

The Preparation for the Clearance System and Its Operational Issues in FUGEN – 14055

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ABSTRACT

The prototype advanced thermal reactor FUGEN is the heavy water-moderated, boiling light water-cooled, pressure tube-type reactor with the thermal power of 557MW and the electrical power of 165 MW. Ever since first criticality in 1978, FUGEN had been operating safely with MOX fuel for more than 25 years, and ended to operate in 2003. In 2008, the decommissioning program of FUGEN was approved, which was started as the first decommissioning of commercial-scale water reactor in Japan. FUGEN decommissioning consists of 4 phases with considering the radioactive decrease of highly radioactive material and carry out step by step. It is scheduled that the whole phases of decommissioning are completed in 2033. FUGEN is in first phase of the decommissioning now, and the turbine equipment with a comparatively low radioactive contamination has been dismantled since 2008.

Radioactive solid waste generated by FUGEN's facilities dismantlement shall be treated and disposed properly according to the classification of radiation-levels (Level-1, 2, and 3). Moreover, the waste which does not need to be treated as a radioactive material by the clearance system shall be recycled.

However the commencing time of the radioactive waste disposal facility operation isn't clear, therefore, it is important to operate the clearance system and take out the dismantled objects from FUGEN in order to push forward decommissioning as much as possible at the current moment. The weight of the objects for clearance was estimated at approximately 40,000 ton, which consists of 4,200 ton of metal and 37,000 ton of concrete. They need to be taken out in a well-planned manner.

Although the dismantled objects generated by dismantling of the turbine equipment have temporarily been stored in the facility, the space for the storing is getting reduced year by year. So, the dismantled objects need to take out from the facility by applying the clearance system in early time. And they must be considered for recycling in outside. Furthermore, for establishing the operation of the clearance system completely, it is necessary not only to consider the recycling in own site, but also to study and sort out the strategies for expansion of how to use in the recycling.

In this presentation, the preparation for the clearance system and its operational issues in FUGEN are reported.

INTRODUCTION

The decommissioning of FUGEN started in 2008 after the decommissioning plan [1] was approved under the act on the regulation of nuclear source material, nuclear fuel material and reactors. In the decommissioning plan, the target facilities were confined to the facilities with the reactor license excluding non-contaminated underground structures and basements.

After the termination of operation, all fuels were removed from the reactor core, and have been stored in the spent fuel storage pool. The heavy water was withdrawn from the heavy water system. The coolant was also drained from the reactor cooling system. Presently, almost of facilities has already closed and maintained to contain the remaining radioactivity safely.

Fig.1 shows the Outline of the decommissioning plan of FUGEN. It consists of four periods as follows; 1) The Spent Fuel Transfer Period, 2) The Periphery Facilities Dismantling Period, 3) The Reactor Dismantling Period, and 4) The Building Demolition Period. The reason for classifying the decommissioning schedule into four periods is that storing spent fuel, gaining experience of

decommissioning and the attenuation of radioactivity are considered. Fig.2 shows the outline of the decommissioning process in each period.

