PIE TECHNIQUE FOR HIGH DENSITY U3Si2-Al FUEL PLATE

B.Briyatmoko, Supardjo, A. Rozak, Suwardi, A. Gogo, Dadang, Suhardyo, A. Wardani, Susworo, Purwanta, S. Permana, Suyatno

Center for Nuclear Fuel Technology-BATAN, Building No 20 Puspiptek Area, Serpong, Tangerang-Selatan, Banten 15310 - Indonesia

Sudiyono, Kowkab, Hasnul

Center for Multipurpose Reactor-*BATAN, Building No 30 Puspiptek Area, Serpong, Tangerang-Selatan, Banten 15310 - Indonesia*

batan

INTRODUCTION

Indonesia has three research reactors each in Bandung, Yogyakarta and Serpong.

Multipurpose RSG-GAS Reactor 30 MW, Serpong. Built in 1983, first criticality in March 27, 1987, inaugurated on August 20, 1987, full-power operation in March 1992.

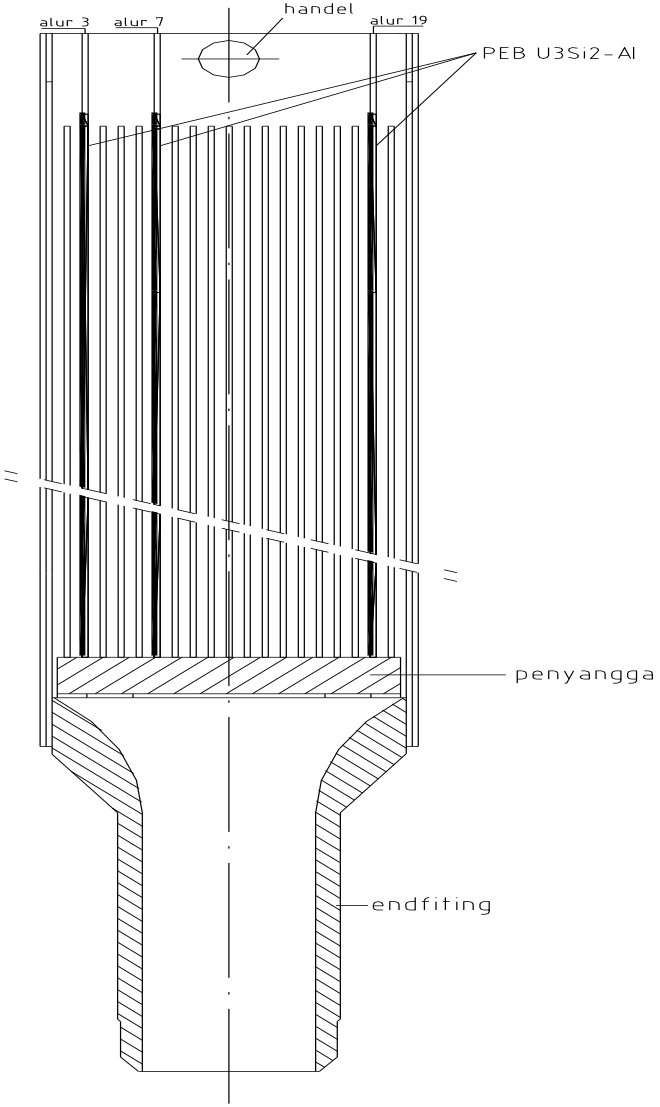
TRIGA 2000 KW, Bandung. Built in 1960, first criticality in October 10 1964, inaugurated on February 20, 1965.

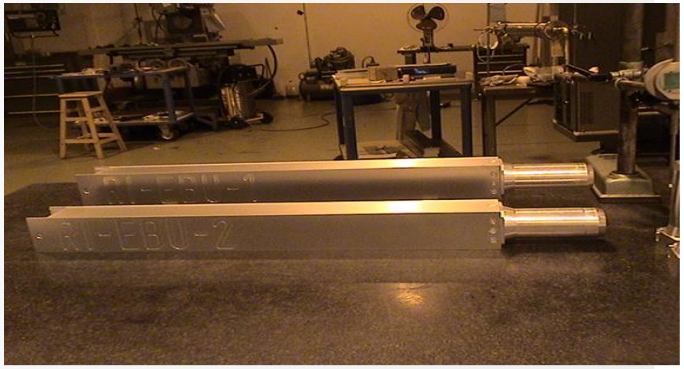
TRIGA 250 KW, Kartini Reactor, Yogyakarta. Built in 1974, first criticality in January 25, 1979, inaugurated on March 1, 1979.

