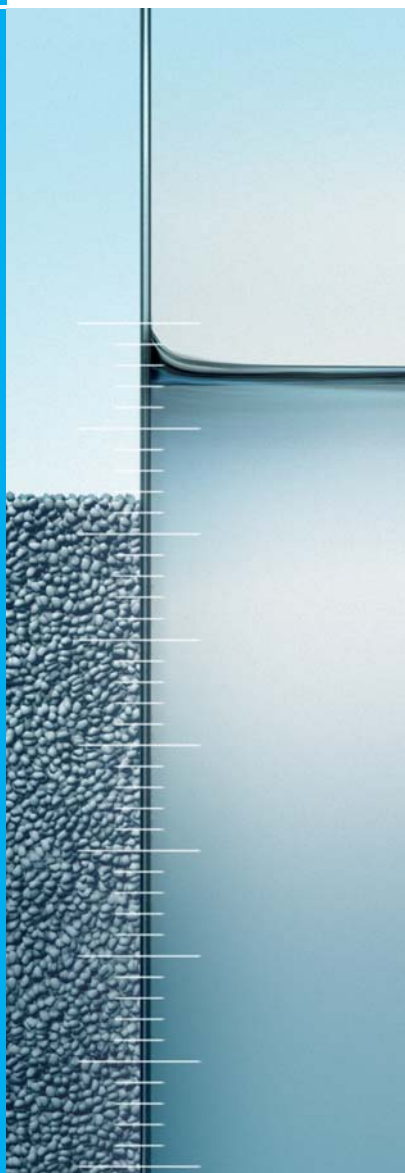
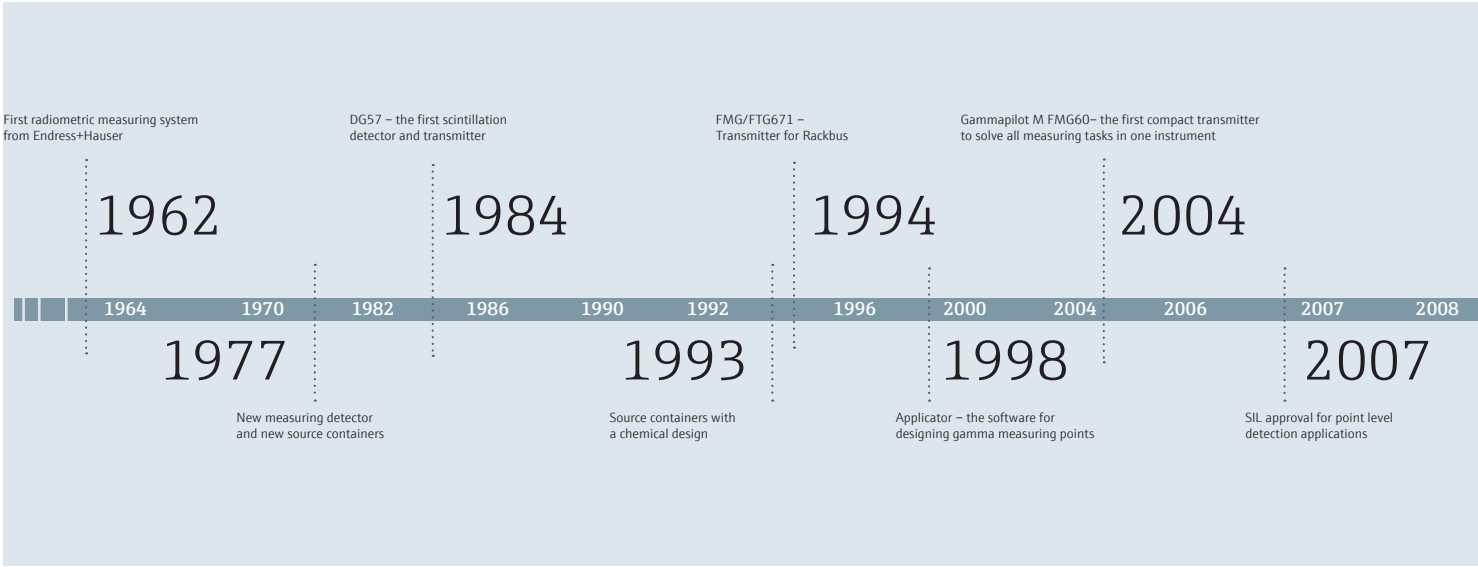


## Radiometric measurement technology

A safe principle that meets the highest demands





# Competence in radiometry

Many industries and extensive fields of process automation have trusted radiometry for the most difficult measuring tasks for decades. As early as 1962, the first radiometric measuring line of Endress+Hauser was launched. Since then, more than four decades have passed and this measuring principle still offers its decisive advantages.

Radiometry is used where other measuring principles are excluded due to extreme process conditions or mechanical, geometric or design factors.

This measuring method operates noninvasively in relation to the process medium. The instrument is installed on the outside of the tank and measures through its wall which safeguards the highest degree of

availability and reliability of measurements - unaffected by the medium or its properties.

Endress+Hauser is a full-range supplier and supports its customers from engineering and logistic processes through to commissioning and pertaining services including the return of sources.

## Typical industries and markets for radiometric instrumentation



Chemical industry



Petrochemical industry



Oil and Gas



Pulp and Paper



Primaries and Mining



Energy

Gamma  
Modulator FHG65

GammapiLOT FTG20 – completely revised  
Geiger-Müller counter for point level detection

2009

2013

2009 2010 2011 2012

2011

New source containers  
FQG60 and FQG63

# Measuring principle

The radiometric measuring principle is based on the attenuation of gamma radiation as it penetrates materials. The radioactive isotope (gamma source) is installed in a container, also referred to as shielding, which emits the radiation only in one direction. The source container and the compact transmitter detecting the radiation are usually mounted on opposite sides of a tank or pipe.

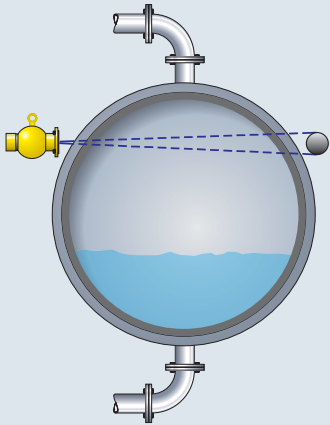
The emitted gamma radiation passes through the tank walls and the medium contained in the tank. The actual measuring effect results from the absorption of the radiation by the medium. The compact transmitter calculates the level, density or the concentration of the medium from the radiation received. The higher the level or the density of the medium in the tank the lower the intensity of the radiation received.

