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Decontamination for decommissioning Decontamination of buildings and concrete

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SCK•CEN

Decontamination Techniques Used in Decommissioning Activities



- Objectives and selection criteria
 - General considerations
 - Objectives of decontamination technologies
 - Selection of decontamination technologies
- Full system decontamination
- Decontamination of components/parts
- **Decontamination of concrete and building surfaces**



- Decontamination is defined as the removal of contamination from **surfaces** by any means, i.e.:
 - Washing
 - Heating
 - Chemical or electrochemical action
 - Mechanical cleaning
 - Others (melting...)

Decontamination for decommissioning



- In decommissioning, decontamination techniques can be destructive, the main goal being the removal of as much activity as possible (high DF)

Decontamination Of concrete and buildings



Objectives : Reduction of radioactive concrete waste or Release of building

Concrete Surface

- Mechanical Method
- Scabbler
- Shaver
- Blast Method
- Innovative techniques

Concrete Demolition

- Jackhammer
- Cutting/sawing
- Drill & Spalling
- Explosives

Selecting a specific decontamination technique



- Need to be considered
 - **Safety** : Not increased radiological or classical hazards
 - **Efficiency**: Sufficient DF to reach the objectives
 - **Cost-effectiveness**: should not exceed the cost for waste treatment and disposal
 - **Waste minimisation**: should not rise large quantities of waste resulting in added costs, work power and exposure
 - **Feasibility of industrialisation**: should not be labour intensive, difficult to handle or difficult to automate.

Parameters for the selection of a decontamination process



- Type of plant and plant process
- Operating history of the plant
- Type of components : pipe, tank
- Type of material : steel, Zr, **concrete**
- Type of surface : **rough, porous, painted**, coated...
- Type of contaminants : oxide, crud, **sludge, dust, spills**, ...
- **Composition** of the contaminant (activation products, FP, actinides...) and radionuclides involved
- **Ease of access** to areas/plant, internal or **external** contaminated surface
- Decontamination factor required
- **Destination** of the components/structure after decontamination
- Time required for application
- Capability of treatment and conditioning of the **secondary waste** generated
- Potential **airborne contamination**

Some examples about the type of material



- **Stainless steel:** Resistant to corrosion, difficult to treat, need a strong decontamination process to removed several μm
- **Carbon steel :** Quite porous and low resistance to corrosion, need a soft process but the contamination depth reach several thousand μm (more secondary waste)
- **Concrete:** The contamination will depend of the location and the history of the material, the contamination **depth can be few mm to several cm.**

Some examples about the type of surface



- **•Porous:** Avoid wet techniques which are penetrant.
- **•Coated:** Do we have to remove paint ? (contamination level, determinant for the use of chemical techniques e.g.)
- Presence of crud : what are the objectives ? (reduce the dose or facilitating the waste evacuation)



Right decontamination technique

Some aspects about the treatment of secondary waste



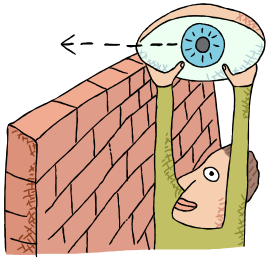
- Availability of a facility to treat secondary waste from decontamination (chemical solutions, aerosols, sludge, debris...)
- Final products (packaging, decontamination effluent...) has to be conform for final disposal.
- In decontamination process, the final waste are concentrated, representing sometimes a significant radiation source.

