PACE CM3

Where speed and accuracy combine

druck.com

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Introduction

Druck, a Baker Hughes business, has been developing and delivering pressure measurement solutions to customers for more than 40 Years, across many applications in Aerospace, Oil & Gas, Industrial, Metrological Laboratories and many others. One of Druck's main areas of technical expertise is Pressure Controllers. These are used in many different industrial applications and by metrological laboratories as calibration standards around the world.

Druck's PACE pressure controllers are widely recognised as the world's fastest, with the ability to fill and control volumes of 300cc in under 5 seconds.

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As Druck's proprietary sensing technology known as TERPS (Trench Etched Resonant Pressure Sensor) has evolved, Druck has planned the expansion of the PACE platform, in particular increasing the pressure range of the PACE control modules by adding to the already successful CM3 high accuracy pressure controller modules. This paper focuses on the introduction to the market of new pressure controller modules in the CM3 range and what their performance will mean for Druck's customers.

Druck is expanding its PACE CM3 control modules from the already successful 2 bar and 3.5 bar absolute products to include new pressure ranges. Druck has recently released new absolute pressure controller ranges of 8, 11, 21, 36 and 71 bar and the associated pseudo gauge controller ranges 7, 10, 20, 35 and 70 bar. Druck will continue the development of future pressure ranges, with up to 211 bar absolute pressure planned for release during 2021.

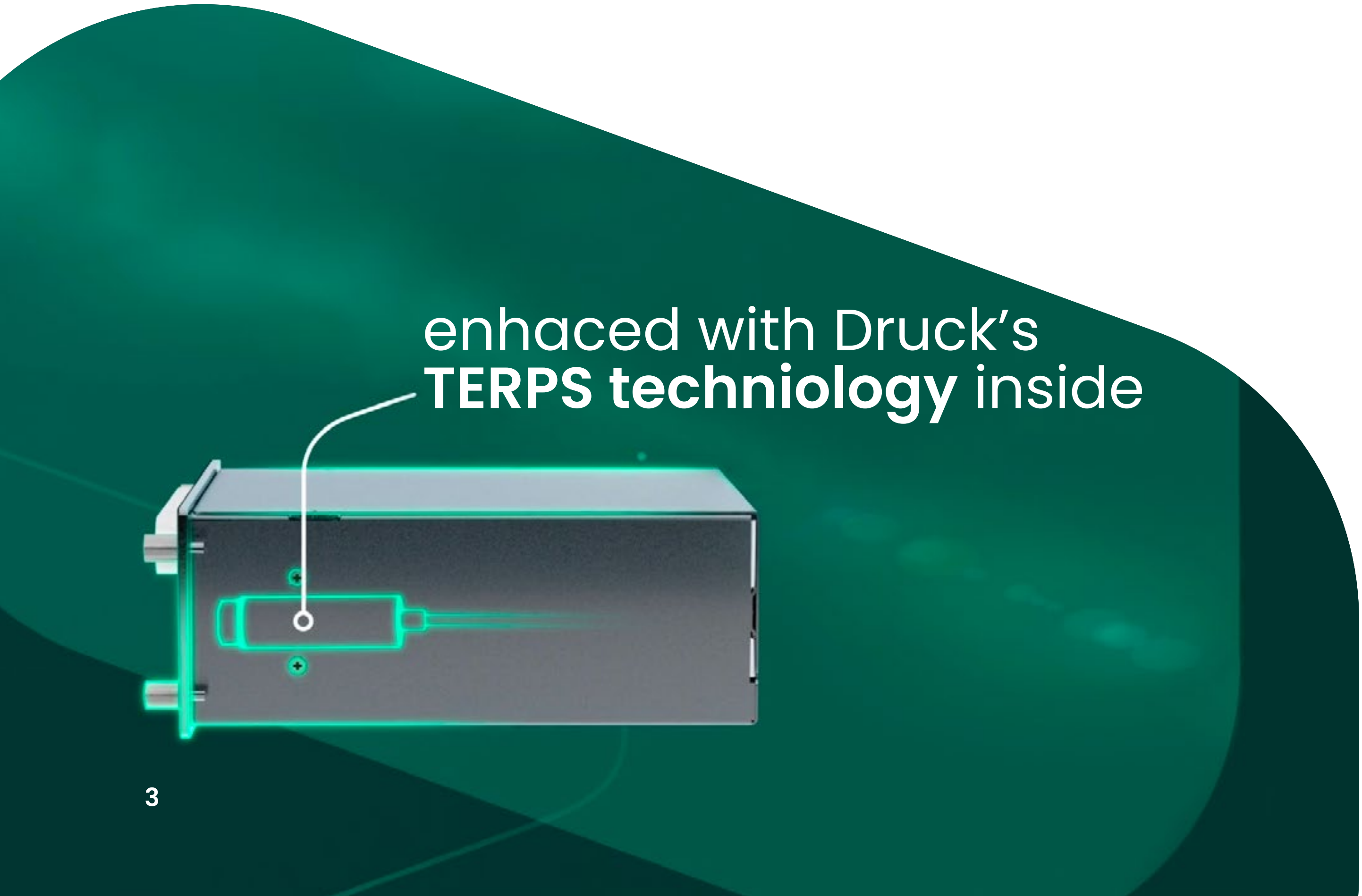
PACE CM3 will utilise Druck's established TERPS® (Trench Etched Resonant Pressure Sensor) technology at its core, which delivers unprecedented metrological characteristics and resultant levels of performance for PACE controllers.

