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Tracerco
Providing Insight Onsite

Avoid unnecessary costs by understanding process problems before taking action

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When a piece of process equipment starts experiencing problems and producing off-spec product, every engineer's reaction is to make a change to "fix" the problem and get it back on-spec. Yet, many plants lack adequate instrumentation to completely diagnose the cause of the poor performance. Without a more complete understanding of the root cause of the problem, "corrective action" could have little effect or make the problem worse. Gathering supplemental data can sharpen the "image" of the problem and lead to the appropriate action being taken.

Case study 1 - high differential pressure in H_2S absorber

An ammonia plant engineer found that the H_2S Absorber in the unit was displaying a higher than normal differential pressure. The gas stream from the top of the column was still on-spec, but the inlet pressure of the gas to the column was higher than normal and climbing. This was putting a strain on the compressor and increasing energy costs. As is typical on most columns, the only pressure sensors on the column were at the top and bottom.

High differential pressure in a distillation column can be caused by several things. These can include fouling, damaged trays, instruments out of calibration, changes in feed composition or conditions, and unexpected contaminants. Being an experienced engineer, an analysis of the amine was ordered to ensure correct concentration and to look for contaminants. The instrument team checked the bottoms level instrument, the temperature probes, and the two pressure meters for proper calibration. The engineer asked the lab to check the calibration of the lab instruments used to perform compositional analysis of the gas feed to the column. All of these tests failed to identify a problem and gave the engineer confidence that there was a physical problem with the internals of the column.

It was suspected at this point that the column was either fouled or some internals had been damaged. However, the cost of the corrective action was highly dependent upon the actual cause. Damaged or fouled trays were both going to necessitate an unplanned shutdown, but the duration and costs associated would differ greatly. The engineer decided to perform a Tru-Scan™ on the absorber column.

A Tru-Scan™ is performed by positioning a source on one side of a column at the top tangent line and a sensitive detector on the opposite side at the same elevation as shown in the orientation drawing in Figure 1. The scan line through the column does not have to be across a full diameter, but can be across a chord. The chord length does need to be consistent from the top of the column to the bottom. The chord is chosen such that the scan line is across an active area of the trays, avoiding the downcomers. A purposeful scan along the downcomers can also be performed to gain additional operational information, but the tray active area scan is normally performed and analyzed first.

The source and detector are synchronously lowered down the column incrementally. At each elevation, a reading is recorded of how much of the signal transmission passes through the column. In parts of the column where the average material density is low, such as just under the trays, most of the signal from the source passes through the column. Just above the trays, where the average density of the aerated liquid is highest, the liquid absorbs most of the signal. The Tru-Scan™ results are then provided in a plot of the measured signal counts versus elevation (Figure 2). This plot can be interpreted to indicate the state of operation on each tray in the column.

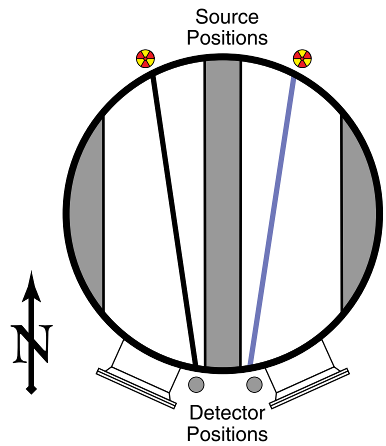

Figure 1 – Scan line orientations for a two-pass tray arrangement.

The H_2S Absorber column was constructed with two pass trays. About three years before the more recent troubles, the unit had been through a turnaround and a baseline scan had been performed after re-start. This is a useful practice since it shows a column in normal operation for comparison to when it is not

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Inside this Issue…

Define coke drum foam profiles and verify level detection devices

Tracerco's Tru-Scan™ technologies are used to define foam profiles inside coke drums and to fine-tune the accuracy of the drum level detection devices. The knowledge obtained from our Coker Optimisation Services will educate operations personnel on their unit and allow refineries to increase throughput whilst minimising the risk of carryover.

An unplanned coker shutdown can cost a refinery millions of dollars. A Tru-Scan™ can be used to view the coker's performance whilst the drum is online, allowing operations staff to achieve higher throughput and increase unit reliability. The measurement of density differences in delayed coke drums detect vapour and foam interfaces.

Knowing where the foam level is at any time during the batch cycle is vital to controlling coker operations. This is particularly true during "switch", the time when coker feed is diverted from one coke drum to another. A Tru-Scan™ will identify the location of the foam front during the switch.

