1

Context

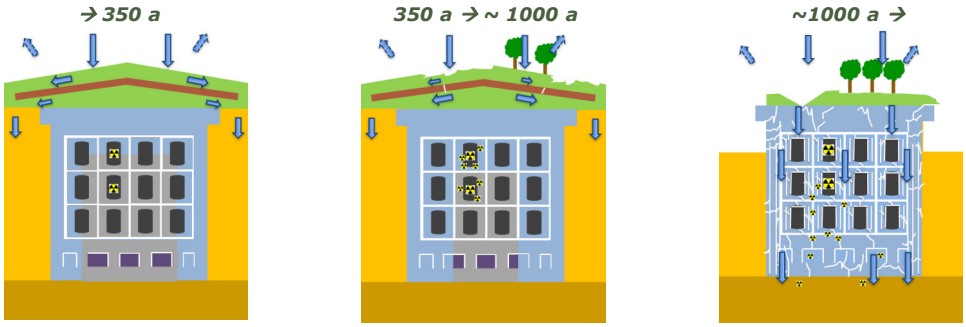
- License application is underway
  - Royal Decree for the creation & operating licence in May 2023
    - ➔ Start of the Construction:
      - Public tendering on-going, 2024
      - Contractual delivery First Phase Q2 2028
  - Royal Decree for confirmation (expected ~ 2029)
    - ➔ Start of the Operation
- License with the **License conditions**

- Demonstrate that we are compliant with the **License conditions**
  - Construction
  - **Waste ➔** ***Demonstration of the "Disposability" of the category A waste (conformity criteria)***

2

2

Why new conformity criteria?



➔ The waste should not disturb the expected evolution of the system

No negative impact on the EBS
➔ Limitation:
- Chloride (corrosion)
- Sulphate (attack of concrete)

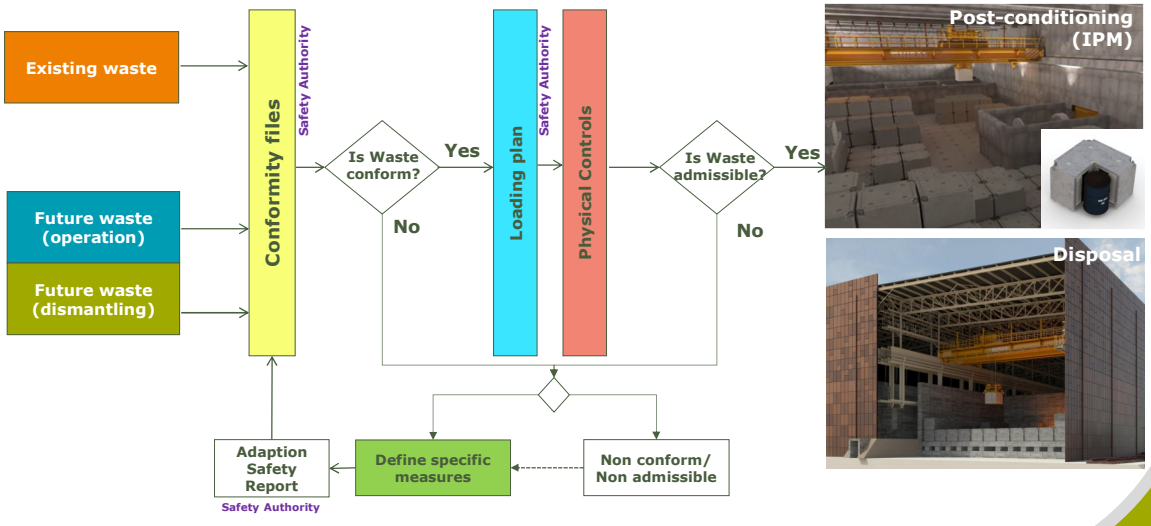
➔ No expansive reactions
(e.g. ASR = Alkali-Silica-Reaction for concrete waste)

No significant increase of the radiological impact (leaching)
➔ limitation chloride and cellulose (Complexation)

