TRACERCO Diagnostics™ FCCU Study
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TRACERCO Diagnostics™ FCCU Study

General Overview

The Fluidized Catalytic Cracking Unit (FCCU) is the economic heart of today’s refinery. Small increases in yield can bring significant gains in productivity and revenues. TRACERCO Diagnostics™ FCCU studies have diagnosed operating problems and helped improve the performance of all major components of FCC units.

Each project is customized to provide the information needed to optimize or troubleshoot your specific process. All testing is performed while the unit is online and will not interfere with normal unit operations or production scheduling. Data collected can be used to identify operating parameter changes to improve unit productivity, or gauge the accuracy of process modeling and simulation. Tracerco’s experience involves numerous studies performed on units worldwide allowing a better understanding of the integrated processing components of today’s FCCUs.

A TRACERCO Diagnostics™ FCCU study utilizes our diagnostic capabilities with both sealed source and tracer technologies. These are used to measure the velocity, distribution and residence time of the catalyst or vapor phase through any part of the system. This includes testing to determine the efficiency of riser termination devices, cyclones or distribution devices.

A typical study may employ upwards of 50 detectors, measuring almost the entire system from a common injection point. The tagged process stream can be followed completely through either the reactor vessel or the regenerator.

For example, tracer material injected into the riser can provide:

- catalyst and vapor traffic velocities and slip through the riser
- determination of efficiency of the riser termination device
- flow distribution through the reactor and stripper
- cyclone distribution/operating characteristics
- reactor/stripper residence times

Vapor traffic is tagged using an inert gas. The catalyst traffic may be tagged using system native catalyst – E-Cat, Fines, or any specific particle size distribution – which has been activated by Tracerco.
TRACERCO Diagnostics™
FCCU Study

**FCCU Reactor**
- Reactor Scan
- Riser Termination Efficiency
- Residence Time Distribution
- Cyclone Distribution Study
- Cyclone TRU-SCAN®

**Reactor Stripping Section**
- Stripper Tru-Grid™ Scan
- Catalyst Distribution & MRT
- Steam Distribution & MRT

**FCCU Regenerator**
- Regenerator Scan
- Catalyst/Air Distribution Study
- Residence Time Distribution
- Cyclone Distribution Study
- Cyclone TRU-SCAN®

**Spent Catalyst & Regenerated Catalyst Standpipes**
- Standpipe Scan
- Slugging Study

**FCCU Reactor Riser**
- Riser Density Scan
- Riser Tru-CAT™ Scan
- Flow Rate Measurement of Catalyst and Vapor Phases
Reactor Riser: Scanning
Density Profile and Flow Distribution

TRU-SCAN® Catalyst density profile
Poor fluidization or poor mixing of catalyst and oil causes localized variances in the oil-to-catalyst ratio and cracking reactions. The over-cracked portion of the feed generates low-value light components, while at the same time the under-cracked portion produces more residue. A TRU-SCAN® of the riser provides the catalyst density profile down the height of the riser. Results illustrated in Figure 1 show the density profiles at high and low steam rates. In this example the overall catalyst density in the riser feed zone at scan elevation 13-18 ft. decreases with the higher steam rate. The scan also indicated that the catalyst and oil mixture traveled upward approximately 8 ft. from the oil feed nozzles before the oil was completely vaporized.

Tru-CAT™ Scan flow distribution
This method generates a detailed cross-sectional density profile of the Reactor Riser at a fixed elevation or riser cross section. The information is used to determine the uniformity of distribution between the catalyst and feed, and to identify flow inefficiencies such as catalyst maldistribution. A Tru-CAT™ Scan is often used to evaluate changes in design and operation of feed injection or lift steam nozzles. An example of this is shown in Figure 2 where two Tru-CAT™ Scans were performed, one with all 6 feed nozzles open and another with one of the nozzles shut (nozzle #3) to simulate a plugged or fouled nozzle.

Figure 1: TRU-SCAN® detector placement and density profile
Figure 2: Tru-CAT™ Scan Simulated Plugged Nozzle
Reactor Riser: Tracer
Flow Rate of Catalyst and Vapor Phases

One common application applied to an FCCU is measurement of stream velocity. Ideally catalyst and vapor should be in plug flow condition to eliminate back-mixing, which can produce undesirable secondary reactions. However, because of its greater density, the catalyst always flows up the riser slower than the oil vapor. This phenomenon is known as “catalyst slip”. An ideal plug flow riser should have a slip factor of 1.0.

