Setting the Standard for Automation™

ISA Delhi Section

Fertilizer Symposium - 1st December 2018

Advantages of Advanced Radiometric Measurement

ISA-D: "Fertiliser Symposium-2018"

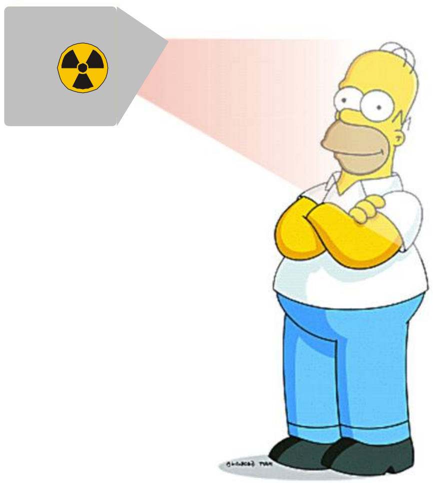
Radiometric Measurement Technology

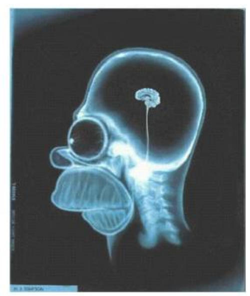
Why gamma measurement technology?

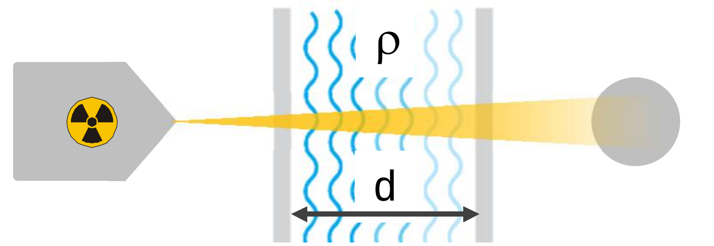
- Contactless, non-invasive
- For severe operating conditions
  - High temperature
  - High pressure
  - Foam formation
  - Corrosive media
  - Wall build-ups
- Long-term solution
  - Maintenance-free!
  - No recalibration

Measuring Principle – Radiometry

What is really behind it?





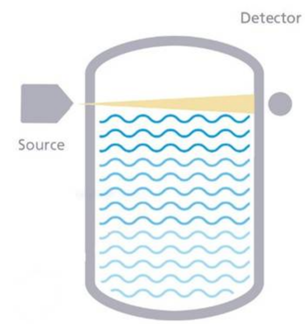


$$I = I_0 \cdot \exp(-\mu \cdot \rho \cdot D)$$

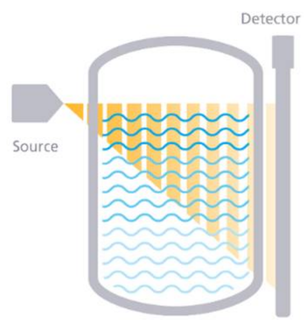
- Source: emits gamma radiation I_0
- Object: attenuation of radiation
- Detector: measures radiation intensity

Applications – measure where others fail

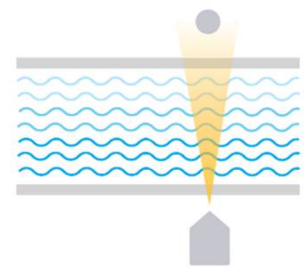
Radiometry is versatile!



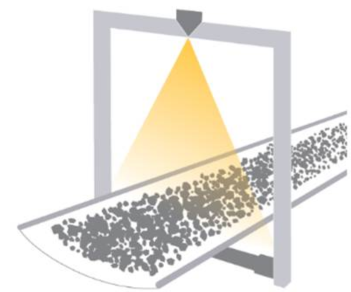
Limit Switch



Level



Density / Concentration



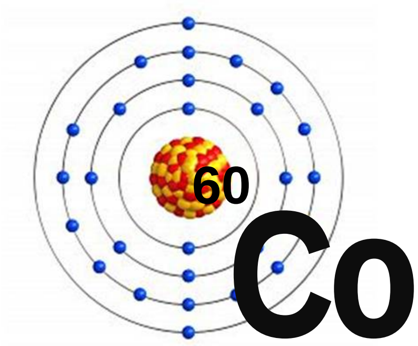
Bulk Flow

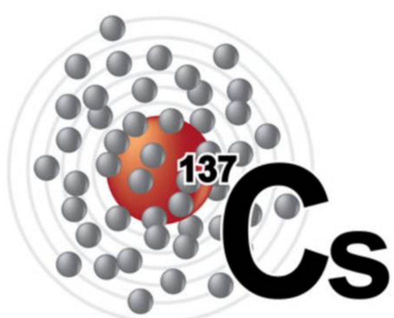
Furthermore:

- Interfaces
- Potassium content
- Moisture measurement (neutrons)
- and many more

Industrial Used Nuclear Isotopes

Cobalt – 60 or Cesium - 137





- There are many known natural and artificial isotopes
- However just a few are really used for measurement purposes.
- This is mainly Cobalt – 60 and Cesium – 137
- They vary from decay scheme, energy, intensity, half life time, etc
- Make the best selection for the measurement purpose
- Cobalt – 60 has some unique advantages in fertilizer production

Isotope Selection

Cobalt-60 or Cesium-137

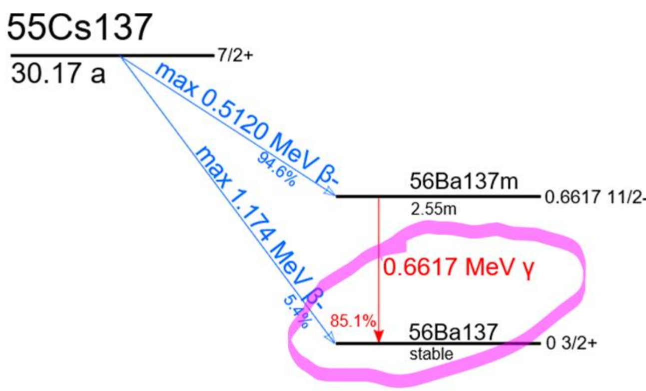
Isotope	Cs-137	Co-60
		
Energy	660 keV	1200 keV
Half-Life Time	30.18 years	5.27 years
Half Value Layer (steel)	16mm / 0.63in	21.6mm / 0.85in
Gamma efficiency per decay	0.85	2

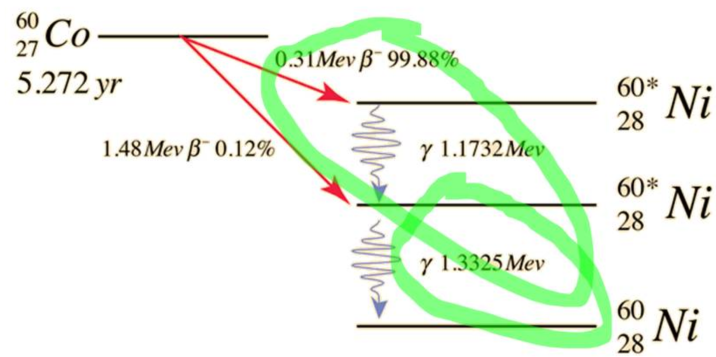
- Half-Life Time ≠ Source Life Time
- Recommended working life of sources (acc. ISO2919) is ~10-15 years and is incorporated by design, independent of isotope incorporated by design
- Depending on governmental requirements
- Real operating lifetime can be even longer