Drum carryover and its effects on fractionator performance creates a more serious problem. Because of foam instability, most refiners choose to operate their coker unit well below optimum capacity, minimising the risk of drum carryover at the expense of unit throughput. Tracerco's Coker Optimisation Service uses proven methods to optimise coker performance and minimise the risk of drum carryover.

Coke drum optimisation case study

A Tracerco customer requested a Coke Drum Optimisation study be performed on their A and B coke drums to determine foam heights and verify the accuracy of their level devices. They also wanted to determine the effectiveness of their current antifoam system. Coke drums A and B were scanned (Figures 6 and 7) at various times before, during and after the switch to verify the coke level changes during the cycle. Tru-Scan™ results for coke drums A and B are shown as tables below Figures 6 and 7.

Nuclear level device calibration

Stationary monitoring scans were performed on drums A and B at each elevation where a nuclear level device was installed. Scan results at each location provided the dates, times, radiation intensity count rates, the presence of foam and when antifoam was introduced. These time studies were used to determine density versus time to establish the sensitivity of the level indicating devices. Figure 8 shows the results of one of the stationary monitoring scans performed at the elevation of the bottom nuclear level device on Coke Drum A where the foam front was advancing as evidenced in the reduction in the count rate. Figure 9 shows the results from Coke Drum B where the foam receded after the antifoam injection.

Using the results from the stationary scans,

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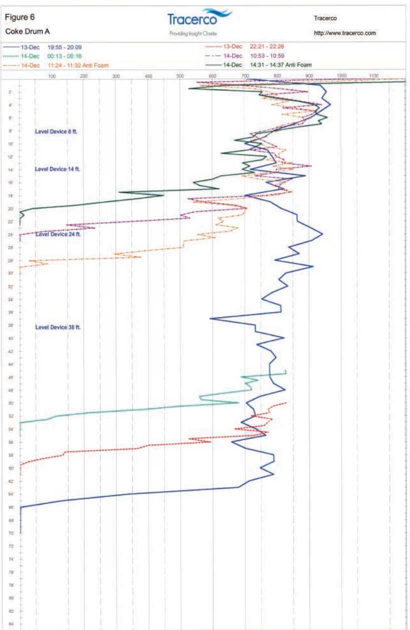
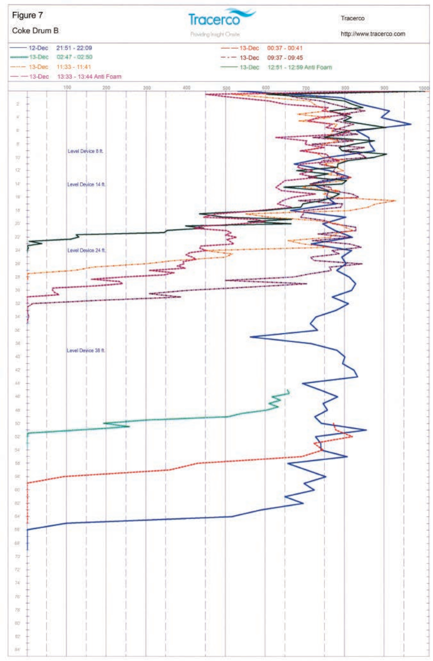


Results of Coke Drum A	Rise (feet) of Dense Material	Dense Material Below Top Tangent (feet)
Baseline Scan		64 ft.
2nd Scan - 2.5 hours later	8 ft.	56 ft.
3rd Scan - 2 hours after 2nd scan	16 ft.	50 ft.
4th Scan - 10 hours later	42 ft.	22 ft.
5th Scan - 2 hours later-after antifoam	38 ft.	26 ft.
Final Scan - 3 hours later	49 ft.	17 ft.

Figure 6 – *Results of the final scan indicated an increase of dense material of 11 ft.*



Results of Coke Drum B	Rise (feet) of Dense Material	Dense Material Below Top Tangent (feet)
Baseline Scan		65 ft.
2nd Scan - 2 hours later	10 ft.	56 ft.
3rd Scan - 2.5 hours after 2nd scan	7 ft.	49 ft.
4th Scan - 7 hours later	19 ft.	30 ft.
5th Scan - 2 hours later	25 ft.	24 ft.
6th Scan - 1 hour later-after antifoam	29 ft.	20 ft.
Final Scan - 1 hour later	21 ft.	28 ft.

