

Non-destructive Tests for Irradiated Mini Fuel Plates in Hot Laboratory

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1. Introduction

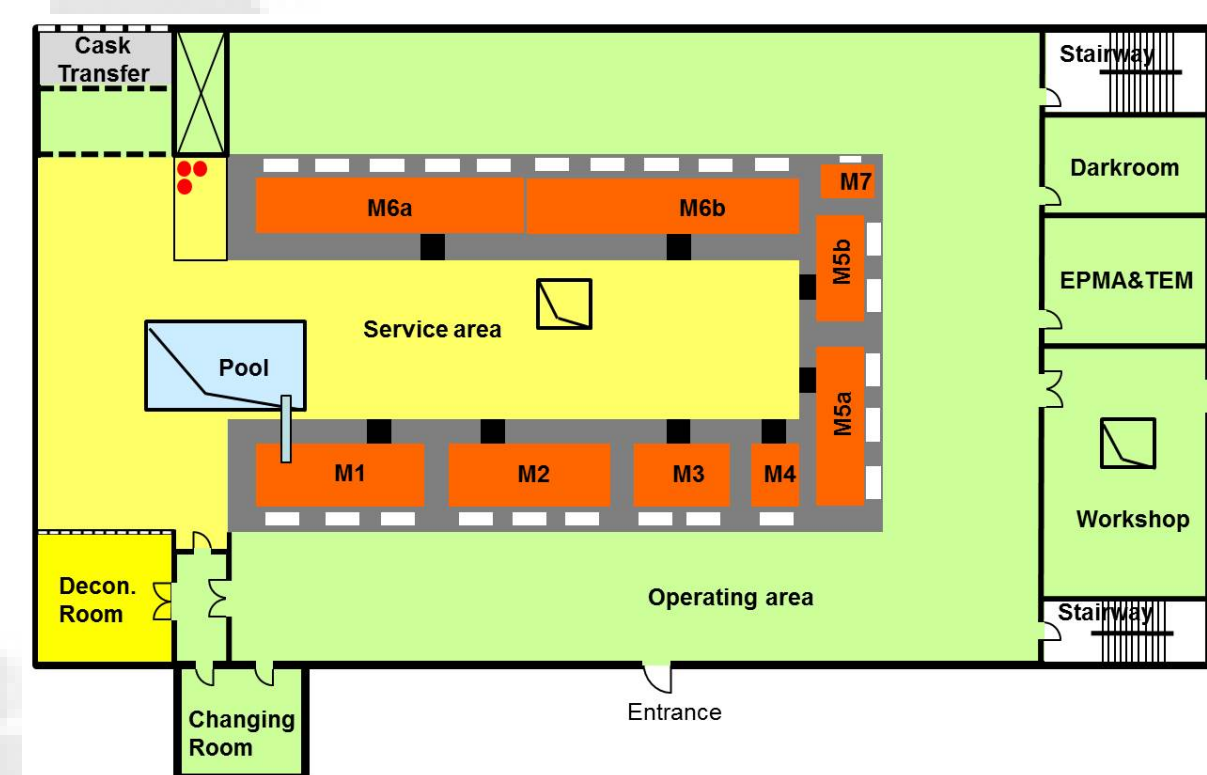
Aluminum fuel plate is useful for research reactors. The meat of plate are still being developed to enhance reactor performance. Currently, U_3Si_2/Al dispersion fuel have been used in research reactor as operating fuel with high enrichment, but U-Mo fuel is recommended and developed as new material in meat on fuel plate with low enrichment. Many irradiation of fuel plates(U-Mo/Al dispersion) have been performed to observe better effects with Mo-contents in Uranium and Si added in the Al matrix. After irradiation of the mini fuel plate in HANARO research reactor, non-destructive test(X-ray inspection, 2-D gamma spectroscopy, 2-D thickness measurement, 2-D oxide layer thickness measurement and blistering test) was performed as well as destructive test. Non-destructive test for the mini fuel plates in IMEF (Irradiated Material Examination Facility) were introduced in this presentation.

2. Methods and Results

PIE of Mini fuel plates were performed in IMEF (Hot laboratory in KAERI). Especially, Non-destructive tests including Blistering test were carried out at M1 hotcell.



