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PRESENT STATUS OF JAERI TOKAI HOT CELL FACILITIES

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日本原子力研究所
Japan Atomic Energy Research Institute

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Hiroharu ITAMI and Minoru MOROZUMI +

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(Received January 7, 1992)

JAERI Tokai has three hot cell facilities to examine high radioactive materials; the Research Hot Laboratory, the Reactor Fuel Examination Facility and the Waste Safety Testing Facility.

This report describes briefly the current status of their post-irradiation examination activities including general description of the facilities.

Keywords: Hot Laboratory, Post-irradiation Examination,
Nuclear Fuels, Nuclear Structural Materials, HLW

+ Office of Operational Safety Administration

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原研東海研究所におけるホットセル施設の現状

日本原子力研究所東海研究所ホット試験室
伊丹 宏治・両角 実+

（1992年1月7日受理）

本報告書は平成3年11月11日から4日間，日立市において開催された第3回研究炉に関するアジアシンポジウム（ASRR－Ⅲ）のために作成したものである。

内容は原研東海研究所が運転管理している大型ホットラボ施設，（ホットラボ施設，燃料試験施設，WASTEF）の概要と，照射後試験の現状について概説した。

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Contents

目　　次

1. Abstract

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The Research Hot Laboratory (RHL) was constructed for post-irradiation examination (PIE), especially general basic research experiment, such as metallurgical, chemical and mechanical examination on fuels and materials irradiated in research and test reactors. This facility has 10 large dimension concrete and 38 lead cells. At present the RHL is used for various kinds of examinations of high radioactive samples such as fuels of research and test reactors, power reactors and high temperature testing reactor (HTTR), and structural materials.

The Reactor Fuel Examination Facility (RFEF) was designed and constructed for carrying out PIE of irradiated full-size fuel assemblies of light water reactors (LWRs). This facility has a storage pool, 8 concrete and 5 lead cells. They are currently used for safety evaluation on high burnup and advanced LWR fuels as part of the national program.

The Waste Safety Testing Facility (WASTEF) was designed and constructed for safety research on long-term storage and disposal of high level radioactive wastes generated by fuel reprocessing. The WASTEF has 5 concrete cells and 1 lead cell. Examinations on the behavior of various long-lived fission products in a glass form and in a canister and, releasing behavior of them out of a canister are carrying out under the condition at storage.

2. Introduction

Nowadays the mission of PIE facility for high radioactive materials becomes more important than ever with progress of nuclear research and development. In the early stage of nuclear research and development at the JAERI, radioactive samples irradiated in the small research reactor Japan Research Reactor-1 (JRR-1) had not so high radioactivity. Therefore a small hot cell was installed in the reactor building, mainly to separate irradiated samples from capsules.

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Following the construction of large scale research reactor JRR-2, the RHL capable for PIEs on very high radioactive materials irradiated in the JRR-2 was constructed in conjunction with the JRR-2, and has been operated since 1961. With increasing wide variety of PIE items for nuclear fuels and structural materials irradiated in JRR-2, -3, Japan Material Test Reactor (JMTR) and the commercial gas cooled power reactor of Japan Atomic Power Co. (JAPCO), numerous modification and additions of the hot cells became necessary. Under these circumstances, extension of the facility and installation of the new PIE apparatus were carried out.

Since LWRs were introduced in Japan, new important needs occured; one is PIE of full-size fuel assembly to verify the good performance of fuel assembly throughout its life in reactor core, and the other is examination of high level waste disposal. The facility for the former is the RFEF, and for the latter is the WASTEF. These facilities were established in late 1970's.

3. The Research Hot Laboratory (RHL)[1,2]

The Research Hot Laboratory (RHL) was built to examine nuclear fuels and materials irradiated in research or test reactors, and started operation in November 1961. Initial design of the RHL was as follows;

- 4 concrete caves for metallurgical and mechanical property examination
- 2 concrete caves for chemical treatment
- 14 lead cells for radiochemical analysis
- 3 semi-hot cells for radiochemical experiment on small samples

Main PIEs in the early stage were mechanical property and metallurgical examination on reactor fuels and reactor structural materials irradiated in JRR-2 or foreign country reactors.

To monitor fuels and moderator graphite samples, and to survey reactor vessel steel samples of Tokai Power Station of JAPCO, the extension of the facility was started in 1963, and completed the work in 1965. The monitoring tests on these materials have been carried out as one of the main PIEs at the RHL.

