

MEASUREMENT SOLUTIONS FOR THE REFINING INDUSTRY

Optimize your production
throughput with increased
safety and reliability



 **BERTHOLD**

REFINING INDUSTRY

THE APPLICATIONS

Berthold Technologies radiometric instruments for non-contacting level and density measurement are widely used in the global oil refining industry. Among our customers are well-known companies like Exxon Mobil, Sinopec, Shell, BP, Conoco Phillips, Lukoil and Total – just to name a few.

Our measurement solutions, utilizing gamma absorption technology, assist our customers in achieving reliable process control. This ensures safe operations, maximizes efficiency, and ultimately boosts profitability.

Berthold is renowned for cutting-edge technology and high-quality products. We offer an extensive array of industry-standard solutions, while also collaborating closely with our customers and licensors to design customized systems that cater specifically to their unique processes and measuring requirements.

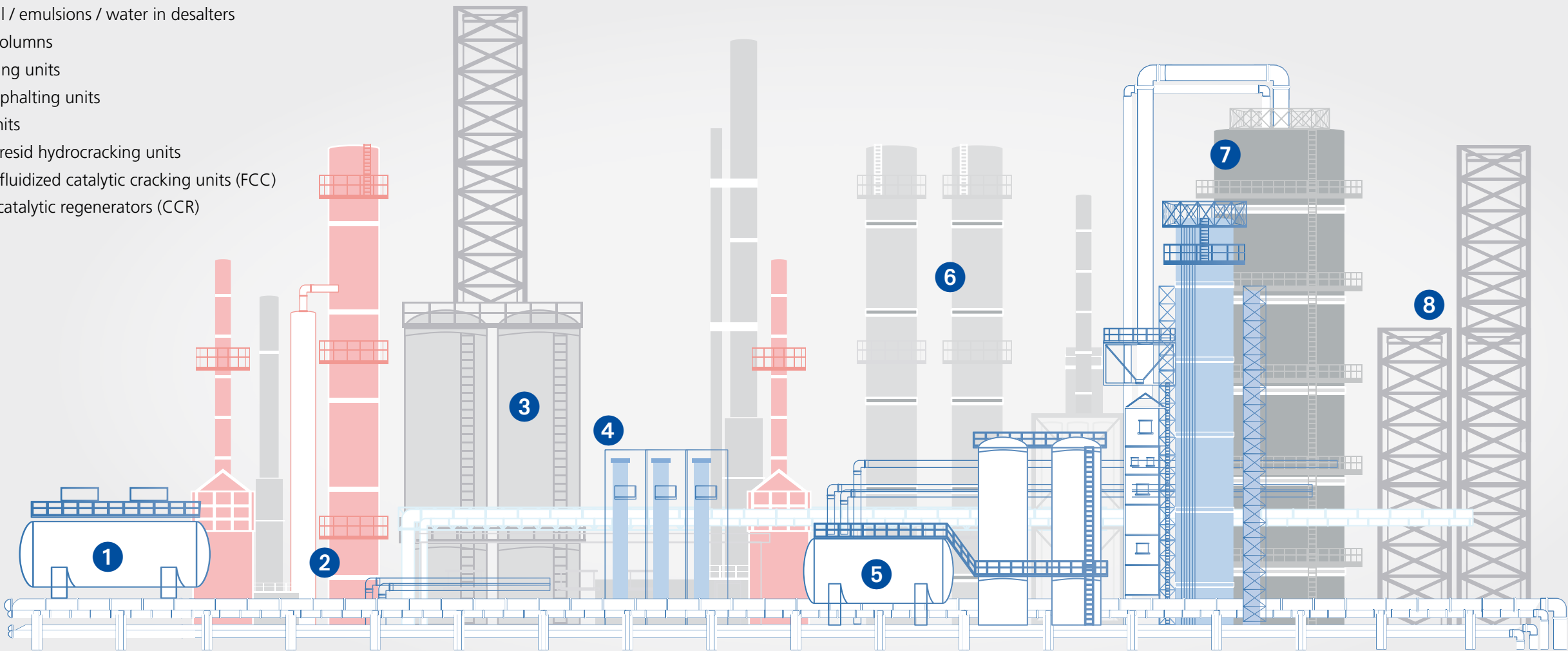
Features

- Online measurement: real-time process information
- Excellent reading stability: no need for frequent recalibration
- Ruggedness: no moving parts
- Total reliability: high accuracy with very good reproducibility
- Outstanding sensitivity: excellent results even with remarkably low source activities
- Lowest cost of ownership

Contactless and non-intrusive

- Berthold’s measurement solutions function in a non-contact and non-intrusive manner. Therefore, there is no exposure to process media. Thus, our products remain unaffected by acidic, corrosive, abrasive, dusty and sticky conditions as well as by high temperatures, pressure changes or foaming.
- Easy mounting on existing installations
 - No down-time
 - No modifications
 - Free of wear and tear

- 1 Measuring the interface levels of oil / emulsions / water in desalters
- 2 Measuring the level of distillation columns
- 3 Measuring the level in delayed coking units
- 4 Measuring the level in solvent deasphalting units
- 5 Measuring the level in alkylation units
- 6 Measuring the level and density in resid hydrocracking units
- 7 Measuring the level and density in fluidized catalytic cracking units (FCC)
- 8 Measuring the level in continuous catalytic regenerators (CCR)





MEASURING THE INTERFACE LEVELS OF OIL / EMULSIONS / WATER

Fresh water is added to the incoming crude to help remove dissolved salts and minerals, thereby reducing corrosion and fouling of downstream operating units. The electrostatic grids induce water coalescence, which attracts salts and minerals. Hereby, a transition zone of varying densities forms between the oil and brine levels. Precise control of this is vital for the desalter's proper functioning. If the zone is too high, the electrostatic grids may short circuit, causing reduced coalescence of water, salts, and minerals. Conversely, if the transition zone is too low, hydrocarbons may be discharged with the brine water, resulting in complications for wastewater treatment and potential environmental fines. To ensure that the retracted brine is free of oil and the water doesn't impact the electrostatic grid or enters the oil outlet, the different levels have to be controlled carefully. Berthold's MPLM is used to reliably monitor the separation process online. Berthold offers unique solutions: a standard version providing a pure density profile and a complex version measuring the continuous level of distinct layers. The system is suited for all API oil grades - even heavy and extra heavy crudes.