## Areas of application

Radiometric systems are used for point level detection, continuous level, density and interface measurement. The areas of application of this noninvasive measuring method comprise liquids, solids, suspensions through to sludges as well as extreme process conditions like high pressures, high temperatures, corrosiveness, toxicity and abrasion.

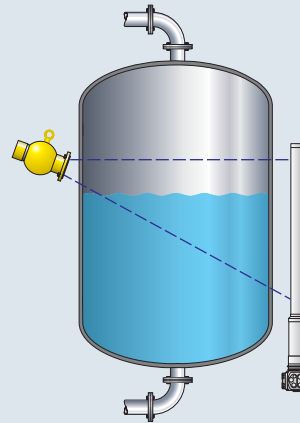
### Point level detection

Overfill prevention according to WHG, Safety Integrity Level SIL2/3 for monitoring of minimum/maximum point level



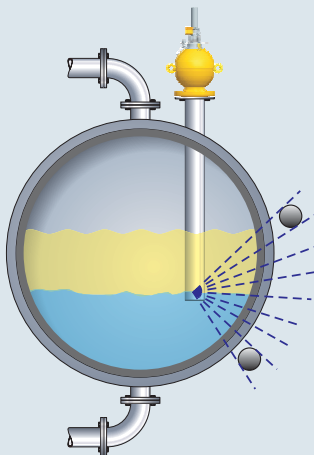
### Level measurement

Continuous measurement in cascade (series of transmitters) or double sensitivity (transmitter in parallel)



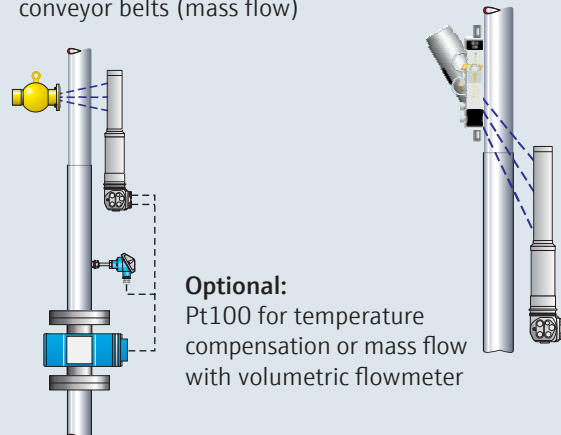
### Interface measurement

Two-phase level measurement, e.g. oil/water



### Density measurement

In pipes, absorption measurement or on conveyor belts (mass flow)





# Radiation and safety

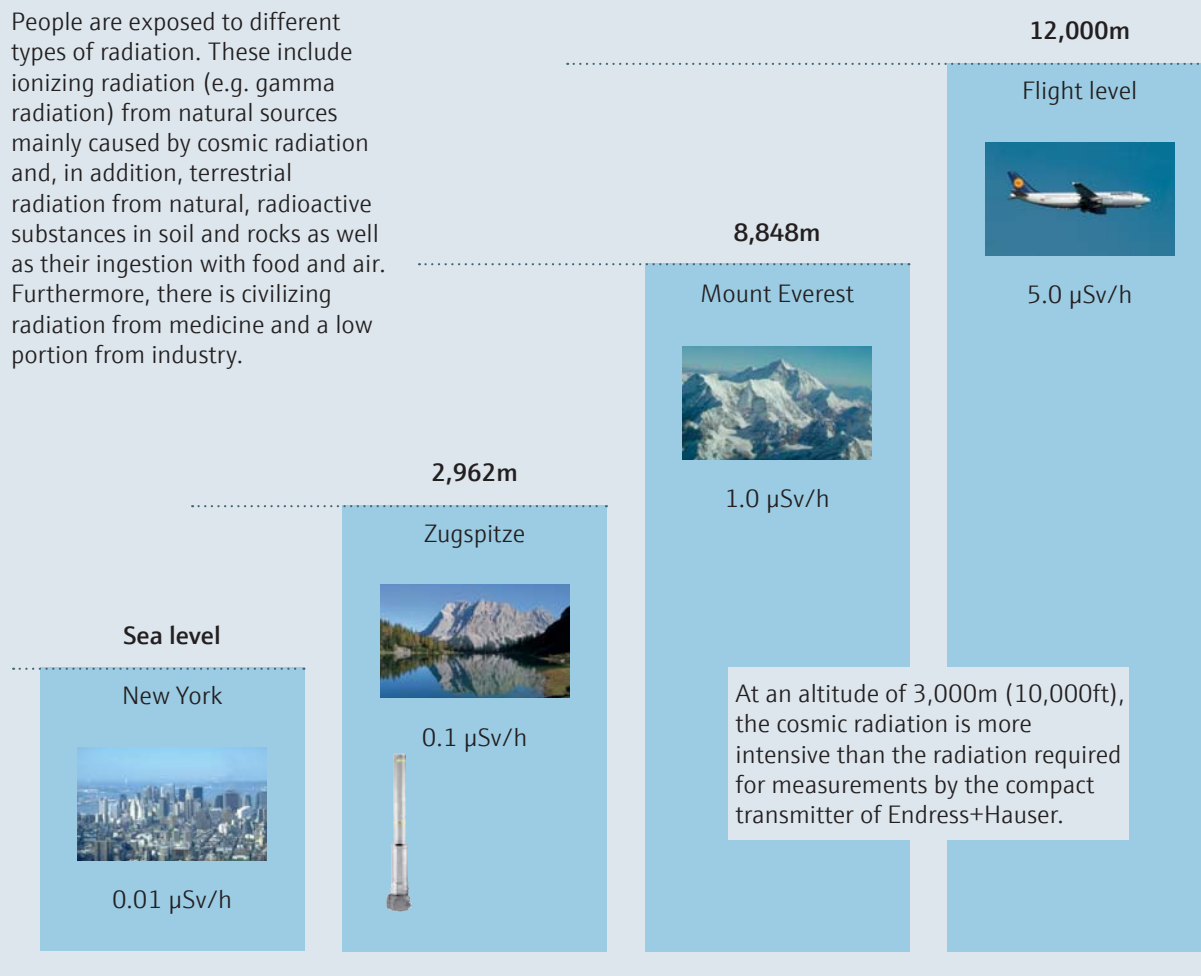
## Safe source containers

The gamma source is installed in a container and thus protected against mechanical and chemical impacts. High-density lead is used in the steel enclosure as shielding material. The radiation emerges in a narrow angle and can be switched on and off. The medium, the tank wall and the source container cannot be contaminated by the emitted gamma radiation.



## Natural and civilizing radiation

People are exposed to different types of radiation. These include ionizing radiation (e.g. gamma radiation) from natural sources mainly caused by cosmic radiation and, in addition, terrestrial radiation from natural, radioactive substances in soil and rocks as well as their ingestion with food and air. Furthermore, there is civilizing radiation from medicine and a low portion from industry.



