



LEVEL

The Right Tool

for Tricky Measurement Jobs

Gamma nuclear level gauges handle the toughest applications.

by Walt Boyes

Let's say you have a reactor vessel. It is 6 ft. (1.8 m) in diameter, glass-lined, has a big agitator in it, and has both a jacket made of 1-in. (25-mm) copper cooling coils and a 4-in. (100-mm) layer of insulation covered with thin steel lagging. Worse yet, there are no accessible entrances into the top of the vessel that aren't already being used for something. For the process to work, you must measure the level in the vessel with significant precision. You've even tried weigh cells, but there isn't enough precision to just weigh the contents of the reactor, with all that tare weight. Oh yeah, and you can't stop the reactor to modify it, and since it is a glass-lined and code-stamped vessel, you can't drill any holes in it either. What do you do?

Or, suppose you're making glass for a variety of products. The glass is produced by melting silica sand, glass frit from recycled bottles and some trace minerals in a very hot furnace with firebrick walls that are over 1 ft (300 mm) thick. The glass is too hot to pump, so it must flow by gravity down a firebrick-lined channel to where it is cast or molded or extruded. Your requirement is that you have to measure the level of the molten glass and control it to ± 0.0005 in. (± 0.013 mm), or the process doesn't work. Glass castings have holes called holidays in them, and extruded glass, whether tube or sheet, has flaws and holes.

What do you do?

You are responsible for the air pollution control system for a very large coal-fired power plant. You have electrostatic precipitators that remove the fly ash from the stack gas before it gets released into the atmosphere, causing international pollution incidents and costing your utility millions in air-pollution-control violation fines. But the hoppers that hold the precipitated fly ash keep plugging up, and fly ash is very hot and also acts like concrete and sticks to everything. You need some way to tell when the hoppers are full, so you can empty and clean them, but

anything you stick into the hopper just gums up and fails so fast that you have given up. What do you do?

Sound familiar? Nearly every plant, from mining to wastewater and every process vertical in between, has a level application that is both critical and difficult, if not impossible, to measure.

Enter the Gamma Level Gauge

Since the 1950s, the answer to all of these applications has been the proper application of a gamma level gauge. Gamma gauges work based on both the inverse-square law—radiated energy decreases with the square of distance—and the fact that dense materials absorb gamma energy—1 in. (25 mm) of steel, for example, cuts the energy from a gamma beam by 50%.

Very early on, engineers came up with the idea that rising material or liquid would change the amount of energy reaching a detector on the other side of the vessel from an emitting source. In the case of a point level switch measurement (Figure 1), rising material would simply trigger a relay if the energy beam were interrupted. In the case of a continuous level measurement (Figure 2), the rising material would cause a decrease in the intensity of the energy beam reaching the detector that could be calibrated to be proportional to the rise in level, and when the level fell, then the energy would likewise increase.

Designing to Fit

In order to figure out how much energy will reach the detector, essentially all you have to do is to add up the densities and thicknesses of all the materials between the energy source and the detector, and make the energy beam intense enough to pass

through all that material and reach the detector. Safety requires that the intensity of the energy beam be designed to be as small as possible and still make the measurement.

“Modern detector designs have made it possible to use significantly lower activity sources than in previous years,” says Mick Schwartz, business unit manager of Berthold Technologies USA LLC (www.berthold.com), a manufacturer of gamma level gauging products. “This means that the risk of exposure to gamma energy for personnel is minimized and amenable to proper safety precautions. Gamma energy does not cause any of the measured product or the vessel to become radioactive.”

All manufacturers of gamma level gauges have software that makes the calculation of energy source size straightforward. You or the vendor plug in the numbers for the thicknesses and densities of the material, not forgetting the air gap between the walls of the vessels—air has density, and energy decreases with the square of distance—and the software spits out an optimized energy source size and, in most cases, the appropriate housing design and detector selection.

