Chell

Instruments

Steam Turbine Air In-Leakage Monitor AIM100

- ***Online monitor for improved turbine efficiency***
- ***Diagnose condenser tube fouling, air blanketing and faulty vacuum pumps***
- ***Provides post shut-down diagnostics***
- ***Easy single point installation***
- ***Five continuous 4-20mA outputs***
- ***RS232 or RS485 interface***
- ***Payback in days or weeks on many installations***

Design Philosophy

The benefits of improved steam turbine power plant efficiency not only help power utilities' financial performance, they also result in significantly reduced emissions. All Efficiency Engineers strive to improve their plant's performance, yet the benefits of monitoring air in-leakage are not yet universally understood.

Steam turbine operators may, perhaps, regard their plant as optimised but have not realised that their turbine condenser conditions may be costing the business millions a year in lost output.

The AIM-100, when continuously monitoring condenser exhaust conditions, has frequently provided its users with a payback of days or, at most, weeks!

Often considered a reliable component of the generation cycle, the condenser processes exhaust steam under vacuum & returns it to the plant as water condensate feed to the boiler, where it is once again turned to steam.

One of the most critical factors of this whole cycle is the level of vacuum achieved in the condenser because it controls the turbine backpressure and therefore the level of energy extracted from the steam.

The greatest contributor to poor levels of vacuum is air in-leakage from the many flanged joints, pipe and component welds in the steam containment system.

For over 20 years, Chell's AIM, now in its latest Mk3 guise, has been reliably providing efficiency engineers worldwide with the data they need to manage condenser performance scientifically.

Continuous trending of plant conditions via. 4-20mA and RS485 outputs of Absolute & Differential Pressure, Temperature and Air Flow, enables detailed analysis of condenser overall conditions.

Additionally, the temperature indication provides trending feedback on tube fouling and absolute pressure on increasingly faulty vacuum pumps.

The latest design refinements incorporated in the AIM-100 include the placement of the circuit on a well-proven dual-processor board common with two other Chell multi-channel products, further aiding long-term reliability and serviceability.

Economic Justification

Excessive air in-leakage and ineffective non-condensable gas removal can lead to condenser inefficiencies of over 20%. One generator recently estimated the cost of air in-leakage on a 500MW turbine as in excess of £1600 ($2400) per mbar (0.03inHg) per week.

