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*November 3rd 2015, Brussel*

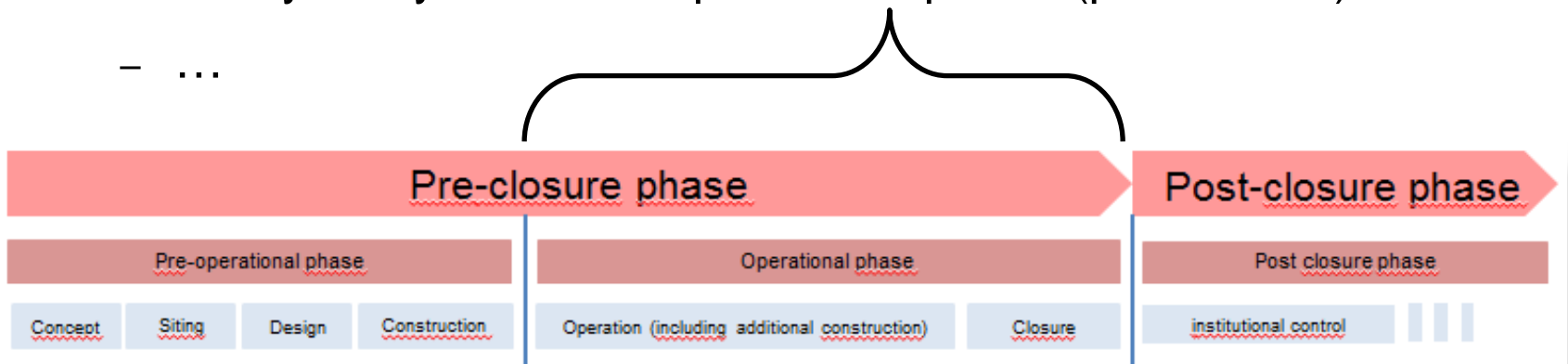
# Accident analyses for deep geological repositories in Germany

# Safety Case

- GRS has long experience
- proof of safety for final disposal facility
- includes a number of different safety analyses

for example:

- long - term safety analysis (post closure)
- safety analysis for the operational phase (pre closure)
- ...

