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Post-Irradiation Examination Capabilities of M1 Hotcell in IMEF

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KAERI
Korea Atomic Energy Research Institute

Contents

▣ Irradiated Materials Examination Facility (IMEF)

❑ **Conducting PIE on irradiated materials used in the HANARO research reactor and power plant reactors**

- Irradiation behavior evaluation of developing fuels and structural materials for next-generation reactors
- Integrity and life estimation of the structural parts in an operating reactor
- Back and fuel cycle demonstration tests

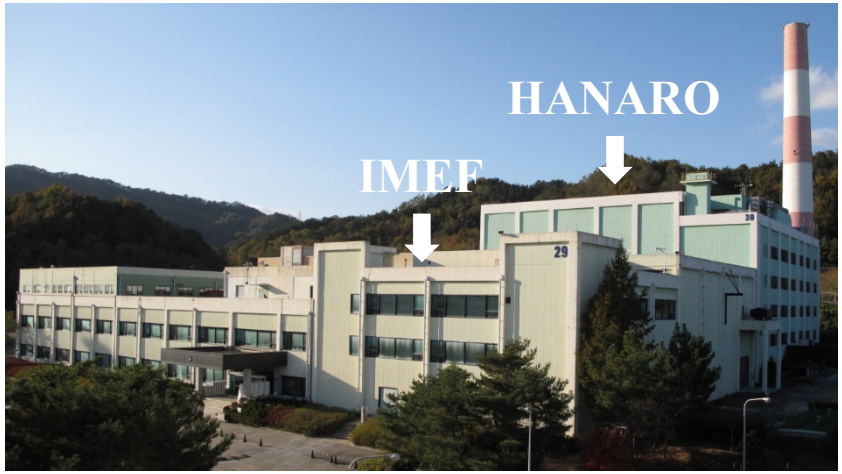


Figure. IMEF and HANRO building

Figure. Operating area of IMEF

Introduction

▣ IMEF outline

- Construction : 1988 yr ~ 1993 yr
- 3 stories and a basement (4,000 m^2)
- 71m in a total hot cell length
- 8 hot cells with 31 working units

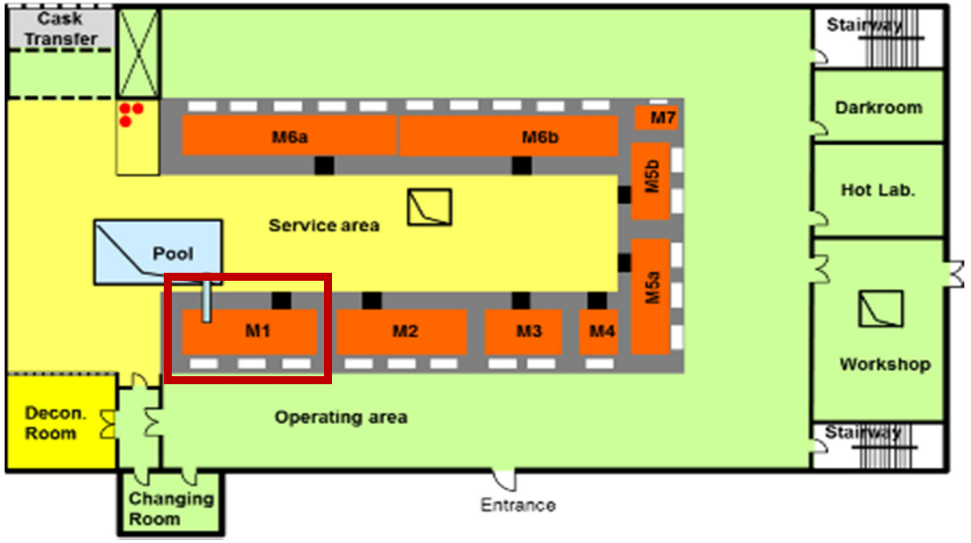


Figure. IMEF 1st floor layout

Table. Main function and equipment of hotcell

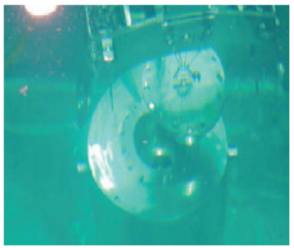
Hotcell	Main Function	Equipment
M1	Non-destructive test	Gamma scanning system, X-ray CT, Dimension measurement system, Fission gas analysis system, Vacuum heating system
M2	Dismantling & Cutting	CNC milling M/C, Capsule cutting M/C
M3	Specimen preparation	Micro cutting M/C, Mounting press, Polishing M/C
M4	Specimen storage	Storage rack
M5 line	Mechanical tests	Impact tester, 2-D optical coordinate tester, UTM
M7	Microscopy	OM, Hardness tester, Density equipment, SEM
Hot Lab.	Material Morphology	Shielded EPMA, TEM with EDX, Micro X-ray CT