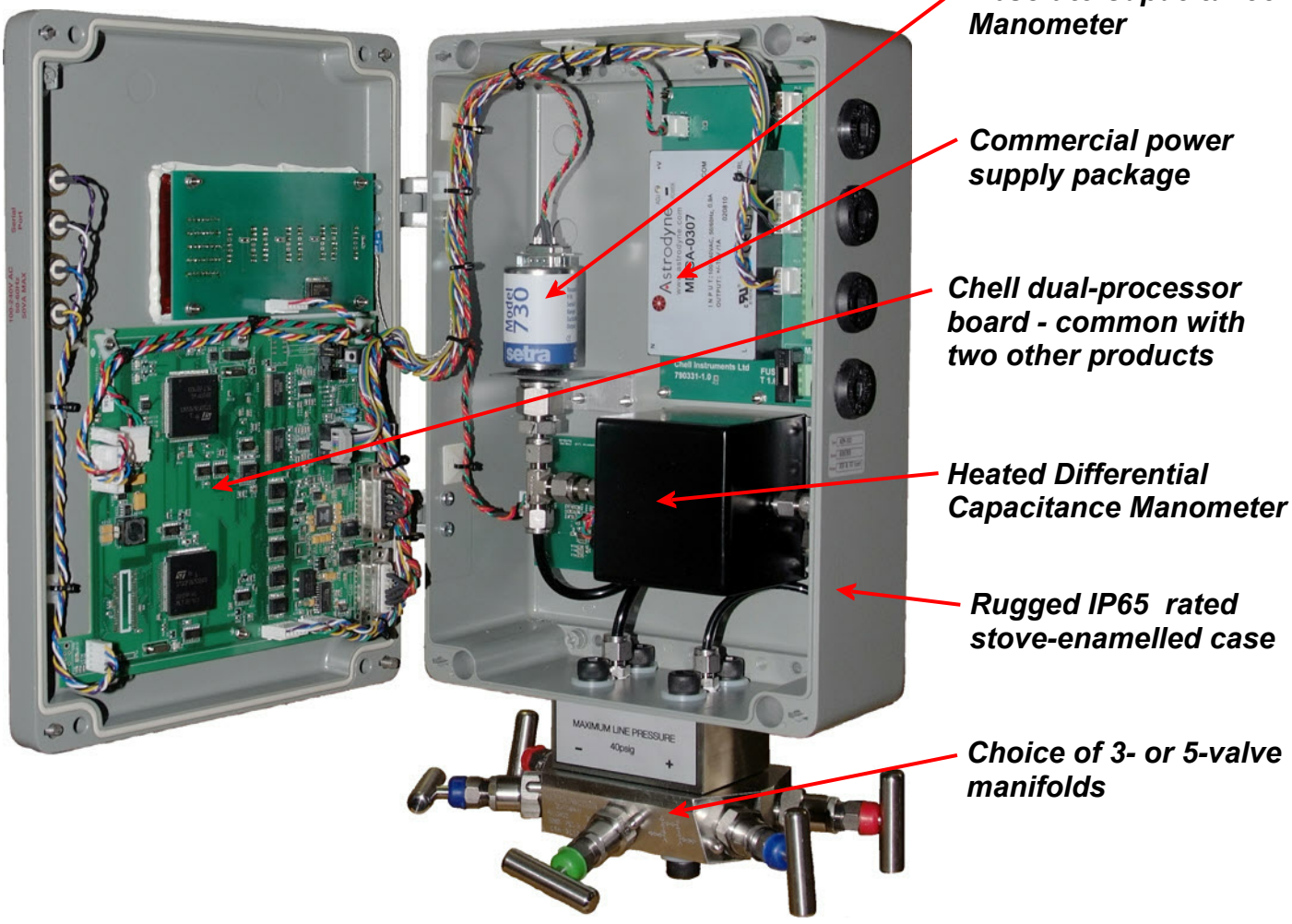
In addition to increased generation costs, the man-hours taken to locate the source of the leak are a major concern.

AIM enables trends to be picked up at an early stage and relevant corrective action to be taken.

Once air in-leakage is detected, comparison of the individual measured parameters under differing plant load conditions with historical data and with other plant measurements, is useful in indicating the most likely source of leak.

Continuous output of all the measured parameters via 4-20 mA signals and RS232 or 485 interfaces allow data logging, further analysis of the information, trending and full integration into the plant management system. Users also report much faster plant start-up after shut-down or maintenance.

