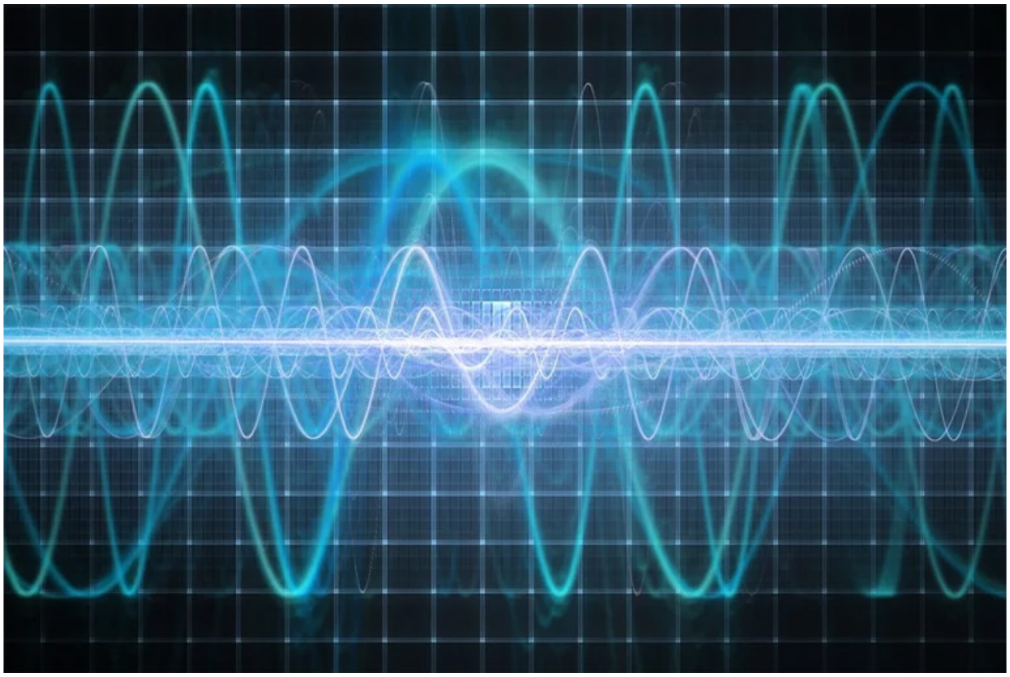


X-ray Interference and Radiometric Measurement

Radiometric measurement is the most reliable technology for many challenging applications. When presented with complications of high process temperatures and pressures, corrosion, steam, and other challenges to intrusive sensor technology, longer term reliability with a lack of regular maintenance is an advantage of radiometric technologies. But radiometric measurement also has an Achilles heel: X-ray interference.

What is X-ray interference? How can it influence radiometric sensors used for process measurement? How can it be handled reliably?

What is X-ray interference?

The use of radioactive isotopes in industry is more frequent than many people would expect. Those reading this have likely experienced the use of gamma ray emitting materials in process measurement, such as level, density or weight measurement. In those cases the gamma energy from a source is directed through a vessel, pipe or conveyor, is attenuated by the mass in/on those items, and is then registered by a detector on the opposite side. The detector measures the radiation field strength and then infers the amount of mass in/on the vessel, pipe, or conveyor.

Other uses of radioactive isotopes in the industries that employ radiometric process measurement equipment include NDT through X-ray radiography used to qualify vessel/piping weld integrity, and radiographic tomography on vessels as an analytical tool.

In most cases these services are conducted using isotopes similar to those used for process measurement. Rather than using an electrically powered X-ray generator such as in medical X-rays, these industrial services employ radioactive isotopes of the elements Cadmium, Iridium, Cobalt, and Cesium. These elements are poorly collimated so they broadcast radiation over large distances and directions.

X-ray interference occurs when gamma energy from other than the intended source reaches the process measurement detector.

The influence of interfering X-rays on radiometric detectors

X-ray interference can lead to measurement error, and even damage to radiometric detectors designed for process measurement.

Without diving into a detailed description of radiometric process measurement, it's important to understand that X-rays and gamma rays will be registered by radiometric detectors as counts per second. Furthermore, a relatively higher count rate is indicative of a lower process condition such as low % level, specific gravity, weight, or even an uncovered switch.

When radiometric detectors receive X-rays/ gamma rays from a source other than that associated with the measurement, the registered count rate will increase. The response of the detector then is output of a lower value of the process variable to the control room. It is expected that the reader can see the negative implications here.

It may also happen, when the interfering source of radiation is in close proximity to the radiometric process measurement detector, that permanent damage be done. Radiometric detector technology used for process measurement today is ultra-sensitive and able to respond reliably in radiation fields as low as background radiation. When one of these devices is exposed to a high-intensity hit of gamma or X-rays, the sensing elements may prematurely age or even suffer permanent damage, effectively burning out.