3

3

Demonstration of the "Disposability" of the category A waste : The process



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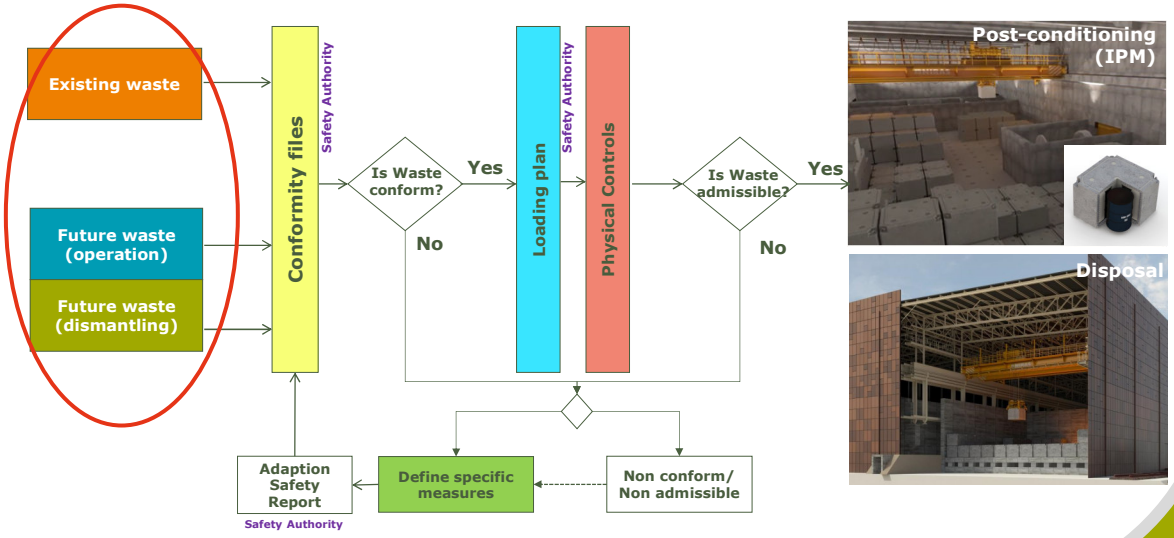
Demonstration of the "Disposability" of the category A waste : The process



5

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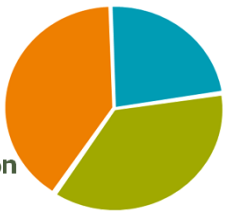
Inventory of category A waste: 32 Modules

Existing waste
12.8 Modules

Future waste (operation)
7.2 Modules

Future waste (dismantling)
11.7 Modules



Waste produced based on **current ACRIAs** (i.e. generic surface disposal)

➔**loading of the missing information** (to check conformity with the conformity criteria) with waste producers

Waste will respect the **new ACRIAs** that are coherent with the conformity criteria of the safety report

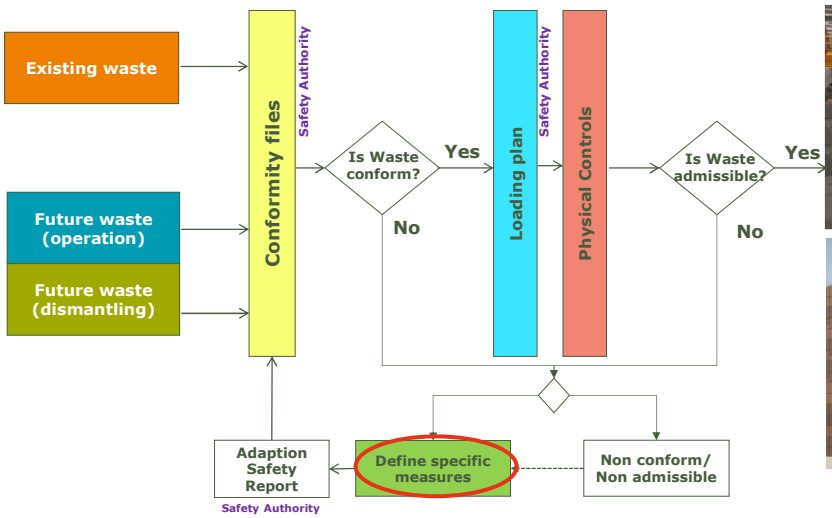
➔ **Extend the waste acceptance system (until disposal)**

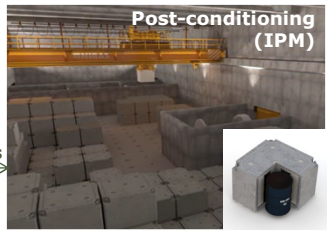
➔ **Production of conform waste (waste producers)**

6

6

Demonstration of the "Disposability" of the category A waste : The process





7

7

Define specific measures

Modification of parameters / models

Objective: Reduction of the level of conservatism/uncertainty ➔ new scientific knowledge (e.g. R&D on sorption values)

Modification of the EBS

Objective: Make the waste compatible with the disposal system by adapting the EBS - Engineered Barrier System (e.g. compressible materials, fiber reinforced concrete)

Modification of the waste

Objective: Make the waste compatible with the disposal system by adpating the waste (e.g. Thermal treatment of the waste)