Decontamination Techniques Used in Decommissioning Activities



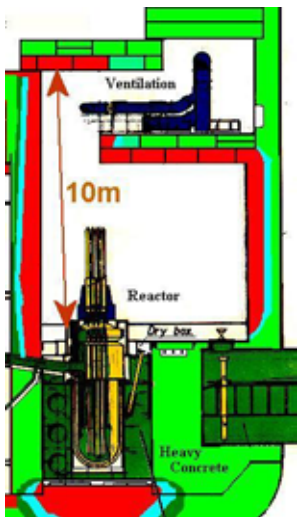
- Objectives and selection criteria
- Full system decontamination
- Decontamination of components/parts
- **Decontamination of building surfaces**
 - General considerations
 - Techniques
 - Guidelines for selecting appropriate techniques

A first step before decontamination: **characterization** of the concrete



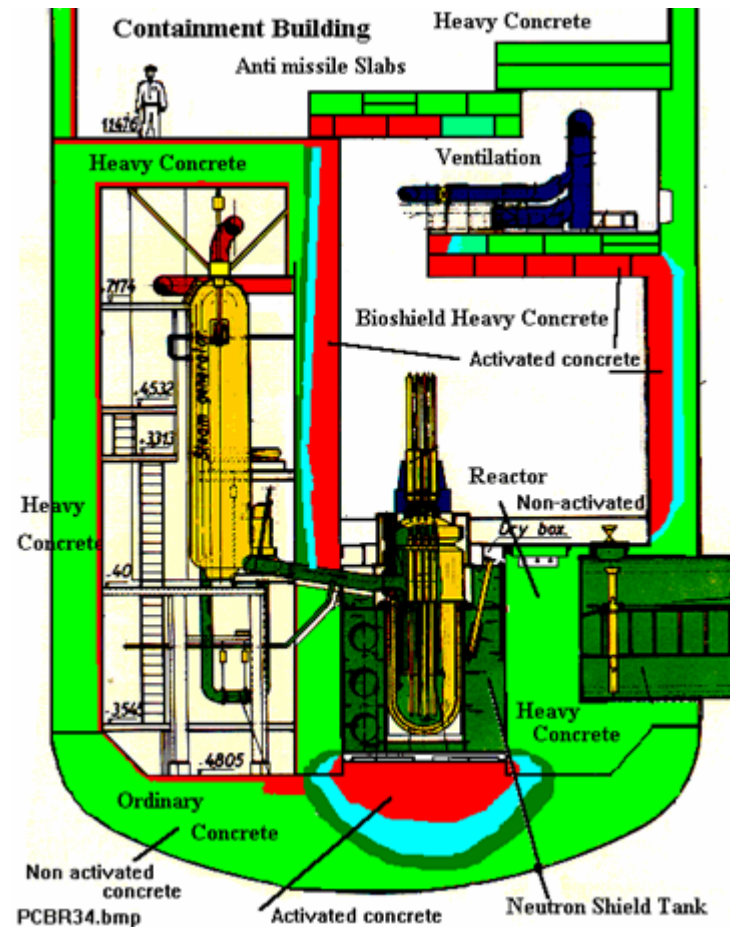
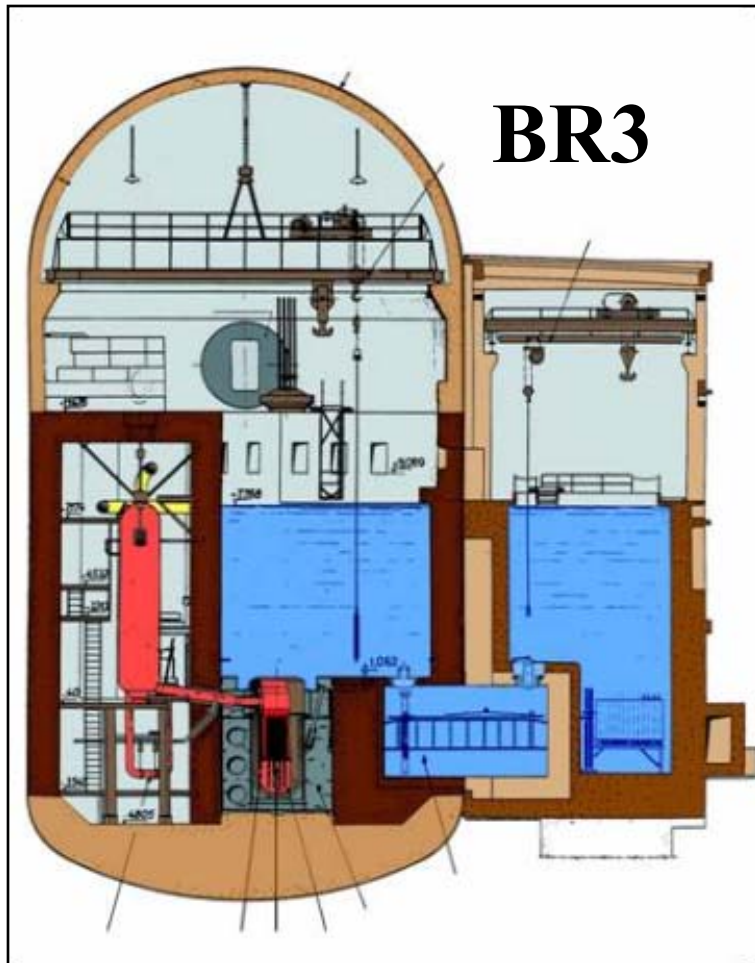
- Activated / contaminated ?
- Depth of the contamination ?
- Type of contaminants
 - Dust, spills, vapour...
 - Type of radionuclides
- Sampling programme / Model