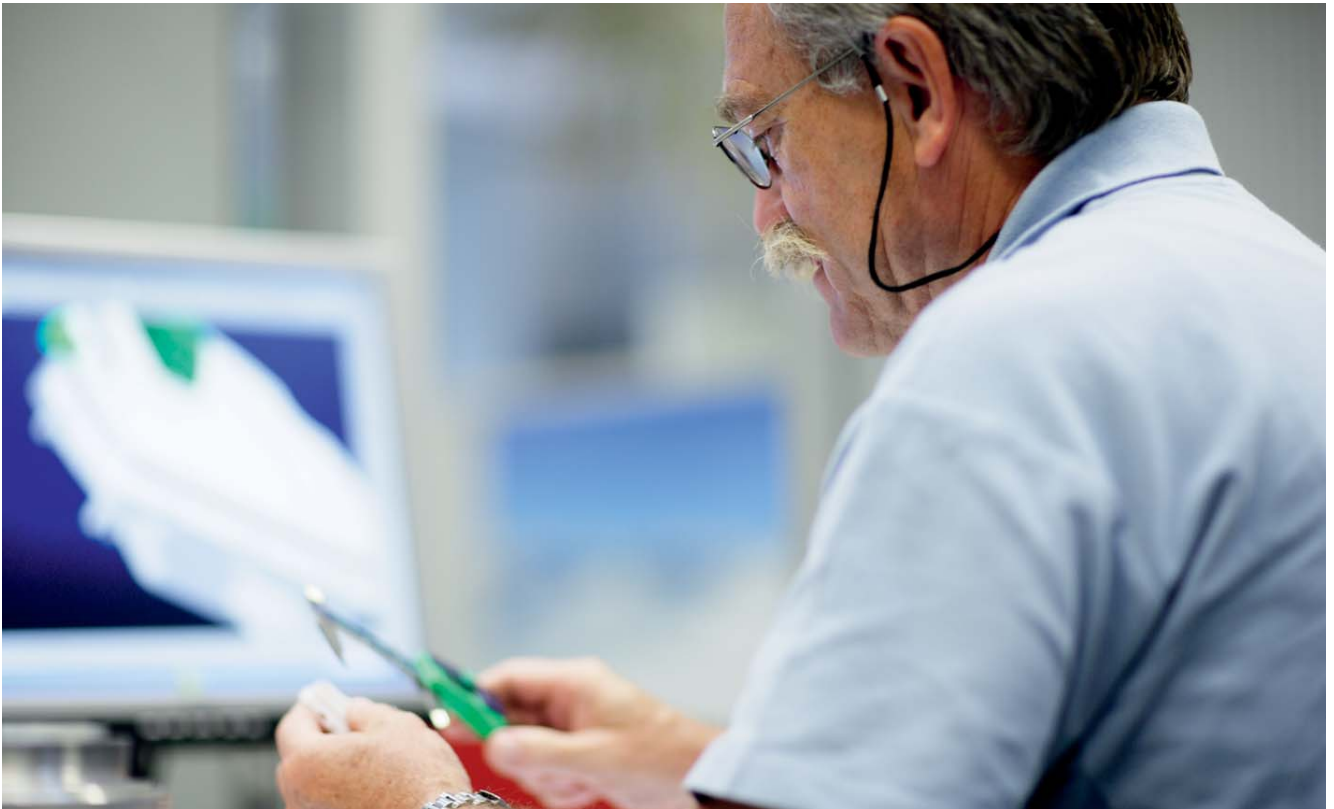
## Test and validation



The instruments are subjected to strict quality controls. They must safeguard absolute reliability in daily operation. Certificates and approvals are thus not only a piece of paper which offers safety to customers. These documents are the result of a number of reviews, tests and verifications of product properties. To this end, Endress+Hauser has created a state-of-the-art test and validation center.

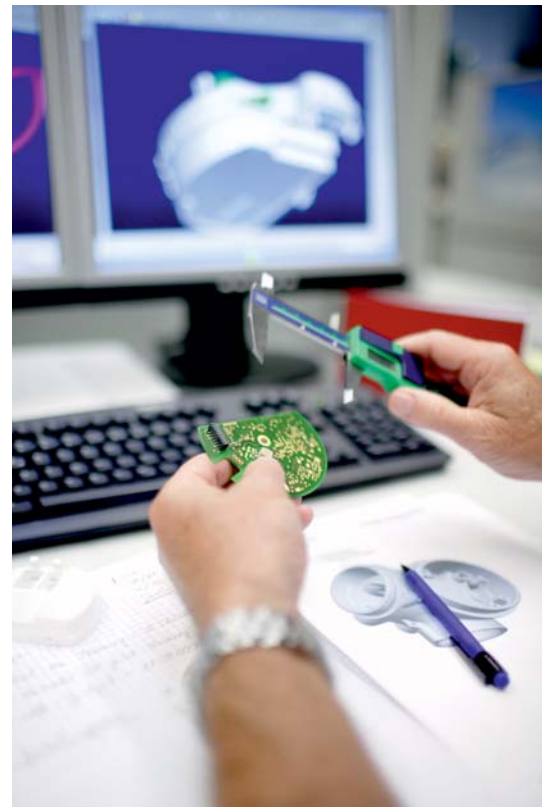


# Research and development



Innovation does not occur automatically. It needs good preconditions: A solid basis of knowledge and skills, of openness and creativity, the willingness to change and the determination of thinking ahead. But new ideas, materials and technologies are always achieved by people who develop optimum solutions for specific tasks.

Teamwork creates the final product from the idea. This is realized by the close cooperation of all groups involved, e.g. the sections for design, electronics and software development.



# Planning reliability

## Applicator provides planning reliability – fast and flexibly

The Endress+Hauser Applicator software is a convenient selection and sizing tool for planning processes. Using entered application parameters Applicator determines a selection of suitable products and solutions. Supplemented by sizing functions and a module for project administration this software alleviates the daily engineering work.

The Applicator sizing gamma area is available for the special calculation of the required source activity as well as the controlled range and the component selection. Providing sketches, diagrams and product comparisons Applicator offers a comprehensive overview of selected products and solutions. Applicator is available in an online version as well as on a CD-ROM for installation.

