Tracerco News

Volume 1 Edition 4

Delivering diagnostic services and measurement solutions worldwide.

Gamma Scans Indicate Where and Why Flooding Occurs

By Lowell Pless – Operations/Business Development Mgr. – Scanning, Pasadena, Texas USA

Flooding in distillation columns has been defined as "excessive accumulation of liquid inside the column," (1) "inoperability due to excessive retention of liquid inside the column," (2) and even a point where "it is difficult to obtain net downward flow of liquid, and any liquid fed to the column is carried out with the overhead gas." (3) While these descriptions appear to be similar at first glance, they actually describe different stages or degrees of flooding. Excessive accumulation of liquid may or may not cause inoperability, and inoperability may or may not carry the feed liquid out with the overhead gas.

However, when existing columns require troubleshooting or debottlenecking, inconsistent definitions of the flooding initiation point may lead to different – sometimes even wrong – revamp designs, due to lack of understanding about the cause and location of the flooding condition.

Tracerco's TRU-SCAN® gamma scan application has proven to be a reliable tool for determining the location and extent of flooding in trayed towers, because they can measure the liquid holdup in a column directly. This is accomplished by simultaneously lowering a gamma-ray source and a detector down the sides of a column. The gamma-ray transmission through the column is affected by column internals, the process fluids, and possibly by external influences, such as manways or stiffening rings. Any external influences are documented during the scan and are labelled as comments on the data results.

In addition to solving flooding problems, insightful analysis of the dynamic flooding mechanism will benefit the development of an advanced control system and improve operating procedures for pushing a column to its maximum capacity.

The following case study investigates the flooding phenomena in a trayed tower. The incipient-flood-point (IFP) data on a column must answer two questions – when (at what throughput) and where (at what location) the column starts to flood. Traditional measurements of pressure

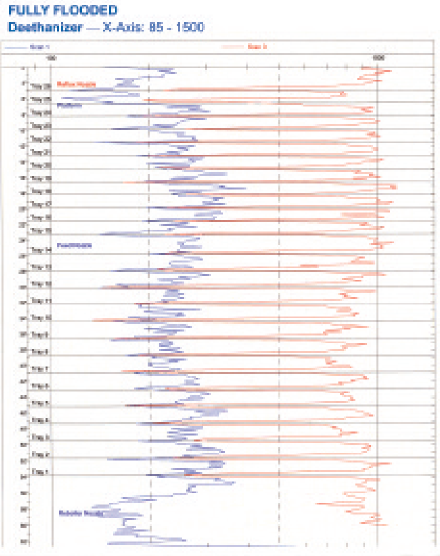

Figure 1 - *Blue scanline shows abnormally dense tray-vapor spaces, indicating tray spaces that are full of liquid or a flooded column. The Red scanline shows the tower at normal operating conditions*

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TRACERCO™ Interface gauge – Solves Expensive Polyethylene Overflow Problem

By Bram Beinart – Regional Mgr., Perth, Australia

A leading manufacturer of low-density polyethylene (LDPE) recently upgraded their process plant. As a result of the upgrade production in this high pressure system had increased by approximately 50%. The upgrade had been achieved without increasing the size of major vessels.

However, after the upgrade four separator vessels at this plant were experiencing higher flow velocities through the separators which had resulted in them becoming highly susceptible to significant level fluctuations. The vessels are used to disengage unconverted ethylene gas from molten liquid polyethylene product. They operate at a pressure of around 300 bar. The previous capacitance probe based polyethylene interface level control systems worked in conjunction with radioisotope based high level trips. It was found that the instruments simply could not cope with the new demands being placed on them. After upgrading, the vessels frequently suffered liquid polyethylene carryover into the ethylene gas exit lines. This resulted in liquid solidifying in the gas lines leading to unacceptable down time and product loss.