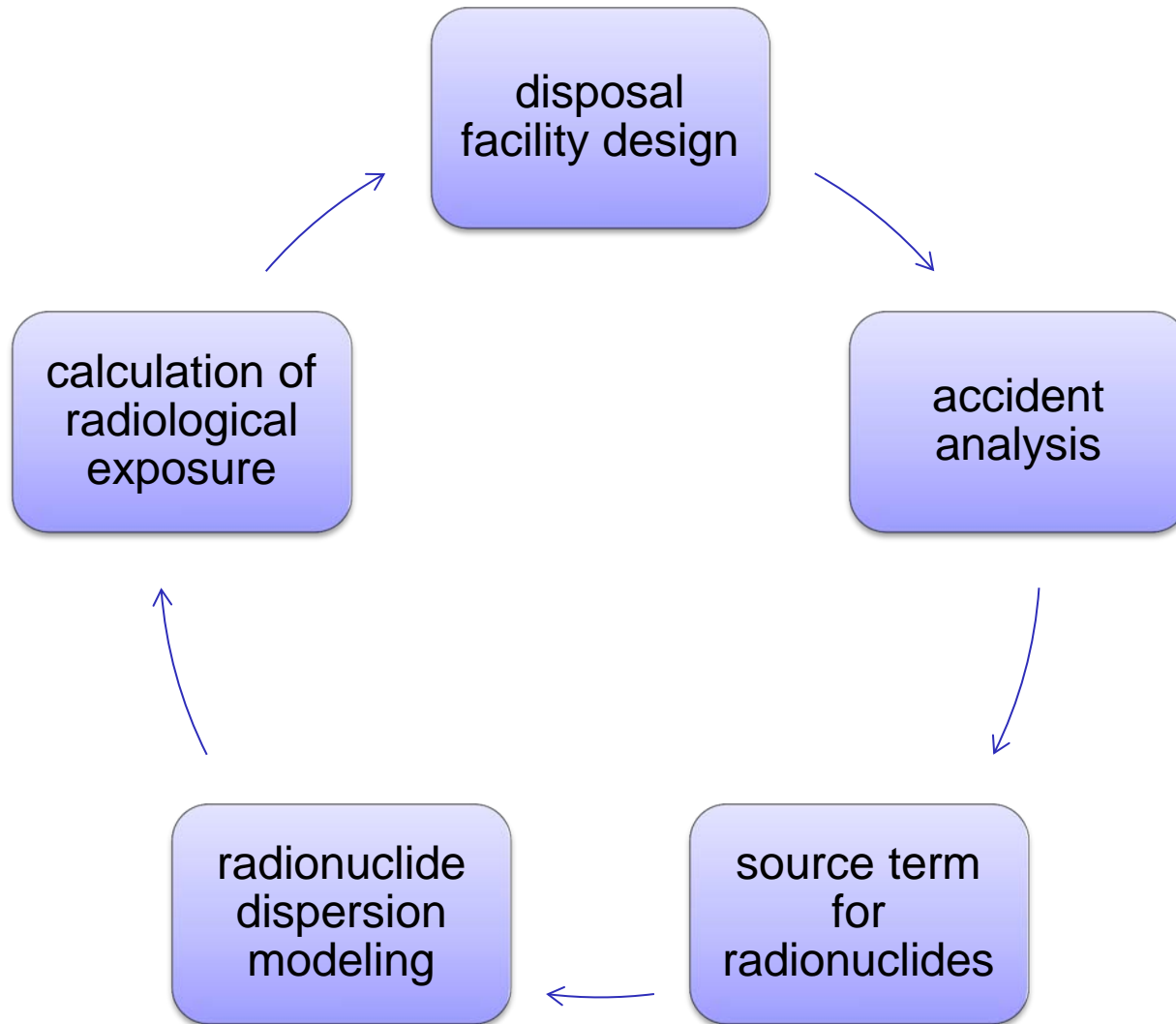


reference: IAEA TECDOC "Managing integration of pre-closure and post-closure safety in the Safety Case for Geological Disposal"

# Safety analysis for operational phase

- proof of safety during operational phase
- includes an examination of **malfunctions and incidents** (e.g. hoisting cage crash, fire)
- accident analysis
  - based on deterministic approach
  - iterative process

# Iterative process



# Accident analysis in Germany

- Based on accident analysis for nuclear power plants (NPP) from 1983 (analogously)
- German approach includes following aspects
  - event analysis
  - categorisation of incidents
  - grouping of similar incidents
  - identification of covering incidents
  - derivation of incidents not excludable
  - calculation of application of energy



# Event analysis

- screening for incidents with potential radionuclide releases
- contemplation of entire disposal facility and surrounding area (site characteristics)
- especially consideration of transport - path of waste containers and involved components (sequence of operation)
- consideration of provisions made
- result: „list of potential incidents“
- trigger can be internal and external hazards



reference:  
<http://www.abwassersysteme.info/Bilder%20HP%206.4.10/analysieren.jpg>

# Categorisation of incidents

- in reference to time of operation
- two categories
  - not excludable incidents
  - avoidable incidents
- not excludable incidents
  - implications have to be limited
- avoidable incidents
  - are assigned to residual risk



reference: <http://thetechnicgear.com/wp-content/uploads/2014/02/sorting-lego.jpg>

# Categorisation of incidents

- using expert judgement and by considering
  - operational experience
  - technical feasibility
  - provisions
- supported by probabilistic calculations



reference: <http://thetechnicgear.com/wp-content/uploads/2014/02/sorting-lego.jpg>



# Grouping of similar incidents

- objective
  - reducing the number of incidents to be considered
- grouping incidents (separately for each facility area)
  - analog sequences
  - similar implications
- therefore analysis and comparison of
  - sequences of each incident
  - implications of each incident
  - provisions for each incident



# Covering incidents

- objective
  - focus on incidents with highest implications
- identifying highest implications for each incident - group
- outcome
  - „list of covering incidents“



reference: <http://getafteritsales.com/wp-content/uploads/2015/07/Brett-Zalaski-Group-Leader.jpg>

## Not excludable covering incidents

- Identify not excludable incidents in „list of covering incidents“
- focus on not excludable incidents for derivation of load assumptions

