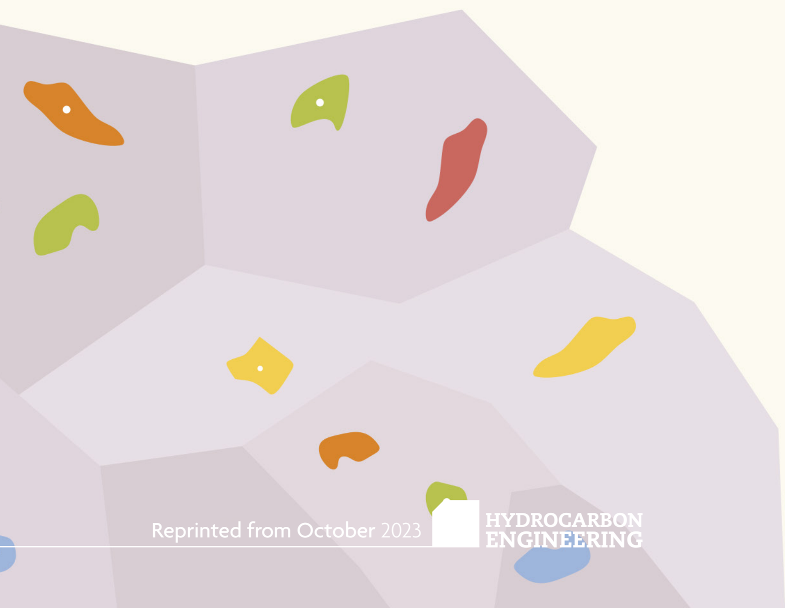
**Neil Murch, Jaspreet Nijjar and Oliver Riddle, Tracerco,** detail the use of nucleonic instruments in challenging level measurement applications.

# Taking it up a level

As the petrochemical industry has grown and developed, there have been great challenges in obtaining accurate, real-time data relating to the operating conditions inside process vessels and pipelines. The evolution and diversification of feedstocks brings with it challenging operating conditions, fast changing process parameters, and a greater need for instrumentation to be able to quickly adapt to these issues. Accurate and complete field data not only leads to maximised output and increased efficiency, but it also provides insight to allow for faster, evidence-based decision making capabilities, and the correct control of process levels and additives, contributing to the achievement of net zero ambitions.

This is where the continual development of nucleonic instrumentation has started to lead the field. In response to operator concerns, instruments and software that can be tailor-made to suit most measurement applications are now widely available. System designs range from instruments that are in contact with the process to measure multi-phase density,



to fully external, non-contact solutions that make retrofitting much simpler and safer. But with the availability of a number of product options and configurations, each with differing sensing technologies, it can be difficult to understand just which solution offers the most value to the application or need.

## Overview of nucleonic measurement technologies

Nucleonic measurement using gamma ray absorption is split into two primary sensing types: Geiger Müller (GM) and scintillator technology. A GM tube detects the ionisation of gas between two electrodes in the presence of a radiation field. This interaction produces pulses of current in the form of counts per second (cps), which can be conditioned to provide a number of measurement variable outputs. Scintillation detectors measure radiation slightly differently by detecting photons generated by the excitation effect of gamma-ray interactions with the sensing crystal, measuring light intensity rather than electrical current.

Both technologies work very well for industrial measurement, but each are used in different applications due to their sensing properties. Scintillators are more sensitive to radiation fields and can see higher equivalent count rates when compared to GM-based technology. This makes it the ideal solution for upgrading existing equipment that may be operating at low dose rates due to the age of the source, leading to noisy output.

While the sensitivity of instruments using GM technology may be less than scintillators, they do have their own advantages. They offer higher operating temperature ranges and greater stability when used in applications where environmental or process-driven temperatures may fluctuate. There is added functionality in the form of segmented level measurement. Unlike scintillation detectors that have a single sensitive element, segmental systems have several, which increases the number of data points available over the same measuring range. These additional data sets can enable a number of unique features when combined with software, in order to overcome process measurement uncertainty in applications where build-up or deposition may occur.

