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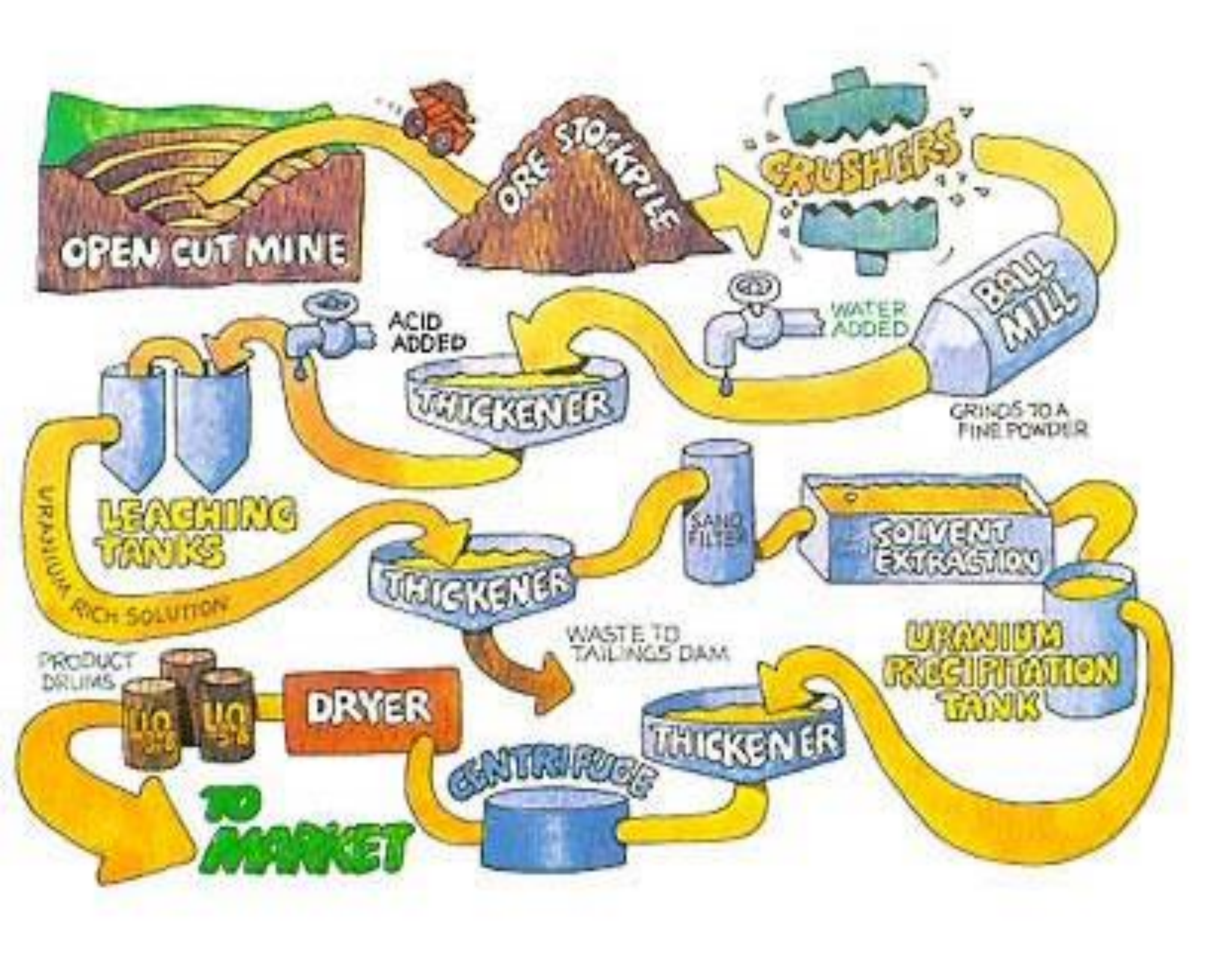
Case Study Processing

Training Package on Occupational Radiation Protection in Uranium Mining and Processing Industry

