Storage of Radioactive Waste

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Frederik Van Wonterghem

Federal Agency for Nuclear Control

BVS-ABR E&T event

Radioactive waste "from cradle to grave"

23-09-2022

Overview

1. **Storage of radioactive waste and spent fuel**
   - Definition, reasons for storage
   - Types of storage
2. Safety Requirements for (interim) waste storage facilities
   - International
   - National
3. Current issues in waste storage

Storage of radioactive waste and spent fuel - Definition /Reasons

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- **Storage =** The holding of spent fuel or of radioactive waste in a facility that provides for their/its containment, with the intention of retrieval. (WENRA)
- Reasons:
  - Decay storage before discharge or clearance
  - Buffer storage: collect & accumulate sufficient amount before treatment & conditioning
  - Long term storage awaiting disposal facility
- Covers wide range of facilities for the storage of spent fuel and radioactive waste, for which the hazard potential may vary significantly

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Different types of storage

- Location:
  - On site
  - Off site (centralized or national waste storage)
- Storage periode : days → decades
- Radioactive inventory:
  - Low / medium level waste
  - High level waste
  - Spent Fuel
- Physical form: liquid, solid, (un) conditioned

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Decay storage

- Important for clearance of radioactive waste containing short lived isotopes: laboratories, hospitals,…
- Decay storage period should be long enough to reduce the initial activity to levels lower than the clearance levels
- Segregation from other types of waste

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Storage of low/medium level waste

- Low level waste: e.g. conditioned 400 l barrels destinated to surface disposal
- Safety functions: confinement, shielding
- Examples: Belgoprocess 151X

COVRA (NL)

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Storage of high level waste

- High level waste: e.g. vitrified waste from reprocessing
- Safety functions: shielding, heat removal, confinement
- Examples: Belgoprocess building 136X

COVRA (NL)

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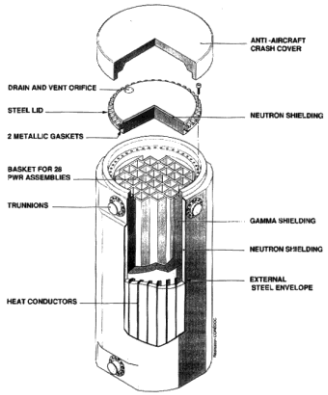
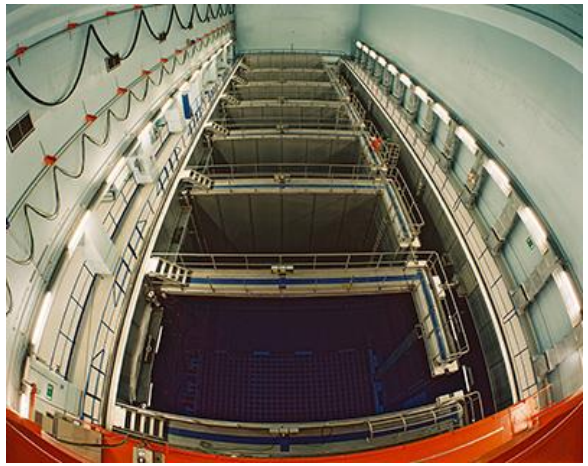
Storage of spent fuel

- Storage types:
  - Dry storage in casks or vaults
  - Wet storage in spent fuel pools
- Safety functions: subcriticality, shielding, heat removal, confinement
- Examples :

SPG - Doel



Tihange – Building DE



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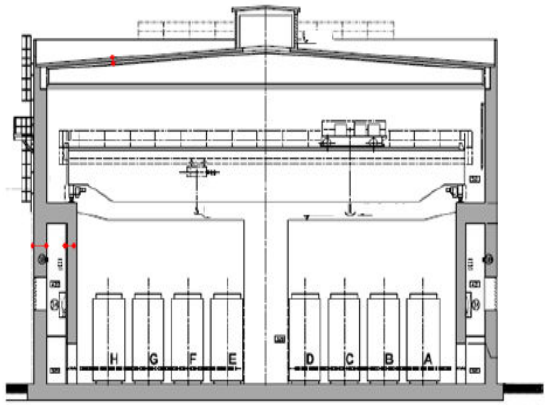
New Spent fuel storage facilities (SF^2) - Doel & Tihange

- Additional storage capacity necessary to remove spent fuel from the reactor pools to enable their decommissioning
- SF^2: spent fuel storage facilities developed by EBL for its two sites at Tihange and Doel. Concept is based on dry storage in dual purpose casks.



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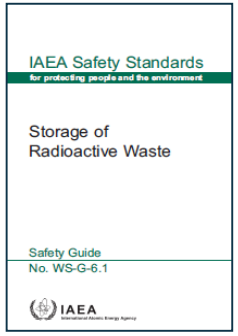
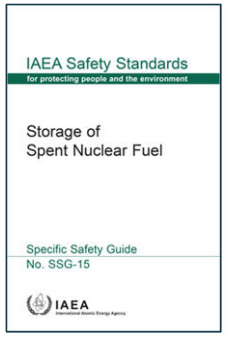
Safety requirements for interim storage facilities

- International :

  IAEA safety standards





WENRA reference levels ➔ National requirements

WENRA reference levels transposed into Belgian legislation:

- <u>General requirements</u> for nuclear installations:
  already transposed earlier via R.D. 30/11/2011 “Safety prescriptions for nuclear installations” (“KB-Wenra”)
- <u>Specific requirements</u> for waste and spent fuel storage facilities:
  transposed via R.D. 29/5/2018 (“KB-Opslag”)
  supplementing the R.D. 30/11/2011 with a new chapter 4, concerning the storage facilities for spent fuel and packages with radioactive waste

