Vaisala's new SPH10/20 static pressure heads, ideal for outdoor installations, were designed to eliminate the effects of wind on barometric pressure readings.

SPH10/20 static pressure heads for

Reliable Barometric Pressure Measurement in All Wind Conditions

Vaisala has launched its new SPH10/20 static pressure heads designed to eliminate the effects of wind on barometric pressure readings. Effects caused by wind lead to major errors in the barometric pressure measurement. According to WMO recommendations, meteorological measurements must account for these wind-induced effects.

Effects caused by buildings

Wind-induced effects are, perhaps, the main source of errors in the barometric pressure measurement. Wind can be both a direct and an indirect source of error to the measurement. Based on the patented principle, Vaisala's new SPH10/20 static pressure heads are used to minimize wind-induced errors.

Indirect influence means changes in the pressure field around an object, which can, for instance, be a building. When moving air encounters an object it will cause an over pressure or under pressure around it. Neither the pressure inside a building is immune to the wind surrounding it. Potential sources of error are due to pressure fluctuation inside the building caused by wind, as well as by the building's possible air conditioning. Therefore, buildings should not be used as 'static pressure heads'.

Direct influence means dynamic pressure changes to the pressure intake of the instrument, caused by wind. A barometer will not give a true reading of the static pressure, if it is affected by gusty wind. Instead, its reading will fluctuate with the speed and direction of the wind. This effect on the pressure reading may be in the order of several hectopascals.

These effects are also discussed in the WMO[1] guide.

Minimizing a wind-induced error

A preferable location for a barometer would be an open field without any obstacles close to the barometer, which

Timo Ranta-aho, Tech. Lic.
Product Manager
Sensors Systems Division
Vaisala Helsinki
Finland

could disturb it. In strong and gusty winds, the direct effects can be cancelled out by using a static pressure head to 'filter out' the effect of dynamic pressure[1]. This type of head needs to be designed carefully and thoroughly.

In addition to having the properties to minimize wind-induced error, several other factors must also be taken into account in the design of a pressure head. It should preferably be small with a hardy structure. It should not contain channels that could easily become blocked due to rain or condensed water. All channels should also remain open in snowy and icy conditions. The structure should be such that the head is easy to remove for service and cleaning.

All of these things have been carefully considered in the design of the new Vaisala SPH10/20 static pressure heads. The structure of the pressure heads consists of two convex plates with openings to the pressure channel at the axis bar between the plates. The structure is both vertically and horizontally symmetrical, minimizing any effects due to the wind direction. The lower plate has openings on its base to allow rain and condensed water to flow out. The plates are made of PC plastic and the bar is made of sea aluminum, so as to be corrosion resistant.

Two versatile models

There are two different models available: the SPH10 is a basic version and the SPH20, is a heated version to ensure reliable operation in snowy and icy conditions. The SPH heads were designed in co-operation with the Laboratory of Aerodynamics at the Helsinki University of Technology (Finland), and their wind tunnel was used for testing the prototypes[2].

A static pressure error is defined as the difference between the measured static pressure (through the pressure head) and the actual static pressure. Results can be presented as pressure differences in pressure units (hPa), but also as a pressure coefficient C_p, which is useful in comparing the results of different pressure heads, and the measurement made at different air flow speeds.

The pressure coefficient C_p is defined as:

$$C_p = \frac{\text{static pressure error}}{\text{kinetic pressure}}$$

where

kinetic pressure = 0.5 x (density of the air) x (wind speed)^2

For example, a pressure coefficient of 0.1 means that 10 % of the kinetic pressure is still left as a pressure error in the pressure reading. Positive sign means measuring too high, and negative sign means measuring too low a pressure through the pressure head. As the static pressure error is comparable to the square of the wind speed, it cannot be numerically compensated with a constant coefficient. Proper compensation would require a compensation coefficient for vertical and horizontal wind speed and direction, making numerical compensation a very complicated task.

Measured pressure difference and pressure coefficient

Figures 1 and 2 show the measured pressure error and pressure coefficient of SPH heads as a function of the angle of attack of the air flow. At an angle of zero, the air flow comes directly from the side of the head. In negative angles the air flow hits the pressure head from above and, in positive angles, from below.

The most important aspect of the graphs is the angles close to zero, because the pressure head is installed vertically, and is generally relatively close to the ground. Pressure heads usually tend to have some offset at their pressure coefficient which is usually negative, even at angles close to zero. This means that part of the kinetic pressure always remains as a pressure measurement error in the barometer output at all wind speeds.

In SPH heads the geometry sets the pressure coefficient between the plates as slightly positive. This is then adjusted to zero by allowing the air to leak to a lower pressure region. Figure 2 shows that with SPH heads at the angle of zero the pressure coefficient is also close to zero. Therefore the pressure inside the pressure head closely corresponds to the static pressure of a free air flow, regardless of the wind speed.