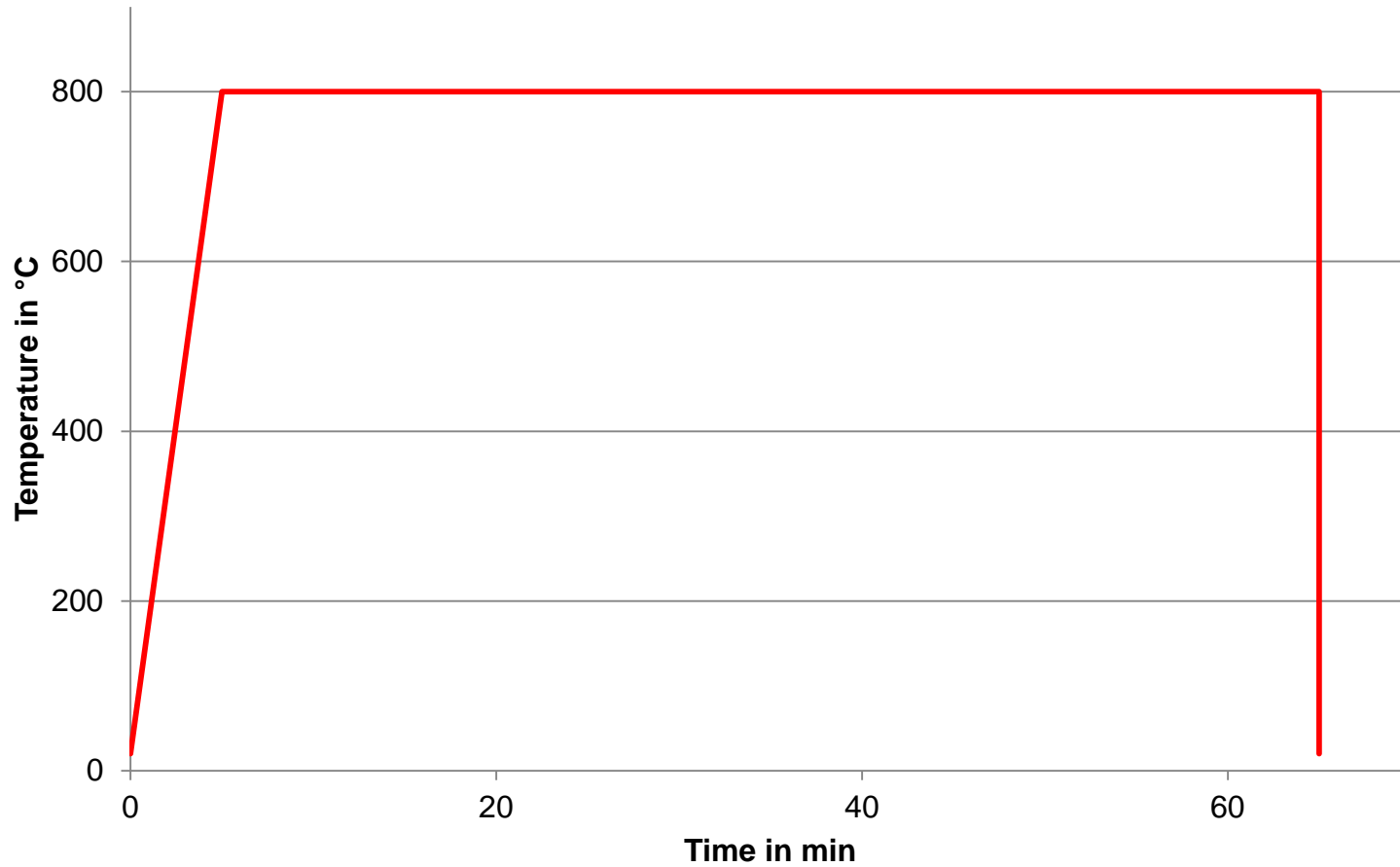


reference: <http://thetechnicgear.com/wp-content/uploads/2014/02/sorting-lego.jpg>