Tracerco was approached by plant management to install a reliable interface measurement system. They required a system that could be trusted to indicate the exact position of the interface between the relatively high-density gas and the relatively low-density liquid. The gas density was about 0.2 g/cc. The liquid was about 0.5 g/cc. After a thorough investigation and detailed evaluation, plant management decided to install the

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Air Ingress into Vacuum Column Located with Helium

By Dave Ferguson – Business Development Mgr. – Tracers, Pasadena, Texas USA

Some distillation operations are greatly enhanced or only possible under vacuum conditions. The most commonly known vacuum columns are in refinery crude units. The bottoms product from the atmospheric column is further refined by the vacuum column to remove more light fractions and separate the heavier crude oil fractions. Several chemical plant separations are also best conducted at pressures below atmospheric.

Vacuums are achieved by use of steam aspirators and vacuum pumps. The operation of these devices to produce a vacuum is a cost to the distillation operation, just as is the use of steam for reboilers. If there is air ingress into the process, these devices have to be pushed to greater effort to maintain appropriate vacuums, which increases the cost of operation. Sometimes, the devices cannot meet the demands and appropriate vacuums cannot be maintained, reducing the efficiency of the separation process.

Air ingress can occur in many places. Every gasket flange, threaded fitting, sight glass, block valve, and valve stem is a potential point for an air leak. Identifying these leaks is a daunting task. The most effective approach is to perform a TRACERCO Diagnostics™ Helium Leak study.

Method

A mass spectrometer is used to analyze the exhaust from the steam ejectors. The arrangement of the sampling process varies according to the piping of the exhaust, but the mass spec is arranged to continuously draw vapor in from the steam ejector exhaust. One crew member is monitoring the readout from the mass spec during the testing. The second crew member of the team is equipped with a small bottle of helium, mounted with a trigger valve and piece of tubing.

This crew member starts near the bottom of the vessel and squirts a small amount of helium near a flange, valve, or other item where air could possibly be drawn into the system. As he does this, he marks the item to indicate that it has been tested. Depending on the size of the vessel and the distance from the leak point to the mass spec sampling point, several minutes may be required for helium to pass through the vessel and be detected by the mass spec. When the technician monitoring the mass spec identifies a positive indication, he will have the other crew member backtrack the tested items until they can identify the location of the leak.

Case Study

The plant management of an asphalt unit called with a concern about a vacuum column. When feed rates were at normal conditions, there was a loss of vacuum. There was concern that either air was leaking into the column or that excess light ends was leaking into one of the recycle streams. The feed to the crude column passed through one heat exchanger with Light Vacuum Gas Oil (LVGO) on the other side. The Crude feed also passed through a pair of exchangers with Heavy Vacuum Gas Oil (HVGO). There was a suspicion that the crude was leaking into the LVGO and/or the HVGO and entering the Vacuum column with the recycled LVGO or HVGO.

The plant management asked for leak tests to be performed on the exchangers. A radioactive tracer was injected into the crude inlets to the exchangers. The LVGO and HVGO outlet lines from each exchanger were monitored for the presence of the radiotracer. None of the exchangers indicated a leak.

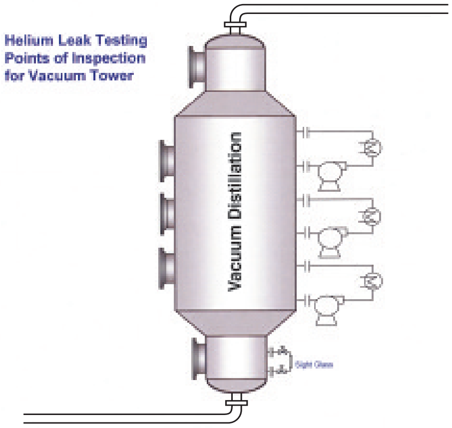
The remaining task was to perform an air ingress test using helium. The mass spec was set up to sample the exhaust of the steam ejectors and helium was sprayed around the possible leak points.

The first leak was found at the top of the bottoms level sight glass. The second leak was on a blind flange where the gasket had aged and cracked. The third leak was a valve stem leak on an open valve. The last leak was on the overhead line where the insulation sheath had been damaged and the insulation stayed wet. The helium was sprayed under the insulation. When the insulation was removed, the pipe wall was found to have corroded and pinhole leaks were present.