See also the chapter on the characterization



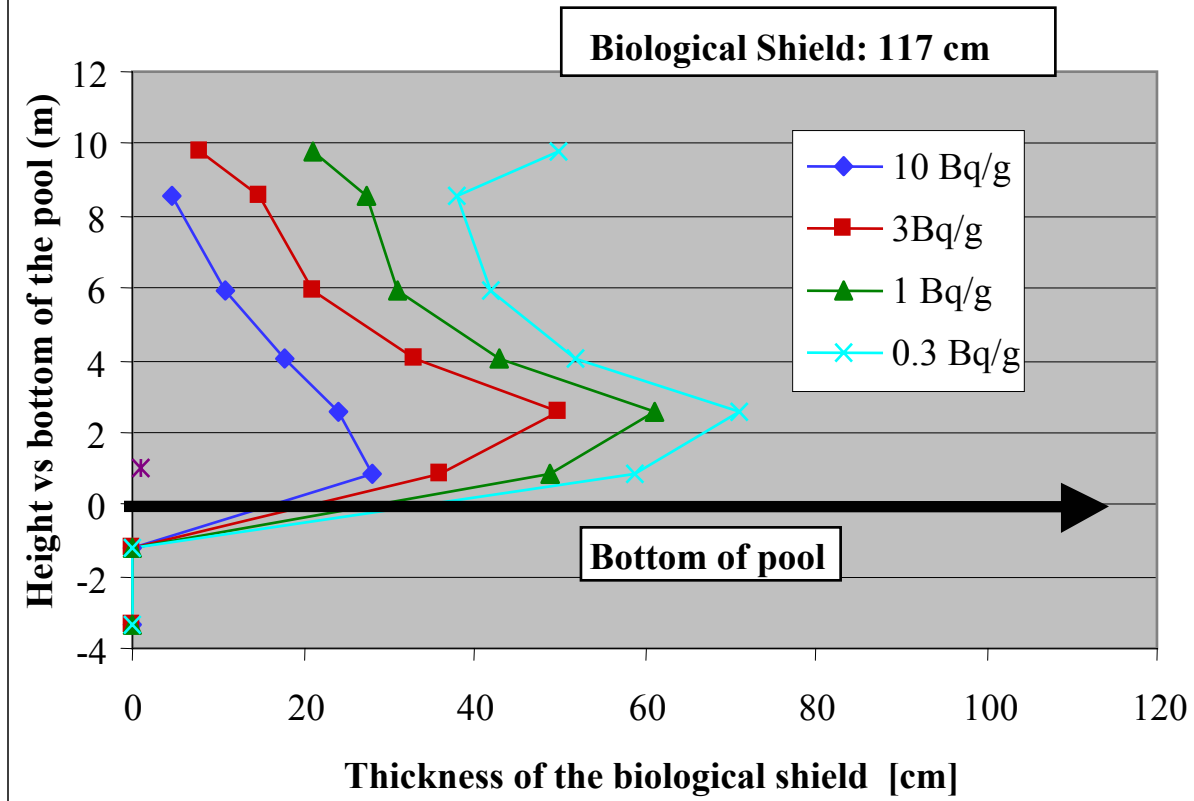
- Traces of **activation** found far (up to 10 meters) from the reactor core
- Main activation nuclides: ^{133}Ba in concrete, ^{60}Co in rebars
- **Contamination** layer found everywhere due to primary water vapour spill (history)