Cobalt-60 vs. Cesium-137

Decay Schemes

Isotope	Cs -137	Co-60
		
Energy	660 keV	1200 keV





$$I = I_0 * e^{-\mu * \rho * d}$$

$$\frac{I_0^{Co}}{I_0^{Cs}} = \frac{2.0}{0.85} = 2.35$$

- Cobalt is more efficient in emitting gamma radiation

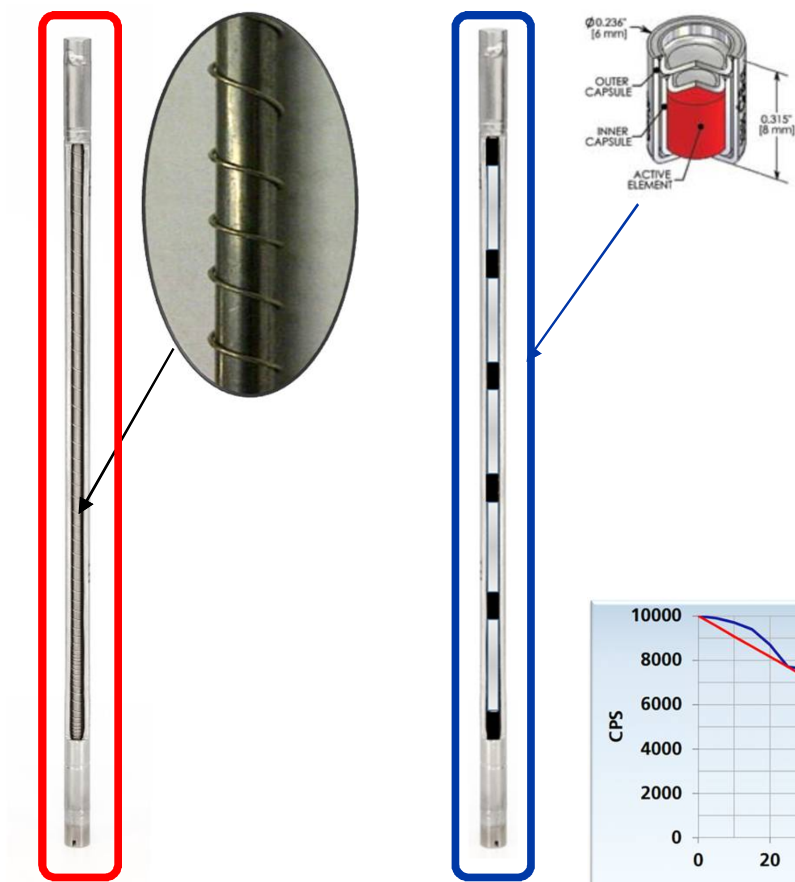
Advantages of Cobalt-60

What makes it isotope of choice for fertilizers?

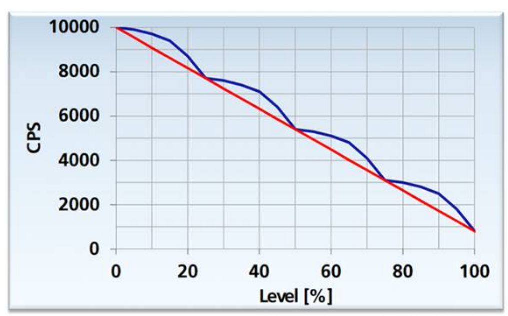
- Higher gamma efficiency (factor 2.35)m, more countrate per activity
- Higher energy
  - More resilient against gas property changes, especially at lower count rates
  - Better radiation through massive walls
- Cost efficient rod sources
  - Rod sources provide full linearity and highest accuracy

Advantages of Rod Sources

Why only Cobalt – 60 can make a real rod source!

