Why Cat 3 sources still find it’s application in the Industry

Presented at The National Academies of Science, Engineering and Medicine

Welcome

Ralf Matthaes

Head of Department Business Development

Endress+Hauser Level & Pressure Maulburg, Germany

- Gamma (Nucleonic, Radiometric)
- OEM business
- Moisture Measurement

54 years, married

37 years with Endress + Hauser

Facts and figures 2019

Endress+Hauser

Endress+Hauser in the world

We align ourselves with our key industries

Endress+Hauser

Our product offerings

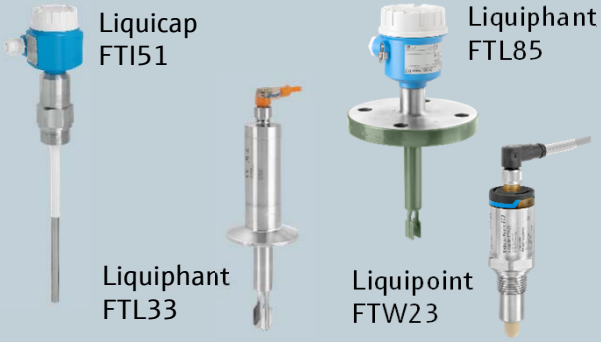
Endress+Hauser

Selection of the complete product portfolio for pressure measurement

	Pressure	Differential pressure	Hydrostatic pressure
Ceramic	 Cerabar PMC51  Cerabar PMC71	 Deltabar FMD71 el. dp	Waterpilot FMX21 
Silicon	 Cerabar PMP71  Cerabar PMP11	 Deltabar PMD55 Deltabar PMD75 	
Contite			 Deltapilot FMB50  Deltapilot FMB70

Endress+Hauser

Selection of the complete product portfolio for level measurement

	Point level detection	Continuous level measurement	Density measurement
Liquids	 Liquicap FTI51 Liquiphant FTL33 Liquiphant FTL85 Liquipoint FTW23	 Micropilot NMR81 Prosonic FMU30 Levelflex FMP55 Micropilot FMR20	 Liquiphant FTL50 + FML621 Proservo NMS80
Solids	 FTG20 Solicap FTI77 Soliphant FTM50	 Levelflex FMP56 Prosonic FMU43 Micropilot FMR57 FQG61 + Gammapilot FMG50	

Endress+Hauser

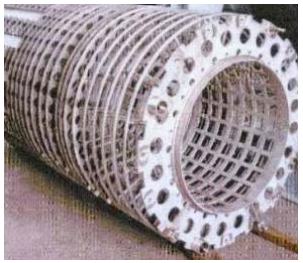
Why radiometric measurement?

Used when other measurement principles fail because of extreme process conditions…