Characterization of concrete in the containment building





Ba-133 Activation profile of the wall of the refuelling pool



$^{152}\text{Eu}/^{133}\text{Ba} = 0.05 \text{ to } 0.07$
 $^{154}\text{Eu}/^{152}\text{Eu} = 0.08 \text{ to } 0.1$
 $^{60}\text{Co}/^{133}\text{Ba} = 0.05 \text{ to } 0.08$

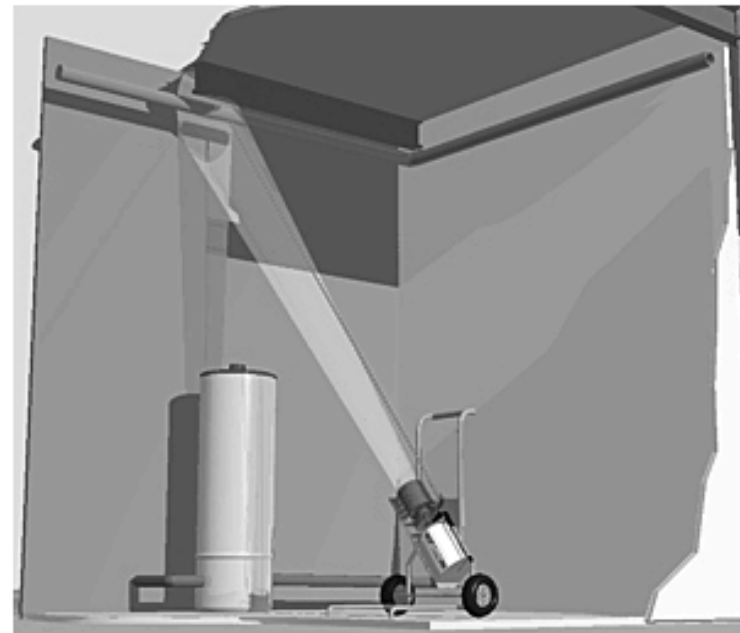
^{60}Co in first layer
 of rebars
 15 to 20 Bq/g

Core drilling for sampling



Measurement of cores slices

Characterization using ISOCS (In Situ Objects Counting System)



In general concrete decontamination or dismantling is very “dirty”



- Foresee confinement
- Avoid airborne contamination
- Filtration unit
- Collection of dust / water / sludge at the production tool
- Individual protection if needed





- Surface decontamination
 - Scabbling
 - Shaving
 - Milling
 - Cutting/sawing
 - Grinding
 - Sand blasting / (Wet abrasives)



- Demolition techniques
 - Jackhammer
 - Drill/spalling
 - Explosives



- Some "Innovative" techniques

Scabbling:

a commonly used technique



- Scabbling is based on the use of tungsten carbide tipped bits, hammering the concrete surface
- Electrically or pneumatically driven
- Hand held (one head) or multi-headed machines available
- Air aspiration around the tool
- Various efficiency reported

	m ² /h
Hand held	0.25-0.5
Floor scabbler	4 - 8
automated	up to 15

Examples of Handscabbling



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Examples of floor scabbler



Shaving: an improvement to scabbling



- Shaving is constituted of a diamond tipped rotary cutting head designed to give smooth surfaces which are easier to measure and ready for painting
- capable of cutting through bolts and metal objects
- Compared to scabbling:
 - About 3 times higher mean working rate for floor decontamination
 - 30% lower waste production than by scabbling at a comparable decontamination efficiency
 - less physical load on the operators due to the absence of machine vibration