Figure 7 – *Results of the final scan indicated that the antifoam had knocked the level down by approximately 8 ft.*

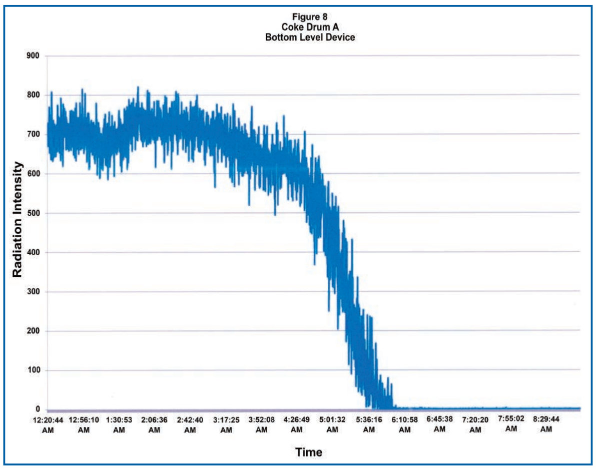


Figure 8 – *Stationary monitoring scan result of one of the scans performed at the elevation of the bottom nuclear level device on Coke Drum A where the foam front was advancing as evidenced in the reduction in the count rate.*

Coke Drum Foam

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the level devices were calibrated to allow the customer to determine the appropriate amount of antifoam.

Conclusion

Based upon the coke drum Tru-Scan™ results, it appeared as though foam was not being carried overhead at any time during the study. The Tru-Scan™ results indicated that the antifoam was successful in reducing the foam front. The ultimate objective of a Tracerco Coke Drum Optimisation Study is to modify operating procedures in order to implement a more precise foam height control strategy. This includes periodic testing, to assure that the coker utilisation strategy is appropriate for the feedstock, charge rate, and other conditions that are subject to change. Optimising antifoam rates alleviates unnecessary maintenance and turnarounds of downstream hydrotreater units in addition to enabling refiners to increase coker throughput with little or no capital cost. Tru-Scans™ performed before and after a switch identify the minimum outage that is safely achievable.

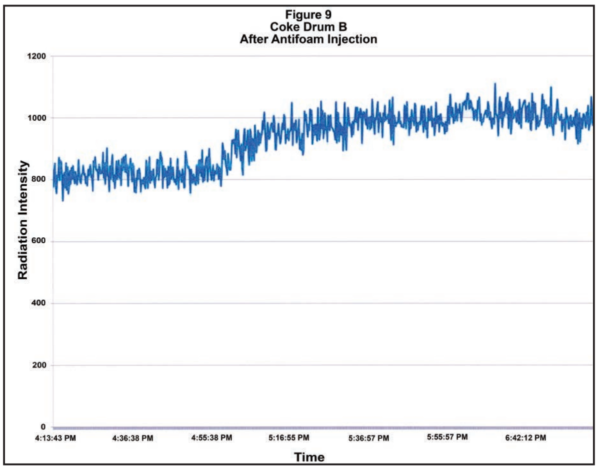

Figure 9 – Results from Coke Drum B where the foam receded after the antifoam injection.

Tru-Scans™ document liquid sulfur levels in a Sulphur Recovery Unit (SRU) Reactor during a catalyst wash.

Using Tru-Scan™ to detect liquid levels in pressure vessels and catalyst levels in reactors is a fast and extremely reliable measurement performed online. One of the problems operations staff faced when planning a catalyst "wash" was not having an indication of any accumulated liquid level in the bottom of the vessel to monitor the procedure. Tracerco was contacted to assist with monitoring the liquid level throughout the planned wash campaign.

Case study project scope – monitoring liquid level during a catalyst wash procedure

A large refiner was planning a procedure to "wash" the catalyst bed of a Sulphur recovery reactor. During the "wash" process any liquid sulfur would accumulate in the bottom of the reactor. The reactor was not equipped with a level instrument so the Engineer inquired whether Tracerco could monitor the level. Any liquid "washed" from the bed would accumulate slowly so a continuous measurement was not required. Our proposal was to perform a baseline scan followed by several scans over a period of days to document the liquid sulfur level during the procedure. After the "wash" was completed and the liquid sulfur reheated one additional scan was done before the reactor returned to normal operations to ensure that all the liquid had been removed.