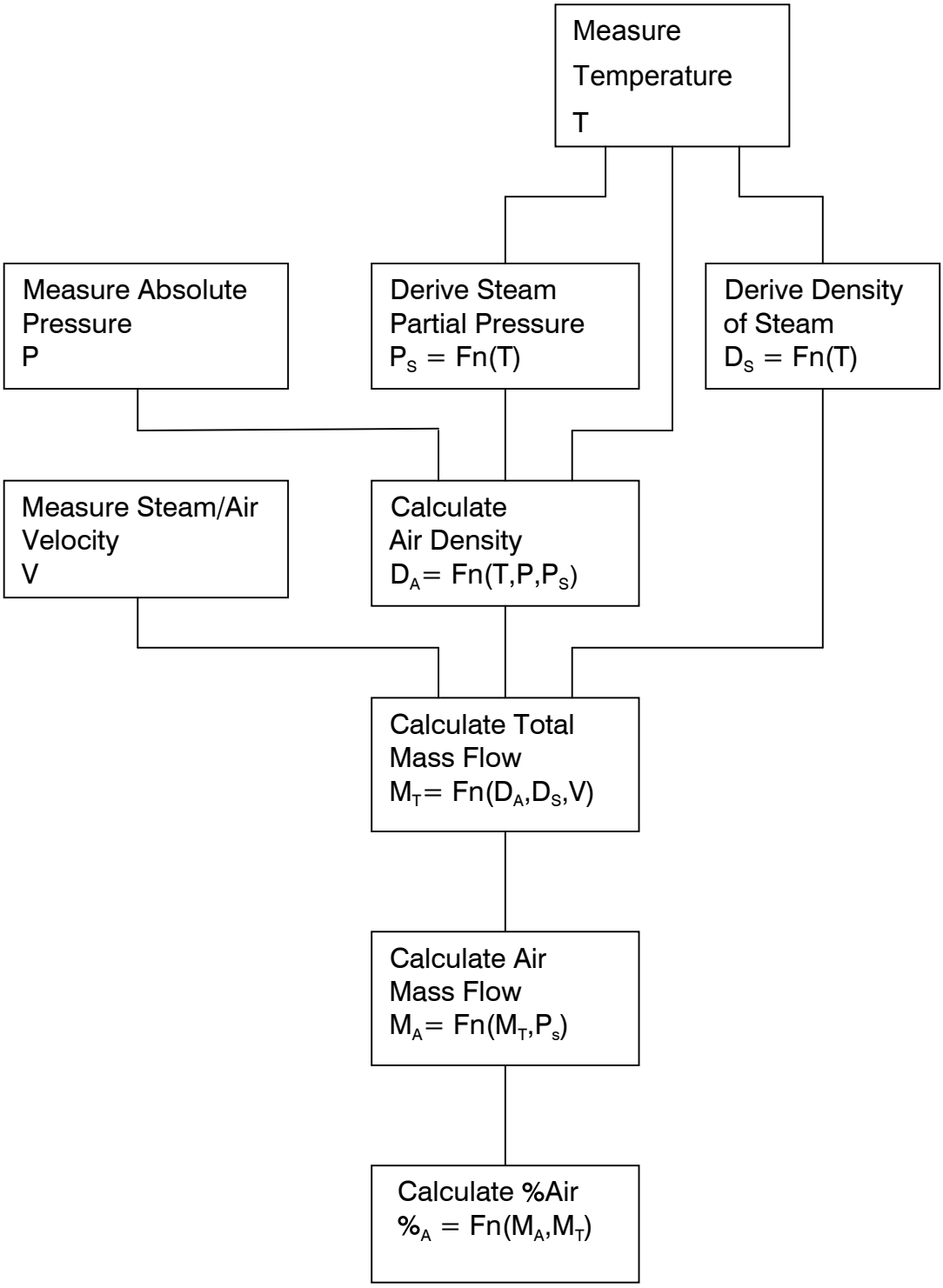
High Integrity Parameter Measurement



The AIM100 incorporates the most stable and repeatable absolute & differential pressure measuring sensors and platinum resistance thermometer instruments and are designed for utmost reliability.

Apart from the microprocessor board, components are selected for their worldwide availability so that in the unlikely event of a failure, repairs may be easily effected in the field, thus reducing downtime. Component accessibility is aided by our design layout giving fast, easy access for field repair by authorised service providers.