Application Profile

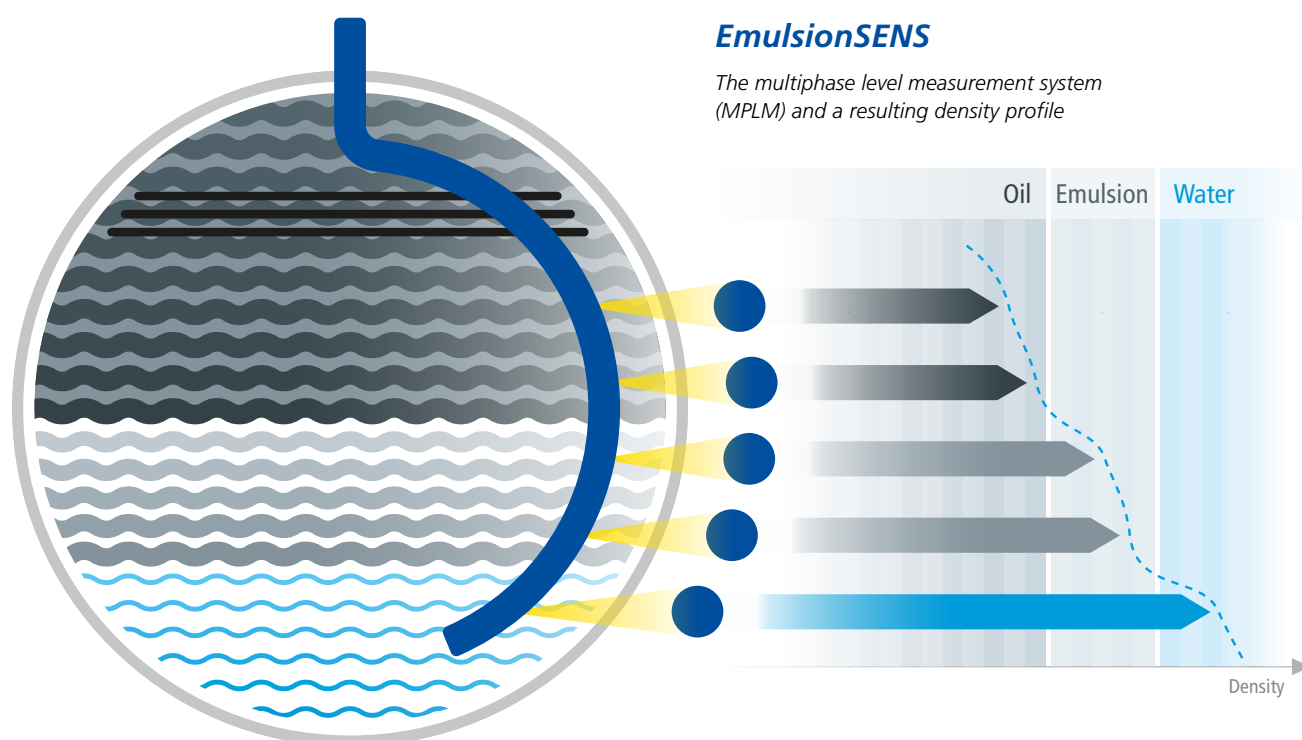
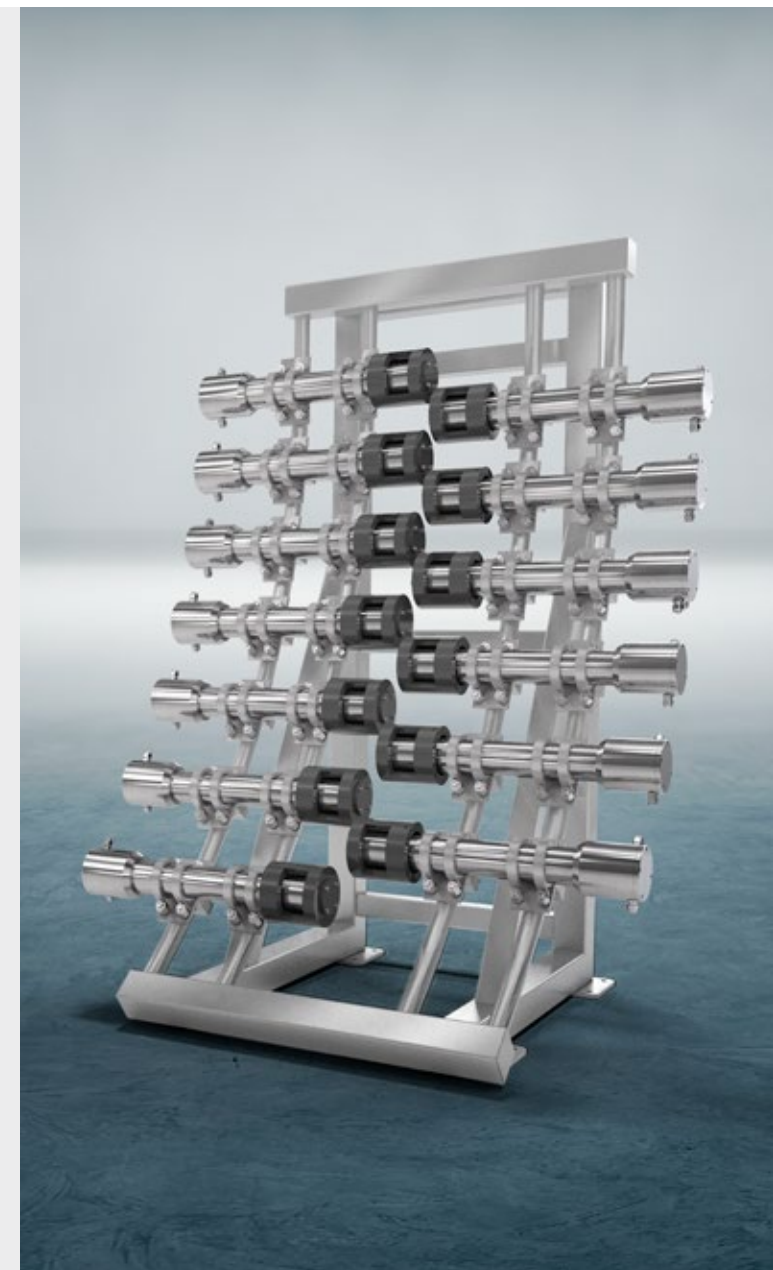
- **Measurement task**
Oil / emulsion / water interface tracking
- **Location**
Desalters, separators
- **Berthold solution**
Multiphase level measurement (EmulsionSENS)