Safety requirements for interim storage facilities

CHAPTER 4 – Specific safety prescriptions related to storage facilities for spent fuel and packages with r.a. waste
SECTION 1 – Design and implementation of the installation

Art. 33: Safety functions for the storage facility

- Fulfil the fundamental applicable safety functions:
  - ❑ Control of sub-criticality,
  - ❑ Removal of heat,
  - ❑ Radiation shielding,
  - ❑ Confinement of radioactive material,
  - ❑ Retrievability

during normal operation and design base accidents

Safety requirements for interim storage facilities

CHAPTER 4 – Specific safety prescriptions related to storage facilities for spent fuel and packages with r.a. waste SECTION 1 – Design and implementation of the installation

Art. 34: Design and implementation

- Take into account the expected operational lifetime of the facility ➔ ageing of SSC
- Incorporate passive safety features as far as reasonably practicable
- Design of adequate handling equipment
- Possibility for inspections of waste or spent fuel to ensure continued integrity during storage
- Possibility to retrieve the waste or spent fuel within reasonable time
- Specify and justify a nominal utilisation rate (reserve storage capacity)

➔ Different choices in storage type have consequences on inspection and retrievability possibilities !

Safety requirements for interim storage facilities

CHAPTER 4 – Specific safety prescriptions related to storage facilities for spent fuel and packages with r.a. waste SECTION 2 – Operation of the storage facility

Art. 36: Operation

- Inspections: as described in inspection program (cfr. Art. 38)
- Correct management of and maintaining the reserve storage capacity
- Inventory : develop and maintain a record system for stored spent fuel/r.a. waste (location, activity, physico-chemical characteristics, volume, mass,…) + keep inventory up to date
- Unique identification with a marking system that will last for the whole storage period

Art. 37: Acceptance criteria

- Acceptance criteria for storage of spent fuel/r.a. waste packages in the installation : with purpose to be compliant with the OLC's

Safety requirements for interim storage facilities

CHAPTER 4 – Specific safety prescriptions related to storage facilities for spent fuel and packages with r.a. waste
SECTION 2 – Operation of the storage facility

Art. 38:Inspection program

- Develop, optimise and implement an inspection program

  Goal = verification of the continuing compliance of the stored spent fuel/r.a. waste packages with the OLC's specified in the safety case
- Program shall adress at minimum :
  - Required ambient conditions in the storage facility (temperature, humidity,…)
  - Physical condition of the spent fuel/r.a. waste packages

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Current issues in waste storage

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Storage capacity

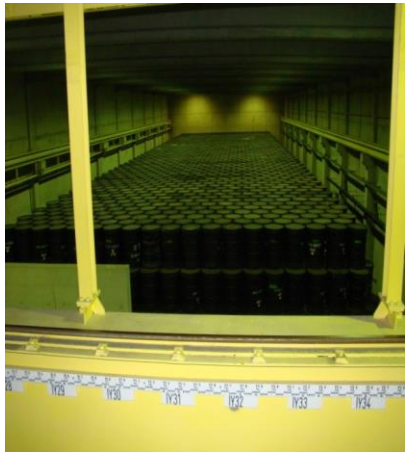
- Large volumes expected from decommissioning projects
- Requires additional storage capacity
- When is a storage facility completely full?
- Optimizing storage capacity
  - <-> ALARA
  - <-> Handling and inspection capability

    e.g. pyramidal stacking of colli -> limited accessibility and visibility

    -> difficult to retrieve non-conform waste packages

    -> risk of contaminating underlying colli in case of leaking colli
  - <-> Safety margins

    e.g. spent fuel re-racking: no longer relying on safe geometry only, but also on correct positioning of additional neutron absorbers, which can degrade in the long run



Current issues in waste storage

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Long term storage

- Disposal of waste often delayed (spent fuel,…)
- Operational lifetime storage facility > original designed lifetime
- Ageing management becomes more an issue
  - Storage facility systems
  - Spent Fuel Casks
- Design of older facilities not up to current standards
- Need for additional inspections of waste packages and/or new facilities?

Current issues in waste storage

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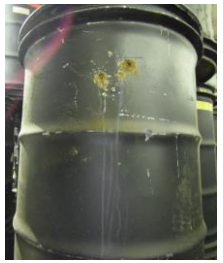
Degradation of stored waste and spent fuel

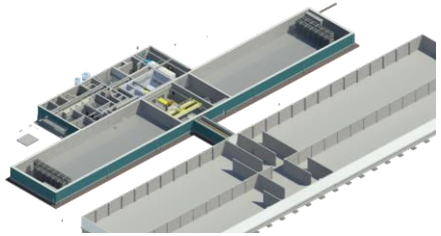
- Long storage periods allow for slow degradation phenomena to become apparent

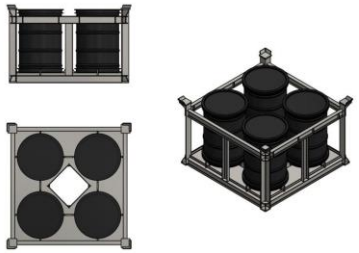
corrosion



alkali-silica reaction

- Contingency measures often require additional waste storage and treatment installations





Conclusions

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- Storage of Waste and Spent Fuel important aspect in waste management
- Requires appropriate design and operation of storage facility:
  - Storage period
  - Safety functions
  - Acceptance criteria for waste packages
  - Inspection programs
- Long term storage requires adequate ageing management programs