Graeme Webb, Berthold Technologies UK Ltd, explains how engineers can achieve an indication of the level of their product, process vessel or tank by using radiometric techniques.

NO HALF MEASURES

Some of the more common measurement methods currently used in the process industry include radar, vibration, rotation paddle, ultrasonic and radiometric.

Equally confusing to the non-initiated is the variety of types of levels that may be needed to suit a particular application. These types of level measurement can include point level, interface level, continuous level and multi-phase level measurement (MPLM). For the purposes of this article, the author will concentrate on radiometric, also known as nuclear, measurement techniques.

Why radiometrics?
Radiometric level measurement is a widely used non-contact method for the measurement of both solids or liquids. It uses the Gamma radiation from a controlled source using most often Co-60 or Co-137 isotopes. In this instance, the gamma radiation acts in a similar way to ordinary X-rays, in that it penetrates the walls of the vessel to enter a detector placed opposite the source. The same way an X-ray distinguishes between bone and flesh, the industrial version – using the more powerful gamma rays – can differentiate between the
constant thickness vessel wall and the variable level of the process material inside.

Radiometric level measurement systems, which are non-contacting, non-intrusive, externally mounted and virtually maintenance free in use. It is also unaffected by the chemical or physical properties of the measured product.

By being non-contact, the radiometric equipment is not affected by the process product so is idea for use where high temperature pressure, or other high demand factors (such as aggressive or sticky media and toxic materials) are used. Radiometric level measurement has a proven record of working where other technologies can fail to perform adequately.

The activity and type of source, along with the size of the detector, is determined at the design stage and is dependent on factors such as vessel size, wall thickness and product density. The positioning of the equipment is also important in order to ensure accurate and repeatable measurements.

**What makes up a radiometric level gauge?**

Other than remote actuators, a gamma detector and bracketry, a typical radiometric level gauge consists of three main parts, as outlined below.

**The source**

This is normally Cs-137 or Co-60, depending on application. Co-60 is normally used when more demanding measurements are required. As Co-60 has a greater penetrating power than other commonly used isotopes, it is ideal for vessels and applications where thick walls, often with water jackets and insulation, need to be penetrated. The radioactive material is double or sometimes triple encapsulated in stainless steel or titanium for maximum safety. It is normally with the operators’ interest to keep the source sizes to a minimum.

The sources are normally designed as a spot, with the radiation beam shield to a ‘far’ shape to direct it to the detector. In some instances, Co-60 ‘rod’ sources are used when high accuracy and repeatability is required in thick walled vessels.

**The shield**

The source itself is encapsulated in stainless steel or titanium, which is manufactured to strict international regulations. The source capsule is mounted in the shield, which is designed to guide the gamma beam through the process material to the detector. The shield is normally manufactured from steel and lead and sometimes, in extreme cases, tungsten. In choosing the correct shield for the application, great care is taken to keep the radiation levels on the surface of the shield to a minimum. This helps operator safety – as well.

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**Figure 1.** Continuous level rod detector mounted in place. The source and shield is mounted on the opposing side of the vessel.

**Figure 2.** A typical arrangement of Co-60 rod sources for continuous level measurement.
workers have exposure limits — and can also prevent 'cross talk' with other radiometric instruments.

The detector
Simply put, the detector receives radiation from the source and then converts that to an electrical signal for process control. Geiger Muller (GM) tubes are the cheapest option of detector generally available in the industrial market although they are somewhat used currently due to their inefficiency. They are also considerately less sensitive to gamma radiation than the more modern scintillator detector. Because of this, GM tubes generally require much larger sources (10 to 20 times larger) for them to operate successfully. GM tubes can be considered false economy because of the larger sources and, therefore, shields required.

Scintillator type detectors are the common option for most industrial level applications and consist of three main parts. The actua, scintillator is normally manufactured from a polymer or a crystal. They can vary in size from 25 mm dia x 25 mm long to 50 mm dia x 8 m long. The scintillator traps the gamma radiation and creates sparks of light, making the gamma radiation visible. The photons from this light are then guided to the second section of the detector, the photomultiplier. This converts the photons to electrons and increases the output to a measurable level. The third part of the detector is the electronics, which amplifies the photomultiplier output and converts it to a usable signal.

Radiometric level measurements

Point level
Point level measurement is the simplest of the main forms of radiometric level measurement. It is often used as a high or low alarm depending on requirement. In other words, it can be configured to trip either when product is present or not. This system has worked successfully for many years on both solid and liquid applications.

Continuous level
Continuous level measurement allows the operator to monitor and control levels in vessels of all shapes and sizes. The continuous level system offers analogue outputs relative to the level. The measuring span is limited by the size of the vessel. Berthold Technologies has installed systems measuring from 500 mm to 32 m using a combination of 8 m long individual cascaded detectors.

Using Cs-137 or Co-60 sources, the radiation is normally beamed through the vessel to a suitably mounted detector. As the level of the product in the vessel rises, more radiation is attenuated and, therefore, less radiation is received by the detector. The opposite is true when the product level drops. This variation of radiation ‘counts’ is then calibrated to represent a continuous level measurement. For some applications, it is good practice to use a ductile iron pipe (DIP) or ‘insert on pipe within the vessel, allowing the sources to be placed closer to the wall of the vessel, reducing the radiation path and keeping source activity as low as practically possible.

Multi-phase level
When a vessel contains a mixture of products with multiple densities, it is sometimes necessary for the control of the process to measure the interface points between the differing products as they settle and separate.

Depending on the application, these phases or differing materials can vary in density from, for example, relatively heavy sand to light foam materials, or even gas.

The radiometric solution for multi-phase level measurement is to insert a number of sources into a DIP and mount a suitable number of detectors on the outside of the vessel. The number of source/detector combinations required depends on the number of interfaces and the measurement resolution required. The Berthold system illustrated uses a number of externally mounted safety integrity level (SIL) rated density gauges to determine the interface levels in a horizontally mounted vessel.

Conclusion
Radiometric level measurement offers the user a solution for difficult to measure process situations, providing a simple and reliable method of controlling important and critical processes within a plant. Because of the non-intrusive, non-contacting nature of radiometric gauges, retrofitting can normally be carried out with minimal downtime and complications. Once fitted and commissioned, a radiometric level system requires a minimal amount of maintenance and checks.