Conclusion

The plant personnel were able to make repairs or fabricate sealing boxes around the leaks while keeping the column on line. The instability of the vacuum column disappeared and product quality returned to normal.

If you would like additional information on our TRACERCO Diagnostics™ Helium study services please contact one of our Tracerco offices in your area or visit our website at www.tracerco.com.



TRACERCO Diagnostics™ Helium study services can be provided on the following equipment:

- Off-line exchangers (tube leak check)
- On-line liquid /vapor exchangers
- On-line vacuum units
- Isolated vessels
- Cold boxes (access permitting)
- Blocked in reactors

Flooding

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drops, temperature profiles, and liquid levels usually cannot tell exactly where flooding has originated in a column, particularly with a large number of trays.

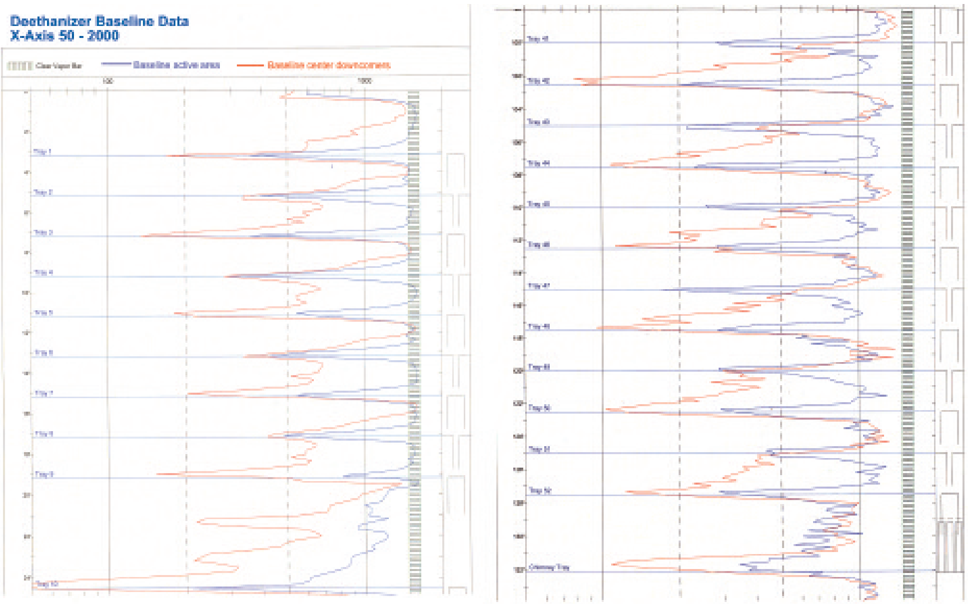

Figure 2 - *Baseline scans showed center downcomers in the bottom of the deethanizer nearly full of froth.*

Case Study illustrating a Fully Flooded Column

A deethanizer column with 26 trays had experienced severe surge problems and poor separation. The column was scanned from its top to its bottom. The tray vapor spaces in the column were extraordinarily dense as the raw gamma-ray "counts" (Fig 1, page 1 - Solid blue line) transmitted through the tray vapor spaces were only 150-200 counts, instead of the expected range of 1,000 counts. Thus, the column must be full of liquid or fully flooded.

In an operating column, unloading or reducing feed rates is the most commonly applied method to relieve the flooding problems(1). And, for a fully flooded column, the accumulated liquid must be drawn off from the bottom until the liquid level is below the reboiler return nozzle. Unfortunately, there was not a functional bottoms liquid level gauge available on this deethanizer. In order to monitor the process of unloading the column, Tracerco used a stationary monitoring technique. A gamma-ray source and detector were set up just below the return nozzle, while operations tried to unload the column.

In this stationary monitoring technique (See Ref A, page 4) the gamma transmission counts will have a sudden increase when the liquid level is lowered below the monitoring spot. Once the bottoms liquid level is detected below the reboiler return nozzle, the column can be slowly returned to full rates.

