Radiometric Level Measurement in DCU

Challenges, Solutions and Interpretation

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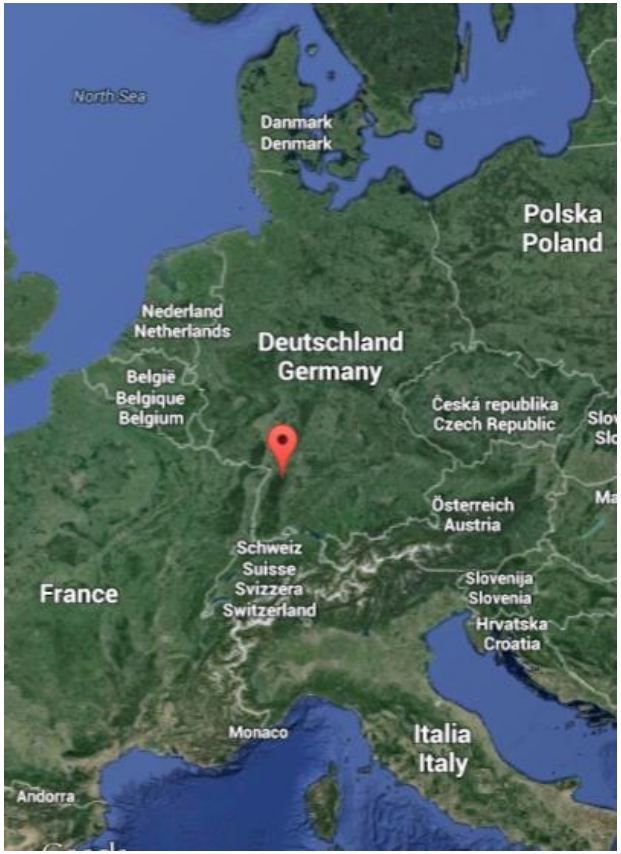
BERTHOLD TECHNOLOGIES
REFCOMM BUDAPEST 2-5 Oct 2017

Agenda

- Company introduction
- Introduction to radiometric measurements
- Level measurements in coke drums
  - Requirements
  - Arrangements
- Challenges and Solutions
  - Uneven coke distribution
  - Scalings
  - Gas properties changes
  - Interference radiation

Who we are

- Located in Bad Wildbad, South West Germany
- Family owned company
- 350 employees worldwide
- Sales ~70 Million Euro per year
- Specialized in radiometric process measurements since 1949
- >20,000 nuclear gauges in operation
- Own source production



Who we are

- Subsidaries in all major markets
  (e.g. USA, China, UK, France, Italy, Austria, India…)
- Partner companies all over the world
  (e.g. South East Europe, Latin America, South East Asia, Russia, Australia, Africa…)

Nuclear Measurements

Why Gamma?

- Non-contacting, non intrusive measurement
- Extreme measurement conditions!
  - High temperatures
  - High pressures
  - Excessive foaming
  - Acid, caustic media
  - Wall build-ups, scaling
- Long-term solution
  - Virtually maintenance-free
  - Typically no re-calibrations

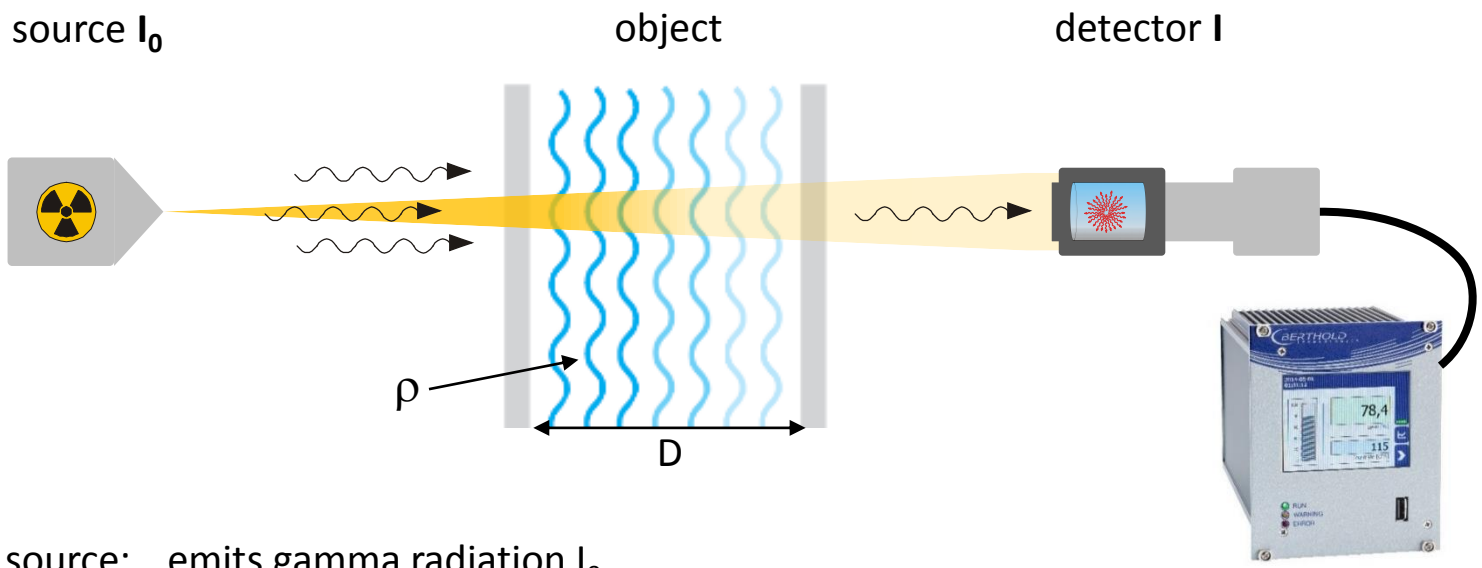
Typical Fields of Applications

Some Nuclear Applications in Refineries

- Desalter
  multiphase level measurements
- Distillation Columns
  level measurement
- Coke Drum
  level measurement
- Fluid Catalytic Cracking (FCC)
  level and density measurements
- Hydrocracker
  multiphase level measurements
- Catalytic Reforming (CCR)
  level measurements
- Sulfur Removal Technology
  level measurements