Discrepancy from 1.0 or design expectation is often used as a measure of the fluidization performance. The slip factor can be determined by measuring the velocities of the oil vapor and catalyst via a TRACERCO Diagnostics™ Flow study. Figure 4 represents test results that involve two tracer injections, one for the oil vapor phase and the other for the catalyst phase. The velocities of the vapor phase and catalyst phase can be measured over the same section of the riser.

- Catalyst Slip Factor = 1.80
- Vapor Velocity: 42.2 ft/s
- Catalyst Velocity: 23.5 ft/s

Figure 3: Riser traffic velocity tracer test detector positions

Figure 4: Riser traffic velocity
**Reactor: Scanning**

**Cyclone Density and Catalyst Level Study**

**TRU-SCAN® for Cyclone Density**

The loss of catalyst through the Reactor or cyclones is a fairly common problem. Identifying the reason for the loss is often difficult. The use of TRU-SCAN® gamma scans can be a powerful tool for gathering needed information about the problem. In Figure 5 four TRU-SCAN® gamma scans were performed to check cyclone operations. A TRU-SCAN® of each Reactor cyclone identified that there was one plugged cyclone and a dipleg that was full of catalyst.

**TRU-SCAN® for Cyclone Bed Level**

TRU-SCAN® gamma scans can be performed to obtain information on the Reactor or Regenerator bed levels. In the example below operations personnel were suspicious of the calibration of the level gauge. Results from the three scans performed (Figure 6) found that at the low level, the bed was so low that the bottoms of the diplegs were uncovered, allowing vapor and catalyst to pass up the diplegs. Utilizing the TRU-SCAN® data results the appropriate height was found to cover the diplegs and the level instrument was recalibrated.

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**Figure 5: Reactor cyclones distribution study**

**Figure 6: TRU-SCAN® results assist with level instrument calibration.**
Since FCCUs have been modified to achieve the cracking reaction in the riser instead of the reactor, the reactor’s present-day role is to minimize post riser reactions by providing efficient catalyst/hydrocarbon disengagement. A TRACERCO Diagnostics™ Distribution study is used to determine relative amounts of vapor or catalyst traffic entering the primary reactor cyclones. A group of radiation detectors are placed at the cyclone inlets and outlets (Figure 7). Usually only the Primary Cyclone inlet and the Secondary Cyclone outlets can be monitored, because the cyclone pairs are internally coupled. For a normal cyclone system, each of the primary cyclones should receive the same amount of vapor and catalyst traffic, so all the detectors should receive the same amount of tracer radiation response. Comparing the integration of the areas beneath each of the distribution detector responses allows identification of flow maldistribution (Figure 8).

Figure 7: Illustrated above is a typical set-up showing the placement of radiation detectors used in a TRACERCO Diagnostics™ Distribution study.

Figure 8: The TRACERCO Diagnostics™ Distribution study illustrated is an example of a typical distribution profile exhibiting maldistribution at the Reactor cyclone inlets.
Stripper: Scanning
Catalyst Flow Distribution

The Spent Catalyst Stripper is designed to prevent hydrocarbon from being carried from the reactor to the Regenerator with the catalyst. Steam is injected counter current to the flow of catalyst to strip the hydrocarbon absorbed onto the catalyst.

A Tru-Grid™ Scan on the Reactor Stripper can identify differences in the density of the aerated catalyst to show if maldistribution of the stripping steam is occurring, if excessive catalyst holdup is occurring on any of the trays, and if the trays are in place. In a Tru-Grid™ Scan, 4 scans are performed through the Stripper in an orthogonal grid pattern (Figure 9).

When the results of the four scans are overlain on a single plot (Figure 10), areas where the scan results do not overlay are areas of the stripper where the aerated catalyst density is different. The absence of low density areas under each tray is an indication of flooded trays.

