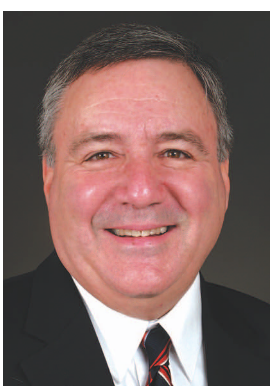
NUCLEAR Myth Busters



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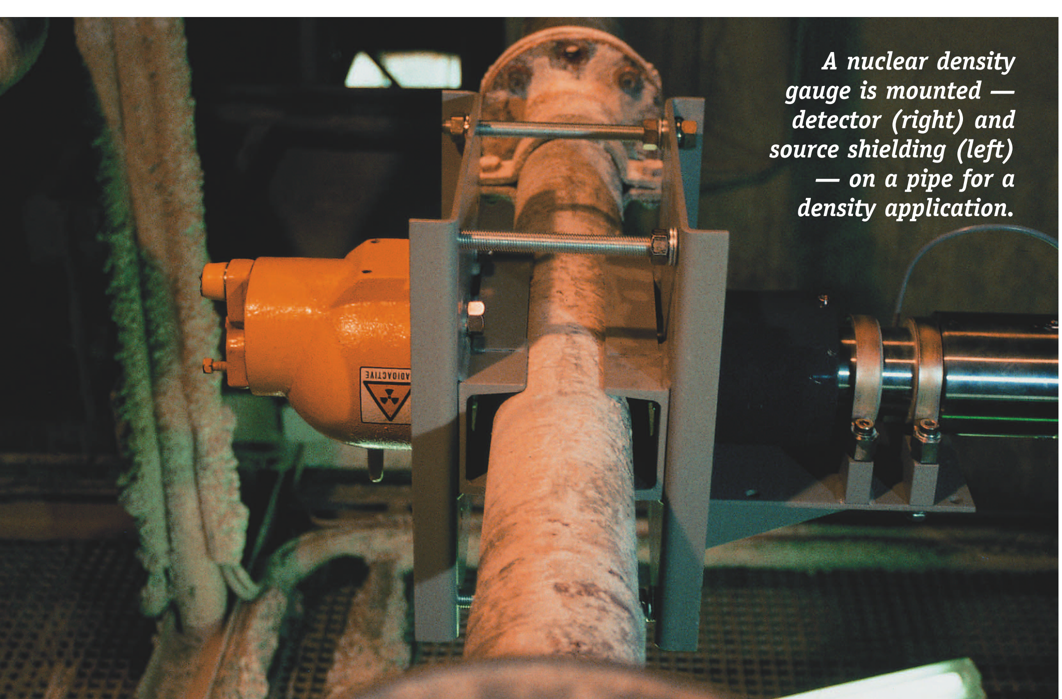
Two experts explain the facts and myths surrounding nuclear measurements



A nuclear density gauge is mounted — detector (right) and source shielding (left) — on a pipe for a density application.

By H. M. Schwartz and Dr. Dirk Moermann

Nuclear measurement gauges for industrial process measurements have been around for many years. They have been a mainstay in making the most difficult level, density, bulk flow, and moisture measurements. Nuclear measurement gauges work where no other technology will. They give excellent performance under hostile and rugged conditions. High temperatures, pressures, and other difficult industrial processes usually pose no problem for a nuclear measurement gauge.

Despite thousands of satisfied users of this technology worldwide, nuclear measurement gauges are sometimes a pariah to companies and their employees. From many companies' perspective, the move to be more environmentally friendly has sometimes superseded the facts about nuclear gauges, their benefits to process operations, and most important, the safety and environmental issues surrounding this measurement technology.

Adding to the confusion and misunderstanding about using nuclear measurement gauges has been the somewhat misleading information disseminated by the media. From "The China Syndrome" to Three Mile Island to dirty bombs, the word "nuclear" generally invokes a negative connotation in the minds of most people. Dirty, dangerous, environmentally non-friendly, and a whole host of other societal ills generally revolve around it. However, in the world of industrial process measurement, nuclear measurement gauges are routinely used in the world's most demanding process conditions.

Many companies have banned nuclear measurement gauges or dramatically restricted their use — often times to the detriment of making highly critical measurements. When this happens, companies can lose literally thousands of dollars a year in lost measurement productivity and increased maintenance required by having to use intrusive and contacting measurement methods.

But how dangerous is it to use nuclear measurement gauges? What are the safety considerations involved? Will employees receive undue exposure to radiation from working around these gauges? These questions should be answered, and the myths surrounding nuclear measurement gauges should be examined.