Basic Principle

Nuclear Measurements



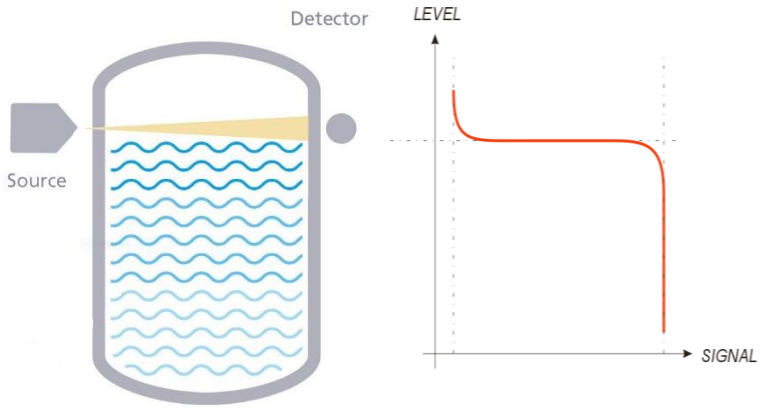
- source: emits gamma radiation I_0
- object: radiation is attenuated
- detector: measures transmitted intensity I

"constant" density distance

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

Nuclear Level Measurements

Level Switch / Point Level

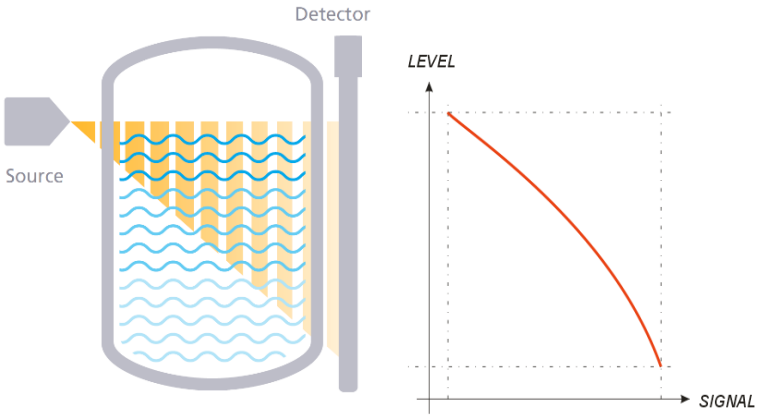


- For Min / Max alarm detection
- Narrow radiation beam
- Point detector
- Point beam

- Typically only relay output
- Very sharp transition

Nuclear Level Measurements

Continuous Level



- Continuous signal (0…100%)
- Wide radiation beam
- Rod shaped detector + fan beam … or…