- High density nuclear fuel development
  - For use in multipurpose RSG-GAS reactor Serpong
  - RSG-GAS reactor is operated using U3Si2-Al fuel, the density of 2.96 g U / cc. Uranium used is low-enriched uranium of about 19.70%.
  - Developed nuclear fuel is U3Si2-Al, density 4.8 g U/cc, plate type
  - Irradiated in RSG-GAS reactor
  - Irradiation is done by varying burn up 20, 40 and 60%.
  - Post Irradiation Examination's success is highly dependent on the sample preparation and irradiation technique
- On this occasion we would like to explain the technique of irradiation test and its fabrication for high-density fuel U3Si2-Al.

METHODOLOGY & DISCRIPTION

- Samples to be tested are U3Si2-Al fuel plates with the density of 4.8 g U/cc.
- The fuel plates are irradiated in RSG-GAS reactor with burn up variation of 20%, 40% and 60% for the U3Si2-Al fuel plate, with density of 4.8 g U/cc.
- Before irradiation, fuel plates are fabricated in Fuel Element Production Installation.
- It has been fabricated 3 fuel plates of U3Si2-Al with density of 4.8 g U/cc
- Three fuel plates of U3Si2-Al with density of 4.8 g U/cc is assembled in one bundle of fuel elements.
- The shape of the fuel bundle elements is the same as the shape of fuel bundle elements used in the operation of RSG-GAS reactor.
- One bundle of fuel elements consist of 21 plates of fuel elements.
- Fabrication method of a bundle of fuel elements U3Si2-Al with density of 4.8 g U/cc, is the same as fabrication method of a bundle of fuel elements U3Si2-Al with a density of 2.96 g U/cc which is used in the operation of the RSG-GAS reactor.

