Remotely-Controlled Shear for Dismantling Highly Radioactive Tools In Rokkasho Vitrification Facility - 12204

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ABSTRACT

A high-level liquid waste vitrification facility in the Japanese Rokkasho Reprocessing Plant (RRP) is right in the middle of hot commissioning tests toward starting operation in fall of 2012. In these tests, various tools were applied to address issues occurring in the vitrification cell. Because of these tools' unplanned placement in the cell it has been necessary to dismantle and dispose of them promptly. One of the tools requiring removal is a rod used in the glass melter to improve glass pouring. It is composed of a long rod made of Inconel 601 or 625 and has been highly contaminated. In order to dismantle these tools and to remotely put them in a designated waste basket, a custom electric shear machine was developed. It was installed in a dismantling area of the vitrification cell by remote cranes and manipulators and has been successfully operated. It can be remotely dismantled and placed in a waste basket for interim storage. This is a very good example of a successful deployment of a specialty remote tool in a hot cell environment. This paper also highlights how commissioning and operations are done in the Japanese Rokkasho Reprocessing Plant.

INTRODUCTION

RRP owned by Japan Nuclear Fuel Limited (JNFL) is the first commercial spent nuclear fuels (SNFs) Reprocessing Plant in Japan. The RRP, located in Aomori prefecture which is northern part of Japan, covers 3.8 million m^2 with several treatment facilities including the vitrification facility. The site construction was started in 1993 and the first SNFs were received in 2000. After initial cold commissioning tests, hot commissioning tests were started in 2006 and the commercial operation will be started in fall of 2012.

In the high-level liquid waste (HLW) vitrification facility, HLW transferred from the separation process facility is mixed with borosilicate glass in two glass melters and then the mixture is poured into stainless steel canisters. The filled canisters are lid-welded, cooled, decontaminated and taken for visual inspection, surface contamination inspection and confinement inspection. After passing the inspections, the canisters are transferred to a Glass Package Storage Facility and temporarily stored in a storage pit. The off-gas coming from the glass melter is cleaned through scrubbers and filters, and eventually emitted to atmosphere (shown in Figure 1).