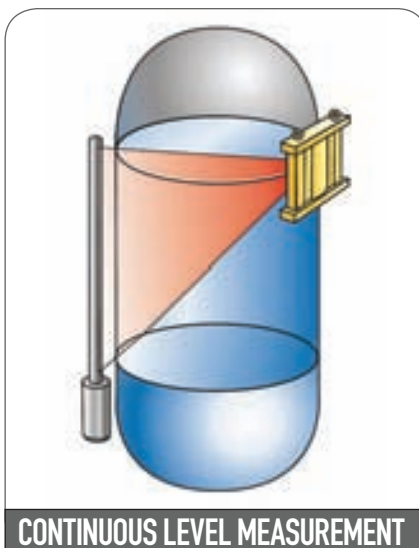
Gauging in the Real World

So let's look at how to do the level application in the jacketed vessel we talked about earlier. This is not quite as easy as putting a source and a detector across from each other because there are vessel internals, including an agitator, that have to be missed. The way to do this application is to “shoot a chord” of the vessel's diameter—that is, put the source and detector off to one side of the diameter. Because the thicknesses that the energy beam will shoot through will be greater, the source activity that will be required will be greater by some amount than shooting the diameter would be. The blades of the agitator



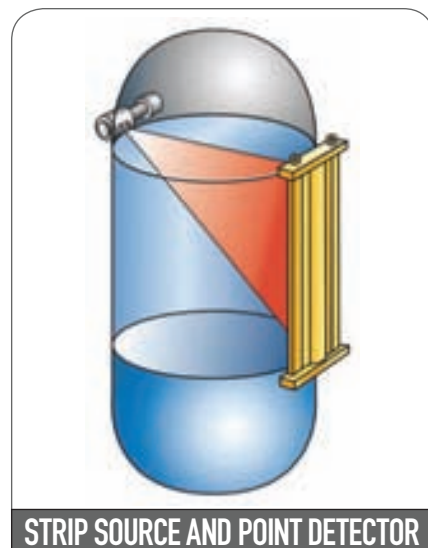
GAMMA POINT LEVEL SWITCH

Figure 1. Rising material triggers a relay if the energy beam is interrupted.



CONTINUOUS LEVEL MEASUREMENT

Figure 2. Rising material decreases the intensity of the energy beam.



STRIP SOURCE AND POINT DETECTOR

Figure 3. Here the apex of the triangle is aimed at the point detector.



Figure 4. A narrowly collimated conical beam is aimed across the vessel at the point detector.

need to be considered, and, if possible, eliminated by shooting the chord between the blades and the vessel wall. If that isn't possible, many gamma level gauges can be programmed to ignore the repetitive density fluctuation caused by blades swinging into and out of the beam. It just makes the signal noisy.

Now let's look at the glass level gauge. There's a lot of firebrick on either side of the glass channel, so it may be necessary to drill holes in the firebrick to reduce its thickness. This will cause the temperature on the outside to rise, so the detector must be water-cooled to bring the internal temperature of the electronics down to the normal range.

There are three geometries that can be used in continuous gamma level measurement. The most common is a point source that is collimated to produce a right-triangle-shaped beam with the 90° angle at the top of the detector. Next is a strip source that is characterized to produce a similar shaped beam, but with the apex of the triangle at the point detector (Figure 3). Third, there is the geometry of a strip source and a strip detector. This geometry is often used for highly precise level measurement on small diameter vessels or pieces of pipe, such as vertical risers.

In point level applications (Figure 4), the source produces a narrowly collimated conical beam that is aimed across the vessel at the point detector. In most point level applications, the reason a gamma gauge is being used is because the inner walls of the vessel are subject to vibration, corrosion, abrasion, or fouling or coating with material. Fly ash hoppers are classic examples of this kind of application. The energy activity of the source must be sized, so that the point level gauge continues to work correctly through a reasonable thickness of fouling or coating, perhaps as much as a couple of inches.