## W@M – life cycle management for your plant

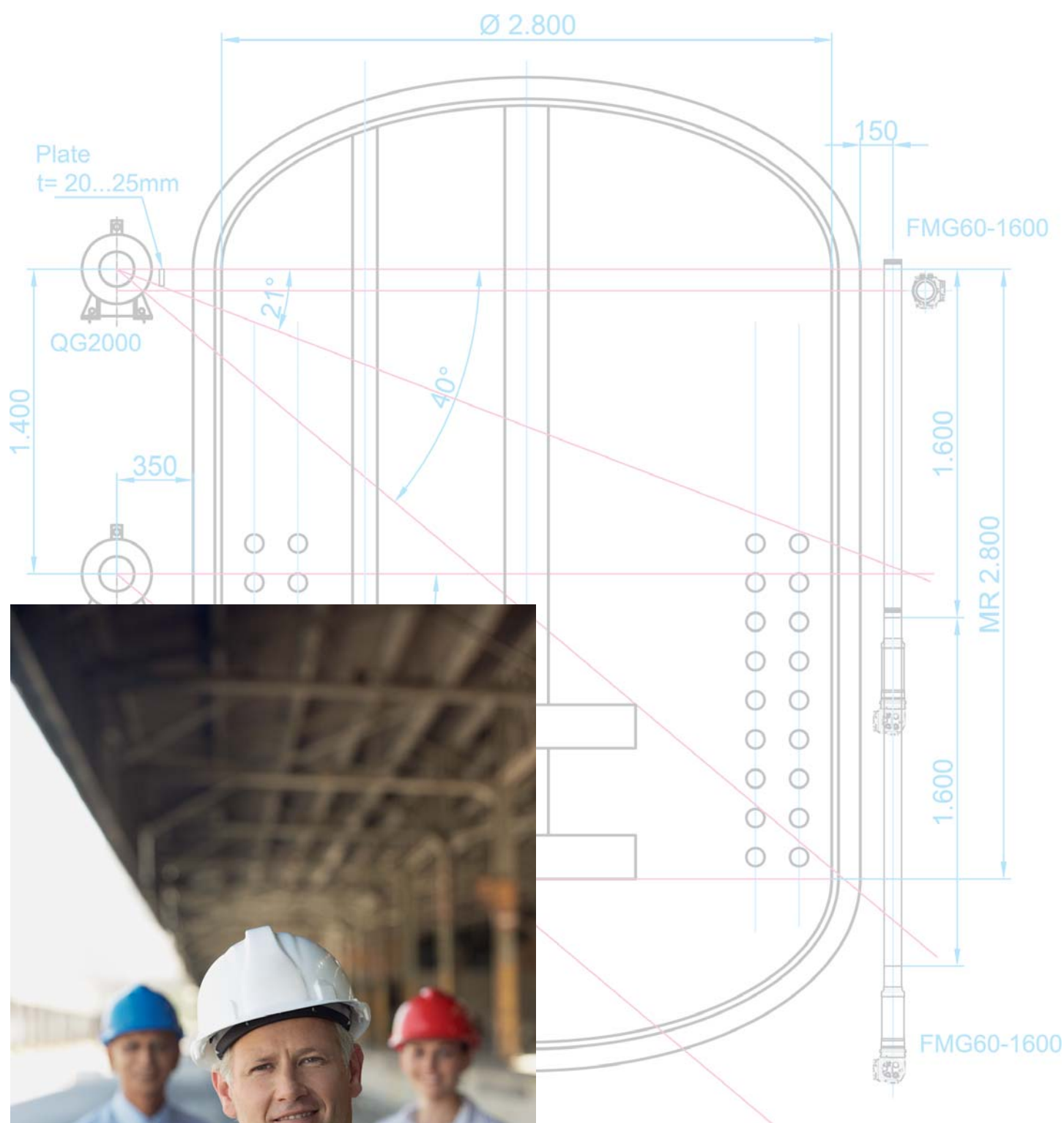
Applicator forms part of W@M, the open information system of Endress+Hauser, for the optimum administration of the entire instrumentation. W@M provides support across the whole process of planning, procurement, installation through to commissioning. The advantages of W@M: Availability of all items of information for every instrument of the plant, around the clock – and that for the entire life cycle.



[www.products.endress.com/applicator](http://www.products.endress.com/applicator)







### Engineering and assembly

Correct sizing of measuring points is guaranteed by the know-how developed during 50 years in radiometry. Apart from sizing radiometric measuring points, Endress+Hauser provides all documents relevant to a project. This includes, for example, overview plans of the arrangements of the instruments on the tank or pipe as well as detail drawings of the instruments and installation instructions.

# Production

## Quality Assurance in production

State-of-the-art production facilities and the latest manufacturing technologies safeguard the quality of our instruments.

## Individual production – adapted to the most varied process requirements

Endress+Hauser produces several thousand compact transmitters and source containers annually. These are manufactured and tested in accordance with the highest quality standards. The high degree of flexibility in processes facilitates the production of specific instruments and brief delivery periods to customers.

## Source container assembly – isotope room

The sources are encapsulated in two double-walled stainless steel enclosures and installed in containers in a specially designed radiation protection cabin. Using two gripper arms from outside an associate grasps the radioactive sources and installs them in fixtures. The associate can observe the inside of the chamber through a window of lead and enlarge the internal working situation with a camera - being constantly protected against excessive radioactivity during the assembly process.





# Processing

## Approvals

Transport, storage, commissioning and operation of radioactive sources are controlled by legislation worldwide and require approvals. The local legislation at the point of installation must be particularly observed. The radioactive material may only be shipped once the respective handling or import license is available. Endress+Hauser specialists offer support worldwide in the approval application process and logistics.

## Logistics

The membership in the ISSPA which is recognized by the IAEA (International Atomic Energy Agency) obliges Endress+Hauser to observe the “Code of good practice” which controls safe handling of radioactive sources. Endress+Hauser only uses source suppliers which are certified according to ISO 9001 and EN 46001. The highest safety measures are taken in the installation of the radioactive isotopes into the source containers as well as packaging and transport. Road and air shipment is exclusively handled by forwarders holding the required licenses.





# Products

## Components of a radiometric measuring line

### Gamma source

The isotope is encapsulated in double-walled stainless steel enclosures and meets the highest classification of radioactive sources with C66646 according to ISO 2919.



In industrial process instrumentation, two radioactive isotopes with different activities are mainly used:

- Caesium  $^{137}\text{Cs}$   
Ideal for continuous level, point level detection and density measurements. The half-life of 30 years permits long usage without exchanging the source.
- Cobalt  $^{60}\text{Co}$   
Used in applications involving thick container walls because of its high penetrating capabilities.



FQG60



FQG61/ FQG62



QG2000



### Source container

Source containers are available in different sizes to guarantee optimum screening in relation to the activity of the radioactive isotope.

FQG63



Multiplex 9S



Special process conditions require a specific adjustment of source containers to the application. For this reason, source containers are available whose radioactive isotope can be inserted in the tank in a double-walled protection pipe.

#### Gammapiilot M FMG60

The compact transmitter consists of a sensor unit with a scintillator to detect the gamma radiation and an electronic unit for the analysis and transmission of the measured values. Different materials and measuring ranges of the scintillator and a standardized software permit the compact transmitters to be adapted to any measuring task.



