Level Measurement in DCU and FCC Fractionators

Challenges and Solutions

Author: Dr. Jan Sielk | 2017-5-11

Agenda

- Company Introduction
- Level Measurement in FCC and DCU fractionators
- Known challenges and limitations with conventional measurements
- Nuclear Level Measurements
- Engineering Phase
- Challenges and Solutions for Nuclear Measurements
- Some words on Nuclear Safety

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

Berthold Technologies

- The Berthold premises comprise 5 major buildings including modern production facilities for detectors, electronics and…
- Own production facility for radiation sources and shielding containers

Berthold Technologies

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

Berthold Technologies USA

- In Oak Ridge, TN
- 20 employees
- Project Engineering and local service support
- Licensing and transportation

Active Areas

Refineries
e.g. Shell, Exxon Mobil, Total, BP, ENI, Chevron, Essar Oil, Rosneft, PEMEX, Petrobras

(Petro)Chemical
e.g. BASF, DSM, Sabic, Eastman, INEOS, Dow Chemical

Steel industry – continuous casting
e.g. Arcelor Mittal, POSCO, Thyssen Krupp…

Mining and Alumina
e.g. BHP Billiton, Rio Tinto, VALE, Anglo American, Peabody…

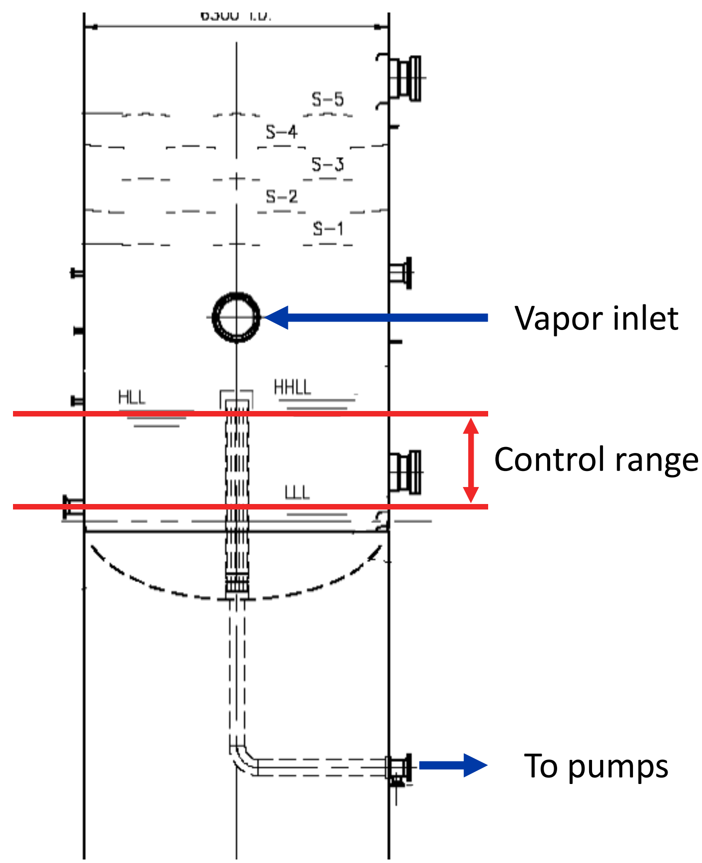
And many others: ***Oil offshore, Coal gasification, Power plants, Pulp & Paper, Cement, Sugar mills, Glass production, Wastewater etc.***

Level Measurement in FCC and DCU Fractionators

Determine Level in Bottom of Fractionator

- Have sufficient control range between the two limits to maintain stable control.
- Protect bottom pumps (meet NPSH requirements)
- Keep liquid from backing into the vapor inlet line.
- Increase throughput

- Control range is the only buffer for process delays, e.g. in delayed coking when switching from one coke drum to the other.