Air In-leakage Calculation

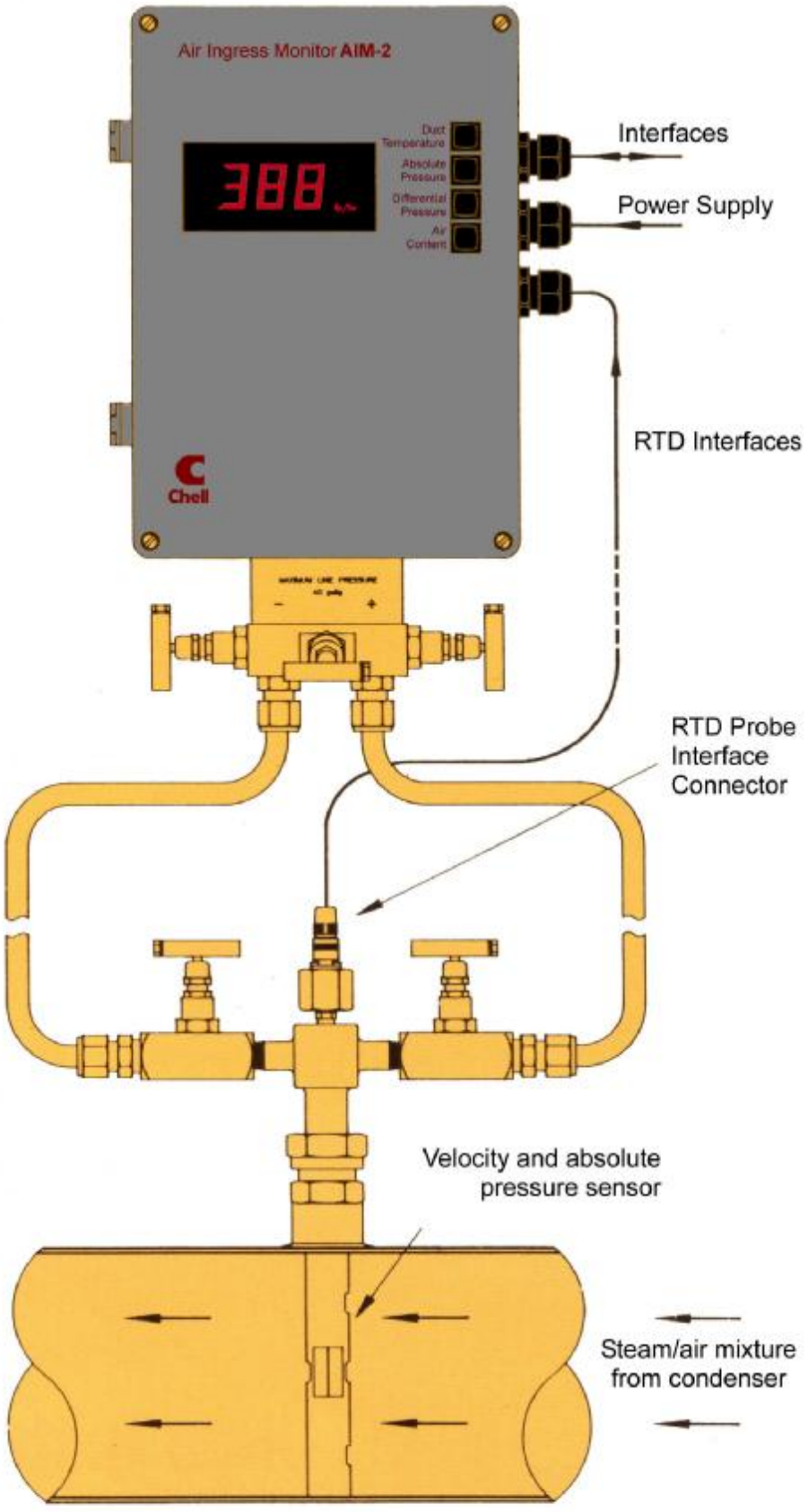


AIM100 makes the measurement of total air flow in the main air extraction or suction pipe between the condenser and the air extraction plant. If the mixture of air and steam flowing in the pipework is considered as two perfect gases, Dalton's Law of Partial Pressures can be used to establish the steam to air mass ratio.

Measurement of the total flow in the pipe using an averaging pitot tube therefore allows the two component flows to be individually assessed.

Dalton's Law requires measurements of temperature and static pressure of the flowing mixture. With the steam partial pressure assumed equal to the saturation pressure corresponding to the measured temperature, the air partial pressure is then obtained by subtraction.

AIM Installation Diagram



AIM100 Principle of Operation

Reliable methods of measuring air in-leakage have long been sought by power plant engineers but unfortunately, due to the flow conditions in the only viable locations to obtain the total air flow, (namely just upstream or downstream of the air extraction plant) most techniques have their drawbacks.

They can suffer from water clogging, poor sensitivity or fragility, with perhaps the biggest disadvantage being that they are not truly continuous. A real time, on-line measurement is what most engineers esire, which would give the plant operators current and trend indications of plant performance.

The principle of the AIM is to measure the total steam-air mixture flow in the air extraction pipework between the condenser and air plant, (this eliminates rogue air leaks at the air plant itself) and by also measuring the steam to air ratio, deduce the component of air.