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Because new research and technology needs to the hot cell facility are increasing, to satisfy these needs, re-extension and improvement of the facility have being considered presently.

4. The Reactor Fuel Examination Facility (RFEF)[3,4,5]

When LWRs were introduced in Japan, it was a matter of concern that the integrity of the fuel assembly throughout its whole life shall be verified by PIE. However, the RHL has not capability to treat full-size commercial LWR fuel assembly, construction of another hot cell facility at JAERI Tokai was decided in 1974, and the new facility RFER started its operation in 1979.

Layout of the RFER is shown in Fig. 3. A storage pool, 6 beta-gamma concrete cells with 3 lead cells, 2 alpha-gamma concrete cells with 2 lead cells are located at the first floor. Main specifications and functions of these cells are shown in Table 3. Major advantages of the beta-gamma cells are capability to receive, store, handle, disassemble and re-assemble full-length of LWR fuel assembly and to carry out non-destructive examination for full-length fuel rods with vertical location. And also, the RFEF has JAERI's first alpha-gamma concrete cells for the PIE of advanced fast breeder reactor (FBR) fuel under development.

Fuel assemblies irradiated in power reactors are shipped to the RFEF using a special transfer cask for PIE. The fuel assembly is first inspected in the pool and cell No. 1, then disassembled in the cell No. 3. After fuel rod cutting, detailed destructive examinations such as metallurgical, mechanical property and analytical PIE for pellets and cladding tube specimens are carried out. These PIE flow is shown in Fig. 4. Following the PIEs, fuel rods are re-assembled and sent to a reprocessing plant at Power Reactor and Nuclear Fuel Development Corporation (PNC)

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So far, PIEs of 2 BWR, 6 PWR and 2 Fugen (ATR) fuel assemblies, and some gadolinia bearing and high burnup of 48 GWd/t fuel rods have been performed successfully as shown in Table 4.

5. The Waste Safety Testing Facility (WASTEF)[6)]

The safety on the long-term storage and disposal of high level waste is one of the most important part in nuclear safety. It has decided that high level waste (HLW) from fuel reprocessing plant is vitrified to solid waste, and will be storaged in deep underground in Japan. Behavior of radioactive substances released from the solid wastes in long-term storage and disposal condition is most important parameter on safety evaluation to this method, and it has to be estimate accurately. Construction of the WASTEF focusing on these experimental items was started in 1978. The facility is composed of 3 beta-gamma concrete cells for solidification and sampling, and 2 alpha-gamma concrete cells, 1 lead cell and 4 glove boxes for experiment and analyses. Layout of the facility is shown in Fig. 5. Main items of the examination are vitrification, radioactivity balance, homogeneity, alpha radioactivity stability, volatility, leachability and devitrification tests. These tests have been carried out since 1982.

To date, more than 40 HLW vitrified samples have been produced. Following the vitrification test, samples were provided for testing on characterization of HLW glass forms, and release behavior of radioactive substances under storage and disposal conditions. In addition, an accelerated alpha radiation stability test continues in connection with characterization of returnable forms from oversea reprocessing.

Figure 6 shows a typical test result on release behavior of ^{134}Cs into the plenum of a canister from a vitrified glass for evaluation of safety in a storage condition.

6. Summary

Hot Laboratories in JAERI Tokai are outlined their specifications, functions and their current activities. The sphere of PIE activities

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Table 1 Specification of hot cells in the RHL

Name of Cells	Inside Dimension W×D×H(m)	Number of Windows ※1	Gamma-Shielding ※2	Gamma-Capacity (TBq)
Clean	10 ×2.6 ×4.2	3	magnetite concrete density 3.5g/cc tickness 100cm	3,700
Dirty	12 ×2.6 ×4.2	4		3,700
Storage	4.4 ×2.6 ×4.2	2		3,700
Maintenance	3.0 ×2.6 ×4.2	1		3,700
Metallurgy A,B,C	2.4 ×2.4 ×4.1 3 cells	3	magnetite concrete density 3.5g/cc tickness 100cm	1,100
Metallurgy D	4.0 ×2.4 ×4.4	2		1,850
Chemistry	2.4 ×2.0 ×3.8 2 cells	2		370
U/M No.1～12	(1～1.6)×1.1 ×1.1 12 cells	12	Lead No.1～4 : 25cm No.5～12 : 17cm	370 18.5
Steel No.1～6	1.5 ×1.3 ×2.3	6	Lead 10cm	0.185
Junior	1.1 ×1.0 ×1.0 14 cells	14	Lead 15cm	18.5
Semi-hot	(1.0～1.2)×0.8 ×(1.0～1.2)	4	Lead 10cm	0.185
SE	2.1 ×1.3 ×1.2	2	Lead 15cm	18.5

※1. Window means working position for PIE.
※2. All of cells are non-gas tight ($\beta-\gamma$ cells).