Known Challenges and Limitations

with conventional level measurements

- Scaling / Build-up when unintentional coking occurs in fractionator
- Foaming
- Turbulences on surface due to vapor inlet
- „Rain“ and splashes from sprinklers and first tray
- Different densities of VRC and condensates
- Speed of measurement

- Mostly DP measurements

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

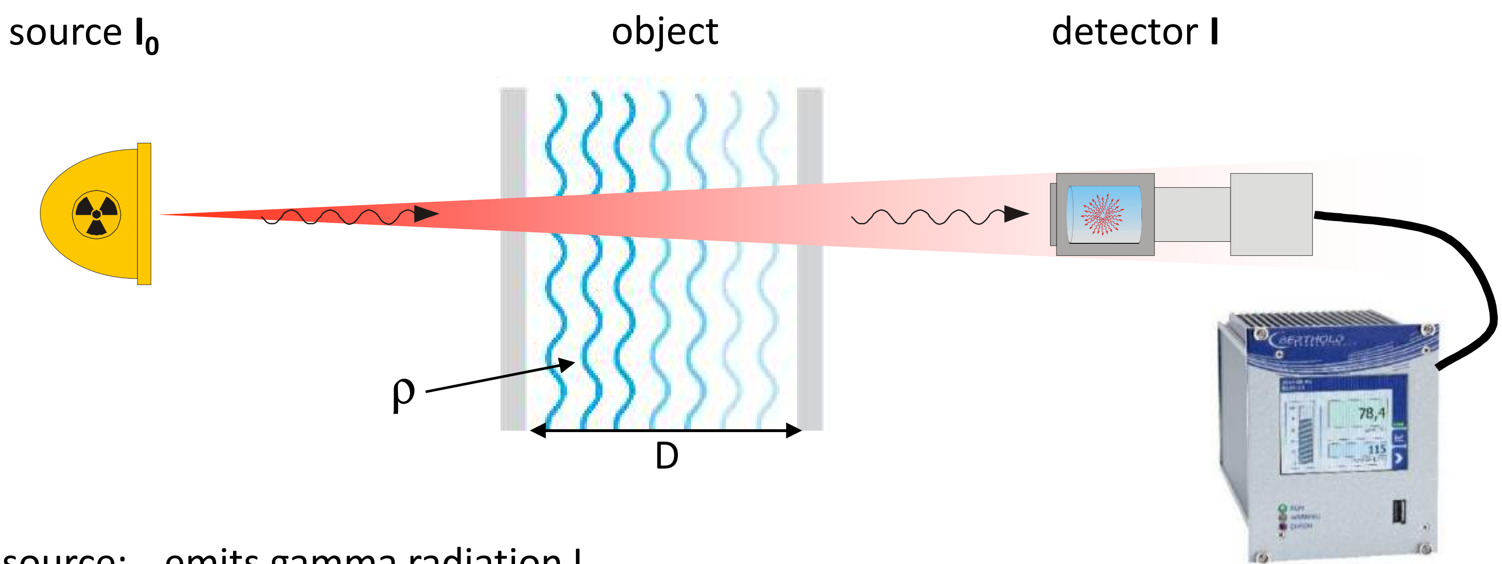
Typical Fields of Applications

Some Nuclear Applications in Refineries

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

Basic Principle

Nuclear Measurements



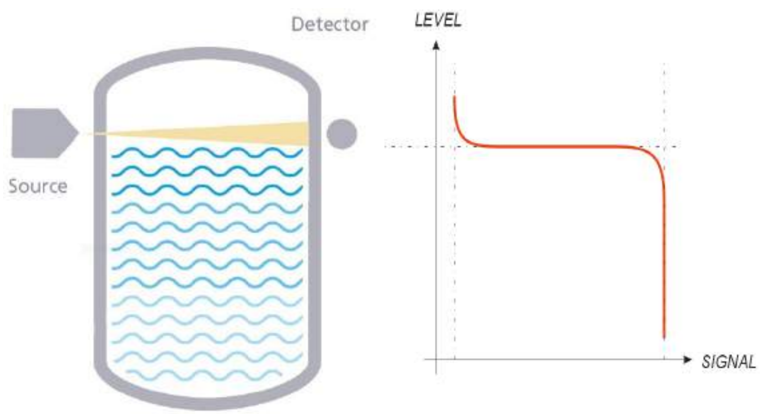
- source: emits gamma radiation I_0
- object: radiation is attenuated
- detector: measures transmitted intensity I