High temperatures

High pressure

Vessel design



Installations

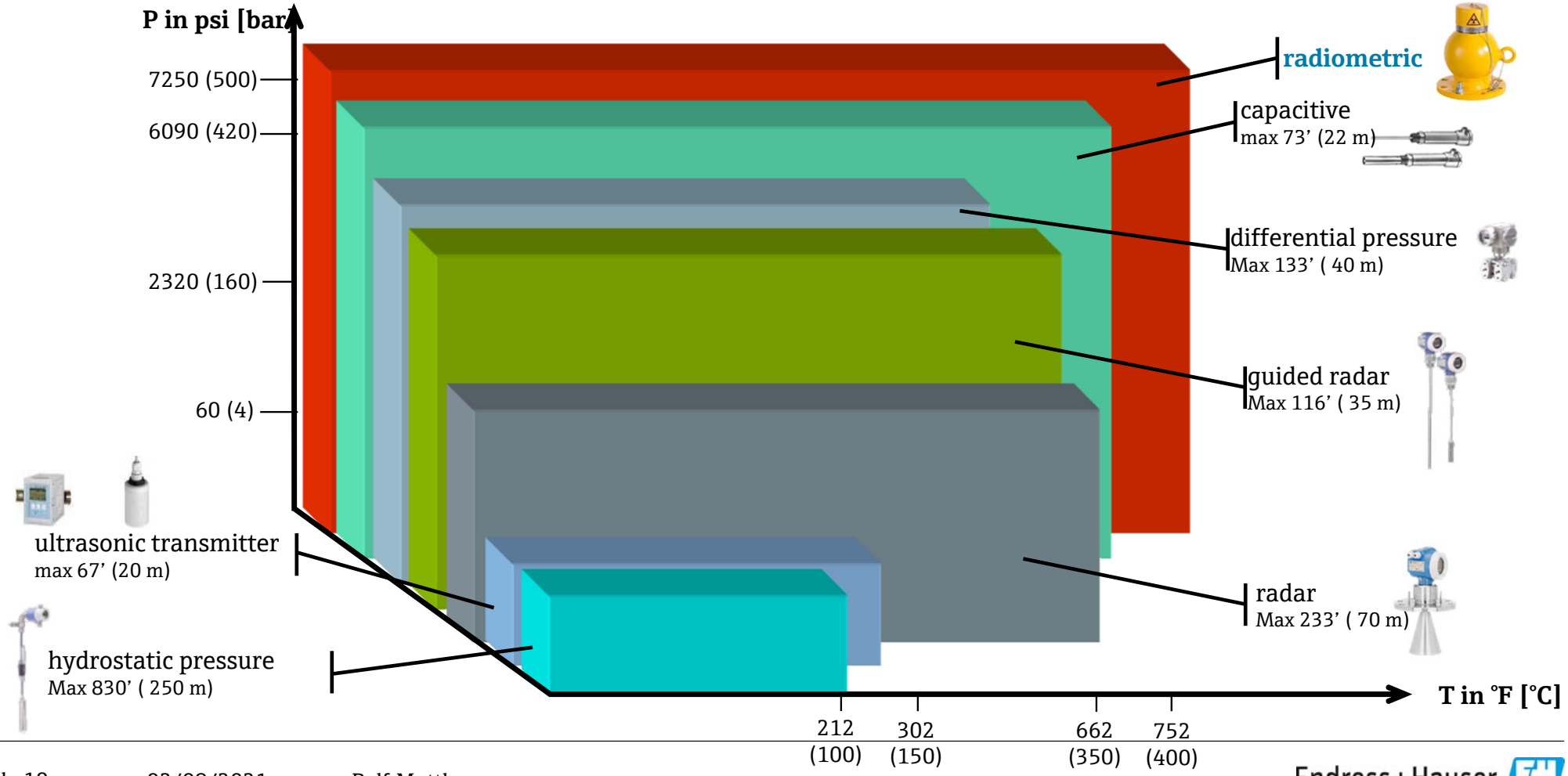
Corrosion

Abrasion

Viscosity

Toxicity

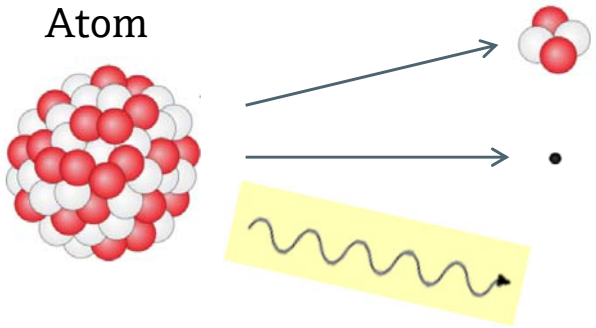
Limitations of measuring principles for level



Endress+Hauser

Radiation come into Existence – Decay

Radioactive **isotope** decay → 3 types of **radiation**



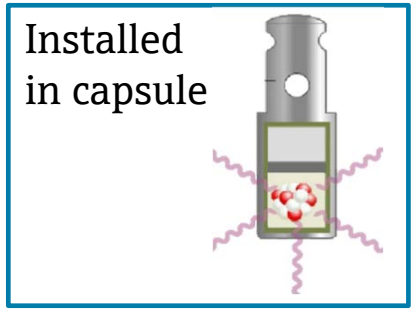
α Alpha radiation Particle

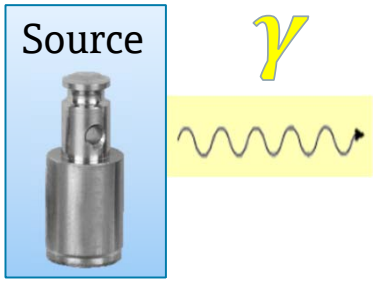
β Beta radiation Particle

γ Gamma radiation
Electromagnetic wave

Number of emitted radiation per time:
Activity (A) = 1 decay/s = 1 Becquerel (Bq)

