Monitoring of Scrap Metal – Experience with Radioactive Sources and Activation/Fission Products

S. Thierfeldt
Brenk Systemplanung GmbH, Aachen

Overview

- Entrance Pathways for Radioactivity into Scrap
- Precautions by the Scrap Metal Industry, Equipment
- How to Proceed when Radioactivity is Detected
- Considerations of the Scrap Industry and Steel Manufacturers
- Considerations of the Nuclear Industry
- Conclusions

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Entrance Pathways (1)

- Main pathways for entrance of radioactivity into scrap:
- Radioactivity of natural origin (NORM):
  - scale or crud on inner surfaces
    - pipes and large vessels or containers
    - originating e.g. from the oil and gas industry
- Radioactivity of artificial origin:
  - radiation sources
    - not properly removed / handled when device is scrapped
  - e.g. sources contained in technical or medical instruments

Entrance Pathways (2)
NORM

- Examples for NORM:
  - dismantling / refurbishment of U mining and milling industry
  - coal mining, e.g. from facilities for mine drainage,
  - prospection, extraction and milling of ore and fossil fuels
  - water treatment facilities including sludges
  - industrial products (welding electrodes, parts of jet engines, incandescent mantles, moulding sands)
  - construction material
  - phosphate fertiliser production
  - paper industry
  - optical industry
  - refractory material
  - chemical industry

Entrance Pathways (3)
Artificial Origin

- Examples for artificial origin:
  - industrial sources for measuring thickness or density
  - industrial sources for radiography, e.g. for inspection of welds
  - medical sources, e.g. for radiotherapy
  - sources used for applications in research and development
  - contaminated or activated scrap from the illicit removal of material or devices from nuclear installations
  - cleared material, where the residual contamination or activation is below legally prescribed clearance levels

Measurement Equipment (1) Overview

- Measurement equipment
  - mainly in the form of radiation portal monitors (RPM)
  - mainly used in gross-gamma counting mode
    - spectroscopic systems also available