< IMEF building >



< Hotcell layout >

2.1 Samples

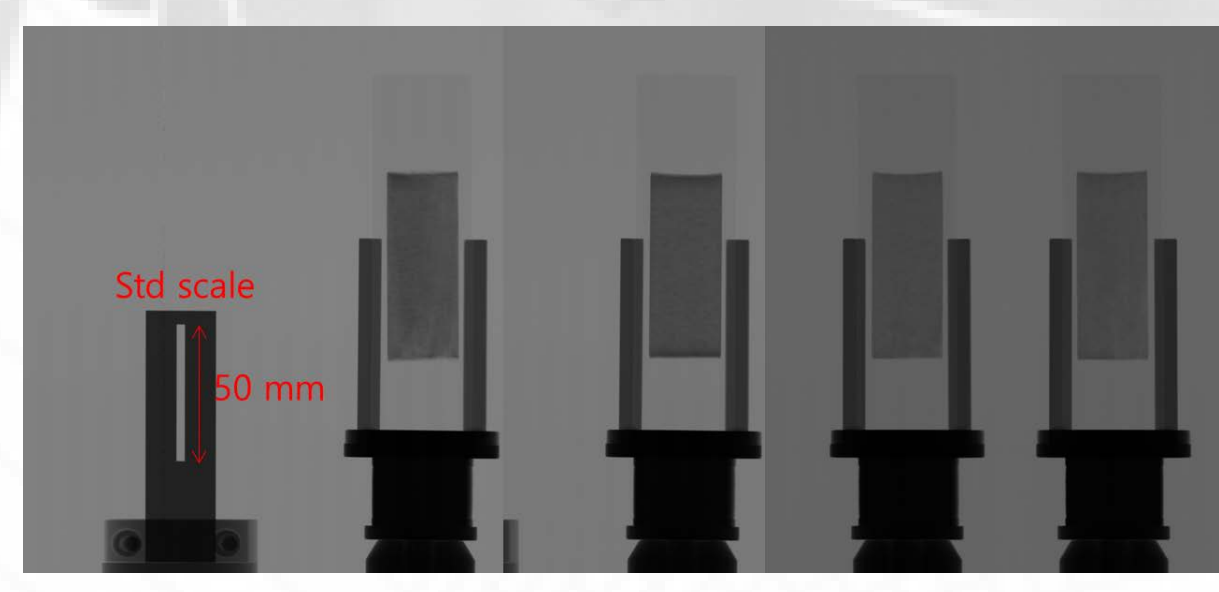
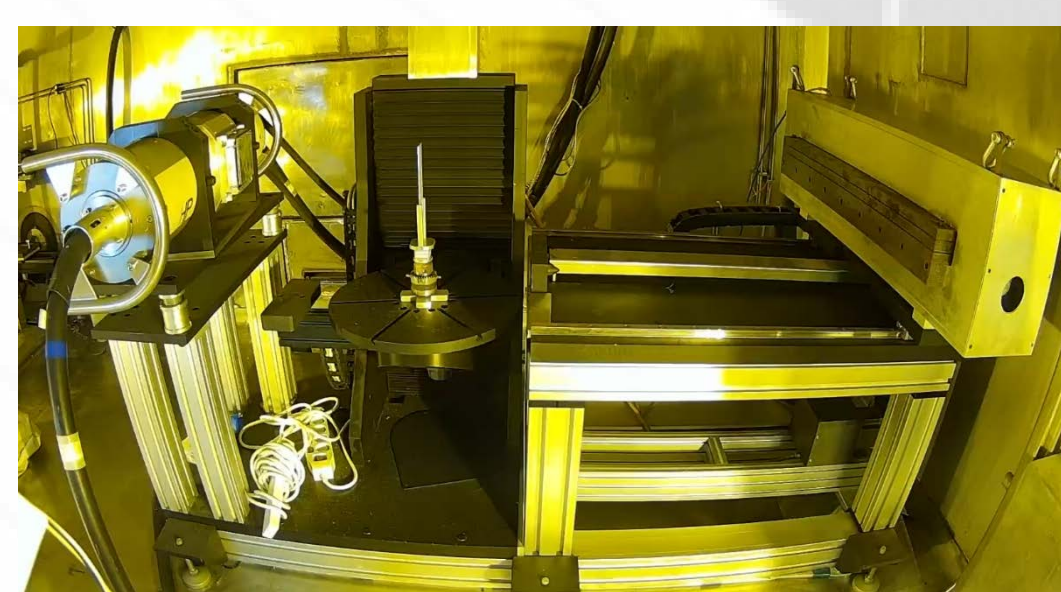
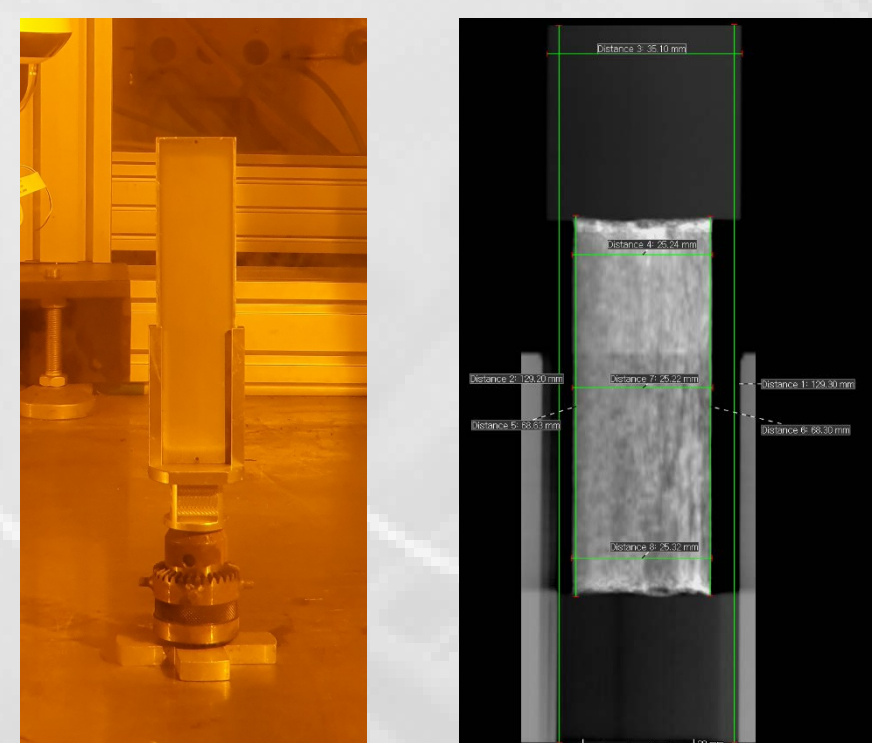
- U-Mo/Al mini fuel plate
- size : 130 mm x 35mm
- irradiated at HANARO Rx



