# Decontamination Processes

# and Wastes Management at BR3

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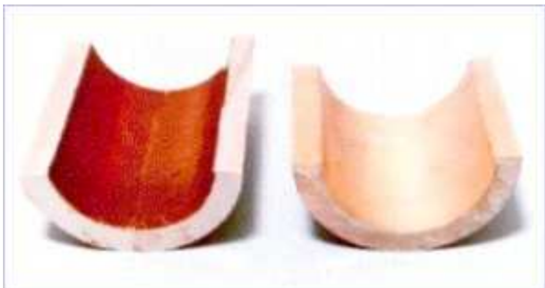
## 1. Decontamination processes



**From laboratory test to industrial application**

*Dismantling a reactor involves many different processes: all of them have been specially tested and developed by the BR3 team.*

*The first operation, decontamination, is performed both before and after segmentation.*

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### 1.1. The C.O.R.D.® process: full system decontamination before segmenting

Decontamination of the primary circuit was the first operation carried out after the reactor shut down and fuel removal.

It involved the reactor pressure vessel, the steam generator and pressuriser, and the purification loop.

The objectives of this first decontamination were to reduce the radiation dose rate in the vicinity of the low- and non-activated components and to limit the transfer of surface contaminants during subsequent segmentation.

Among the different chemical processes then available, the BR3 team finally selected the C.O.R.D.® process, developed by Siemens KWU.

The C.O.R.D.® process, an acronym for Chemical Oxiding-Reducing Decontamination, consists of three successive cycles:

- Oxidation,
- Reduction, and
- Cleaning.

The three successive cycles of the C.O.R.D.® decontamination process allowed to remove 2 TBq of gamma emitters, that is, no less than 90 % of the activity of the primary circuit.

## 1.2. The Me.D.O.C. process: thorough decontamination after segmentation

The next operation aims mainly to decontaminate, after segmentation, a large amount of metallic components and pieces at very low residual radioactivity levels, in order to evacuate them as non radioactive waste.

The BR3 team performed tests at both laboratory and pilot scale, with soft processes, such as the C.O.R.D.® process, and more aggressive processes, such as the fluoronitric acid process and the cerium process or Me.D.O.C. process.

The cerium process or Me.D.O.C. process, acronym for Metal Decontamination by Oxidation with Cerium, is based on the high oxidation potential of cerium at valence 4+ ($Ce^{4+}$), and has been selected to decontaminate the dismantled pieces.

It is able to attack both the oxides and the base metal. The cerium is regenerated electrochemically or chemically and recovered from the spent solution. An important aspect is to minimize drastically the production of secondary waste.

Results obtained so far show that this process can be applied on industrial scale; the cerium process was successfully applied by the team to decontaminate dismantled pieces.

It is now ready for industrial applications which is actually done at BR3.

## 1.3. The Z.O.E. installation : decontamination after segmentation

Other techniques have also been tested and will be applied on industrial scale, namely:

- the wet abrasive cleaning to decontaminate large metallic pieces;
- the anodic electro-polishing to decontaminate stainless-steel pieces with a simple geometry.

The BR3 D&D group operates a decontamination installation for metals based on the use of a Wet Abrasive Decontamination Process.

The Z.O.E., acronym for Zandstraal Ontsmetting Eenheid, is installed in the shipping area of the BR3 building and is currently used to decontaminate the metals arising from the dismantling of the contaminated installations of BR3.

## 1.4. Decontamination of concrete

*Characterization, Decontamination and Demolition techniques*

In the framework of the dismantling of the BR3 reactor, experience is gained in all the aspects of the management of activated and/or contaminated concrete:

- extensive characterization of the activated concrete allowed to determine the activation depth around and above the reactor;
- cold demolition tests performed on 1/1 scale allowed to test and select the optimized demolition method;
- decontamination by scabbling allowed to free release contaminated concrete, and
- active demolition test of an activated slab allowed to test on real scale an industrial demolition technique.

# 2. Waste management

## 2.1. Introduction

Dismantling a nuclear facility generates an enormous amount of radioactive material, which must be evacuated one way or another.

The base philosophy in this evacuation process is to *minimize the volume of radioactive waste*.

Furthermore, during the evacuation process, the material has to satisfy an important condition, namely that *its traceability is assured*. Therefore the *material flow* is a well defined procedure which guides the material from the dismantling until definitive evacuation.

Thus the material which is dismantled undergoes some steps:

- cutting, sorting and identification;
- temporary storage;
- treatment;
- characterization;
- temporary storage;
- evacuation.

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## 2.2. Cutting, sorting and identification

After the dismantling, the large pieces are transported to a cutting-chamber. This is a closed ventilated booth where the dismantled material is cut in smaller pieces.

For the cutting up of the pieces, different techniques are used. The evacuation way can influence the choice of the cutting technique.

Following cutting techniques are used:

| **To be decontaminated** | **Waste/Melting** |
|---|---|
| grinding | plasma cutting |
| nibbling | oxy-acetylene cutting |
| band saw | |
| reciprocating saw | |

Plasma and oxy-acetylene cutting are not used for material which has to be decontaminated, because while cutting, the contamination will (could) be enclosed by the slag on the pieces.

The band saw and the reciprocating saw are used for the cutting of tubes / pipes or "massive" pieces.