Customer Benefit

- Maximum throughput and availability
- Ideal control of drained water quality and oil outlet flow
- Lower operation temperatures in the desalter
- Efficient addition of emulsion breaking chemicals
- Monitoring of potential rag layer forming
- Increased efficiency for mud wash
- Reduced salt carryover – less corrosion in downstream units

Special Features

- Detectors mounted outside the vessel – ease of maintenance and no cooling required
- Increased reliability, operates on all API crudes
- Accuracy of density profile: $<0.002 \text{ g/cm}^3$
- Accuracy of interface level measurement: $\pm 25 \text{ mm}$
- Optional mud level measurement
- Capable of measuring interface levels even when refining with varying crudes, including opportunity crudes





MEASURING THE LEVEL IN DISTILLATION COLUMNS

During the atmospheric distillation process and vacuum distillation, the oil is separated into various fractions. The oil that is not fractionated ends up in the bottom of the column, where it is critical to maintain proper level. If the level is too high, this could lead to tray damage and cause products to be off specifications. If the level is too low, this could potentially damage pump seals or the pumps themselves. By using the radiometric level systems from Berthold the residue can be reliably measured in a non-intrusive manner, regardless of operational and/or product changes

[SIL 2] [SIL 3]

Application Profile

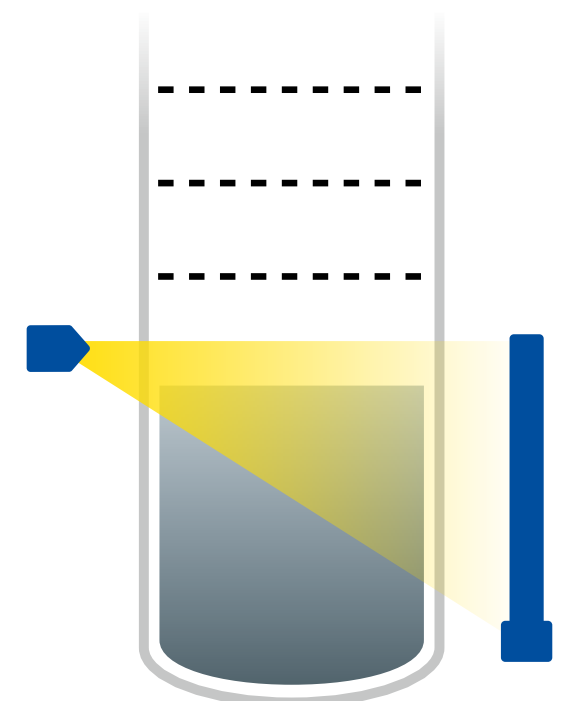
- **Measurement task**
Level of residues
- **Location**
Vacuum distillation column,
Atmospheric distillation column,
FCC fractionator tower bottoms.
- **Berthold solution**
Radiometric level measurement

Customer Benefit

- Reliably prevents pump cavitation
- Prevents of foam or liquid entering upper fractions
- Unaffected by foaming, plugging, build-ups or changes in operational and/or product changes
- Easy to install on existing columns – no process downtime

Special Features

- Continuous level measurement, typically 2 ... 4 m measuring range
- Installed on the cylindrical bottom of the column
- Redundancy can easily be provided
- Typical arrangement uses Cs-137 point sources and scintillation rod detectors
- On small diameter columns Co-60 rod sources achieve best measurement results
- Optional SIL2 / SIL3 certified



*Measuring the level of residuals
in the bottom of the column*

CONTINUOUS CATALYST REGENERATOR (CCR)

The chemical process which is used to convert naphthas distilled from crude oil into high-octane liquid products, so-called reformates, is known as catalytic reforming. Here the hydrocarbon molecules are re-arranged by means of chemical catalysts. The most modern and increasingly used type of catalytic reformer is continuous catalytic reforming (CCR).

CATALYST REGENERATOR

MEASURING THE LEVEL AND LOW LEVEL ALARM

The catalyst used for reforming loses its properties over time and thus regeneration of the catalyst is necessary. CCRs are characterized by a continuous regeneration of some of the catalyst in special regenerators, subsequently the regenerated catalyst is returned to the reactor. Radiometric level systems from Berthold are used on the regenerator ensuring a smooth and continuous reactivation process. Due to high process temperatures, the non-contacting technology is the only one which provides reliable level control – the basis for efficient catalyst regeneration.

[SIL 2] [SIL 3]

Application Profile

- **Measurement task**
Level of catalyst
(continuous level and low level alarm)
- **Location**
Catalyst regenerator
- **Berthold solution**
Radiometric continuous level measurement
in combination with level switches

Customer Benefit

- Optimized control of regeneration process
- Ideal utilization of regenerator capacity
- Reliable control of catalyst feed
- Safe prevention from running empty

Special Features

- Standard: point source / rod detector arrangement
- Highly repeatable and stable over years of operation
- Immune against interfering radiation using X-ray Interference Protection (XIP) or continue measuring level during weld inspections with Radiation Interference Discrimination (RID)
- Optional SIL2 / SIL3 certified



CCR LOCK HOPPERS

MEASURING THE LEVEL AND HIGH / LOW LEVEL ALARM

Reliable and fast responding control of the catalyst level inside the hopper is very important to ensure a high quality process. Each hopper is equipped with continuous level gauges using rod source technology. Rod sources offer the highest precision and reliability because the radiation is ideally distributed over the measurement range. Therefore the system will also detect the formation of cones, which means that the true amount of catalyst inside the hopper is determined and filling can be optimized. In addition radiometric level switches are installed to provide high level or low level alarms for safety reasons.