"constant" *density* *distance*

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

Nuclear Level Measurements

Level Switch / Point Level

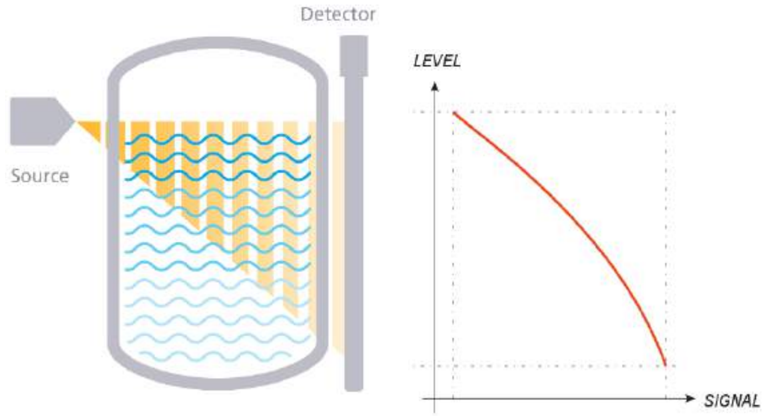


- For Min / Max alarm detection
- Narrow radiation beam
- Point detector
- Point beam

- Typically only relay output
- Very sharp transition

Nuclear Level Measurements

Continuous Level



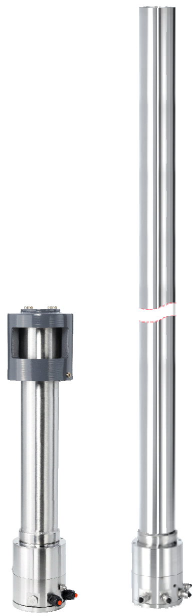
- Continuous signal (0…100%)
- Wide radiation beam
- Rod shaped detector + fan beam … or…

Nuclear Level Measurements

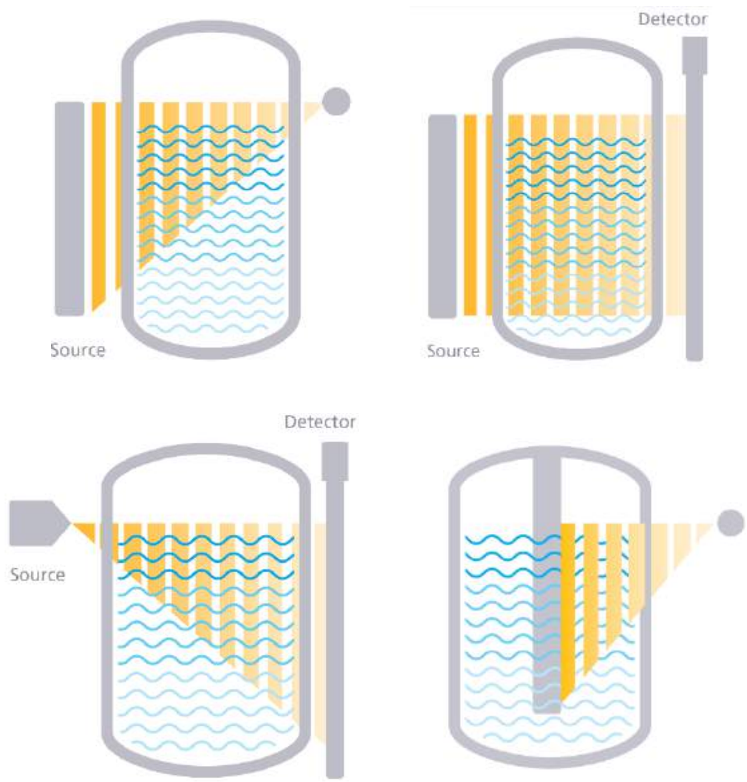
Different Ways of Forming a Radiation Field