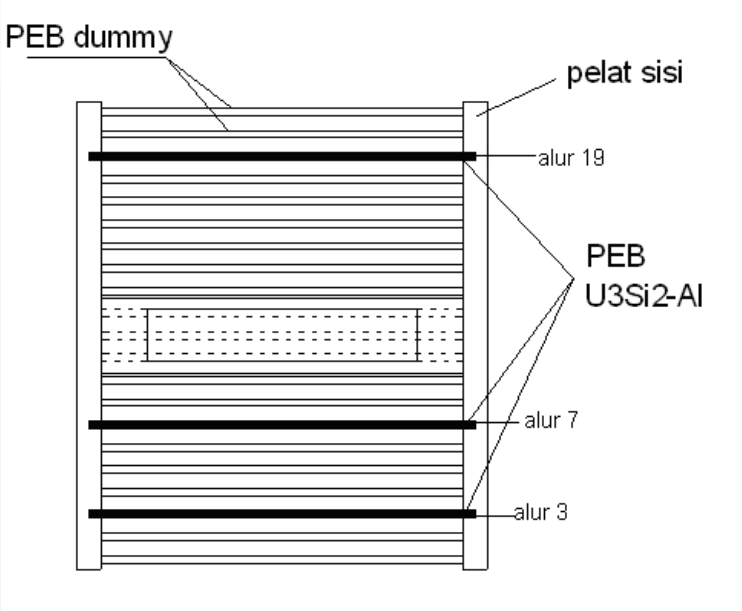


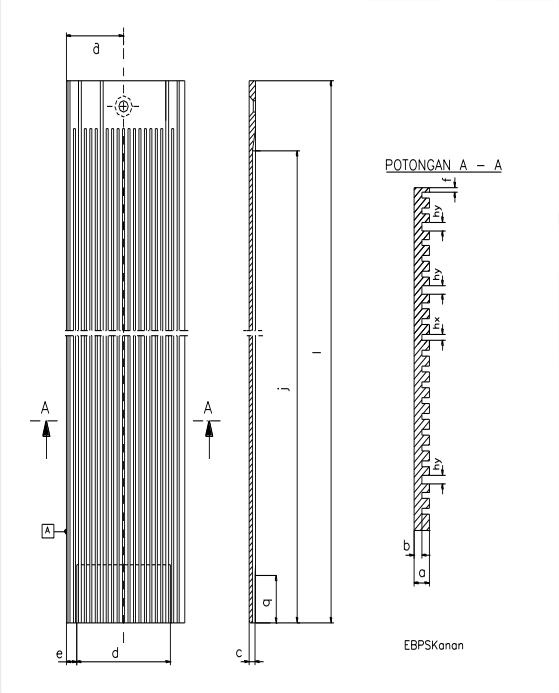


Test fuel elements U3Si2-Al

U3Si2-Al Fabrication

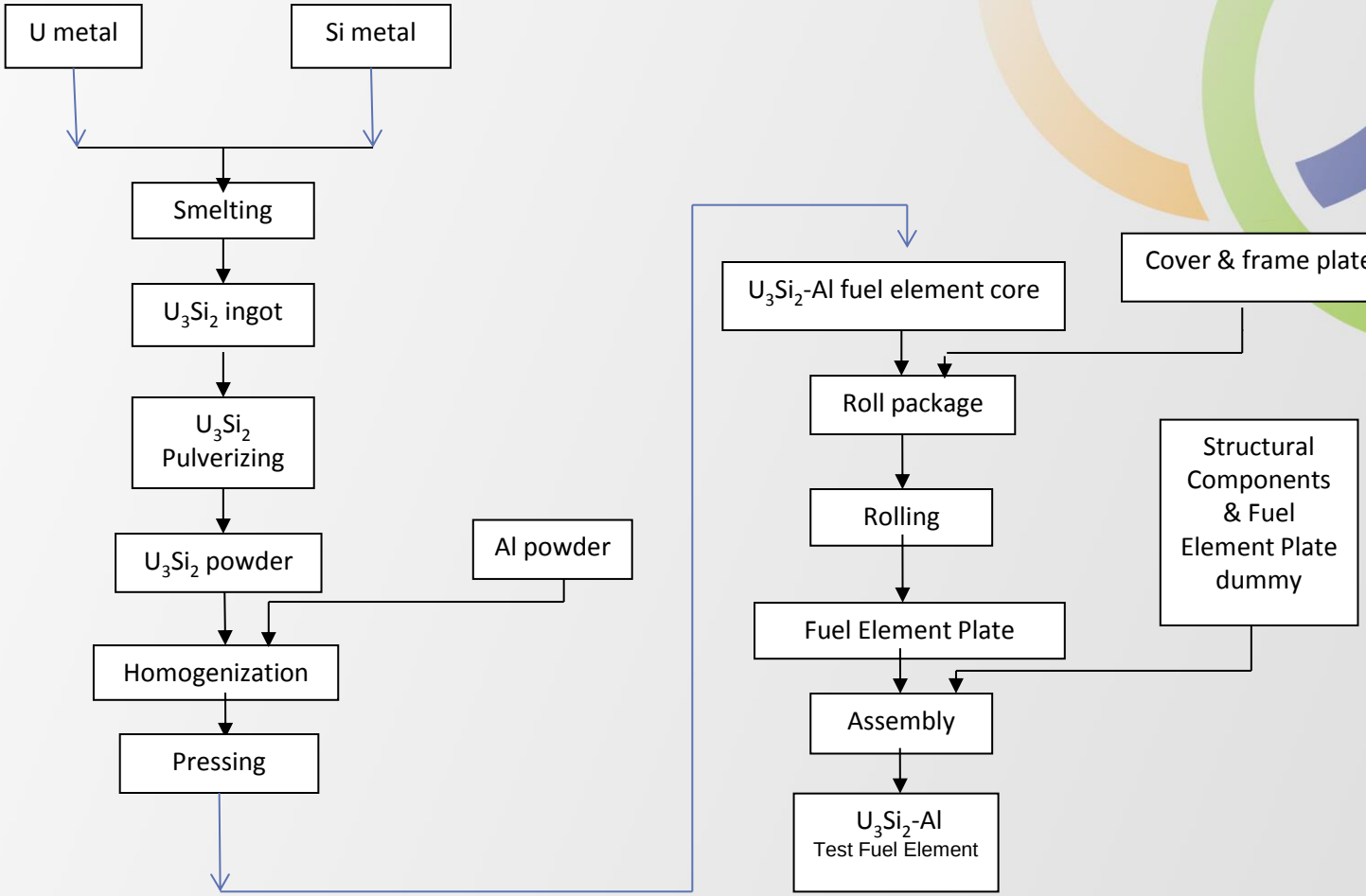
- Fabrication of U3Si2-Al fuel element with uranium density of 4.8 g / cc begins with the synthesis U3Si2 ingots through smelting between uranium metal with enrichment of 19.89% U-235 and high purity silicon metal with a composition by weight of 92.5 % and 7.50%.
- U3Si2 ingot is made into powder by mechanical means (Ring mill and ball mill), and the U3Si2 powder which has been qualified as a fuel dispersion, mixed with Al powder for the fabrication of fuel elements core.
- Fuel element core wrapped with frame and cover plate made of AlMg2, and then formed into fuel element plate through hot rolling. Fuel elements plates are then assembled in the form of test fuel elements U3Si2 -Al for irradiation test in the RSG-GAS reactor.
- U3Si2-Al test fuel elements has uranium densities of 4,8 g U/ cc. The test fuel element composed of 21 plates with the composition of 18 fuel element plate dummy and 3 fuel element plate U3Si2 -Al.
- U3Si2-Al fuel plate elements are assembled in groove number 3, 7 and 19 by inserting into the groove, while 18 fuel elements dummy are assembled with swag roll technique.