[SIL 2] [SIL 3]

Application Profile

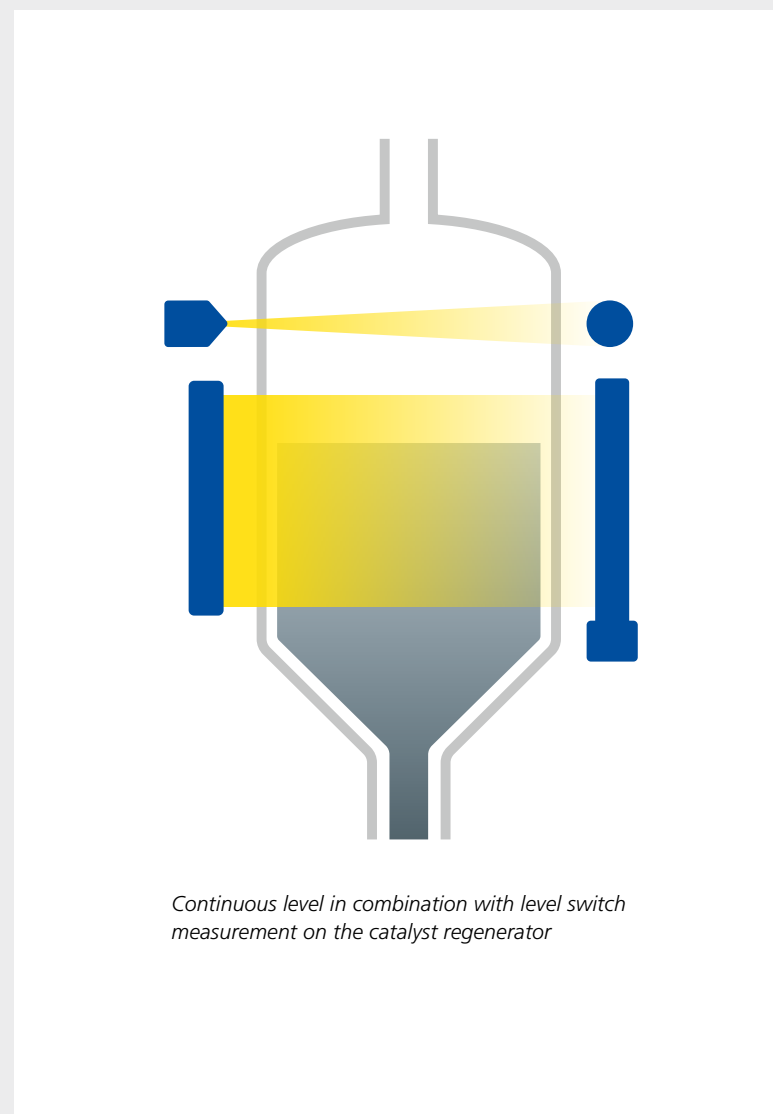
- **Measurement task**
Level of catalyst (continuous level and high level / low level alarm)
- **Location**
Lock hopper, upper hopper, disengaging hopper
- **Berthold solution**
Radiometric level measurement (continuous) in combination with high or low level switch

Customer Benefit

- Reliable information on catalyst level
- Optimal filling and discharging process
- Improved control of catalyst supply for reforming process

Special Features

- The SpeedStar feature ensures extremely fast response times in the millisecond range
- Best results achieved with Co-60 rod source using rod detector arrangement
- Sensitive to cone formation (pile-up cones and downward-pointing cones)
- Immune to interfering radiation with X-ray Interference Protection (XIP) or Radiation Interference Discrimination (RID) to continue measuring level during weld inspections
- Optional SIL 2 / SIL 3 certified

