

DISMANTLING OF LARGE PLUTONIUM-CONTAMINATED GLOVE BOXES

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ABSTRACT

For decontamination and decommissioning (D&D) of the Siemens mixed-oxide-fuel fabrication plant (Brennelementewerk in Hanau, Germany), the dismantling of large Pu-contaminated glove boxes is now in the preliminary testing stage. Various techniques and cutting tools have already been applied in international projects. Such techniques generally include thermal, as well as mechanical, methods. Both require measures to prevent the spread of Pu-contaminated aerosols and the generation of secondary waste.

In order to minimize personnel exposure and project costs when conditioning the glove boxes for disposal, the standard boxes will be packed in final disposal containers without cutting them. Only boxes too large to be packed in final disposal containers have to be cut into smaller pieces. The boxes will be foamed from inside with polyurethane (PUR) hard foam and embedded in cement in containers to obtain the mechanical and thermal stability necessary for disposal.

Our main target, while developing the in-situ dismantling technology, was to keep the spread of airborne Pu-contaminant and of secondary waste to a minimum. The primary advantage of mechanical cutting techniques is the absence of a strong heat source and process gases which can mobilize contamination. The cut through the foamed glove boxes, including internals, required grinding tools and a sophisticated process control system, due to the complicated cutting conditions. The reciprocating (grinding) wire saw was able to cut through all glove box materials examined. The reciprocating motion of the grinding wire kept the spread of airborne Pu-contaminant to a minimum. Thus, the reliability and safety of the entire dismantling technique is much more important than the single parameter "cutting velocity".

Using the grinding wire technology along with attendant measures has not only engineering and economic benefits but also has a positive impact on the environment, health, and safety.

The conditions and procedures necessary to obtain a suitable final waste product are described elsewhere (1, 2).

INTRODUCTION

Beginning in 1972, Pu containing mixed oxide fuel assemblies for fast and thermal (BWR and PWR) reactors were produced in Hanau in Siemens' fabrication facilities (until 1988 ALKEM GmbH) with two production lines. In 1995 Siemens decided to decommission these facilities. Currently, the facility is in the clean out phase and in 2001 dismantling shall be started. The two production lines consist of 162 glove boxes with standardized sizes which can be directly put into containers without any further cutting tasks for final disposal (Fig. 1, green glove boxes). Nearly 50 oversized glove boxes (Fig. 1, red

glove boxes) can only be packaged after cutting down into smaller parts. Due to the working room dimensions an in-situ cutting technique was developed.