Scan results identify accumulated liquid level over a period of several days

The first scan of the reactor on Day 1 was used to obtain baseline data (blue dashed scanline in Figure 10) and to verify that the catalyst bed was in its proper place. As the catalyst wash began three additional scans were performed that indicated no liquid sulfur accumulation.

The following day six additional scans were completed but still no indication of accumulated liquid. On Day 3 the results of the scans showed the density in the bottom of the reactor had increased, signifying the presence of accumulated liquid. (black solid scanline in Figure 10) The reactor level was monitored throughout the day at one hour intervals revealing that the liquid level rose slowly but steadily over the course of the day. The orange solid scanline in Figure 10 was final scan done on Day 3.

Early on the morning of Day 4 the reactor was scanned showing the liquid level had risen to the bottom of the I-Beam support for the catalyst bed. This was the highest liquid level observed (red solid scanline). At this point the washing of the catalyst bed had been completed and further scans performed were used to monitor the liquid level receding. The reactor was scanned two more times after the completion of the wash on Day 5 with each scan indicating a continuing drop in the liquid level.

The final scan performed on Day 8 (green solid scanline) indicated that the reactor had returned to the baseline condition.

Conclusion

Scanning played a key role in this plant maintenance process to monitor the status of the reactor whilst being washed. The monitoring of the liquid level was done to keep the level from getting too high where it could potentially plug some outlet nozzles.

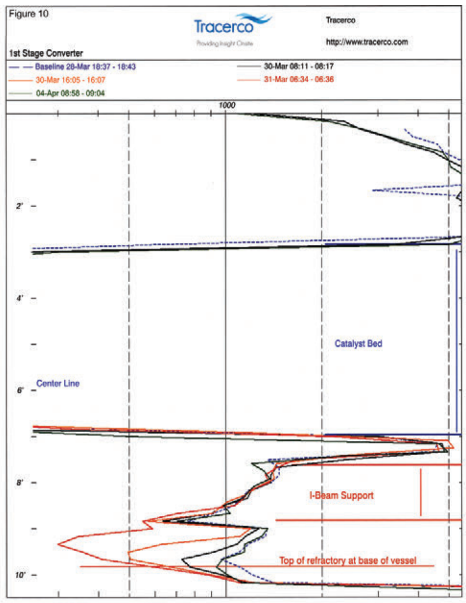

Figure 10 – Scan results monitoring the level of SRU reactor catalyst bed during a wash procedure.

If you are planning to "wash" a catalyst bed of a reactor or any other unusual procedure and have the need to monitor process conditions consider using Tru-Scan™, stationary monitoring or neutron scans to provide insight during the project. Please contact a Tracerco technical advisor in your region to discuss your options.

Process Problems

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operating normally. The orientations of the two scans in this case study are shown in Figure 1.

Figure 2 shows only the section of the column from Tray 79 to Tray 69. The Y-axis is the elevation axis where 0 elevation was the top tangent line and the distance down the column is displayed on the axis. The X-axis is the measured signal and is displayed in a log scale. Low counts are on the left and high counts are on the right. The counts are inversely proportional to the density of the material the signal is passing through. High counts, on the right, are an indication of low material density and low counts, on the left, indicates high material density.

The blue scan line in Figure 2 was the baseline scan and the black scan line was the recent scan with the Absorber having high ΔP. As the blue (baseline) scan drops below Tray 79 at the top of the Figure 2, the counts head toward a maximum reading (low material density or clear vapour). The minimum reading above Tray 79 occurs at the 14.22m (46 ft, 8 in) mark where the aerated liquid on the tray was the densest. The tray decks themselves are very thin and the signal detector is 5 cm (2 in) tall, so the metal of the tray does not absorb nearly as much of the signal as the aerated liquid. This is a typical tray profile for a normally operating tray.

Tracerco reports the performance of the tray as % Froth Height, known as FrothView™ using patented technology. Using the slope of the line defined by the maximum density above the tray and the majority of the data points showing a decrease in the aerated liquid density of the froth, the % Froth Height is the height of froth divided by the available tray spacing. Experiments in a test column with glass windows showed that such a measurement agrees very well with simulation programs that calculate Percent Flood. (Figure 3)

The baseline scan showed that Tray 79 had a % Froth Height of 66%. The baseline scan showed that Trays 79 through 69 had % Froth heights of 50 to 66%, except for Tray 72. The scan of Tray 72, however, suffered from interference from a platform support. The scan indicated the tray was present and holding liquid, but the profile was skewed by the interference of the external structure, so the % Froth Height value was suspect.

