Addressing Frequency Response Effects In Automotive Aerodynamic Pressure Measurements

Because the aerodynamic point of interest, and point of measurement, is connected via a tube to the pressure sensor, or scanner, there can be detrimental effects in the measurement.

These are often categorised under the broad term of Frequency Response Effects.

It's usually unavoidable, as it's very difficult, because of the physical size of the scanner, to locate it exactly where you want to measure. For example, an aerodynamic surface may be many metres from the nearest place you can locate your scanner.

This is a complicated subject – there have been many studies over the years by universities, research establishments and even NASA to try to understand and correct for this phenomenon.

The effect is hard to measure or quantify, as there are so many variables that contribute to the offset that is created by the tubing. Physically, the air that is in the tubing is highly compressible, like having a spring inside the tube, rather than a cable, where the input at one end, is not only delayed in reaching the pressure device, but it is also attenuated or altered. The air temperature, and hence the density and Velocity of Sound, applies an effect on the frequency response, as does the length of the tube. The elasticity of the tube wall also absorbs some of the energy in the pressure wave, as do bends in the tube, as the boundary layer friction of the walls plays a part in the offset.

A further complication to consider is that there are three effects of the tubing – there can be a phase shift where the pulse arrives sometime after it starts, the amplitude becomes distorted, changing the view of the event at the scanner, and there are often also complex resonances set up within the tubing. The tubing also adds cost, the risk of failure and leakage, and a tube bundle can be quite a significant diameter. Kinked tubes will also produce false or no readings, so the geometrical layout of the tubing array is very important and often compromised by existing immovable structures. Add-in then, the complexity that it's not one tube, it's 16, 32 or 64!

Application Note: 010/07/001

So, how different is the pressure when it arrives at the point of measurement?

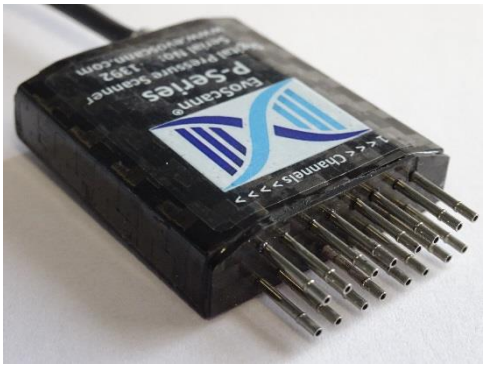
It depends!

In most cases, then, the best compromise is to accept that there is a systematic offset created by the tube you use. Therefore, the best that can be done is to use the smallest diameter tube possible, use the same length of tube and the same tube material for every measurement application, to ensure the same offset every time. This might not be easy to achieve as the tube has bend radius, compatibility and pressure and temperature limitations that may make it unsuitable for your next measurement task.

EvoScann®, Evolution Measurement's innovative range of pressure scanners, are a game changer. The units are physically small enough to be installed extremely close to the point of measurement. In an F1 car for example, the scanner would be mounted in the actual floor or the aerofoil where the measurement is needed, rather than running 4-5m of tubing back to a traditional scanner. Not only is the EvoScann® small, it's also very rugged, very light and it's insensitive to vibration, so it means locating it inside the aero section is low risk to the scanner and not detrimental to the aerodynamic performance of the vehicle.

Whilst the headline spec of the scanner may be way less than 0.1% of a very small pressure value, when it's installed in real-world applications, even with the optimal installation, the total system error including tubing would create a very different picture. By using EvoScann® and keeping the tubing as short as a few centimetres, much of the system uncertainty is removed, ensuring that measurement is done at the point of interest. In terms of installation, then, the EvoScann® would be located at the point of measurement, the unit would be directly connected to the ECU node point and the EvoScann® would talk to the car in its own language, CANbus, without the need for any special software or hardware interface.

EvoScann® Specification:



Compact, high performance Pressure Scanner

- ✓ Smallest, lightest pressure scanner available
- ✓ Wide range of Aerodynamic applications
- ✓ Absolute or Differential measurement
- ✓ Lightweight Carbon-Fibre external construction
- ✓ Integral microprocessor
- ✓ High accuracy output directly in engineering units
- ✓ CANbus, Ethernet and EtherCAT options

EvoScann® P-series is a highly-miniaturised pressure scanner designed specifically to meet the stringent demands of the aerodynamic testing industry where development is rapid and continuous. The P-Series has been designed, from the start, with physical size, weight,
accuracy and functionality in-mind and is available in a variety of configurations from 8-16-64 pressure channels.

SMALL AND LIGHT

Weight and size limit the ability to measure in difficult locations. Weighing in at <15g and with compact dimensions, the EvoScann® P-Series can be located within the tightest of spaces where rapid pressure mapping is needed.

PLUG and PLAY

With no requirement for a remote converter or other hardware, the EvoScann® P-Series transmits accurate, fast data, in engineering units, directly to the test article's central processing unit. Using a single cable to provide the power and transmit the data and with a choice of industry-standard connectors, the EvoScann® P-Series scanner is ready to plug-and-play, producing high-speed synchronous data within seconds of connection.

ROBUST

EvoScann® P-Series is insignificantly light, has integral impact and splash-protection and can be fitted into the smallest of aerofoil or aerodynamic profiles with minimal external influences. A high operating temperature range means that even use in proximity to hot vehicle parts is possible, extending measurement to the most critical areas.

ACCURATE

An array of high-performance piezo-electric pressure sensors ensure the highest accuracy and measurement of a complete aero section in one compact device. EvoScann® P-Series scanners can be supplied in Absolute, Calculated or true-Differential modes across a wide selection of pressure ranges, including custom ranges. Integrated temperature sensors provide useful data, but also apply temperature correction to the pressure sensors, at source, to ensure optimal performance and minimal ambient temperature effects.

In addition to a versatile range of high-performance pressure scanners, Evolution Measurement offer the widest range of accessories including pressure tubulations, tubing and connectors that enable the scanner to be integrated and commissioned very quickly and efficiently.

For more Information:

Watch the Youtube video for a short introduction to EvoScann®: https://youtu.be/omyaFZalflg

Download the datasheets:

http://www.evolutionmeasurement.com/Evoscann.pdf

http://www.evolutionmeasurement.com/product/accessories/

Or talk to us about your requirements:

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