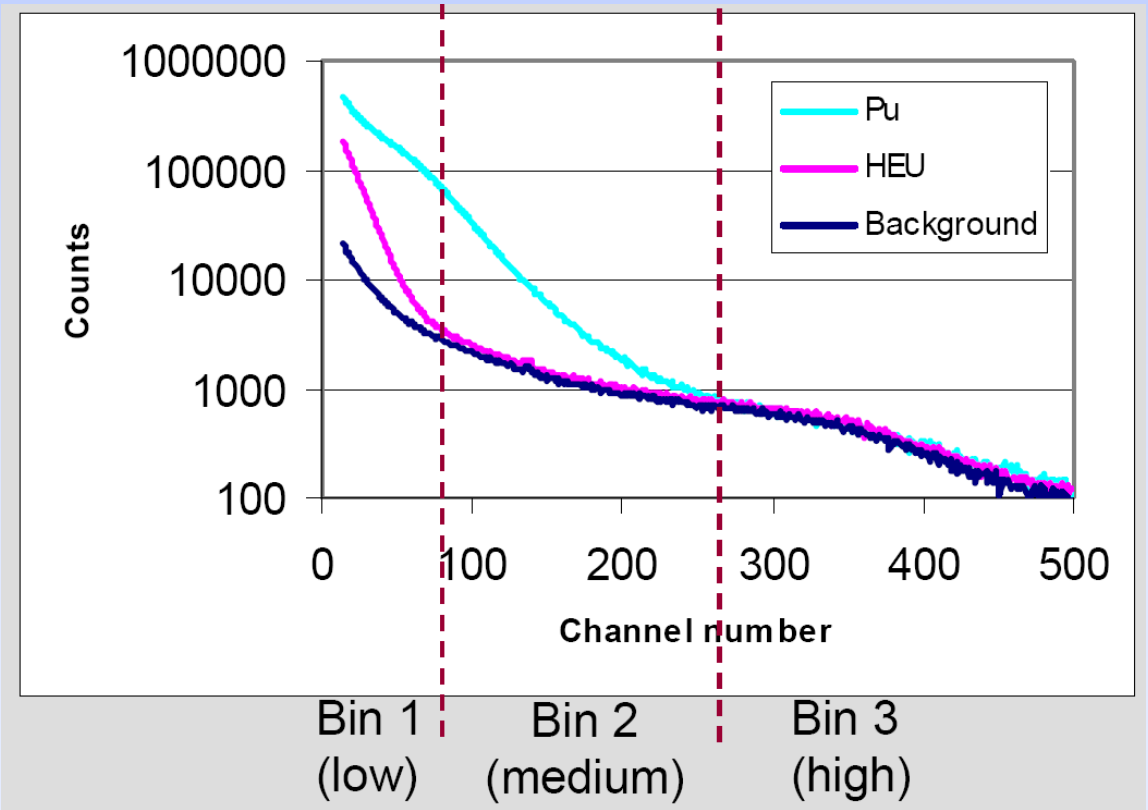
Measurement Equipment (2) Features

- RPMs
  - usually equipped with plastic scintillator monitors
  - detection limit for gross-gamma counting:
    - in the range of a statistically significant increase of dose rate > 5 nSv/h above background
  - continuous measurement of background
- Spectroscopic mode:
  - evaluation of the counts in specified channel ranges (energy ranges)
  - gives indication on presence of radionuclides of artificial and natural origin
    - but e.g. no distinction between NORM and Ra-226 source
  - support cautious approach when Co-60 or Cs-137 detected

Measurement Equipment (3) Features

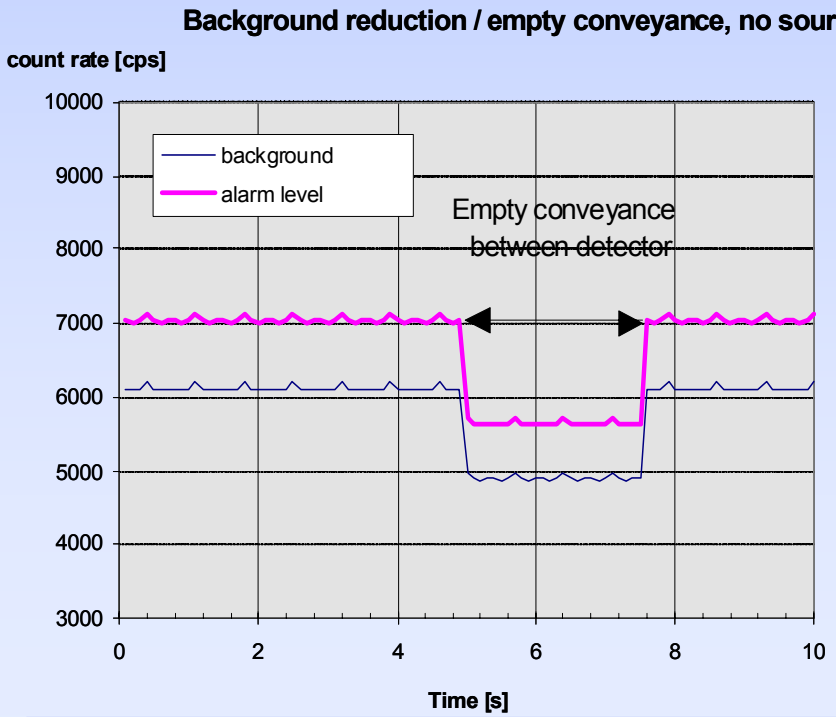
- Spectrometric RPMs
  - also use NaI detectors – higher energy resolution
  - improves identification rates and NORM rejection
  - higher costs

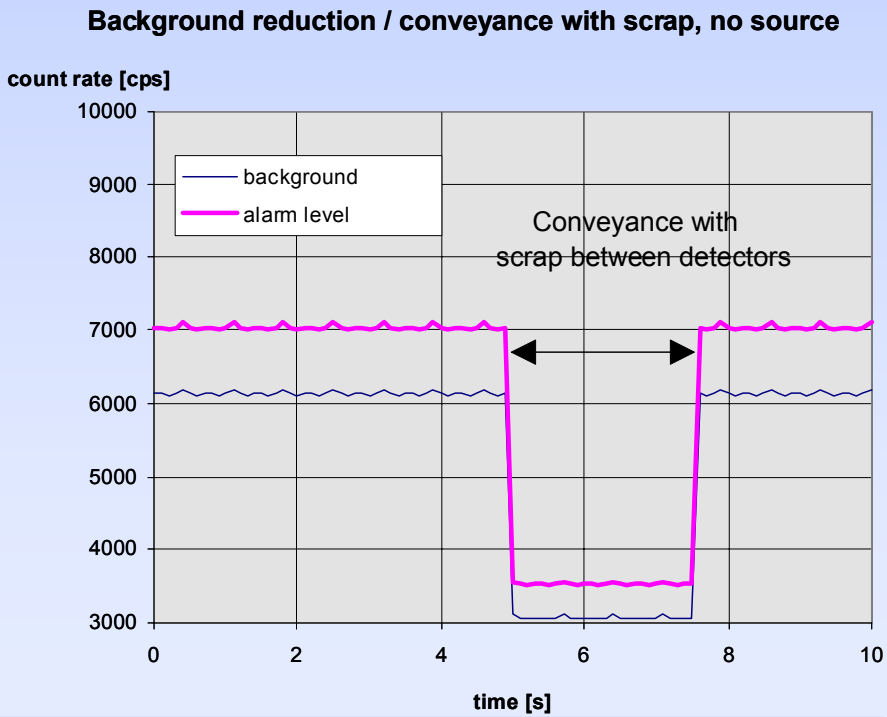
- Example:
  - fissile material in principle identifiable by increase in low-energy bins



