PROCESSING OF ACTIVATED CORE-COMPONENTS

Andreas Friske, Gert Gestermann, Rudolf Finkbeiner

GNS Gesellschaft für Nuklear-Service mbH
Hollestraße 7 A
Germany 45127 Essen

ABSTRACT

Used activated components from the core of a NPP like control elements, water channels from a BWR, and others like in-core measurement devices need to be processed into waste forms suitable for interim storage, and for the final waste repository.

Processing of the activated materials can be undertaken by underwater cutting and packaging or by cutting and high-pressure compaction in a hot cell. A hot cell is available in Germany as a joint investment between GNS and the Karlsruhe Research Center at the latter’s site.

Special transport equipment is available to transport the components “as-is” to the hot cell.

Newly designed underwater processing equipment has been designed, constructed, and operated for the special application of NPP decommissioning. This equipment integrates an underwater cutting device with an 80 ton force underwater in-drum compactor.

UNDERWATER CUTTING AND PACKAGING

Since the mid 1980s, GNS has been processing activated core components from almost all German NPPs of both types - BWR and PWR.

So far, GNS has performed more than 30 processing campaigns of activated core components by underwater processing with mobile units in 17 of the German NPPs, comprising a total quantity of more than 190 tons.

The components treated were water channels from the BWRs and absorber elements from the PWRs. In addition, in core instrumentation probes, neutron sources, and a variety of small parts from reactor cores have been processed.
The activated parts are cut by an underwater cutter, the cut pieces are collected in cylindrical stainless steel canisters. The canisters are loaded under water into MOSAIK® shield casks. The MOSAIK casks weight about 7 tons. After closing the MOSAIK® cask by its lid, the cask is removed from the water. While suspended on the crane, the cask is cleaned with deminerlized water. After positioning the cask at the edge of the pond the lid is fastened onto the cask body. The water in the cask is drained back into the pond. As a final step, the contents of the MOSAIK® cask are vacuum dried. After a final waste package has been produced and after proper documentation the waste package can be shipped to the interim storage facility or to the final repository.

A variety of equipment is necessary for the handling steps described above:

- the underwater shear,
- lifting devices for moving the shear and auxiliaries,
- gripping devices for the pieces to be cut
- gas collecting device
- lifting devices for the MOSAIK® cask
- lifting devices for the MOSAIK® cask lid
- inclining devices for water removal from MOSAIK® cask
- drying unit for final product.

Fig. 1 Underwater cutting tool
The following table summarizes the loading densities that could practically be achieved by the above described underwater techniques:

Table 1. Underwater cutting and packaging - waste density achieved

<table>
<thead>
<tr>
<th>Filling mode</th>
<th>Density achieved (avq.) (% of T.D.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BWR water channels</td>
<td>bulk</td>
</tr>
<tr>
<td>PWR absorber rods</td>
<td>manual, parallel</td>
</tr>
<tr>
<td>PWR absorber el. heads</td>
<td>manual</td>
</tr>
<tr>
<td>PWR spacers FE skeletons</td>
<td>loose</td>
</tr>
</tbody>
</table>

For rod shaped material which was loaded manually under water into the stainless steel canisters, a satisfactory loading efficiency could be achieved, whereas with irregularly shaped cut pieces, the achievable density is between 10 and 15 %.

PROCESSING OF ACTIVATED COMPONENTS IN THE HOT CELL

An alternative to underwater cutting is treating the core components in a hot cell, outside the NPP. In Germany, such a hot cell has been in operation since September 1977 as a joint investment between the Karlsruhe Research Center and GNS.

The parts to be treated are transferred in the fuel pool of the NPP into a removable basket located in a heavy shielded cask denominated MOSAIK® 80 T. This cask is qualified as Type B(U) shipping cask. Handling of the cask is performed by the NPP using special lifting equipment provided by GNS. After loading, closing and dewatering of the cask, the contents are vacuum dried. After that, the cask is shipped to the hot cell.

![Fig. 2. Transport cask MOSAIK® 80 T](image-url)
The cell consists of three main areas:

- the cask arrival building with a lock to connect the cask to the hot cell building,
- the entrance cell with remotely operated cask lid removal equipment and a cart to accommodate the basket with the activated components,
- the process cell with a shear, a saw and a 2,000 ton high pressure compactor.