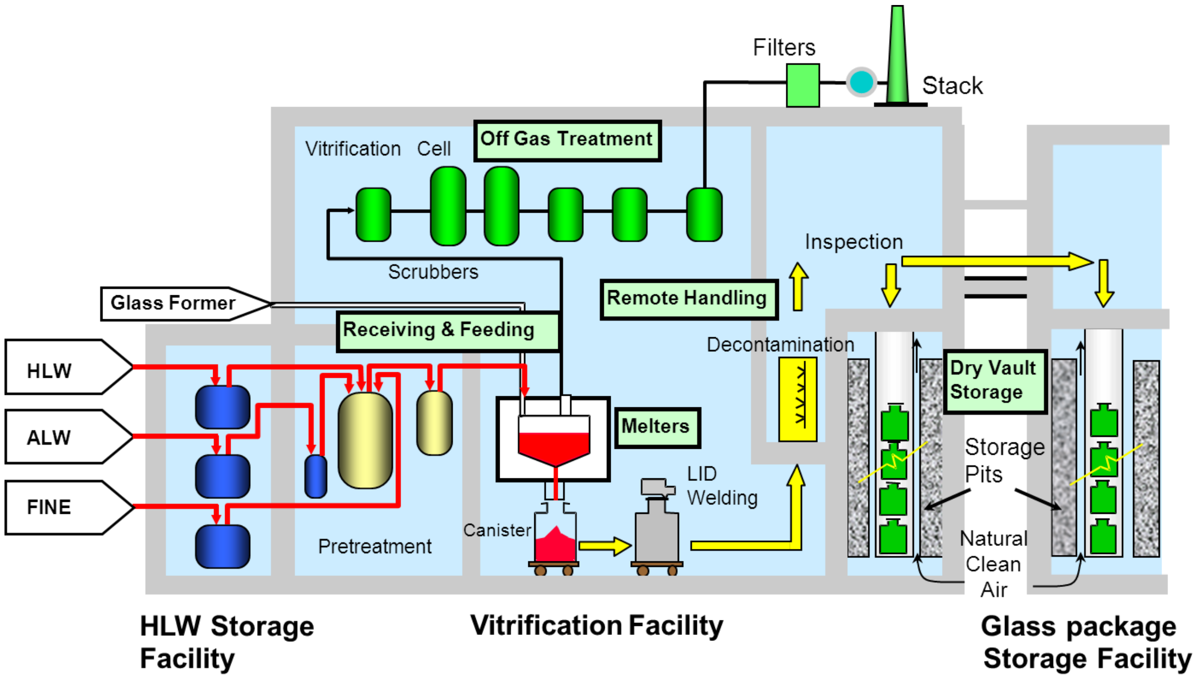

Figure 1: Outline of the Rokkasho Vitrification Facility in the RRP

THEVITRIFICATION CELL

In the vitrification facility the major components of the process are the glass melters, off-gas treatment systems, and canister handling systems. There are two complete process lines with duplicate pieces of equipment. Both process lines are located in a large hot cell called the "Vitrification Cell" which is approximately 40 m long, 15 m wide and 15 m tall (shown in figure 2). In addition, two overhead cranes with power manipulators and some master-slave manipulators are also installed in the cell in order to remotely access and handle the equipment in the cell. The cell has a dismantling area which is approximately 15 m long, 4 m wide and 7 m tall in order to dismantle highly-contaminated solid wastes such as used glass melters, filters and tools.

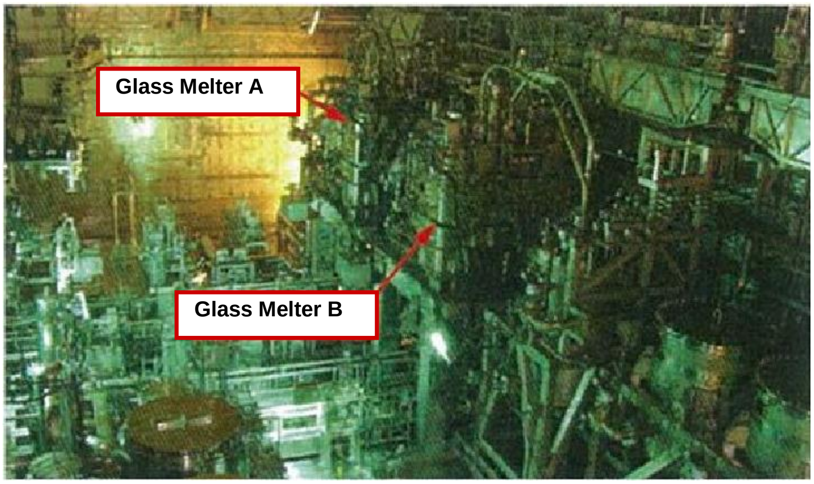

Figure 2: The Vitrification Cell[1]

WASTE TOOLS IN THE VITRIFICATION CELL

One of the main purposes of the hot commissioning tests of the vitrification facility is to confirm the throughput of the vitrification process, mainly consisting of the performance of the glass melter with actual HLW. It is very important for the facility to keep stable performance of the glass melter which is the core of the facility. The tests for the facility have started in2006 and about 100 canisters with vitrified HLW have been produced. On the other hand, some issues related to the glass melter operation have occurred in the vitrification cell during the tests. Various tools were temporarily applied to address these issues. Each of the tools showed good performance and as a result, most of issues have been addressed. However, these tools' unplanned use in the cell has caused the serious issue of reducing working space and blocking the maintenance route in the cell. It has been necessary to promptly dismantle and dispose of the waste tools in order to address this issue.

One of the tools requiring removal is a stir rod used in the glass melter to improve its glass pouring (shown in Figure 3). It is composed of a long rod, approximately 4 m, made of Inconel 601 or 625 which have high heat and corrosion-resistance to agitate molten glass in the melter. It has been highly contaminated due to submersion in HLW molten glass. Unfortunately, the dismantling process for such a long, hard and contaminated tool is special and quite difficult. In order to remotely dismantle the rods and to put them in a designated waste basket, a custom electric shear machine was developed by JNFL, IHI Corporation (IHI) and S.A.Technology Inc. (SAT).