How to Measure a Tank of Tomato Paste

Larry Fontes, maintenance and production supervisor at

Ingomar Packing Co. (www.ingomarpacking.com) in Los Banos, Calif., uses a gamma level gauge on a very difficult food industry application. "We were using a dual remote diaphragm seal system with chemical T diaphragm seals and a 4-20 mA DC HART transmitter to control a valve, which would control the level in a holding tank," Fontes says. "The holding tank is 38 in. (nominal 1 m) in diameter and about 30 ft (9.1 m) tall. The product inside the tank is tomato paste with a specific gravity of about 1.134 at 210 °F to 215 °F (a little over 100 °C) at a flow rate of approximately 250 gallons per minute."

"After a 100-day processing season," Fontes continues, "the diaphragm seals would become coated due to the temperature of the product, and the level indication would begin to drift as the diaphragm was unable to pick up the change in pressure as the level changed."

Fontes reports that the problem became so severe that product spilled out the vent on top of the tank, while the transmitter reported little or no change in percent level.

Fontes looked into other level technologies, including radar. "I was looking for a level system that wouldn't be affected by the properties of the product due to the thermal processing," he says. "We had used a [gamma] device to measure soluble solids from Berthold Technologies, so I was somewhat familiar with the technology. Berthold worked with the consulting engineer we had contracted for the expansion of our aseptic processing system. [Process Resource Inc., www.processresource.com]

"Berthold provided onsite start-up and training for myself and several of our operators," Fontes goes on. "The installation was made much easier with the help of all the individuals from Berthold. We operate the gauge under the general license in the Code of Federal Regulations."

And how has it worked out? "Since the installation of the Berthold level gauge (Figure 5) in 2007," Fontes reports, "we have had instances during a couple of processing seasons that would have resulted in the same issues as before. The dual diaphragm system level indication began to drift, while the gamma level gauge remained constant."

Fontes concludes, "The Berthold level gauge in-



Figure 5. During a 100-day processing season, the gamma level gauge remained constant.

stallation was part of a \$1.3 million expansion to the flash cooler, which is part of our aseptic processing.

The Business of Using Gamma Level Gauges

Similar to every other device that uses nuclear byproduct material, even the smoke detectors in your house, gamma level gauges are required to be licensed. This means that applications, paperwork and rules have to be known, understood, followed and kept current. However, once you are set up to do this, licensing can be relatively simple and not too onerous.

"Many gamma level gauges can be distributed under the general license in most states in the United States," says Berthold Technologies' radiation safety officer (RSO), Mark Morgan, "but the general license does not exist in other countries, and the U.S. NRC plans to do away with it in one to three years anyway, in favor of specific licensing. The NRC plans to make the specific license procedure simpler and more streamlined."

The general license has less paperwork, but has restrictions on gauge geometry, exposure levels, shielding, and other environmental health and safety issues. The other kind of license, used globally as well as in the United States is called a "specific license." This means that you, as the gauge owner, are licensed to do several specific things with the gamma level gauge you own.

So what does this mean for operations and maintenance? Maintenance on the electronics, including the detector, can be done by any plant-qualified instrument tech or maintenance tech. No license is required by persons doing that level of maintenance. Since a gamma energy source is basically a steel-jacketed lead box with a capsule the size of a horse-pill inside of it, maintenance on source housings is minimal. A trained, licensed person is required to change the geometry of the gauge or to move it.

And when you aren't using it anymore, you are required to dispose of it properly—not just send it to a junkyard. Most manufacturers of gamma gauging instruments will accept a returned source, take title to it (so you and your management don't have to keep track of it forever), and send you a document saying that you are no longer responsible for it.

Knowing these simple rules in advance can mitigate management's reluctance to undertake a new regulatory duty.

So There You Have It

Gamma level gauges are a good long-term solution to many of the most difficult level applications you will run into. They will operate with fewer maintenance headaches and, in some cases, operate where nothing else will. ■

Walt Boyes is Control's editor in chief.

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