When the Absorber was scanned with the high ΔP, Trays 79 through 76 had very similar profiles, but Trays 75 through 69 had very different profiles (black scan line in Figure 2). For Trays 74 through 69, the minimum density above each tray was now greater than the maximum aerated liquid density during the baseline scans. This indicated that these trays were liquid stack flooded. The scan of the rest of the column showed liquid stacking flooding originating at Tray 49, with higher than normal % Froth heights on Trays 48 through 1.

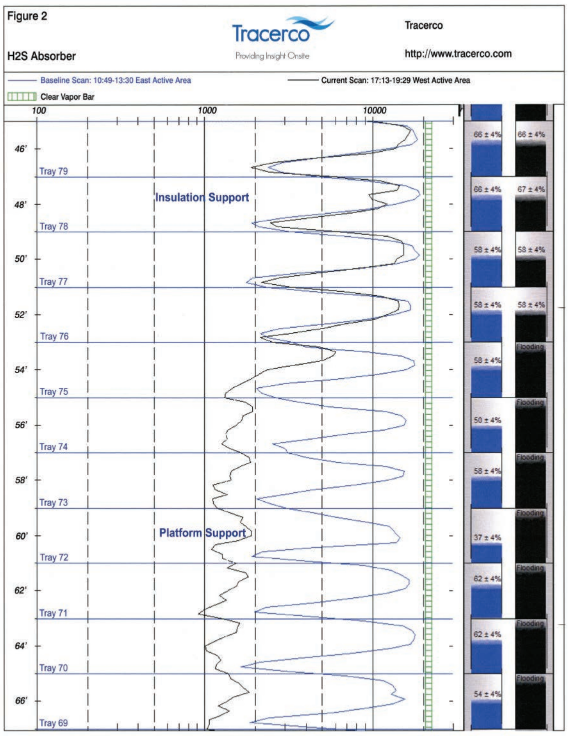

Figure 2 – Radiation intensity (density) profiles for normal and flooded operating conditions

The unit engineer was pleased to see that there was no apparent damage to any of the internals. Even in the area of liquid stack flooding, the pattern indicated that the trays were present. This left the engineer with fouling as the probable cause of the flooding. A plan was put together for an outage to clean the column and execute it quickly, minimising downtime and lost production. The unit engineer did not need to rely on an assumption of damaged trays and order replacements. Such an action in this case would have been very expensive and unnecessary.

Figure 3 – Pilot plant studies confirm that the median "liquid level" was measuring the level about half-way into the froth layer.

Case study 2 - reduction in ammonia converter efficiency

An engineer was looking at data that indicated that an Ammonia Converter had suffered a step change drop in conversion efficiency. Ammonia converters are moderately complex reactors with typically three or four baskets of catalyst. Reaction components flow up and down the converter through annular spaces. Quench lines add reactants to each basket and provide cooling along with an internal heat exchanger. A loss of conversion efficiency can indicate a leak in the external feed/effluent exchanger, a leak in the internal exchanger, or a partial by-pass around a basket of catalyst.

The costs associated with repairing a leaking exchanger were a lot less than repairing a leaking catalyst basket, so confirming the problem before shut down is very attractive. Since there are not many sample points on a converter and there are a limited number of instruments, the methods for troubleshooting are limited. Tracerco offers a service where gas tracer can be used to determine which exchanger is leaking or which basket is being by-passed while the process remains online. The engineer contacted Tracerco to gain insight on the ammonia converter efficiency issue.

The approach Tracerco took was to position one detector on the inlet to the converter, a second detector near the top of the internal heat exchanger, and the third detector on the overhead line some 18m (60 ft) from the top of the internal exchanger. See Figure 4 on page 6.

A gas tracer was injected into the feed to the converter without affecting product quality. See Figure 5 for the responses of the detectors to the tracer flowing through the converter. The injection was evident by the blue response near the 37 second mark. The tracer reached the

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Tracerco™ Life Cycle Management (LCM) – Reliable and effective asset life cycle management

Tracerco provides a range of advanced nucleonic instrumentation to the process industry, including instruments for level, density and phase measurement. Custom designed to meet the needs of specific applications, our instruments provide accurate level, density and interface visualisation, allowing operators to obtain a better understanding of vessel fluid dynamics in order to maximise throughput, enhance safety and reduce downtime.