< Fuel plates after neutron irradiation >

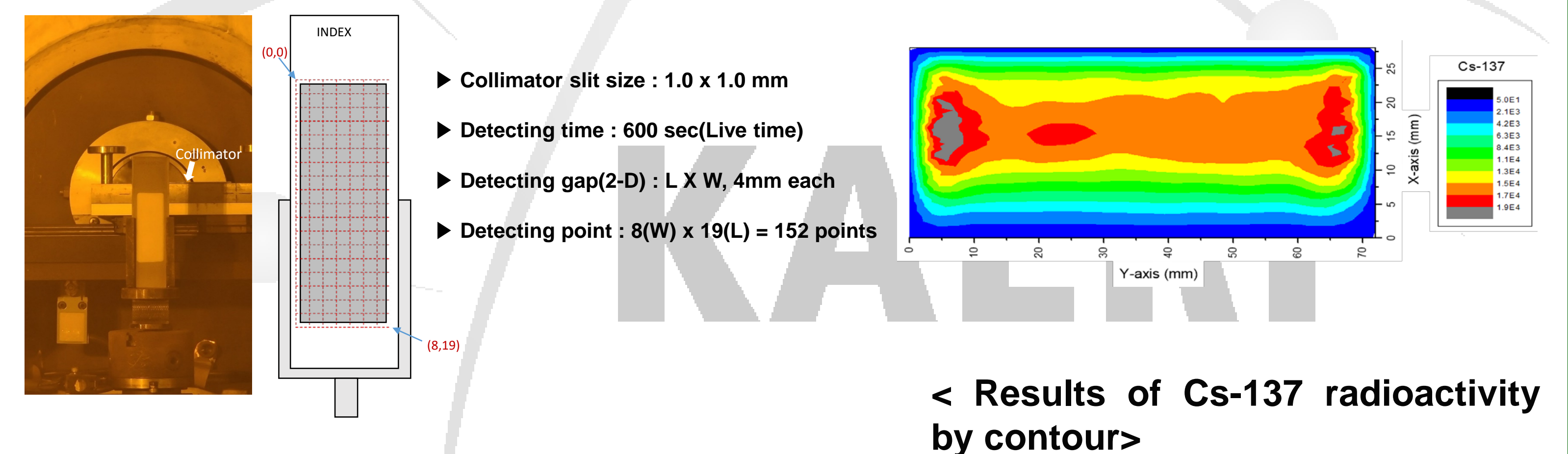
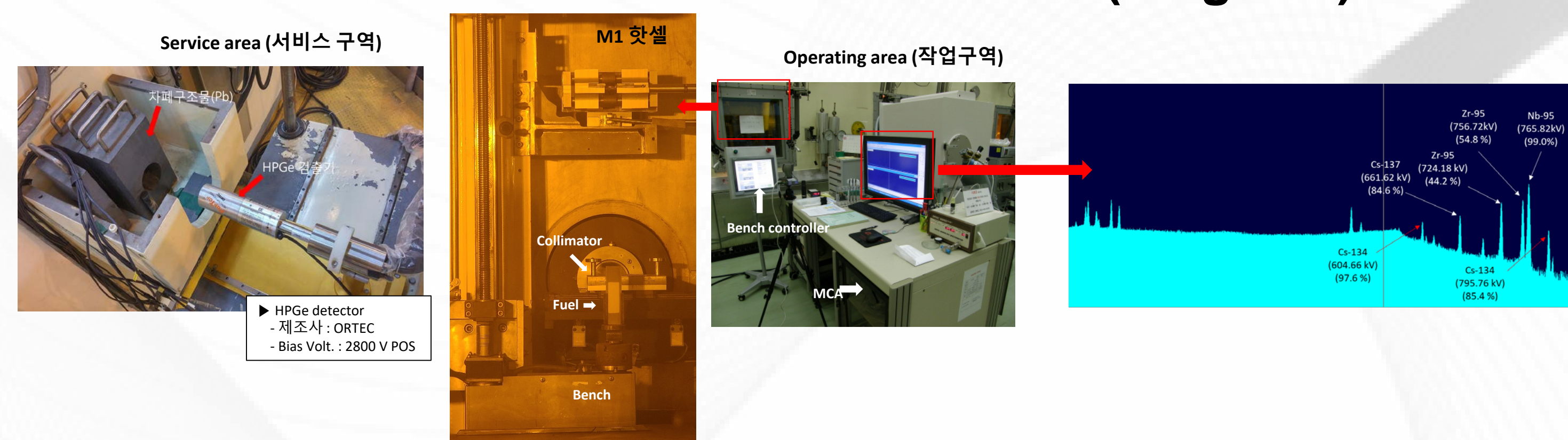
2.2 X-ray Inspection(M1 hotcell)