Upon arrival at the site by rail, the impact limiters are removed from the cask and a crane is used to transfer the cask onto a cart in the arrival building. The cask is moved on the cart to the opening of the cell where it is secured by an inflatable seal. Then the lid is removed horizontally into the cell by the lid removal system. The basket with the parts to be processed is drawn out of the cask and positioned on a cart which can move on a rail system in two directions. The basket is transported to the operating cell. The parts are cut, high pressure compacted, and the resulting pieces are loaded into the MOSAIK® shield casks that are used for underwater operations.

Some 800 water channels from various German BWRs have been processed so far. After slight process modifications, a consistent compacted material density of 3.5g/cm³ can be achieved. This represents more than 50% of the theoretical density. So a considerable volume reduction is achieved compared to underwater packaging of irregularly shaped material.

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**Fig. 3. Loading Density versus No. of MOSAIK® cask**
More than water channels have been processed so far in the hot cell. Last year several 100 liter drums loaded with solid LLW were supercompacted in the cell. This waste is often wet so drying before or after compaction is necessary with special drying equipment adjacent to the hot cell.

Development has been completed for modification of one MOSAIK® 80 T cask in order to accommodate BWR control elements. The respective licensing process is in progress and we expect the first shipment of BWR control elements to the hot cell to take place by the end of 2002.

**PROCESSING OF CORE COMPONENTS BY A SPECIAL UNDERWATER CUTTER WITH INTEGRATED UNDERWATER IN-DRUM COMPACTOR**

In the course of decommissioning of one German BWR power station, a number of activated core components had to be prepared for interim storage in a shielded building at the NPP site. For optimum use of the storage capacity, a maximum volume reduction had to be achieved.

The components treated were 774 water channels and 130 control elements. The resulting material had to be accommodated in specially designed stainless steel drums which initially will be positioned in the fuel pool awaiting subsequent treatment. For accommodation of the material in the drums, the core components had to be cut by an underwater shear, and in order to achieve maximum drum loading the cut material was compacted by an underwater in-drum compactor. An integrated unit consisting basically of the underwater shear and the in-drum compactor was designed and built for this special task.

The working principles of the underwater cutter/compactor are illustrated in Fig 4.

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**Fig. 4. Working principles**
The unit is built up as single modules mounted on a basic frame. All modules are assembled under water by vertical movements only, and guide ducts will assure their proper positioning. The compactor itself is composed of an incline hydraulic cylinder with piston and compacting ram. During compaction the drums are protected from damage by a surrounding metal jacket. The cut material is fed to one of two drum loading stations via a chute. The equipment is surrounded by a metal housing, debris and particulate matter are collected in filters through a directed water flow which keeps the working areas clear. Each working area inside the unit can be viewed by video cameras.

The unit is actuated by a hydraulic system, operating with demineralized water.

The total weight of the unit is 20 tons. The force of the cutting blades is 100 tons and the force of the compactor is 80 tons. The operating pressure of the hydraulic system is 250 bars.

For accommodation of the cut parts two different types of stainless steel drums had to be used:

- a drum with around 240 liter loading capacity for the water channel material, the drive adapter parts of the control elements, and the main parts of the control elements with low activation
- a drum with around 150 liter loading capacity for the material from those portions of the control elements with the highest activation.

With these package geometry's required by the customer, off-site treatment of the components was not possible due to transport logistics.

All the material was processed in 2001.

In total, 104 stainless steel drums were filled with cut and compacted pieces of the various components. The average material densities achieved are shown in Table 2.

<table>
<thead>
<tr>
<th>Material</th>
<th>No. drums</th>
<th>Type of drums</th>
<th>Density (avg.) (% of T.D.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>774 water channels</td>
<td>69</td>
<td>240 liter drums</td>
<td>21.6</td>
</tr>
<tr>
<td>130 control elements, drive adapter parts</td>
<td>2</td>
<td>240 liter drums</td>
<td>25.3</td>
</tr>
<tr>
<td>130 control elements, low activation portion</td>
<td>28</td>
<td>240 liter drums</td>
<td>20.5</td>
</tr>
<tr>
<td>130 control elements, high activation portion</td>
<td>5</td>
<td>150 liter drums</td>
<td>22.1</td>
</tr>
</tbody>
</table>

During operation a large variation of the deformation behavior of the water channel materials were observed. The variation was from very ductile to very strong and elastic to brittle. In some cases plastic behavior during compaction could not be achieved. This led to a range of 6 to 14 compacted water channels per drum. It is clear that high burnup increases the loading density.