# A Proven Method for Performing Steam Dryer Segmentation on BWR Plants - 11479

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## ABSTRACT

Steam dryers are used on Boiling Water Reactors (BWR's) as the final stage of moisture removal to provide the highest possible quality steam to the turbine. The segmentation of steam dryers can be required as part of a decommissioning project when a plant is permanently shut down. In some other cases, utilities decide to replace steam dryers on their operating plants to address component aging issues or to cope with power uprate programs. This latter strategy is of increased interest in the U.S, Sweden and Finland. In both cases, there is a need to perform a segmentation of the reactor vessel internals with proven methods for long term waste disposal.
For more than twenty years, Westinghouse has developed several concepts to dismantle reactor internals based on safe and reliable techniques, including plasma arc cutting (PAC), abrasive waterjet cutting (AWJC), metal disintegration machining (MDM), or mechanical cutting.
Mechanical cutting has been used by Westinghouse since 1999 for both PWR's and BWR's and its process has been continuously improved over the years.
The complexity of the reactor internals segmentation projects requires well designed and reliable tools. Westinghouse has streamlined its segmentation strategy by selecting mechanical cutting methods over abrasive and thermal methods. The use of mechanical cutting reduces the risk of a secondary waste spill which can significantly impact final clean up issues and increase personnel exposure due to the spread of contamination.
For steam dryer segmentation projects, Westinghouse has developed a disk saw cutting method that provides outstanding performance records during project implementation. The disk saw is very powerful and can be adapted to different lifting and clamping devices. Westinghouse has developed more than 15 different disk saw clamping devices to cut the very difficult geometries of the BWR steam dryers. The disk saw is remotely controlled and the design enables the saw to make deep cuts with a swiveling arm, and long cuts with a sledge moving on a rail. The disk saw is driven by a hydraulic motor and has a modular design to improve tool availability.
Detailed 3-D modeling is the basis for tooling design and provides invaluable support in determining the optimum strategy for component cutting and disposal in waste containers, taking account of the radiological and packaging constraints.
The purpose of this paper is to provide an overview of the Westinghouse mechanical cutting process, with special emphasis on the steam dryer segmentation projects that have been completed to date.

## INTRODUCTION

Some commercial nuclear power plants have been permanently shut down to date and decommissioned using dismantling methods. Other operating plants have decided to undergo an upgrade process that includes replacement of reactor internals. In both cases, there is a need to perform a segmentation of the reactor vessel internals with proven methods for long term waste disposal.
The steam dryer is one of the components that is most frequently replaced on operating Boiling Water Reactors (BWR's). It is used as the final stage of moisture removal to provide the highest possible quality steam to the turbine. Its replacement is usually dictated by power up-rate considerations. It is a big stainless steel structure of about 6 meter high and 5 meter diameter. Therefore, segmentation is usually required after its replacement to dispose it and free space at the plant. Figure 1 illustrates a steam dryer.