But first, let's discuss what a nuclear measurement gauge is and how it operates. A beam of radiation is generated by a small radioisotope. This radioisotope is an unstable form of an atom that is continuously breaking down,

A nuclear density gauge is mounted at a 45-degree angle for small pipes or narrow measurement spans.

much like the sun generating heat and cosmic radiation. There are many different types of radioisotopes; however, the two most common in industrial process measurement are Cesium 137 (Cs-137) and Cobalt 60 (Co-60). Each one has different purposes and applications based upon the measurement, pipe or vessel geometry, and other process conditions.

Nuclear measurement gauges operate on a simple yet sophisticated concept. The radioisotope (the size of a saccharine tablet) is placed in a rugged, steel-jacketed lead housing. The housing shields the radioactive beam except in the direction where it's supposed to travel. Using a small collimated aperture in the shielding, the beam can be projected at various angles into the pipe or vessel. On the other side of the pipe, vessel, conveyor, or other type of process container is a highly sensitive scintillation detector.

The detector contains a small crystal made from synthetic material or sodium iodide. The crystal is optically coupled to a photo multiplier tube, which converts light into electrical pulses. When the radioactive beam strikes the crystal, after having passed through the vessel/pipe walls and process, it generates thousands of light pulses that are recorded by the photomultiplier tube. This is converted into a signal, which can be used for a display or an analog output into a DCS or PLC.

Nuclear measurement gauges operate on the principle of attenuation — if there is nothing in the way of the beam, then the beam will be strong. If there is something in the way of the beam, its strength will be less. This principle applies to virtually any nuclear measurement.

Nuclear measurement technology is also highly repeatable. Using the laws of physics, statistics, and sophisticated software, if proper application information is given, the success of making any nuclear-based measurement is almost 100 percent. Considering the benefits of a totally non-contacting and non-intrusive technology, nuclear measurement technology becomes the number one method for doing the most difficult and challenging process measurement applications.

In addressing physical exposures and radiation, there are three important concepts that affect exposure. One is the amount of time a person is working in the area around a nuclear measurement gauge. The second is the distance between a person and the nuclear measurement gauge. And the third is the amount of shielding between a person and a nuclear measurement gauge. Time, distance, and shielding combined will have an effect on the body exposure.

In comparing body doses and exposures, millirems (mR) are used as a unit of measurement to compare the effect on the body by nuclear radiation. Typically, a person receives somewhere between 150-300 mR per year — including exposure working around nuclear measurement gauges. The part received working around nuclear gauges is low — only about 10-30 mR.

(For more information, refer to the following "MYTH" and "FACT" section of this article.)

The majority of exposure is from things having nothing to do with working near nuclear gauges — radiation from a variety of sources including medical X-rays, the earth itself, the sun, and even a person's own body.

A rod-type nuclear source is mounted on the outside of a vessel.

So why do many companies go out of their way to look at other technologies to make particularly difficult process measurements when the best solution is nuclear measurement? The reasons are many; however, almost all of them revolve around misunderstandings and misconceptions on health and safety. Management and labor often have incorrect notions about using nuclear measurement equipment in their companies.

To help shed light on nuclear process measurement equipment, let's now review some common facts and myths.

MYTH: Working around nuclear gauges will cause cancer, leukemia, and radiation sickness, etc.

FACT: Nothing could be further from the truth. The exposure received from working around a typical nuclear gauge is extremely minimal — and far under any ceiling for exposure to radiation. The average person gets more radiation exposure spending time on a beach in the summer than working around a nuclear measurement gauge.

MYTH: Working around nuclear gauges will make one sterile.

FACT: Not true! Once again, the exposures are nowhere close to providing harm to bodily organs.

MYTH: By using nuclear measurement gauges, you will contaminate any process in which they are used.

FACT: Totally false. The nuclear measurement beam does not contaminate any process. A good analogy is taking a glass of liquid and shining a flashlight or laser pointer through it. The "process" will attenuate the beam (if you hold your hand on the other side of the glass, you will probably see that the beam looks different). However, the liquid inside is not contaminated — only the "radiation" has passed through. Any trace of it is gone when the light is switched off. If for some reason, the nuclear material was in solid form and got into the process, then it would certainly be contaminated. But a radiation beam is just that — a beam with no

EXPOSURES AND EFFECTS

As you will see from the statistics below, it's virtually impossible to receive harmful radiation exposure when working around a nuclear measurement gauge.

- **Average exposure of 300 mR/year (general population including process measurement workers working around nuclear gauges) — No noticeable effect**
- **Up to 20,000 mR in a few days — No noticeable effect**
- **Up to 100,000 mR in a few days — Slight changes of blood structure is possible but no body damage likely**
- **Up to 200,000 mR in a few days — Radiation hangover, vomiting, serious illness possible, recuperation possible**
- **600,000 mR in a few days — Increased chance of death**
- **More than 600,000 mR in a few days — No chance of survival**

physical properties that can contaminate any process.

MYTH: You cannot use nuclear measurement gauges in processes such as food or dairy.