#### Gammapiilot FTG20

The radiometric point level detector Gammapiilot FTG20 consists of two separate units. A detector which contains one to three Geiger-Müller counter tubes and a transmitter. Gammapiilot FTG20 features a modular design and can thus be used with one, two or even three Geiger-Müller counter tubes with very high sensitivity.






#### Gamma Modulator FHG65

Nondestructive material tests using gamma radiation or radiating media may impair radiometric instruments. Endress+Hauser has developed the Gamma Modulator system component which compensates such external radiation. (For more information, see pages 24/25)



#### Features overview of Gammapiilot M FMG60

Installation options	From outside
Sensor length/ measuring range in mm (")	Density: 50 Point level detection: 200/400 (7.87/15.7) Level/interface: 400...2,000 (15.7...78.7) cascading if required
Process temperature	Independent
Process pressure	Independent
Accuracy	0.1% (NaJ) / 0.5% (PVT)
Reproducibility	0.1% / 0.5%
Output/communication	4...20 mA HART®, PROFIBUS® PA, FOUNDATION™ fieldbus
  	
Approvals	ATEX, FM, CSA, IECEx, TIIS, NEPSI
Further information	For density measurement: Connection for a Pt100 temperature sensor for temperature compensation
Housing	Aluminium or SS316L

#### System integration

The standardized communication protocols of HART®, PROFIBUS® PA and FOUNDATION™ fieldbus are available for the connection and operation of the Gammapiilot M compact transmitter. It may be operated via the separate display and operating unit (FHX40) or via the FieldCare plant asset management tool. The smooth integration into all current control systems is also possible.

#### Functional safety (Safety Integrity Level)

The development in accordance with IEC 61508 equips the compact transmitters to meet the requirements of functional safety (SIL2/SIL3) in the area of point level detection. Gammapiilot M thus offers the highest degree of safety and reliability to ensure the protection of people and the environment at any time.



# Chemical and Petrochemical industry



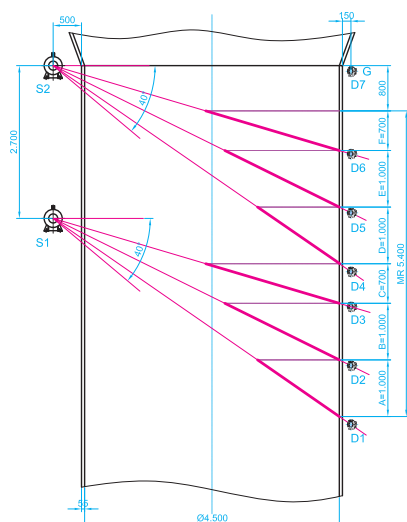
Be it in the chemical or petrochemical industry, in the solution or decomposition of solids, the neutralization of acids, the determination of crystallizing temperatures or in fractional distillation – subjects like safety, resistance against aggressive media, monitoring and documentation of the production processes as well as ensuring product safety play a major role.

To meet these requirements, all details of the production processes must be mastered and, at the same time, more and more process variables have to be recorded. For in-process monitoring, exact information on the product quality is indispensable. Radiometry makes an important contribution in this respect.



### Level measurement in fluidized bed reactors

Some processes use fluidized bed reactors in the production of polyethylene or polypropylene. In these reactors, solid particles are fluidized by gas flowing upwards which generates a close contact between the fluidized product (solid particles) and the fluidizing medium (gas). This close contact increases the reaction rate.



### Measuring task

The fluidized product in the reactor does not form a defined surface. The density profile of the solids content, the fluidized bed, has to be determined for process control and optimizing.

### Solution

Special positioning of several compact transmitters permits the measurement of the density of the fluidized bed in different reactor zones. A "solid profile" is derived from these density values which shows the desired product properties in a targeted fashion.



### Benefits

- Targeted representation of product properties
- Constant and high product quality
- Optimized utilization of product capacity

### Process optimizing in polymerization reactors

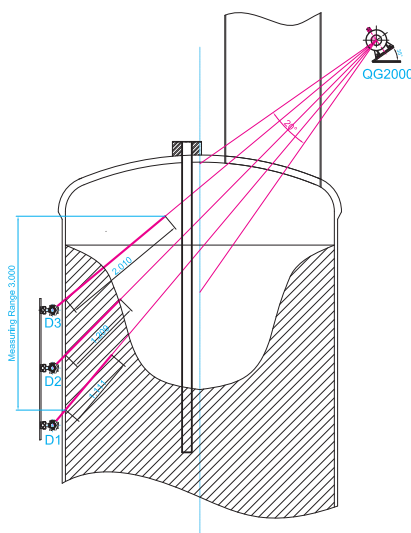
Funnels often occur in reactors with agitators.

### Measuring task

In a classic measuring arrangement, the upper funnel edge level would be recognized as the level. Details concerning the profile of the funnel are not available.

### Solution

The absorption measuring method can simultaneously monitor the level in the reactor and determine information concerning the position and shape of the funnel.



### Benefits

- Improved utilization of the reactor capacity based on more exact information concerning the funnel profile
- Non-contact measuring system

# Oil and Gas



The oil and gas industry places special demands on instrumentation. Under the severest of conditions, different parameters like level and density have to be determined in a highly precise manner in onshore and offshore tanks. This requires robust instruments developed in line with the standards of the oil and gas industry.

To safeguard an effective operation, the extracted mixture of gas, oil, sand and water must be reliably separated. Apart from optimizing the separation process for efficiency increases, the lowest possible degree of environmental pollution by the oil production process is to be achieved.

A radiometric measuring system to determine the density profile in a separator opens a window to the internal separation process. This density profile can visualize the layers of crude oil, the emulsion, water and possibly present sediments.



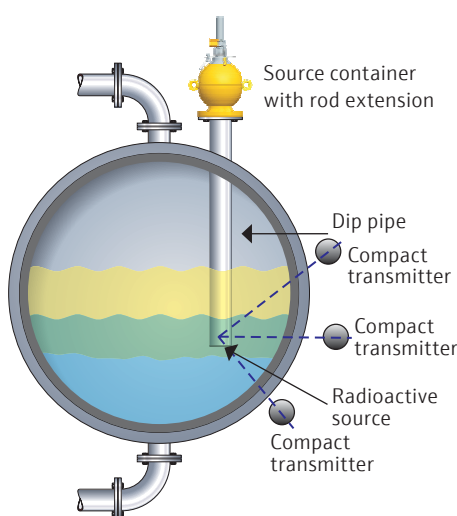
### Interface measurement in separators

Separators split the mixture of gas, oil, water and sand extracted in the oil field. Heavy parts like sediments sink to the bottom, light parts, e.g. methane, rise and are removed at the top of the tank. An emulsion layer forms between the oil and the water and is kept as small as possible by the addition of demulsifiers. The process proceeds in an optimum fashion if a defined interface layer occurs between the oil and the water.