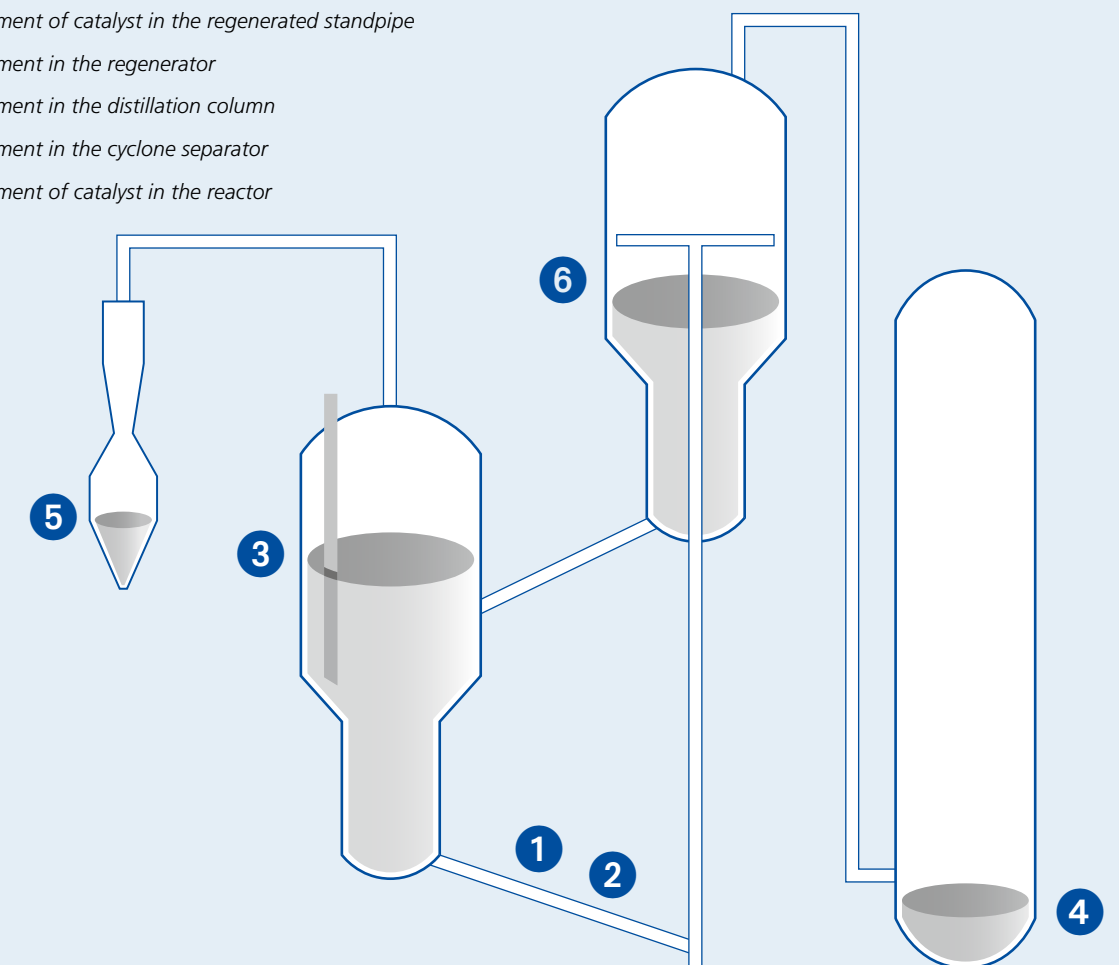


FLUID CATALYTIC CRACKING (FCC)

Fluid catalytic cracking (FCC) is one of the most important conversion processes used in petroleum refineries. In an FCC unit, the catalyst circulates between reactor and regenerator to ensure efficient conversion. Radiometric level measurements from Berthold are applied on several sections, e.g. the cyclone separator, regenerator, reactor, electrostatic precipitation hopper and regenerated standpipe.

The ability of the radiometric devices to measure solid catalyst under the high temperatures needed in a FCC unit, makes it the ideal measurement solution to maintain safe and reliable operation.

- 1 Density measurement of catalyst in the regenerated standpipe
- 2 Level measurement of catalyst in the regenerated standpipe
- 3 Level measurement in the regenerator
- 4 Level measurement in the distillation column
- 5 Level measurement in the cyclone separator
- 6 Level measurement of catalyst in the reactor



FURTHER APPLICATIONS:

Vessels that use radiometric devices in the FCC besides cyclone separators are electrostatic precipitation hoppers, reactors and distillation tower bottom levels. The radiometric level measurement on the fractionator tower bottom, unlike differential pressure, is unaffected by the changing percentage

of catalyst fines. This increases the reliability of the level, potentially preventing tray damage if level gets too high, or pump damage if level gets too low. Level and density measurements of the fluidized bed in the standpipe is also a frequently required measurement task.

CYCLONE SEPARATOR

MEASURING THE LEVEL OF CATALYST FINES

Catalyst fines have to be removed from the regenerator flue gas to fulfill regulatory requirements and to protect downstream equipment. Thus cyclonic separators are used to filter out the remaining catalyst fines. The solid particles settle down at the bottom of the separator, where their level is controlled by radiometric level systems from Berthold. The non-contacting technology is ideally suited for this kind of application since dust and temperature have no impact on the measurement performance.

[SIL 2] [SIL 3]

Application Profile

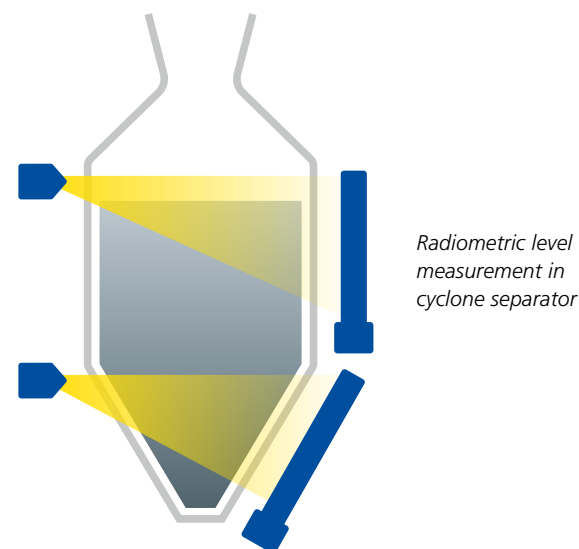
- **Measurement task**
Level of catalyst fines
- **Location**
Cyclone separator
- **Berthold solution**
Radiometric level measurement

Customer Benefit

- Improved catalyst removal
- Optimal utilization of vessel capacity

Special Features

- Continuous level measurement, typically 2 ... 4 m measuring range
- Installed at the bottom conical section
- Typical arrangement uses Cs-137 point sources and scintillation rod detectors
- High repeatability and long-term stability due to automatic sensitivity stabilization based on cosmic radiation
- Immune to interfering radiation with built in XIP feature, or continue level measurements during weld inspections with RID model.
- Optional SIL2 / SIL3 certified



REGENERATOR

MEASURING THE LEVEL IN CATALYST REGENERATORS

Proper level control in the regenerator of a FCC unit is critical for maintaining optimal operation and protecting equipment. In the regenerator, spent catalyst from the reactor is regenerated by burning off the coke deposits. The level of catalyst needs to be maintained above the dip legs of the cyclone separators for effective separation of the catalyst particles from the flue gas. This helps to ensure the efficiency of the regeneration process and to prevent the catalyst from being carried out with the flue gas, which can lead to erosion or damage to downstream equipment.

Radiometric level systems are used in the regenerator to maintain the appropriate catalyst level. This non-contacting, non-invasive technology provides several advantages for this unit such as accurate catalyst level control insensitive to process conditions.