Process Description

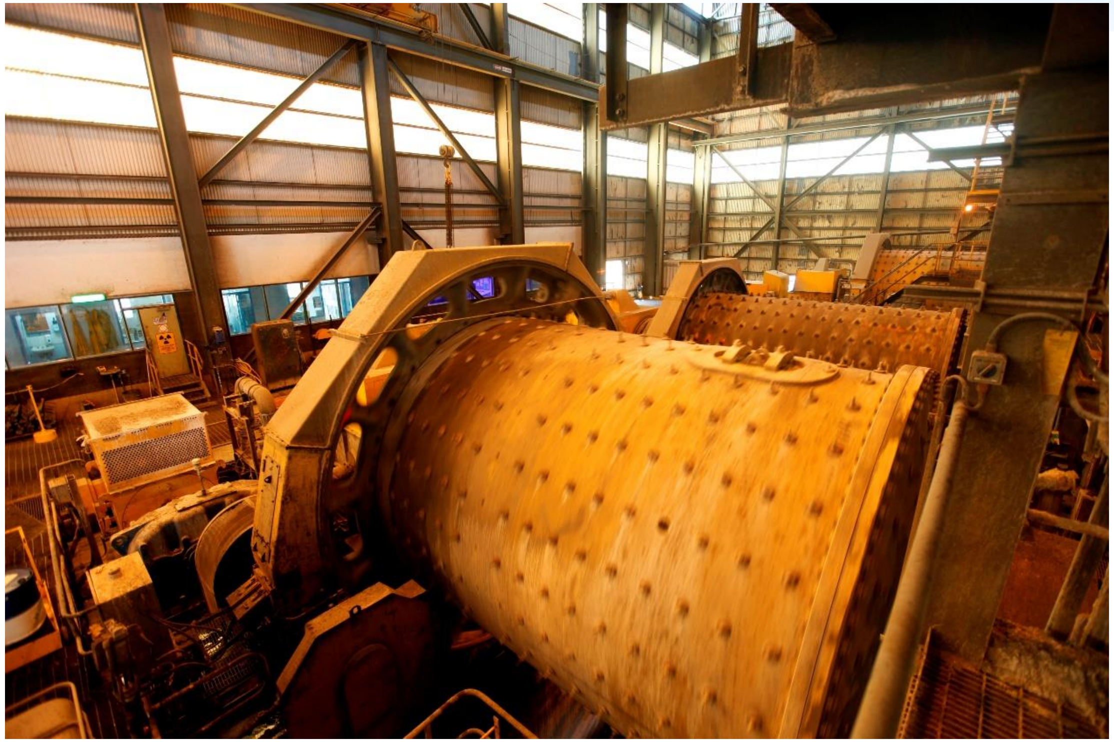
- Once the uranium bearing material has been extracted, the uranium must be concentrated and purified to create the final uranium concentrate product
- There are a number of options and stages available for this phase:
  - Acid leach
  - Alkali leach
  - In situ leach
  - Solvent extraction
  - Ion exchange
  - Calcination