Measurement Equipment (4) Background

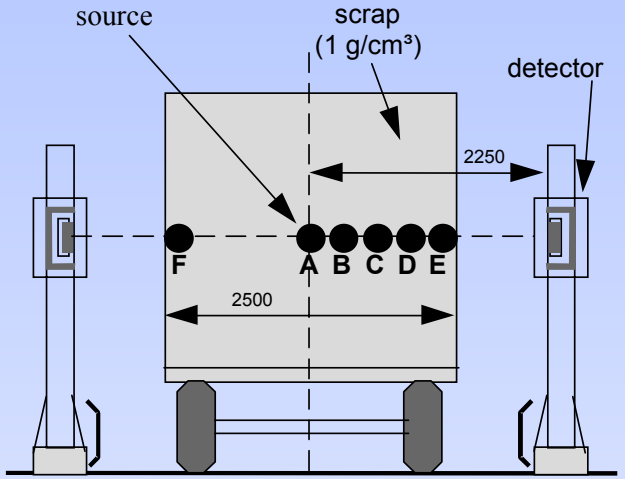
- Background count rate depends on
  - varying radiation from the environment
  - shielding of the conveyance and load between detectors
- RPM has to accurately detect position of vehicles

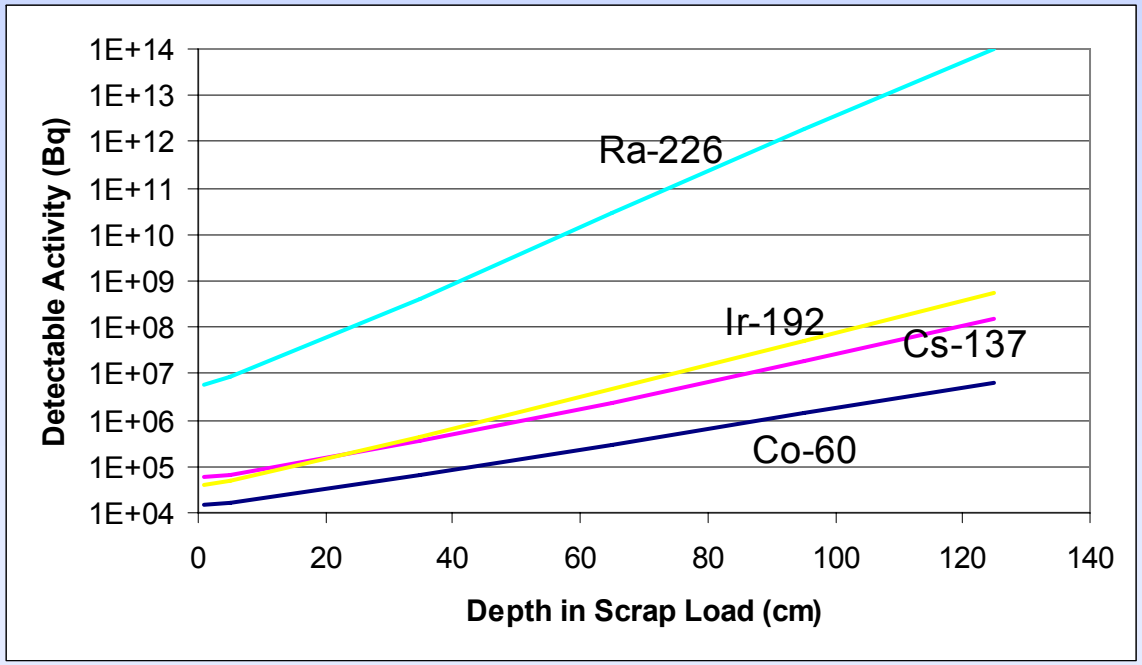




Measurement Equipment (5)
Detectable Activities

- Detectable activities of radionuclides depend on:
  - nuclide (energies)
  - position inside scrap load
  - density of scrap