Detector + Source = Multiple Combinations

- Point detector
- Rod detector



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

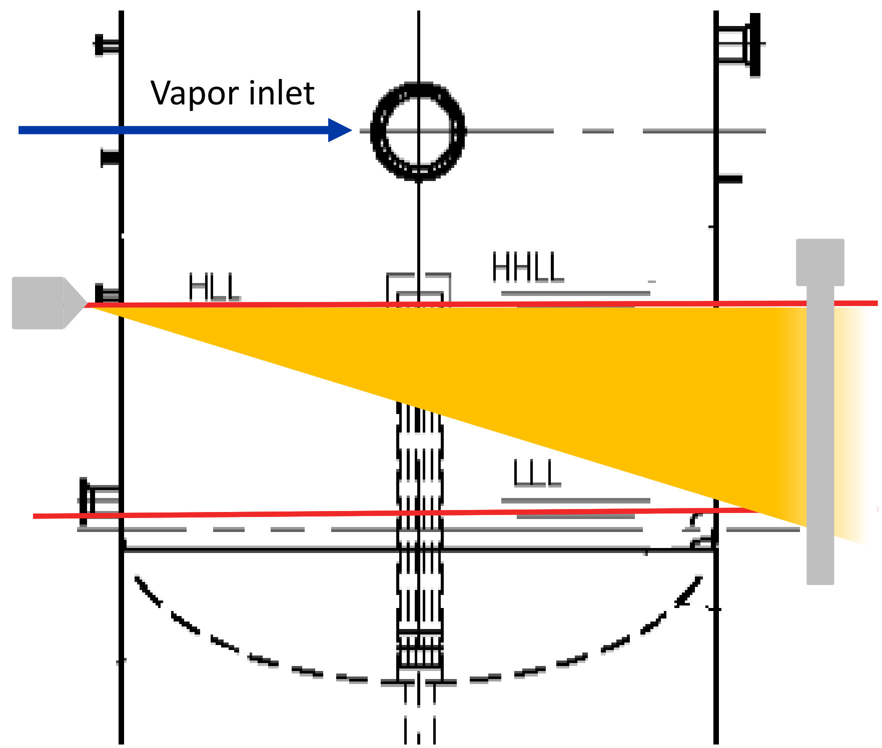


Level Measurement in FCC and DCU Fractionators

How do we solve it?

Most commonly:

- Cs-137 Point Source
- Rod detector
- Approx. 2 meters or less measuring range

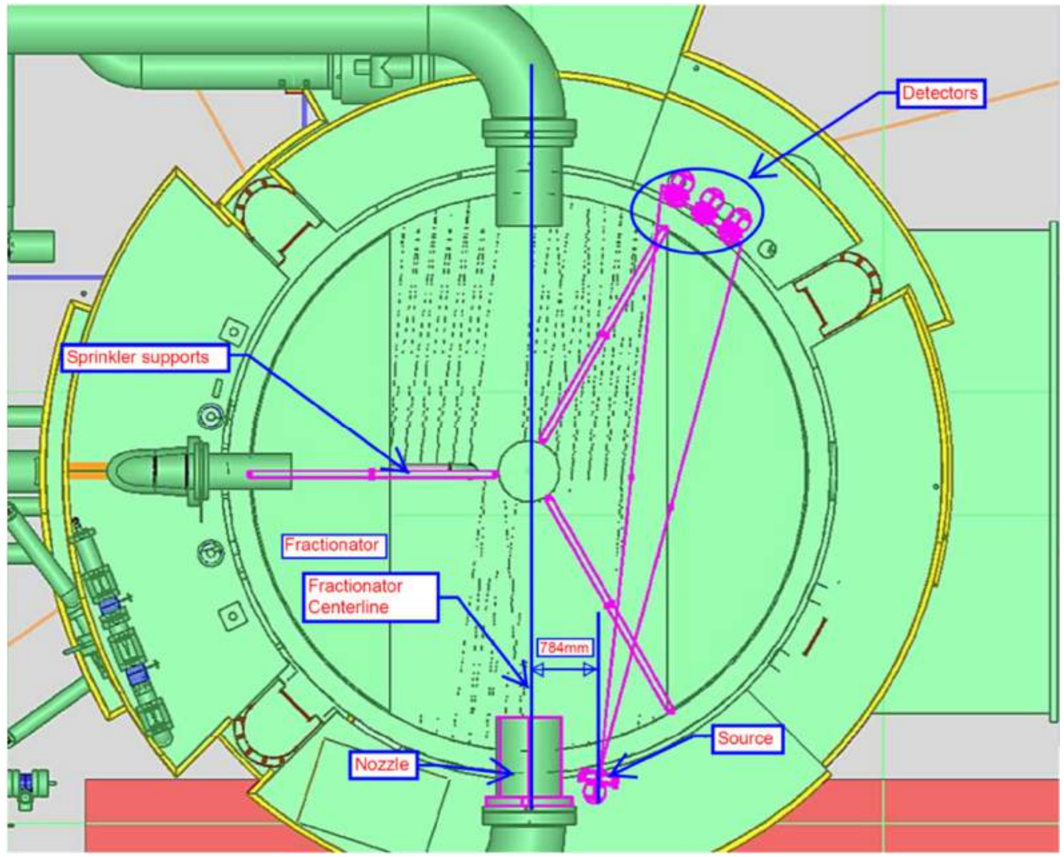


Engineering Phase

What to take care of prior to installation?

- Avoid hitting supports
- Off-center! There are obstacles in the way
- This example:
  Triple redundancy!

  1 source – 3 detectors



Redundancy

Increase your uptime!

- Redundant measurements
- Increased process reliability
- If one fails – measurement continues with other system
- SIL 3 usually requires two independent measurement principles
- Berthold detectors:
  SIL 3 in homogeneous redundancy
  (both nuclear!)

Engineering Phase

What to take care of prior to installation?

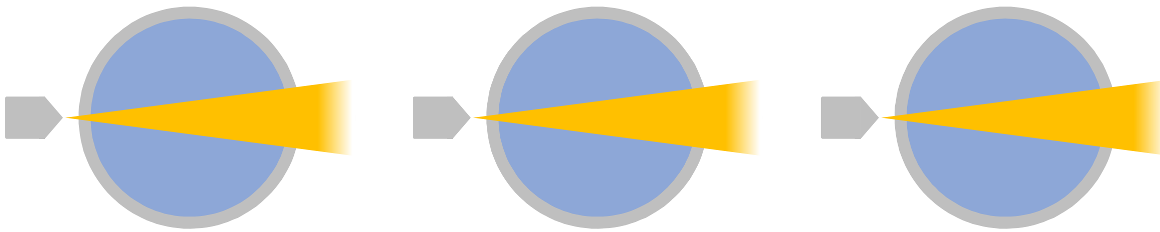
Source activity needs to be calculated for each project individually. Influenced by:

- Wall-thickness
- Distances
- Obstacles
  - Pipes
  - Holding structures
  - (Discharge) pipes
  - Fluid dropping from first column plate
- Etc.

How to avoid problems with nuclear measurements

Think about plant layout!