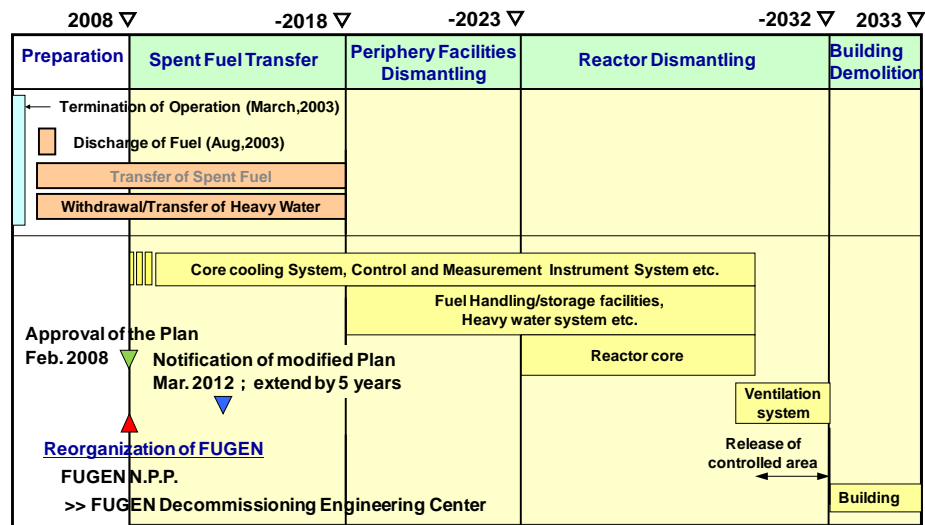


Fig.1. Outline of FUGEN decommissioning plan

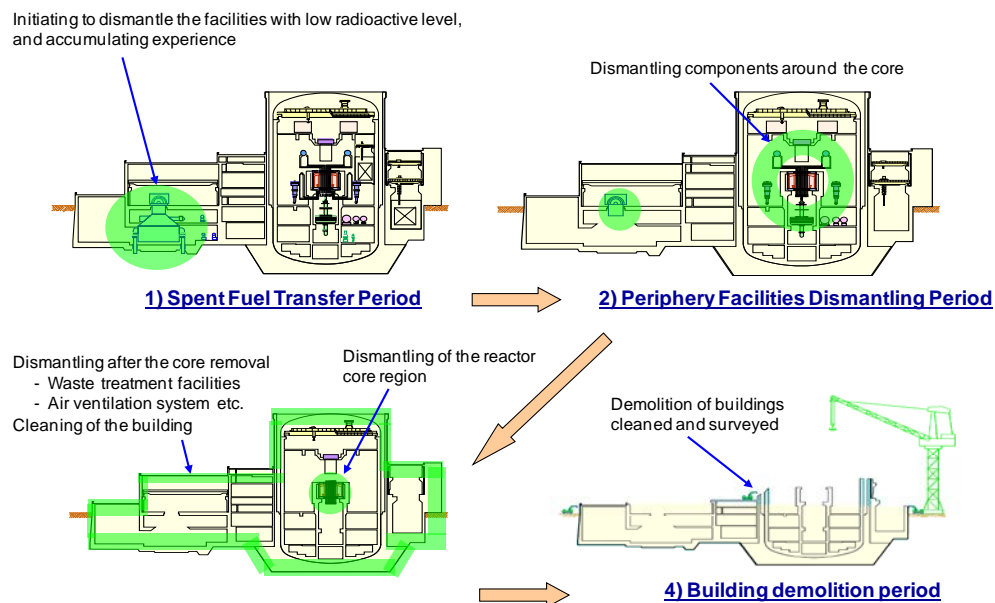


Fig.2. Procedures of FUGEN Decommissioning

In the Spent Fuel Transfer Period, both the spent fuel and the heavy water are transferred to outside of FUGEN. The spent fuels have been transported to Tokai Reprocessing facility of JAEA for its reprocessing. The heavy water is also transported to Canada for reuse at CANDU reactors. Besides some related systems for spent fuels storage such as the pool water cooling system etc. have to be operated until the transfer of spent fuel will be completed, it is initiated to dismantle the lower contaminated facilities such as the turbine device, etc. which were closed already.

In the Periphery Facilities Dismantling Period, the periphery facilities of the Reactor Core such as the reactor cooling system, the heavy water system etc., are dismantled to enable for accessing to the Reactor

Core in the next period. Because the Reactor Core part will be planning to dismantle under water in order to shield the radiation ray around the core and prevent airborne dust in cutting, the temporary pool structure and the remote-operated dismantling machines need to be installed above the core.

In the Reactor Dismantling Period, the reactor core will be dismantled by remote-operated machine under the water. The structures of the reactor core were highly activated owing to long term operation, but its nuclides are mainly Co-60 and Fe-55 nuclides whose half-life is a few years. Therefore, taking account of the decay of radioactivity due to time passage, the reactor dismantling period is allocated on the timing when it is expected that the exposure dose in the work is minimized to equivalent dose with annual inspection during the plant operation. Moreover, all of the contaminated facilities will be also removed, and buildings will be decontaminated. The radiation-controlled area will be released before the demolition of the buildings.

Finally, in the Building Demolition Period, the buildings will be demolished by common methods and processes to be applied for the demolition of ordinary buildings.

The radioactive materials which remain in a system even before the start of dismantling is removed by the decontamination work. The purposes of this work are to reduce the specific radioactivity of the dismantling waste, reduce the radiation exposure of the radiation worker, and prevent the radioactive materials from leaking to the outside of the system. The contamination of the facility mainly originates in the radioactive corrosion products. They were generated by radioactivation of Fe, Co, etc. that were eluted from metal in the reactor cooling system and the heavy water system etc. through the operation of the nuclear reactor for about 25 years. Moreover, since heavy water was used for the moderator, there is H-3 contamination generated by radioactivation of heavy water.