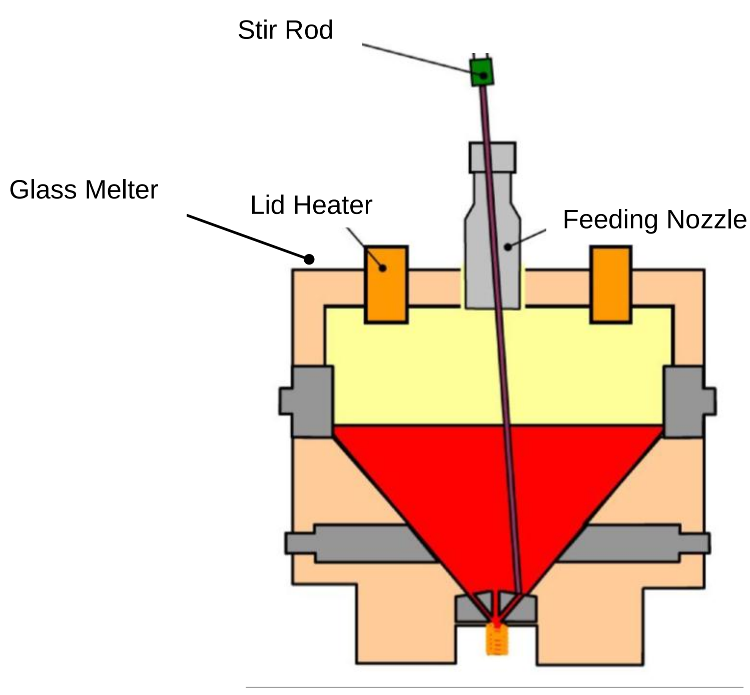

Figure 3: Stir rod[2]

DEVELOPMENT OF THE SHEAR

The shear was designed and fabricated between 2009 and 2010 (shown in Figure 4).Major specifications and requirements of the shear are shown in Table 1.

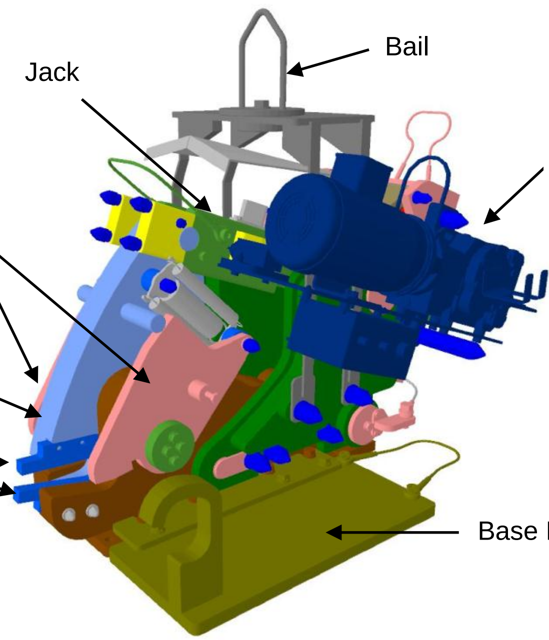

Figure 4: The remotely-controlled shear

Table 1: Major specifications and requirements of the shear

Items	Specifications	Requirements
Type of cutting	Shear-type cutting machine	Minimize scattering chips when the wastes are cut
Power Source	Electric	Prevent complicated operation and maintenance (Hydraulic is not suitable)
Dimensions	L: 1320 mm, W: 630 mm, H: 900 mm	Smaller size is preferable
How to set and cut the waste	The waste are laid on the shear and cut by a vertical moved jaw	4 m long rod has to be safely fixed and cut
Length of cut piece	0.4 m at the maximum	Cut piece has to be disposed in a designated waste basket which is 0.5 m diameter and 0.9 m tall.
How to transfer	Hooking a bail arranged just above the gravity center by a crane	Easy remote handling
Material of the blade	D2 material (High carbon high chromium cold work tool steel)	The material Inconel 601 and 625 coated with the HLW glass have to be cut
Replacement	The blades are replaced by only	Easy remote replacement of the blade

of the blade	one master-slave manipulator's arm	
Disassembling	Easily disassembled to eight units by remotely.	All parts of the shear have to be placed into the designated waste basket.

The main reason that a shear-type cutting machine has been employed for dismantling highly contaminated waste tools in the vitrification cell was to minimize scattering chips and HLW glass attached on the tools. It seemed that a disk cutter and a saw generated a lot of fine chips and scattered them so they were not suitable for this requirement. Also, to prevent complicated operation and maintenance in the cell, an electric-powered shear was adopted. A hydraulic-powered shear could be smaller than an electric one, but was not suitable because its maintenance was seen to be too complicated.