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Examples of floor shaver



Diamond tool



Courtesy from Belgoprocess



Close up view
of the machine



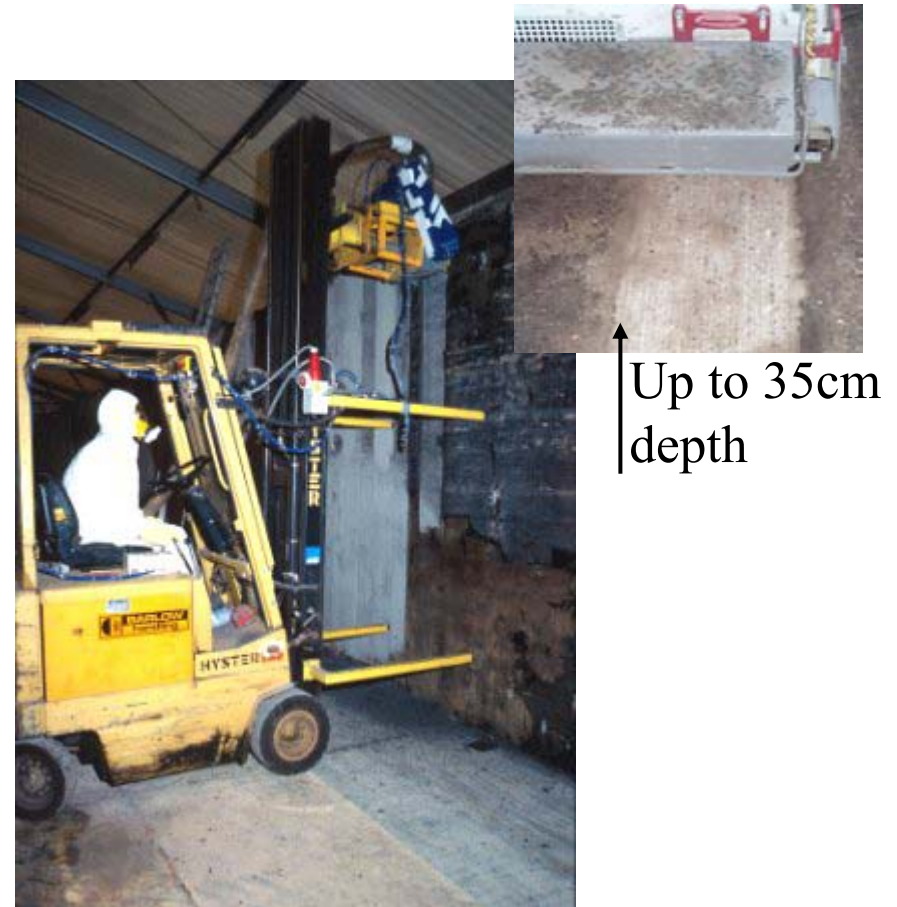
Courtesy from Belgoprocess



Use on a reprocessing cell wall



- For deep contamination penetration ($> 1\text{cm}$), shavers should need several steps
- The use of a **milling cutter** can be recommended
- Allows single pass for thick (several cm) layer removal



Courtesy from Belgoprocess

When the contamination has deeply penetrated in the concrete and on structures easily accessible



- Cutting or sawing can be the solution
 - Using diamond equipped tools:
 - Saws
 - Wires
 -
 - Precise definition of the cutting depth
 - Often needs cooling (water)
 - The cooling water traps most of the aerosols
- Also used for dismantling of large infrastructures