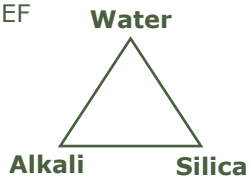
8

8

Avoiding processes that can lead to expansion

Processes that can lead to expansion of the waste must be avoided in the period during which the physical integrity of the SSCs is counted upon

- Two processes identified for cement materials: ASR and DEF
- **ASR (Alkali-Silica-Reaction)**
  - Swelling reaction that occurs over time in concrete between **highly alkaline cement paste** and the **silica** (aggregates, sand) in presence of **water**



- DEF (Delayed Ettringite Formation)
  - Ettringite is a normal product of early cement hydration
  - If high early temperature in the concrete occurs, this will prevent the normal formation of ettringite
  - A delayed formation could occur (rate and extent of the expansion depends on available water)
  - And could create expansion and cracking of concrete

9

9

Avoiding processes that can lead to expansion

Processes that can lead to expansion of the waste must be avoided in the period during which the physical integrity of the SSCs is counted upon

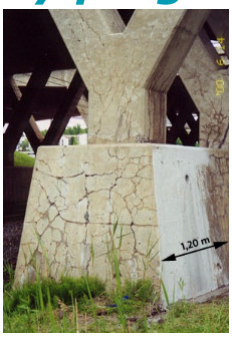
- **For a cemented waste package:** conditionering matrix (heterogeneous waste) or waste form (homogeneous waste) must be **insensitive to ASR**
  ➔ To be demonstrated through representative samples and appropriate tests (ASTM C 1260 of ASTM C 1293)
- **For a cemented waste package** the conditionering matrix (heterogeneous waste) or the waste form (homogeneous waste) must:
  - Have an evolution of its internal temperature ≤ 60°C
  - be **insensitive to DEF**. Insensitivity to be demonstrated through representative samples and appropriate tests
- In case of **Concrete Waste** in **waste package** or in a **MON$_{III}$**, must be insensitive to ASR and DEF. Insensitivity to be demonstrated based on the waste properties or through representative samples and appropriate tests

10

10

ASR – Link to disposability programme

Risk observed for Homogeneous cementation of concentrates
➔ ASR Reaction



"Concrete Waste" (dismantling) represents about 50% of the first tumulus
➔ ASR to be avoided

ASR top 1 priority!

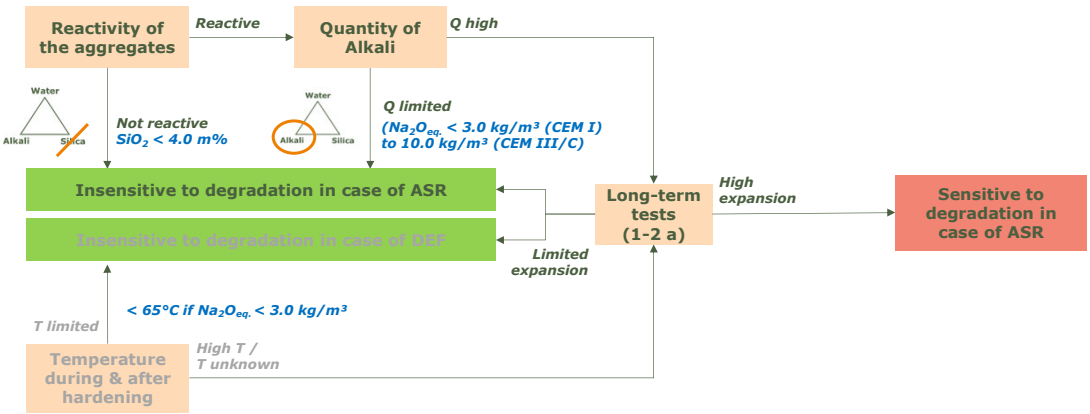
Raw estimate – for illustrative purpose only

11

11

Avoiding processes that can lead to expansion (expected evolution)

Processes that can lead to expansion of the waste must be avoided in the period during which the physical integrity of the SSCs is counted upon