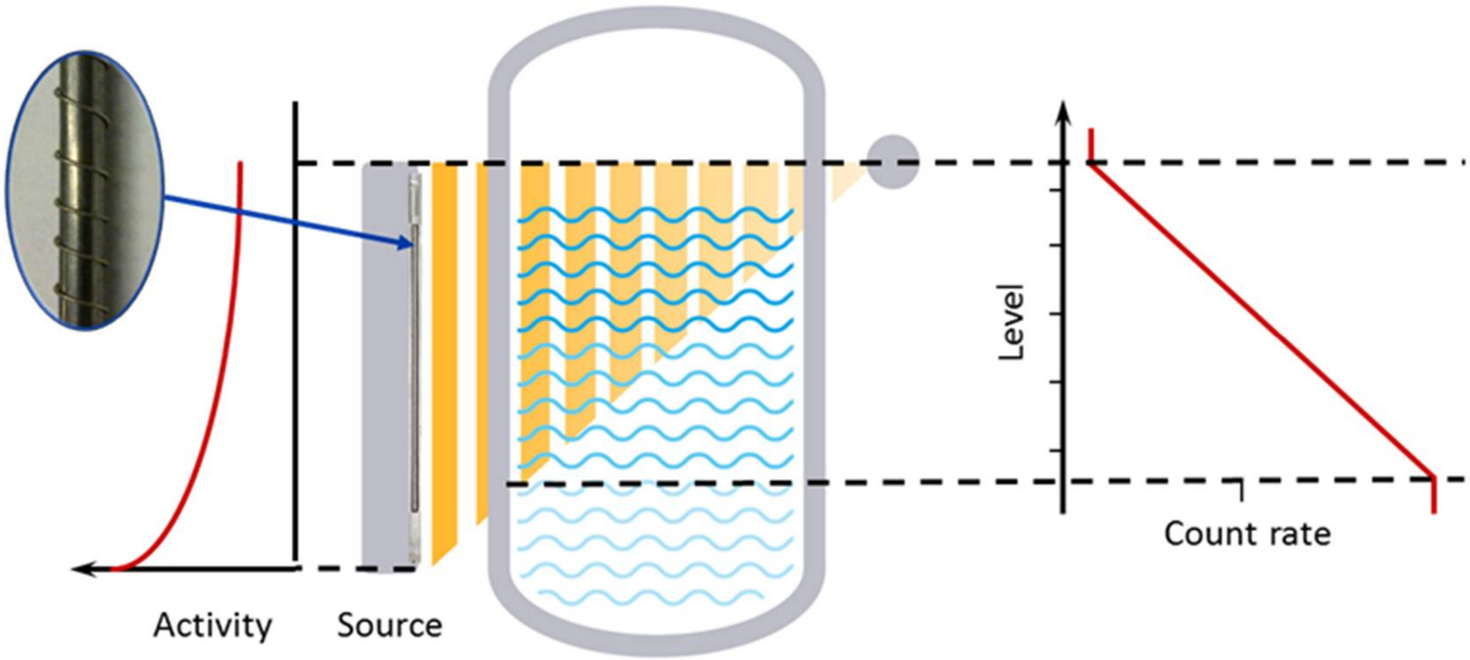


- With Co-60, activity is distributed over the complete source length
- Co-60 wire wound around a core
- By changing the pitch the activity distribution can be controlled
- Highest achievable accuracy and linearity
- Customer specific design
  Adapted to the individual geometry



Rod Sources

100 % Linearity for highest Accuracy



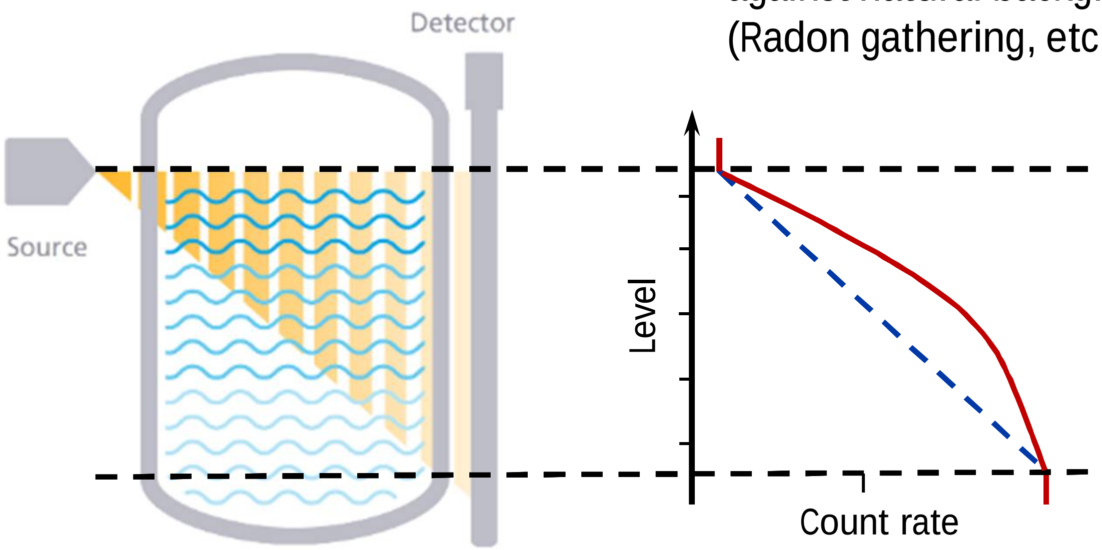
- With a custom specific activity distribution, we can an reach a linear measurement curve
- Point detector very tolerant against background variation yield to high accuracy in a level measurement