### Measuring task

If the thickness of the interface layer is not reliably monitored, water may pass over the weir in the separator. An excessive water portion in the oil after the separator causes problems in downstream oil production processes. If the water surface subsides to a low level, oil is withdrawn at the bottom of the separator instead of water. This means a high financial loss as well as environmental pollution and must be avoided under all circumstances.



### Solution

The position of the interface layer is determined by the density profile of the liquids. The source container is mounted on a double-walled protection pipe and the source is inserted in the protection pipe using a rod. The detectors are arranged on the outside of the separator in correspondence with the minimum and maximum position. This instrument arrangement monitors the changes in liquid density and thus the position of the interface layer.

#### Benefits

- High reliability
- Detectors are easily accessible
- No moving parts in the process
- Optimized usage of additives to reduce the emulsion layer



### Delayed coking

Petroleum coke is produced in coke drums. The residues from the vacuum distillation are heated to approx. 500°C (932°F) and transferred to the active coke drum where they are cracked by hot gas. Gas is continually withdrawn during the filling operation of the coke drum. Strong foam formation occurs on the product surface.

### Measuring task

Antifoaming agents are added as certain levels are reached in order to keep the foam layer as low as possible.

### Solution

Radiometric level measurement continually monitors the position of the surface of the foam. The signal controls the spraying operation of the antifoaming agent. Additional overfill prevention is provided by the measurement of the maximum level. This measurement prevents both foam and product from entering the gas vent.

#### Benefits

- Improved use of plant capacity due to higher filling level
- Cost reduction because of optimized use of antifoaming agents
- No plant downtimes caused by gas vent blocking

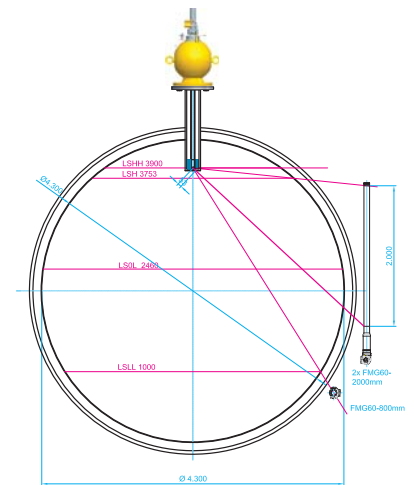


# Primaries and Mining

Be it in mining or wet processing of mixtures of solids and water, the acquisition of levels, product densities or concentrations plays an increasingly significant role in the early recognition of undesirable product changes. Robustness, reliability, simple handling, resistance against abrasion as well as increased plant availability are other aspects of great importance for the primaries industries.

## Measurement in autoclaves

In nickel and cobalt extraction, ore-containing sludges are condensed and fed into an autoclave (pressure vessel). The metal compounds are dissolved under high pressure, high temperature and the addition of sulphuric acid. In further cleaning, separation and reaction steps, nickel and cobalt are separated and respectively produced as a highly pure powder through hydrogenation in another autoclave.



### Measuring task

Process conditions in an autoclave are extreme, typically they range around 250°C (482°F) and 40bar (580psi). The mixture of ore sludge and sulphuric acid is abrasive and corrosive which prohibits measurements in contact with the medium.

### Solution

Since the wall thickness of an autoclave may exceed 100mm (4"), the radioactive source is positioned in the autoclave in a double-walled closed immersion tube of titanium. The detector is mounted on the outside of the autoclave. The level in the autoclave can thus be continually monitored.



#### Benefits

- High degree of availability and reliability
- Very low radiation exposure
- Simple commissioning



### Density measurement in ore sludges

Density monitoring is a major task of quality assurance in ore sludge wet processing. In addition, mines are often in areas with limited water supplies. This makes density monitoring of sludges an essential task to save precious water.

### Measuring task

Ore sludges are strongly abrasive and often aggressive. This makes density measurement inside of a pipe impossible.

### Solution

The radiometric measuring system is clamped onto the pipe externally. Density changes of the ore sludge can be measured noninvasively through the pipe walls. In addition, the rate of flow may be determined using an electromagnetic flowmeter.



#### Benefits

- Non-contact measurement
- High accuracy
- Efficient water management within the plant





# Pulp and Paper



Optimum control and monitoring of production processes are a basic precondition in pulp production and paper fabrication in order to achieve the best possible plant availability while ensuring the highest degree of product quality.

Reliable instrumentation, chemically resistant materials but also functional safety are key criteria which, among other aspects, are used for the qualification of components and instruments. This is particularly true for direct density measurement on pipes. Level and point level applications

occur in storage silos, on digesters, preheating and storage tanks as well as dry run protection on screw conveyors.

## Chemical pulp production – digesting process

Wood is the most important raw material in paper production. To obtain the required fiber, the wood is subjected to different processing steps. One of them is the digesting process in which the chipped wood is cooked together with chemicals and water. This process removes lignin and produces wood fibers.





### Measuring task

A screw conveyor transfers the wood chips to the digesting process. The chips in the feeder hopper of the screw conveyor may not surpass a certain level since this would prevent an optimum transfer to the digester. Water, chemicals and lyes are added or withdrawn during the digesting process depending on the method employed. This requires continuous non-contact monitoring of levels within the reactor.

### Solution

Radiometric limit measurement monitors the maximum level in the feeder hopper of the screw conveyor. The non-contact radiometric system permits measurements without any impairment caused by product adhesion or density fluctuation. The level of the mixture of chips and cooking liquor in the digester is continually acquired by another radiometric measuring system and transferred to the process control system.



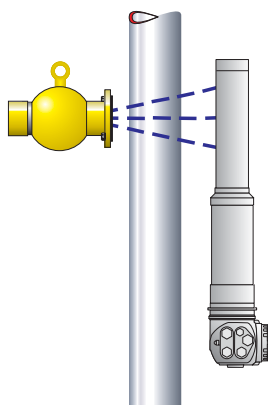
#### Benefits

- Highest availability
- Absolutely maintenance-free
- No mechanical parts in contact with the medium



### Treatment of spent liquor

Residues from the digesting process are transferred to the recovery system.



### Measuring task

Residues from the chemical treatment are strongly alkaline. The density measurement at different points of the recovery process constitute an important process variable to evaluate the composition, e.g., of the green, white or black liquor. A measurement in contact with the medium is not recommendable due to the strong corrosiveness of these liquors.

### Solution

Radiometric density measurement operates noninvasively and exactly from outside through pipes. This permits valuable chemicals to be returned to the processes.