As suggested in the deethanizer case, the bottoms liquid level should continue to be monitored to make sure it stays below the reboiler return nozzle. Our experience has shown that a significant number of columns flood due to lack of control of, or lack of a correct indication of, bottoms liquid levels.

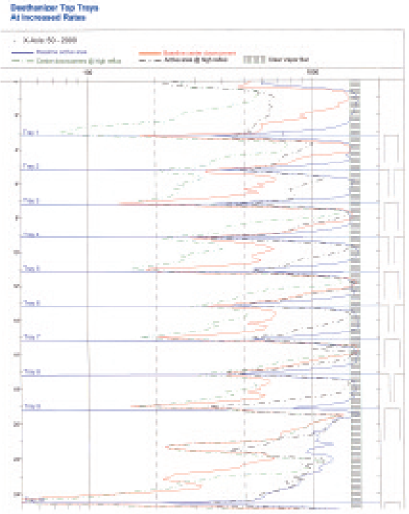

Figure 3 - *The scans of the deethanizer showed the top three trays flooding with reflux carried overhead.*

The measurement of a tower's base liquid level is one of the most problematic causes of tower malfunctions. In an industry survey problems with the tower base and the reboiler return was the number 2 cause of tower malfunctions (4). Of these malfunctions the measurement of the base liquid level was half of all the problems. Tracerco, relying on its developed expertise in radiation detection instruments has a line of reliable nuclear instruments including liquid level instruments. If you have a particularly challenging or troublesome base liquid measurement application, contact your friendly Tracerco Technical Advisor.

Once the deethanizer column was stabilized, a second scan was performed to check the integrity and operating condition of the trays. The second scan showed that the liquid holdups on all 26 trays were at the proper elevations and that the trays were holding aerated liquid (Fig 1, page 1 - Red Scanline) The deethanizer trays appeared to be operating with slight to moderate entrainment.

Case Study – Catching the Incipient-Flood-Point (IFP)

When we wish to push an operating column to its maximum, or to de-bottleneck a column, we need to know where flooding starts, what starts it, and the liquid load or vapor load when it starts. When evaluating the IFP in a large column, one needs to follow a systematic, logical approach. This case study involves a company that was increasing the capacity of a natural-gas treatment plant. Simulations showed that the deethanizer column was going to be a capacity bottleneck. The engineers wished to know, in more detail, the conditions where and when the deethanizer became limited; that is, the IFP of the deethanizer.

The first step was to establish a baseline set of data on the column. At the existing plant capacity there were no known problems with the operation of the deethanizer. A baseline scan of the 2-pass trayed deethanizer, was made on tray active areas and center downcomers to document the deethanizer operating condition at this given set of test conditions. In this particular case the baseline results (Fig 2)

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Flooding

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showed a hint of where the IFP might be. All of the tray active areas looked good; none had any severe entrainment. The center downcomers of all the trays, except the bottom two trays, appeared normal. However, the center downcomers of the bottom two trays, Trays 49 and 51, appeared to be full of aerated froth.

To simulate the operation at the proposed increased rates, the reflux was increased 15% with an appropriate increase in reboiler rates to maintain the deethanizer heat balance. The deethanizer was scanned again for both active areas and center downcomers. The results showed flooding at the top of the deethanizer (Fig 3, page 3). The top three trays were flooded with reflux being carried overhead from the deethanizer. The flooding gradually subsided until the 8th and 9th trays matched the baseline profile.

In the bottom of the deethanizer (Fig 4), the tray active areas still appeared the same as they had on the baseline but the center downcomers had filled to capacity with froth. The scan at the higher rates showed two problem areas, but it was unclear which had happened first. It would have been a logical conclusion to believe that the bottom trays would flood first, since their downcomers had been full at the baseline conditions. But since the top trays unexpectedly flooded at the increased rates, it was possible that the top trays were the starting flood point.

To confirm exactly where the flooding started first, the operating rates were returned to the baseline conditions. Three points were selected for stationary monitoring - between the top two trays, above the bottom tray, and below the feed point. As rates were slowly and gradually increased, these points were continuously monitored to see which would flood first.