Introduction

Receiving area

Cask receiving

Pool

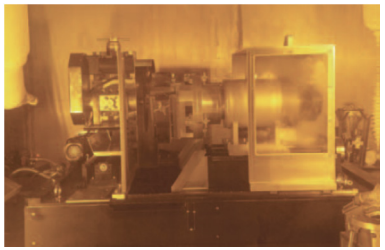


Opening cask

Bucket elevator

Moving into M1 hotcell

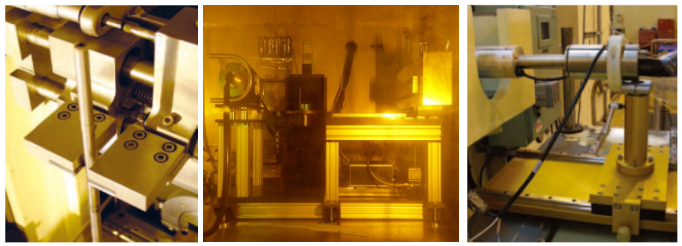
M2 hotcell



Dismantling capsule

Fuel

M1 hotcell



Non-destructive tests

M3 hotcell

Specimen preparation

Hot Lab.

EPMA

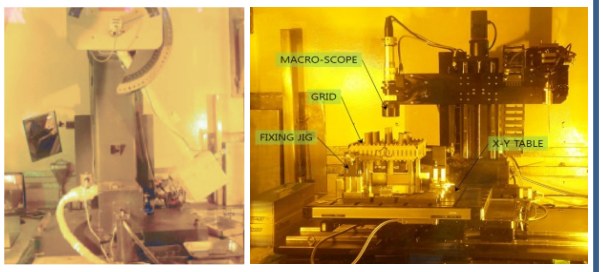
TEM

Material

M5b hotcell

Mechanical tests

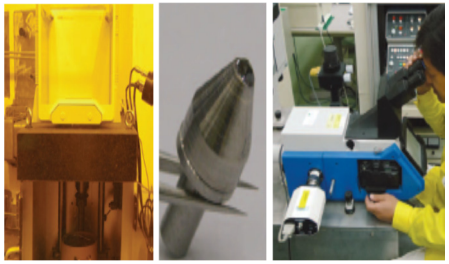
M5a hotcell



Impact test

Dimensional Measurement

M7 hotcell



Density, Hardness, OM ...

M1 hotcell equipment

▣ Gamma scanning

- Installed in operating area : MCA, PC, Bench controller

  on the outside the hotcell wall(service area) : HPGe detector
- Automatically measuring radionuclide using the bench system
- Using tungsten collimator to minimize the detector deadtime