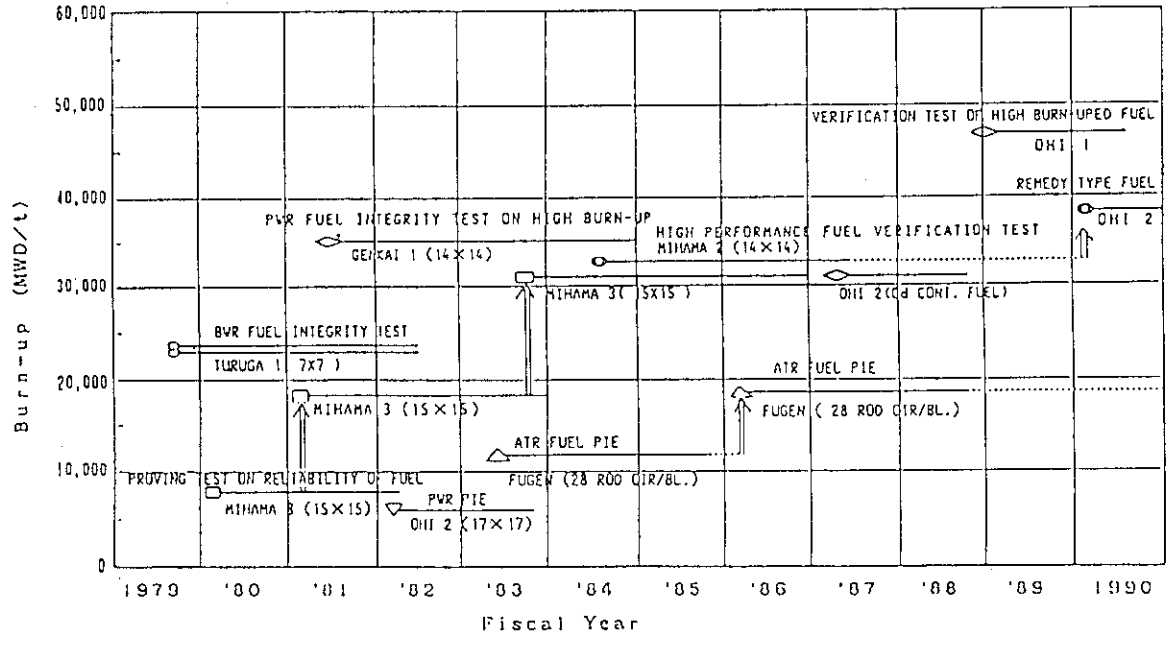
Table 2 Available PIE items in the RHL

Name of Cells	Items of Post-irradiation Examination
Storage	Loading, Unloading, Storage
Clean	NDE ; Visual Inspection, Dimension measurement, X-ray radiography
Dirty	Dismantling (fuel elements, Capsules) Waste disposal; Cutting, Compressing, Packaging
Maintenance	Decontamination and repair of equipment
Metallurgy	Cell A: Dismantling, Storage; Cell B・C: Tensile test (Max. 1500 °C), Visual Inspection, Weighing Cell D: Gamma-scanning, Creep test (max. 900°C)
Chemistry	・Fission gas collection (Puncture) ・Electrolytic deconsolidation and acid leaching ・Dissolution of fuel for burnn-up datamination
U/M No.1～12	Metallography and its preparation work ; Sampling, Mounting, Polishing, Etching, Optical micrography, Autoradiography, Hardness test, etc.
Steel No.1～6	Tensile and Compressive test, Instrumented impact test. Fracture toughness test
SE	SEM Observation, X-ray microanalysis
Junior and Semi-hot	Visual Inspection, X-ray microradiography X-ray diffraction, Compression test and Very high temperature heating of coated particle fuel

