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International Atomic Energy Agency
Atoms for Peace and Development

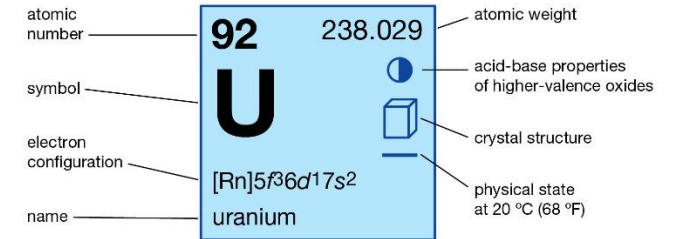
Introduction to Uranium Mining and Processing

Training Course for Occupational Radiation Protection in Uranium Mining and Processing

Uranium – A Global Perspective

- Uranium is a relatively common constituent in the earth's crust and is present in low concentrations in most materials
- Via various **geological and hydrogeological processes** uranium may concentrate to such an extent that **it is viable to mine and process**
- **The discovery, exploitation and closure of these deposits are the basis of uranium mining and processing**

Uranium



 Actinide elements	 Solid
 Orthorhombic	 Equal relative strength

Uranium Reserves

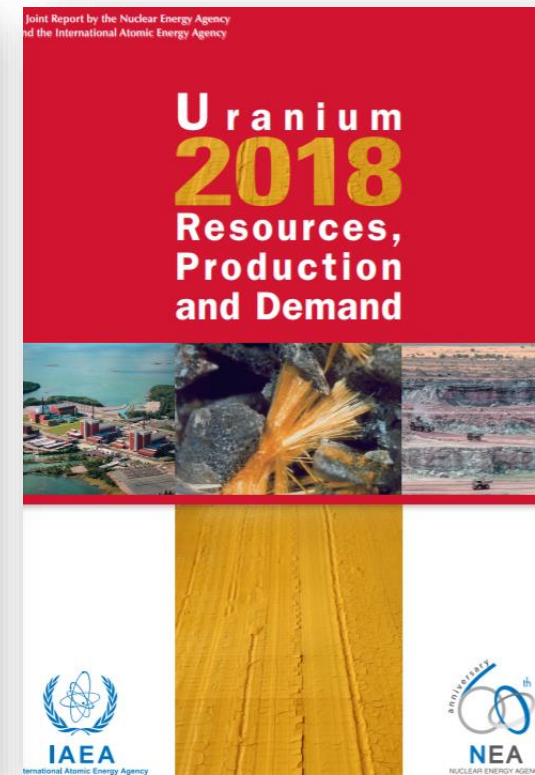
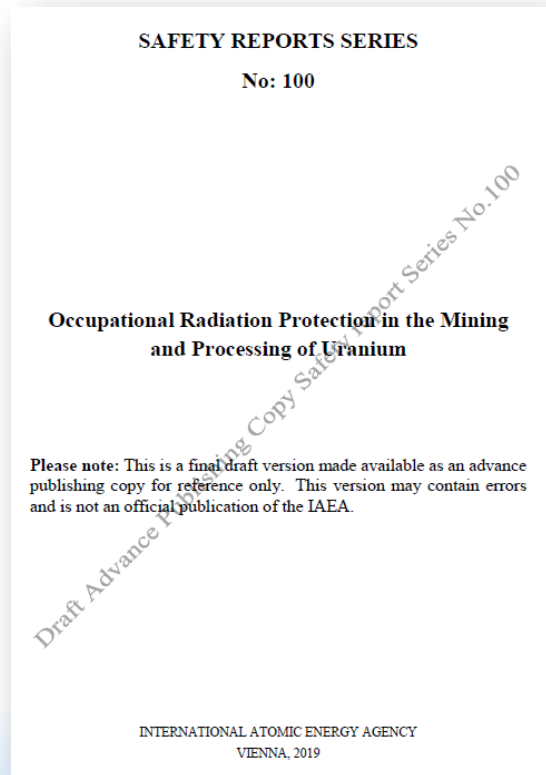
- **Global reserves of uranium are highly dependent on the cost of extraction**
- The IAEA Red Book detailed that 2017 reasonably assured resources of uranium were 713 thousand tonnes with a recovery cost of <US\$40/t
- More resources are present but have a higher cost for recovery or are in areas where mining is not possible