#### Benefits

- Non-contact measuring method
- Highly precise measurement, high availability
- Maintenance-free, all components of 316L



# Special applications

## Layer thickness measurement in a centrifuge

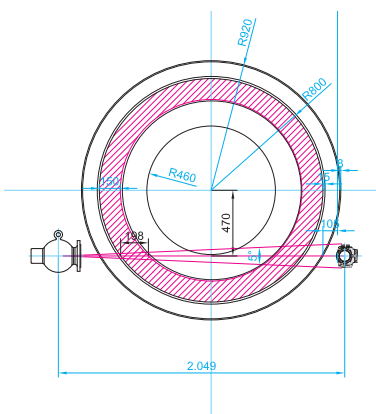
Many processes, e.g. in the production of pharmaceutical products, employ centrifuges to separate solids from a liquid. The solids are deposited on filter walls and then removed.

### Measuring task

The layer thickness of the filter cake must be measured and monitored to ensure an efficient use of the capacity of the centrifuge. Mechanical measuring systems have a low useful life in the performance of this task due to the high dynamic strain of these processes.

### Solution

The radiometric measuring system works noninvasively and decoupled from the centrifuge. The growing layer thickness in the centrifuge is monitored and the removal is started as the maximum layer thickness is reached. During the subsequent cleaning process, the quantity of washing liquid is monitored by the same measurement which facilitates its efficient and thus cost-effective use.



### Benefits

- Maintenance-free due to non-contact and mechanically decoupled measurement
- High availability of the centrifuge is safeguarded
- Cost savings through efficient use of washing liquid



## Cyclone monitoring in cement production

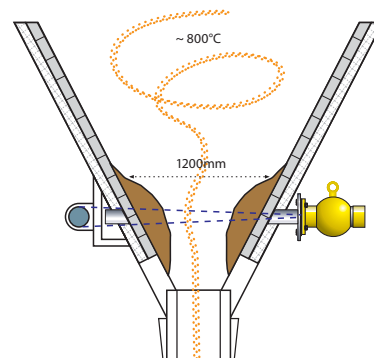
Cement is predominantly produced in a continuous dry process. In clinker production, cyclones are used to preheat the raw meal before the same enters a rotary kiln which has a temperature of approx. 1,400°C (2,552°F).

### Measuring task

The raw meal fed into the cyclone tends to form build-up which can lead to blocking in the lower part. The cyclone is monitored for build-up formation to avoid downtimes. If the thickness of the layer on the wall exceeds a certain value, the build-up is removed by compressed air. The continuous use of compressed air is cost-intensive and might damage the brick lining.

### Solution

The radiometric measuring system mounted on the outside of the cyclone monitors the growing layer on the walls. In case of need, the build-up is removed from the walls using compressed air.



### Benefits

- Continuous build-up measurement
- Non-contact measurement
- Brick lining is preserved
- High plant availability



### Flue gas cleaning

Apart from other arrangements, electrostatic filters are used in flue gas cleaning. These filters remove flue ash from the exhaust gas of the plant. The separated flue ash is withdrawn in the lower part of the filter.

### Measuring task

The flue ash must be continually withdrawn. If the ash collects in the outlet, blocking and subsequent downtime of the plant can occur. Furthermore, dispersing of the flue ash must be avoided in order to prevent an impairment of the efficiency of the separation process.

### Solution

The radiometric measuring system ensures that the outlet is free of ash.



#### Benefits

- No downtimes
- Unaffected by abrasive media and build-up formation on the walls
- No temperature limits

### Mass flow measurement on suction dredgers

Suction dredgers are used for land reclamation work in the sea or port facility excavating.

### Measuring task

The excavated quantity as well as the portion of solids of the absorbed medium is ascertained. Depending on the application and the size of the ship, pipes can have a diameter of up to 1,300mm (51.2").

### Solution

Radiometric density measurement is combined with flow measurement. The density value from radiometric measurement is transferred to the Promag flowmeter of Endress+Hauser. The mass flow is calculated from this density value and the measured flow rate of the medium.

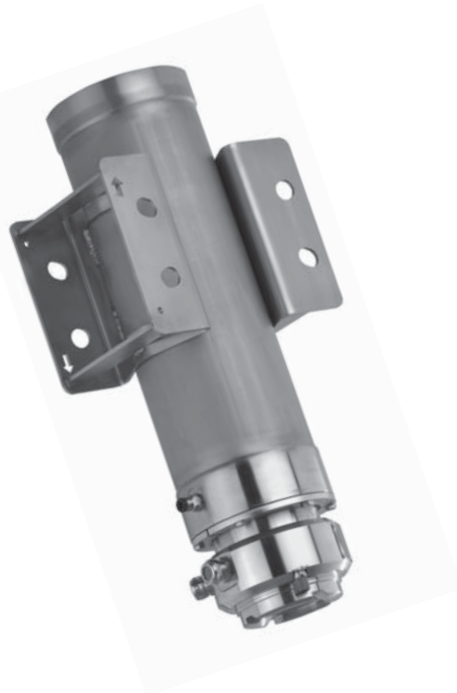


#### Benefits

- Direct mass flow signal received via flowmeter
- High availability despite very abrasive media
- Instrumentation from one source