- „Cross talk“ between neighboring vessels…

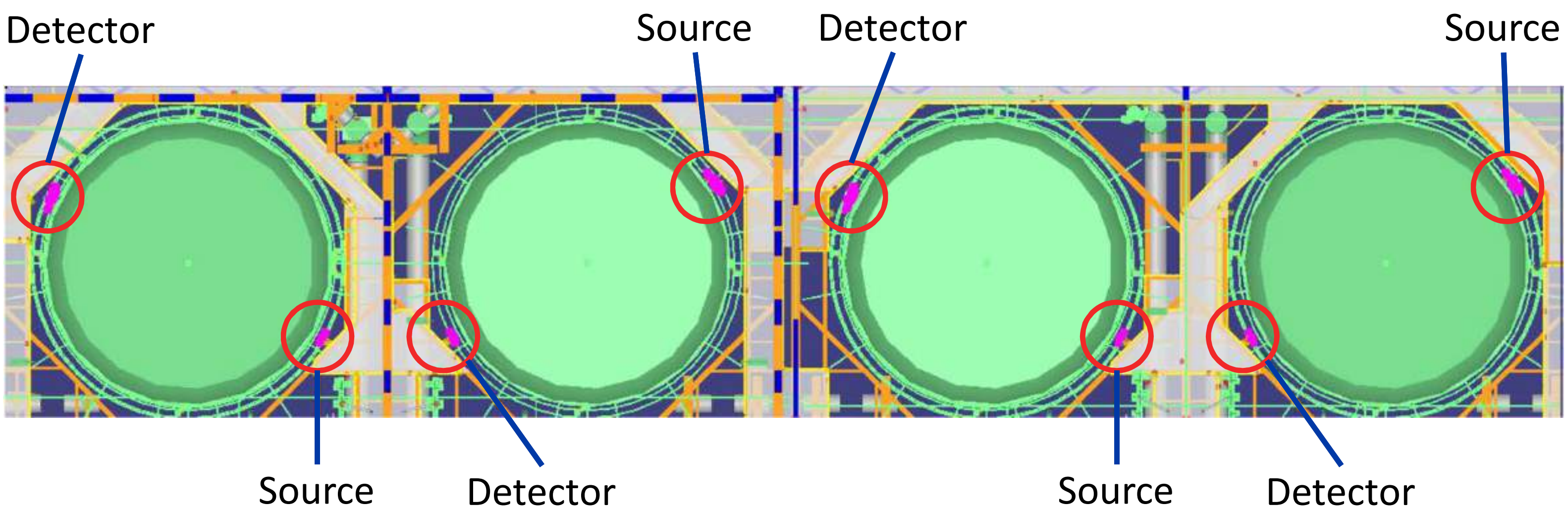


- …and how it can be avoided

How to avoid problems with nuclear measurements

Think about plant layout!

- Avoid „Cross talk“ between neighboring vessels!

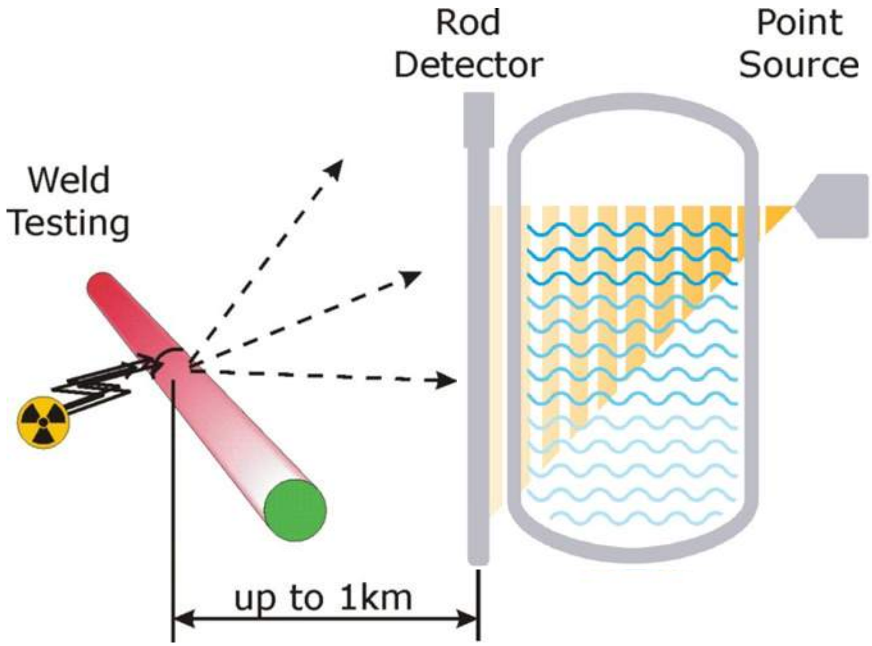


How to avoid problems with nuclear measurements

Interfering radiation?