The total flow is measured by a heated high accuracy differential capacitance manometer connected to an averaging pitot-static probe carefully sited in the air suction pipework.

The steam/air ratio is obtained by accurately measuring the absolute suction pressure with an absolute capacitance manometer and the local temperature using a igh accuracy platinum resistance thermometer on the centreline of the probe. The simple application of Dalton's Law of Partial Pressures by the microprocessor then provides the solution.

The gathering, processing and display of data is all microprocessor controlled, housed with the rest of the interface electronics and the transducers in a robust fixed enclosure. All the parameters, namely measured differential pressure, absolute pressure and temperature, with calculated air flow rate and percentage air can be displayed locally, sent via 4-20mA signal or RS232/485 interfaces to control rooms or outstations for logging and trending.

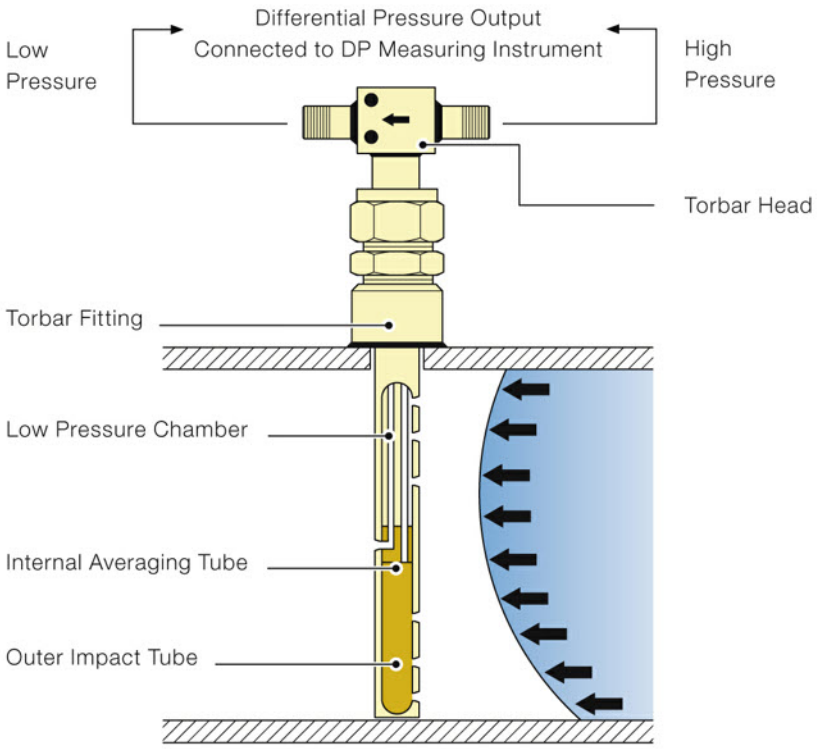
TORBAR Averaging Pitot Tube

The pitot tube is designed to span the process pipe diameter and comprises four components:

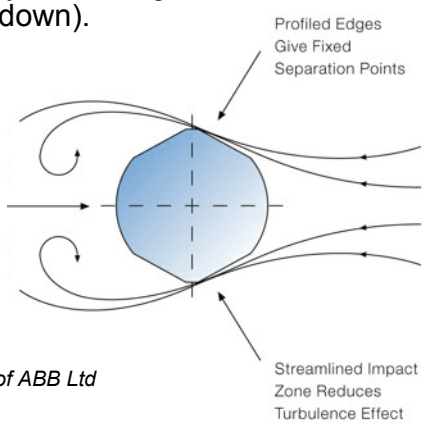
Outer one-piece impact tube - Internal averaging tube - Low pressure chamber - Head

The outer impact tube has a number of pressure sensing holes facing upstream which are positioned at equal annular points in accordance with a log-linear distribution. The "total pressures" developed at each upstream hole by the impact of the flowing medium are firstly averaged within the outer impact tube and then to a second order (and more accurately) averaged within the internal averaging tube.