- X-ray tube : 450 kV(225 kV each.)
- Tube focus : 0.4 / 1.0 mm, ~15 mA
- Detector : Line Detector
- Pixel Pitch : 254 μ m pitch, 1984 elements in 32 modules
- Collimator : 1 mm, tungsten
- Std scale : Tungsten



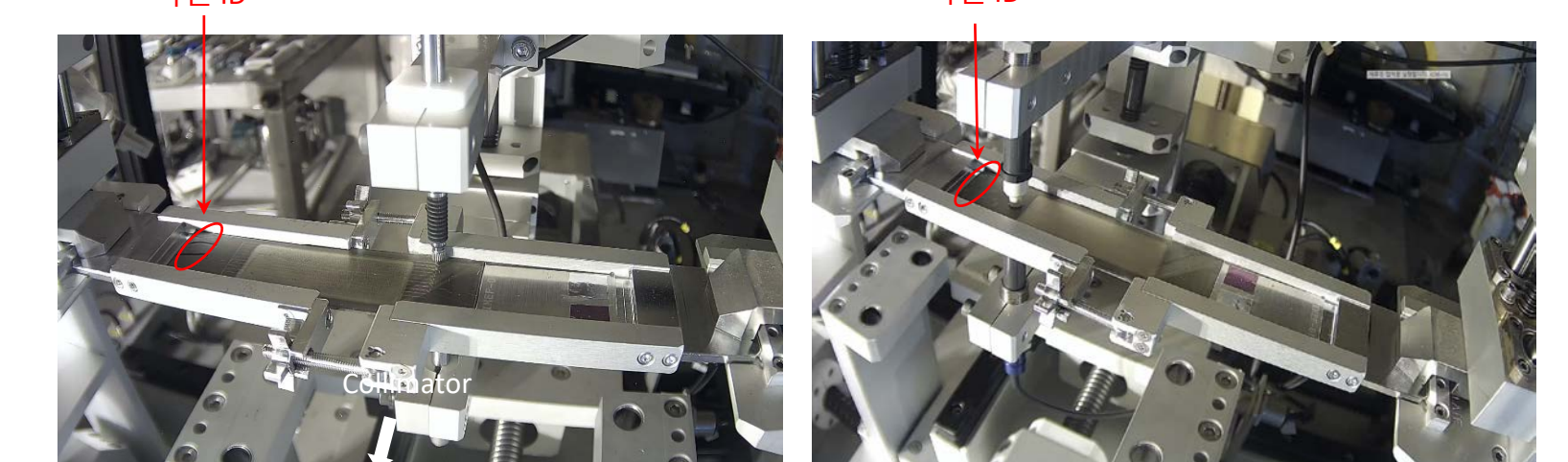
