Lessons Learned from Recent Startup

RefComm Rotterdam 2019
Agenda

- Who we are?
- Where we are?
- Radiological Issues
  - Mounting Recommendations
  - Locations
- Operational Issues
Berthold Introduction
... and where we came from

- **1949**:
  - Prof. Dr. Rudolf Berthold founded the company “Laboratorium Prof. Dr. Rudolf Berthold”

- **1955**:
  - First density systems supplied

- **1959**:
  - Use of Rod shaped sources for highly accurate level measurements

- **1960**
  - Development of the first industrial process measurement based on γ-Transmission (Level Switch - BASF)

- **1973**
  - High-sensitive scintillators replaced Geiger-Müller technology

- **1989**
  - Re-privatization renamed Berthold Technologies

- **1995**
  - Acquisition by EG&G

- **2000**
  - SuperSENS most sensitive detector

- **2003**
  - SIL2/3 certified detectors

- **2014**
Refinery Applications
Where we are in Delayed Coking?
Coke Drum Levels
The Berthold Solution - Typical Arrangement

- Continuous Level measurement
  - 8m – 30m/26 – 98 ft
  - TowerSENS detector, 8m / 26 ft
  - Usually 2 or 3 fan beam point sources
- Gas Property Compensation
  - Located at or slightly above 100 % of cont. Level span is recommended
  - 1 or 2 further point within the continuous level span (optional)
- Auto-SENS and Outage available
Important Aspects
TowerSENS – One detector does it all

- Patented temperature and aging compensation
  - Gain Control
- No recalibration needed
- XIP (X-Ray Interference Protection)
- Scintillators:
  - Solid scintillation crystals
  - Diameter of 2” / 50 mm
- 2” Photomultiplier
  - About 10 times higher count rate
Installation Example
Radiological Issue
Radiological Issue
High Radiation Fields

10µSv/hr
(1mR/hr)

Limit is 3µSv/hr (0.3mR/hr) @ 300mm
Radiological Issue
Why?
Radiological Issue

Solution!
Radiological Issue

Results

3μSv/hr
(0.3mR/hr)
Radiological Issue
Added protection
Transforming science into solutions
- Radiation over the length of the detector
- Detector average the strength of radiation over the entire length
- No spatial Resolution
Top Point Detector
- Located as high as possible
- Uses
  - Gas Property Compensation
  - High Level to shut off water
  - Monitor for Particulate Matter Carryover
  - Monitor Coke build up for dome clean outs
Gas Properties Compensation „GPC“
Compensate the gas density changes

- Gas properties change during the process
- High gas pressure/density results in more absorption
- Without, level will lower than actual after switching
- 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
Transforming science into solutions
Common Questions
Non-Destructive Testing – Radiography

- Radioactive source is used
  - Co-60 gamma energy ≈ 1.25MeV
    - 1.8 – 3.7 TBq (50 – 100 Ci)
  - Ir-192 gamma energy ≈ 0.45MeV
    - 3.7 TBq (100 Ci)
  - Se-75 gamma energy ≈ 0.32MeV
    - 1.48 TBq (40 Ci)
Non-Destructive Testing – Radiography

Typical 3m level

- Calibration on 2m level device
  - Average field of 0.5µSv/hr
  - Detector sensitivity 10000 cps per meter of length per 1µSv/hr
  - 2m * 10000cps * 0.5µSv/hr = 10000 cps
Radiography
Non-Destructive Testing – Radiography

Calculating Radiation Field

- To calculate the field of a point source

\[ I = \frac{\Gamma \ast A}{d^2} \]

- Where:
  - \( \Gamma \) = gamma constant (\( \mu Sv h^{-1} MBq^{-1} \))
  - \( A \) = Activity of Source in MBq
  - \( d \) = distance

\[ d = \sqrt{\frac{\Gamma \ast A}{I}} \]
Non-Destructive Testing – Radiography

Calculating Radiation Field

\[ d = \sqrt{\frac{\Gamma \times A}{I}} \]