As part of our ongoing commitment to customer service, Tracerco provides all manner of technical support for our instrumentation via our Life Cycle Management (LCM) Initiative. Through support contracts, source recycling and upgrades to obsolete equipment, operators can be confident in the knowledge of their asset condition – mitigating any uncertainty or safety risks.

Support contracts

To enable operators to increase uptime and maximise production, while meeting the demanding needs of regulatory compliance, Tracerco offers both long and short term support contracts that are tailored to customer's assets and field requirements. The benefits of support contracts include a dedicated account manager who can provide fast and effective after sales technical support, programming, testing and research on behalf of customers, and scheduled on site service visits to suit operational requirements.

With an extensive network of offices, laboratories and calibration facilities across the globe, 24 hour remote systems support via telephone and email also ensures that operators have quick access to critical information anywhere at any time. Additionally, one of our highly experienced and qualified team of service engineers will also be on standby – should there be an immediate requirement for maintenance optimisation or support.

Equipment and source upgrades / replacements

Tracerco can provide obsolescence reviews to identify any risks to customers continued uninterrupted safe operation. Radiological critical examinations following installation of equipment or following changes that may affect the system, along with annual / bi-annual function testing and inspection of measurement system components will ensure continued full operability and regulatory compliance.

The assessment of sources at or near to recommended working life will also allow operators to determine the viability of their asset, thus enabling continual production and use of Tracerco instrumentation.

In addition to re-calibrations and trip testing of equipment, we can establish present day accuracy of your system through performance assessments and non-intrusive validation services. Such information can give operators confidence in determining the position of level or interfaces within an application and ensure existing equipment continues to meet requirements now and in the future. Regular performance assessments also provide operators with the ability to efficiently maintain equipment to cost effectively manage spares or identify the need for upgrades to maximise asset life.

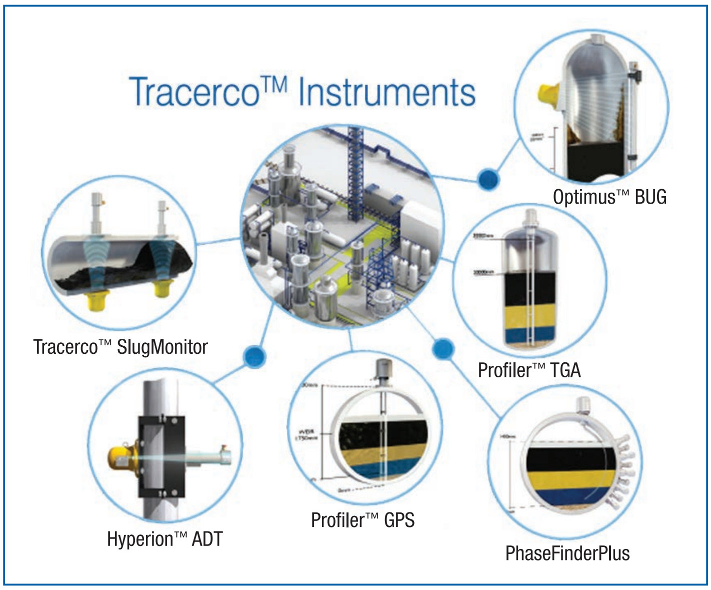
Decommissioning

If assets are assessed and found to be no longer viable, decommissioning planning and execution must begin. The important factor here is to ensure the route taken mitigates risk and that the process is carried out safely and cost effectively, while considering the best interests of the environment.

Tracerco can remove any instrument during decommissioning. With a number of in-house radiation consultants, Tracerco can also manage and remove, recycle and replace sources, as well as provide advice on immediate and long term source requirements. For Tracerco installed equipment, operators also have the option to store sources for short or long periods of time.

At Tracerco we pride ourselves in solving our customers' process control problems and delivering the highest quality, customised instrument solutions.

To learn more about our LCM program, please email your inquiries to lifecycle@tracerco.com



Process Problems

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top of the internal exchanger at the 53 second mark, peaking at 63 seconds, as shown by the red response.

The normal path of the gas and tracer is to flow through the catalyst beds and then come back by the detector at the top of the internal exchanger as it exits the converter and goes past the third detector mounted on the overhead line. Since the tracer made the turn at the top of the internal exchanger in the annular space, the tracer was near the detector and produced a large response. At the same time, the 63 second mark, the third detector showed a response to some tracer, as seen in the green response. This was tracer that leaked into the exit stream. The main body of tracer followed the normal path and started producing a second response from the third detector at the 87 second mark.