The nibbling technique is used for the cutting of tanks: it is a relatively fast technique but has the disadvantage that it leaves sharp ends on the cut pieces.

After the material is cut into smaller pieces, it is sorted following the different evacuation ways.

| **Waste** | | **Melting** | | **Treatment**<br>**manual decontamination**<br>**wet-sandblasting**<br>**chemical decontamination**<br>**scabbling** | |
|---|---|---|---|---|---|
| compactable | non compactable | re-use in nuclear environment | free release | unconditional free release | free release after melting |

Each evacuation way has its own acceptance criteria:

- **Waste**

| | ***compactable*** | ***non-compactable*** |
|---|---|---|
| ***waste package*** | 200 litre-drum | 400 liters drum |
| ***max. length of the piece*** | 0.80 m | 0.95 m |
| ***max. weight of the piece*** | 50 kg | no limit |
| ***max. thickness of the piece*** | 20 mm | no limit |
| ***max. weight of aluminium*** | 10 kg | not allowed |
| ***max. weight of PVC*** | 20 kg | not allowed |
| ***lead*** | not allowed | not allowed |

- **Melting**

  Metal which is technically or economically not possible to decontaminate will be sent to a melting facility.

  For example tubes and valves with a diameter < 1", thin plates and beams, small pieces like bolts, small infrastructural elements, ...

- **Treatment**

  The selection of the material to be treated depends on two conditions:

- ° it has to be technically possible and economically defensible;
- ° it has to be possible to demonstrate that material fulfils the free-release criteria.

The following table gives a global idea of the sorting criteria.

| | ***geometry*** | ***contamination*** | ***examples*** |
|---|---|---|---|
| ***manual decontamination (cleaning, polishing)*** | simple | low level contamination | electrical cables, infrastructural elements |
| ***wet-sandblasting*** | simple good accessibility small surface / weight ratio | fixed contamination up to 5000 Bq/cm² | large infrastructural elements, heavy solid pieces |
| ***chemical decontamination*** | simple to complex | fixed contamination up to 35000 Bq/cm² | tubes and valves with a Ø > 1", pumps, tanks |
| ***scabbling*** | | | concrete blocs |

During the sorting, the batches are created.

A batch can be considered as a group of material which will follow the same evacuation way. The material can be grouped in:

- 200 litres/400 litres drums if it concerns waste or material to be melted.

  Occasionally it can also be material to be free released if the activity is homogeneously distributed (which is for example the occasion for dust, coming from the decontamination of concrete blocs.
- 300 litre plastic containers if it concerns material to be treated.
- or it can be a single piece, if it concerns large pieces for melting.

Every batch is identified by a label sticked to it, on which is written down a unique identification number, the contents and the weight of each category of material which is in the batch.

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## 2.3. Temporary storage before characterization or treatment

When the batches are completed, they are stored in expectation of treatment campaigns or characterization.

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## 2.4. Treatment

To minimize the amount of radioactive waste, the material can be treated in different ways.

A lot of the dismantled material can be treated manually, because its surfaces are only slightly (or even not) contaminated, and the contamination is not fixed at the surface. This material, mostly infrastructural elements, electrical cables, instrumentation, is cleaned with water and detergent.

Pieces with a higher degree of contamination, or where the contamination is fixed (in the rust or in the paint), can be treated by wet-sandblasting (water with sand at high pressure, called ZOE) or "aggressive" chemical decontamination (MEDOC).

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## 2.5. Characterization of the material

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### 2.5.1. Material for free release

After the decontamination of the material, it is measured with hand held monitors (with a measuring surface of 25 cm² and 200 cm²).

The condition here is that the whole surface of the material must be accessible for the monitors; if this is not the case the material will be rejected.

After this measurement, the material that fulfils the free release conditions (surface contamination < 0,4 Bq/cm² for beta-gamma contamination and < 0,04 Bq/cm² for alpha contamination), will be stored in expectation of a second measurement. This measurement will be done by another person and with another type of monitor.

The storage time between two measurements can be 3 months if it concerns material which underwent a chemical decontamination. This is to be able to detect radioactivity released by the "*sweating*" of the material.

The results of the free-release measurements together with the history of the material is collected in a "*free-release dossier*" which has to be approved by the head of the "*Health Physics Department*" before definitive free-release.

As mentioned earlier, material which doesn't allow a 100 % surface accessibility will not be accepted to be measured. For a lot of material at BR3, this is the case, mainly tubes and valves. For this material, there is still no accepted procedure for the measurements.

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### 2.5.2. Material for waste and melting

This category of material is mostly put into barrels (200 litres/400 litres) and is characterized by a gamma-spectrometric system. The large pieces (for melting) are characterized by sampling.

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## 2.6. Temporary storage after treatment and characterization

After the material is characterized, it is stored while it awaits definitive approval for free release, or evacuation.

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## 2.7. Administrative follow up

During the evacuation process (which begins right after the dismantling and ends with the evacuation), a close follow up of the material must be done to assure the traceability of the material.

This means that at all times, the batches must be well identified, the contents must be well known as well as the status of it (awaiting decontamination, already measured for free release, ...). This methodology must allow to evacuate the dismantled material in an as much as possible controlled manner.