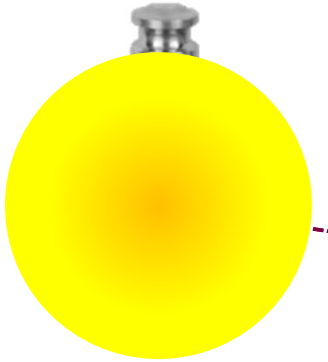
Radioactive Isotope
Cs137 / Co60
Typical **Activity** :
37 MBq to 37 GBq





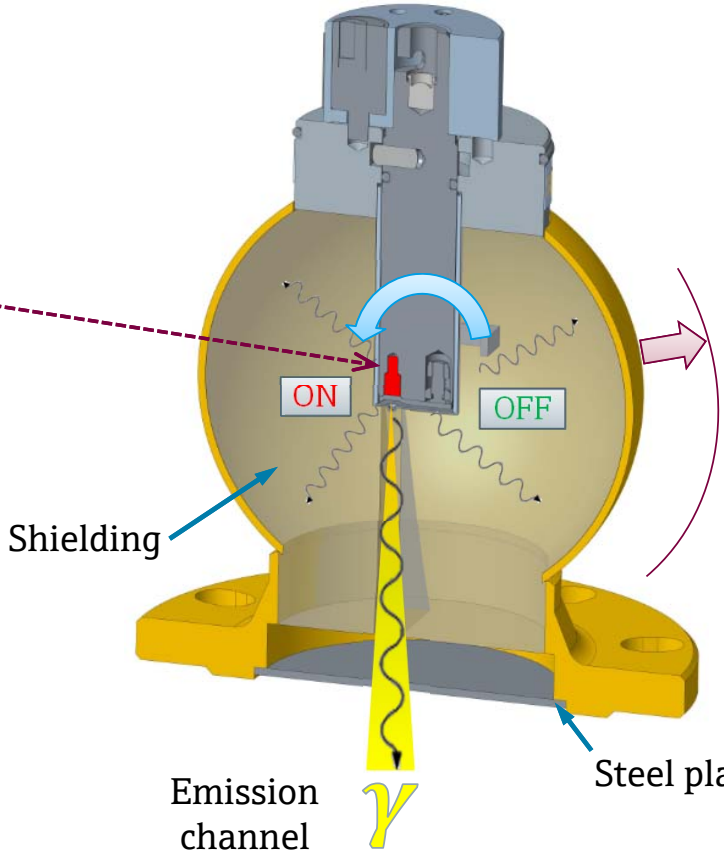
Source installed in source container

Source



- Installed in source container
- Radiation only in direction of emission channel allowed
- In all other directions the radiation is absorbed with the lead shielding
- Radiation can be “switched off” with turning the insert to 180°

Source container



Different sizes of source container

Dose rate in mR/h[µSv/h] shall not exceed the **limit** in specific distance to the surface of the container.

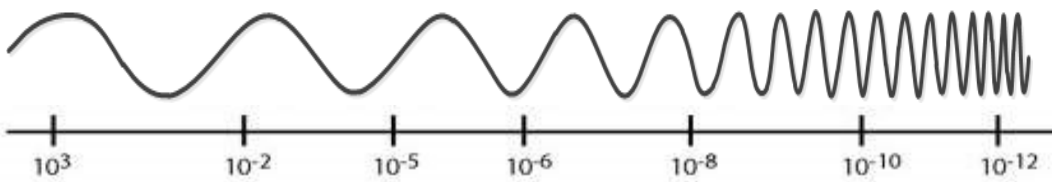
≤ 5mR/h in 1ft
(7.5µSv/h in 1m)