As Figure 5 shows, the top trays flooded first. This testing also confirmed to the designers that the bottom section of the deethanizer operated in the "emulsion" regime - a location where the vapor is bubbling through the continuous liquid phase when operating at higher pressures and higher liquid rates. In the emulsion regime, downcomer limitations are the primary cause of tray capacity problems. This result was expected; but the surprise was that the deethanizer flooding actually occurred first at the top of the deethanizer.

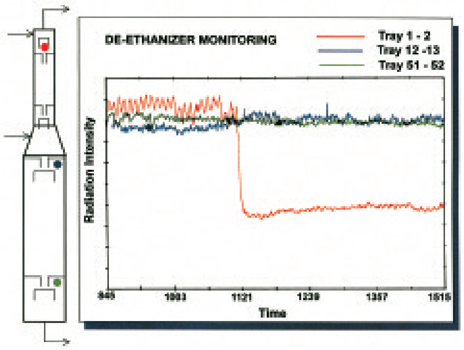


Figure 5 - *As operating rates were increased, continuous stationary monitoring of three key spots on the deethanizer showed that the top trays were the first to flood.*

References

1. Kister, H.Z., "Distillation Operation", Chapter 14, McGraw-Hill, New York, 1990.
2. "Fractionation Tray Design Manual", Sec. 5.2, Sieve Tray Flooding, Fractionation Research, Inc., 1998, p.1.
3. Fair, J.R. Perry's Chemical Engineers Handbook, 7th Ed., "Gas-Liquid Contacting Systems", McGraw-Hill, New York, 1997, pp. 14-25.
4. Kister, H.Z., "What Caused Tower Malfunctions in the Last 50 Years?", Trans IChem E, Vol 81, Part A, January 2003

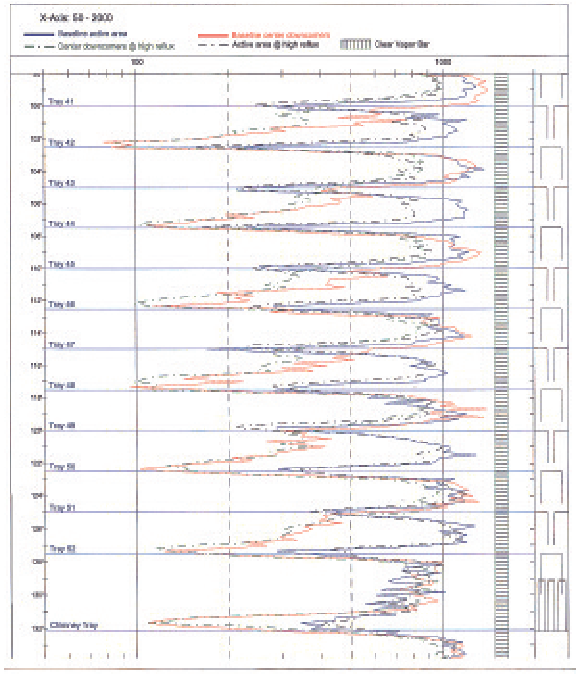
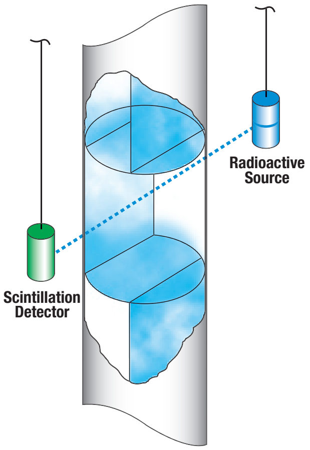


Figure 4 - *Center downcomers of trays in the bottom of the deethanizer were full of froth, but tray active areas looked the same as they did in the baseline conditions.*

REF A: STATIONARY MONITORING

The traditional gamma scan has the source and detector moving down the column in discrete increments. Each discrete gamma measurement is plotted to generate a density profile of the online process. Stationary monitoring, however, utilizes an immobile source and detector at a particular point on the process equipment to monitor density changes versus time – instead of density versus elevation. This technique is useful in numerous applications, such as identifying the incipient flood point of trays or packing; monitoring and calibrating level indication instruments; or liquid entraining studies.