Application Profile

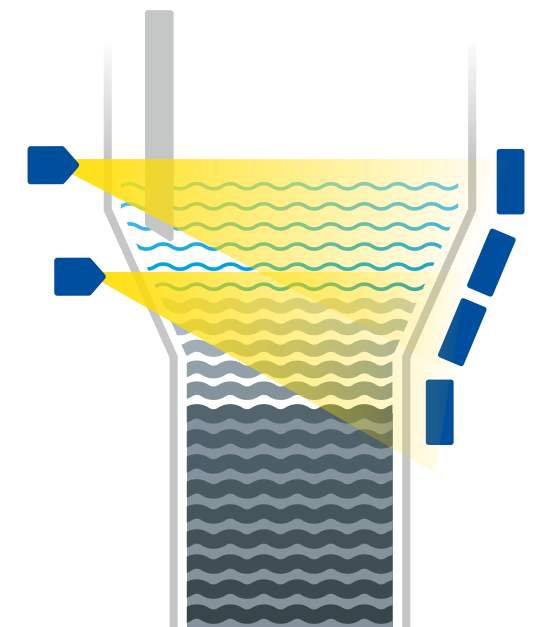
- **Measurement task**
Catalyst level in the regenerator
- **Location**
Regenerator
- **Berthold solution**
Radiometric level measurement

Customer Benefit

- Improved process efficiency and output quality of the regenerated catalyst
- Reduce or prevent catalyst in the gas
- Improved safety and effectiveness of operation
- Avoids impurities or undesirable byproducts in the output stream

Special Features

- Reliable control of catalyst level and feed
- No fouling or clogging
- Not affected by physical properties of the catalyst
- Providing bed density profile and total catalyst level
- Optional gas properties compensation (GPC)
- Optional SIL2 / SIL3 certified



Radiometric level measurement in regenerator

RESID HYDROCRACKING

The resid hydrocracking process is becoming more and more important to refiners since it allows a higher conversion rate than other heavy oil conversion processes. It is used to crack heavy fractions to achieve lighter and more valuable products. There are many different processes and technologies established in the market but radiometric measurements from Berthold are applied in all of them.



FURTHER APPLICATIONS:

Various thick walled vapor/liquid separators, catalyst handling vessel, various towers and in-line densities at high temperature and high pressure are also typical applications. Radiometric level and density measurements are used in the separation section of the hydrocracker to ensure

that proper vapor/liquid separation occurs as the pressure and temperature is lowered through the various separators. Radiometric measurements are also used in the catalyst section of the hydrocracker to ensure the proper amount of catalyst is added or withdrawn from the reaction system to maintain effective cracking.

HYDROCRACKER REACTOR

MEASURING THE LEVEL & DENSITY AT DIFFERENT ELEVATIONS

To achieve optimum control of the cracking taking place inside the hydrocracking reactor, the level of hydrocarbons, catalyst and gas is monitored by means of multiple density measurements spread along the height of the reactor. The radiometric density gauges from Berthold are very fast responding and are capable of or measuring the smallest changes in density, down to a resolution of $\leq 0.002 \text{ g/cm}^3$.

[SIL2] [SIL3]

Application Profile

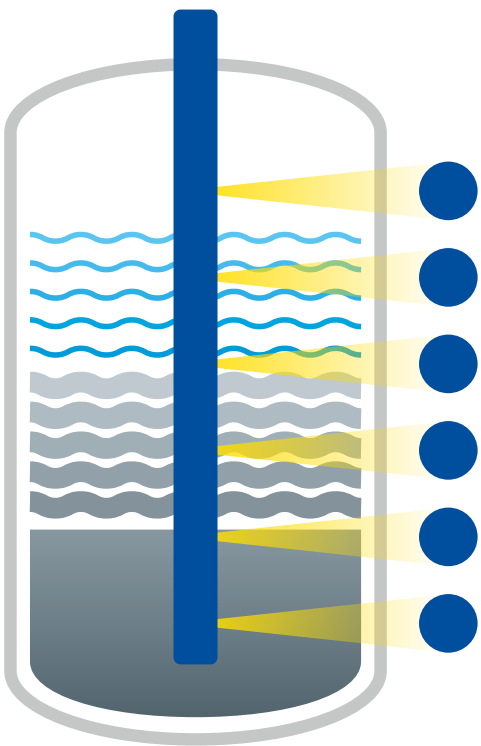
- **Measurement task**
Multiple density measurements at different elevations
- **Location**
Resid hydrocracker
- **Berthold solution**
Multiphase level measurement

Customer Benefit

- Maximum process transparency
- Reliable control over the cracking process
- Increased throughput and availability
- Efficient utilization of catalyst

Special Features

- Multiple point sources inserted in dip pipe
- Typically a reduction of the vessel wall is required for improved measurement effect
- Highly accurate density reading, resolution of $\leq 0.002 \text{ g/cm}^3$
- Very fast responding measurement
- Optional SIL2 / SIL3 certified



EmulsionSENS

Multiple point sources inserted in dip pipe and density detectors mounted outside the reactor

ALKYLATION UNITS

ACID SETTLER

MEASURING THE HYDROCARBON / ACID INTERFACE

Light hydrocarbons are converted into high quality alkylate in the presence of an acid catalyst, either HF or H₂SO₄. In the acid settler the hydrocarbons are separated from the acid due to the density difference and therefore the acid settles down at the bottom. Between the two products an intermediate phase is present. To control the layer thickness of this phase and to ensure that the withdrawn products are not contaminated, the multiphase level measurement system EmulsionSENS from Berthold is used. Due to two different arrangements either the product density at specific heights (aligned arrangement) is provided or the level of different layers can be measured continuously (staggered arrangement).