TABLE I shows the estimated amount of waste that was classified into the radioactive level in the operation of the nuclear reactor and in the decommissioning. The total amount of waste was estimated at about 360,000 tons, which is including about 50,000 tons of low level radioactive waste. About 40,000 tons of radioactive waste will be treated as clearance materials by decontaminating radioactive waste and the amount of radioactive waste will be reduced to about 10,000 tons.

TABLE I. Estimated amount of waste

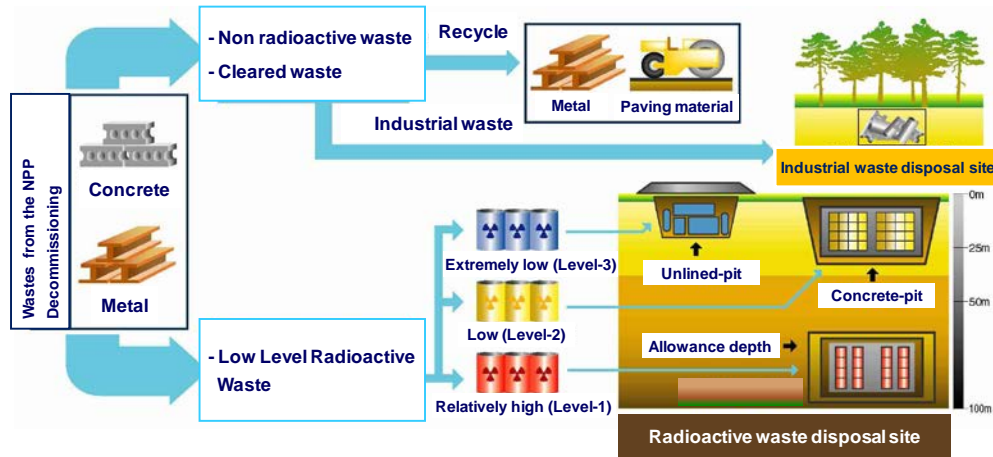
Unit: 10³ Ton

Level of Radioactive waste		In the Operation	In the Decommissioning	Total
Low Level Waste	Level-1 (Relatively high)	0.2	0.3	0.5
	Level-2 (Low)	3.0	1.4	4.4
	Level-3 (Extremely low)	-	45.5 → 5.4	45.5 → 5.4
	Subtotal	3.2	47.2 → 7.1	50.4 → 10.3 ^{*1}
Clearance Materials		-	0.6 → 40.6	0.6 → 40.6 ^{*1}
Non Radioactive Waste			141.0	141.0
Non-contaminated underground structure and buildings (not included in the Program)			170.0	170.0
Total		3.2	358.6	361.8

^{*1} About 40,000 tons of Level-3 radioactive waste will be treated as clearance materials by decontaminating 45,500 tons of Level-3 radioactive waste. Low level waste will be reduced from about 50,000 tons to about 10,000 tons.

As for the waste generated in connection with the operation and the decommissioning of the nuclear power plant in Japan, the disposal methods are decided by law, according to the classification of radioactive concentration. Fig.7[2] shows the outline of the waste disposal in Japan. Although JAEA is supposed to construct and operate the low-level waste disposal facility where the radioactive solid waste

(Level-2, Level-3) generated from FUGEN decommissioning will be buried, the start of the operation is not decided. Moreover, the construction schedule for the Level-1 waste disposal facility has been unclear yet.



Referred from HP of Nuclear and Industrial Safety Agency

Fig.7. Outline of Waste Disposal in Japan

CURRENT SITUATION OF FUGEN DECOMMISSIONING

FUGEN has been decommissioned since the decommissioning plan was approved in 2008. In the initial stage of decommissioning, the turbine system such as the main steam line, the feedwater heater etc. which have low radiation and contamination, has been dismantled in order to accumulate the experience of dismantlement. Fig.3 shows the progress of dismantlement. The amount of dismantling waste has been about 760 tons for 5 years as shown in TABLE II. These have been temporarily kept to the vacant space in the controlled area and these almost will be treated as clearance materials.