Level: Point Source / Rod Detector

„Industry Standard“

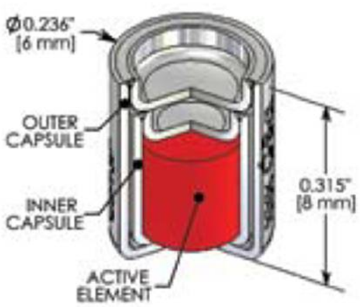
- Typically 2 point calibration at 0% and 100%
- Assumption: Linear Calibration (blue)
- Reality: Not-linear (red)

- Inherent systematically error
  - Lower accuracy
  - However measurement is reproduceable
- Rod detector being very vulnerable against natural background variation (Radon gathering, etc.)



Safety

Co-60 vs Cs-137



Cs-137

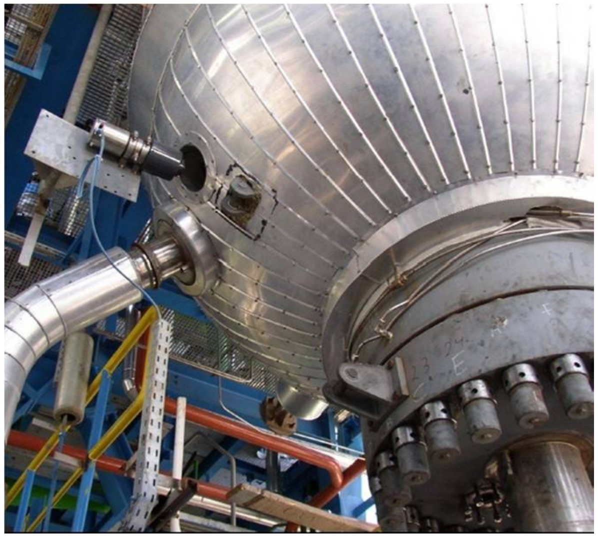
- Is a bound in a ceramic matrix. If this container breaks it can be distributed as powder in the atmosphere, e.g. in the event of fire
- After entering the body, caesium is more or less uniformly distributed throughout the body, with the highest concentrations in soft tissue.
- Cs-137 itself is very reactive and produces a water soluble compound

Co-60

- Co-60 is a metal, not water soluble and remains local when exposed to fire
- Molten Co-60 is forming alloys with the metal from the building structure
- Lower activity to dispose

Typical applications

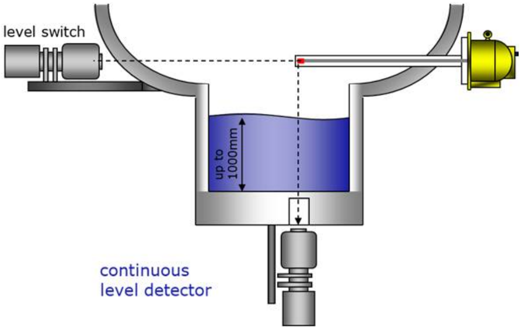
Stripper in Urea Production



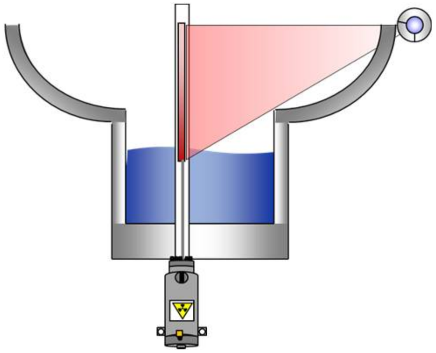
Challenges:

- Thick walls (> 50mm)
- High gas density – high absorption
- Frequent and regular variations of gas property
  → Gas density compensation needed
- High Accuracy required

