Radiometric measurement technology
A safe principle that meets the highest demands
Competence in gamma

Over 50 years experience

Many industries have trusted gamma for the most difficult measuring tasks for decades. Since 1962, the first radiometric measuring line of Endress+Hauser was launched. More than four decades have passed and this measuring principle still offers its decisive advantages. Gamma is used where other measuring principles fail 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 provides 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

First radiometric measuring system from Endress+Hauser

1962

1977

1994

2004

2009

DGS7 – the first scintillation detector and transmitter

1984

1993

1998

2007

New measuring detector and new source containers

FMG/FTG671 – Transmitter for Rackbus

1994

1998

Applicator – the software for designing gamma measuring points

FMG/FTG671 – Transmitter for Rackbus

1996

2000

2004

2008

SIL approval for point level detection applications

Gamma Modulator FHG65

1992

1996

2006

2009

New source containers FQG60 and FQG63

2011

Source containers with a chemical design

Gammapilot M FMG60 – the first compact transmitter to solve all measuring tasks in one instrument

Petrochemical Industry

Energy

Pulp and Paper

Chemical Industry

Primaries and Mining

Oil and Gas
The gamma measuring principle is based on the attenuation of 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 attenuation 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.

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**Point level detection**
(Overfill prevention according to WHG, Safety Integrity Level SIL2/3 for monitoring of minimum/maximum point level)

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

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

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

Optional:
Pt100 for temperature compensation or mass flow with volumetric flowmeter
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 occurring 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, radiation occurs from medicine and other from industry.

At an altitude of 10,000 ft (3,000 m), the cosmic radiation is more intensive than the radiation required for measurements by the compact transmitter of Endress+Hauser.
Components of a gamma measuring system

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 and NRC.

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

- **Caesium Cs\textsubscript{137}**
  Ideal for continuous level, point level detection and density measurements. The half-life of 30 years permits long usage without exchanging the source.

- **Cobalt Co\textsubscript{60}**
  Used in applications involving thick container walls because of its high penetrating capabilities.

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

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

Features overview

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<td>in inches (mm)</td>
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<td>Process pressure</td>
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Gamma Modulator
Nondestructive material tests like weld radiography using gamma radiation or radiating media may result in inaccurate measurement. Endress+Hauser has developed the Gamma Modulator system component which compensates for external radiation. (For more information, see pages 14/15)

System integration
The standardized communication protocols of HART®, PROFIBUS® PA and FOUNDATION™ fieldbus are available for the connection and operation of the Gammapilot 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 enables the compact transmitters to meet the requirements of functional safety (SIL2/SIL3) in the area of point level detection. Gammapilot M thus offers the highest degree of safety and reliability to ensure the protection of people and the environment at any time.
Service and startup

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.

**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 gamma sizing function 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.

**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.
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. Gamma 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.

Process optimizing in polymerization reactors
Vortex often occur in reactors with agitators.

Measuring task
In a classic measuring arrangement, the upper vortex edge 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 vortex.
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.

### 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.

#### 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. 932°F (500°C) 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
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
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**
Gamma point level 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 monitored by another radiometric measuring system and transferred to the process control system.

**Treatment of spent liquor**
Residues from the digesting process are transferred to the liquor recovery system for reuse.

**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 recommended due to the strong corrosiveness of these liquors.

**Solution**
Radiometric density measurement operates noninvasively and accurately from outside the pipes. This permits valuable chemicals to be returned to the processes.
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 material before it enters a rotary kiln which has a temperature of approx. 2552°F (1400°C).

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

Solution
The gamma measuring system mounted on the outside of the cyclone monitors the growing layer on the walls. In case of need, the buildup is removed from the walls using compressed air.

Benefits
- Continuous buildup measurement
- Non-contact measurement
- Brick lining is preserved
- High plant availability
Flue gas cleaning
Electrostatic filters are used in flue gas cleaning. These filters remove fly ash from the exhaust gas of the plant. The separated fly ash is removed in the lower part of the filter.

Measuring task
The fly ash must be continually removed. If the ash collects in the outlet, blocking and subsequent downtime of the plant can occur. Furthermore, dispersing of the fly ash must be avoided in order to maximize the efficiency of the separation process.

Solution
The gamma 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 percent of solids of the pumped medium is measured. Depending on the application and the size of the ship, pipes can have a diameter of up to 51.2" (1300 mm).

Solution
Gamma 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
Eliminates the interference from external radiation

Nondestructive material testing like radiography using gamma radiation or radiating media will impair radiometric measurement.

Nondestructive material testing is 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 testing. If radiometric measuring systems are installed in the vicinity of such test locations, they will be influenced by external radiation even at distances of several hundred yards. For this reason, plant systems are typically placed in manual operation to prevent shutdowns and alarms.

In our Gamma Modulator, we succeeded in developing an automated solution for the suppression of this interfering radiation. The 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 (Cs137 or Co60).

The Gamma Modulator is a component of a complete gamma system. Absorption rods revolve inside of the Modulator and alternatively block 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 external 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 a system thus offering a safe solution to suppress interfering radiation of any type.
Endress+Hauser’s product portfolio

Level
- Capacitance (RF)
- Conductive
- Mechanical
- Vibration
- Ultrasonic
- Radar
- Guided radar (TDR)
- Hydrostatic
- Gamma

Pressure
- Gauge/absolute
- Differential pressure
- Hydrostatic

Flow
- Electromagnetic
- Vortex shedding
- Coriolis mass flow
- Ultrasonic
- Open channel
- D/P flow
- Thermal mass flow

Temperature
- Temperature transmitters
- RTDs/thermocouples
- Sensors

Liquid Analysis
- Conductivity
- pH/ORP
- Chlorine
- Dissolved oxygen
- Turbidity
- Chemical analyzers
- Nitrate/organic sensors
- Sludge level

Recorders & Components
- Paperless recorders
- Visual data managers
- Safety data managers
- Displays
- Barriers
- Power Supplies

Solutions
- Wireless networks
- Inventory control
- Energy monitoring
- Tank farm monitoring
- Life cycle management
- Plant asset management
- Flow management solutions

Service
- Start-up
- Training
- Calibration
- Maintenance contracts
- Installed Base Audit

Endress+Hauser's product portfolio