Table 3 Specification and function of hot cells in the RFEF

Cell or Pool		Inside Dimension(m)	Shielding Wall (cm)	No. of Window	Max. Activity (TBq)	Function
Pool		10x6 x15.5 (Depth)	———	———	3.6×10^{4}	Loading, Storage, Carry out Assy. or fuel rod to / from Cell No.1 via. canal. Visual Inspection, Radiation Measurement
βγ Cell Line	No.1	W x D x H 8.5x 3 x 12.6	120 (High Density Concrete)	8	3.0×10^{3}	Assy: Visual Inspn.& Photo., Metrology, Temp. Measurement, De-cruding Rod: Visual Inspn.& Photo., Profilometory Gamma Scanning, PCG Measurement
	No.2	6 x 3 x 7	120	3	3.0×10^{3}	Rod: X-ray Radiography, Puncture & Gas Sampling, Eddy-current Test, Oxide Thickness Measurement
	No.3	10 x 3x 7	120	5	3.0×10^{3}	Assy: Disassembly & Rod Extraction, Reassembly Rod: Cutting, De-fueling, Re-fabrication for Irradiation Test, SCC Test (Cladding Sample)
	No.4	4 x 3x 4.5	100	2	3.3×10^{2}	Tensile/Compression Test, Expansion Mandrel Test
	No.5	2.5x 3 x 4.5	100	1	3.3×10^{2}	Precise Cutting & Mounting, Micro Sampling, Higt Temp. Released FP Gas Analysis
	No.6	6 x 3 x 4.5	100	3	3.3×10^{2}	Polishing, Etching, Macro-Photo.
βγ Lead Cell	No.1	1.2x 1 x 2	17.7(Lead)	1	3.7	Optical Microscopy
	No.2	1.7x 1 x 2	17.7	2	3.7	Optical Microscopy, Micro Hardness Test
	No.3	2 x 1 x 2	17.7	2	3.7	Micro-γ Scan, X-ray Diffraction, Ultra Micro Hardness Test, Autoradiography
αγ Cell Line	No.1	4 x 3 x 4.5	100	2	3.3×10^{2}	Visual Inspn. & Photo., Profilometory, Gamma Scanning, Puncture & Gas Collection, Density Measurement
	No.2	6 x 3 x 4.5	100	3	3.3×10^{2}	Sectioning & Mounting, Polishing, Etching, Macro-Photo.
αγ Lead Cell	No.1	1.5 x1.8 x 2	17.7	1	3.7	SEM, Mosaic Photo.
	No.2	1.3 x1.8 x 2	17.7	1	3.7	Optical Maicroscopy