Safety study OK

12

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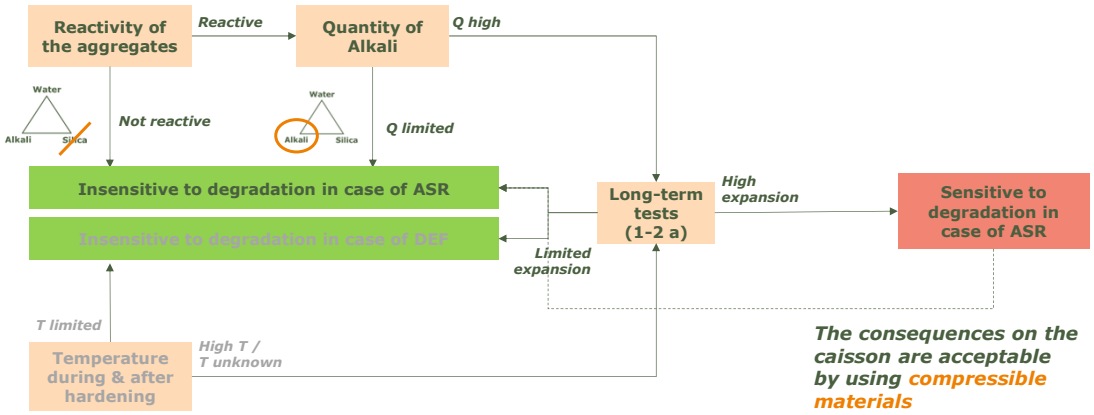
If not … Compressible Materials



The consequences on the caisson are acceptable by using compressible materials

Modification of the EBS

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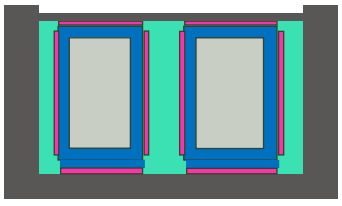
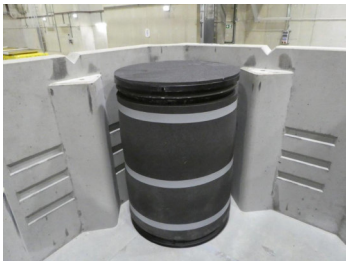
First conceptual prototypes – compressible material

Monolith Type I
with PE foam





Long-term R&D studies ongoing (potential degradation of the material, impact on the sorption)

Conceptual Prototypes to be tested

Caisson | Non-explosive cracking agent (waste) | Compressible material | Mortar | Metallic container

14

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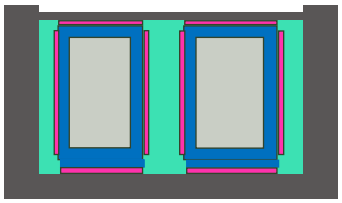
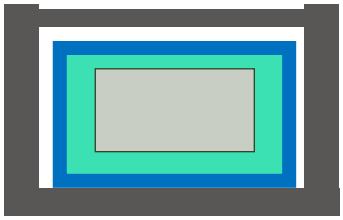
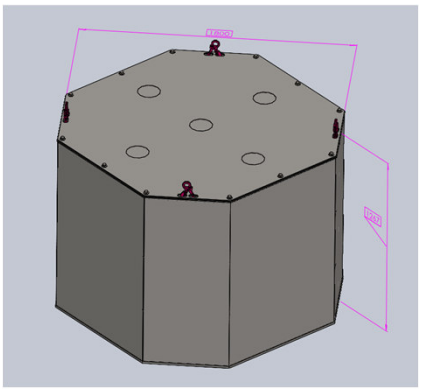
First conceptual prototypes – compressible material

Monolith Type I
with PE foam



Monolith Type III
with a box





First Design of the box

Conceptual prototypes to be built & tested

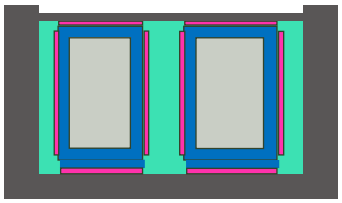
Caisson | Non-explosive cracking agent (waste) | Compressible material | Mortar | Metallic container

15

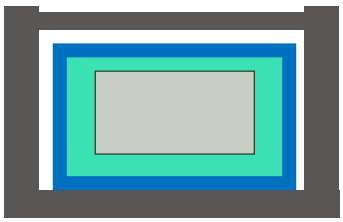
15

First conceptual prototypes – compressible material

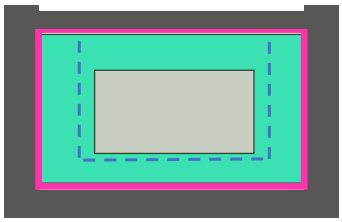
Monolith Type I
with PE foam

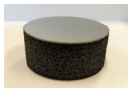


Monolith Type III
with a box



Monolith Type III
with RVC foam (carbon)





Carbon "inert"

Conceptual prototypes to be built & tested

Caisson | Non-explosive cracking agent (waste) | Compressible material | Mortar | Metallic container

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Limitation of Cellulose

Complexation due to the presence of cellulose (degradation product leads to the formation of complexing agent ISA) must not increase significantly the radiological impact