Solution 1

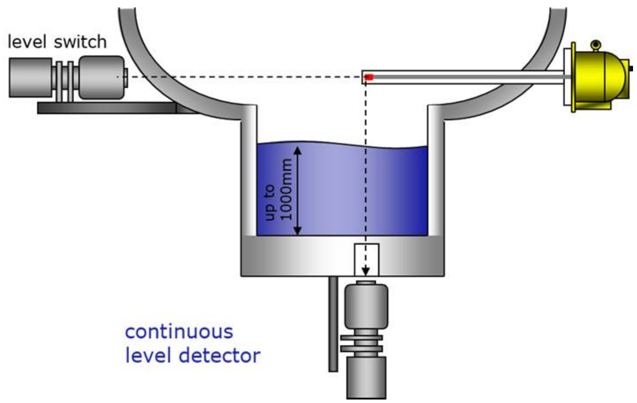


Solution 2



Stripper in Urea Production

Solution 1



Solution:

- Point Source – Point Detector
- Dip Pipe for source arrangement
- Local thinning of a detector window (blind hole)
- Gas density compensation algorithm

Benefits:

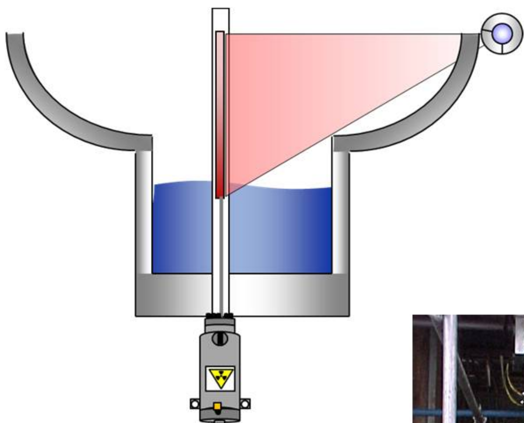
- Easy to calibrate
- Easy handling of source

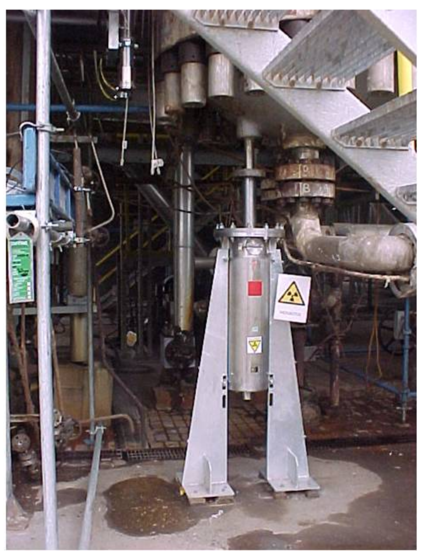
Limitation:

- Limited accuracy, due to non-linearity
- Blind hole thinning required

Stripper in Urea Production

Solution 2





Solution:

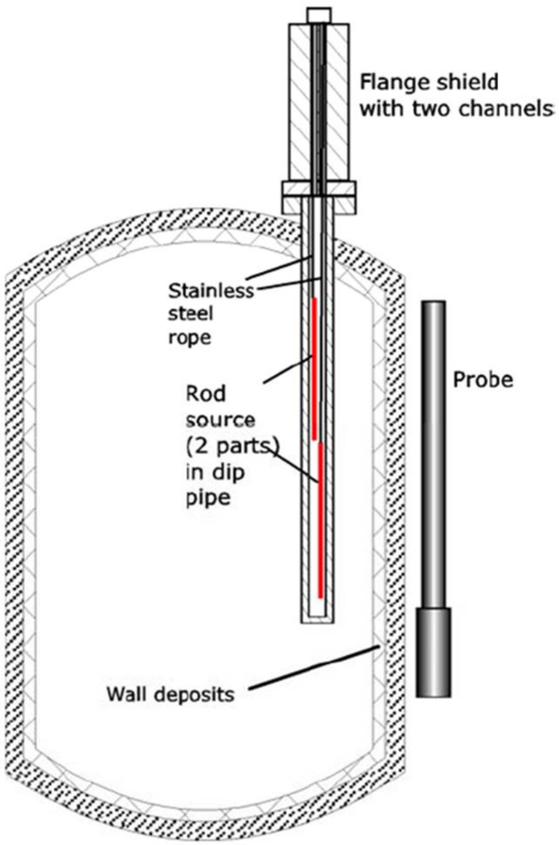
- Rod Source – Point Detector
- Dip Pipe for rod - source arrangement
- Gas density compensation algorithm
- Optimized activity distribution