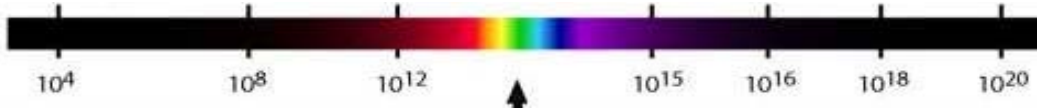
Gamma Radiation – Electromagnetic Wave

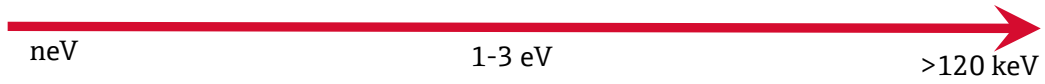
Electromagnetic Waves : spread out with speed of light and transport energy

Electromagnetic spectrum

Radio	Microwave	Infrared	Visible	UV	X-Ray	**Gamma Ray**





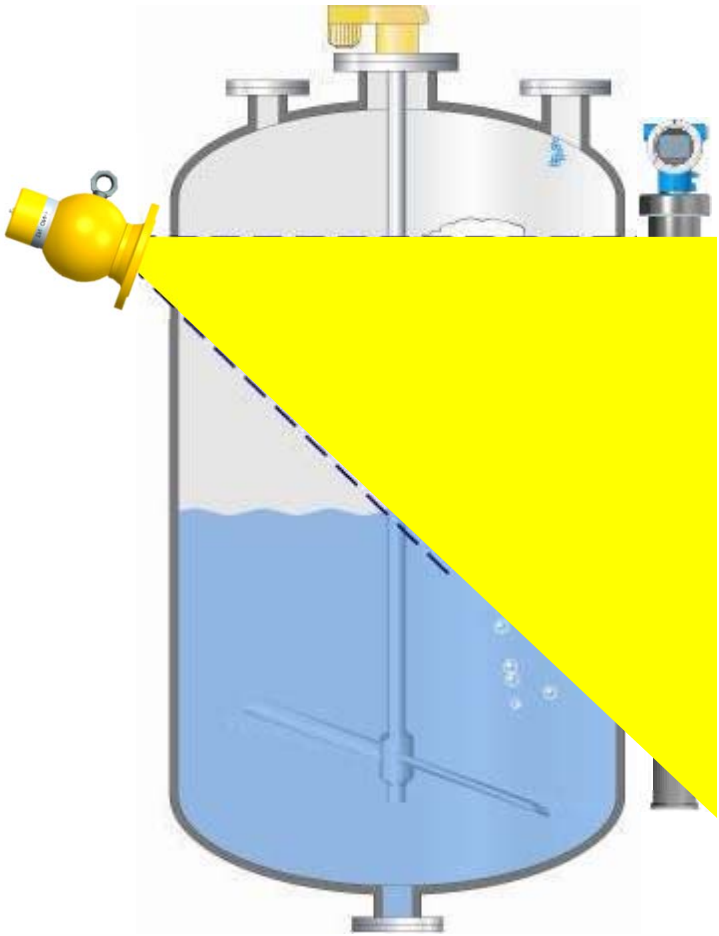


γ Gamma radiation

- Short wavelength
- Very high frequency
- High energy: keV… MeV

Radiometric Measurement System

Source inside
Source container
→ emits γ - radiation



Detector
→ convert radiation into electrical signal

Measuring system
is fitted **externally**
and **measures**
through the vessel wall

Typical dose rate values:

- Level: 0.05mR/h (0.5µSv/h)
- Limit: 0.01mR/h (0.1µSv/h)
- Density: 0.5mR/h (5µSv/h)

Radiometric Measurement System

- **non contact** measurement
- **non invasive** measurement; the measuring system is fitted externally and measures through the vessel wall
- it offers process safety, reliability and availability of the facilities

Used for

- Continuous **level** measurement
- **Point level** detection
- **Density** measurement
- **Interface** measurement

Radiation Protection - ALARA

Basic guideline of radiation protection:

ALARA *"As Low As Reasonably Achievable„*

ALARP "*As Low As Reasonably Practicable*"

The aim is to minimize the risk of radioactive exposure.