This pressure is represented at the head as the high pressure component of the DP output. The low pressure component is generated from a single sensing hole located on the downstream side of the outer impact tube.



The TORBAR is an improvement on round sensor designs due to the unique profiled flats which are positioned around the downstream hole in order to define the flow separation point as the fluid passes around the outer impact tube. This feature creates a stable pressure area at the downstream pressure sensing hole, thereby maintaining a more constant flow coefficient at high velocities, enabling a very wide range of flow measurement (turndown).



TORBAR data courtesy of ABB Ltd

AIM Configuration

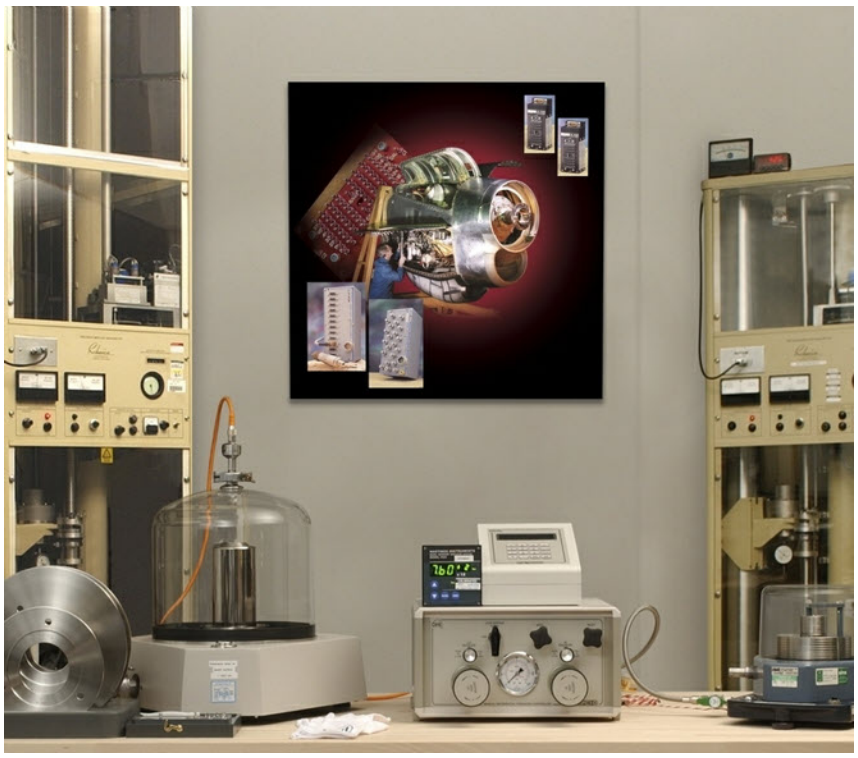
Every power plant has its own individual design features and the easiest way to optimise an AIM installation is by completing the Configuration Questionnaire to be found at :

www.chell-instruments.co.uk/chell/pdfs/aimconfig.pdf

Many features such as multiple vacuum exhaust lines, horizontal, vertical and with many bends have already had successful AIM installations and our Applications Engineers are always happy to visit your site to assist in completion of the form.

Final location of the pitot tube insertion may be determined by reference to this advice from the manufacturers: www.chell-instruments.co.uk/chell/pdfs/pitotinstallation.pdf

Calibration & Support



The AIM100 has been designed to give long, reliable service in typical power plant environments, indeed most of the first generation are now 20 years old & are still giving good service. Some users prefer to have their instrumentation on a calibration cycle, returning their instruments to Chell's UKAS Laboratory for both calibration and any firmware upgrade available.

Having some of the lowest uncertainties available for pressure, vaccum & gas flow calibrations, the Chell calibration laboratory provides our customers with the highest confidence in their subsequent on-plant measurements. We also offer an on-site calibration service for those who wish to avoid the downtime.

USA Support

In the USA, our LRM distributor, Exelon PowerLabs LLC provide an American Association of Laboratory Accreditation (A2LA) accredited calibration service for the AIM100. A2LA has recognised Exelon PowerLabs calibration laboratory competence through accreditation to ISO17025.

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