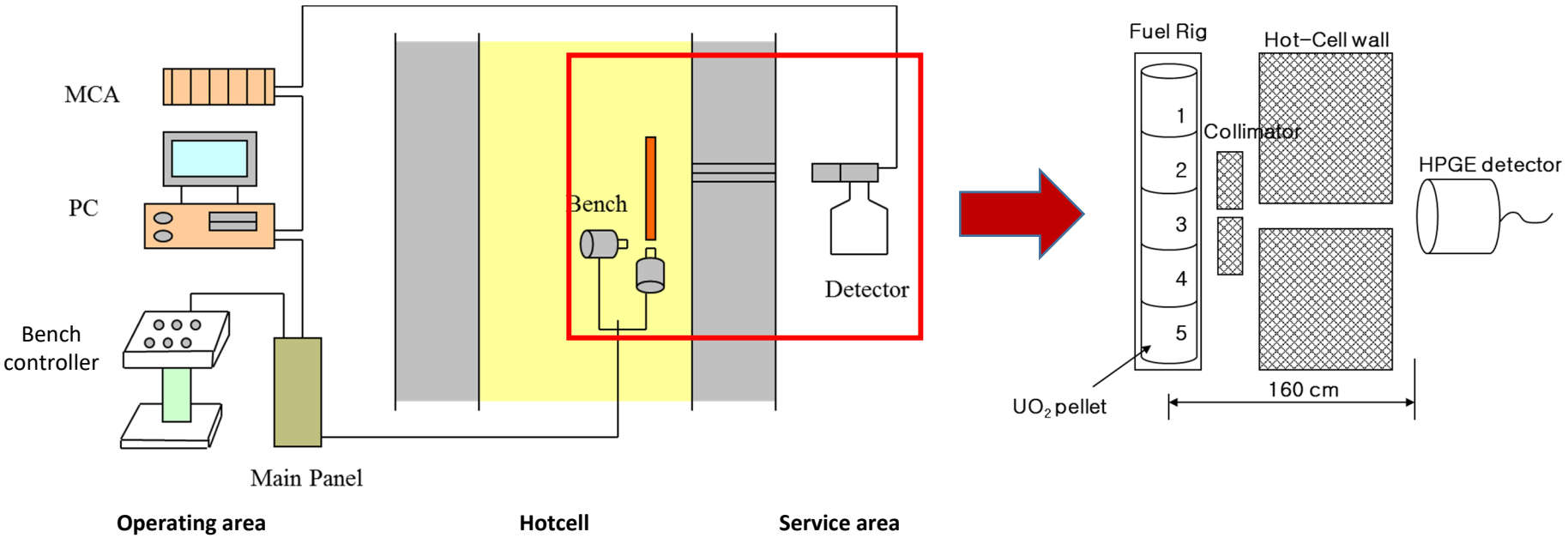
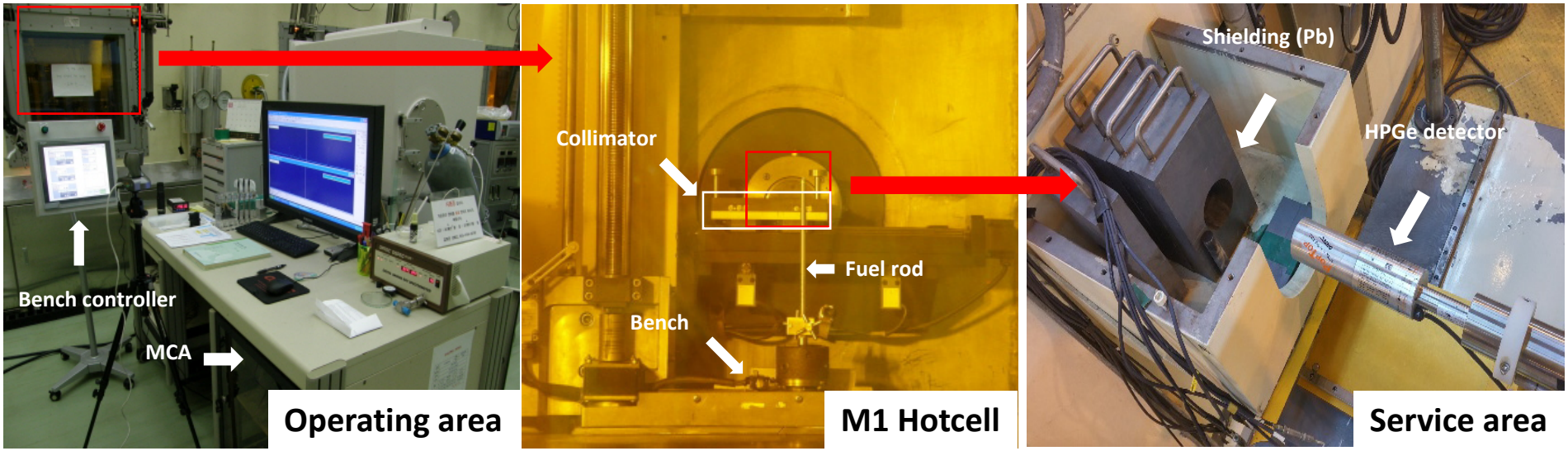
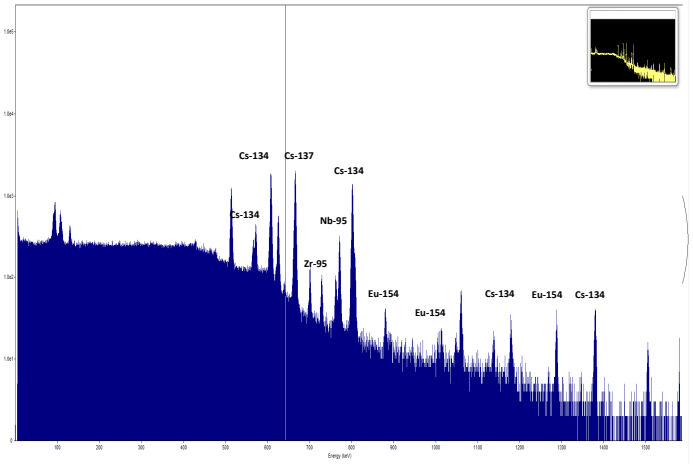


Figure. Schematic diagram of gamma scanning installed in M1 hotcell

M1 hotcell equipment

▣ Gamma scanning





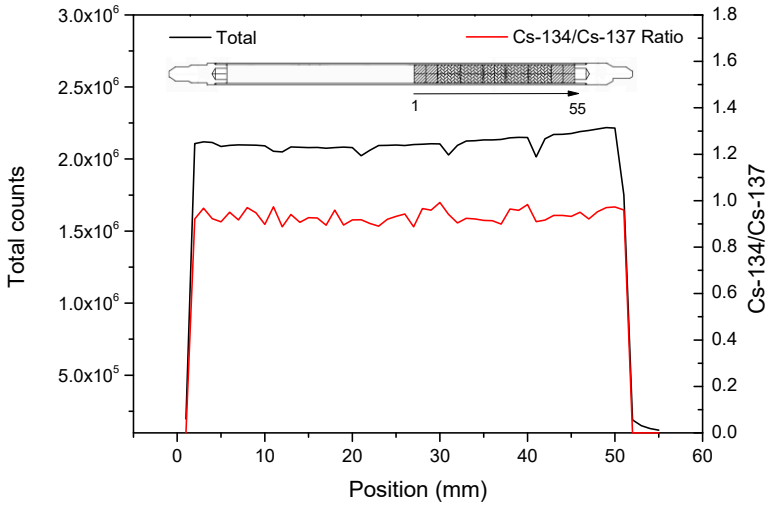


Figure. Example of gamma scanning for R&D research fuel

M1 hotcell equipment

▣ Dimensional measurement

- Measuring diameters of fuel rods using the LVDT
- Automatically measuring the diameter using the bench system
- Confirming a change of diameters and swelling