Generally speaking, non-nucleonic instrumentation will struggle with these types of process conditions where bridles can become blocked due to plugging; fluctuating process conditions push instruments outside of their operating envelope; or fouling of instrument probes makes it difficult to identify the correct phases or interfaces. Nucleonic instruments can offer greater resolution and higher repeatability, leading to increased reliability and confidence in the measurement data being received from the field.

## Measurement challenge

One area that poses a particular measurement difficulty is operations where changes in process conditions can cause solid deposition on vessel walls or liquid fall from overflow trays. In these situations, conventional scintillator-based nucleonic instruments cannot provide accurate and reliable level measurements, as the increased density from these process phenomena result in a greater attenuation of signal to the detector, leading to a false high liquid level. This shortfall in the ability of scintillator-based nucleonics led to device and software development of GM-based nucleonic instruments by Tracerco, named Optimus™.

Similar to the scintillator-based nucleonic instruments, this technology works by using the principles of gamma ray absorption. As depicted in Figure 1, a gamma field is emitted from a radiation source (shown in yellow container) through the vessel and its contents, to a detector on the opposite side. The size or activity of the source is calculated based on the vessel design, such as wall thickness, insulation and the process contents. The amount of radiation incident on each individual GM tube within the detector array is inversely proportional to the process condition, including the liquid level and any build-up that may present in the radiation path. An analogue signal and digital information over the Highway Addressable Remote Transducer (HART) is transmitted via an isolated 4-20 mA repeater power supply to the Optimus control unit, where signal and processing using proprietary algorithms are performed. The control unit provides up to 150 device variables over HART, providing corrected process level, build-up levels and, in some cases, foam height.

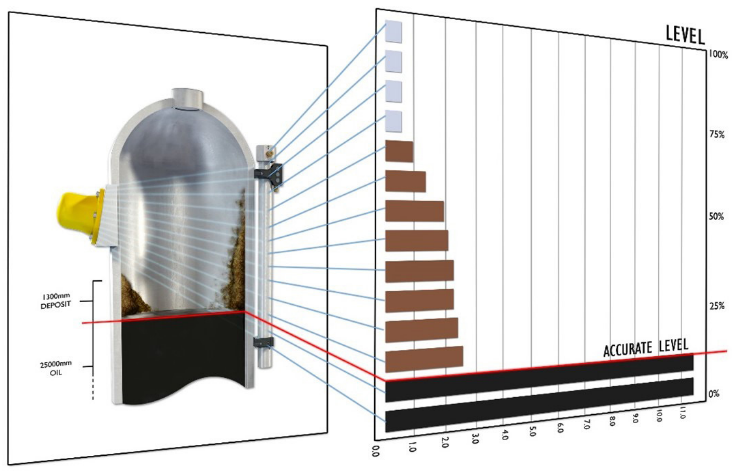



**Figure 1.** Schematic illustrating the Optimus instrument and segmental level output.

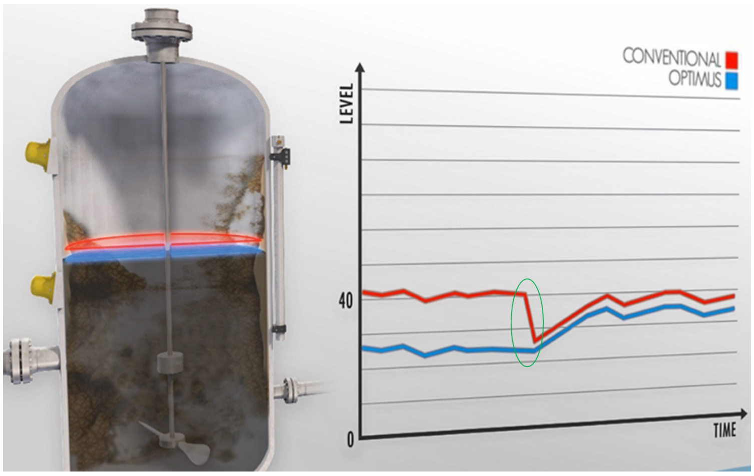



**Figure 2.** Effect of deposit drop off on level measurement by using conventional vs Optimus instruments.

The segmental nature of the GM tubes in the instrument enables multiple measurements to be obtained along the sensitive length of the detector. This, coupled with the unique and specialist algorithms, enables the instrument to accurately and reliably differentiate between true and false liquid levels in a versatile range of processes, involving product build-up on vessel walls, pressure fluctuations, sprays and mists.

