Radiation Protection at Rössing
Open-pit uranium mining: Rössing

- low radon
- High dust
- Low external radiation
Radiometric map showing uranium grade
Natural Background Radiation

Natural radiation exposure in mSv/a:

- World Average: 2.3 mSv/a
- Namibia (Erongo): 3.0 mSv/a
- Erongo (Arandis): 5.4 mSv/a
Sources of external gamma radiation

- Granites
- Uranium and thorium rich ores
Sources of dust (long-lived alphas)

Tailings

Mining

Blasting

Crushing

East Wind
Sources of radon (short-lived alphas)

Waste Rock Dumps 0.6 Bq/m²

Open Pit 0.5 Bq/m²

Tailings 1.6 Bq/m²

Radon concentrations: 25 – 1,200 Bq/m³

Equivalent dose: 0.15 – 7.6 mSv/a
Radiation Levels (Gamma)

- Levels determined by the low ore grade (0.03% uranium in the

<table>
<thead>
<tr>
<th>Area</th>
<th>Typical dose rate (μSv/h)</th>
<th>Annual dose rate (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Pit</td>
<td>0.5 - 1.0</td>
<td>1.0 – 2.0</td>
</tr>
<tr>
<td>Crushers</td>
<td>0.5 - 1.0</td>
<td>1.0 – 2.0</td>
</tr>
<tr>
<td>Extraction Plant</td>
<td>1.0 - 3.0</td>
<td>2.0 – 6.0</td>
</tr>
<tr>
<td>CIX plant</td>
<td>2.0 - 10</td>
<td>4.0 - 20</td>
</tr>
<tr>
<td>SX plant</td>
<td>0.5 - 10</td>
<td>1.0 - 20</td>
</tr>
<tr>
<td>FPR</td>
<td>0.5 - 10</td>
<td>1.0 - 20</td>
</tr>
<tr>
<td>Tailings</td>
<td>1.0 - 1.4</td>
<td>2.0 – 2.8</td>
</tr>
<tr>
<td>Workshops</td>
<td>0.2 - 0.5</td>
<td>0.4 – 1.0</td>
</tr>
<tr>
<td>Offices</td>
<td>0.2 - 0.3</td>
<td>0.4 – 0.6</td>
</tr>
</tbody>
</table>

- Enhanced levels are found in the CIX plant, SX plant and FPR

Time restrictions if dose rate is above 10 μSv/h

This is the dose that would result if you were exposed to the dose rate all the time while at work.
System of Radiological Protection (ICRP)

- **Justification**
  - No practice involving exposure to radiation should be adopted unless it produces a net benefit to those exposed or to society generally.

- **Optimization**
  - Radiation doses and risks should be kept as low as reasonably achievable (ALARA), economic and social factors being taken into account.

- **Limitation**
  - The exposure of individuals should be subject to dose or risk limits above which the radiation risk would be deemed unacceptable.
Radiation Protection Standards

- **Recommendations of the ICRP** (International Commission for Radiological Protection) and adopted by the **IAEA** (International Atomic Energy Association) are followed:

  - **Maximum Equivalent Dose**
    - for employees = 100 mSv/5years (**20 mSv/year average**) with a maximum of 50 mSv in a single year.
    - for public = 5 mSv/5years (**1 mSv/year average**)
    - Dose constraint = 0.25 mSv/year

- **Rössing Standard**
  - for employees and contractors: **20 mSv/year maximum**
Radiation Management Plan

- **Background**: detailed description of operation
- **Pre-Operational Safety Assessment**: Impact and dose assessments
- **Organizational Arrangements**: Responsibilities and Authority
- **Occupational Radiation Protection Programme**: Detail of radiation management programme
- **Public Exposure Monitoring Programme**: Exposure pathways and monitoring programme
- **Waste Management Programme**
- **Emergency Preparedness and Response**
- **Transport Plan**
- **Safety and Security of Radiation Sources**
Radiation Control