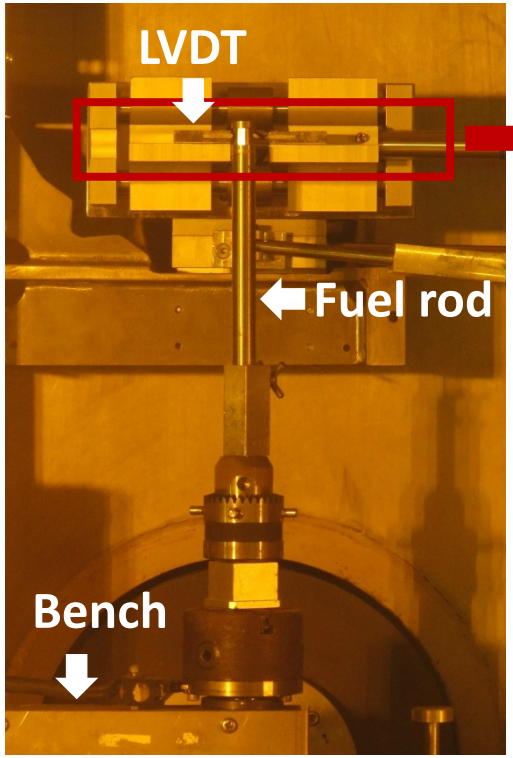


Figure. LVDT installed in M1 hotcell

Figure. Bench controller

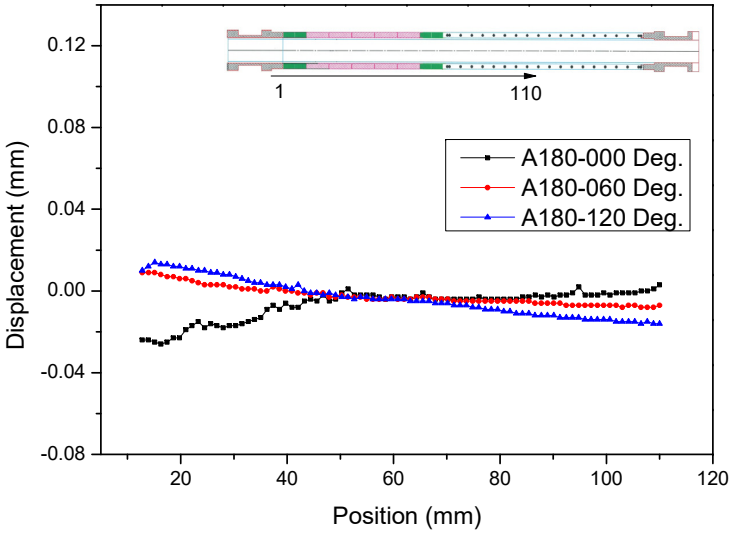


Figure. Example of diameter measurement

M1 hotcell equipment

▣ Dimensional measurement

- Developed for measuring thickness and oxide thickness of plate fuel
- Measuring the plate thickness and the oxide thickness using a LVDT and ECT respectively after performing the calibration by standard specimen
- Maximum measureable size: ~ 700 mm(L) , ~ 100 mm(W)