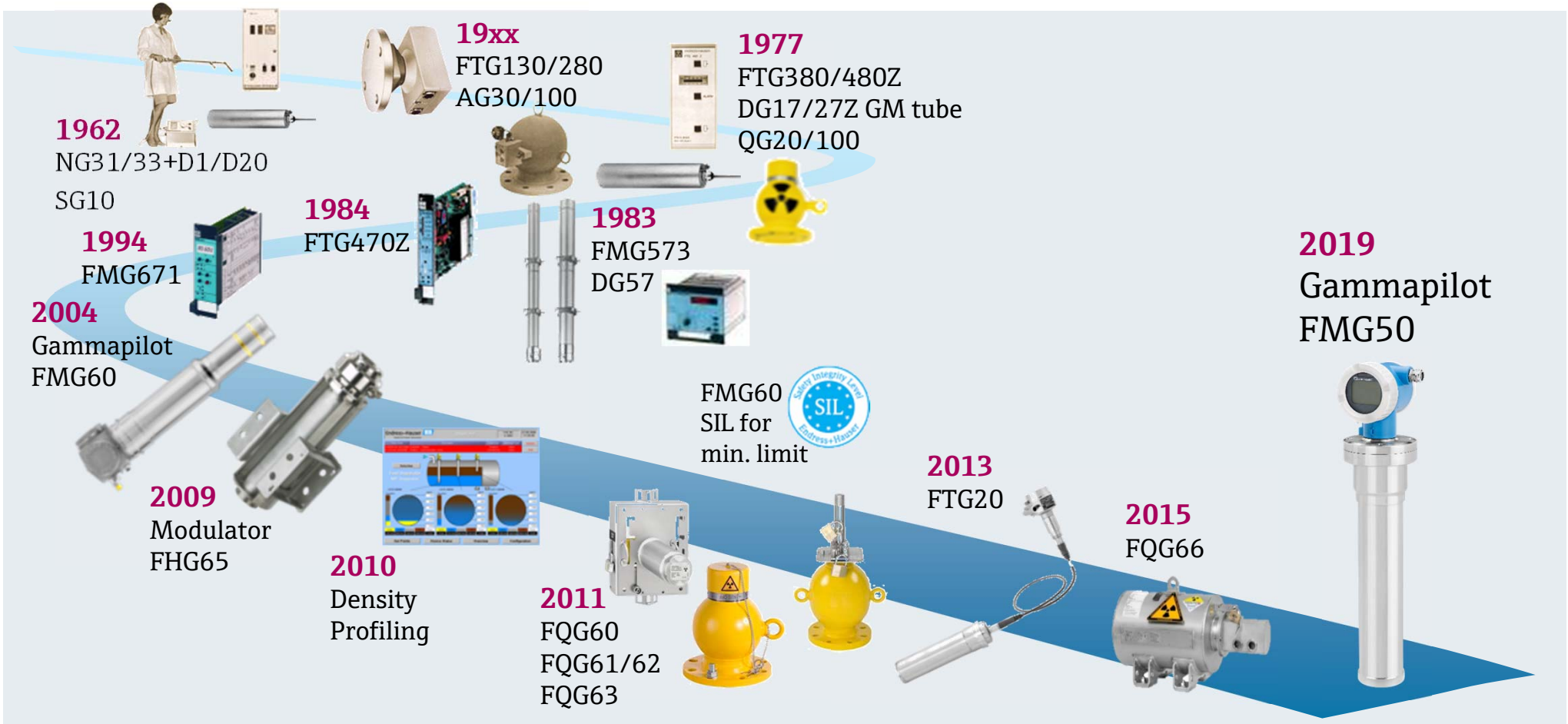
Implementation in regulation:

→ part of the European safety standard

→ took in national laws: Radiation protection regulations

→ worldwide NSC: Nuclear Safety Commission

Gamma History – 59 years of experience!