Uranium 2018 Resources, Production and Demand



Uranium Production

- Worldwide global production of uranium is driven **by a range of factors** but currently it is driven by economics (the uranium price)
- As of 2017 (IAEA Red Book) the global production was 62 thousand tonnes of uranium



Types of Uranium Operations

- There is a **wide range of different types of uranium deposits** and as such the choice of extractive approach is dependent on the **specific feature of the deposit** as well as other site specific factors
- Examples of some of the approaches include
 - Underground Mining
 - Surface Mining
 - In-Situ Leaching
 - Heap Leaching
 - Non-Conventional Uranium Extraction
- Associated with these approaches are initial exploration, processing, disposal of waste material (i.e. tailings), transport of material and decommissioning of the mine and associated facilities

Types of Uranium Operations

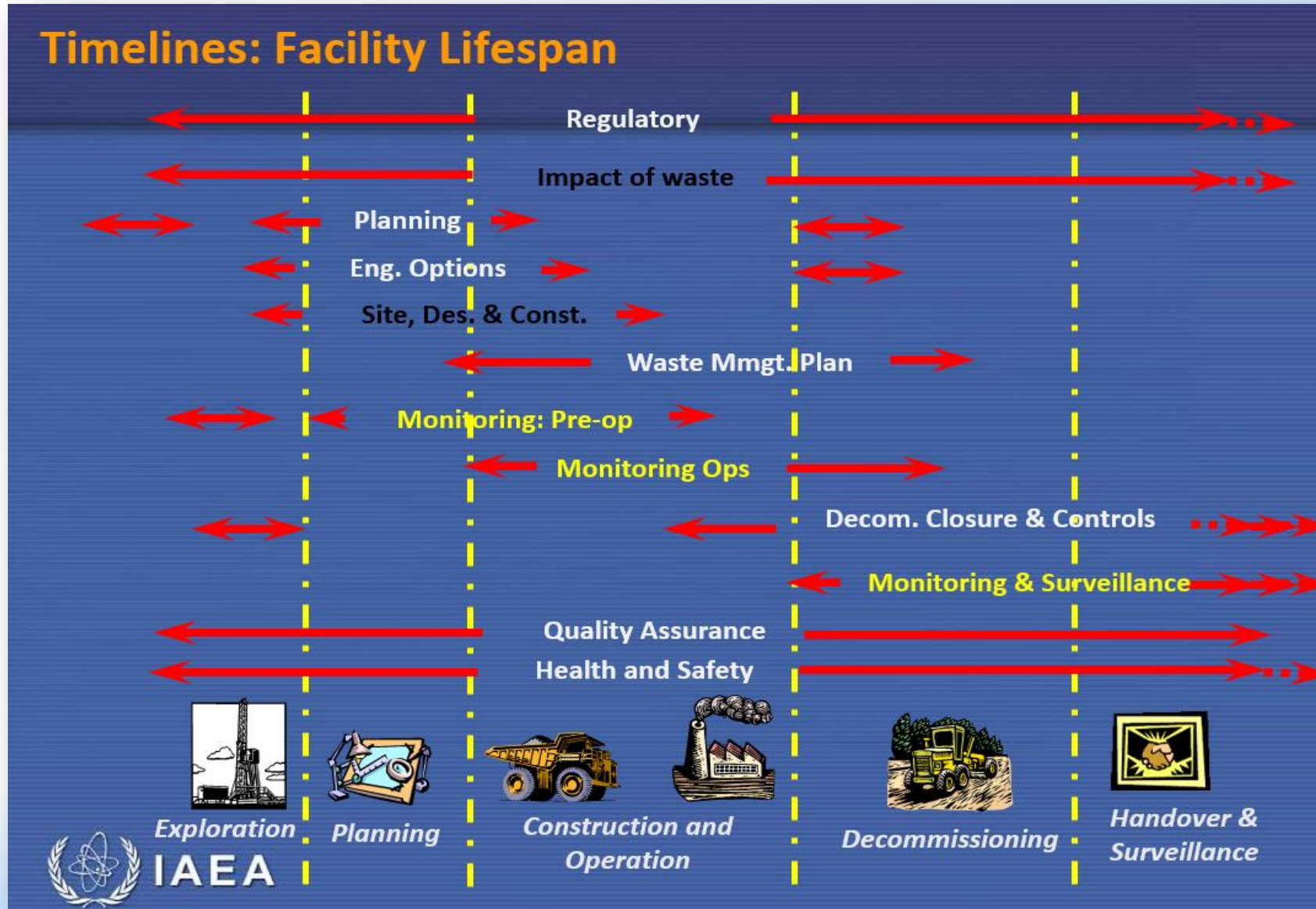
- The different types of uranium operations may have different **risks with respect to radiation protection**
- Some mining approaches may require special measures for specific hazards where as they may not be of concern for other mines
- A “one size fits all” approach is unlikely to be the best for radiation protection purposes