Time

Distance

Shielding
Other Methods Used

- Occupancy limitation;
- Warning signs and labels;
- Ventilation;
- Dust or fume control measures;
- Personal hygiene facilities;
- Contamination control;
- Training (Induction and radiation awareness training);
- Personal protection (PPE)
PPE

- Dust: Wearing of dust masks
PPE

- Final Product Area
- SX
  - Wearing of respirators

- Final Product Area
  - Wearing of respirators, gloves, boots, overalls
  - Full-body disposable liner for roaster cleaners
Monitoring

- **Area**
  - External Beta and Gamma (yearly)
  - Alpha contamination (yearly, weekly in radiation areas)
  - Radon and thoron (per SEG, yearly)
  - Dust (ongoing)

- **Personal**
  - Dosimeters (TLD: radiation workers, ongoing)
  - Dosimeters (Electronic: per SEG, yearly and per request)
  - Uranium in Urine (only radiation workers)
  - Dust (per SEG, yearly)
  - Yearly medicals

- Contamination of ground water – control systems in place to prevent this and monitoring done to confirm control

- Public dose assessment

- Contamination monitoring prior to release off site
  - Permits for transport of radioactive material
Personal Monitoring

- External (gamma) radiation
  - EPD (electronic personal dosimeter)
    - Low radiation areas
    - Reads dose electronically
  - TLD (thermo luminescent device)
    - CIX and FPR
    - Wearing period 4 weeks
    - Sent to lab for dose result
- Uranium in urine
Personal Monitoring

- Internal (alpha) radiation in dust
  - Personal air sampler
    - Pumps air through filter, which is then analysed for radionuclides
- Internal (alpha) radiation from radon daughters
  - Radiation spectrometer
    - Measures alpha activity from radon daughters
Area Monitoring

• Surface contamination of equipment and objects going off site
  – Rate meter
    • Measures gamma activity on surfaces
  • Area gamma monitoring
    – Dose rate meter
      • Measures gamma activity and converts to dose
• Surface contamination in areas
  – Sample counter
    • Measures alpha activity of swipes from surfaces
What are the Personal Doses?

2007 Average radiation exposure for similar exposure groups at RUL, in mSv/a

Overestimate because respirators are worn!
Water monitoring: seepage control

Daily monitoring of seepage control installations on the tailings dam is carried out by the Tailings Dam Area Operators, while the Hydrogeologist evaluates the flow rates, water levels and general effectiveness of the systems.
Water monitoring: boreholes

On a yearly basis the boreholes monitored rotate as to give a broad spectrum of the quality of the effluent.

Every year about 40 boreholes of the 150 monitoring boreholes are sampled.
Public Monitoring

- Radon Surveys
- Dust Surveys
- Borehole surveys
- Public dose assessments using ICRP dose conversion factors for inhalation and ingestion. Principle of critical groups is used, and maximum public dose assessments are below 250 µSv/annum.
Transport and Off-site movement

• Drum activity: on packing
• Container activity: on packing, swipes on departure
• Harbour stacking area: monitor before arrival of containers
• Containers: monitor after loading
• Labelling of drums and containers
Waste Management

- Sealed sources: lock-up procedures and demarcation of areas
- Tailings: radionuclide monitoring of borehole water
- Contaminated material:

<table>
<thead>
<tr>
<th></th>
<th>Contaminated</th>
<th>Uncontaminated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard</td>
<td>Radiation Clearance</td>
</tr>
<tr>
<td>Non-fixed Radioactivity</td>
<td>&gt; 0.4 but &lt; 4 Bq/cm² (averaged over 300 cm²)</td>
<td>Required</td>
</tr>
<tr>
<td>Fixed radioactivity</td>
<td>&lt; 400 Bq/cm² (averaged over 300 cm²)</td>
<td>Required</td>
</tr>
<tr>
<td>Dose Rate at 1 m from item</td>
<td>&lt; 0.5 μSv/h</td>
<td>Required</td>
</tr>
</tbody>
</table>

- People: no PPE going off site.