This paper will present the main attributes of PACE CM3 enabled pressure controllers and resultant performance, namely:

Druck's PACE pressure controller is widely recognised as the world's fastest

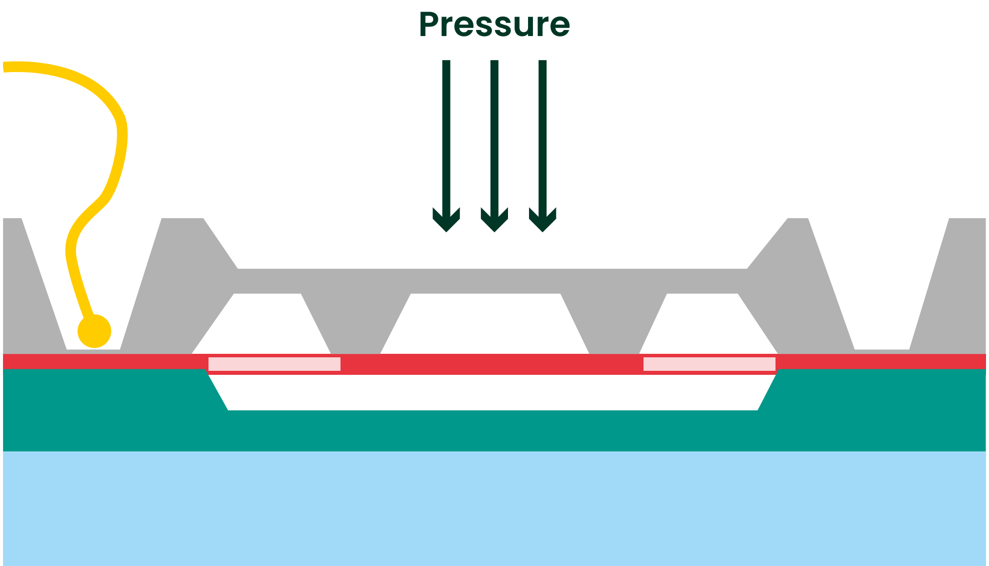
- TERPS® technology
- Accuracy and its factors
- Long Term Stability
- Pressure controlling abilities
- PACE's modular construction using control modules such as PACE CM3
- Automated calibration and data integration using Druck's 4Sight2 software
- Customer support and service

Druck's philosophy is to provide customers with solutions aligned to their needs, where specifications meet customers' requirements and to provide openness and transparency concerning the company's instruments' capabilities.



TERPS® Technology

TERPS® relies on the straining of a resonant structure to change the frequency of the transducer, which is proportional with the pressure applied onto the sensor's diaphragm. The unique design of TERPS® is the base of its great performance, especially in terms of drift and hysteresis (pressure & temperature).