- Avoid, sort and incinerate
- If not possible, limitation to
  - **≤0.4 kg cellulose by monolith**
  - → limit by **waste package**: 0,4 kg divided by # of waste packages in a monolith
    - 220L: ≤0.08 kg
    - **400L: ≤0.1 kg**
    - 600L: ≤0.4 kg

ISA = Isosaccharine Acid

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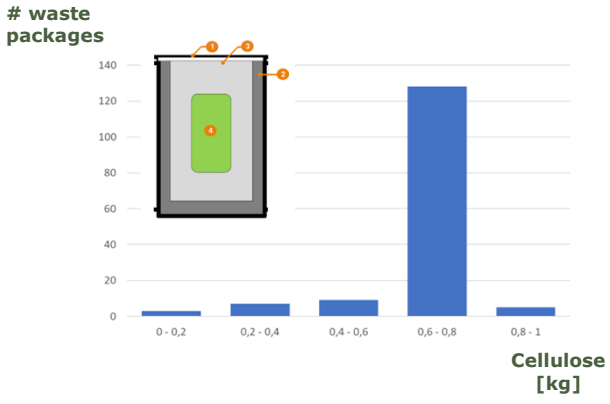
Cellulose – Link to disposability programme

Supercompacted waste

- Cellulose allowed up to **10 – 20 kg / 400L**
- From 2010, limit for non-conditioned waste: no info required if $M_{cellulose}$ < 0.5 kg
  3-5 compacted drums / 400L
  ➔ Risk: **1.5 – 2.5 kg in a 400L**

~ 50% NPPs' filters with cellulose



Raw estimate – for illustrative purpose only

18

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Limitation of Cellulose (expected evolution)

Complexation due to the presence of cellulose (degradation product leads to the formation of complexing agent ISA) must not increase significantly the radiological impact

- Avoid, sort and incinerate
- If not possible, limitation to
  - **400L:**
    - **0.1 kg if HCP [63-190[kg/m³**
    - **0.2 kg if HCP [190-316[kg/m³**
    - **0.3 kg if HCP [316-443[kg/m³**
    - **0.4 kg if HCP [443-570[kg/m³**
    - **0.5 kg if HCP [570-696[kg/m³**
  - **2.7 kg for a Monolith Type III**

Safety study OK

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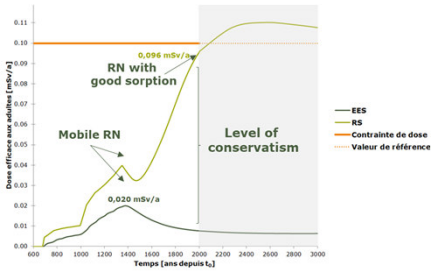
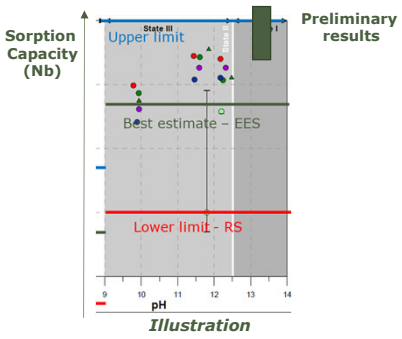
Limitation of Cellulose

- Cellulose:
  - **Future waste: sorting!**
  - Existing waste: Modification of the conformity criteria (~2-3 kg / 400L) by reducing the level of uncertainties and hence the high level of conservatism in the scenario

➔R&D project on sorption on cement





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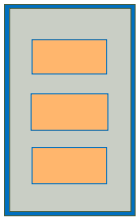
Limitation of chlorides

- Chloride-ions in the waste must not disrupt the surrounding concretebarriers by accelerated reinforcement bar **corrosion** in the period during which the concrete barriers are considered as non-degradated
- **Complexation** by the presence of chloride-ions in the waste must not increase significantly the radiological impact from lixiviation

- For a Type I/II Monolith (waste package): mass of chloride ions in waste form ≤ 0,4m% of cement mass of conditioning mortar
- For a MON_{III}: mass of chloride ions in waste form **≤ 0,4m%** of cement mass of filling mortar
- Chloride-ions = not for covalente bond
  ➔ PVC OK



400L:
Drum: 100 kg
Waste: 500kg
Conditioning mortar: 300kg
(Cement 100kg)

➔ 0.4 kg /Cl^- 400L

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Limitation of chlorides (expected evolution)

- Chloride-ions in the waste must not disrupt the surrounding concretebarriers by accelerated reinforcement bar **corrosion** in the period during which the concrete barriers are considered as non-degradated
- **Complexation** by the presence of chloride-ions in the waste must not increase significantly the radiological impact from lixiviation