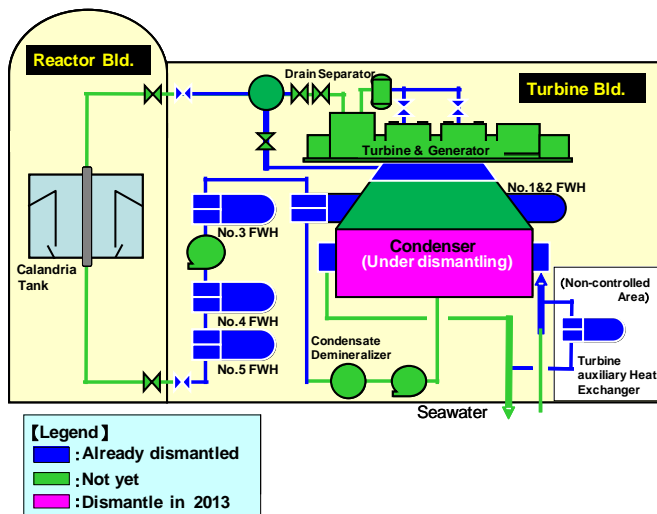


Fig.3. Progress of Dismantlement

TABLE II. Amount of dismantling waste

Fiscal Year	Dismantled amounts* (ton)	Dismantled facilities
2008	259	No.3,4 FWH
2009	45	No.5 FWH
2010	169	Piping and Valves around Condenser
2011	178	No.1,2 FWH, a part of Condenser body
2012	107	a part of Condenser body and internals
total	758	

*:Almost is Metal, including Concrete & Insulation

H-3 was generated from activation of the heavy water in reactor core. It is important to collect the heavy water contaminated by H-3 from the system as much as possible prior to dismantling work for the system. After draining the heavy water from the system, the residual heavy water has been withdrawn by suctioning partially, and H-3 has been removed by applying the drying process. The collected heavy water is being transferred to Canada for re-use since 2005. 240 tons of the heavy water was transferred so far. The rest of the heavy water will be transferred in this year.

The spent fuels are to be transferred to JAEA Tokai reprocessing facility. However, JAEA Tokai reprocessing facility has not been operated due to the delay of seismic measures and the influence of the Great East Japan Earthquake etc. Therefore, the decommissioning plan was modified in 2012 to extend the spent fuel transfer period for 5 years. There are 466 spent fuel assemblies in the spent fuel storage pool.

CLEARANCE SYSTEM

The clearance system on which the ministerial ordinance was enforced in December, 2005 is performed under the act on the regulation of nuclear source material, nuclear fuel material and reactors. Fig.4 shows the procedure of the clearance system. First, the nuclear operators apply to Nuclear Regulation Authority for the clearance measurement and judgment, and it is necessary to be permitted. After the permission, the nuclear operators must execute on the permitted clearance measurement and judgment. Then, it becomes possible to recycle and to deal with clearance materials as ordinary materials after Nuclear Regulation Authority confirms the result of the clearance measurement and judgment. The clearance materials are no longer regulated under the act on the regulation of nuclear source material, nuclear fuel material and reactors and those are regulated under Regulation by Wastes Disposal and Public Cleansing Act. Therefore, Nuclear Regulation Authority is supposed to inform Minister of the Environment about the clearance Permission and Confirmation.

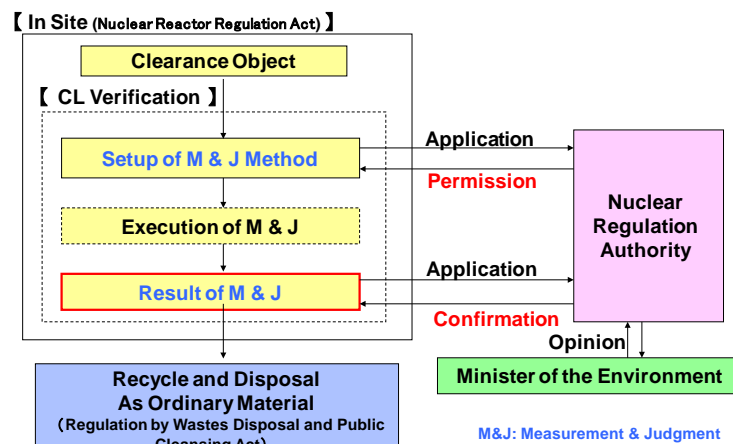


Fig.4. Procedure of Clearance

STATE OF PREPARATION FOR CLEARANCE SYSTEM

The estimates of the clearance materials in FUGEN are about 4,200 tons of the metal and about 37,000 tons of the concrete in consideration of decontamination. Currently, the preparation of the 1st application for approval for the clearance is advanced. The wet blasting decontamination device and the clearance

monitor were introduced, the temporary storage space of the dismantling waste have been prepared. Fig.5 shows the state of the preparation for the clearance system. The target of the 1st application for approval for the clearance is due to be about 1000 tons of the metal waste which are generated by dismantling the turbine equipment. The material qualities of the metal waste are the carbon steel and the stainless steel.

