Experiences in Monitoring and Dealing with Radioactivity in Recycling Steel at Outokumpu Tornio Works

Hot Rolling Mill, Eero Huhtalo, January 7, 2009
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- Radiation detection after smelting
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- Procedures after melting of a radiation source
- Final placement for radioactive waste
1. Introduction
Outokumpu Tornio Works

• Full capacity after latest expansion:
  FeCr  270 000 tons
  Slabs  1 650 000 tons
  Coil products  1 200 000 tons
  of which:
  White hot rolled  300 000 tons
  Semi-cold rolled  150 000 tons
  Cold rolled  750 000 tons

• Specialized in:
  • Custom-made mass production in selected product areas
  • Supplying cost efficiently high quality volume products
  • Using best available technology
  • New products from RAP line

• About 2 400 employees
Radiation detection systems at Tornio works

Scrap yard

1. Rad. gate
2. Rad. gate
3. Rad. gate
4. Rad. gate

Shredder

5. Rad. detection

12. Grapple radiation detector
8. Grapple radiation detector
10. Grapple radiation detector

9. Grapple radiation detector

6. Rad. detection

FeCr-converter

17. Rad. detection

Melt shop 1 Electric arc furnace

13. Rad. detection
14. Rad. detection

Melt shop 2 Electric arc furnace

15. Rad. detection
16. Rad. detection

18. Rad. detection

Laboratory

Molten steel / slag

Molten FeCr / slag

Samples to laboratory
## 2. Radiation detection before smelting

<table>
<thead>
<tr>
<th>Ref</th>
<th>Type</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5x 50 l plast</td>
<td>Harbour portal monitor</td>
</tr>
<tr>
<td>2</td>
<td>6x 25 l plast</td>
<td>Weighing station portal monitor</td>
</tr>
<tr>
<td>3</td>
<td>12x CsI scintillators</td>
<td>Weighing station portal monitor</td>
</tr>
<tr>
<td>4</td>
<td>5x 25 l plast</td>
<td>Train Weighing station portal monitor</td>
</tr>
<tr>
<td>5</td>
<td>1x 25 l plast</td>
<td>Shredder monitoring station, conveyor belt</td>
</tr>
<tr>
<td>6</td>
<td>1x 33 l plast</td>
<td>Alloy transfer monitor 1, conveyor belt</td>
</tr>
<tr>
<td>7</td>
<td>1x 33 l plast</td>
<td>Alloy transfer monitor 2, conveyor belt</td>
</tr>
<tr>
<td>8</td>
<td>2x 3 l plast</td>
<td>Grapple monitor</td>
</tr>
<tr>
<td>9</td>
<td>2x 3 l plastic</td>
<td>Grapple monitor</td>
</tr>
<tr>
<td>10</td>
<td>2x 3 l plastic</td>
<td>Grapple monitor</td>
</tr>
<tr>
<td>11</td>
<td>2x 3 l plastic</td>
<td>Grapple monitor</td>
</tr>
<tr>
<td>12</td>
<td>1x NaI scintillator</td>
<td>Grapple monitor</td>
</tr>
</tbody>
</table>

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6 | January 9, 2009 | Eero Huhtalo

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OUTO KUMPU
Ref 3. Weighing station portal monitor / limitation of background radiation

2 detectors at roof
Background count rate about 250CPS

4 detectors at each side
Background count rate about 100 - 200CPS

2 detectors at bottom
Background count rate about 50CPS

Detectors boxes (blue)

Steel plates.

Steel pole
Cement, concrete and asphalt has been replaced with steel poles, steel scrap and steel plates.
Foundations for the new weighing station portal monitor

Steel pole

Steel scrap to decrease background radiation as much as possible.

Steel plates.
## 3. Radiation detection after smelting

<table>
<thead>
<tr>
<th>Ref</th>
<th>Type of monitor</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>1x NaI scintillator</td>
<td>Line 1, molten steel and slag monitoring, redundant with 14</td>
</tr>
<tr>
<td>14</td>
<td>1x NaI scintillator</td>
<td>Line 1, molten steel and slag monitoring, redundant with 13</td>
</tr>
<tr>
<td>15</td>
<td>1x NaI scintillator</td>
<td>Line 2, molten steel and slag monitoring, redundant with 16</td>
</tr>
<tr>
<td>16</td>
<td>1x NaI scintillator</td>
<td>Line 2, molten steel and slag monitoring, redundant with 16</td>
</tr>
<tr>
<td>17</td>
<td>2x NaI scintillators</td>
<td>FeCr-converter, molten FeCr and slag monitoring</td>
</tr>
<tr>
<td>18</td>
<td>1x NaI scintillator</td>
<td>Automatic slag sample measurement in laboratory</td>
</tr>
<tr>
<td>19</td>
<td>1x CsI scintillator</td>
<td>Line 1, slag sample measurement</td>
</tr>
</tbody>
</table>

Ref. 13-16

Ref. 17
## 4. Handheld instruments

<table>
<thead>
<tr>
<th>Ref</th>
<th>Type of monitor</th>
<th>Purpose of use</th>
</tr>
</thead>
</table>
| 1   | GR-110 Telescope arm NaI-detector | To establish the radiation:  
- in scrap yard  
- ladles after the radiation incidence has been happened  
- all over the melting shop after the radiation incidence has been happened |
| 2   | GR-135          | Spectral analyzer to clarify the radionuclide after the incidence has been happened |
| 3   | TSA PRM-470B    | To establish the radiation in scrap yard |
| 4   | RD-110          | To check the dose rate value [\(\mu\text{Sv/h}\)] |
5. Where and how radiation is detected after smelting

1. Start situation - melted steel in the EAF

2. Melted steel will be poured into the steel ladle

3. First radiation measurement for melted steel

4. Second radiation measurement during slag removing
   Slag and steel can be checked in the same time

5. In case of radiation alarm the ladles can be checked again until the radiation has been actually established.

Ladle transfer car can be moved under the radiation detectors. Incase that both of the detectors give an alarm then the operators can be sure that the radiation incident has been happened.
Locations and cooling of the radiation detector installations

Location of the first radiation detector.