For some complicated applications, several stationary monitoring points on a column are needed for observing the dynamic changes of different locations simultaneously.

Interface gauge

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TRACERCO™ Interface gauge on all four of the Separators. There were several reasons plant personnel selected this type of measurement system.

- **Safety** - was the main concern. Disastrous fires had occurred on the plant site in the past. Tracerco supplies the only non-invasive level or interface gauge that is intrinsically safe for zones 0, 1 and 2 use. It is therefore designed not to initiate any fires or cause highly flammable ethylene gas to explode.
- **System Reliability** - had to be assured. The TRACERCO™ Interface gauge has an independently assessed Mean Time between failure rating of 14 years.
- **Accuracy and Speed** - Due to the random nature of radioactive decay, long time constants are desirable for high accuracy when using nucleonic systems. However, the system had to be both accurate and fast. Fast response requires a short time constant.

  The Tracerco gauges are designed with dual dynamically selectable time constants. While the control units automatically choose a long time constant under steady state conditions they choose a short time constant under fluctuating conditions. This ensures no compromise between the two key performance areas of accuracy and response time.
- **Pressure Effects** - The Tracerco systems have pressure compensation built in. The density of the ethylene gas can fluctuate dramatically due to system pressure swings. A sudden drop in pressure could cause dissolved gas in the melt to begin escaping. This causes foam to begin to rise from the level of the melt. However, the immediate effect is for more radiation to pass through the lower density gas. This results in the anomalous situation that competing nucleonic gauges not corrected for gas pressure would initially indicate the level moving in the opposite direction i.e. falling as a result of increased radiation at the detector. Competing systems would therefore begin to drive control systems in the wrong direction.
- **Accuracy of Measurements** - TRACERCO™ Level gauge or TRACERCO™ Interface gauge detectors use Geiger Muller tube technology. These do not operate too close to background radiation levels, as do some competing scintillator detectors. They are therefore less susceptible to minor disturbances to the radiation field due to e.g. process inflows. They will allow for a build-up of a polyethylene 'skin' on the walls to be "calibrated out".

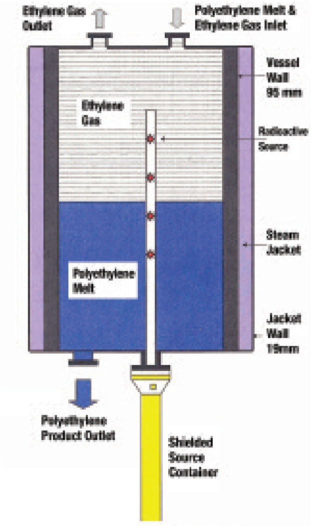

Figure 6 - *The TRACERCO™ Interface gauge fitted to the polyethylene separator vessel*

Each TRACERCO™ Interface gauge had the same design. (Fig 6) Four radioactive sources were strung together using a stainless steel cable. As with most interfaces gauges, these were inserted into a pocket (or well or dip-pipe) that had been inserted into the bottom of

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Tracerco Featured Product

TRACERCO Diagnostics™ RapidScan

Do you want an installed method of regularly assessing the operation of your distillation tower, reducing operating costs and shutdown time?

Tracerco would like to introduce our next generation scanning system for repeatable scans and towers with limited or no access to the top. Tracerco's team of experts has engineered an alternative technique to scanning trayed and packed columns. The TRACERCO Diagnostics™ RapidScan system is permanently installed on a column to provide process engineers the option of on-line repeat scans or scanning multiple times at different rates to evaluate mechanical, rate or process related problems. Costs to build scaffolding or crane rentals to work from a basket can now be eliminated.