  Minimum measureable gap : ~ 1 mm

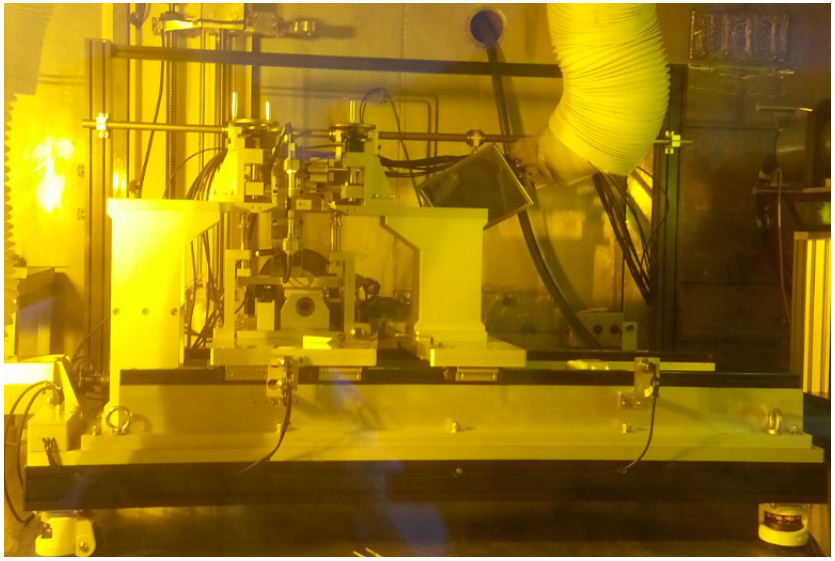


Figure. 2-D dimensional measurement system for plate fuel

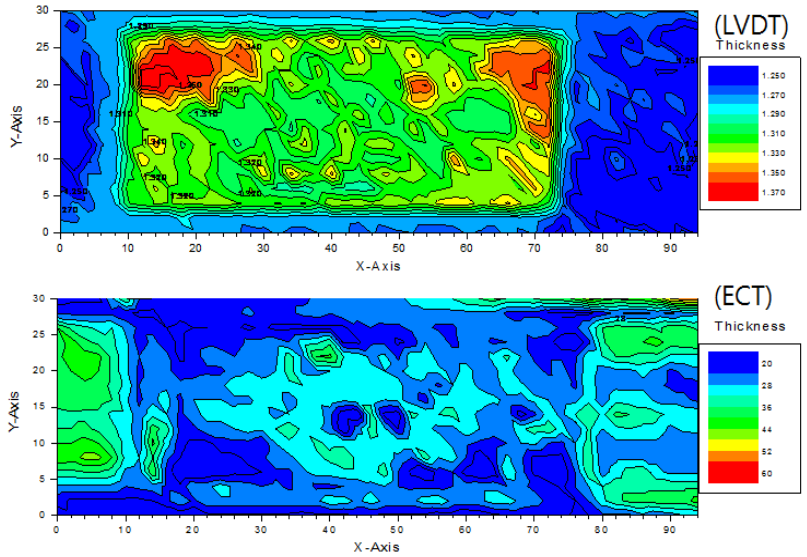


Figure. Example of thickness and oxide thickness measurement

M1 hotcell equipment

▣ X-ray CT system

X-ray Tube	Voltage	20 - 450 kV
	Current	0 - 15 mA
	Focus size	0.4/1.0 mm
Line Detector Array (LDA)	Length	500mm(effective), non-curved
	Pitch	254 ㎛ pitch, 1984 elements in 32 modules
	Scintillator	CdWO4
	Collimator	1 mm, tungsten
Sample bench	Turn table diameter	400 mm
	Max. height and width(sample)	Height : 400mm Width : 120mm
	Focus-detector distance	800 ~ 1500 mm
Software	CT software with GOST module	

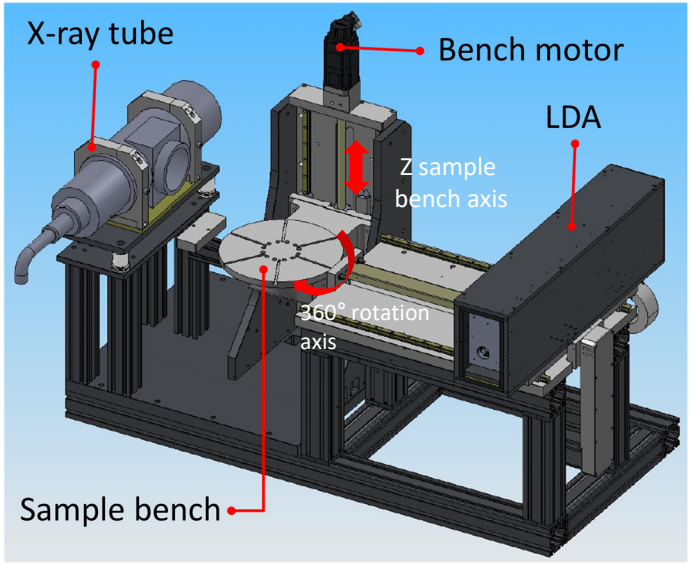


Figure. 450kV X-ray system layout

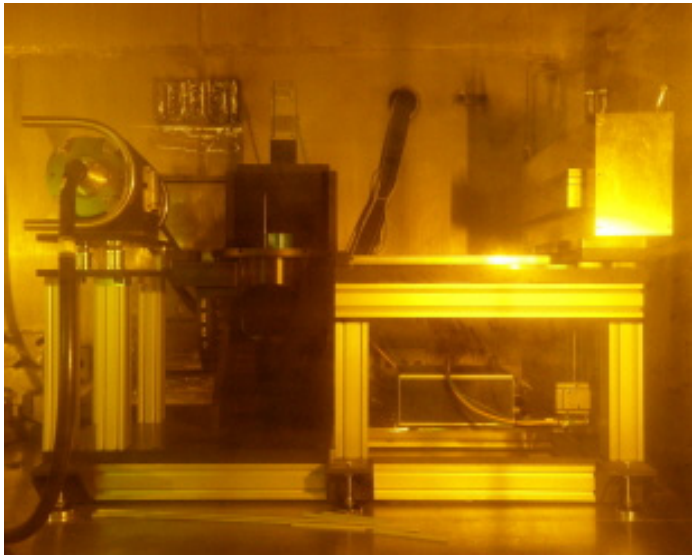


Figure. 450kV X-ray system installed in hotcell

M1 hotcell equipment

▣ X-ray CT system

- Observing internal fuel shapes and cracks without destruction
- Measuring the dimensions using the 3D software and CT technology
- Reducing specimen waste during the cutting by providing precise fuel shapes and position