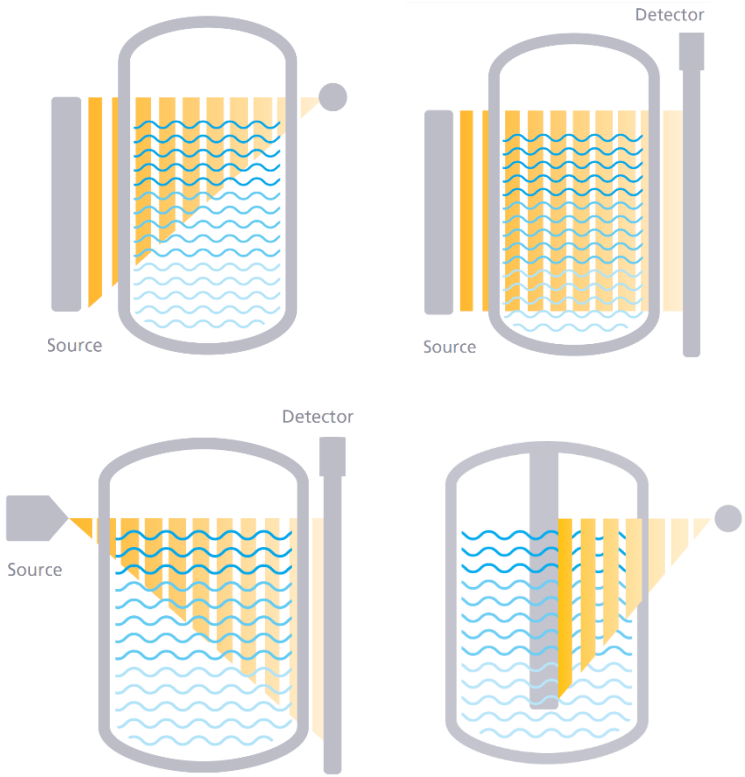
Nuclear Level Measurements

Different Ways of Forming a Radiation Field

Detector + Source = Multiple Combinations

- Point detector
- Rod detector

- Cs-137 or Co-60
- Point Source
- Rod Source



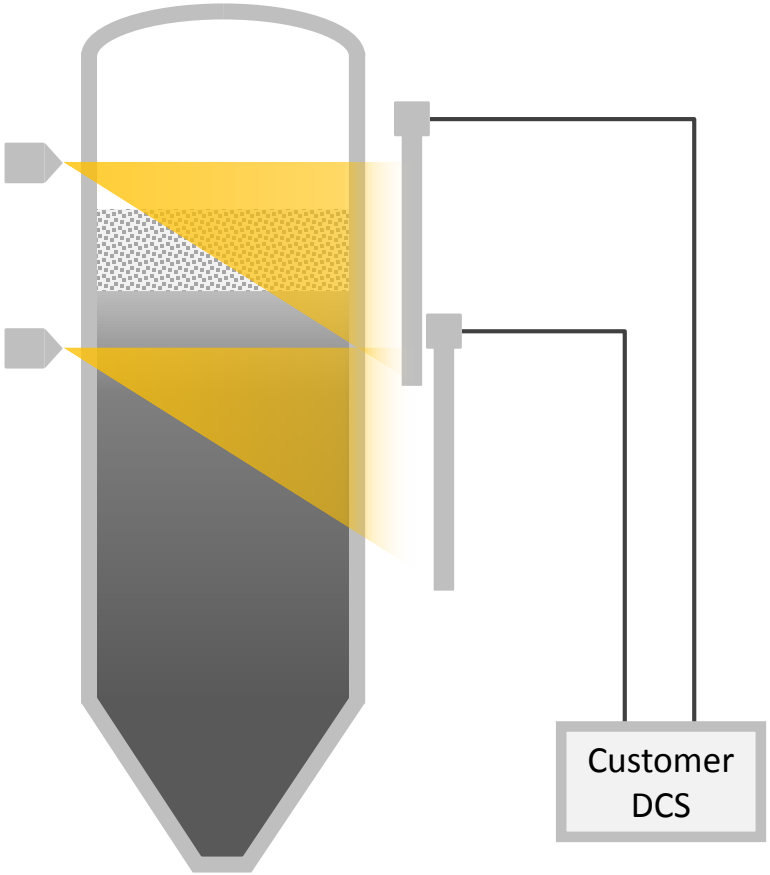
Why to measure level in a coke drum?

- **Timing** is essential
  - A typical coking cycle takes several (e.g. 16) hours
  - While one of the two cokers is in filling process , the second must be steamed, quenched, drained, preheated,….
  - There is small safety reservoir only!
- **Anti-foam** is not only costly, overdosing reduces coke quality and can polute the subsequent products and processes
- **Foam spillover** will cause coking and tremendous problems and costs in the overhead vapor lines

Arrangements

Individual Level Measurements – combined in DCS

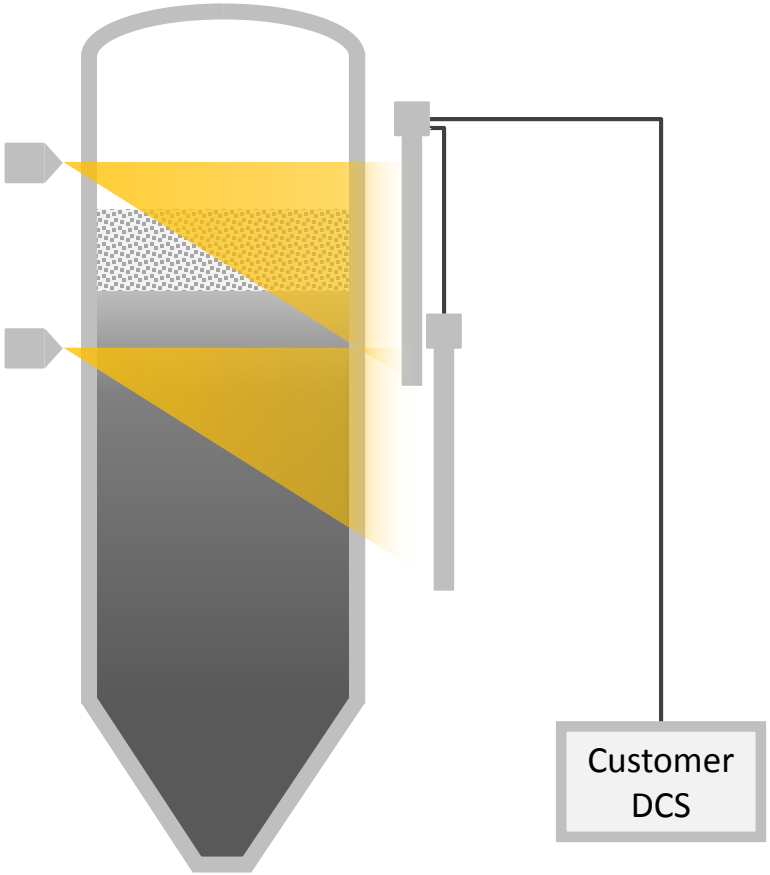
- Advantages:
  - Best linearity / accuracy
  - Spatial resolution to detect wall build-ups
  - Detector failure affects only part of the span
- Disadvantages:
  - Highest cost for devices
  - Most cabling needed (adds cost)
  - Programming of DCS required to calculate overall level
  - Responsibility in customer's hand



Arrangements

„Cascaded“ – Detectors interconnected and combined level calculated

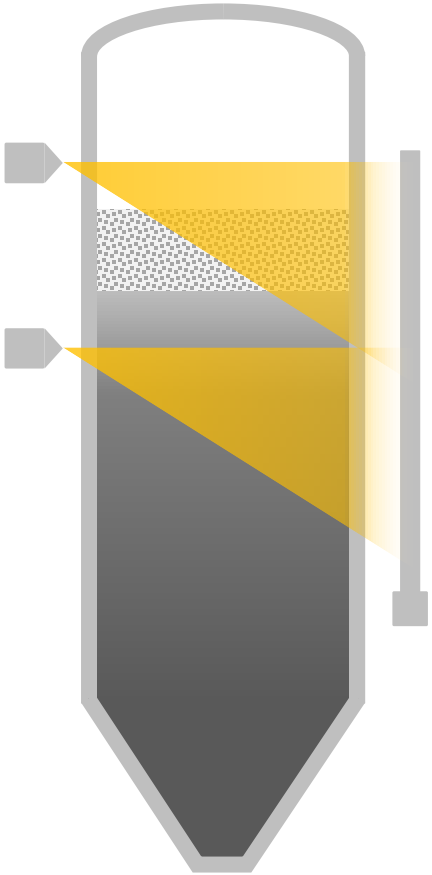
- Advantages:
  - Best linearity / accuracy
  - One combined level to DCS
  - Less cabling effort than individual detectors
- Disadvantages:
  - Highest cost of devices
- Important aspects:
  - Instruments must be able to deal with high count rates
  - Instruments should detect failures in each detector and report it to the master
  - Self-diagnosis of all detectors should be accessible through the master detector