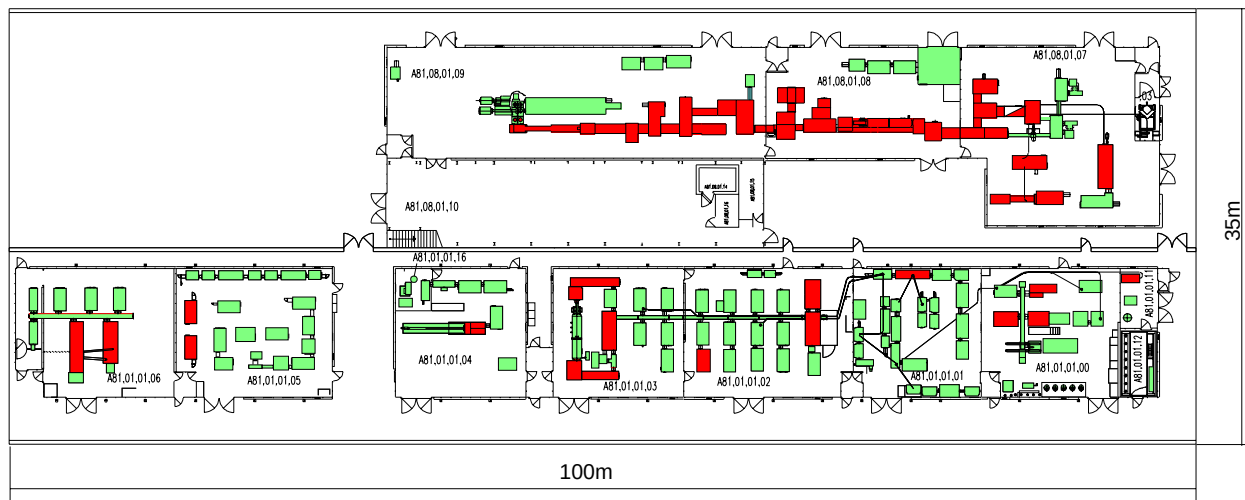


Fig. 1 Production Lines for MOX Fuel Assemblies at Siemens Brennelementewerk (Hanau/Germany)

GENERAL ASPECTS

Decommissioning wastes from MOX-fuel fabrication contain high amounts of alpha-emitters. Especially the spread of Pu-contaminant into the working area should be prevented in order to dismantle safely. An appropriate method for this is to foam the glove boxes with PUR hard foam which serves to fix the contamination.

When radiological and economical issues are considered, large Pu-contaminated glove boxes should be dismantled in-situ, i.e. without transporting them to a specially equipped dismantling caisson. Simplifying the tool supports further minimizes waste.

The most important target while planning the in-situ dismantling procedure is to leave the Pu-contamination inside the glove box or, in case of mobilization, in a relatively small working room (tent). Minimizing the spread of Pu-contaminant and easy handling of the dismantling equipment under complicated working conditions are important goals.

General Requirements to Dismantling Techniques

The mass ratio between secondary and primary waste mainly depends on the cutting method. The mobilization of airborne contaminants caused by thermal cutting techniques requires HEPA filters with significant increase of secondary waste. The mass ratio between additional and primary waste depends on the decommissioning technology employed. In other words, after performing the "planned" decommissioning tasks it is also necessary to decontaminate or dismantle the dismantling equipment. In a worse case scenario there is more contaminated equipment than primary waste.

To avoid this, cutting methods should be applied whereby the kerf material is relatively coarse and does not generate airborne dust. In order to reduce the necessity of heavy tool supports, tools with less

reaction force are preferred. For example, tools with:

- “undefined geometry of the cutting edge” (e.g. grinder, rope saw, abrasive suspension jet),
- alternating reaction force (e.g. hacksaw, jig saw),
- short reaction force flux (e.g. nibbler, hydraulic shear)

The main advantage of mechanical cutting techniques in comparison to thermal techniques is the absence of a strong heat source which can mobilize contamination.

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State of the Art

Various techniques and cutting tools have already been applied in international projects. Such techniques generally include thermal as well as mechanical methods. Both require measures to prevent the spread of Pu-contaminated aerosols and the generation of secondary waste. The main target while developing this dismantling technology was to keep the spread of airborne Pu-contamination to a minimum. Furthermore, the chosen technique should minimize the generation of secondary waste including aerosol filters, worksuits, heavy cutting equipment, and special dismantling caissons.

The main advantage of mechanical cutting techniques is the absence of a strong heat source and process gases which mobilize contamination. For reasons of practicality and economics, the cutting technique should be able to cut a glove box cross-section of more than 1m² in one step. This requires cutting tools such as a ropesaw and bandsaw. But the disadvantage of these techniques lies in the difficulty of encapsulating fast moving tool parts to avoid spread of contamination and in the necessity of cooling liquids (additional waste). Another disadvantage is in the large size of these tools which usually prevents in-situ dismantling.

After investigating and comparing the benefits of various techniques, it was decided to develop the mechanical cutting technique that required a minimal working area.

Glove Box Analysis

The plutonium contaminated areas of the Siemens MOX-fuel plant in Hanau are primarily glove boxes made from stainless steel. These boxes are linked to other boxes to transfer the MOX-fuel and contain windows made of glass or plastic. They also have openings for gloves, filters, and maintenance.

