# Design and Characteristics of the MET3A High-Performance Dual Pressure Port

**(DigiPort)**

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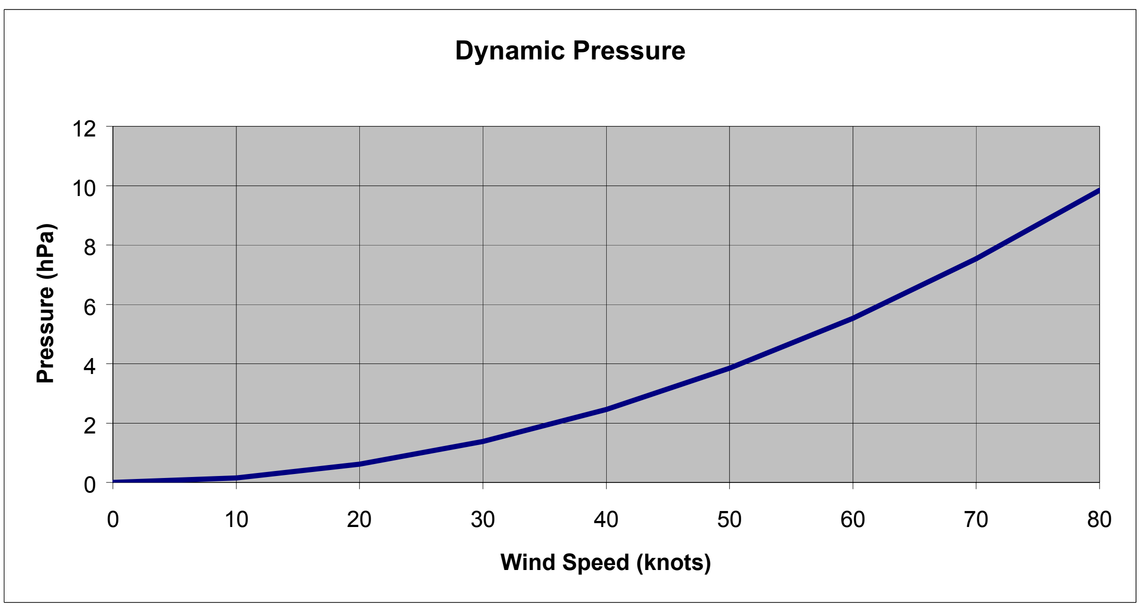
# Design and Characteristics of the MET3A High-Performance Dual Pressure Port

The high-performance dual pressure port arrangement of the MET3A Meteorological System minimizes dynamic pressure errors under windy conditions. The static pressure port is engineered to provide barometric accuracy of better than 0.08 hPa in strong winds, all wind directions, pitch or tilt angles up to 25 degrees, rain, and freezing conditions. This pressure port is the best engineering solution available for measuring ambient pressure under a variety of environmental conditions. It outperforms open ports, single ports, single disks, shrouded pipes, closely spaced dual-disks, multi-hole probes, probes incorporating spheres or cones, and swiveling pitot tubes with static pressure inlets.

## Pressure Port Design Considerations

There are many high-accuracy applications for measuring atmospheric static pressure in outdoors settings. These include weather stations, digital altimeter setting indicators at airports, ocean buoys, and installations to measure pressure fluctuations around buildings, infrasound pressure fluctuations, and turbulence from airplanes.

Wind produces a dynamic pressure Q (also called impact pressure) that rises as $\frac{1}{2} \rho v^2$, where $\rho$ is the density of air and v is the wind speed. Even low wind speeds produce considerable dynamic pressure, reaching 0.1 hPa at winds of 4 m/s (8 knots), and rising quadratically to values of 2.5 hPa at a wind speed of 20 m/s (40 knots).