# Load assumptions

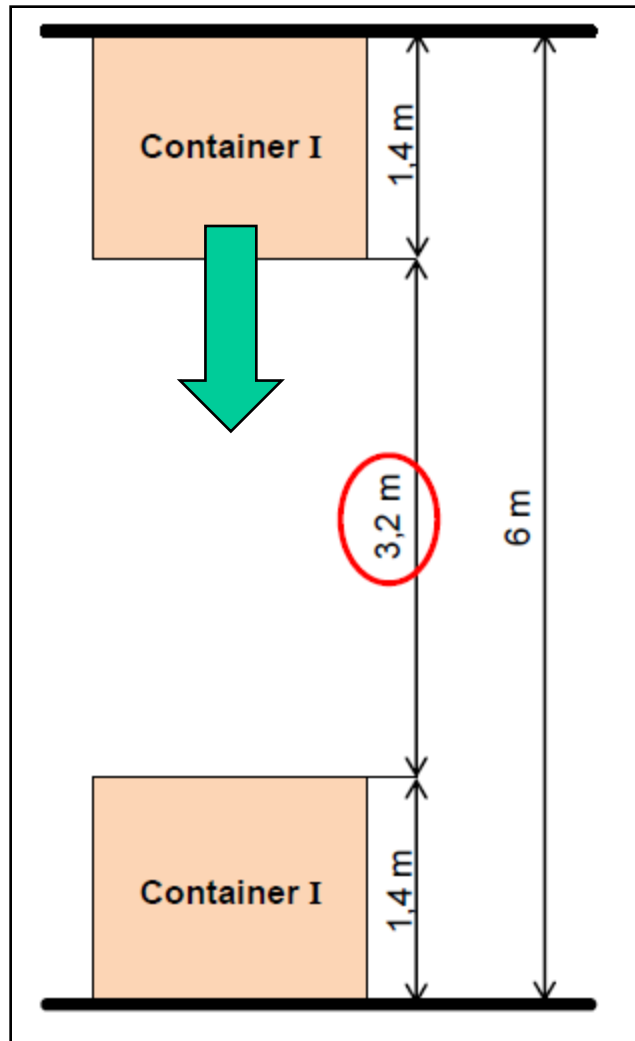
- numeric implications
- classification by type of load
  - mechanical load
  - thermal load
- defined for not excludable covering incidents by considering
  - provisions

# Load assumptions



reference: Stephan Uhlmann - Überprüfung der betrieblichen Sicherheitsanalyse der Schachanlage Konrad mit dem Schwerpunkt der thermischen Störfälle auf den Stand von Wissenschaft und Technik, 2013

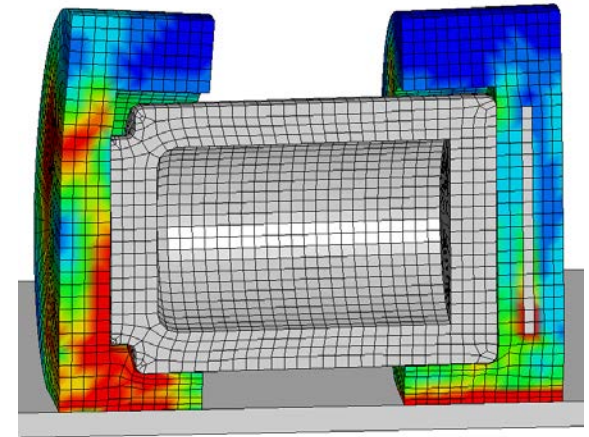
# Load assumptions



reference:  
Angelika Krischer - Überprüfung der Störfallanalyse für das Endlager Konrad  
mit den Schwerpunkten Konzeptprüfung und Analyse mechanischer Lastannahmen, 2013

# Input Force

- calculation of the input force into the waste package / waste
- thermal load
  - experiments and simulation of the heating of the waste by using computer software
- mechanical load
  - experiments and simulation of the mechanical load on container by using computer software



reference: [http://www.wti-juelich.de/vorlagen/berechnungen\\_mosaik.png](http://www.wti-juelich.de/vorlagen/berechnungen_mosaik.png)

## Next Steps

- definition of source term
- radionuclide dispersion modeling
- calculation of radiological exposure at point with the highest radiological exposure
- dose limit of 50 mSv per incident (effective dose) by the § 49 StrISchV (Radiation Protection Ordinance)



reference: [http://www.rochumanresources.com/images/stories/istock\\_000015674373small.jpg](http://www.rochumanresources.com/images/stories/istock_000015674373small.jpg)



# International comparison

- similar methods in Sweden and Switzerland
  - deterministic methods
  - probabilistic methods
- IAEA advices
  - deterministic methods for accident analysis of disposal facilities
  - probabilistic methods for determination of probabilities of incidents
  - Intentions for stronger combination of deterministic and probabilistic methods



reference: <https://www.iaea.org/sites/default/files/images/2012/04/flagsvic330x200.jpg>

## GRS research project

- addresses the enhancement of the methodology of the accident analysis for deep geological repositories (DGR)
- review of
  - methodologies to deviate incidents (screening)
  - probabilistic methods like the PSA for NPP
- check if methodologies can be transferred, adapted and applied in the accident analysis for DGR
- key aspects
  - stronger integration of probabilistic methods
  - screening process in scenario development for long term safety analysis



# Thank you for your attention