The shear had to be installed in a dismantling area in the vitrification cell by remote cranes and master-slave manipulators. For easy remote handling, an adjustable bail was arranged just above the gravity center. The shear was required to be as small as possible because of limited space to be installed. Also, the 4m long stir rod and other similar shaped equipment had to be safely fixed and sheared on the shear. Therefore, the shear was designed so that the rods were laid on it and cut by a vertical moved jaw as this configuration met both required size and performance. The length of the cut piece was adjusted to 0.4 m at the maximum in order to be disposed of in a designated waste basket which was 0.5 m diameter and 0.9 m tall.

Some hard tool steels including tungsten carbide were originally tested to cut the stir rods. Tungsten carbide was originally thought to be suitable because of its high hardness. However, it was found to be brittle and as a result it was easily broken doing testing. Finally, D2 material (High carbon, high chromium cold worked tool steel) was selected for the blade. It had moderate hardness and ductility and it was never broken doing the cutting tests. The blades were also required to be easily replaced by the master-slave manipulators. Captured fasteners were adopted to set the blades and they made the blades' replacement possible using only one master-slave manipulator's arm (shown in Figure 5)

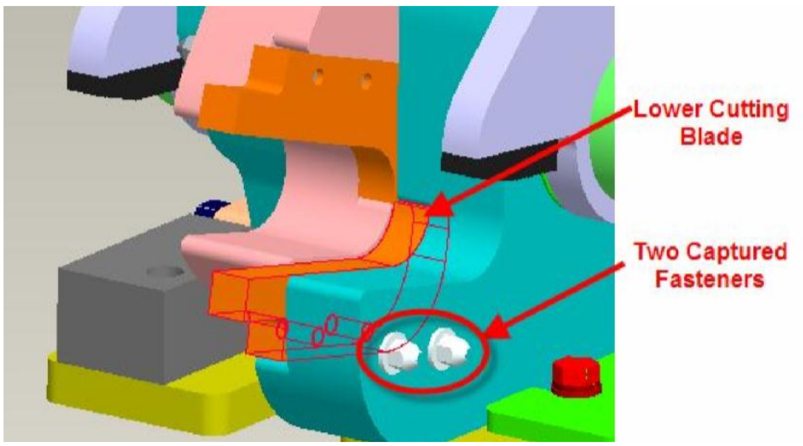

Figure 5: Blades of the shear

The most challenging thing constraint of the design was to meet the requirement that the shear could be easily disassembled into several units by master-slave manipulators and cranes remotely. All parts of the shear had to be placed into the designated waste basket as shown above when its use was finished. However after extensive design work, a system for simple dismantling with minimal procedure was developed (shown in Figure 6).