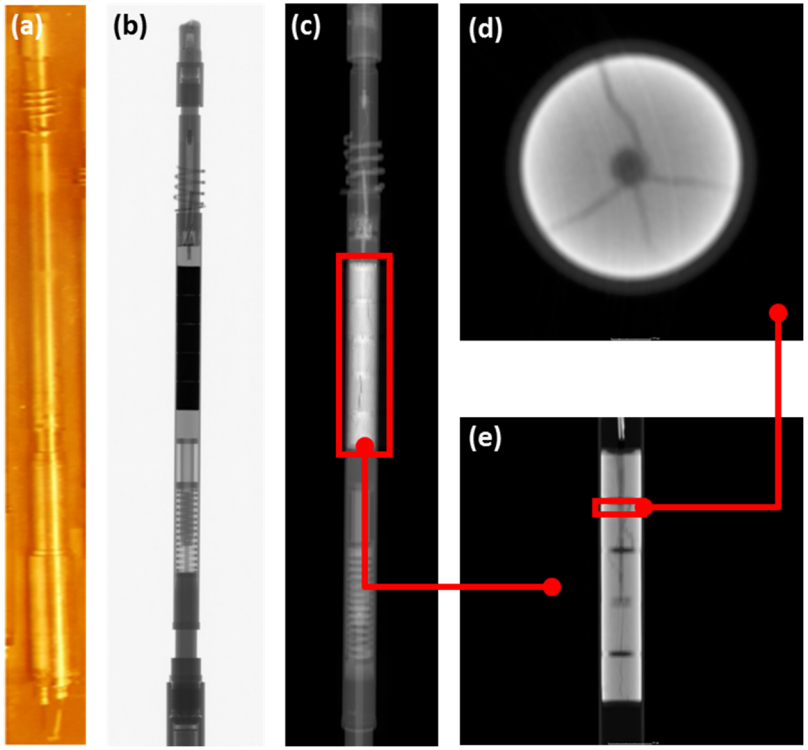


Figure. (a) Research reactor fuel, (b) DR scan image, (c) CT scan image
(d) CT scan image(section view) and (e) CT scan image(section view)

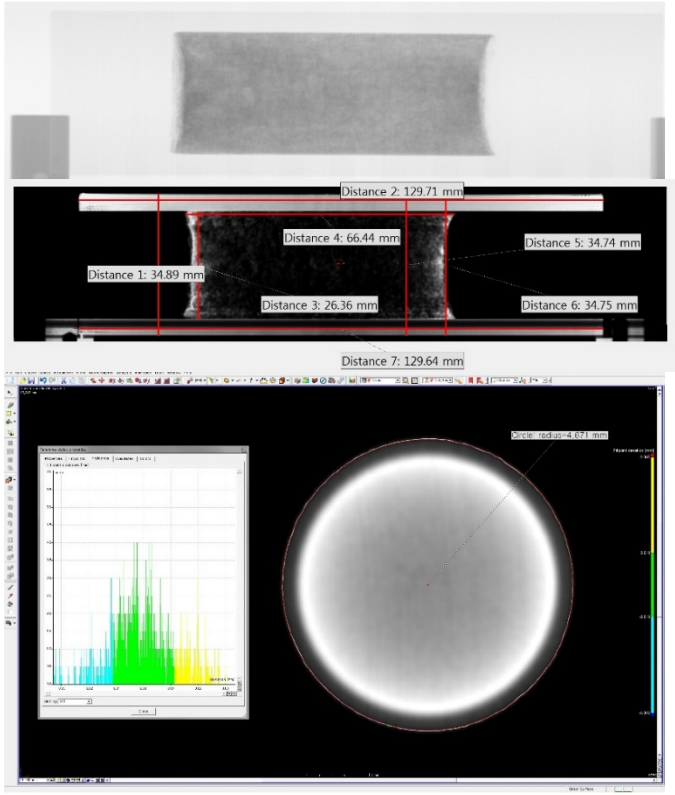


Figure. Example of dimensional measurement using X-ray program

M1 hotcell equipment

▣ Fission gas analysis

- Measuring an internal void and a released fission gas
- Puncturing a fuel rod using the laser system
- Analyzing ratio of a released fission gas using the QMS after performing a calibration
- Laser : Fiber laser, 250 W
- QMS : 1 ~ 200 amu