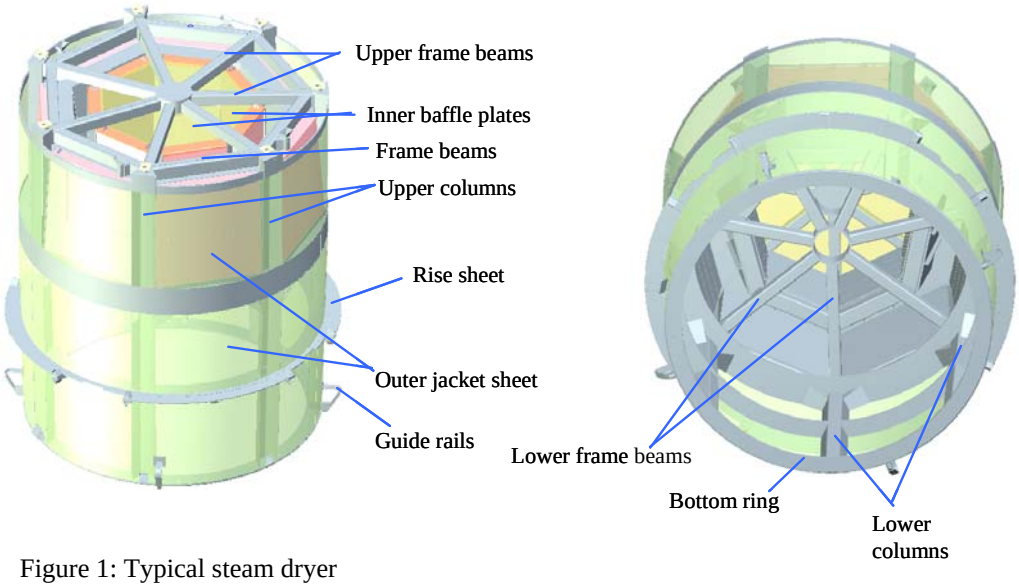


Figure 1: Typical steam dryer

**PROJECT EXPERIENCE**

For more than twenty years, Westinghouse has developed several concepts to dismantle reactor internals based on safe and reliable techniques, including plasma arc cutting (PAC), abrasive waterjet cutting (AWJC), metal disintegration machining (MDM), or mechanical cutting.
In recent years, Westinghouse has streamlined its segmentation strategy by selecting mechanical cutting methods over the other methods for cost and minimization of risk reasons.
Mechanical cutting has a number of advantages that make it suitable for most applications:

- The technique produces almost no secondary waste.
- The visibility during cutting is very good because the cutting produces only a negligible amount of micro particles.
- Chips from the cutting process falls down to the bottom of the cutting pool and are easy to collect.
- No gases are produced that can cause airborne contamination.
- The technique is safe and reliable.
- All reactor internal sizes, materials and thicknesses can be cut.

Since 1999, Westinghouse has segmented all types of BWR reactor internals in Sweden and Finland, using mechanical cutting methods. The projects have been performed at Forsmark 1, 2 and 3, Oskarshamn 1, 2 and 3 and Olkiluoto 1 and 2. The most recent BWR segmentation projects are being performed in Olkiluoto (Finland) and Forsmark (Sweden).
Based on this solid experience, Westinghouse recently won three contracts related to Pressurized Water Reactors (PWR's) for the dismantling of the Chooz A reactor (France), the segmentation of the reactor internals of the Zorita plant (Spain) and the segmentation of Guide Tubes for EDF (France).
A detailed reference list is provided in table 1 here after.

Table I. Segmentation projects performed and contracted

| Scope of Supply | NPP Unit | Country | Type | Year |
|---|---|---|---|---|
| Core Shroud | Forsmark 2 | Sweden | BWR | 2000 |
| Core Shroud | Forsmark 1 | Sweden | BWR | 2001 |
| Core Shroud Cover | Oskarshamn 2 | Sweden | BWR | 2003 |
| Core Shroud Cover | Oskarshamn 2 | Sweden | BWR | 2004 |
| Core Shroud Cover | Olkiluoto 2 | Finland | BWR | 2004 |
| Core Shroud Cover | Olkiluoto 1 | Finland | BWR | 2005 |
| Core Shroud Cover | Forsmark 2 | Sweden | BWR | 2010 Ongoing |