Figure 9: Tru-Grid™ Scan detector placement

Figure 10: Response Profiles
Stripper: Tracer
Catalyst/Vapor Flow Distribution

At the base of the reactor, stripping steam is used to strip the adsorbed hydrocarbons from catalyst. In the stripper section trays, or packing, are installed to improve the stripping efficiency. Steam/catalyst distribution can be inferred from the Stripper Tru-Grid™ Scan results previously described in the Stripper: Scanning section. However, if superficial velocities and mean residence times are to be measured, then the relative steam/catalyst distribution can be measured simultaneously using a tracer injection technique. Uniform distribution of catalyst and steam in the stripper is critical to achieve high stripping efficiency (less carry-down of the hydrocarbon products from reactor to regenerator).

The TRACERCO Diagnostics™ Distribution study on the Stripper section of an FCCU requires two groups of radiation detectors (4 or more detectors for each group) placed respectively at the top and bottom of the Stripper (Figure 11). The vapor and catalyst response profiles can be overlaid and interpreted for superficial velocity and distribution. (Figures 12 and 13)

![Detector placement](image)

Figure 11: Detector placement

![Catalyst Flow and Distribution](image)

Figure 12: Catalyst Flow and Distribution

Figure 12 and 13: Study of the catalyst and steam flow requires two tracers injected separately, one for tracing the catalyst and one for tracing the steam.

![Vapor Distribution](image)

Figure 13: Vapor Distribution
Regenerator: Scanning Catalyst Bed Level and Cyclone Density Study

The dense bed level elevation in a Regenerator can be determined with the sealed source TRU-SCAN® and Tru-Grid™ Scan technology (Figure 14). The TRU-SCAN® will produce a density profile at the catalyst bed level area that will indicate dense phase and dilute phase levels. It can be performed over varying operational conditions to assess the changes in level and help calibrate level control.

A more accurate indication of the Regenerator's catalyst bed level can be determined with a Tru-Grid™ Scan. Overlaying the four scanlines will identify the dense and dilute phase catalyst levels and determine if the levels are uneven which may be indicative of air maldistribution and air grid problems (Figure 15).

As with Reactor Cyclones, a TRU-SCAN® can be performed on each Regenerator Cyclone to search for high catalyst levels in diplegs or plugged Cyclones that will explain high catalyst loss.

Figure 14: Illustration of a Tru-Grid™ Scan orientation used on a Regenerator.

Figure 15: Tru-Grid® Scan results to determine the Regenerator catalyst bed level.
A TRACERCO Diagnostics™ Flow study can measure several flow parameters around the Regenerator with a single injection of radiotracer. For example both the air rate and flue gas rate can be determined simultaneously with a study of the air distribution from the air grid and/or the vapor distribution to the cyclones.

This is accomplished by placing a group of detectors at a known distance apart on the air supply line to the Regenerator and another set on the flue gas line leaving the Regenerator (Figure 16). The flow rates will be calculated by converting the measured velocities to volumetric flow with respect to line diameter, process pressure and temperature.

Figures 17 and 18 illustrates vapor distribution test results when 8 detectors were position near the 8 primary cyclone inlets (Figure 17) and 12 detectors were positioned in a ring just above the Upper Air Ring (Figure 18). Test results showed that some detectors had much larger responses than others, indicating maldistribution.

Figure 16: Detector placement

Figure 17: Vapor distribution at cyclone inlets

Figure 18: Vapor distribution above air grids
Stationary Monitoring Slugging Study

This test is designed to measure density variations over time as the catalyst circulates. A small source and detector are positioned vertically on the standpipe being inspected, and the transmitted radiation is continuously monitored (Figure 19). Fluctuations in the transmitted radiation are recorded and provide a relative measurement of the fluid density variations within the pipeline over time. (Figure 20)

Spent & Regen Cat Standpipes: Scanning Slugging Study

Figure 19: Set-up for Slugging Study

Figure 20: This case study was performed because of catalyst circulation problems. A TRU-SCAN® stationary monitoring test was designed to observe and record density fluctuations. The sources and detectors were positioned and connected to a computer to collect data over time. These results justified a short outage where a hole was found in the overflow well. The hole allowed air to leak into the downward flowing catalyst and be entrained into the standpipe. Operations can also make changes to the re-circulation rate to see the effect of the fluidized flow density profile in the standpipes.
Spent & Regen Cat Standpipes: Scanning Density Profile

Catalyst Density Profile
A TRU-SCAN® of the Spent Catalyst Standpipe can be performed to investigate the cause of circulation problems. Scan results from two scans of a spent cat standpipe showed an increase in density in the standpipe, but the red scan (North-South Scan, Figure 21) showed an area of very low density below the area of high density. This was theorized to be a blockage that caused the catalyst to flow to one side of the standpipe, leaving the area under the blockage clear of catalyst. With this information, a shutdown was authorized and a large piece of refractory was found to be causing the blockage.