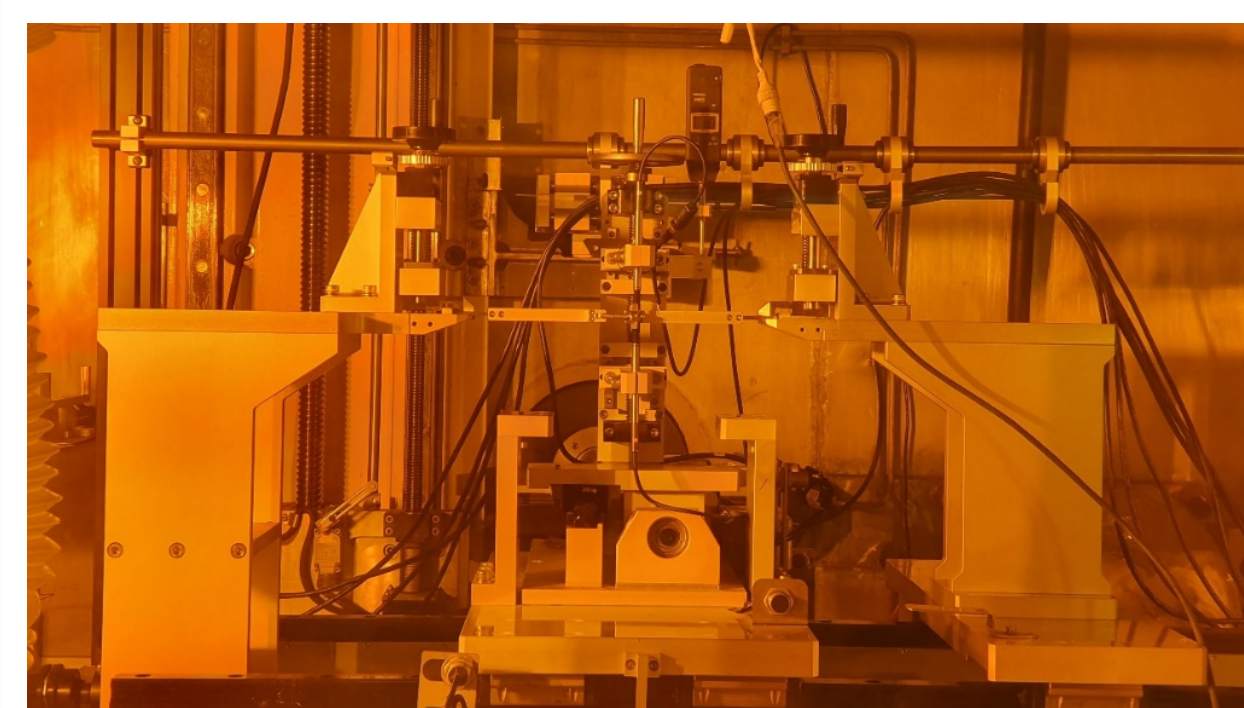
2.3 Gamma Spectroscopy(M1 hotcell)

- Detector : HPGe (ORTEC), 18%
- Collimator : 1mm x 1mm or 0.5mm x 0.5mm (tungsten)



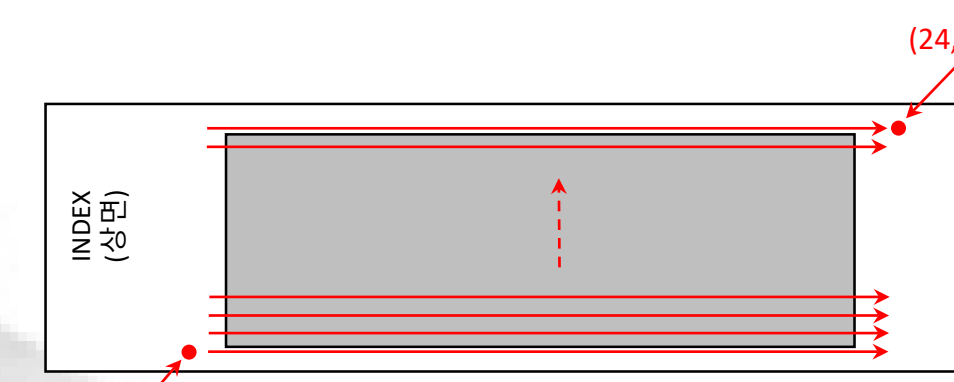
< Gamma Detecting condition >

2.4 2-D dimensional Measurement(M1 hotcell)