Application Profile

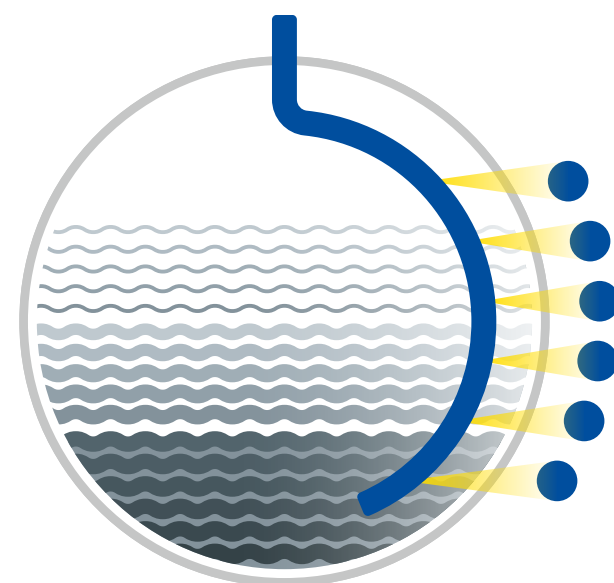
- **Measurement task**
Hydrocarbon / acid interface
- **Location**
Acid settler
- **Berthold solution**
Multiphase level measurement

Customer Benefit

- Online monitoring of separation process
- Reliably prevents acid carry-over
- Increased process safety
- Virtually no need for maintenance or care-related work, keeping work time in the acidic area to a minimum

Characteristics

- Multiple detectors and sources distributed along the measurement range
- Accuracy of density profile: <0.002 g/cm³
- Accuracy of interface level measurement: +/- 25 mm
- Immune to interfering radiation, with XIP, or continuing operation during weld inspections with RID
- Optional: control unit for visualization and operation



EmulsionSENS

Sources inserted in a dip pipe and multiple detectors mounted on the outside of the acid settler

ACID STORAGE DRUM

MEASURING THE LEVEL OF ACID

The acid used in the alkylation process is stored in acid storage drums. Measuring the acid level is important to fulfill the highest safety standards, especially in an emergency situation where all acid has to be pumped back into this drum. Therefore, it is of extreme importance that the level measurement is reliable and fast responding. In addition to the level gauge, Berthold also provides a radiometric level switch for high level alarm.

[SIL2] [SIL3]

Application Profile

- **Measurement task**
Level of acid
- **Location**
Acid storage drum
- **Berthold solution**
Radiometric level measurement and level switch

Customer Benefit

- Real-time information on acid level
- Increased safety in case of emergency shutdown

Characteristics

- Repeatable and long-term stable measurement due to patented sensitivity stabilization
- Immune to interfering radiation, radiation with XIP, or continuing operation during weld inspections with RID
- Optional SIL2 / SIL3 certified



FURTHER APPLICATIONS:

By using EmulsionSENS, operators can safely control the acid level, ensuring that acid is not carried over or hydrocarbons are not removed from the bottom of the settler.

Minimize vessel leak points by using radiometric level measurement in various column bottoms such as depropanizer, acid rerun column and acid storage/emergency dump drum.

RELIABLE LEVEL CONTROL IN DELAYED COKING UNITS

Residues are cracked or converted in the delayed coking unit. The heated residues are fed to the coke drum where they are cracked into light more valuable hydrocarbon chains while the extra carbon is rejected. Solid coke remains in the drum which slowly fills up. The radiometric level technology from Berthold is ideal for monitoring the coke level due to its non-intrusive nature. Since large temperature variations through the whole operational cycle of a coke drum are a known issue to the operators, our patented automatic stabilization technology based on cosmic radiation has proven to be the most important feature to guarantee a stable and reliable level measurement without the need for recalibration. Separate level alarms ensure additional process safety. The same applies for the fractionator. Our level gauges are used to monitor the bottom liquid level – an important parameter for the efficient control of the complete coking cycle. The measurement is unaffected by surface turbulences, product falling down from the trays, different product densities and scaling/coking.

Application Profile

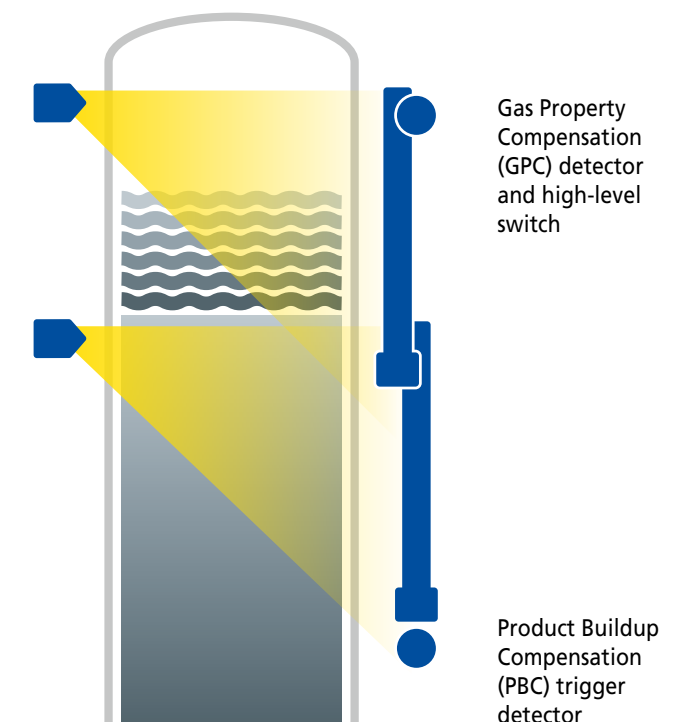
- **Measurement task**
Level of coke and bottom liquids
(continuous level and high level alarm)
- **Location**
Coke drum and fractionator
- **Berthold solution**
Radiometric level measurement

Customer Benefit

- Improved utilization of drum capacity
- Efficient use of anti-foam agent
- Increased throughput and safe operation

Characteristics

- 8 m long TowerSENS detectors cascaded to cover up to 32 m
- Highest sensitivity due to solid scintillators leading to significantly lower source activities
- Immune to interfering radiation with built in XIP, or continue measuring during weld inspections with RID
- Outstanding compensation functions (GPC and PBC) prevent falsification of measured values by process influences, such as wall build-ups or fluctuating gas properties