Under dynamic pressure, it is very difficult to measure static ambient pressure. Open pressure ports, i.e. open pipes, are unsuitable for high-accuracy measurements. One solution is to place a perpendicular port in the center of a single disk, which is oriented horizontally into the wind. However, small pitch changes of the wind (or tilt of the port, e.g. on an ocean buoy) still produce large pressure errors of magnitude {sine(pitch) * Q}. At 10 degrees pitch, the errors reach 0.4 hPa at a wind speed of 20 m/s (40 knots). Placing the pressure port out of the wind is not a good solution either. The obstacle that blocks the wind creates unpredictable turbulence and generally lowers the air pressure by the Bernoulli effect (which states that an increase in flow over an obstacle must be accompanied by a corresponding decrease in pressure). On windy days, the pressure in buildings, or in ship enclosures, etc. is generally considerably lower than the actual static pressure. Thus placing the barometers inside airports or weather stations is usually not optimal. Besides, the action of heating and air-conditioning systems, and the opening and closing of doors also perturb the static pressure inside a building.

### The MET3A Pressure Port Design

The MET3A pressure port is largely immune to wind effects by an ingenious arrangement of holes that cancel the dynamic air pressure. This is achieved by a dual-layer arrangement of holes that face up and down on two inner disks, which are placed between two larger outer disks. The outer disks provide some channeling direction, but are spaced wide enough to avoid Bernoulli effects from increased air flow velocity between closely spaced dual plates. In addition, the outer disks protect the pressure holes from direct rain. If precipitation enters the inner disks, it is simply drained by the holes facing down, and does not enter the pressure lines leading to the sensor. The entire disk arrangement is circular, thus independent of wind direction (omni-directional). The relatively large size of the pressure holes prevents the port from plugging up under freezing conditions or from biological contamination. The disks are made from lightweight aluminum, surfaced with a reflective white paint, and can easily be cleaned.

### Characteristics of the MET3A Pressure Port

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|---|---|
| Material | Aluminum with white surface |
| Outer disk diameter | 18 cm |
| Outer disk spacing | 7 cm |
| Height above sensor enclosure | 32 cm |
| Wind dependence at 5 m/s (10 knots) | Less than 0.01 hPa |
| Wind dependence at 10 m/s (20 knots) | Less than 0.03 hPa |
| Wind dependence at 20 m/s (40 knots) | Less than 0.12 hPa |
| Wind pitch or tilt range | -25 to 25 degrees (negligible pressure errors) |
| Wind speed tested | 0 to 60 m/s (120 knots) |
| Rain | Holes protected from rain and self-draining |
| Condensation | Flow-restricted drain port below sensor enclosure |
| Ice and biological contamination | Multiple holes keep port open |