Tracerco's TRU-SCAN® or Tru-Grid™ Scans generate density profiles of distillation columns that are used to identify damaged trays and packing, liquid maldistribution, rate related problems such as weeping or entrainment, and process problems such as fouling or foaming.

A few of the benefits you will receive when installing the TRACERCO Diagnostics™ RapidScan system in your plant are:

- Eliminate the costs of scaffolding or cranes for columns that do not have access for scan set-up
- Alternative scanning technique for frequently scanned towers or multiple scans at different rates
- Fixed orientations for repeatable scans increasing the reliability of scan data
- Wireless detection system for rapid data acquisition

If you would like to learn more about the TRACERCO Diagnostics™ RapidScan system please contact a technical advisor in your area.

Interface gauge

(Continued from page 5)

the vessel. The reasons for this are twofold:

1. It avoids the need to radiate through two thick vessel walls and through two steam jacket walls.
2. It ensures that the radiation actually passes through even the densest phase and arrives at the detector. This is different to a normal level system where the bulk process contents of a full vessel will usually cut the radiation at the detector to background levels.

On a simple application such as indicating the interface level on an oil/water separator one would firstly obtain purely oil between the sources and the detector. The pulses received by the control unit under such a condition would be made to represent 4 mA.

The next step would be to ensure that there was only water between the sources and the detector. The input to the control unit under this condition is set to represent 20 mA. The control unit will then give a 4 to 20 mA output that represents exactly where the level of the interface between the oil and the water is located. However the plant management did not want the vessels filled to the top of the measuring range with polyethylene. The management-team was very concerned about the possibility of carry-over or over-flows. Therefore not only system design but also commissioning had to be completed partly by calculation.

The previously installed nuclear gauge was a high-level switch with a Co-60 isotope as its source of radiation. The Tracerco team selected Cs-137. The Cs-137 has a much longer half-life at 30.0 years than Co-60 at 5.26 years. This was not the most significant reason for choosing the Cs-137 as the Tracerco control unit automatically compensates for source decay no matter whether it is Cs-137 or Co-60 or indeed Americium 241. The most compelling reason for choosing the Cs-137 was it's lower Gamma energy at 662 keV as opposed to the Co-60 Gamma energy being as high as 1330 keV. This would make the system far more sensitive to the presence of low-density gas or liquid. Whereas the Co-60 gamma ray would tend to penetrate the process medium with very little attenuation the Cs-137 gamma ray would fluctuate more readily with changes in its' density.

Commissioning:

After instrument design and source activity sizing was completed the various methods of commissioning that Tracerco had used on similar plants around the world were reviewed in conjunction with plant management. The calculation method that most suited the situation was adopted.

The radiation arriving at the detector causes square wave (digital) pulses to be fed into the control unit. As the density of the product between the sources and the detector increases, the dose rate at the detector reduces. This results in a concomitant reduction in the pulse rate. The equation that governs this reduction is:

$$I = I_o e^{-\mu \rho x}$$

Where ‘I’ is the attenuated radiation due to the ethylene gas or polyethylene product, ‘μ’ is a Gamma ray constant for Cesium. ‘ρ’ is the density of either the gas or the melt and ‘x’ is the path length of the product that the radiation travels through. I_o is the initial maximum pulse rate when the vessel is brought to operating temperature but kept empty and de-pressurized. The ‘I’ value for the ethylene gas was calculated. The plant instrumentation specialist then arranged for the vessel to be charged with ethylene gas.

It was noticed that the pulse rate fell to a similar level to that which had been calculated. The polyethylene melt pulse rate was also calculated and the two values were then entered into the control unit.

Operational experience:

The plant was operated under various extremes of process conditions (such as maximum output and sudden shutdown) for a period of nine months with the Tracerco equipment. Not a single moment of production was lost during this period due to separator vessel overflow. The investment in the TRACERCO™ Interface gauge equipment was recovered within the first month after commissioning.

TRACERCO™ Interface gauge instruments offer reliability and accuracy even when an application is particularly arduous. If you would like to learn more about Tracerco's specialist measurement instruments please contact a representative in your area or visit our website at www.tracerco.com.

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