Arrangement

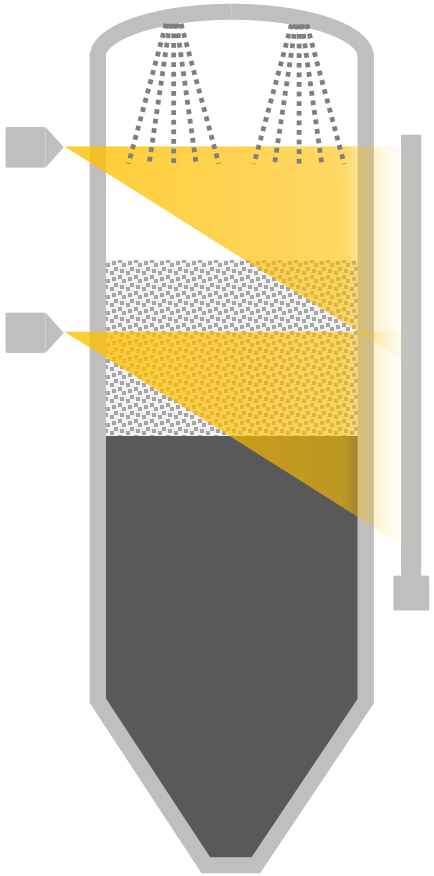
TowerSENS – One detector does it all

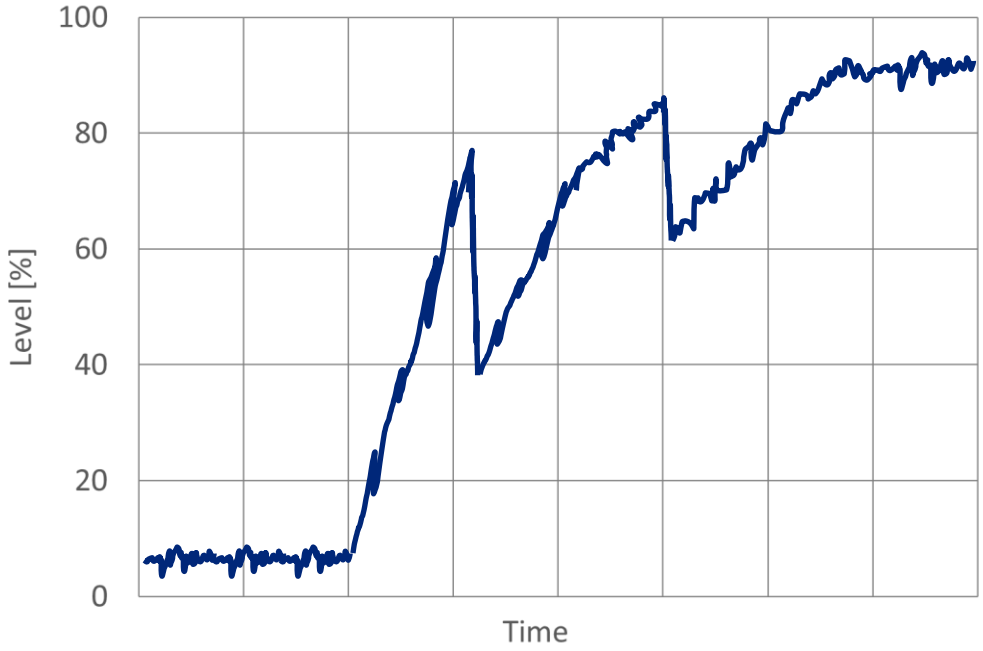
- Advantages:
  - Up to 8m with one electronics
  - Lowest cost (device and cabling effort)
  - Covers up to 32m in master/slave arrangement
- Disadvantages:
  - Reduced linearity (accuracy) of measurement
- Important aspects:
  - Temperature stability of devices of greater importance