Endress+Hauser

Estimated inventory Cat 3 sources for density, level and point measurement

Globally every year more than 5 Mio measuring points are potentially purchased by customers

- Only < 0.2% are nucleonic based (estimated with 5-10,000 sources)
- Mainly Cat 5 (90%) and Cat 4 sources (10%) for Cs137 and Co60
- Cat 3 sources are estimated with <1% → 50-100 pcs./a globally
  - In US market estimated 10-20pcs./a
  - Estimated inventory globally considering a recommended working live time of 15 years: 750-1500 sources
  - Estimated inventory in US: 150-300 sources

Global trend is slightly increasing due to:

- Increasing vessel diameter
- Increasing process pressure

  → more wall thickness to penetrate through

Licensing regulatory requirements for Cat 3 sources

- Always local rules are mandatory to be fulfilled
- HAS sources (Cat 3) needs to be specifically declared to regulators as High Activity Sources.
- Depending on Countries / States more strict regulations needs to be followed such as a dedicated storage area with fence and lockable.
- Note to fire workers

Typical Applications for Cat 3 sources

- Mining
- Dredging
- Petrochemical
- Oil & Gas

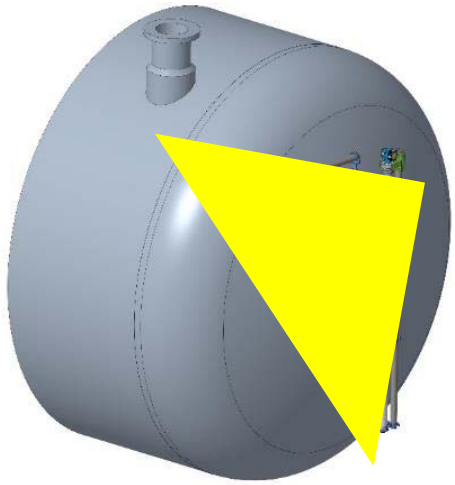
Mining – Autoclave (Copper, Nickel, Gold)

Measurement task:

Level measurement and point level of the ore slurry

Challenge / Process information:

- Large diameter
- Thick vessel walls
- Measuring range 80”(2000mm)
- Aggressive ambient conditions
- Very abrasive medium



Solution:

- Source container with extension
- **Internal source 5Ci Cs137 (185Gbq)**
- Detector FMG60
- Clamping device FHG60

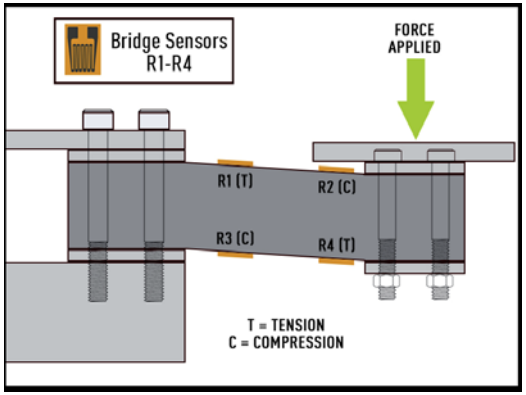
Alternative solution

Differential pressure

- Very bad accuracy due to changing medium density
- Very short sensor lifetime because of abrasiveness

Load cell

- Extremely costly → factor 10-20 to nucleonic gauges
- Hard to install
- Bad accuracy



Source: Wikipedia

Endress+Hauser

Dredging

Line 1: ID 48” (1200mm)
→ 1000mCi Co60 + FMG60- 48”(1200mm)

Line 2: ID 40”(1000mm)
→ 500mCi Co60 + FMG60-32”(800mm)