To develop the best procedure using mechanical cutting tools, it was necessary to analyze the glove box's structure. The structure has two parts:

- the glove box wall area with uniform materials and geometric (stainless steel framework, 30mm thick bottom plate and sheathing plates) and
- internal glove box parts, i.e. technical equipment including vessels, tubes, chains, spindles and bearings made of hardened steel, glass, plastics etc.

Planned Treatment

In order to minimize personnel exposure and project costs when conditioning the glove boxes for disposal, the standard boxes will be packaged into final disposal containers after disassembling without any further cutting. Nearly 50 oversized glove boxes (Fig. 1, red glove boxes) can only be packaged after cutting into smaller pieces with a size of 2.9m x 1.7m x 1.4m. With respect to the working room dimension, an in-situ cutting technique was necessary.

Airborne Contamination Prevention Measures

Additional sheathing of the glove boxes produces a new glove box surface without contamination. This allows the cutting tool to be guided with direct contact along a smooth surface. This new surface also allows kerf material to be collect while cutting and easier handling after cutting.

An additional improvement, to avoid the spread of contamination, was to coat the planned cutting kerf with a “gel belt”. The gel bonded contaminated kerf material while cutting.

To fix the contamination inside the glove box while cutting and handling the cut pieces, the glove boxes were foamed with PUR hard foam. This fixation of the internals is advantageous but not necessary for wire saw applications described below.

Most of the kerf material generated by mechanical cutting needed to be bonded inside the glove box. Thus, an atomized bonding liquid was directed through the cutting gap. For better precipitation of the bonding liquid, several cooling phases with CO₂ were used.

Thus, the majority of contaminated kerf material will be bonded through these measures.

Cutting Techniques

Due to the above-mentioned glove box description, common sawing tools were designed to cut through the glove box surface (depth: approx. 100 mm), and avoid internal cuts. For this procedure a hacksaw was chosen (Fig. 2).

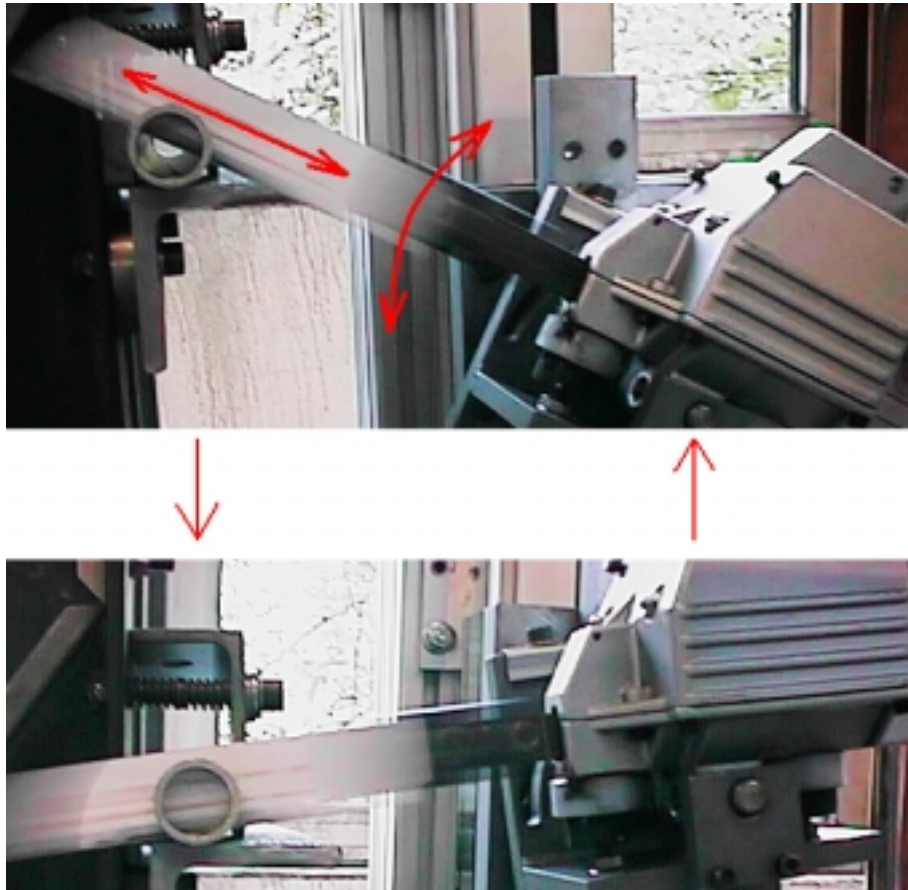


Fig. 2 Hacksaw for Glove Box Wall Cutting (variable cutting direction)