- For a Type I/II Monolith (waste package): mass of chloride ions in waste form ≤ 0,4m% of cement mass **(Waste + conditioning mortar)**
- For a MON_{III}: mass of chloride ions in waste form **≤ 0,4m%** of cement mass **(Waste + filling mortar)**
- Chloride-ions = not for covalente bond
  ➔ PVC OK

Safety study OK

Chemichal & Biological conformity criteria

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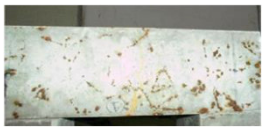
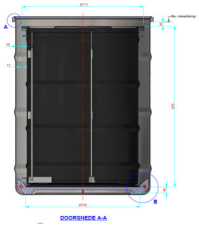
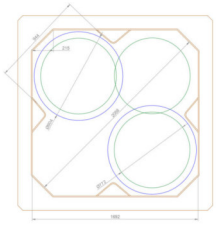
Other RD&D activities

- Fiber reinforced concrete for the caisson
  - Resistance corrosion ➔ 5 m%
  - However to increase the limit also sorption to consider (➔ R&D project on sorption on cement)

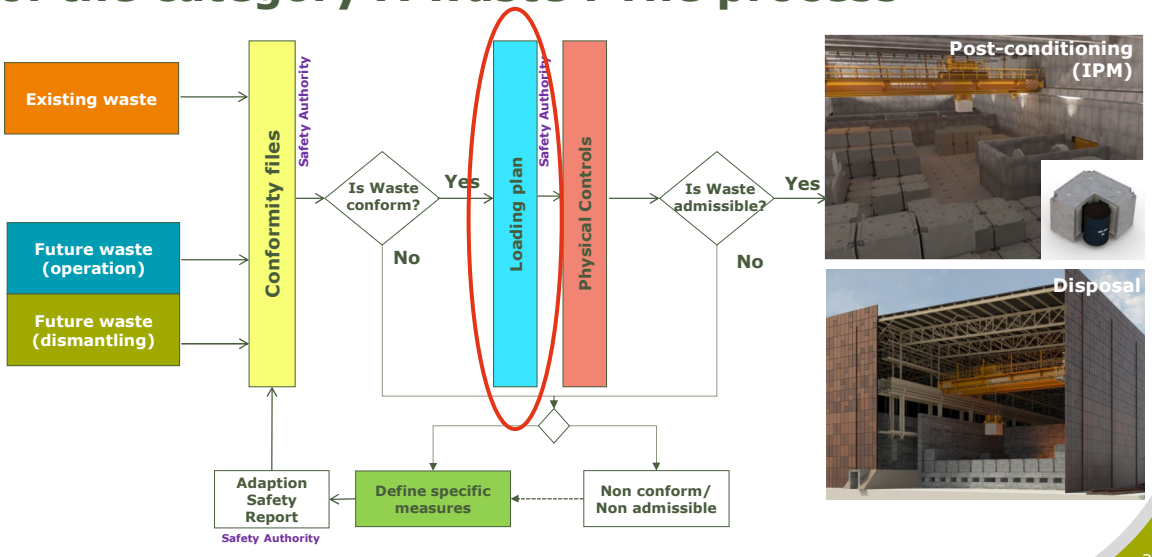


- Development of inox watertight overpack
  - To be reassessed after realization of prototypes for compressible materials



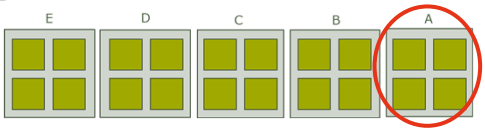


Demonstration of the "Disposability" of the category A waste : The process



DRAFT

The Phased loading plan



- Focus on 1 phase
  (4 modules filled simultaneously)
- **Preliminary loading Plan**:
  - Waste available for the operation of phase A
  - Existing waste & future waste
  - A priori conform waste & potentially conform waste (link BCDs)
  - First evaluation of the filling rules
- **Dynamic loading Plan**:
  - Continuous reality check & follow-up of the filling rules
  - Guide the production of the monoliths
- **Final loading Plan**:
  - Monoliths in the modules
  - Confirmation of the respect of the filling rules

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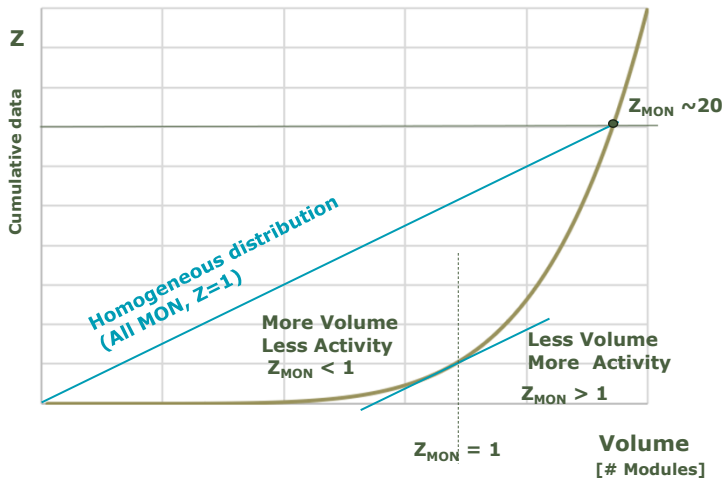
DRAFT - Preliminary loading Plan