The unique design of TERPS® is the base of its great performance

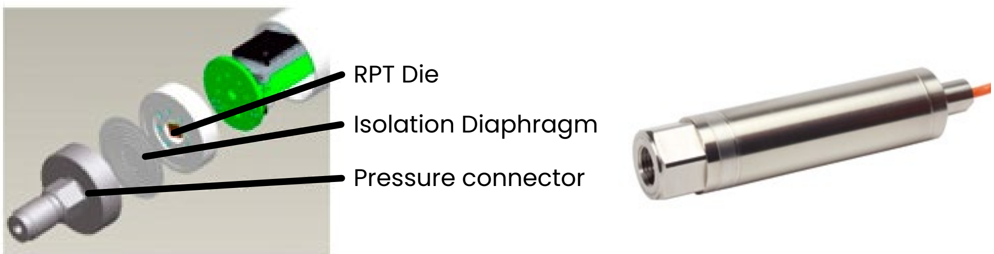


Figure 1: Isolated TERPS configuration

The TERPS® structure and build has the following characteristics:

- Well defined resonant frequency by using Silicon-on-Insulator (SOI) to control thickness and mass of resonating structure;
- Insensitive to media viscosity by using deep reactive ion etching (DRIE) to create well defined patent structures for dynamic mass and force balance;
- Harsh media isolation by using DRIE to create a complex low impedance sensing technique;
- Low thermal and pressure hysteresis by using silicon fusion bonding (SFB)

The entire TERPS structure is mechanically and dynamically balanced

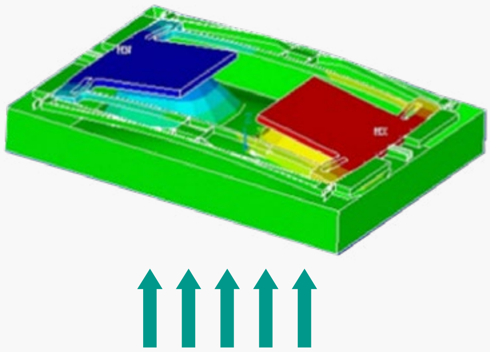


Figure 2: Isolated TERPS configuration

The whole structure (diaphragm and resonator) is mechanically and dynamically balanced to ensure that as pressure (i.e. strain) is applied, the change in frequency occurs in a continuous manner, without signal discontinuities. This is particularly important in providing the high precision of the transducer and whilst Druck quote precision as 15 ppm FS on the product datasheet, many of the Druck's TERPS outperform this specification.

Accuracy

As per the VIM (Vocabulaire International de Métrologie) definition, accuracy is a qualitative term, defined as **"closeness of agreement between a measured quantity value and a true quantity value of a measurand"**.

The term **"accuracy"** should be associated with the specified measurement error, including the impact of systematic error, random error and drift (in cases where accuracy is specified over a defined time period). Definitions of accuracy should consider the application and the needs of the customer.

Accuracy is defined as 'closeness of agreement between a measured quantity value and a true quantity value of a measurand'

The following is a typical expression of accuracy for Druck's PACE pressure controller with a TERPS-enabled PACE CM3 control module incorporated within the instrument:

Precision =+/-15ppm FS (error to the calibration standard)

Calibration expanded uncertainty (sigma=2) = +/-22ppm FS

Drift = +/- 25ppm FS/year (2 & 3.5 bar a)
+/- 10ppm FS/month when zeroed 8-71 bar a

Note: The above 3 factors are uncorrelated and follow normal distributions.

For the new PACE pressure ranges Druck achieves an accuracy of +/-11ppm rdg + 26ppm FS with a 95.45 % confidence interval (k=2). However extensive testing suggests PACE shows the potential to perform considerably better than this quoted value.

Regarding accuracy, other manufacturers' instrumentation may be defined in alternate methods which have subtle implications for the user. For example:

Definitions of accuracy should consider the application and the needs of the customer

Manufacturer A expresses accuracy as:
80ppm rdg down to 33%FS then 80ppm of 33%FS

Manufacturer B expresses accuracy as:
100ppm rdg or 30ppm %fs whichever is the greater.