The hacksaw was guided by the same tool support as the reciprocating drive for the wire saw described below. This type of hacksaw has also been used in nuclear dismantling under water (3, 4).

In principle, cutting the 30mm bottom plates of the glove boxes can also be performed by using the grinding wire saw. However, for a better performance it is helpful to make a 25mm deep cutting kerf using a circumferential saw, if access is possible. After this preparation step, the reciprocating wire saw starts inside the kerf.

Sawblades (e.g. of bandsaws) require strong and precise guidance. Nevertheless, they have a tendency to go astray if cutting components are not at the ideal 90°-position. After losing the planned cutting direction, it is impossible to correct the cutting process without repeating the procedure. To avoid this, the cross-section of the saw "blades" should be circular like a wire. Consequently, special grinding wires were chosen and modified.

To minimize the spread of Pu-contamination, the tool was designed for reciprocating rather than endless motion of the grinding wire.

The wire saw consists of two vertical tool supports which each carry a reciprocating grinding wire drive. The tool supports alternately move up and down after a preselected cutting time while the grinding wire always reciprocates with varying intensity depending on the cutting conditions caused by various materials, and stress (Fig. 3).

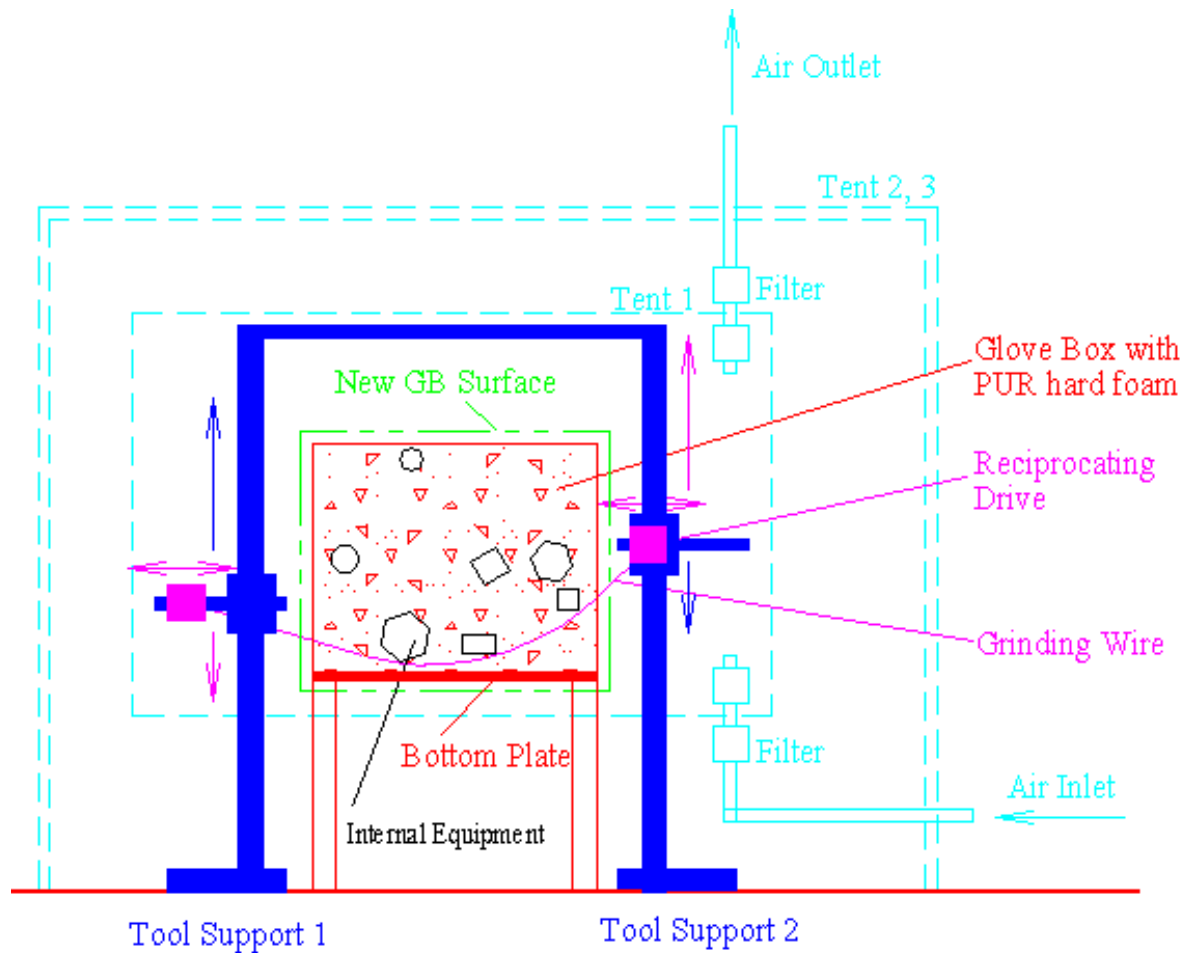


Fig. 3 Reciprocating Wire Saw with Tool Supports for In-Situ Dismantling of Glove Boxes at Siemens Brennelementewerk (Hanau/Germany)

DETEC and Siemens Brennelementewerk performed cutting tests with mock-ups of glove box internals. Among stainless steel profiles, it was possible to cut bearings (Fig. 4).