- For Co-60
  - \( \Gamma = 0.369 \ \mu Sv h^{-1} \ \text{MBq}^{-1} \)
  - \( A = 3.7 \ \text{TBq} \text{ or } 370000 \ \text{MBq} (100 \text{ Ci}) \)
  - \( I = 0.5 \mu Sv/\text{hr} \)
  - \( d = 1652 \text{ meters} \)
  - \( d = 2337 \text{ meters for a field of } 0.25 \mu Sv/\text{hr} \)
Non-Destructive Testing – Radiography

Calculating Radiation Field

\[ d = \sqrt{\frac{\Gamma \times A}{I}} \]

- For Ir-192
- \( \Gamma = 0.163 \, \mu Sv h^{-1} \, MBq^{-1} \)
- \( A = 3.7 \, TBq \) or 3700000 MBq (100 Ci)
- \( I = 0.5 \mu Sv/hr \)
- \( d = 1098 \, meters \)
- \( d = 1553 \, meters \) for a field of 0.25\( \mu Sv/hr \)
Transforming science into solutions
Non-Destructive Testing – Radiography

- Radioactive source is used
  - Co-60  gamma energy ≈ 1.25MeV
    - 3.7 TBq (100 Ci) has a field of 0.5μSv/hr (.05mR/hr) at 1652 meters
  - Ir-192  gamma energy ≈ 0.45MeV
    - 3.7 TBq (100 Ci) has a field of 0.5μSv/hr (.05mR/hr) at 320 meters
  - Se-75  gamma energy ≈ 0.32MeV
    - 1.48 TBq (40 Ci) has a field of 0.5μSv/hr (.05mR/hr) at 242 meters
Non-Destructive Testing – Radiography

Typical 2m level

- Calibration on 2m level device
  - Average field of 0.5µSv/hr
  - Detector sensitivity 10000 cps per meter of length per 1µSv/hr
  - $2m \times 10000\text{cps} \times 0.5\mu\text{Sv/hr} = 10000\text{cps}$
- Level @ 50% $\approx 5000\text{cps}$
- 10000cps from NDT source, drives PV to -50% (15000cps, 10000cps from NDT, 5000cps from installed source)
Non-Destructive Testing – Radiography

Shielding

- Radioactive source is used
  - Co-60 gamma energy ≈ 1.25MeV
    - HVL of lead = 12.5mm (0.49”)
  - Ir-192 gamma energy ≈ 0.45MeV
    - HVL of lead = 4.8mm (0.19”)
Non-Destructive Testing – Radiography

Calculating Shielding reduction

- To calculate the reduction

\[ I = I_o e^{-\mu \rho t} \]

- Where:
  - \( I \) = field after shielding
  - \( I_o \) = Initial field strength
  - \( \mu \) = attenuation coefficient
  - \( \rho \) = density of material
  - \( t \) = thickness of material
Non-Destructive Testing – Radiography

Calculating Shielding reduction

- To calculate the reduction

\[ I = I_0 e^{-\mu \rho t} \]

- Where:

  - \( I \) = field after shielding
  - \( I_0 \) = Initial field strength
  - \( \mu \) = .0493 cm²/g
  - \( \rho \) = 11.25 g/cm³
  - \( t \) = 1.25 cm

- Reduction is 50%, if the initial field was 0.5 µSv/hr then the resulting field is 0.25 µSv/hr
Non-Destructive Testing – Radiography

Calculating Shielding reduction

- To calculate the reduction

\[ I = I_0 e^{-\mu \rho t} \]

- Reduction is 50%, if the initial field was 0.5 µSv/hr then the resulting field is 0.25µSv/hr
- 1.25cm = 50% (still getting 5000cps) = 50% of span
- 2.5cm = 75% (still getting 2500cps) = 25% of span
- 3.75cm = 87.5% (still getting 1250cps) = 12.5% of span
- 5cm = 93.75% (still getting 625 cps) = 6.25% of span
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Thank you for your attention!!!!

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