Measurement Equipment (6) Conclusions

- RPM are mature and reliable
  - as long as detection limits are observed
  - limited use of “spectroscopic” systems
- Features needed for every-day use:
  - robustness, high reliability, easy operation
  - low detection limit, i.e. optimisation for gross gamma counting
  - low error rate (avoidance of false alarms)
- For spectrometric systems:
  - variable adjustment of the region of interest to distinguish between NORM and artificial sources

Procedures after Detection of Activity (1) General Considerations

- There is no optimum procedure
- Procedure depends on case:
  - origin of load, possibility of presence of high-active sources
  - measured dose rate, localisation
  - experience and knowledge of the personnel

- It is no solution to just send back the scrap
  - proper determination of activity contents
  - alert scrap yards, foundries, steel works in the vicinity to prevent the driver from taking the scrap elsewhere
  - sending back may be illegal, depending on the activity

Procedures after Detection of Activity (2) Procedures

- Proposal for dose rate action levels in Germany (1997):
  - criterion: highest dose rate at outside of conveyance
  - dose rate < 5 µSv/h:
    - approaching and investigation of scrap possible
    - visible inspection may reveal NORM as cause: melting can take place
    - prolonged exposure should be avoided
    - material may be sent back or melted
  - dose rate > 5 µSv/h
    - prevent conveyance from leaving premises or direct it to a place where scrap can be unloaded
    - radiation protection specialists should be brought in to assure protection of the workers
    - material may be melted if only contamination present

Procedures after Detection of Activity (3) Procedures

- Proposal for dose rate action levels in Germany (cont.):
  - dose rate > 100 µSv/h:
    - stop work in vicinity of conveyance immediately
    - prevent conveyance from leaving
    - erect a barrier at dose rate line of ~ 5 µSv/h
    - call in the authorities
    - further approach may only be made by radiation protection specialists

Procedures after Detection of Activity (4) Implementation of Procedures

- Actual implementation of procedures based on dose rate action levels in Germany:
  - depends on the authorities of the administrative district
  - is often based on two dose rate action levels:
  - below lower action level:
    - action to be decided by the scrap yard, foundry, steel work etc.
  - between both action levels:
    - actions have to be agreed with the authority (information, not necessary involvement)
  - above higher action level:
    - any further action may be unsafe, radiation experts need to take over

Procedures after Detection of Activity (5) Implementation of Procedures

- General procedure:
  - a) alarm is triggered by the RPM
  - b) make sure that this is a real alarm by passing the lorry or freight car through the detectors several times
  - c) ascertain detection of radioactivity by additional dose rate measurements at outside of conveyance
  - d) move conveyance to place nearby suitable for unloading and separating the scrap if dose rate permits
  - e) separate and measure the scrap, determine relevant radionuclides, secure radioactive material by radiation protection experts
  - f) determine how to proceed on the basis of the results of the radiological assessment

Procedures after Detection of Activity (6)
Procedures at Borders

- RPM at borders: various tasks
  - detection of large radiation sources
  - detection of fissile material (U, Pu)
  - detectors optimised for detection of photons and neutrons
  - detection limits usually higher than of RPMs at entrance gates
- Alarm at RPM at border:
  - material is usually prevented from entering the country

Considerations of the Scrap Industry and Steel Manufacturers (1)

- General tendency:
  - prevent radioactivity of any origin to enter the steel pool
  - no distinction of origin of radioactivity
    - cleared material, NORM, sources etc.
- Criterion:
  - any material with dose rate above background levels is regarded as radioactive
- Contracts:
  - general clauses in standard contracts:
    - presence of activity in the scrap constitutes a fault
    - gives the buyer the right to reject the scrap
  - consignor has to bear costs for locating and removing activity or for sending back the load

Considerations of the Scrap Industry and Steel Manufacturers (2)

- Standard clause in contracts in Germany:
  - "… we guarantee that we will deliver only such scrap that has been monitored with our own measurement equipment to be free of ionising radiation. Therefore, we … can declare to the best of our knowledge that on the basis of the aforementioned measurements, that the scrap will be free of ionising radiation above ambient background radiation." (*translated*)

Considerations of the Scrap Industry and Steel Manufacturers (3)

- Relevance for clearance:
  - interests of the scrap industry and steel manufacturers are disparate to those of the nuclear industry
  - activity that remains undetected in RPM will not be regarded as radioactivity by the scrap industry
    - sufficiently small amounts of gamma emitting radionuclides that will not be detected
    - large amounts of beta or alpha emitting radionuclides which cannot be detected at all
- Problems will occur:
  - if RPMs at vendor (consignor) and buyer (consignee) are different
  - if the configuration of the load has changed during transport, altering shielding and position of activity