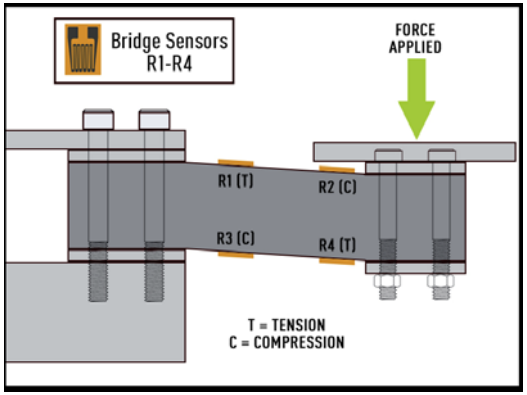
Alternative solution

Ultrasonic systems

- High installation effort
- Hard to calibrate
- Sensitive to vibration

Weighing cell

- Costly
- High installation effort
- Bad accuracy
- Sensitive to vibration



Source: Wikipedia

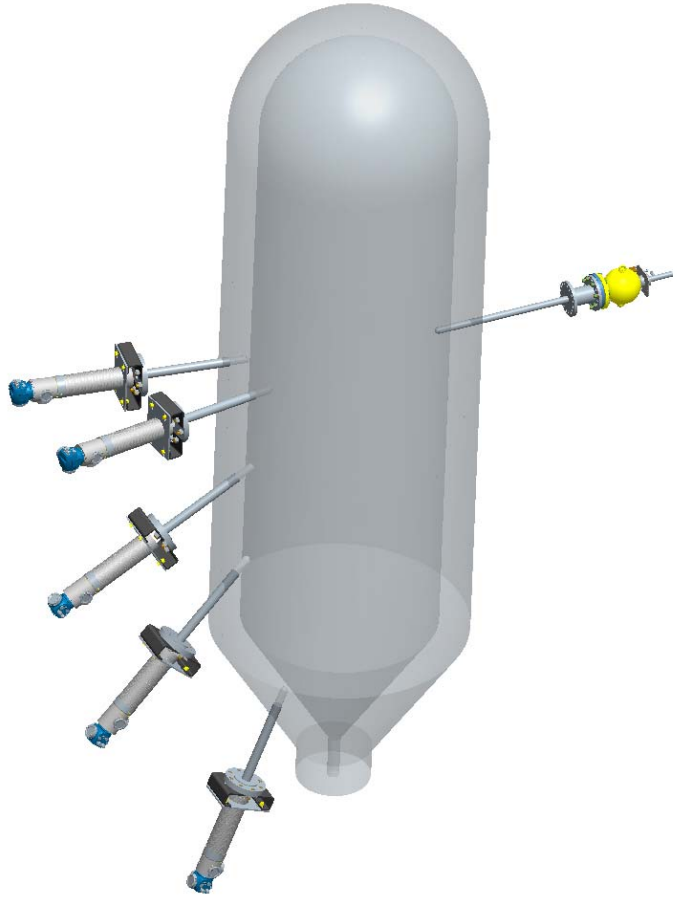
Petrochemical – High Pressure Product Separator

Challenge:

- Diameter: Ø 5 ft (1480mm)
- Very thick walls, t= 9” (225mm)
  → has to be reduces with holes
- Pressure: 4300- 4800psi (300-330 bar)

Solution for level measurement with absorption principle:

- Source container with rod extension
- Source Co60, 1000mCi (37GBq)
- Detector: PVT scintillator



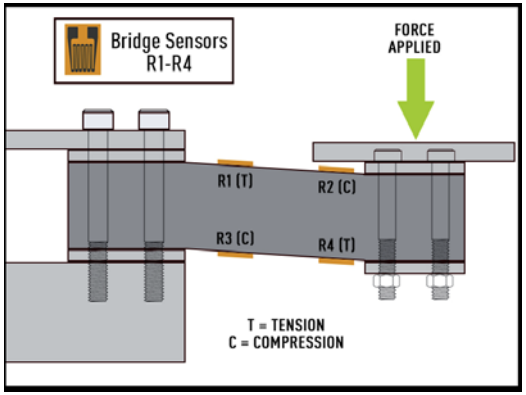
Alternative solution

Differential pressure

- Very bad accuracy due to changing medium density
- Very short sensor lifetime because of abrasiveness