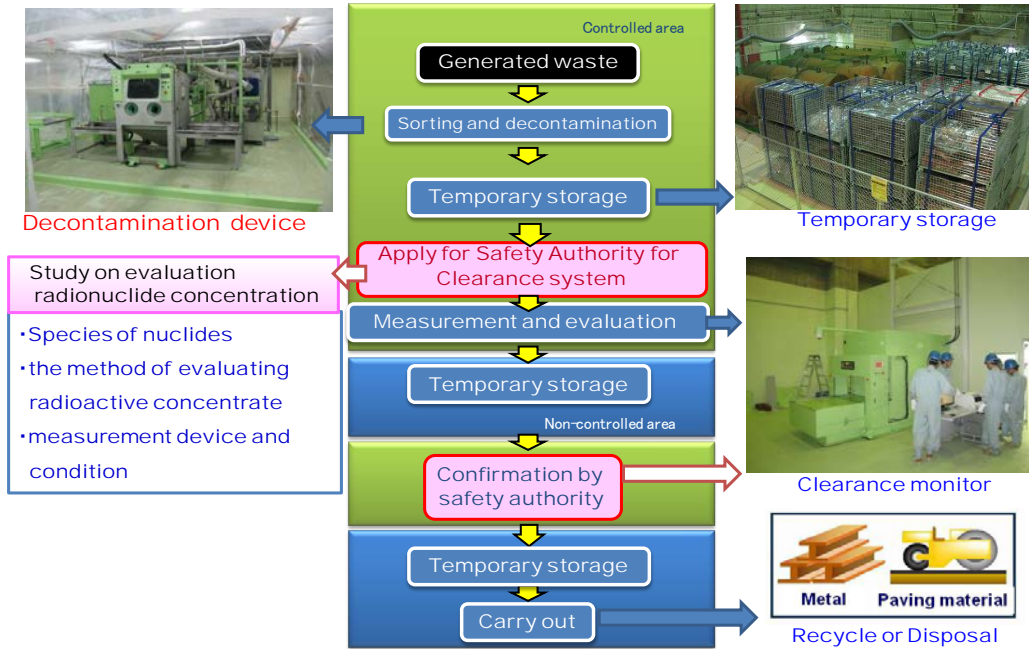


Fig.5. State of Preparation for Clearance system

The radionuclides used for clearance evaluation are considered to be 10 nuclides(H-3, Mn-54, Co-60, Sr-90, Cs-134, Cs-137, Eu-152, Eu-154, Pu-239, Am-241). As for the evaluation method of radioactive concentration of 10 nuclides, first, the radioactive concentration of Co-60 is evaluated from the counting rate measured by the clearance monitor. Then, the radioactive concentration of 9 nuclides other than Co-60 is evaluated from the result of having analyzed radioactive concentration of the samples collected from the equipments in advance. Fig.6 shows the cross section and the specifications outline of the clearance monitor.

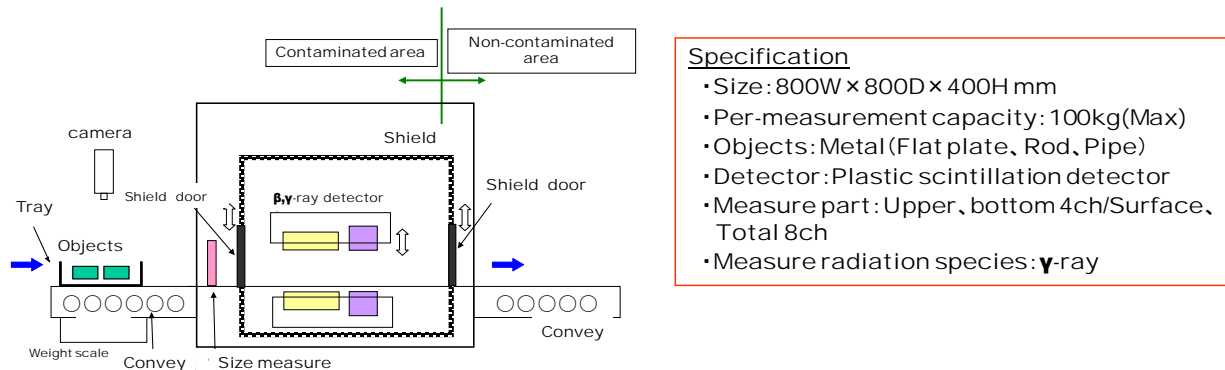


Fig.6. Cross Section and Specifications Outline of Clearance Monitor

The clearance judgment will be performed on the basis of the clearance standard as follows.