Benefits:

- Easy to calibrate
- Rod source shield can cover the whole rod
  → no radiation exposure during maintenance
- 100% linearity
- Highest accuracy
- Reliable and repeatable

Typical applications

Continuous Reactor Level in Urea Production

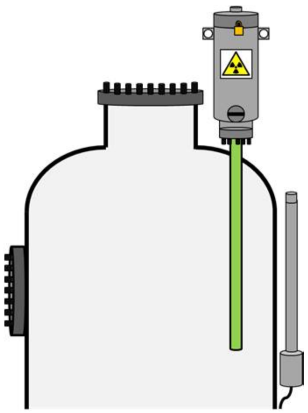


Challenges:

- Thick walls (> 50mm)
- High gas densityy – high absorption
- Frequent and regular variations of gas property
  → Gas density compensation needed
- High Accuracy required – linear measurement curve
- Source container to contain the complete rod source during maintanance

Continuous Reactor Level in Urea Production

Rod Source – Rod Detector



Solution:

- Rod source in dip line
- Rod detector outside
- High Accuracy required – linear measurement curve
- Source shield design to hold rod source and shield completely
- Optimized activity distribution

Benefits:

- Easy to calibrate
- Rod source shield can cover the whole rod
  → no radiation exposure during maintenance
- 100% linearity
- Highest accuracy, reliability and repeatablity

Compensation of gas property changes

What is causing the higher absorption?

Changing gas properties simulate level changes, that do not exist. Increasing gas density simulates increasing level

- Changes of gas density
- Change of hydrogen content

absorption coefficient

gas density

$$I = I_0 \cdot e^{-\mu \cdot \rho \cdot d}$$

attenuated count rate

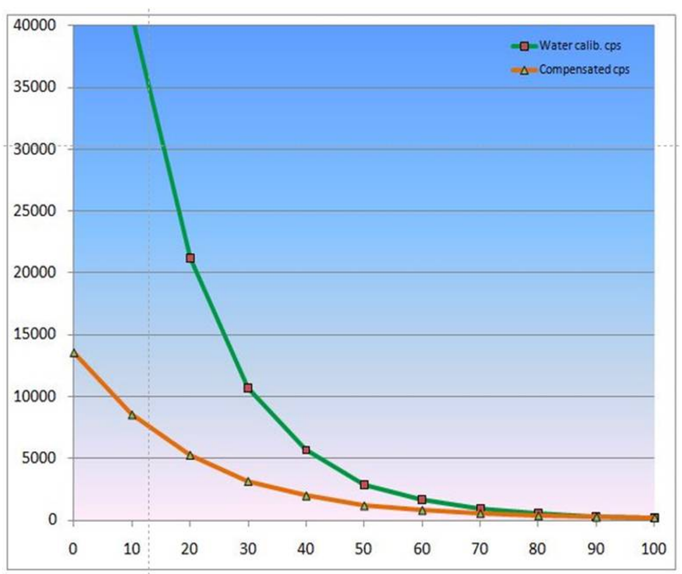
original count rate

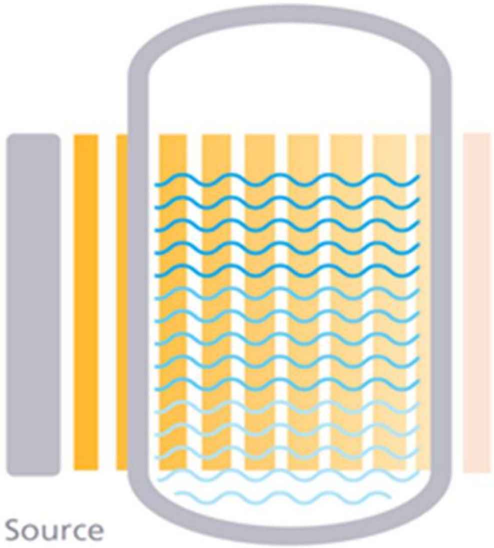
Compensation of gas property changes

How to compensate?

Here are two way to mitigate the influence of gas property changes

- If the changes are repeatable and stable, a "calculated" compensation can be factored in
- Real Measurement of gas density, with an additional detector





Any Questions?

Thanks for your attention!

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