Installation Example at CNOOC Huizhou, China

The Filling Process

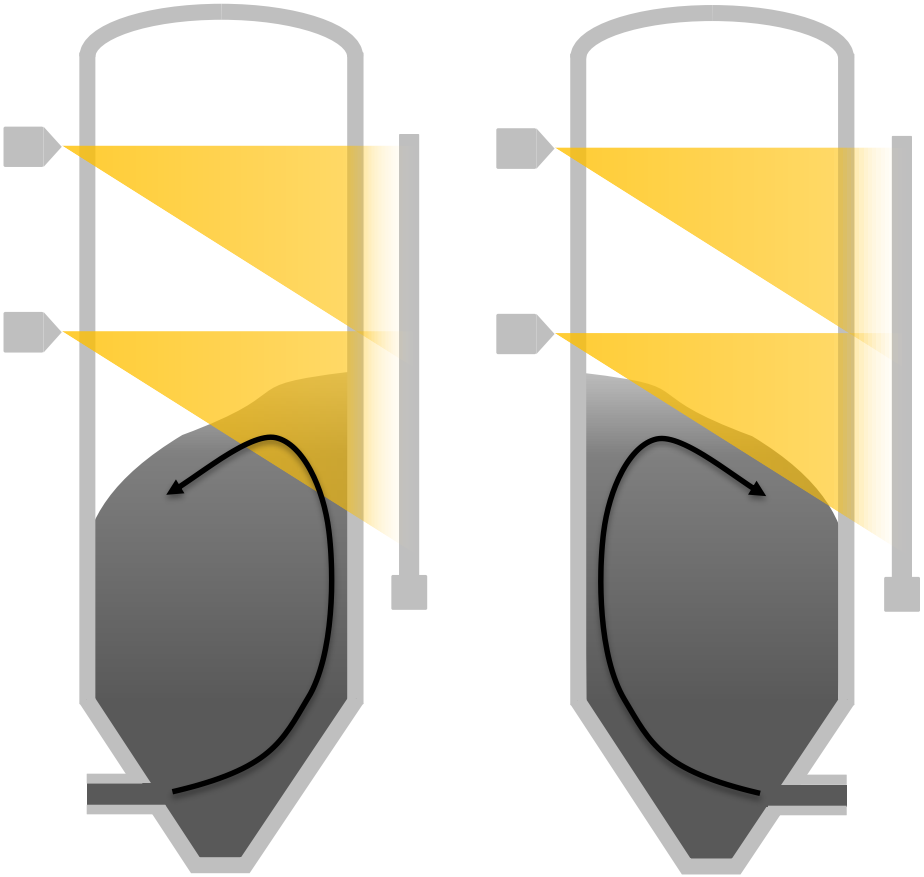




Effects during the filling process

- Sensitive region for level measurement is a „2D-triangle“
- Uneven distribution of coke during the filling process will be indicated differently

- To avoid:
  Optimize arrangement, e.g. perpendicular to filling valve



Level indication before filling?

How that can happen!

Instrumentation faulty?

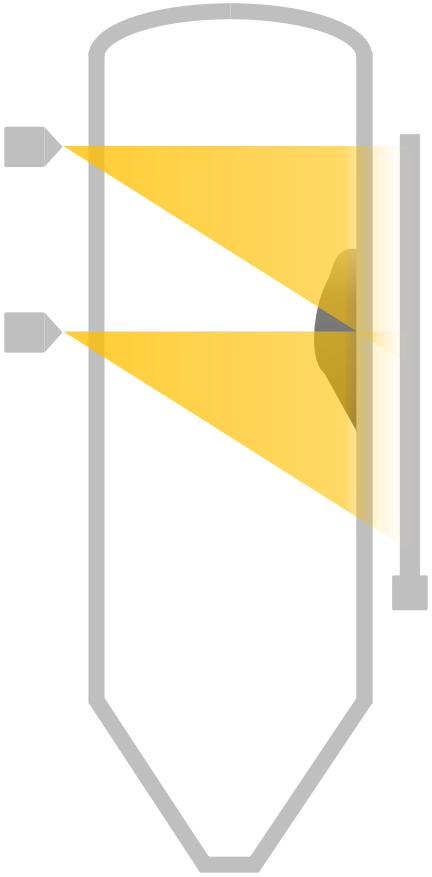
- Temperature affects detector reading if not stablilized
- Internal stabilization failed or faulty
- Self-diagnostics feature should report this

Process related?

- Chunks / Build-up after emptying of coke drum
- No spatial resolution!
- Drum pressurized and calibration without pressure?

If it happens repeatedly…

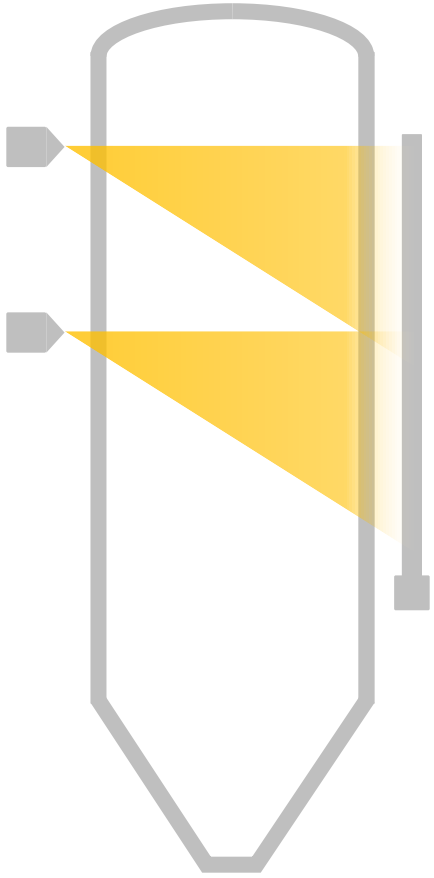
- Recalibrate („empty adjust“)
- Improve process or check instrumentation



Calibration

Easiest calibration procedure

- Usually simple two-point calibration is performed at atmospheric pressure
- First step
  - Empty vessel
  - Source shields open
- Second step
  - Empty vessel
  - Source shields closed
- To measure outage compare with measurement after quench!