A Typical Uranium Processing Plant

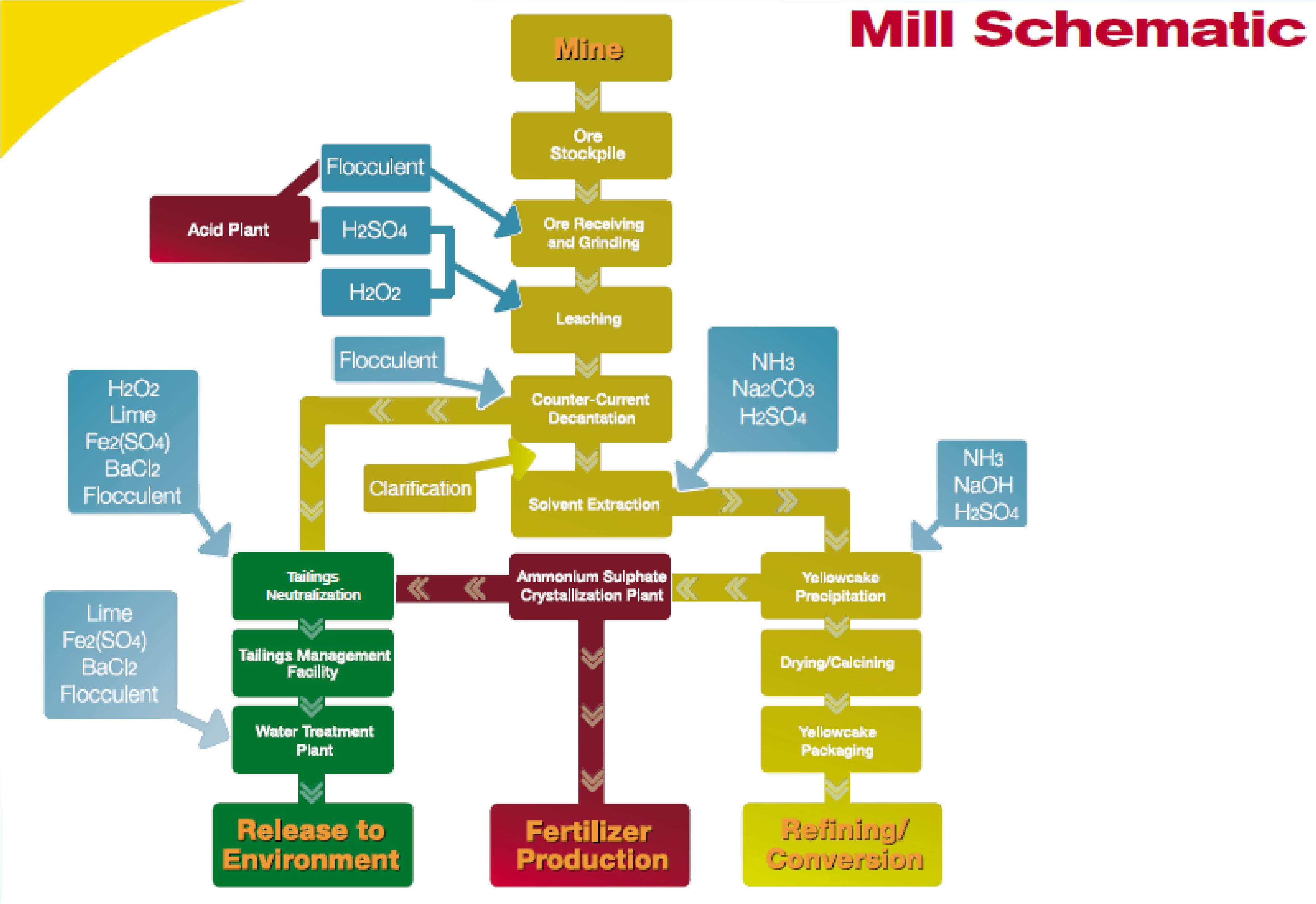


General Stages in Processing

- Ore handling and preparation
- Leaching uranium into solution
- Clarification and liquid/solid separation
- Concentration and purification
- Drying and packaging
- Final product storage and shipping
- Tailings preparation and storage
- Liquor treatment



Delve a Little Deeper



Good Radiation Protection Relies on Knowing the Process

- Processing causes the various radionuclides to behave differently according to their chemical and physical properties
- Dominant exposure pathways depend on the process
- Sometimes it is the small parts of the process with the most potential for occupational exposure

The Choice of Process

- The choice of process will be driven by a range of factors
  - Minerology
  - Ore grade
  - Other contained materials/minerals/contaminants
  - Other products
  - Availability of reagents
  - Quantity of material processed and uranium produced
  - Siting factors

Build your own Processing Plant

- Chose your ore preparation – mill or liquor from a leach plant (in situ or heap)
- Chose your leaching process – acid, alkali or from a leach plant (in situ or heap)
- Chose your means of clarification – Counter current decantation, clarifier/settler tank, flocculation tank, filtration circuit
- Choose your purification method – Solvent extraction, ion exchange
- Choose your drying method – low temperature drying, calcination
- Choose your tailings disposal methodology – surface disposal, underground disposal, in pit disposal, not required
- Are there any by-products produced

Model Answer Plant Design

- Conventional mill processing 5Mt pa of low grade ore
- Acid leach followed by CCD array and a clarifier tank and then sand filters
- Solvent extraction followed by precipitation using ammonia
- Centrifuge followed by calciner for packaging of U_3O_8
- Surface tailings disposal
- No by-product production

Determine the Exposure Pathways for your Plant

- For each stage assign a relative level for the importance of the exposure pathway
  - VH-very high, H-high, M-medium, L-low, VL-very low
- Special is for unusual cases such as maintenance