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

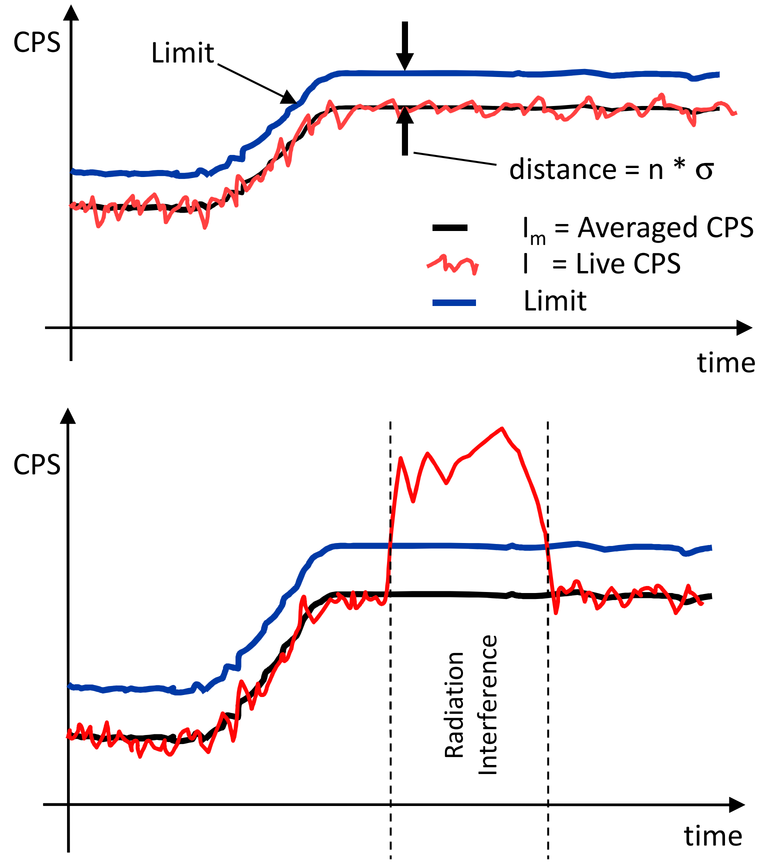
- Use of high activity sources (3-80 Ci) mostly Ir-192
- Wrong measurement due to excess count rate
- Too low level will be displayed



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

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	Locatio
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 - DC
UfaNefteKhim	Ufa, provir Bashkortos

Rev: 16.03.2017 Page 1/3

Extract of Refere

Coke Drum

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

The following Coke Drums are equipped with radi 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, PRC
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

Rev: 16.03.2017 Page 2/3

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Extract of Reference List

Coke Drum

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

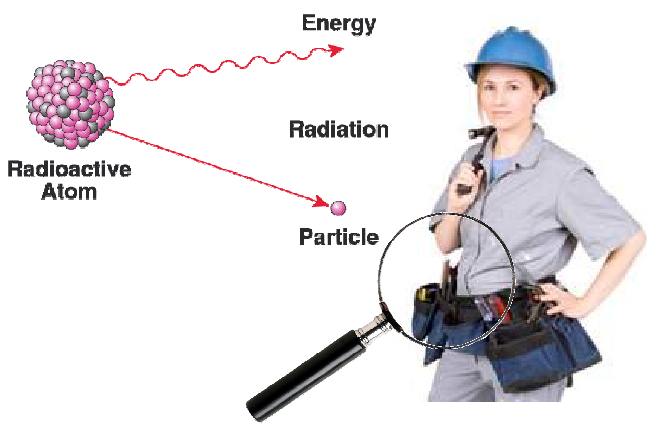
The following Coke Drums are equipped with radiometric level measurement systems from BERTHOLD Technologies (extract):