Z is an important parameter for loading plan



Z defined for monoliths, modules, …

$$Z_{item} = \frac{1}{N}\sum_{i=1}^{N}\frac{\#items, tumulus\ oost\ \mathrm{x}\ A_{i,item}}{OLI_{i,tumulus\ oost}}$$

Z → 1 ("homogeneous")

Waste with **more** activity than the acceptable average concentration must be compensated by waste with **less** activity than the acceptable average concentration

Specific rules for the loading plan to limit the heterogeneity

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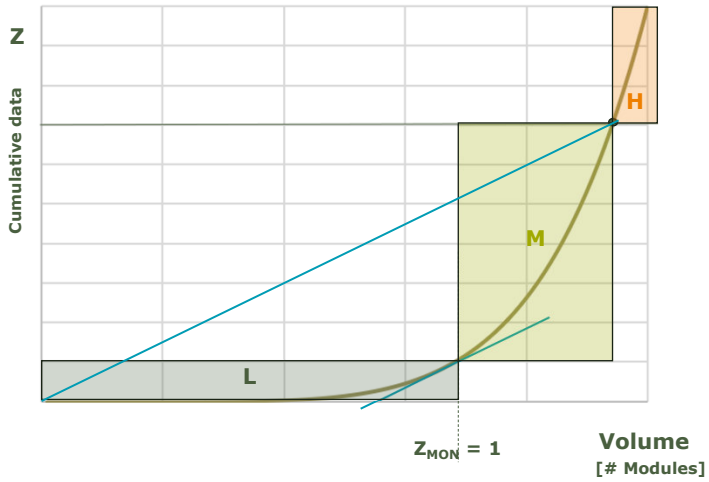
DRAFT - Preliminary loading Plan

Based on the Z curve, definition of 3 slices



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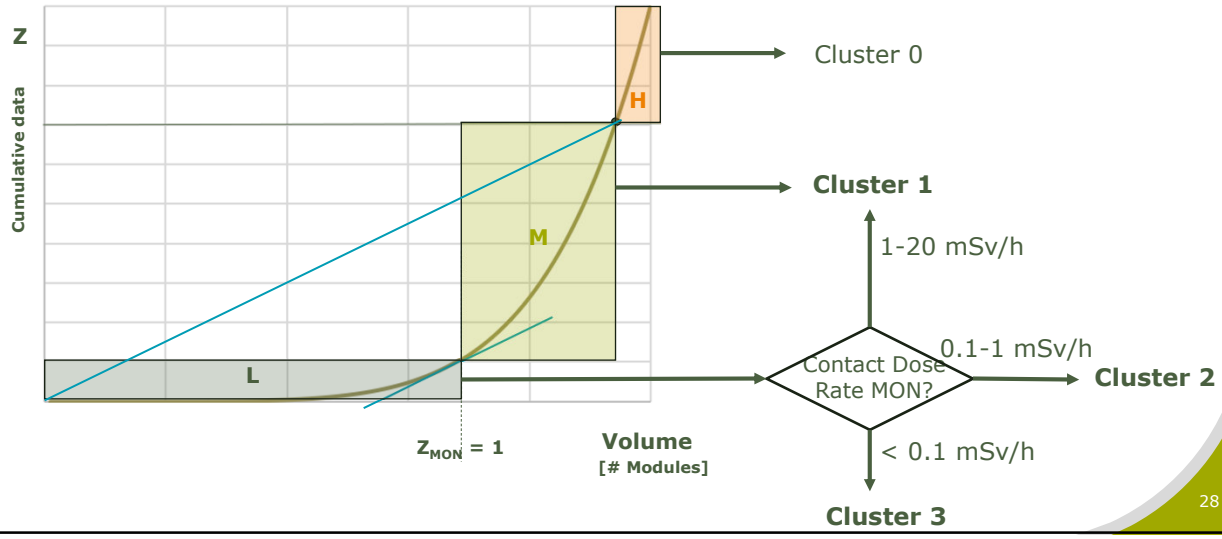
DRAFT - Preliminary loading Plan