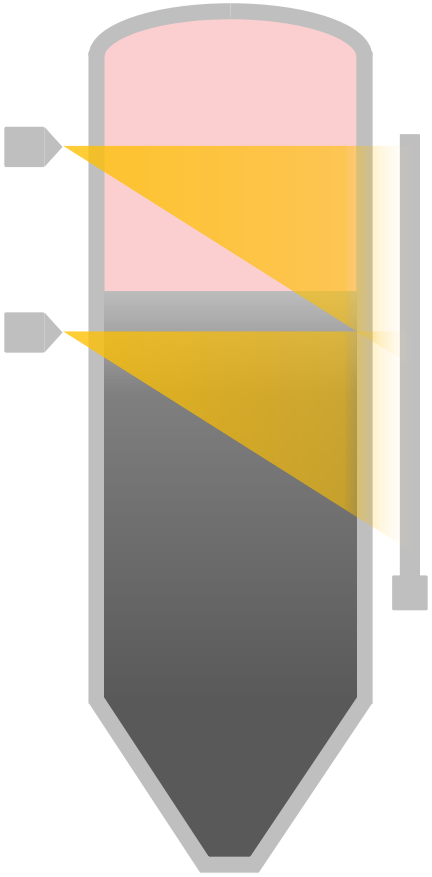
During operation

Effects of pressurized drum

- Coke rises
- Also gas pressure – hence gas density – rises

- Level indication before filling starts
- Level indication is higher than actual coke level
- Can be observed when measuring outage (Coke level measured after draining compared to indication during process)

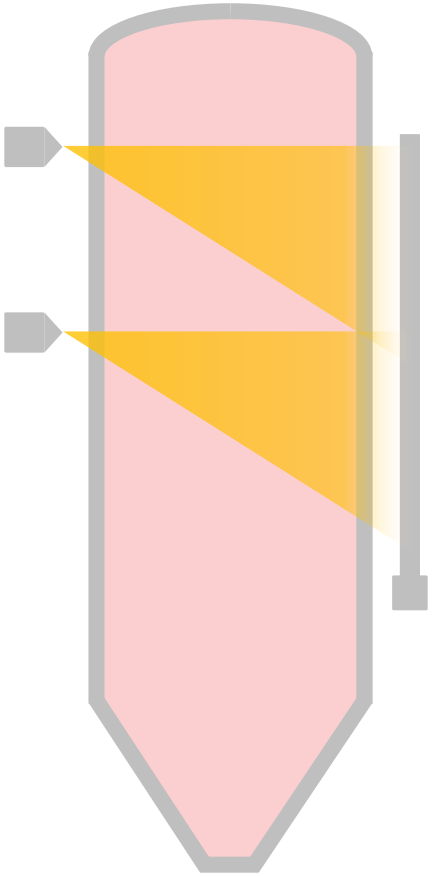
- Effect more severe for Cs-137 than for Co-60



Improved Calibration

Calibrate under process conditions

- Pressurize drum! – Operating conditions
- First step
  - Empty vessel
  - Source shields open
- Second step
  - Empty vessel
  - Source shields closed
- To measure outage compare with measurement before quench!

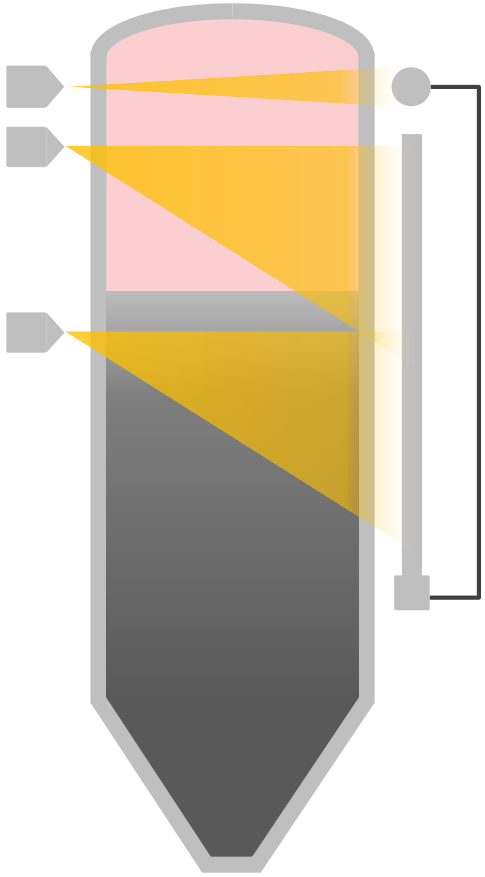


Gas Properties Compensation „GPC“

Compensate the gas pressure

- Gas properties change during the process
- High gas pressure / density results in absorption
- Displayed level is higher than real

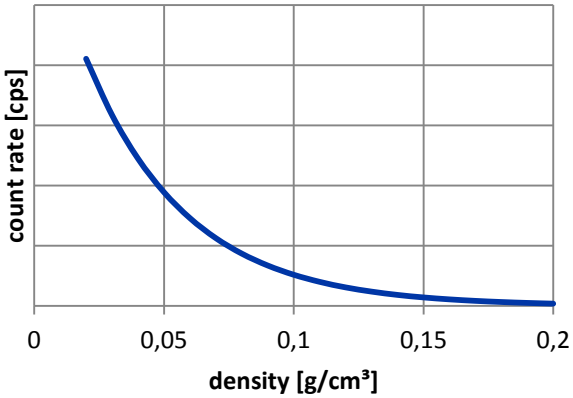
- The solution:
  - Measuring the gas phase by using the high level switch
  - Input gas phase to the level detector
  - Correction takes place in the level detector
  - Level is recalculated according to gas conditions during measurement



Co-60 versus Cs-137

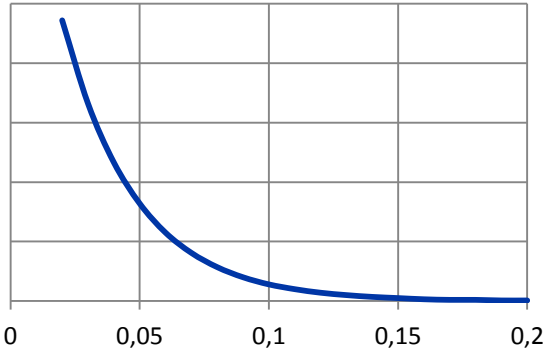
Make your guess first

- Co-60 has a higher energy (1200 keV) compared to Cs-137 (660 keV).
- The higher energy of Co-60 is less attenuated so