Determine the Exposure Pathways for your Plant

Stage/Pathway	Gamma	Radon Progeny	LLRD*	Special
Ore Handling				
Leaching				
Clarification				
Purification				
Drying				
Tailings				

* LLRD – Long Lived Radioactive Dust

Model Answer Exposure Pathways for your Plant

Stage/Pathway	Gamma	Radon Progeny	LLRD*	Special
Ore Handling	M	L (H*, M*)	L (wet based)	H* in tunnels, M* in buildings
Leaching	M (H*)	L (wet based)	L (wet based)	H* density gauge
Clarification	M (H*)	L (wet based)	L (wet based)	H* density gauge
Purification	L	VL (no Radium)	L (wet based) (H*)	H* maintenance
Drying	M (packing)	VL (no Radium)	VH	Contamination
Tailings	M	M	M	

* LLRD – Long Lived Radioactive Dust

What are the potential critical areas for radiation protection

?

Model Answer Critical Areas

- During normal operation the critical area will be in the drying and packing of the final product with exposure coming mainly from Long Lived Radioactive Dust (LLRD), some gamma and the potential for accidental ingestion from contamination
- Other areas of potential concern
  - Radon progeny in ore reclaim tunnels and other confined spaces in the early stages of the plant
  - Gamma exposure due to the use of density gauges
  - LLRD and potential contamination during maintenance work in solvent extraction and precipitation if the area becomes dry

What Monitoring is Required

- Gamma – which groups need personal monitoring, can monitoring be optimised
- LLRD – breakdown what radionuclides in what areas, how to determine, activity measurement
- Radon progeny – where and when in the plant to monitor
- Contamination – what is the critical area(s) and do you need biological monitoring (uranium in urine)
- Control Monitoring – what program needs to be developed to monitor controls?

Model Answer Monitoring

- Gamma – personal dosimetry for final product workers and maintenance personnel who work with density gauges, other workers use work group averages for gamma dose (dosimeter moved between individuals in work group each monitoring period). Periodic area monitoring to identify any areas of higher gamma dose rate and isolate or restrict entry as appropriate
- Radon progeny monitor in place in tunnels or during confined space access and duration of entry logged
- Personal LLRD used extensively for final product area and during dry based maintenance activities. Area monitors and low frequency personal monitoring used in other areas
- Periodic contamination monitoring in final product area and if frequent exceedances of derived levels occur than U in urine analysis considered

What are Some of the Critical Controls

?

Model Answer: Critical Controls

- The product packing area will have special controls to prevent the generation of LLRD and to reduce the potential for contamination these include:
  - Automated drum filling and sealing in a negative pressurised sealed area
  - Frequent wet based wash down of all work areas and immediate wet based clean up of any spills
  - All personnel require special clothing to enter the final product area (cleaned on site) with showering when leaving the area
- Entry to the ore reclaim tunnel and confined spaces restricted and monitored with entry permits and radon progeny measurements prior to entry. Forced ventilation is used if the radon progeny levels are above a trigger value
- Density gauges clearly identified and only qualified workers may move, operate or modify the density gauges
- Maintenance work in the solvent extraction and precipitation areas to be wet based. If dry based work is required then PPE and additional monitoring is required

Dose Assessment

- How do assess gamma for those not given personal monitors
- What is the dose conversion factor (DCF) for the various areas and what does it consider – radionuclides, particle size, solubility

Model Answer Dose Assessment

- For personnel in process areas not having personal monitoring, use workgroup averaging
- For LLRD, assume secular equilibrium up until leaching and clarification. After clarification the product process stream uses ^{238}U and ^{234}U. The tailings (solid) stream uses equilibrium minus ^{238}U and ^{234}U
- For the plant, except final product, use an AMAD (particle size) of 5μm and the highest DCF for each solubility of each radionuclide
- For the final product area, assume a AMAD of 5μm and conduct laboratory tests for solubility

Key Messages

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- Each processing plant is different and the radiation protection program must be optimised for the plant
- A successful radiation protection program relies on detailed understanding of radionuclide behaviour within the plant
- Use of assumptions such as equilibrium or gross measurements may lead to radiological issues
- Any chemical or physical process may disrupt equilibrium
- Knowledge of the process is the key to control and good radiation protection

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Thank you!