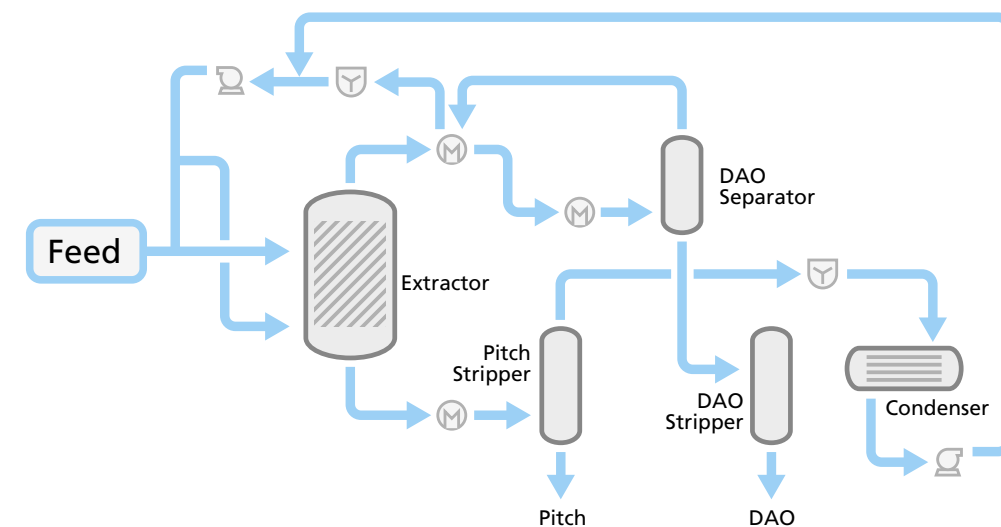


Level measurement arrangement at coker unit



MEASURING THE LEVEL IN SOLVENT DEASPHALTING UNITS

Solvent deasphalting (SDA) is a solvent extraction method used to extract up to two thirds of the vacuum reduced crude to be used as good quality feed for a fluid catalytic cracking unit to convert it to gasoline and diesel fuel blending stock. This technology uses light hydrocarbons (propanes to pentanes) as the solvents and uses subcritical extraction methods but supercritical techniques to recover the solvents thus increasing cost efficiencies. This technology can be used in conjunction with delayed cokers and resid hydrocrackers such as CLG's LC-Fining and AXEN's H-Oil processes. Typical uses of radiometric devices within a SDA unit include: extractor, pitch stripper, DAO stripper, resin stripper and DAO separator.



In the extractor, there is an interface between the solvent and the extracted asphaltenes. This interface is typically not a clean interface, meaning that there is a zone where the two products of different densities separate. This zone is a gradient change in the density. The level is typically measured by means of a float or differential pressure. Other technologies measure the physical characteristics of the fluids. If the physical characteristics change slightly, this leads to errors in the level measurement.

The vessels using radiometric devices in this process have a large advantage over other level technologies

which tend to malfunction, or where measurement errors occur due to the coating that can occur with heavy asphaltenes. The radiometric measurement from Berthold is non-intrusive, and therefore this coating and fouling does not affect our level measurement.

Characteristics

- Highly reliable measurement not affected by coating or fouling by the product
- Can be used on high temperature and high pressure vessel



COMMITTED TO TECHNOLOGICAL LEADERSHIP

Outstanding long-term stability

A reliable measurement is vital for the efficient operation of a process and is therefore our highest priority. Due to various patented technologies, Berthold's detectors operate consistently, irrespective of even large variations in ambient temperature or degradation caused by aging. The result: many years of operation without the need for recalibration or maintenance and a measurement that you can rely on!

Protected against X-Ray interference (XIP, RID)

Every Berthold detector features our X-ray Interference Protection (XIP), allowing the system to detect interference radiation, like weld inspections (NDT), and freeze the output before false readings are transmitted. By using Berthold's unique Co-60 rod sources in combination with our patented RID (Radiation Interference Discrimination) function, it is even possible to continue the measurement even while NDT is being performed. Berthold's detectors are not affected in any way by the excessive radiation and automatically return to normal operation after the interference has ceased.

Gas Property Compensation (GPC)

Gas property fluctuations in large vessels can greatly impact the output level value. Berthold compensates for such effects by using a second detector positioned at the top of the vessel which continuously monitors the gas phase. The gas property compensation (GPC) feature of Berthold's systems uses the gas density signal to compensate the level signal for accurate and reliable process control. It reduces the risk of errors or failures, and helps customers achieve better efficiency, safety and reliability.

Product Buildup Compensation (PBC)

The PBC-trigger-detector causes the PBC-feature to adjust the calibration curve to a new zero percent level for the continuous level detectors when the product level drops below the height of the trigger-detector. The new zero point remains active until the vessel is emptied and the PBC is triggered again. This ensures more accurate measurements, as PBC compensates for any buildups that may affect the continuous level detectors.

ALARA – As Low As Reasonable Achievable

Berthold's SuperSENS detector with its large scintillation crystal is the most sensitive detector on the market. Due to their excellent efficiency, our detectors can be operated with low source activities, providing safe handling and major cost savings. In fact, Berthold detectors can even be retrofitted on existing measurements using original sources too weak for other detectors.

SIL2 / SIL 3 certified

The SENSseries LB 480 detectors are certified for use in SIL 2 and, with homogenous redundancy, in SIL 3 applications. The certificate covers all measurement applications, from high-level or low-level alarms to continuous level and density measurement.



THE EXPERTS IN MEASUREMENT TECHNOLOGY

Berthold Technologies stands for excellent know-how, high quality and reliability. The customer is always the focus of our solution. We know our business!

Using our varied product portfolio, our enormous specialized knowledge and extensive experience, we develop suitable solutions together with our customers for new, individual measurement tasks in a wide variety of industries and applications. Berthold Technologies is specialised in radiometric process measurements for 75 years. This is our core competence with state-of-the-art and cutting edge products and solutions covering a vast range of industries and applications.

We are here for you – worldwide!

The engineers and service technicians from Berthold Technologies are wherever you need them. Our global network assures you fast and above all competent and skilled assistance in case of need. No matter where you are, our highly qualified experts and specialists are ready and waiting and will be with you in no time at all with the ideal solution for even the most difficult measurement task.

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