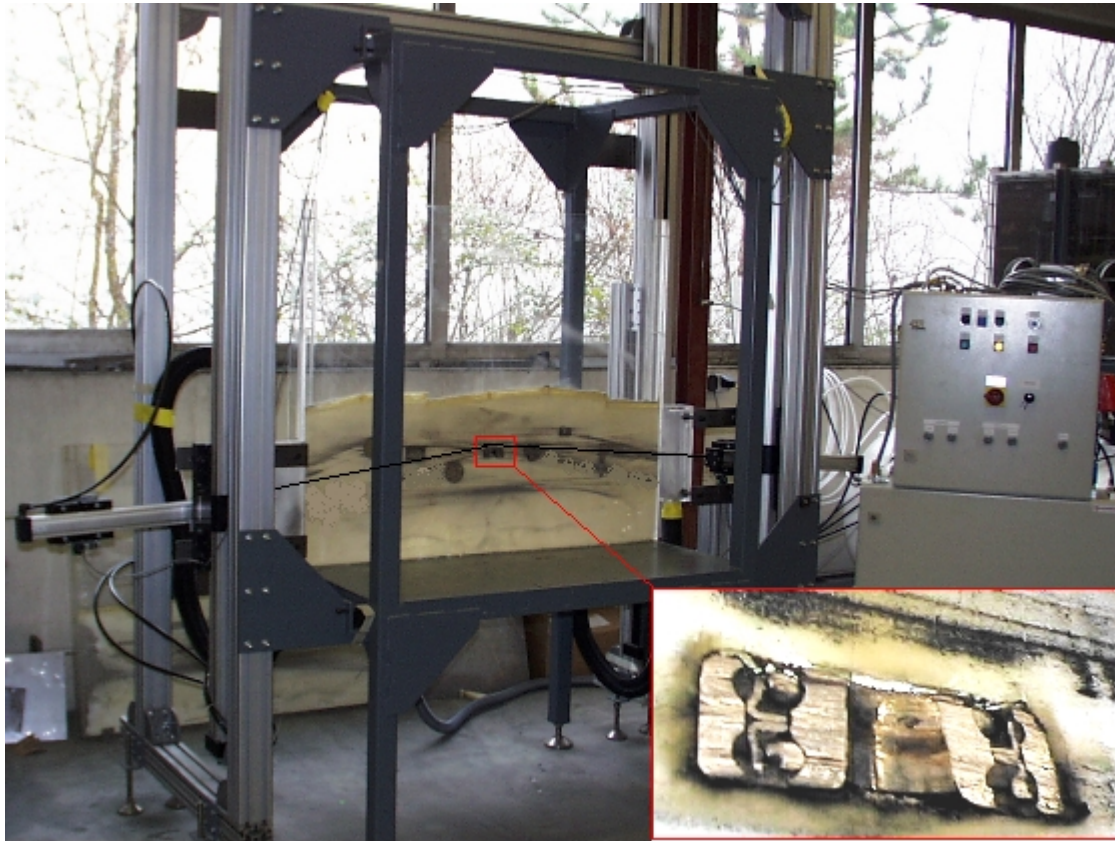


Fig. 4 Test Facility for the Reciprocating Wire Saw for In-Situ Dismantling of Glove Boxes, Cut Bearing

Process Control System

Glove box internals are often under mechanical stress while cutting. The grinding wire or the saw blade will break if there is no process control.

To achieve practical cutting results, the resulting cutting direction has to be changing continually. The frequency of this change depends on a preselected cutting time and on the wire load resulting from the mechanical stress of glove box internals to be cut.

For programming the control unit, a mathematical model was replaced with fuzzy functions and rules that only describe a small section of the whole system to attain the safest and most reliable way to cut glove boxes.

The fuzzy process control reacts such, that the tool support force stops before the tool is overloaded and continues after the tool charge decreases to normal parameters. If the increase of tool load is too fast there is an immediate change in cutting direction. This control method even allows for the positioning of the tool supports in different rooms.

The process control for the hacksaw is, in principle, comparable to the grinding wire control software.

Thus, the hacksaw always changes cutting direction depending on the sawblade load while cutting various wall materials under various material stress loads (Fig. 2).

RESULTS

For the development of the in-situ dismantling technique of large Pu-contaminated glove boxes the results shown on table I were achieved.

Table I Glove box Dismantling, Goals and Results

GOAL	RESULT
minimize aerosol generation while cutting	no thermal or fast moving cutting techniques
minimize handling procedures of glove boxes to be dismantled	in-situ dismantling
minimize preparation work for dismantling inside the glove boxes	universal cutting technique (based on grinding)