Figure 3 demonstrates how Druck's PACE performs when comparing accuracy against other Pressure Controller manufacturers. Further accuracy improvements can be made on a PACE6000 if utilising the auto-ranging feature in conjunction with two appropriately ranged control modules

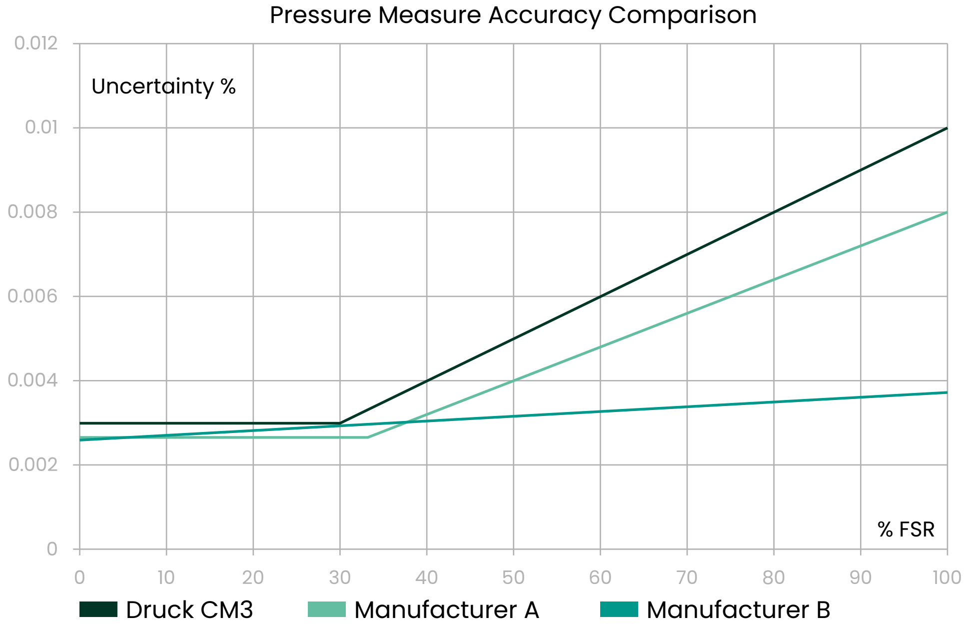


Figure 3: PACE expanded uncertainty comparison as % of range

Drift

Drift is a very important metrological characteristic, as it will often dictate the accuracy of the instrument between two successive calibrations, which involves both time and cost for the user.

The graph in Figure 4 represents the typical drift for Druck's TERPS® for the 2 bar absolute pressure range and compares its drift performance over time against the drift performance claimed and achieved by other instrument manufacturers. Whilst Druck's specification includes a 25 ppm FS drift per annum, the achieved drift performance over time of TERPS®, in many cases is much better than the stated specification.

[Drift will often dictate the accuracy of the instrument]

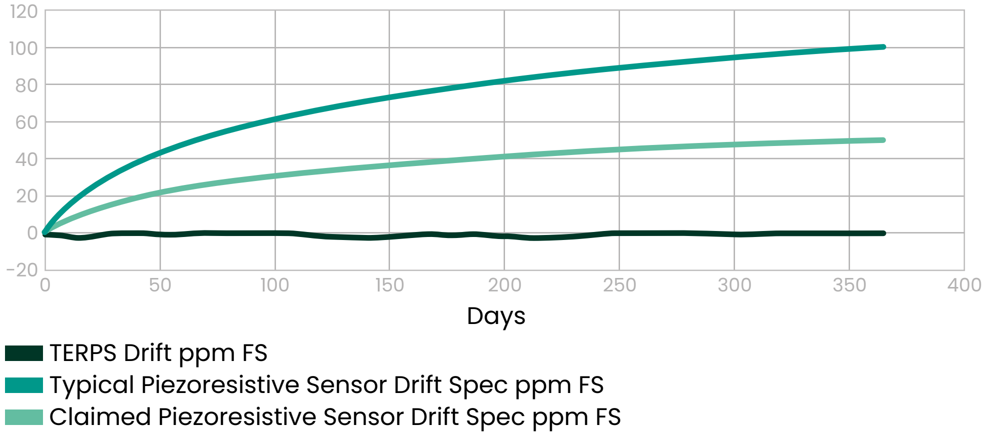


Figure 4: TERPS® drift performance versus competitor's specifications

Druck has introduced an innovative method of taring the drift against a highly accurate barometric sensor