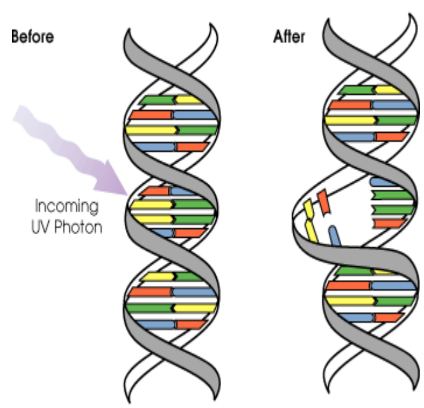
Customer	Location	Country	date
Abu Dhabi Oil Refining Co. (Takreer) - Carbon Black & Delayed Coker	Ruwais, Abu Dhabi	UAE - United Arab Emirates	2013
BP Refinery	Lingen	Germany	2014
Gabriel Passos Refinery	Contagem	Brazil	2014
JSC NAFTAN Refinery - licensor FOSTER WHEELER	Novopolotsk	Belarus	2014
TANECO 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

Rev: 16.03.2017 Page 3/3 Refernce List Delayed Coker

Radiation Safety

Radiation Protection: Ionization

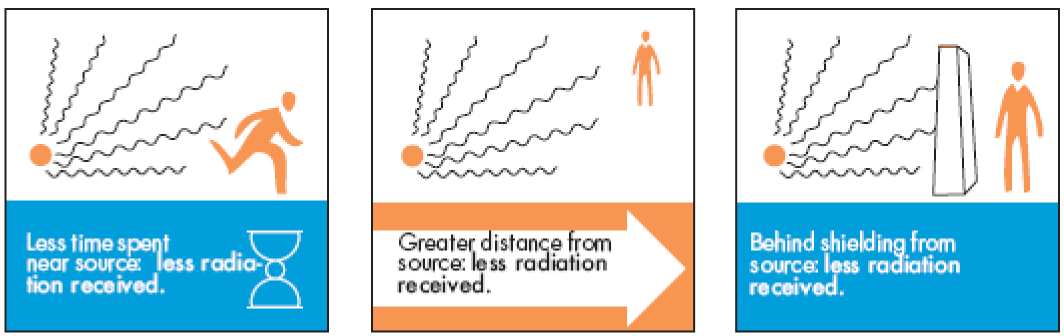




- Radiation transports energy
- Atoms ‚absorb‘ energy ⇒ Ionisation
- Free electrons ionize molecules: radiation damage
- DNA can be damaged
  - Cell dies…or…
  - …is correctly repaired…or…
  - …cell is incorrectly repaired…

Dose – the unit of radiation protection

- Measure for the transferred energy
- Unit: Sievert (Sv) (often mSv)
- 1 Sv = 1 J / kg (1 Sv = 100 rem)



A	*Source activity*
Γ	*Gamma dose rate constant*
r	*Distance to source*
T	*Time*
S	*Shielding effect*

$$\text{Dose H} = \frac{A \cdot \Gamma}{r^2} \cdot T \cdot \frac{1}{S}$$

Typical dose values

▪ At detector (density)	~1-10 µSv/h
▪ 30 cm from shield	~3 µSv/h
▪ Schwarzwald (black forest)	0.2 µSv/h
▪ Air plane in 10.000m height	5 µSv/h
▪ Flight Frankfurt – Houston (11 hours)	55 µSv
▪ X-ray jawbone	10 µSv
▪ Mammography	500 µSv
▪ Computer tomography	2.000-10.000 µSv
▪ Tumor irradiation	70.000.000 µSv

(Note: 1 mrem = 10 µSv)

Thanks for your attention!

www.Berthold.com