Reliably handling X-ray / Gamma ray interference

Responsible handling of interfering X-ray events is an important job of a radiometric detector. The task includes these main objectives:

1) Prevention of process overfill events
2) Avoidance of process shutdowns
3) Protection from permanent damage

On the first task, VEGA detectors make use of two schemes to prevent inadvertent vessel overfill during the interference event. As a review, keep in mind when X-rays / gamma rays shine on a radiometric detector the registered count rate goes up in response to the elevated radiation field strength. The process value is inversely proportional to the count rate, so the detector then perceives that level in the vessel has decreased. Normally this leads to a fill stream being activated to maintain proper level, and in this instance can lead to overfilling the vessel.

The first scheme available in VEGA radiometric detectors is an internal software algorithm activated when the count rate registered is more than 25% higher than the highest count rate found in the calibration table. When this is the case the detector goes into an X-ray alarm state, and will alert the control room that an X-ray event is ongoing. In this case caution should be used when interpreting the measurement value.

The second scheme is designed to provide reliable operation in the presence of "soft" X-ray events. These events are defined here as those that elevate the count rate produced by the detector, but not to a point that the count rate goes higher than the maximum count rate found in the units calibration table. The detector then has no reason to believe that anything other than a level change has taken place.

The VEGA solution for this case is a low cost radiometric point level switch serving only to measure the background radiation in the area. When a radiography test begins and those X-rays reach the X-ray detector its count rate will of course increase. When that count rate goes above that produced by background radiation, it will send an alarm to the measurement detector, and the control room if desired, that an X-ray interference event is taking place. The measurement detector will then go into X-ray alarm state and will alert the control room that an X-ray event is ongoing. At that point the control room should use caution when interpreting the level reading.

On the second task of avoiding process shutdowns during X-ray interference, VEGA allows for the choice of output behavior when in the X-ray alarm state. The user can specify the output current to hold the last valid value and dither (output a square wave of the user's design), or go to error current (fail high of low, 3.6mA or 22mA). In the case where an error current output will cause a process shutdown then the hold last value and dither behavior is best.

Specific to permanent damage protection, VEGA radiometric detectors utilize a built-in self-preservation utility by which, in the presence of high intensity X-rays / gamma rays, the power to the PMT (photo-multiplier tube) in the detector is cut for a period of time. After that user selectable period of time the power to the PMT is again applied and the unit measures the radiation field strength. If it is still too high then the cycle repeats, until that field is below the point at which damage would occur.

In summary, VEGA strives to reliably accomplish two goals in regard to X-ray interference events:

• Reliably alert the end user when X-ray interference is occurring, without process shutdown.
• Protect the ultra-sensitive detector from permanent damage, or burn-out.

Other topics on X-ray interference and radiometric measurement

VEGA does not promote live measurement during an X-ray. Doing so requires the end user to take some risk.

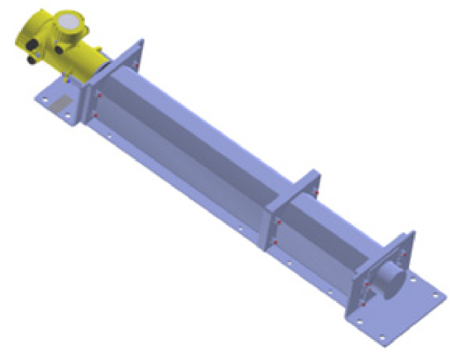
While investigation has been done to provide this solution, the large scope of variables involved in X-ray interference events (isotope, source activity, distance, direction and time of X-ray events, among others) makes a reliable solution for measuring live during X-ray interference a risky business. Most processes employing radiometric measuring systems do not allow for risk since that can lead to hazards.

What about shielding the detector from X-ray interference?

Shielding is a key factor associated with radiometric hardware and measurement. Placing mass between a source and a detector will reduce the radiation field strength. But reducing it to 0% requires an impractical amount of mass. The reduction is commonly expressed in terms of half value layers. A ¼" thick lead plate will reduce the Cesium 137 radiation field strength by 50%. 1" thick lead plate still leaves over 6% of the radiation field strength present. A 1" thick lead shield placed around a continuous level detector of 23 feet length will weigh over 1.5 tons, and still leave 6% of the background radiation field to reach the detector.

Shields are offered by VEGA, but they are designed to offer additional burn-out protection to detectors to those customers that commonly X-ray on vessels near their installed radiometric detectors. Not with a promise to eliminate X-ray interference, but as a second line of damage defense.

An interesting concern when using detector shields is creation of "soft" X-ray events when radiography takes place. In that event the count rate increases, but the radiation field strength reduction of the shield may result in only a small count rate increase. In that event the onboard detector X-ray alarm facility may not kick on. The increased count rate may stay within the calibrated range of count rate. In that case only the external X-ray detector will provide notification of the external event.



Shields are best used as an extra degree of burn-out protection, and in conjunction with an external X-ray alarm switch.

In summary, while radiometric process measurement provides very reliable measurement in the most difficult of process conditions, the technology is influenced by interfering sources of radiation. VEGA strives to provide reliable measuring solutions, so approaches the X-ray interference issue from the point of view of always alerting the control room when an interfering event takes place, and to protect the detectors from burn out.

VEGA makes no claim to measure live through an X-ray event since our experience tells us there are too many variables associated with the interference to allow that to be done reliably. VEGA does offer shield hardware as an extra level of protection against burn out, but not to eliminate X-ray interference altogether.

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