Co-60

- But anyway none is capable of a foam density measurement



Cs-137

Comparison Cs-137 vs. Co-60

	Co-60	Cs-137
Energy	1.2 MeV	660 keV
Half-life time	5.3 years	30 years
Recommended working life	15 years	15 years
Effect of scalings	Lower	Higher
Effect of gas properties changes	Lower	Higher
Required activitiy	Lower (typically 100 - 500 mCi)	Higher (typically 500 - 2000 mCi)

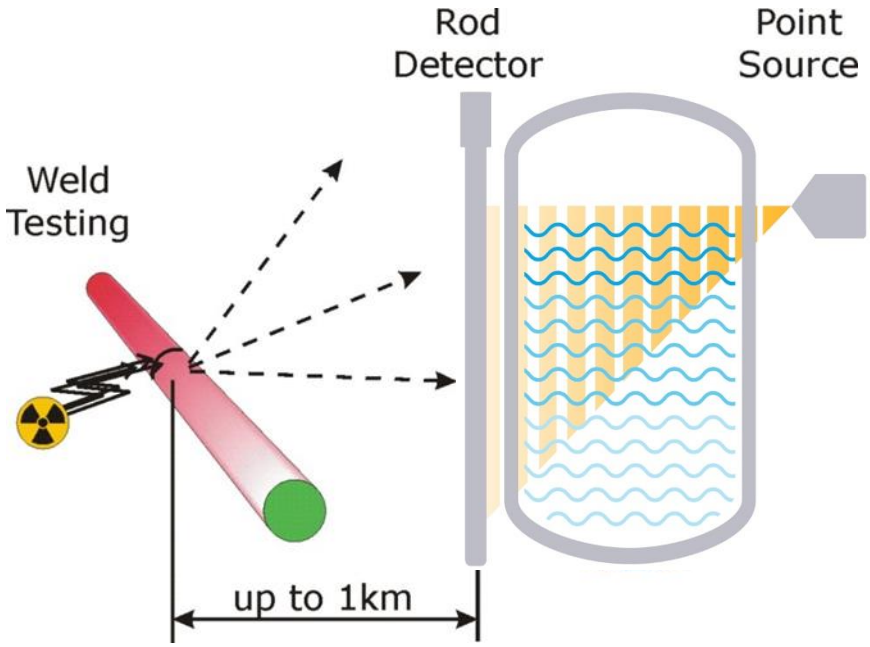
How to avoid problems with nuclear measurements

Interfering radiation?

- Non-destructive testing (NDT) may cause unwanted effects

- Use of high activity sources (3-80 Ci) mostly Ir-192
- Wrong measurement due to excess count rate
- Too low level will be displayed

- But: Berthold will recover from interference automatically

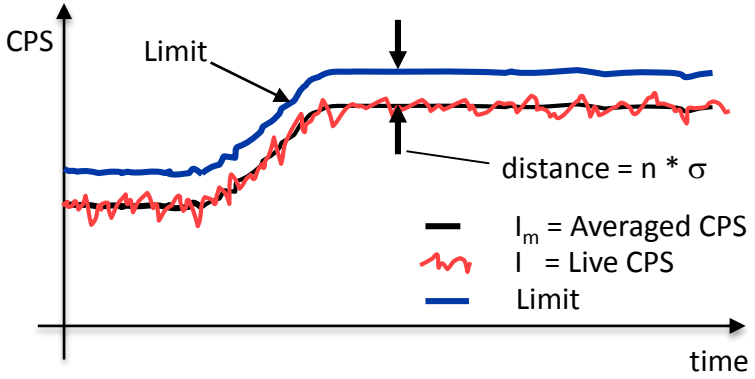


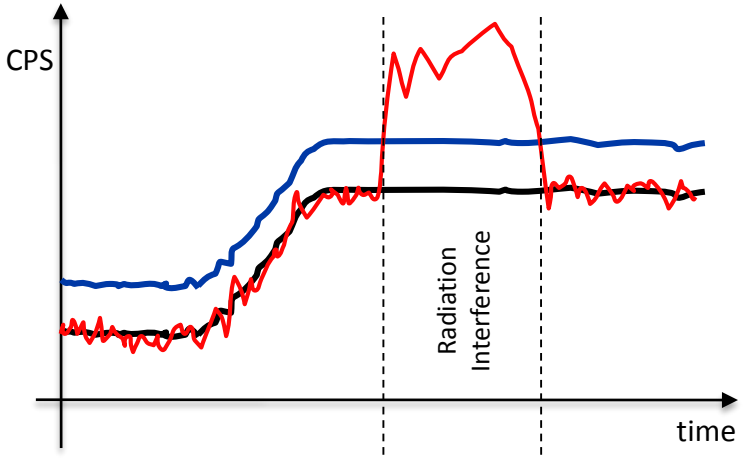
How to avoid problems with nuclear measurements

Interfering radiation? – X-ray Interference Protection (XIP)!

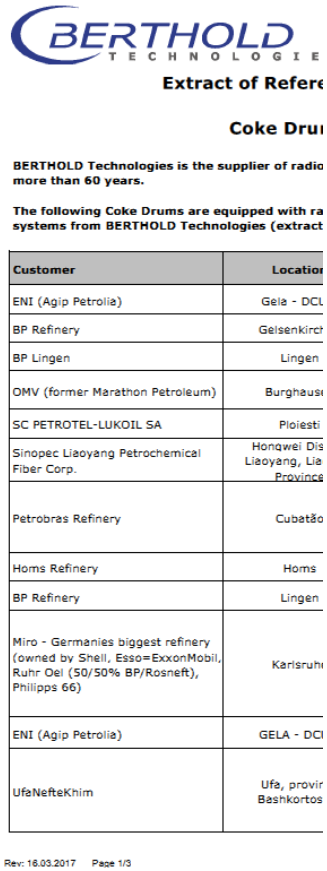
- Berthold detectors do not get destroyed from excessive radiation!
- „Freeze“ the process value, when rapid and large changes are detected:
  - $I > 1.5 * I_0$
  - $I > I_m + n * \sigma(I)$, $(n > 8)$
- Standard feature that can (and must) be activated
- No additional detector required!