Table 4 PIE schedule of LWR fuels in the RFEF



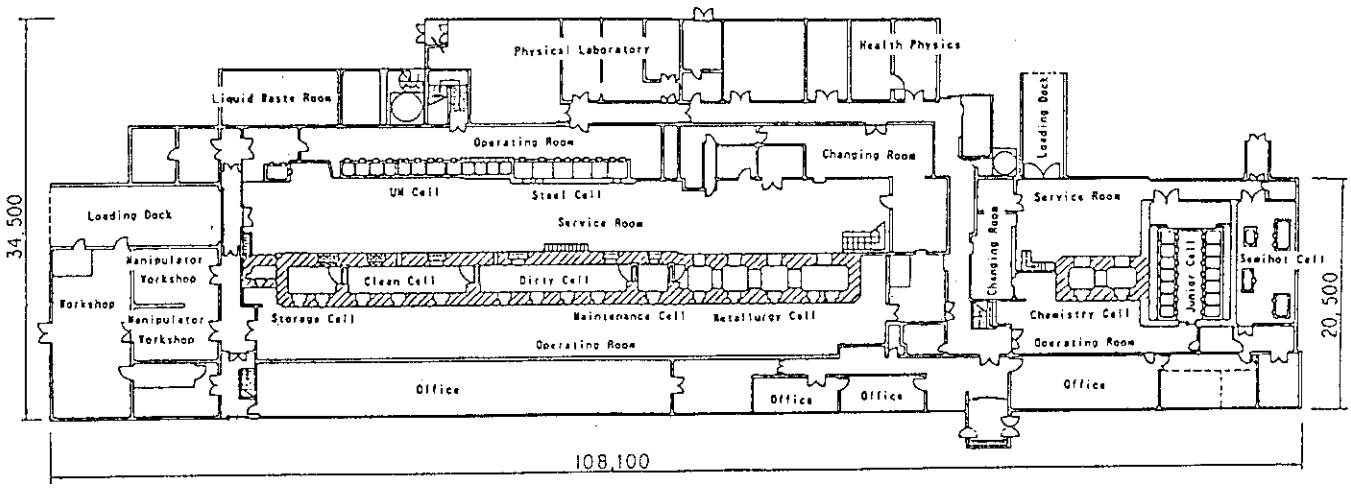


Fig. 1 Floor layout of the RHL

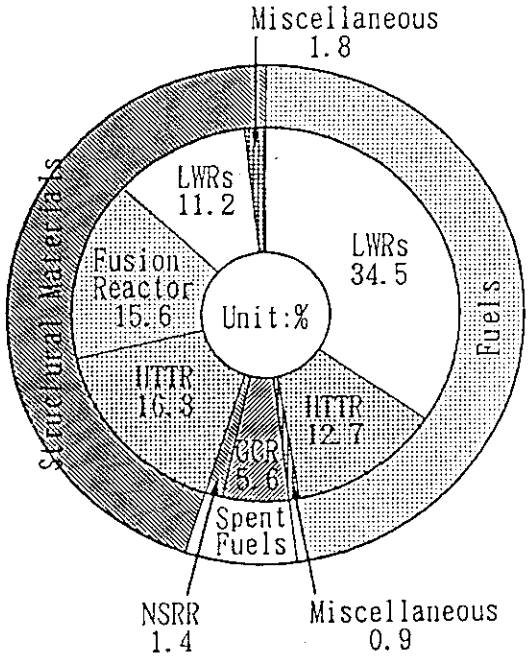


Fig. 2 Utilization of the RHL in 1990

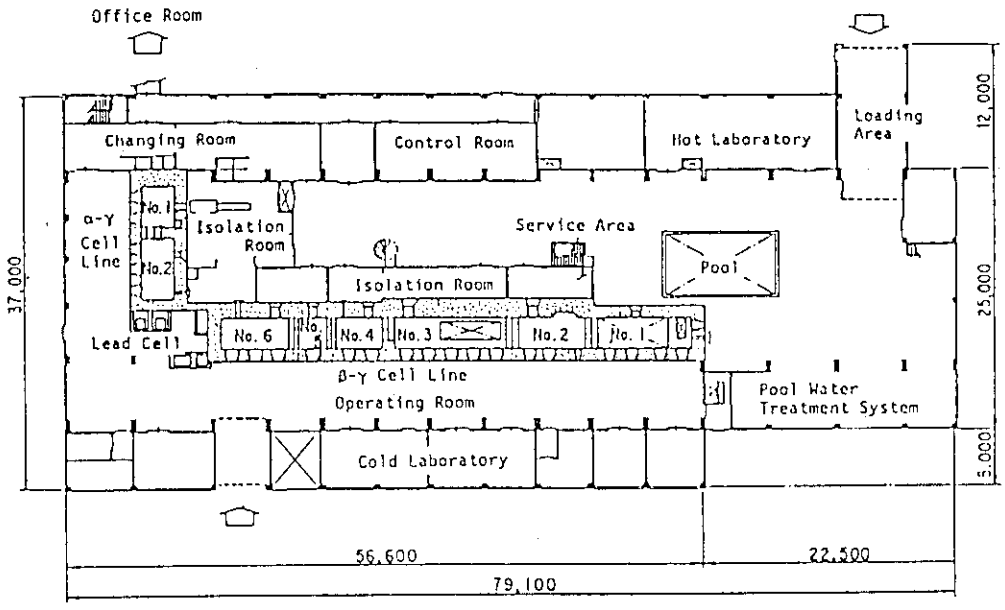


Fig. 3 Floor layout of the RFEF