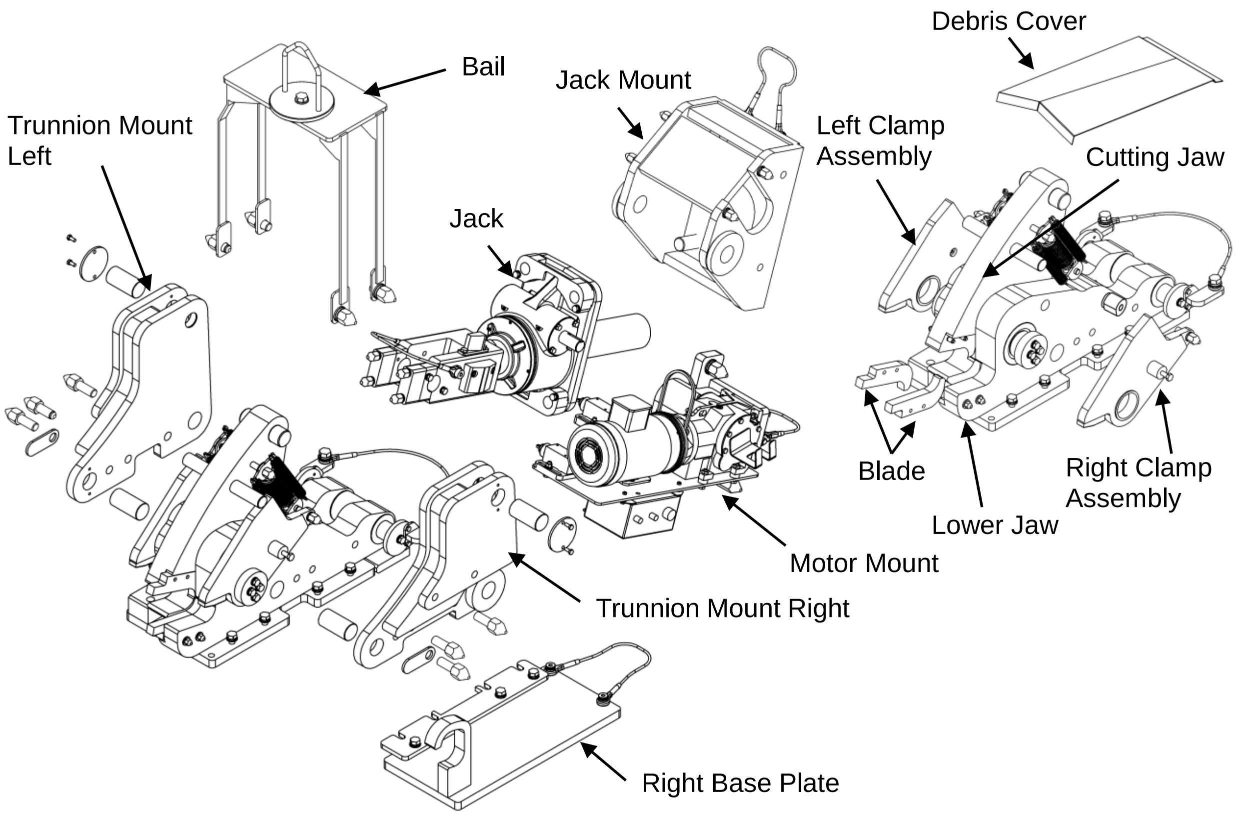

Figure 6: Disassembling the shear

After the fabrication of the shear was finished at SAT (Loveland, Colorado) in May 2010, the cutting performance of the shear was tested. In this test, the shear successfully performed over 50 cuts of the specimens coated with simulated HLW glass with no blade replacement.

After arriving at the RRP site in Japan, the cold commissioning tests for the shear were performed between June and September 2010 in order to check the remote controllability such as transfer, installation, maintenance, and dismantling procedures.

ACCOMPLISHMENT

Through some modifications, the shear was finally transferred and installed in the vitrification cell in the middle of October 2010. Cables for connecting the shear and the control panel were put into the cell through penetration piping on the outside of the cell. The shear and control panels were then connected by master-slave manipulators (shown in Figure 7). The shear was operated through the shielding window located on the dismantling area of the cell and some in-cell cameras helped to observe the operation.

The operation of the shear has been going since October 2010. 4 numbers of the stir rods and other long tools have been successfully dismantled and disposed of into waste basket by the end of May 2011 (shown in Figure 8). As a result, a reduction of approximately 50 %of vitrification cell waste (2.5 metric tons)has been accomplished.