flexibility of the cutting tool	tool support consists of modules
reliable performance	fuzzy-based process control
minimize swarf generation during cutting	cutting tool, that produces small kerf
minimize additional waste	no heavy tool supports, reaction-force-”free” cutting tools
avoid injuries	remote controlled and riskless tools

Steps of the Dismantling Technique

The dismantling technique we developed consists, basically, of three parts:

- **Preparation**
 - remove glove box internals from the cross-section to be cut, if possible (ALARA)
 - use PUR hard foam to bind contamination in the glove boxes
 - take measures to prevent airborne contamination (gel belt)
 - create a new glove box surface
- **In-situ cutting**
 - encapsulate the in-situ cutting work area in tents
 - saw the glove box bottom (without cutting through)
 - hacksaw the remaining glove box walls (without cutting of internals)

- cut the glove box internals using the wire saw
 - use various methods to prevent airborne contamination (bonding liquid aerosol, inert gas cooling, collection of kerf material)
 - fix the contamination between the cut glove boxes (foam)
 - cut through the foam between the cut glove boxes
- **Final conditioning**
 - embed the packed boxes in accordance with the final storage requirements

CONCLUSION

Cutting speed loses its importance because of the emphasis on the reliability of the entire dismantling technology. Under the given conditions, the best dismantling technique combines common sawing and our newly developed grinding wire saw. Additionally, appropriate radioprotection measures are necessary.

The application of this in-situ dismantling technology along with attendant measures has not only engineering and economic effects. Furthermore, the chosen approach has a positive impact on the environment, health, and safety.

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