Both 2 & 3.5 bar absolute exhibit similar behaviour in terms of drift performance. However, for ranges of 8 bar absolute pressure and above, Druck has introduced an innovative method of taring the drift against a highly accurate barometric sensor, which is included in all Druck's PACE CM3 control modules. As with all other factors, the uncertainty contribution of taring PACE CM3's main range against the barometric sensor is included in the expanded uncertainty evaluation (accuracy). Figure 5 below assumes a typical case scenario where the barometer has an expanded uncertainty of 10 Pa (through good calibration 5 Pa is achievable) and it shows that at 71 bar range, the contribution will become negligible (~1 ppm FS).

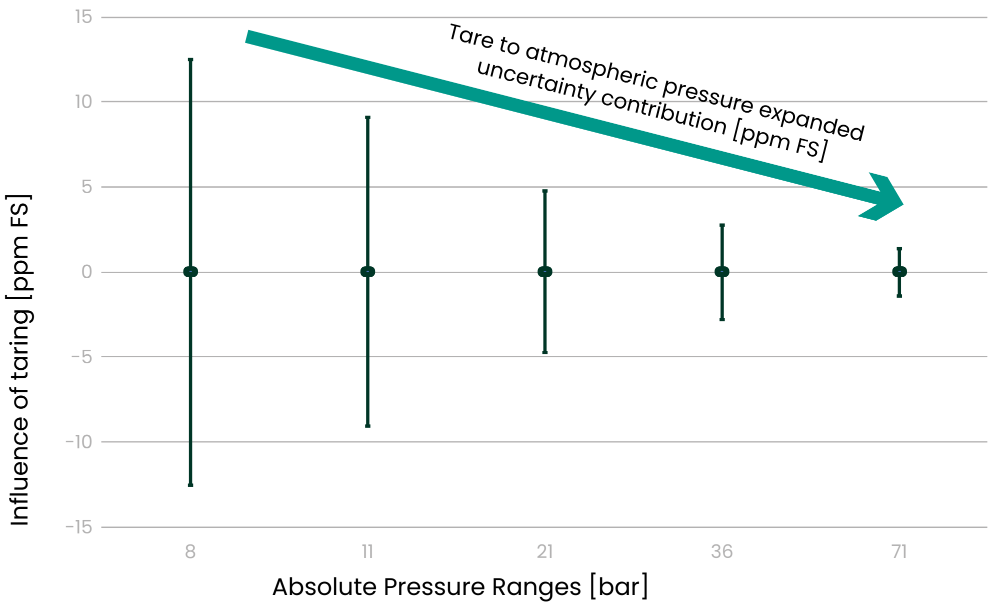


Figure 5: Expanded uncertainty contribution of taring by pressure range

The buyer should investigate whether the accuracy value stated in the manufacturer's specification includes drift

Before purchasing a pressure controller, the buyer should investigate whether the accuracy value stated includes drift for the recalibration period. If not, then the accuracy figures stated is valid only at the point of calibration and not over the course of time between calibrations. Knowing this will helps the end user to calculate the total cost of ownership of their instrument.

Control Stability and Offset Importance

When a pressure controller is used in an automated calibration system, the time taken to get to the setpoint and stabilise is often critical in achieving increased flow through the production line without sacrificing accuracy. Druck's PACE pressure controller is the market leader in time taken from command to setpoint, because of the advanced pressure control algorithm.

Once the controller has stabilised controller noise and offset will also impact the speed of measurement taken. When the controller is 'noisy', readings must be averaged over a period to reduce the peak error that would otherwise impact the uncertainty budget.

The PACE product is the market leader in time taken from command to setpoint

Controller noise can only be averaged out if the noise signal is random and evenly distributed either side of the aim value. If the controller has a non-random deviation, then the measured signal can be in error due to aliasing leading to an offset in the signal. Care must be taken if averaging poor controllers with high noise values. The best method is to reduce the peak noise value and offset while minimising low frequency deviation with optimised control strategy found in the PACE controller.

Controller offset is simply the average difference between the commanded value and the controlled pressure. Controller noise is the deviation of the pressure around the average controlled pressure. This is shown in Figure 6 below.