Considerations of the Nuclear Industry (1) Relevance of Clearance

- Relevance of clearance:
  - Clearance of material is an essential part of material management within the nuclear industry
    - in particular for decommissioning of nuclear installations
  - material is usually decontaminated to meet clearance levels
    - but some residual activity will remain on surfaces (or in material from activation)

- Nuclear industry has an interest
  - to keep clearance a viable option
  - to sell scrap for melting

Considerations of the Nuclear Industry (2) Recommendations on Clearance

- Clearance levels for metals:
  - several international recommendations
  - many national regulations

- Examples:
  - EU:
    - Recommendation RP 122 part I on general clearance
    - RP 89 on clearance of metal scrap (prescribed first use)
  - IAEA:
    - Safety Guide RS-G-1.7 “Application of the Concepts of Exclusion, Exemption and Clearance” valid for all types of materials.

Considerations of the Nuclear Industry (3) Clearance Levels

- Overview of clearance levels for selected radionuclides:

Purpose	H 3	C 14	Ni 63	Co 60	Cs 137	Sr 90	U 235	Am 241	Pu 239	Unit
Unconditional clearance, RP 122/I [6]	100	10	100	0.1	1	1	1	0.1	0.1	Bq/g
Unconditional clearance, RS-G-1.7 [8]	100	1	100	0.1	0.1	1	-	0.1	0.1	Bq/g
Metal scrap for recycling or reuse, RP 89 [7]	1,000	100	10,000	1	1	10	1	1	1	Bq/g
Building rubble, RP 113 [15]	100	10	1,000	0.1	1	1	1	0.1	0.1	Bq/g

- Example Co-60:
  - 0.1 Bq/g unconditional (general) clearance (reuse/recycling)
  - 1 Bq/g clearance for melting only
  - reason for difference: melting is prescribed first use

Considerations of the Nuclear Industry (4) Detection of Cleared Material

- Detection of scrap load with cleared material depends on
  - nuclide composition
    - presence of gamma emitting radionuclides
  - clearance level
    - e.g. 0.1 or 1 Bq/g for Co-60
  - exhaustion of clearance levels
    - general case: ~ 10 – 50 % exhaustion
    - determines average activity levels e.g. for Co-60:
      0.01 … 0.05 Bq/g for unconditional (general) clearance
      0.1 … 0.5 Bq/g for clearance for melting

Considerations of the Nuclear Industry (5) Detection of Cleared Material

- Example:
  - scrap load, 1.5 Mg/m³ density, 20 m³, 30 Mg
  - shielding by side walls of lorry 0.5 cm
  - contamination by Co-60 only
  - for unconditional clearance levels, 30% exhaustion:
    - dose rate ~3 nGy/h in 50 cm → no detection
  - for clearance levels for melting, 30% exhaustion:
    - dose rate ~30 nGy/h in 50 cm → detection possible
- Conclusion:
  - use of unconditional clearance levels on the order of 0.1 Bq/g for Co-60 and use of standard clearance procedures ensures cleared metal scrap will not be detected in RPMs

Considerations of the Nuclear Industry (5) Willingness to Accept Cleared Scrap

- Scrap dealers:
  - absence of an alarm from a radiation portal monitor may be interpreted as absence of activity of any concern
  - freight papers still tell about the origin of the material
  - what will they do?
- Reasons for accepting material from nuclear installations:
  - good quality, well sorted
  - cleaned, no or very little impurities
  - reliable source for a well-defined quantity arising for defined period of time (several years)
- A small number of scrap dealers in Germany accept material also with higher clearance levels

Conclusions (1)

- RPMs at entrance gates of scrap yards, steelworks, foundries etc.
  - generally capable of detecting dangerous activity levels
    - preventing radioactive sources from entering the facility
  - help avoiding harm to workers and general public
  - help averting financial disaster for the facility caused by melting a large radiation source
- RPMs
  - are reliable
  - can detect sufficiently low activities of gamma emitting nuclides even in larger scrap loads
  - generally operated with individual settings
  - absence of an alarm does not mean absence of activity

Conclusions (2)

- Metal industry
  - generally considers a scrap load to contain radioactivity if RPM produces an alarm
    - alarms based on increase in dose rate above background
  - accepts material where no measurable increase in dose rate is detected
  - procedure laid down in standard contracts
- Nuclear industry
  - needs clearance as integral part of material management
  - cleared material will usually not trigger alarms at RPM if “general clearance levels” are used (0.1 Bq/g Co-60)
  - has agreed special procedures with some scrap dealers to accept material even cleared with higher clearance levels