And clustering of waste packages



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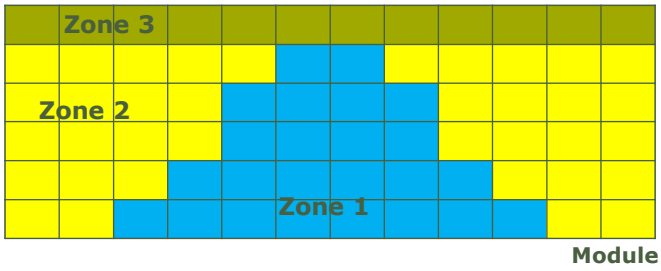
DRAFT - Preliminary loading Plan

Clusters allocated in Zones in the Module



Cluster 1 in Zone 1

Cluster 2 in Zone 1/Zone 2

Cluster 3 in Zone 1/Zone 2/Zone 3

- Guide the loading of the modules
- Continuous follow-up & reality check during filling to ensure the respects of filling rules (dynamic loading plan):
  - Contact dose rate (outer stacks, by layer)
  - Heterogeneity (module/4-module)
  - Radiological impact (several scenario's)
  - ...

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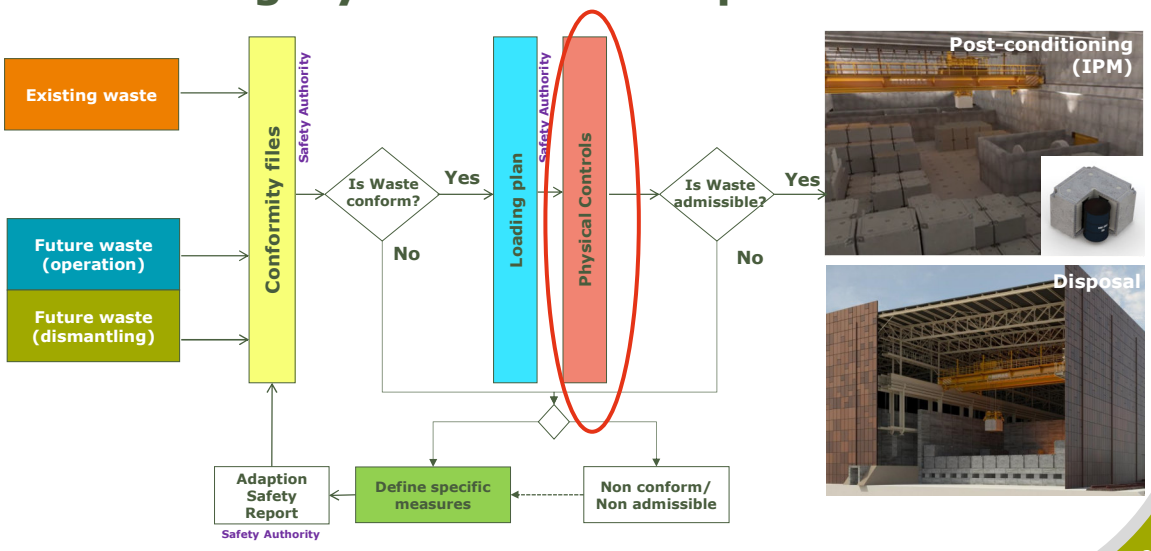
Demonstration of the "Disposability" of the category A waste : The process



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Confirmation of the conformity of the waste through physical controls

	Standard controls	Complementary controls (DT/NDT)
Frequency	Every Waste Package (WP)	Sample-based
Control	Identification of the WP, visual control, collo, Visuele controle, non-fixed surface contamination, mass, dose rate (& comparison with the data from the inventory)	Relevant conformity criteria (Through conformity file)
Temporary solution	**Manual**	To be develop in **existing installations**
Finale Solution	**Mobile installation** 	Development of a **dedicated building** for DT/NDT controls

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Destructive controls of legacy waste

Pilot project in the CILVA facility to control the content of the legacy waste (11 waste packages)
→ Building knowledge on adequate techniques for the controls on an industrial scale
& on the nature on legacy waste

Removal of drum

Core drilling

Cutting & dismantling of pellets

Sorting & characterisation of waste materials

32

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Conclusion: Processes are setting up to ensure the disposability of cat. A waste

- Conformity criteria are defined & first modifications on-going
  - ➔ Ensure production of (potentially) conform waste
  - ➔ Extension of the Waste acceptance system (Reinforcement of Controls at the source)
- Development of solutions for non-conforming waste
  - Sorption tests for cellulose/chloride
  - Production & testing of prototypes with compressible material
- Development of methodologies for the loading plan
- Development of protocols for DT/NDT techniques to confirm the disposability of the waste

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