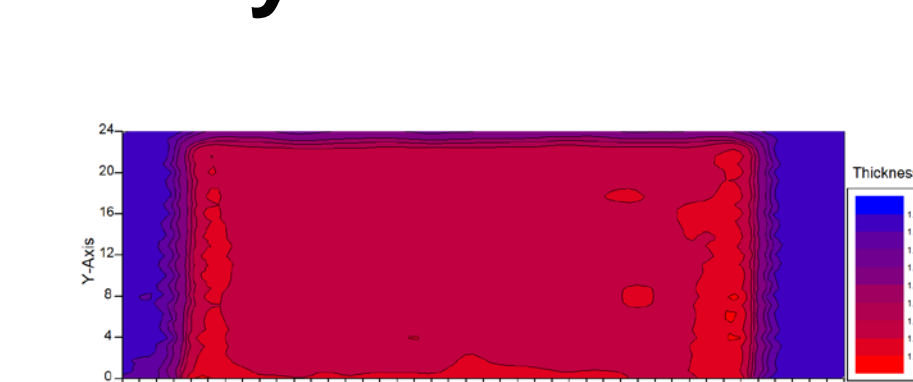


< specimen loading and measurement by sensors >

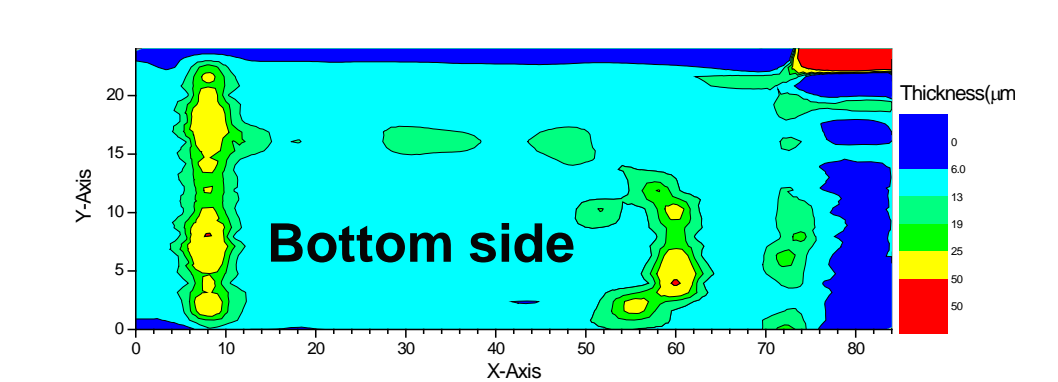
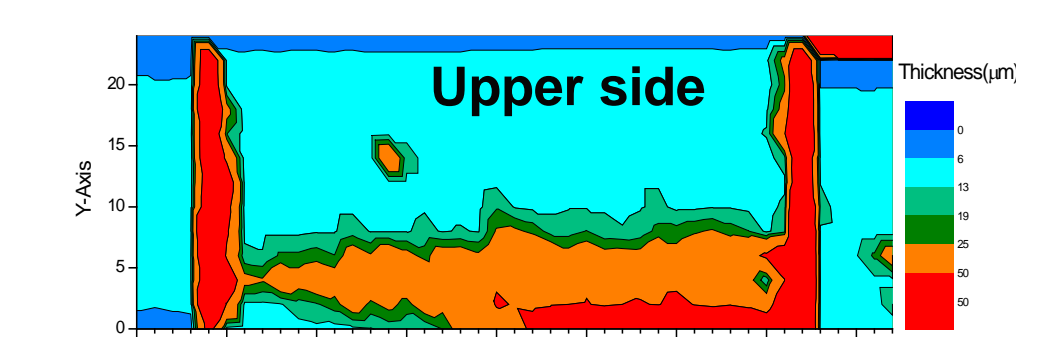
- Max. length : 700 mm
- Max. width : 100 mm
- 2 LVDT for thickness measurement
- 2 ECT sensor for Oxide layer measurement