Load cell

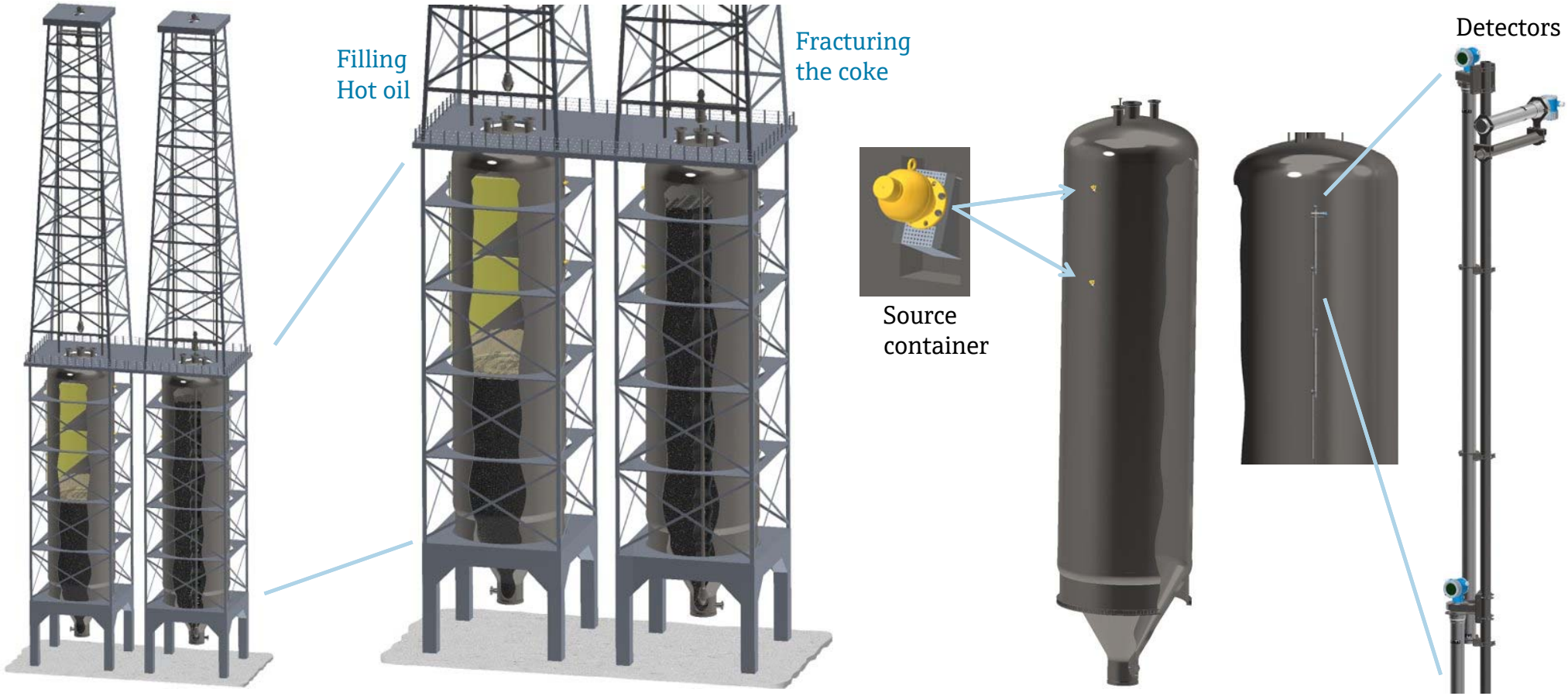
- Extremely costly → factor 10-20 to nucleonic gauges
- Hard to install
- Bad accuracy



Source: Wikipedia

Endress+Hauser

Oil&Gas, Refinery – Coke drum



Endress+Hauser

Alternative solution

- None
- More sensitive detectors results in lower source activity to use Cat 4 sources

Trends

More sensitive detectors

- will reduce the amount of new cat 3 sources → new Cat 4
- Existing Cat 3 sources can be used further even passing its Half Live

Other technologies improving in its performance and partly replaces nucleonic gauges

- Radar,
- Guided Wave Radar and
- Laser

This trend is ongoing but will not replace all nucleonic gauges

Conclusion

- Cat 3 sources are a very small part being used with industrial gauges (<1%)
- Whenever possible lower source activities are used by increasing detector sensitivity
- We follow ALARA (As Low As Reasonably Achievable)
- Known physical principles are improving its performance

For more details please contact:

ralf.matthaes@endress.com

Thank You for watching!