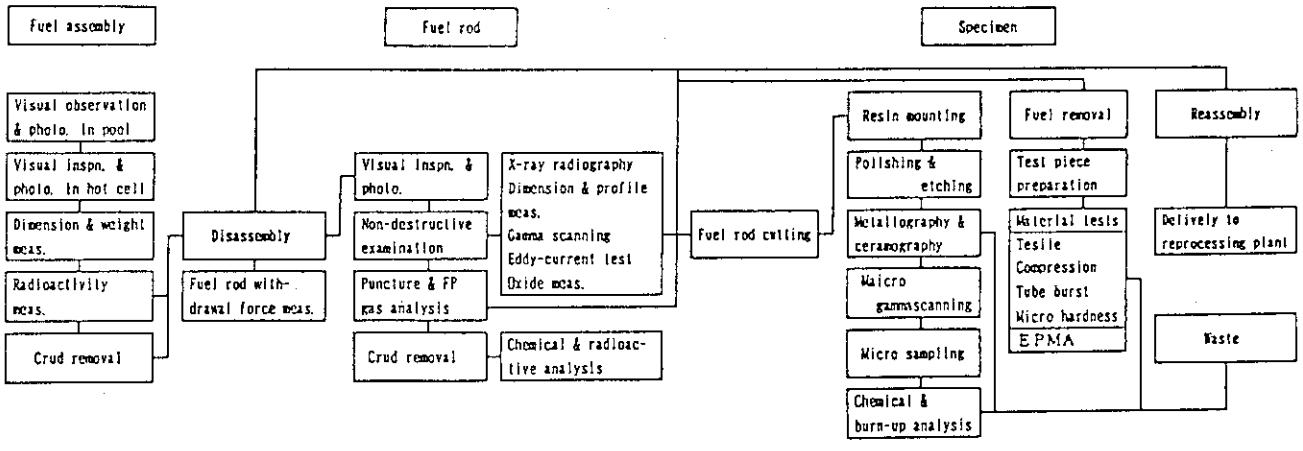


Fig. 4 Flow of Examination in the RFEF

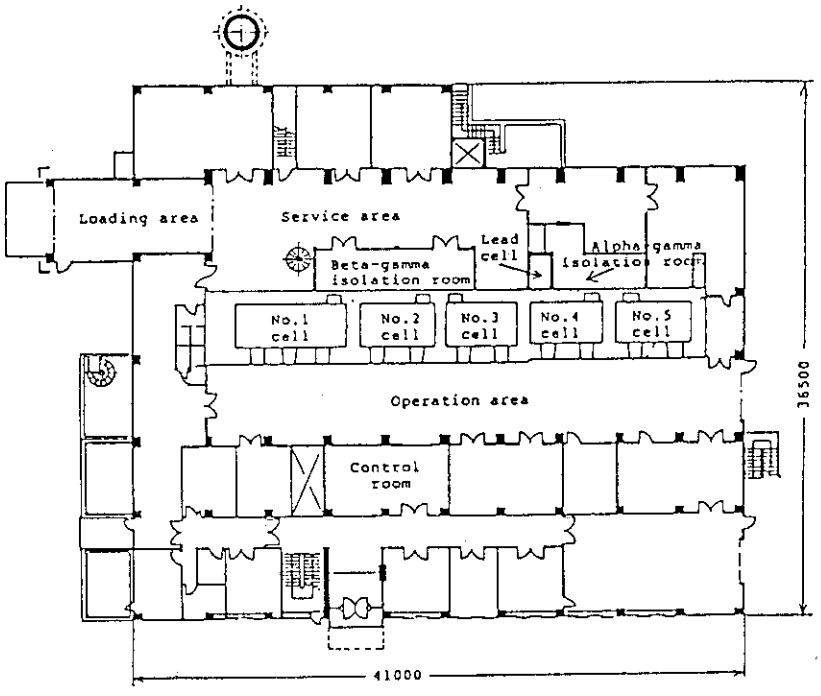


Fig. 5 Floor layout of the WASTEF

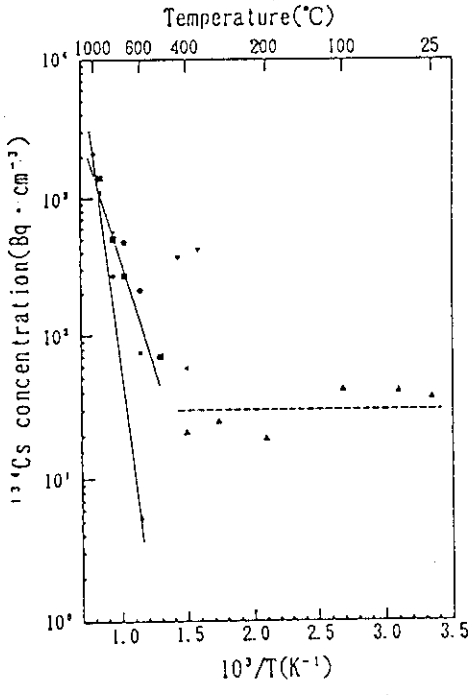


Fig. 6 Release behavior of ^{134}Cs in a canister contained vitrified glass