< sensor moving direction >

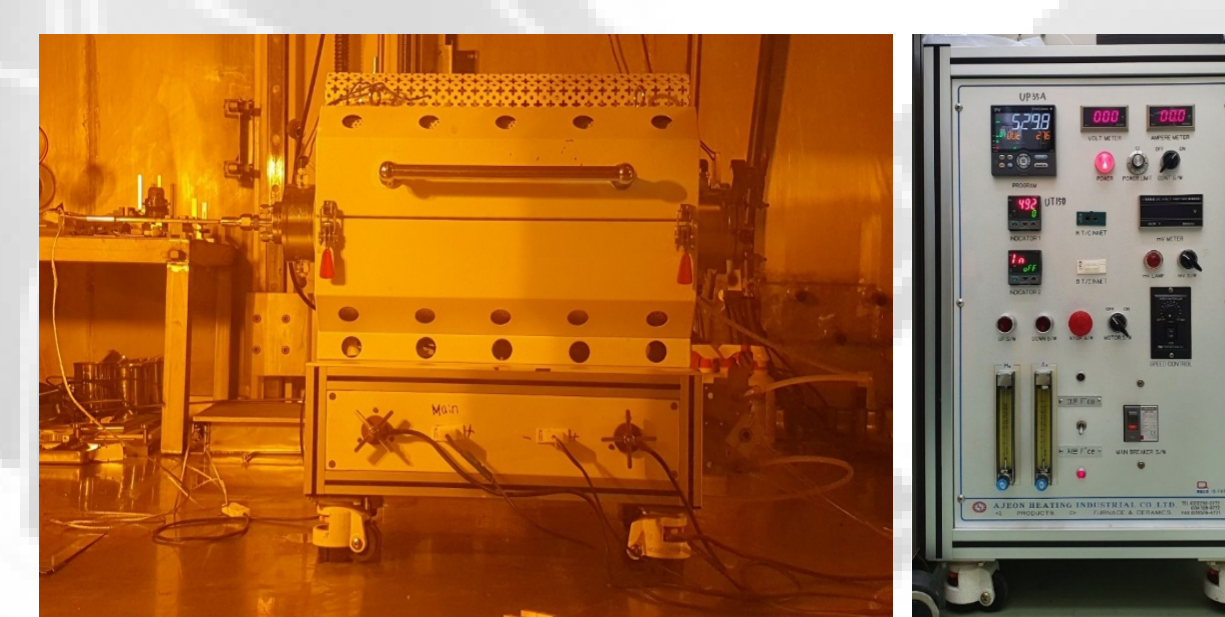


< results of thickness >

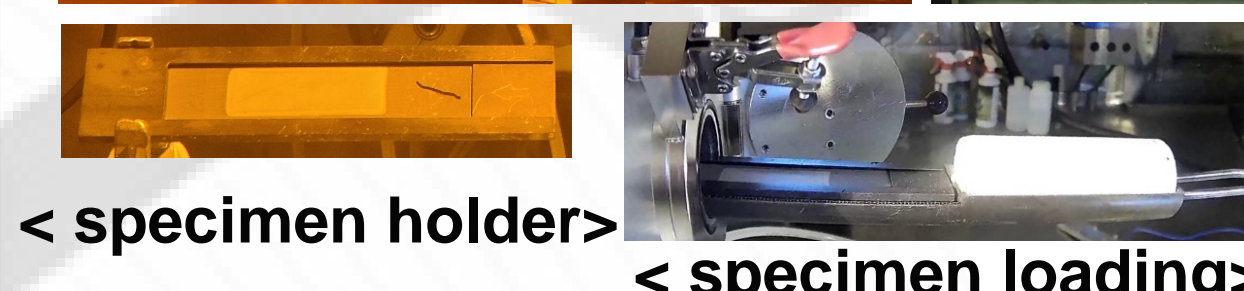


< results of oxide layer >

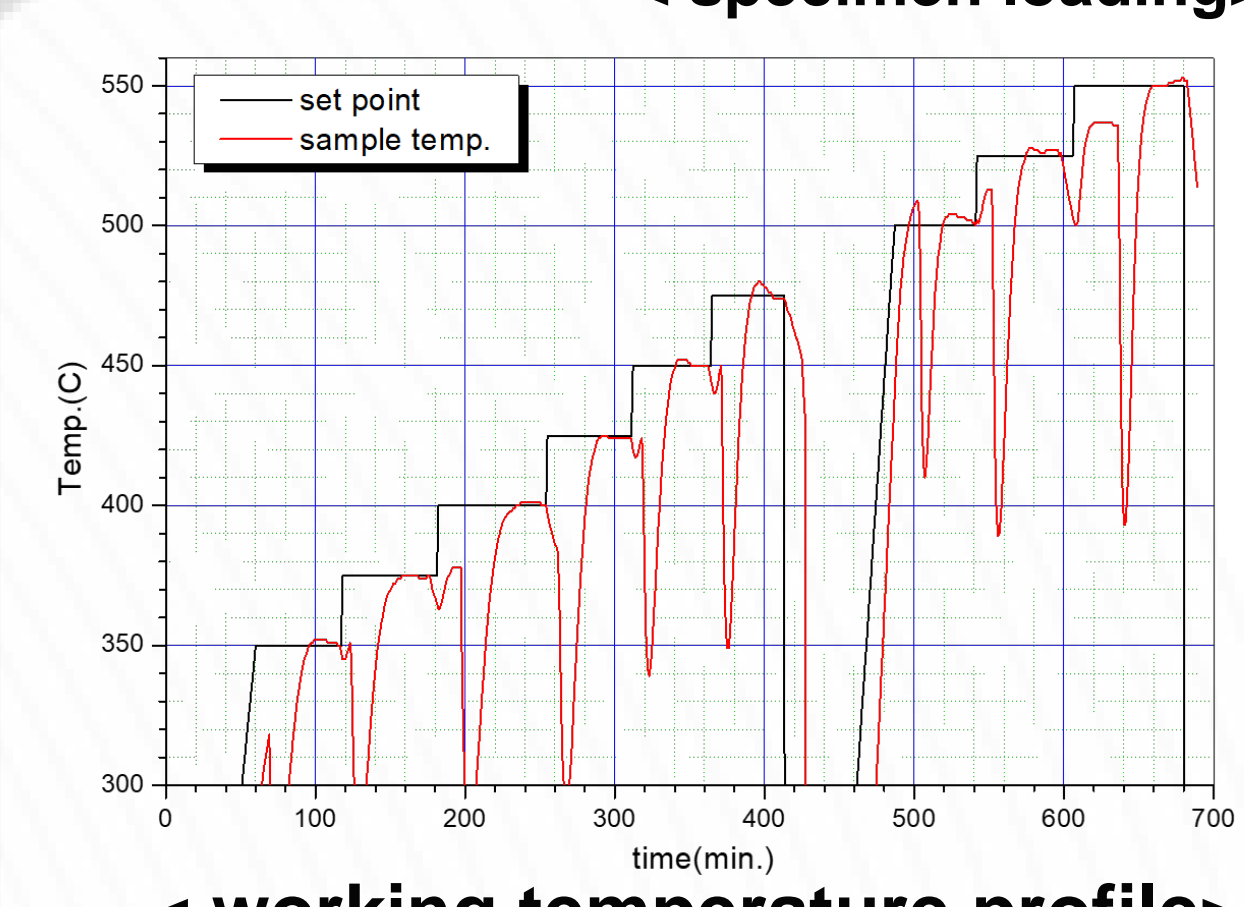
2.5 Blistering Test(M1 hotcell)



- Max. Temp. : 1,000 $^{\circ}$ C
- Heating source : Electric Resistance
- Air condition
- 2 T.C(for heating source and center of specimen) – K-type



< specimen holder >
< specimen loading >



< working temperature profile >

- ▶ Blistering temp. : 350 $^{\circ}$ C, 375 $^{\circ}$ C, 400 $^{\circ}$ C, 425 $^{\circ}$ C, 450 $^{\circ}$ C, 475 $^{\circ}$ C, 500 $^{\circ}$ C, 525 $^{\circ}$ C, 550 $^{\circ}$ C (total 9 heating points)
- ▶ Duration time of each heating point : 20 min.
- ▶ After each heating point, specimen Image on both side were obtained by camera
- ▶ Heating specimen by ascending temperature points were carried out until F.G released from specimen which was detected by R.M.S.



< blistering on specimen >

3. Conclusions

To develop fuel plate for research reactor, U-Mo fuel has been studied with low enrichment. Mini fuel plates were irradiated in HANARO Research reactor and moved to IMEF(hot laboratory) for PIE. For Non-destructive test, several devices were installed in M1 hotcell. Hotcell camera, X-ray inspection system, gamma spectroscopy system, 2-D dimensional measurement system and furnace for blistering test in one hotcell space were needed in this study. In this PIE, manufacturing condition of fuel meat was interesting with fuel density, homogeneity and burnup. So, that was the reason to perform 2-D observation on fuel meat. The results of 2-D gamma detection, thickness and X-ray inspection were agreed each other. Those results were informed to manufacturing process of fuel meat.