Figure 1 also shows that with SPH heads, the pressure error is below 0.3 hPa at all angles measured, (WMO recommendation for operational network station barometers[1]) and below this limit also at a flow of 20 m/s between angles of –20…+20 °. The results are the same, regardless of the horizontal direction of the air flow. In many pressure heads this is not the case due to some supporting arm or other structure breaking the symmetry of the head. Also, the pressure coeffi-

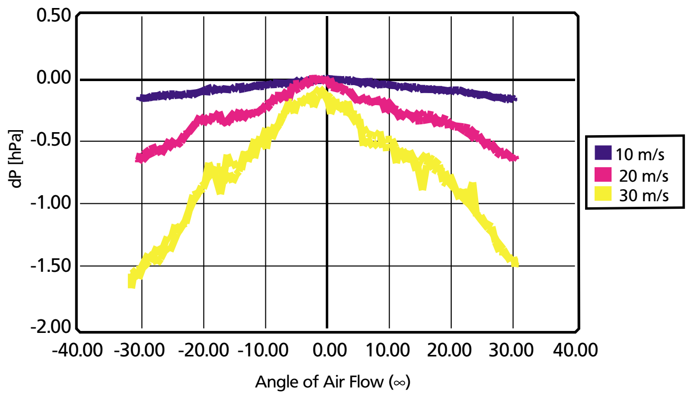

Figure 1. The pressure error (dP) measurements in a wind tunnel through SPH heads as a function of the angle of the attacked airflow.

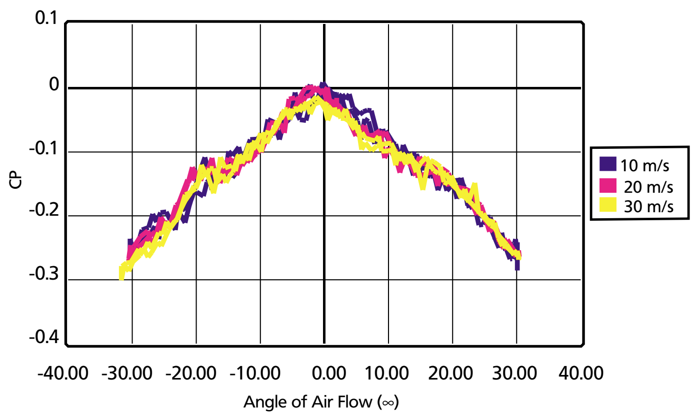

Figure 2. The pressure coefficient (C_p) measurements in a wind tunnel through SPH heads as a function of the angle of the attacked airflow.

cient in the vertical direction often behaves asymmetrically.

Ideal for outdoor installations

The new pressure heads SPH10 and SPH20 are easy to install and easy to disassemble for service and cleaning, even at the installation site. The plates are made of ultra violet stabilized PC plastic to ensure that the head maintains its correct shape in all outdoor conditions. The axis bar is made of corrosion tolerant sea aluminum. The warmed SPH20 contains a thermostat to switch on the warming power at temperatures where there might be a risk of freezing. In addition to minimizing the wind error, SPH heads also protect against rain and condensed water, preventing capillary condensation of a water column in the pressure channel, which would lead to a pressure error.

The new Vaisala PTB210 Digital Barometer can be directly installed on top of the SPH heads. All other barometers can be connected to the SPH head with pressure tubing. SPH10 and SPH20 are the perfect pair to complement all Vaisala barometers, as they ensure an accurate and reliable measurement in all weather conditions. ■

1] World Meteorological Organization (WMO), Guide to Meteorological Instruments and Methods of Observation, Sixth Edition, WMO-No. 8, 1996.

2] Palomäki P., Measurement of Barometric pressure in the Wind, Master's Thesis (in Finnish), Helsinki University of Technology, 1999.

The PMI20 Digital Barometer Display is a

Perfect Partner for Vaisala's Digital Barometers

Vaisala's new PMI20 Digital Barometer Display is ideal for manned weather stations and laboratories and offers extensive possibilities, as it confers additional properties to barometers. The PMI20 is a barometric display which can be connected directly to Vaisala's barometers.

The PMI20 Digital Barometer Display is ideal for laboratories.

There are several vital requirements for barometers used in meteorological installations. They include good accuracy and long term stability, as well as stability over variations of ambient temperature. Additionally, the barometer should provide quick and easy readings and should also, preferably, indicate the trend of pressure changes. The new PMI20 barometric display is ideal for these purposes.

Remote display with control outputs

The PMI20 Digital Display is compatible with all of Vaisala's current barometers with a serial output, as well as with the PTU200 Pressure, Temperature and Humidity Transmitter. The PMI20 can be connected directly to a barometer. The display automatically identifies the type of unit connected and sets the serial communication parameters.

The PMI20 is ideal for manned weather stations and laboratories. It has both an RS232 and an RS485 connection to the barometer and to a PC. As the RS485 allows for a distance of up to one kilometer between the barometer and the display, the display may be used as an in-house remote display for a barometer installed outdoors at the actual measuring site. The display can easily be installed in a standard panel cutout. Five programmable, open collector-type control outputs allow the display to also be used as a control unit and to control external relays, for instance.

Various displayed values

The PMI20 digital barometer display is easy to use and the whole operating menu can be controlled with one knob. The PMI20 has a large backlit display with 150 x 32-pixel resolution. The measured data can be outputted either in metric or non-metric units and the pressure unit can be selected from eleven different alternatives. Display settings can be secured by setting a key code, which prevents all changes to the unit and stops it from being switched off without the code.

The barometric display shows the current pressure output of the barometer, the calculated three-hour pressure trend and the WMO pressure tendency code simultaneously. Furthermore, a height-corrected pressure (HCP) can be calculated and displayed for ±40 meters. This enables the measured pressure to be reduced to a reference altitude level – for example, the surface of the runway at an airport or the sea surface level in the case of a ship installation.

The display of the PTU200 transmitter shows all three measured parameters at the same time; i.e. pressure, humidity and temperature. The user can also select the PMI20 special mode as wished to show a dew point (frost point) value.

The PMI20 has a battery secured memory which stores the data measured over the last 24 hours. The user can view data on the display as graphical trends or download it to a PC. ■