- Do not confuse it with our LB 440-RID!
  - Here the measurement is continued with a lower sensitivity during NDT. Only available for LB 440 with Co-60.





References



BERTHOLD TECHNOLOGIE

Extract of Refere

Coke Dru

BERTHOLD Technologies is the supplier of radio more than 60 years.

The following Coke Drums are equipped with ra systems from BERTHOLD Technologies (extract

Customer	Location
ENI (Agip Petrolia)	Gela - DCU
BP Refinery	Gelsenkirch
BP Lingen	Lingen
OMV (former Marathon Petroleum)	Burghaus
SC PETROTEL-LUKOIL SA	Ploiesti
Sinopec Liaoyang Petrochemical Fiber Corp.	Hongwei Dis Liaoyang, Lia Province
Petrobras Refinery	Cubatão
Homs Refinery	Homs
BP Refinery	Lingen
Miro - Germanies biggest refinery (owned by Shell, Esso=ExxonMobil, Ruhr Oel (50/50% BP/Rosneft), Philipps 66)	Karlsruh
ENI (Agip Petrolia)	GELA - DCI
UfaNefteKhim	Ufa, provir Bashkortos

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BERTHOLD TECHNOLOGIE

Extract of Referei

Coke Drum

BERTHOLD Technologies is the supplier of radion more than 60 years.

The following Coke Drums are equipped with rad systems from BERTHOLD Technologies (extract):

Customer	Location
Sinopec Tianjin Petrochemical Fiber Corp.	Dagang, Tianj 300271, PR
Pertamina	Dumai
Petrochina Urumuqi branch Co	Urumqi
Novoufimsk "Novoil" Refinery	Novoufimsk
Sinopec Tianjin Petrochemical Fiber Corp.	Tianjin, PR
BP Refinery	Gelsenkirche
CNOOC Huizhou China National Offshore Oil Company	Huizhou, Guang
Henrique Lage Refinery	São José dos Ca
Essar Oil Refinery, Jamnagar Refinery - DCU1 - 2010	Vadinar, Jamna Gujarat
SC ROMPETROL RAFINARE SA	Constanta
Essar Oil Refinery, Jamnagar Refinery - DCU2 - 2012	Vadinar, Jamna Gujarat
Petron Refinery - Master Plan Phase 2	Limay, Bataa

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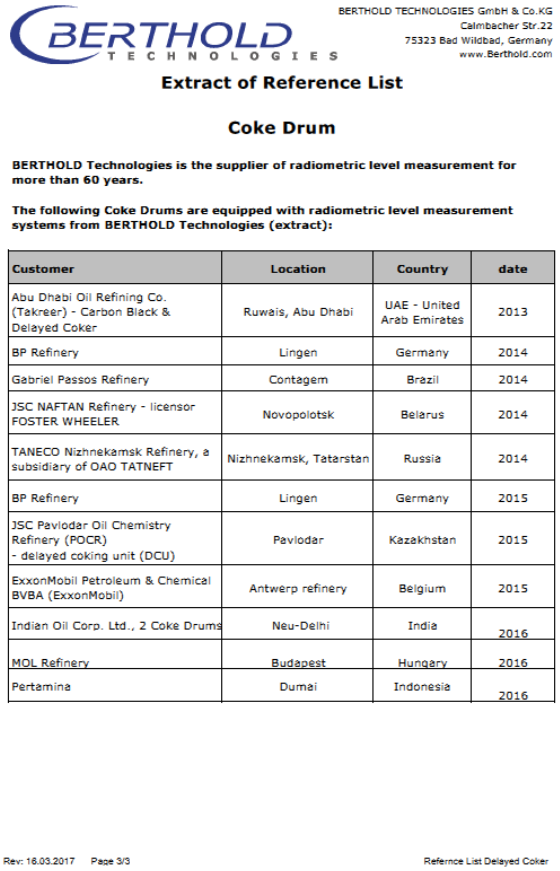

BERTHOLD TECHNOLOGIES

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75323 Bad Wildbad, Germany
www.Berthold.com

Extract of Reference List

Coke Drum

BERTHOLD Technologies is the supplier of radiometric level measurement for more than 60 years.

The following Coke Drums are equipped with radiometric level measurement systems from BERTHOLD Technologies (extract):

Customer	Location	Country	date
Abu Dhabi Oil Refining Co. (Takreer) - Carbon Black & Delayed Coker	Ruwais, Abu Dhabi	UAE - United Arab Emirates	2013
BP Refinery	Lingen	Germany	2014
Gabriel Passos Refinery	Contagem	Brazil	2014
JSC NAFTAN Refinery - licensor FOSTER WHEELER	Novopolotsk	Belarus	2014
TANECO Nizhnekamsk Refinery, a subsidiary of OAO TATNEFT	Nizhnekamsk, Tatarstan	Russia	2014
BP Refinery	Lingen	Germany	2015
JSC Pavlodar Oil Chemistry Refinery (POCR) - delayed coking unit (DCU)	Pavlodar	Kazakhstan	2015
ExxonMobil Petroleum & Chemical BVBA (ExxonMobil)	Antwerp refinery	Belgium	2015
Indian Oil Corp. Ltd., 2 Coke Drums	Neu-Delhi	India	2016
MOL Refinery	Budapest	Hungary	2016
Pertamina	Dumai	Indonesia	2016

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Thanks for your attention!

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