remark is included in the observation. There are three possible remarks generated; PRESRR and PRESFR uses a 20 minute comparison of the station pressure and are reported in the hourly or special observations if the criteria are met. The pressure change tendency, which uses three hours of data, is denoted by the "5" indicator in the 3-hourly observation. If any of the pressures are missing, the remark is denoted as 5////. Other remark criteria are:

PRESRR - If $(P_s - P_{s(20min)}) > 0.025$

PRESFR - If $(P_s - P_{s(20min)}) < 0.025$

4. Limitations.

For proper performance, all pressure vent tubing must be clear of obstructions and not be crimped, cut or pinched by any objects.

It has been noted that there may be times when pressure rising and pressure falling remarks may not always be representative of current pressure trends in the context of previously reported manual trends because of the short 20 minute ASOS time intervals versus the detection of features at a larger scale of motion.

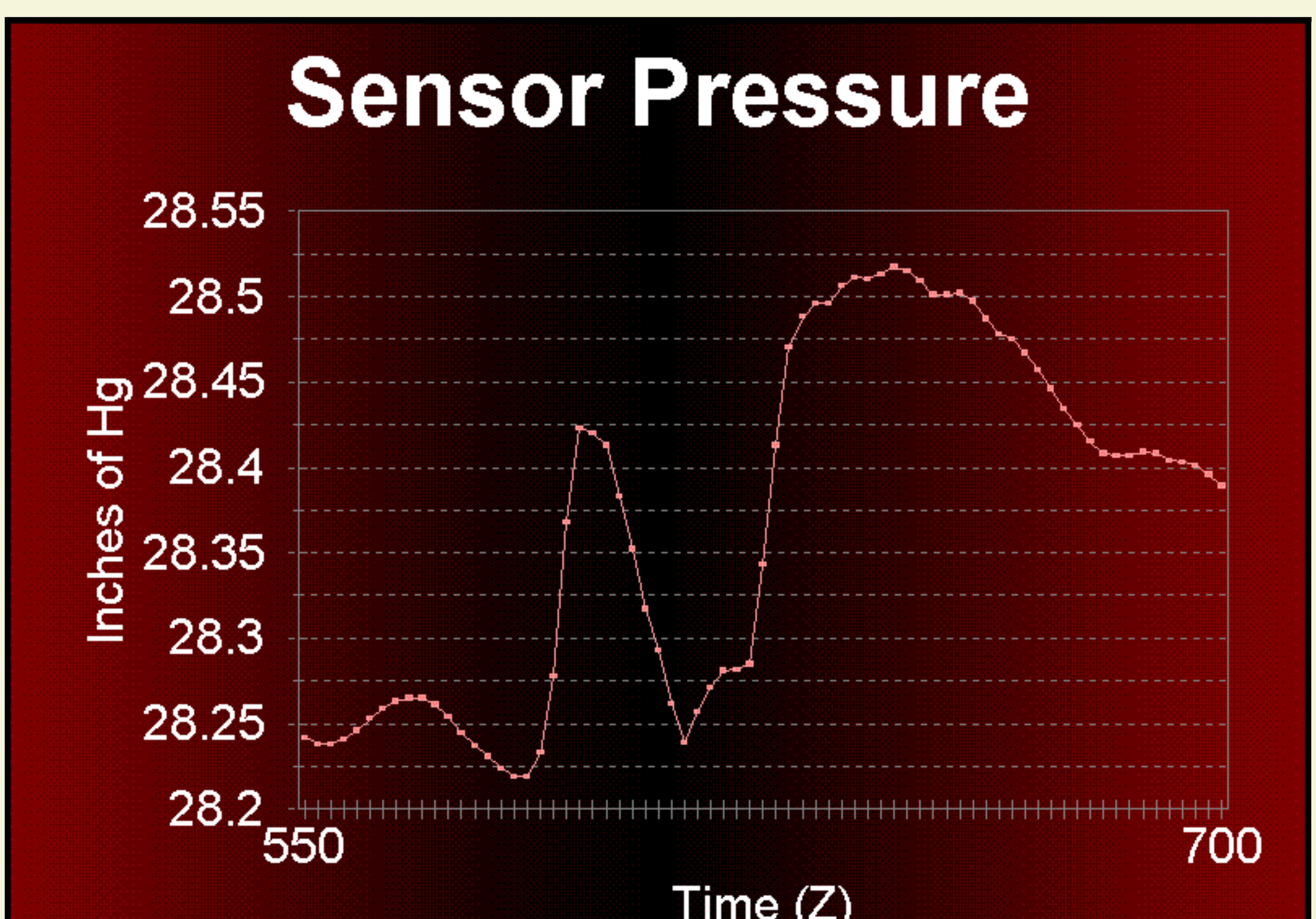
In addition, with automated systems, the pressure measurements are more responsive to rapidly changing atmospheric conditions, such as cyclogenesis. Remember that the lowest pressure measured of the two or three sensors is the one that is actually reported.

5. Comparison Studies and Data Uses.

A study at the Atlantic City, New Jersey airport between January and May, 1992 (Hayes and Huhl, 1995), noted that 98% of the ASOS observations had altimeter readings within 0.02 inches of the corresponding manual observations. They noted that ASOS reported 3 times as many pressure falling rapidly (PRESFR) remarks as manual observers did, and about 2 1/2 as many pressure rising rapidly (PRESRR) remarks. They attributed this to the continuous weather watch capability of ASOS and the difference in the way the algorithm computes pressure remarks.

The 1-minute pressure data from ASOS was used to study a high wind event which occurred across northern Alabama. The winds, which were in excess of 70 mph, were attributed to a gravity wave that could be followed in the ASOS wind and pressure data. (For additional details see the Birmingham NWS web page.)

A graphic example of the type of detailed pressure information that ASOS can provide can be seen in the following figure of the 1-minute pressure change during a wet microburst which occurred at Concordia, Kansas on July 8, 1992.



One-minute pressure measured by ASOS during a downburst at Concordia, Kansas, between 0550 and 0700 UTC, 8 July 1992.

6. Summary.

a. The automatic ASOS pressure sensor operates continuously and produces more pressure remarks than manual observations.

b. Since each pressure transducer shares the same tygon sensor tube, each receives the same barometric pressure input level, ensuring reliable reporting of barometric pressure information.

c. Each pressure sensor is polled for data once every 10 seconds and compared to verify the accuracy of the measured data.

d. Because the pressure sensors are critical to aircraft safety a technician is required to take a positive action to clear a data quality failure and bring the sensor on-line.

e. A technician must verify the accuracy of data from the pressure sensors by comparing pressure sensor output data against a calibrated portable pressure standard.

f. The station pressure is calculated using the average pressure reading and the average temperature in degrees Rankine.