Since its development, Optimus has been deployed across a wide range of challenging oil, chemical and petrochemical industry applications. Examples of these applications include vacuum and distillation towers, three-phase separators and slug catchers, knock-out drums, glycol contactors, cokers, and polymer reactors. In processes involving hot water washes to remove solids build-up, the installation of Optimus has resulted in decreased OPEX costs for several operators by offering the ability to see when the wash has successfully removed the deposit, meaning reduced wash times and ultimately decreased energy and maintenance costs.

## Case study: build-up

The invention of Optimus followed a discussion with Oriental Petrochemicals Taiwan Co. (OPTC), a purified terephthalic acid (PTA) manufacturer that was experiencing difficulties obtaining accurate level control using a scintillator-based nucleonic instrument in its process. The PTA synthesis process inherently caused solids accumulation on the inside of the vessel wall, which was interfering with the level measurement obtained by the scintillator instrument. Accurate and reliable level control inside the vessel was vital for the customer to ensure efficient processing and avoid mechanical damage to the agitator.

Optimus was installed onto the customer's vessel and an approximately 10% error in the level measurement was observed between the scintillator and the new instrument, which was attributed to build-up on the vessel wall. The scintillator interpreted the higher attenuation of radiation from the build-up as a level change, and incorrectly reported a higher than actual liquid level. In comparison, the segmental design of Optimus enabled the system to compensate for level error by differentiating between build-up and actual liquid level.

The level readings became more polarised as time went on, evidenced by the area shown in the green circle in Figure 2. At this point, there is a significant drop in the level reported by the scintillator whilst the level reported by Optimus remains constant. It was understood that a large piece of deposit had detached from the side wall, resulting in an increase of measured radiation and a drop in the reported level. As the instrument was used in the control loop, the valve automatically opened up to top up the level to 40%, illustrated by the spike in the level measurements of both the scintillator and Optimus instruments.

In order to reduce the deposition on the vessel walls, the customer washed liquid up the sides of the vessels. It was found that, after the washing cycle, the difference between the level measurements became more pronounced, with the conventional instrument indicating a level close to 40% in stark contrast to Optimus, which indicated a level close to 0%.

In consultation with the customer, it was thought that the washing of the vessel walls with liquid was in fact adding another element of build-up. In order to prove this, the radiation at the detector was measured using a dose rate monitor. The dose rate monitor detected 1.3 µSv/hr opposite the source where the instruments were situated, whereas background levels of radiation (0.03 µSv/hr) were detected at other points around the circumference of the vessel. The 1.3 µSv/hr of radiation detected was in line with that expected from a 0% level reading, proving that the new instrument was showing the true reading and the conventional level gauge was showing a false reading as the anomaly of build-up was interfering.

Consequently, the scintillation detector was replaced with Optimus technology, which eliminated the need for the hot flush that was routinely carried out, resulting in greater efficiency in daily production operations.

## Conclusion

Historically, nucleonic instruments have been seen as the last resort, or where the nature of their design is most suited to very challenging measurement applications, but technological developments in both hardware and software over recent years has accelerated their use and deployment in a number of duties across processing units. In particular, duties involving changing process conditions have witnessed a rise in the implementation of nucleonic instruments due to the increased resolution and repeatability that they offer over conventional instruments. The two nucleonic technologies (GM and scintillator) are suited to different applications, with the higher sensitivity of scintillators making them more appropriate for use in lower radiation duties, whereas the segmental nature of GM technology enables it to be exploited in duties involving build-up or deposition.