$$\sum_{i=1}^n \frac{D_i}{C_i} \leq 1 \quad (\text{Eq.1})$$

where n is the number of radionuclide used for the clearance estimation; D_i is the average radioactive concentration of the nuclide i ; C_i is the clearance level of the nuclide i . TABLE III shows the clearance levels of 10 nuclides.

If the summation is less than or equal to 1 from Eq.1, the measured clearance objects will be judged to be clearance materials.

TABLE III. Clearance levels of 10 nuclides.

No.	Radionuclide	Clearance Level [Bq/g]
1	H-3	100
2	Mn-54	0.1
3	Co-60	0.1
4	Sr-90	1
5	Cs-134	0.1
6	Cs-137	0.1
7	Eu-152	0.1
8	Eu-154	0.1
9	Pu-239	0.1
10	Am-241	0.1

OPERATIONAL ISSUES ON CLEARANCE SYSTEM

Currently, the dismantling waste generated from FUGEN decommissioning is temporarily kept to the vacant space in the controlled area until the clearance system start. So as to continue the dismantling work, it is necessary to apply the clearance system to the dismantling waste and take it out from the controlled area in FUGEN, because there is almost no vacant space. That is effective in the radioactive waste reduction.

In the operation of the clearance system, it is important that the quality assurance activity is carried out appropriately until the clearance materials will be taken out from the plant premises. In addition, it is necessary to ensure the traceability of the recycled clearance materials. The clearance materials as the recyclable resources cannot be taken by the industrial waste disposers until the clearance system takes root in society. After the clearance system takes root in society, the clearance materials as the recyclable resources can be taken by the industrial waste disposers.

The final target to be achieved is to treat the clearance materials as the recyclable resources or the general industrial wastes, it is called the free-release of the clearance materials. However it is necessary to obtain the public acceptance of the clearance system. That will take a step-by-step approach. To achieve the public acceptance, as the nuclear operators in Japan pledged, the first step must be to recycle the clearance materials inside the nuclear facilities or the plant premises owned by them. Aiming for the future free-release, the nuclear operators should acquire the successful results of controlled recycling continuously in a transparent manner.

In addition, it is important to perform the activities to obtain understanding of the local government and the stakeholders, when the nuclear operators outsource casting and manufacturing etc. to the manufacturers in order to recycle the clearance materials.

The nuclear operators must decide what to cast etc. and where to install on the nail. Additionally, from the

WM2014 Conference, March 2 – 6, 2014, Phoenix, Arizona, USA

aspect of the management of the clearance materials, it is difficult to recycle the clearance materials through a complicated manufacturing process. Therefore, the choice of the recycled products is restricted. Some issues to secure the material flow of the clearance materials are to determine or create the demand for the recycled products of the clearance materials, to ensure the supply of the recycled products and to secure the budget.

FUGEN is presently planning to cast the guard fence, the drain cover and the paving block etc., install them at FUGEN premises to recycle the clearance metals. But it is extremely difficult to recycle all clearance metals at FUGEN. Therefore it is necessary to develop plan to install any recycled products in JAEA facilities except for FUGEN, the nuclear operators and others.

CONCLUSIONS

It is necessary to apply the clearance system to the dismantling waste in order to continue the dismantling work. Currently, the preparation of the 1st application for approval for the clearance is advanced in FUGEN. Then the wet blasting decontamination device and the clearance monitor were introduced, the temporary storage space of the dismantling waste have been prepared. In order to carry out the free-release of the clearance materials in the future, we'll conduct the restrictive recycle, in which dismantled wastes are recycled inside our facilities, as a first step of the application of the clearance system. It is also important to accumulate the successful results of restrictive recycle operation, and to open the results for obtaining the understanding of the local government and the stakeholders.

REFERENCES

1. K. Kitamura et al., ICEM2009-16108, Liverpool, October 11-15 (2009)
2. Home page of the former Nuclear and Industrial Safety Agency