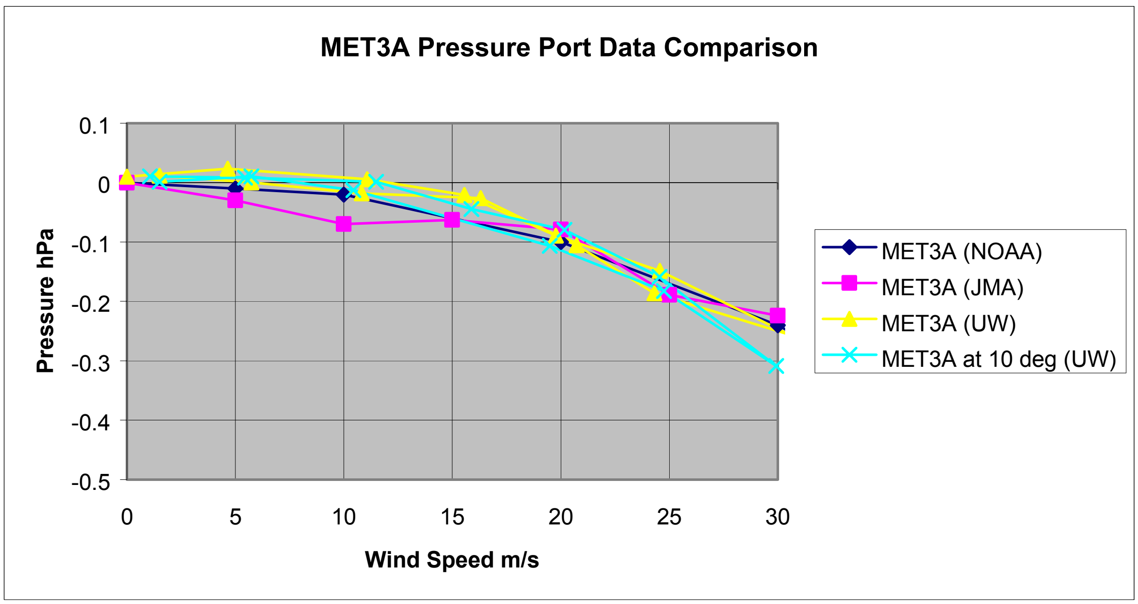
## Test Data

Paroscientific, Inc., performed tests in the Kirsten Wind Tunnel of the Aeronautical Laboratory at the University of Washington (UW), Seattle.

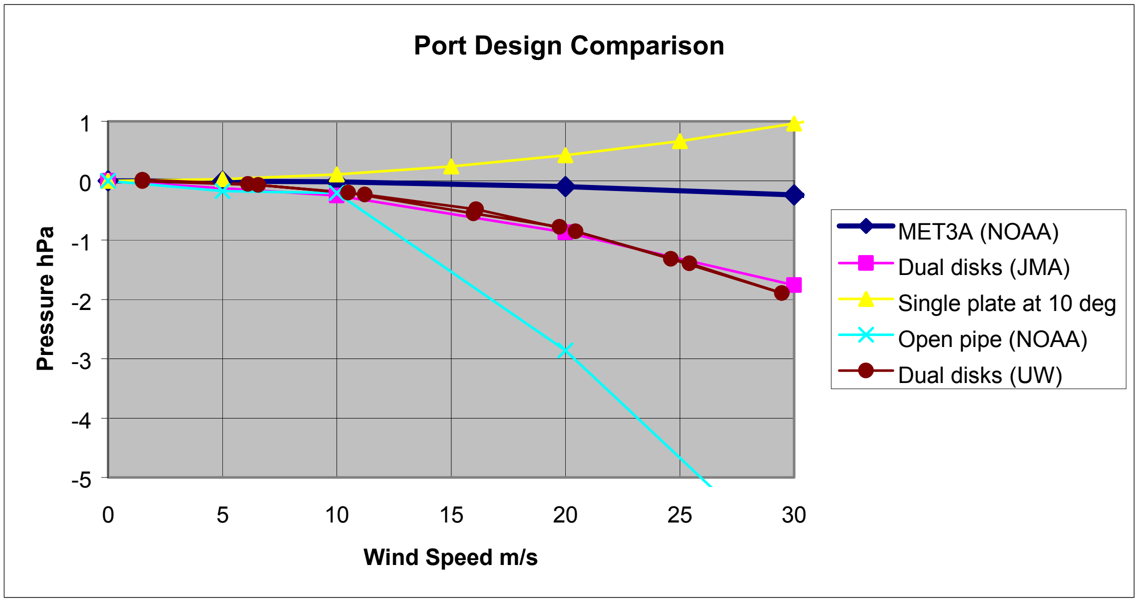
Additional wind tunnel data on the MET3A port performance were kindly provided by:

- National Data Buoy Center; wind tunnel tests performed at NOAA, Stennis Space Center, MS (NOAA)
- Japan Meteorological Laboratory (JMA)

The first graph shows several data sets recorded in wind tunnels of different laboratories showing the dependence of sensor pressure on wind speed. The agreement between data sets is very good. The pressure change follows a quadratic curve of $dP = a\ v^2$, where $a = -0.00029$ (pressure units in hPa, wind speed in m/s), as determined by a least-squares fit of the data shown.




The second graph shows how much better the MET3A port performs as compared to closely spaced dual disks, open pipes, or single plates at small pitch angle.




## Conclusions

Accurate measurements of barometric pressure require an environmentally rugged pressure port design that minimizes pressure errors under dynamic wind conditions. Wind tunnel and field tests of the MET3A Meteorological System dual pressure-port arrangement show superior performance over all other ports. Barometric readings with the MET3A pressure port system easily meet the requirements of GPS Meteorology, Weather Stations, Digital Altimeter Setting Indicators, High-Resolution Measurements of Atmospheric Waves, and Aircraft Wake-Turbulence Detection.

(TPS 8/21/00)