Figure 21: A TRU-SCAN® of the Spent Cat standpipe can be performed to investigate the cause of circulation problems.
Tracerco has provided gamma scanning services worldwide to evaluate trayed and packed columns to identify damage, fouling, flooding, maldistribution and many other problems that can exist inside of the column without having to shut the column down for a visual inspection.

A Main Fractionator was not operating properly at normal capacity and was showing symptoms of flooding from Tray 2 (red curve, Figure 22). Tracerco’s TRU-SCAN® application pinpointed the location of flooding that was probably due to fouling (coking).

After the Main Fractionator was cleaned a baseline scan (blue curve) was performed to use for future diagnosis of coking problems at an earlier stage before the flooding reached such a severe condition.

A scan a few months later (green curve) showed that Tray 2 was again building a problem with coking and the subsequent liquid holdup and flooding. Using this data plant operations and maintenance were able to determine where the limitation in the column was occurring and prepare corrective action.

Figure 22: TRU-SCAN® baseline and troubleshooting results provided operations and maintenance personnel advance warnings of approaching problems so they could prepare for corrective action.
Main Fractionator

TRACERCO™ Level Gauge

Tracerco provides a range of specialist measurement solutions to the process industry, measuring key parameters such as level, density and interface. These instruments are all non-wetted devices, allowing them to be used in the harshest of process conditions such as high temperatures, slurries and corrosive materials.

TRACERCO™ Level gauge

The TRACERCO™ Level gauge, which provides real-time measurements, has been applied to FCC Main Frac towers to measure the bottom liquids level. The gauge is mounted externally on the tower for easy retrofit or new build installation. There are no moving parts, which eliminates the possibility of mechanical failure or fouling by debris such as coke.

The inaccurate 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 reboiler return were the number 2 cause of tower malfunctions. Tracerco, relying on its developed expertise in radiation detection instruments has a range of reliable nuclear instruments including liquid level instruments. If you have a particularly challenging or troublesome base liquid measurement application, contact a Tracerco Technical Advisor in your area.
The TRACERCO Advantage

Tracerco is offering TRACERCO Diagnostics™ technologies for the oil and gas industry.

Tracerco offers a range of diagnostic services and specialist measurement instruments to that can be used to assess process operations, platform inspection, pipeline pigging and reservoir investigations. These services include:

Specialist Measurement Instruments
TRACERCO™
Density gauge
Level gauge
Interface gauge
Radiation monitor
Mud monitor
Catalyst probe
SmartGauge
Level alarm
PhaseGauge
SlugMonitor
Contamination monitor

TRACERCO™
TRUTEC™
TRACERCO Diagnostics™
TRACERCO™
The TRACERCO Profiler™
Scanning Services
TRU-SCAN®
Tru-Grid™ Scan
Tru-CAT™ Scan
TruTec™ Pipe Scan
TruTec Towerview™
TruTec™ Neutron Backscatter
FCCU study
Separator study
FMI
Pipeline assurance
Flow study
Residence study
Distribution study
Maximizer
Interwell study
Wellbore study
Flow profile
Leak study
Temperature study
Mercury study
MUI
SlugMonitor
RapidScan
PhaseCal
TankVision
100 Series
200 Series
300 Series
400 Series
500 Series
600 Series
700 Series
800 Series

How to find out more –

Whether benchmarking an FCCU after a turnaround, planning modifications for the next turnaround, or troubleshooting abnormal operations, the FCCU process engineer can utilize TRACERCO Diagnostics™ and TruTec™ Scanning Services to better understand operational and mechanical problems. This leads to better performance for the FCCU resulting in enhanced profitability.

If you would like further details on how our team of experts can provide you with TRACERCO Diagnostics™ FCCU study services please contact your local Tracerco representative.