Cooling air hose.

Location of the second radiation detector.

Cooling air hose.
Detector head installation and measuring window temperature protection

Measuring window covered with temperature resistant textile.
## 6. Procedures after melting of a radiation source

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Immediate works after a radiation incidence at the melt shop</td>
</tr>
</tbody>
</table>
| 2    | Works at the smoke and dust filter plant:  
- Stop the smoke and dust filter  
- Planning how to minimize the amount of contaminated material  
- Stopping the transport of contaminated dust to recycling plant  
- Determine the moment when the transport to recycling plant can be started again |
| 3    | Works at masonry work shop:  
- Plans for the special dismantling works for contaminated furnaces and ladles  
- Dismantling for the contaminated furnace and ladles  
- Taking care for the contaminated material |
| 4    | Finding the final placement for the contaminated waste |
Immediate works after radiation incidence at melt shop

1. Initiate respirator usage:
   • The workers inside the melt shop must use respirators.
   • This rule affects all people, who are working inside the factory hall where the contaminated dust can spread to.
   • The respirators have to be used until air purity can be established.
   • During the last Am-241 incidence on 18.10.2008 respirators were used for about 24 hours.
   • For Am-241 the respirators must meet the minimum P3 requirements of the EN140 standard.

2. Give an overall radiation alarm for melt hall.
   • Check for individuals with the possibility of internal contamination (i.e. persons in the factory hall during the melt)

3. Limitation of the works inside the factory hall:
   • All work inside the factory hall has to be minimized until air purity has been established and the factory hall is cleaned.
   • Only the most important process work and emergency work are allowed.
4. Investigate the radionuclide:
   - The incidence handling depends a lot of melted radionuclide.
   - At Tornio Works we have been able to determine the Am-241 radionuclide immediately after the radiation alarm.

5. Notification to Finnish authorities:
   - The notification to authorities has been given about 30 minutes after radiation alarm.
   - Together with authorities we have planned the cleaning methods and other works with special radiation considerations.

6. Limitation of contaminated dust dispersal:
   - All slag ladles and other contaminated material are carried outside the factory hall.
   - The slag ladles are coated with sand.

7. Start to organise the works at smoke dust filter plant.
8. Start to organise the factory hall cleaning work
9. Installation of the air samplers for radiation detection.
Into action...
Checking measurements from slag and steel ladle
Installation of air samplers for dust collection

Maximum measured values for air activity in the 18.10.2008 event were 1.5 and 3.5 mBq/m³.
Works at masonry work shop

Ladle dismantling work at masonry work shop

EAF preliminary cleaning with high pressure water.

EAF water cooling section waiting for cleaning.
EAF dismantling work

Seacontainer for radioactive waste. Open roof.

Contaminated EAF water cooling elements.
### 7. Final placement for radioactive waste

<table>
<thead>
<tr>
<th>Date of incidence</th>
<th>Maximum measured values for air activity</th>
<th>Maximum measured values for dust samples gathered from factory hall floor</th>
<th>Maximum measured values for slag activity / weight</th>
<th>Maximum measured values for steel activity</th>
<th>Maximum measured values for foundry dust activity / weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 24.11.2006</td>
<td>200 [µBq/m³] 80 [Bq/kg]</td>
<td>230 000 / ~100</td>
<td>0,5 [Bq/kg]</td>
<td>540 / ~400 [Bq/kg] / [ton]</td>
<td></td>
</tr>
<tr>
<td>2 1.11.2007</td>
<td>500 [µBq/m³] 300 [Bq/kg]</td>
<td>100 000 / ~50</td>
<td>4 [Bq/kg]</td>
<td>450 / ~200 [Bq/kg] / [ton]</td>
<td></td>
</tr>
<tr>
<td>3 18.10.2008</td>
<td>3500 [µBq/m³] 290 [Bq/kg]</td>
<td>136 000</td>
<td>0,9 [Bq/kg]</td>
<td>224 [Bq/kg] / [ton]</td>
<td></td>
</tr>
</tbody>
</table>

Slag ladles and seacontainers containing foundry dust waiting for the final placement
New waste site

Reserved area for radioactive materials.
Final placement for radioactive material

Radioactive material. Lowest activity.

Radioactive material. Medium activity.

Radioactive material. Highest activity.

Detailed explanation for section B-B on next page.
Previous picture section B-B

- Surface soil
- Protective layers for bentonite carpet.
- Bentonite carpet
- Radioactive material. Lowest activity.
- Radioactive material. Medium activity.
- Radioactive material. Highest activity.
- Bentonite carpet
- Filter carpets
- Filter sand layers
- Water drains
- Clay 500mm
Leachate sampling.

The leachate and ground water has to be controlled for future. The water samples will be taken four times per year.

Finnish authority will do radiation analyses for water samples.
Conclusions (my own)

• For good detection results, a defence in depth type of approach for monitoring is required.
• Even with sophisticated defence in depth monitoring arrangement, radioactive sources can get through.
• All parts of the process should be monitored.
• Be prepared.
• Emergency management plans are not enough, training is also required.