# Gamma Modulator



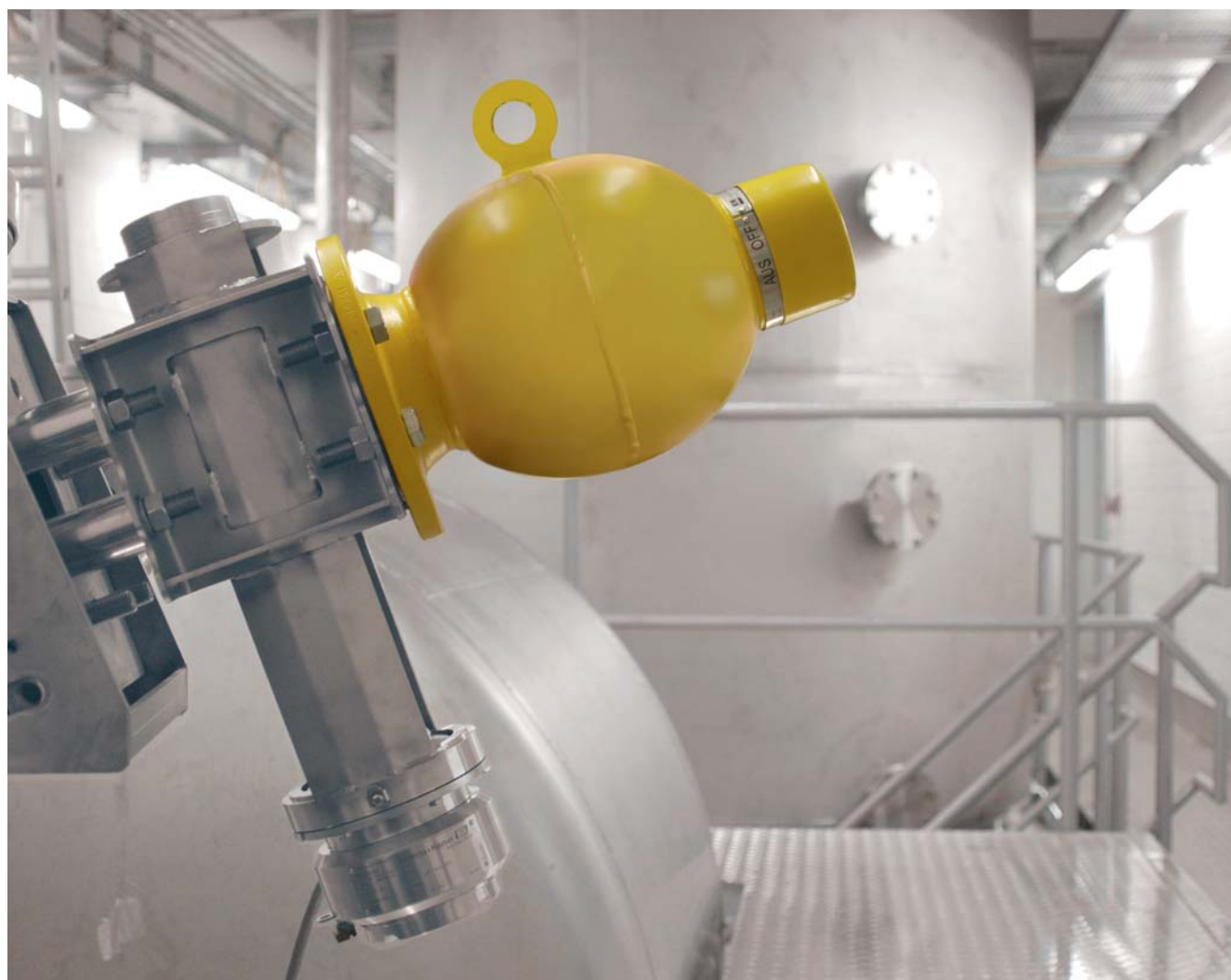
**Nondestructive material testing using gamma radiation or radiating media may impair radiometric instruments.**

Nondestructive material testing is also employed in the construction or reconstruction of plant sections, for example when welding seams of pipe connections or pressure tanks have to be checked. Very strong radioactive isotopes are used in this work. If radiometric measuring systems are installed in the vicinity of such test locations, they may be impaired by external radiation even at distances of several hundred meters. For this reason, measurements are realized in manual operation to prevent shutdowns and alarms.

In our Gamma Modulator, we succeeded in developing an automated

solution for the suppression this interfering radiation. The mode of operation of the Gamma Modulator is unaffected by the type of isotope used for material testing as well as by the type of isotope used in the radiometric measurement ( $^{137}\text{Cs}$  or  $^{60}\text{Co}$ ).

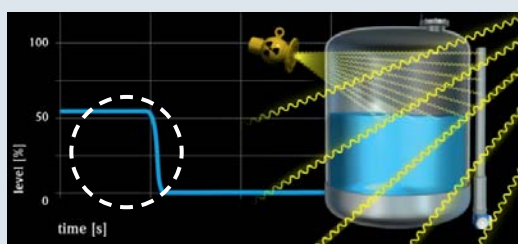
The Gamma Modulator is installed in a measuring point as a system component. In order to modulate the useful radiation emitted by the radioactive isotope it is mounted in front of the radiation emission channel of the source container. Cylinders revolve inside of the Modulator and alternatively screen the gamma radiation or permit it to pass. This generates a gamma radiation which is modulated on a fixed frequency and detected and analyzed by the compact transmitter.



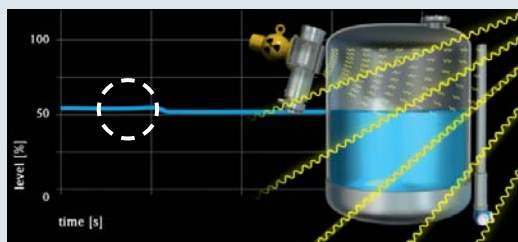
If interfering radiation occurs, the compact transmitter receives both the modulated useful and the unmodulated interfering radiation. It recognizes the modulated useful radiation and analyses only this part of the overall radiation. Continuing measurement is thus possible even in the presence of interfering radiation and safety and plant availability are significantly increased.

The Gamma Modulator can also eliminate any interference with radiometric measurements due to radioactive particles in the medium to be measured, e.g. in case of uranium ore in mining.

The Gamma Modulator does not require any maintenance work and can easily be integrated into existing systems thus offering a safe solution to suppress interfering radiation of any type.



Interfering radiation influences level measurement



Safe measurement in spite of interfering radiation





## Service

Your plants have to work – consistently and reliably. This requires expedient planning, good technical equipment and proper upkeep. We offer you customized services across the entire life cycle of process instrumentation. You can count on our support for plant optimization from engineering and upkeep concepts through to modification. Our global service provides fast spare part supplies as well as competent assistance in commissioning.

### Commissioning

Correct commissioning of instruments is of paramount importance. We support you in this respect providing trained associates with the required test equipment to familiarize your staff members with the instruments after commissioning so that they are aware of the maintenance requirements of the plant within a very brief period of time. After commissioning, you receive a detailed service report.

### Maintenance

Together with you, we determine the maintenance concept required for your instruments to ensure the optimum performance of your plant. We test the serviceability of your instruments in the course of maintenance work in order to safeguard optimum efficiency. If required, we certify that the instrument complies with applicable laws and regulations. Regular checks in line with SOPs (Standard Operating Procedures) can be combined in an optimum fashion.







### Training and seminars

You are cordially invited to get to know the manifold aspects of modern instrumentation at our premises. Be it at a product forum for a basic overview, at specialized seminars with compact information concerning important subjects or at service courses which impart comprehensive knowledge in relation to instrument operation, commissioning and defect localization on basis of hands-on training on instruments. We also offer you individual service courses at your premises.

### Return of sources

The responsibility for a product does not end with its sale. Our experienced service associates are available to you concerning the legally stipulated disposal of sources. We also offer you the return of sources to us for the purpose of checking them for possible reuse.

Visit us at



[www.gamma.endress.com](http://www.gamma.endress.com)

– you will receive further information concerning radiometry on this site.

[www.addresses.endress.com](http://www.addresses.endress.com)

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