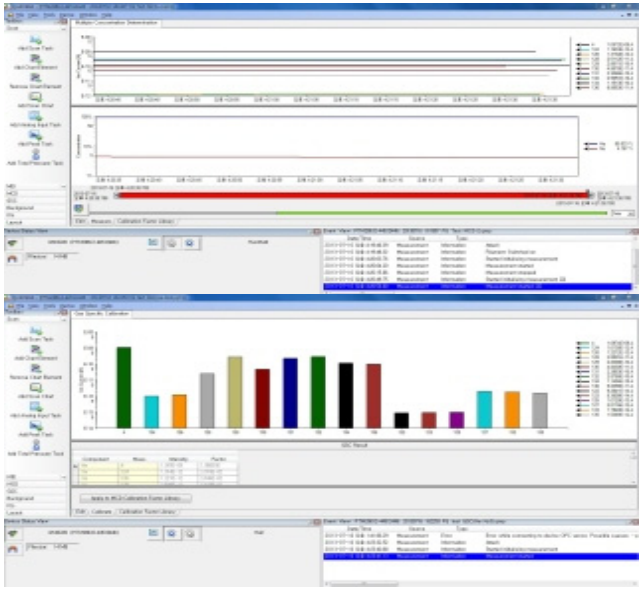


Figure. Example of fission gas analysis results

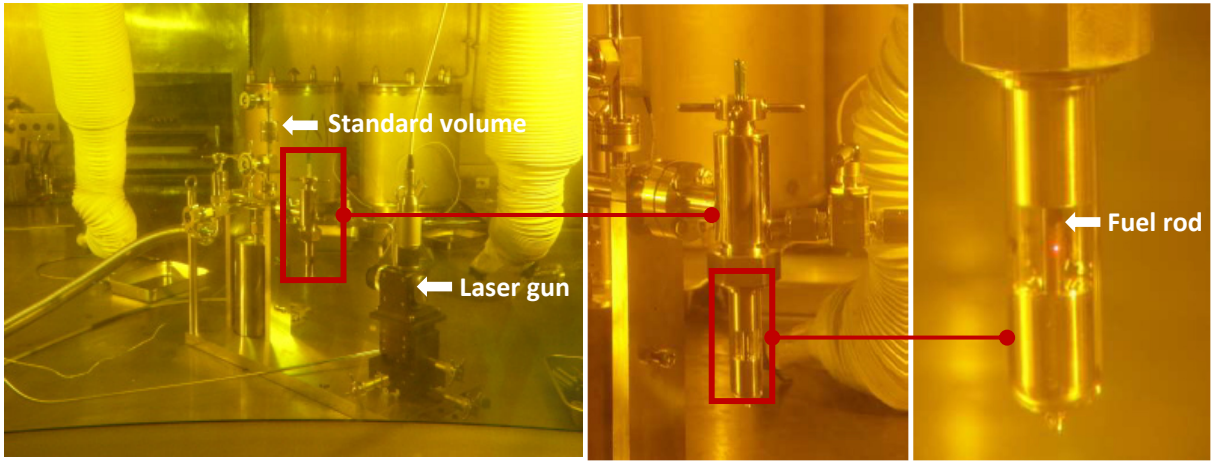


Figure. Laser puncturing system installed in hotcell

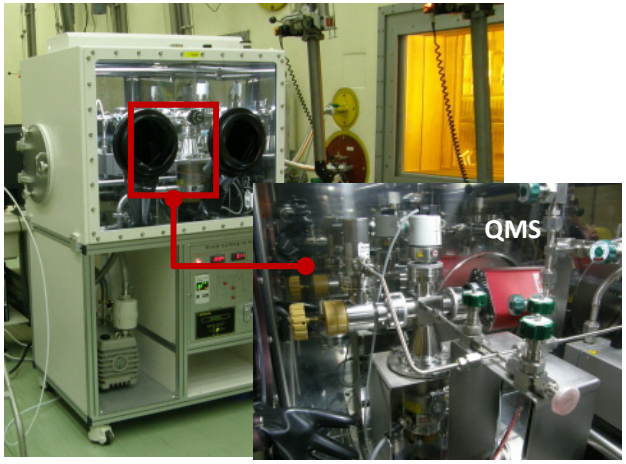


Figure. Glove box and vacuum system

M1 hotcell equipment

▣ Heating system

- Developed to confirm various reactions according to the temperature
- Renovated as a vacuum heating furnace to prevent a oxidation of a specimen
- Using the rotary and diffusion pump (~10^{-6} Torr)