FACT: There again, nuclear measurement gauges are used to measure processes in a variety of food processes. Measuring the solids density of tomato paste is one such application. As mentioned above, the radiation beam does not contaminate the process. Many people confuse irradiation of food with nuclear process measurement equipment. The systems used to irradiate meat and other food stuffs contain sources that are literally thousands of times stronger than the average nuclear measurement source.

MYTH: The source housings will leak out and disseminate dangerous radiation.

FACT: Since sources are double-encapsulated in stainless steel housing and then encased in a steel-jacketed lead outer housing, it is virtually impossible for nuclear sources to leak radiation from inside the source housing. In fact, there are cases where nuclear source housings have been involved in explosions and blown hundreds of feet from their original location. No radioactive leakage was found, and there was no danger to the surrounding area. The source shieldings are designed to ensure that the lead casing will melt around the source capsule — permanently sealing it and preventing undue radiation exposure.

MYTH: You have to wear dosimeters to work around nuclear measurement gauges.

FACT: This is false. There is no federal or state requirement that dictates that workers must wear any dosimeters when working around nuclear measurement gauges. The dosages received when working around nuclear measurement gauges are so low that it's almost impossible to distinguish them from natural background radiation (radiation that occurs naturally from the earth) and exposure from nuclear measurement gauges. Many people confuse the requirement for wearing dosimeters in some areas of nuclear power plants with areas containing nuclear measurement gauges. This comparison cannot be as there is no way to equate the exposures received.

MYTH: When working on a nuclear measurement gauge, especially the source shielding, you must wash your hands directly after working on it.

FACT: Once again, as with most myths, nothing could be farther from the truth. There are no radioactive contaminants present that would require washing your

SAFETY SCENARIO

In order to illustrate the safety of working around nuclear gauges, let's examine the following scenario.

- **Imagine that someone stays for one year within one foot of a nuclear measurement gauge — the shielding or part that contains the nuclear source. For the sake of this illustration, the person remains in a stationary position. How much exposure would that person receive?**
- **Assuming that the exposure is 5 mR per hour at one foot from the source shield (typically the maximum exposure permitted by law), the exposure would be as follows:**
  365 days per year X 24 hours = 8,760 hours in one year
  8,760 hours X 5 mR per hour = 43,800 mR in one year
  As a result, this person would receive half the exposure that could cause slight changes in the blood. If this person backed away one more foot, thereby doubling the original distance, then this person would receive one-quarter less exposure (or approximately 10,000 mR) due to the inverse square law of physics.

hands or other part of your body after coming into contact with any part of a nuclear measurement gauge. The only reason you might need to wash your hands would be to remove the dirt and dust from the surrounding environment.

MYTH: Nuclear measurement gauges produce far more radiation exposure than medical X-rays and other natural occurrences.

FACT: Wrong again. Let's look at X-rays first. A typical chest X-ray produces about 40 mR, which incidentally is about the exposure the human body produces in a year by itself (from radioactive elements in the bones). Other types of medical X-rays, especially CAT scans, can produce up to 1,000 mR. More examples are cosmic rays from the sun (30 mR), the soil (30 mR), and living at higher altitudes — people living in Denver receive about 50 mR per year, 50 percent more than at sea level. By comparison, though it's difficult to predict because of all the variables involved, typical exposure of someone working around a nuclear measurement gauge would be somewhere in the 10-30 mR range. However, as mentioned earlier, the three factors (time, distance, and shielding) have more to do with exposures people receive than any other single factor or event.

Conclusion

Nuclear measurement gauges are an excellent solution for critical measurements where contacting or intrusive-type equipment will not work. They are attractive in today's process measurement landscape due to their simple yet elegant technical concept — and a few laws of physics thrown in. They can save thousands of dollars each year in reduced downtime and equipment and maintenance costs. Since nuclear measurement gauges have no moving parts or components inside pipes and vessels that need replacement, they are the ideal answer for accurate and repeatable measurements in the most rugged and hostile process environments. ●

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STUDY AND STATS

You would assume that someone who works around nuclear gauges (loading, transport, etc.) would receive more exposure to nuclear radiation than someone who does not? But is that truly the case? Let's consider the following.

- **In a study done in 2002, two people at Berthold Technologies USA compared their radiation exposures for that year. One handled nuclear sources; the other did not.**
- **The study revealed that the person handling the sources did not receive more exposure. In fact, it showed that factors such as lifestyle and travel habits play a far more profound effect on exposure to radiation. The person who worked around nuclear sources received approximately 185 mR during the year. The person who did not work around nuclear sources received approximately 270 or almost 50 percent more radiation exposure. Their lifestyles played a significant role. The second individual, a manager, had three chest X-rays that year with each one an estimated 40 m/R. He also took six round-trip flights of more than 10,000 miles each. For every 10 hours at 35,000 feet, a person receives approximately 5 mR. This alone accounted for 60 mR.**