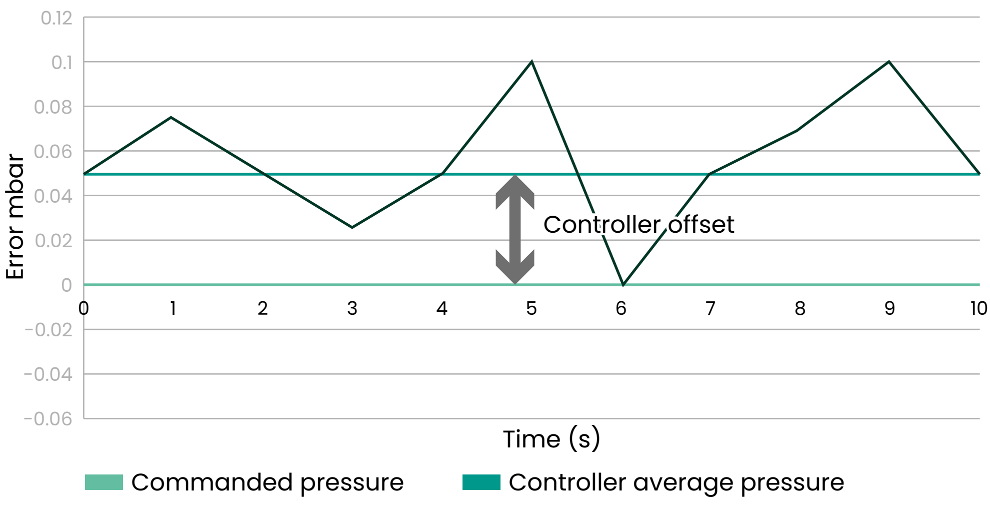


Figure 6: Controller offset and noise

The controller noise in the PACE products is less than 10 parts per million of full scale. This noise is factored into the uncertainty budget for the sensor, removing the need for the system integrator to allow for this in their error budgets. This compares favourably with 30 parts per million control stability of similar competitive products.

PACE's modular construction

The modular nature of PACE's construction means that existing customers can easily upgrade their PACE controllers from CM2 (or below) to the improved accuracy CM3 range with very little downtime being incurred. There is also the added benefit that the control module itself can be shipped to Druck for upgrade, repair or calibration by itself, without having to remove the chassis from any rack or testbench, thus providing further savings on downtime and maintenance costs. This also allows for the Druck Service team to perform a health check on the entire control module, which is not possible with some competitor's models, where only sensors are returned for repair/calibration.

Additional advantages of the PACE construction with respect to the control modules being 'plumbed in' directly mean that PACE can achieve the fastest speed to setpoint of any pressure controller, as well as being less susceptible to leaks.

For new and existing customers, the addition of the PACE CM3 range now brings even more flexibility to the PACE product line in terms of price vs performance.

Easy installation of the PACE CM3 unit

Modular PACE CM3 unit

Compatible with PACE 5000 and 6000

Automated calibration and data integration using Druck's 4Sight2 calibration management software

Druck's 4Sight2 Calibration Management Software integrates seamlessly with its PACE pressure controller to offer end-to-end automated calibration. There are no manual interventions and therefore this eliminates documentation errors and increases the quality of calibration data.

4Sight2 Calibration Management Software offers end-to-end automated calibration with PACE CM3

4Sight2 controls Druck's PACE and DPI range of digital pressure indicators and calibrators, running tests which can be initiated with a single button click and automatically capturing data for each test point. Results are saved within the software to ensure the user's calibration process is efficient, completely integrated with their Druck hardware and paperless. In addition this removes the possibility of user input/data recording error as well as freeing up the operator to focus on other tasks simultaneously.

Furthermore, 4Sight2 calculates expanded uncertainty, which provides greater confidence over the calibration measurement data and helps ensure devices function within defined limits, in accordance with industry standards. All calibration data, drift analysis and traceability information are securely stored and are readily available, ensuring users are audit ready at all times.

Customer support and service

To maintain and keep PACE within its optimum performance range, Druck offer customers a range of calibration and service options to provide the peace of mind that comes from dealing with the OEM (Original Equipment Manufacturer).

For all enquiries please contact us or find local phone numbers here

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