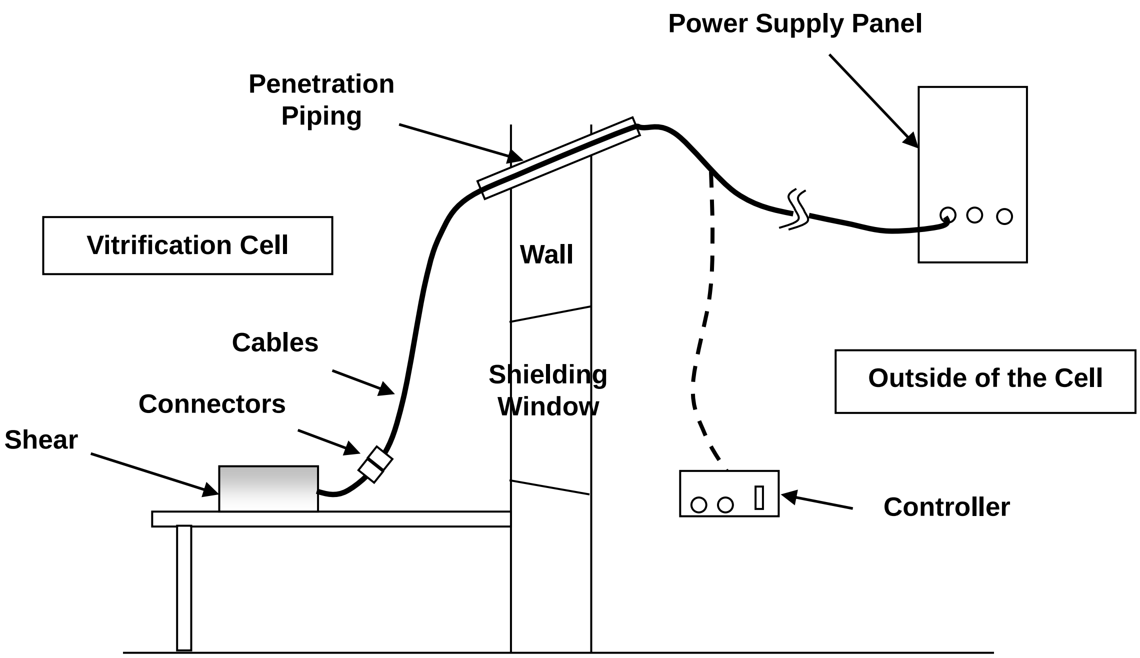

Figure 7: Connection of the shear and the control panel

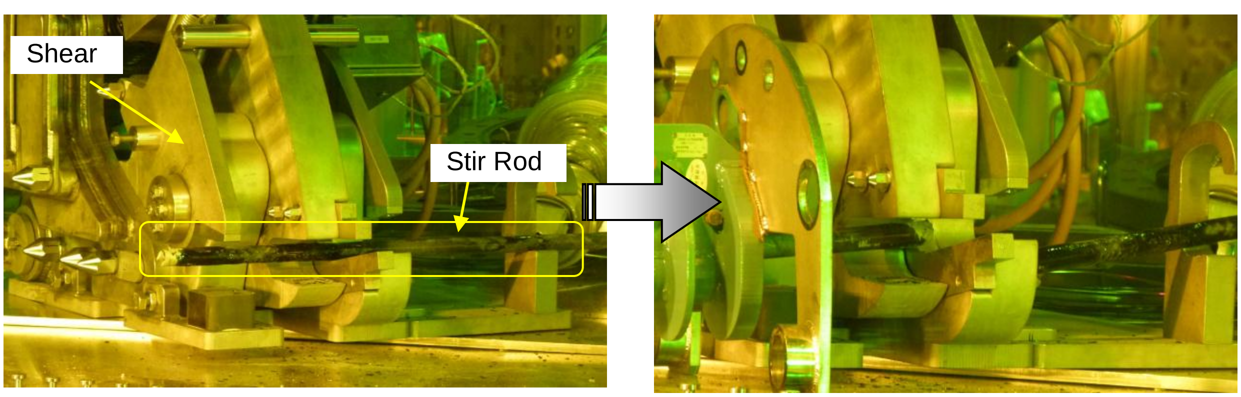

Figure 8: Performance of the shear in the vitrification cell

FUTURE ACTIVITIES

The waste stir rods will periodically need disposal as they will be continuously generated during melter operation as a commercial plant. That will bring continued operation of the shear. In addition, there is a possibility that the use of the shear will be expanded to dismantling other waste tools in the cell.

After starting the plant operation, the melter will be replaced every 2.5 years (every five years for each melter). Dedicated devices for dismantling the melter such as laser cutting devices and some power manipulators will be also installed in the dismantling area of the vitrification cell by 2014.

CONCLUSION

A remotely-controlled custom electric shear was developed for dismantling special and highly-contaminated waste tools in the vitrification cell of Rokkasho Vitrification Facility, Japan. It was designed and fabricated to meet requirements under limitations such as a highly radioactive environment, limited space and the cutting of long rods made of Inconel coated with HLW glass. The shear was installed in a dismantling area of the cell and has been operated with great success. As a result, the application of the shear has made a contribution to reduce the wastes in the vitrification cell.

JNFL and IHI have a plan to continuously develop more useful tools for smooth remote dismantling work for various challenging waste in the cell.

REFERNCES

1. Japan Nuclear Fuel Limited: High-level Liquid Waste Vitrification Facility (Japanese) Information found on the internet at http://www.jnfl.co.jp

2. Nuclear Fuel Cycle Safety Subcommittee, Advisory Committee for Natural Resources and Energy, METI: The forty first minutes (Japanese)
Information found on the internet at
http://www.meti.go.jp/committee/materials2/data/g100309fj.html