| Scope of Supply | NPP Unit | Country | Type | Year |
|---|---|---|---|---|
| Core Shroud Cover | Forsmark 1 | Sweden | BWR | 2011 Contracted |
| Core Shroud Cover | Forsmark 3 | Sweden | BWR | 2011-2012 Contracted |
| Core Shroud Cover | Oskarshamn 3 | Sweden | BWR | 2013-2014 Contracted |
| Core Support Grid | Forsmark 2 | Sweden | BWR | 2000 |
| Core Support Grid | Forsmark 1 | Sweden | BWR | 2001 |
| Core Support Grid | Oskarshamn 2 | Sweden | BWR | 2003 |
| Core Support Grid | Oskarshamn 1 | Sweden | BWR | 2004 |
| Core Support Grid | Olkiluoto 2 | Finland | BWR | 2004 |
| Core Support Grid | Olkiluoto 1 | Finland | BWR | 2005 |
| Feed Water Spargers (6 pcs) | Oskarshamn 2 | Sweden | BWR | 2003 |
| Steam Separators (19 pcs) | Olkiluoto 2 | Finland | BWR | 2004 |
| Steam Separators (19 pcs) | Olkiluoto 1 | Finland | BWR | 2005 |
| Core Spray System | Forsmark 1 | Sweden | BWR | 2003 |
| Core Spray System | Forsmark 2 | Sweden | BWR | 2003 |
| Core Spray System | Forsmark 3 | Sweden | BWR | 2004 |
| Core Spray Riser Pipes (8 pcs) | Oskarshamn 2 | Sweden | BWR | 2003 |
| Core Spray Riser Pipes (8 pcs) | Oskarshamn 1 | Sweden | BWR | 2004 |
| Test Channels (3 pcs) | Oskarshamn 2 | Sweden | BWR | 2003 |
| Test Channels (9 pcs) | Oskarshamn 1 | Sweden | BWR | 2004 |
| Control Rods | Forsmark 3 | Sweden | BWR | 2010 |
| Control Rods (120 pcs) | Olkiluoto 1 | Finland | BWR | 2009 |
| Control Rods (81 pcs) | Olkiluoto 2 | Finland | BWR | 2009 |
| Steam Dryer | Olkiluoto 1 | Finland | BWR | 2009 |
| Steam Dryer | Olkiluoto 2 | Finland | BWR | 2011 Contracted |
| Steam Dryer | Forsmark 2 | Sweden | BWR | 2010 |
| Steam Dryer | Forsmark 1 | Sweden | BWR | 2011 Contracted |
| Steam Dryer | Oskarshamn 3 | Sweden | BWR | 2013-2014 Contracted |
| Upper Internals | Zorita | Spain | PWR | 2012-2013 Contracted |
| Upper Internals | Chooz A | France | PWR | 2013-2016 Contracted |
| Lower Internals | Zorita | Spain | PWR | 2012-2013 Contracted |
| Lower Internals | Chooz A | France | PWR | 2013-2016 Contracted |
| Operational Waste | Zorita | Spain | PWR | 2012-2013 Contracted |
| Operational Waste | Chooz A | France | PWR | 2013-2016 Contracted |
| Reactor Vessel | Chooz A | France | PWR | 2013-2016 Contracted |

**SEGMENTATION PROCESS**

Detailed planning is essential for a successful project, and typically a “Segmentation and Packaging Plan” is prepared to document the effort. The usual method is to start at the end of the process, by evaluating the waste

disposal requirements imposed by the customer, what type and size of containers are available for the different disposal options and working backwards to select the best cutting tools and finally the cut geometry required. These plans are made utilizing advanced 3-D CAD software to model the process. Another area where the modeling has proven invaluable is in determining the logistics of component placement and movement in various stages of segmentation. The main objective of the segmentation and packaging plan is to determine the strategy for separating the highly activated components from the less activated material, so that they can be disposed of in the most cost effective manner. Typically in the U.S., highly activated components cannot be shipped off-site, so they must be packaged such that they can be dry stored with the spent fuel in an Independent Spent Fuel Storage Installation (ISFSI). Less activated components can be shipped to an off-site disposal site depending on space availability. All segmentation tools are remotely controlled since the mechanical segmentation projects that Westinghouse has executed so far have been performed under water due to the high radiation levels. ALARA and personal safety is the number one priority during the site work. The complexity of the work requires well designed and reliable tools. Before going to site, testing and qualification are therefore performed on full scale mock-ups in a specially designed pool for segmentation purposes (see figures 2 and 3).

Figure 2: Westinghouse test facility

Figure 3: FAT (Forsmark, 2009-2012)

**DISC SAW TOOLING**

The first disc saw was developed and used in Olkiluoto in 2004, for cutting of beams on a BWR Core shroud head. Since then, a new disc saw has been developed and successfully used on the most recent steam dryer segmentation projects.

This disc saw can be adapted to different lifting and clamping devices. Westinghouse has developed more than 15 different disc saw clamping devices to be able to cut the very difficult geometries of the BWR steam dryers. The saw is remotely controlled and the design enables the saw to cut both deep cuts with a swiveling arm and long cuts with a sledge running along a rail. A hydraulic power unit connected to the motor with two hoses makes the disc to rotate with the desired speed. The feeding of the arm and the sledge is controlled by an “intelligent” electrical system that optimizes the cutting speed for the different cutting conditions.