Stages of a Uranium Operation

- Irrespective of the type of a uranium operation there are a number of stages which will occur:
 - Exploration
 - Planning
 - Construction
 - Operation
 - Decommissioning
 - Handover and Surveillance
- **Each of these stages have unique aspects which must be considered with respect to occupational radiation protection**

Stages of a Uranium Operation



Challenges of the different stages

- **Exploration**
 - often little awareness of radiation protection requirements, relies on worker actions rather than engineering controls
- **Design**
 - Good planning is critical to achieving strong radiation protection (i.e. engineering controls) during operation but it is often a secondary design consideration
- **Operation**
 - The major area for potential occupational exposure and where active controls are in place
- **Decommissioning**
 - Occupational radiation protection often a secondary issue but there are potentially high exposures if controls are not in place
- **Handover and Surveillance**
 - Generally a low exposure stage

Characteristics of Uranium Extraction (Difference)



- **Fundamentally the only significant difference between uranium mining and other mines is the need for radiation protection**
- Generally conventional hazards (physical and chemical) are far more significant in terms of real risk than any radiological risks
- However, radiation risk is of significant concern to the majority of stakeholders (both internal and external) and a strong emphasis is given to ensure radiological protection
- By having strong radiological protection practices in place you can significantly reduce conventional risks.
- Conversely, radiation protection can be incorporated into conventional health and safety systems as the methodologies are very similar

Key Messages



- **Uranium is not uncommon but commercially viable deposits are rare.**
- The viability of a uranium deposit is heavily dependent on the uranium price.
- There are a range of different extractive approaches and the correct one is the one which suites the **deposit and the site specific factors.**
- **A uranium extraction operation goes through a number of different stages with their own radiation protection challenges.**
- Apart from the need to protect against radiation, mining and processing approaches are similar to that used for other minerals.
- Generally the **conventional occupational health and safety (OHS) risks are far higher than** the radiological risk but the control for both conventional and radiological risk go hand in hand.

Guidance Questions



- Why is there not a single simple approach to uranium mining?
- How does the different stages in the life span of an operation affect the approach to radiation protection?

Guidance Questions



- Why is there not a single simple approach to uranium mining?
 - The correct approach depends heavily on the nature of the deposit (depth, grade, location, geology) and local site factors (climate, topography, social factors, water, political, etc.)
- How does the different stages in the life span of an operation affect the approach to radiation protection?
 - Radiation protection needs change as the operation develops.
 - During exploration there are less engineering controls and a strong reliance on workers.
 - Planning has no risks but correct design will prevent or reduce risks at later project stages.
 - Operational stages have the most risk but also the strongest active controls.
 - Decommissioning may potentially have high risks but lower active controls due to loss of knowledge.



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Thank you!