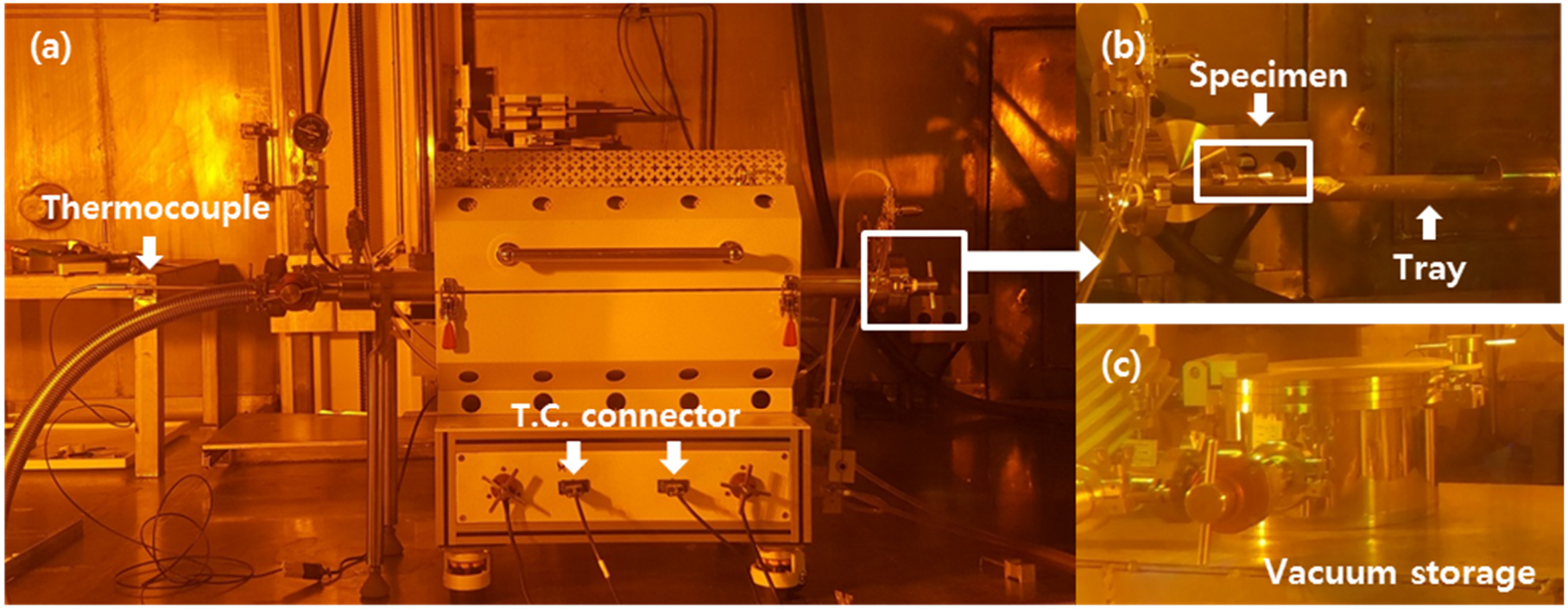
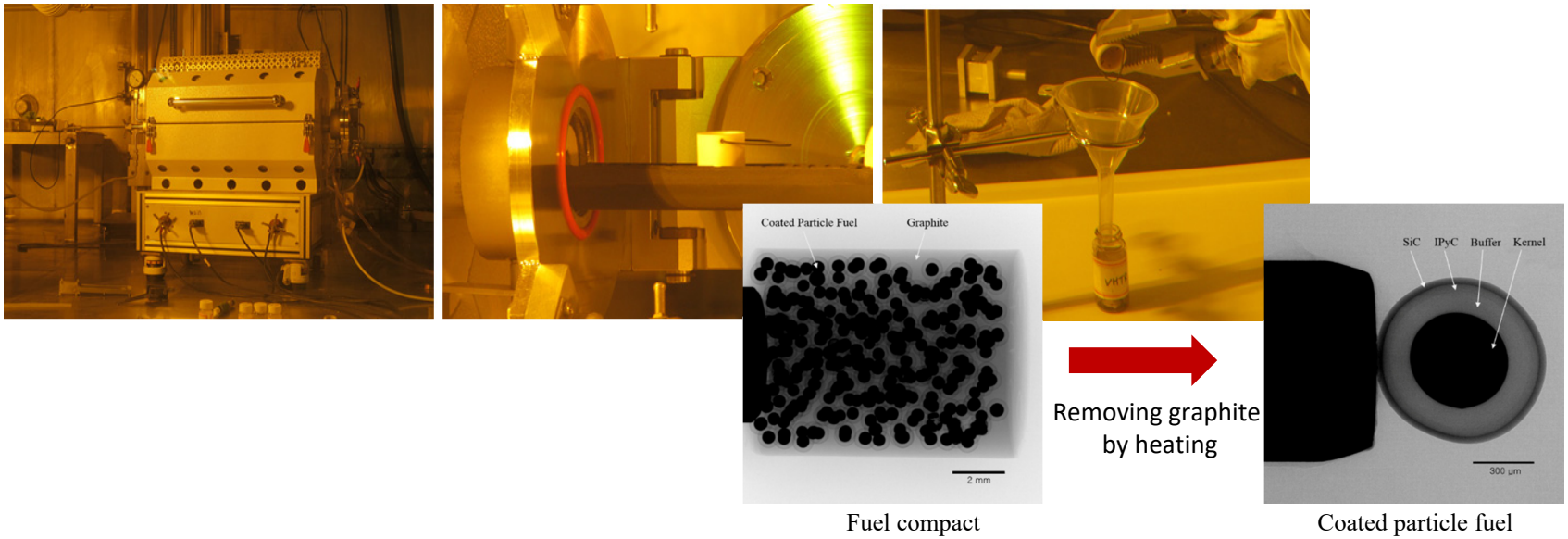


Figure. Vacuum heating system installed in M1 hotcell

M1 hotcell equipment

▣ Heating system



Fuel compact

Coated particle fuel

Figure. Example of heating test for R&D research fuel

Summary

1. Test equipment and jigs for NDT have been developed and operated in M1 hotcell. And various PIEs were successfully performed and provided a high-quality PIE data.

2. Burst test and hydriding for the surveillance test of the pressure tube will be performed in M1 hotcell.

3. Through this, IMEF has been devoted to supplying high-quality PIE data to R&D projects on nuclear fuel and materials.

Thank you

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