The disc saw is attached to the cutting position by a clamping device with hydraulic cylinders. It can be equipped with different kinds of discs depending on material and sizes of the object to cut.

The total weight of a standard disc saw is between 200-500 kg. The cutting speed varies, depending on the equipment to cut, material properties, location and disc condition. The thickness of the discs can vary between 4-8 mm, depending on their type and outer diameter.

Lifting tools connected to the crane are used to create pretension to the cut piece and prevents jamming problems.

**STEAM DRYER SEGMENTATION PROJECTS**

Westinghouse has been awarded several contracts that included segmentation of steam dryers  This paragraph provides an overview of the tools and method that have been used.

**Segmentation in Olkiluoto (2008-2011)**

During the outages in 2005 and 2006, the steam dryers of Olkiluoto 1 and 2 (Finland) have been replaced and stored in pools at the plants. Westinghouse has been awarded the contract for the segmentation of those steam dryers. One

steam dryer has been segmented at Olkiluoto 1 between the outages of 2008-2009 and the second one is planned to be cut at Olkiluoto 2 in 2011.
The technique for cutting the steam dryers is based on the disc cutting technique which has been used in an earlier project in Olkiluoto and has been further tested and developed at the Westinghouse test facility in Västerås, Sweden, with very satisfactory results. About 10 different disc saw setups have been used to segment the complex geometry of the Olkiluoto 1 steam dryer. Figure 4 shows the cutting of the steam dryer under water.

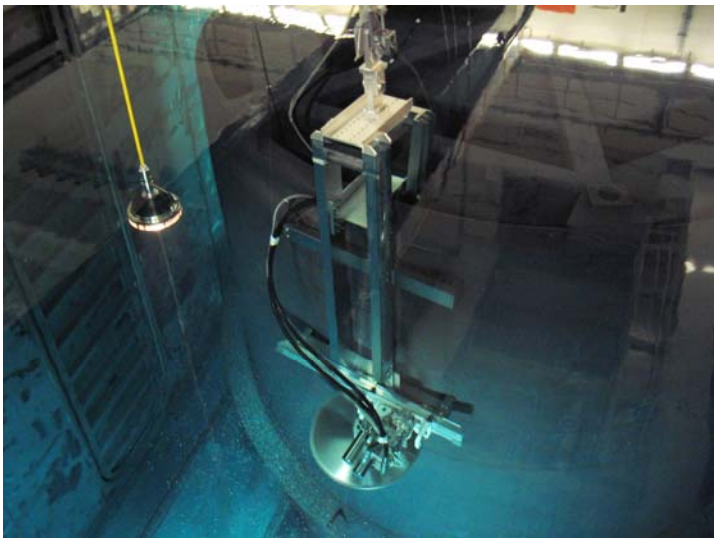

Figure 4: Cutting of Steam Dryer in Olkiluoto 1

**Segmentation in Forsmark (20010-2012)**
Westinghouse has an ongoing segmentation project at Forsmark in Sweden as a result of a power up-rate of the three nuclear plants and replacement of a large amount of reactor internals. As part of the scope of work, two steam dryers have to be segmented.
Westinghouse was awarded the contract in June 2006 and the segmentation work started on site in January 2010. All equipments and tools has been designed, manufactured, tested and qualified to-date. All testing and approval qualification have been performed on full scale mock-ups in a specially designed pool for segmentation purposes. The steam dryer in Forsmark 2 has been successfully segmented.in 2010.

**Segmentation in Oskarshamn (2013-2014)**

Westinghouse has also been contracted in December 2009 a segmentation project at Oskarshamn 3 in Sweden following a significant power up-rate. The scope of this project includes the segmentation of the steam dryer which is planned to start in 2013 on site.

## CONCLUSIONS

Westinghouse has accumulated a combined experience with design capabilities and project execution skills necessary to successfully perform dismantling of reactor vessel internals. Westinghouse’s selected platform is mechanical cutting which is currently used for the segmentation of BWR steam dryers replaced during plant modernization projects. Westinghouse continues to develop this technology to address the market needs.