This test proved that there was a leak in the internal exchanger. Additional detectors were mounted on the external exchanger. It was tested and proven to be operating without any leaks. Additional injections were made into each quench line to see if any tracer exited early, but none did. These tests proved that the only leak in the converter system was in the internal exchanger.

The engineer took a short outage to repair the exchanger and quickly returned the unit to full production.

Conclusion

Both of these engineers could have taken incorrect and expensive actions based on the limited available knowledge from plant instrumentation and testing. However, they chose to seek more information so they could make an informed decision. Tracerco has a range of techniques that gather information that either cannot be gathered any other way or will be more difficult, costly and time consuming to gather. Tracerco is ready to help when more information is needed when troubleshooting your own process plant problems or trying to optimise process volume throughput.

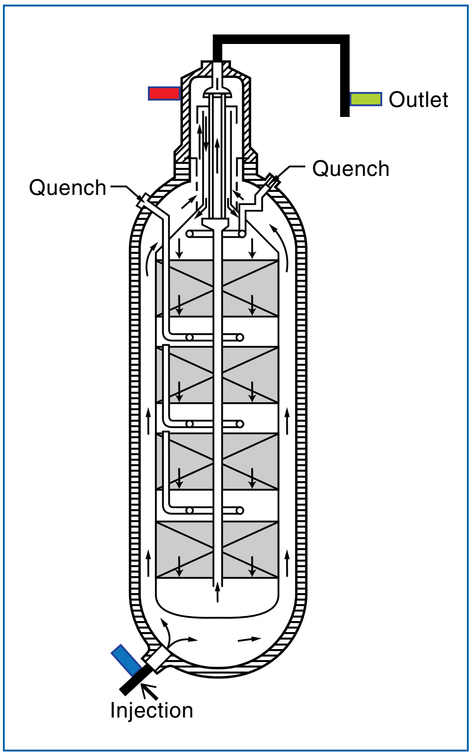

Figure 4 – *Detector placement for leak test of ammonia converter baskets and internal heat exchanger.*

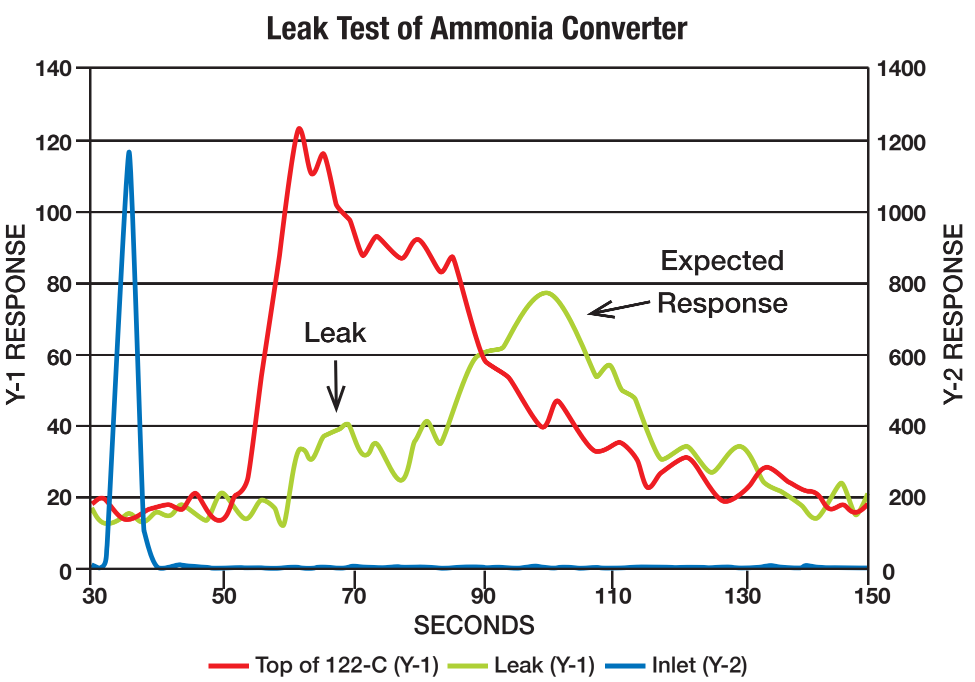

Figure 5 – *Detector responses from injection of tracer into ammonia converter.*

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