Examples of diamond wire cutting



Cutting of thick concrete

Removal of a contaminated layer



Cut through concrete and rebars



Example of hand cutting



Not very commonly
used in nuclear
decommissioning



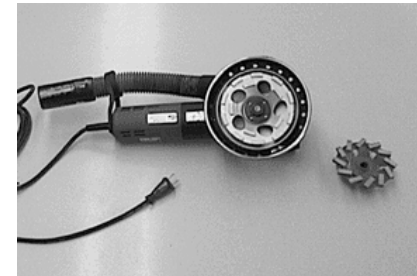
For small items (like blocks e.g.)
grinding can be envisaged



- Simple tool easy to use
- Hand held
- Various sizes

BUT

- Labour intensive
- Not convenient for large surfaces
- No included air filtration (needs confinement)



Hand grinding on concrete blocks



For large amounts of small pieces: **dry** abrasive blasting



- Dry abrasive blasting has proved efficiency for metallic pieces
- OK if carried out in confined/ventilated space



- Used for concrete blocks at Belgoprocess
- 88% of material released
- cost represents about 45% of radwaste cost

Courtesy from Belgoprocess

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For deep contamination or activation
jackhammer can be used
(decontamination / dismantling)



- Simple tool easy to use
- Can be remotely controlled (deployment)
- Very efficient
- Relatively easy to collect the produced debris

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Remote controlled jackhammer



Courtesy from Belgoprocess



Mock up of the bioshield



Blasting



Result



- Difficult to prepare (drill holes)
- Safety issues (unexploded loads)
- Labour intensive post operation
- Filtration issues (shock wave)
- Airborne contamination
- Not always efficient (rebars)

Drilling, and spalling (chemical or mechanical) can also be used



- Drilling (diamond core drills)
 - Easy method, easy to set up
 - Not very efficient
 - Same kind of generated waste as for cutting (sludge, dust, water)
 - Multiply by factor π the length of cut
- Spalling
 - Mentioned in various handbooks
 - Not very commonly used in nuclear decommissioning

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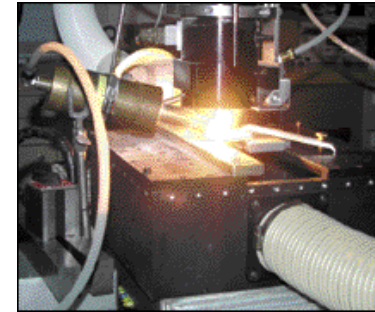
For demolition of buildings:
Concrete "crushing" using hydraulic
shears



Various “innovative” techniques were tested or are in development



- **Laser** ablation (Japan JAERI, US ARNL...)
 - In development (relatively low efficiency)
- **Microwave** heating (EC RTD programme)
 - Tested; poor efficiency; complex set up
- **Mini-blasting** (Belgium, CSTC)
 - Tested; difficult to set up; safety issues
- High pressure **water jetting** (various)
 - Tested (and used): in some cases let the contamination penetrate deeper in the material
- **Electrical heating** of the rebars (Belgium, CSTC)
 - In development; difficult to set up; poor efficiency up to now
- Electrokinetic decontamination (using gel or paste electrolyte)
- Lime (**chemical**) spalling
- **Induction** heating
- **Foam** decontamination
- ...



After decontamination, **characterize**



- Important for clearance
- 100% surface or bulk sampling
- Difference between α and β, γ contamination
 - α more difficult to measure
 - for α surface roughness can play a role in the measurement process

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Example of characterization for clearance (100% surface measurement)



Last measurement before clearance



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Example of characterization for clearance: crushing and sampling



Concrete crushing and sampling machine (Belgoproces)





- Characterize before decontamination or dismantling
- Decontaminate
 - Various techniques
 - Waste management
 - Safety and radioprotection (airborne contamination)
 - Cost / duration / confinement / future operation
- Characterize after decontamination