Top view of Test fuel elements U3Si2-Al & side plate

Fabrication Process Diagram



Testing & Analysis

- Testing & analysis are performed on each stage of the process include:
  - Powder analysis of U3Si2 fuel
  - The content of uranium and impurities
  - The size distribution of powder
  - Powder density
  - Analysis of aluminum powder
  - Analysis of aluminum alloys
  - Measurements / weight calculation of U and U235 in the test fuel element
  - U distribution measurement in meat of fuel element plate
  - Cladding thickness measurement
  - Tensile test for swag roll specimen
  - Measurement on dimensions and cooling gap of test fuel element

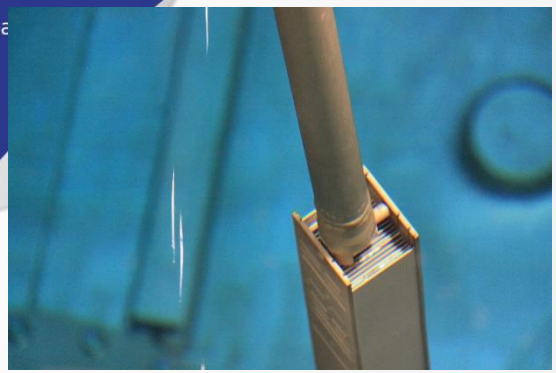
Irradiation procedure

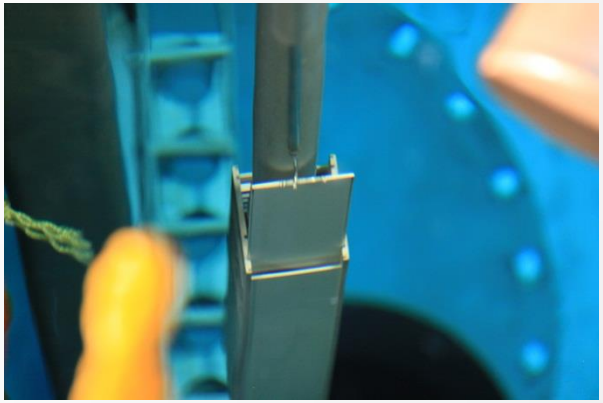
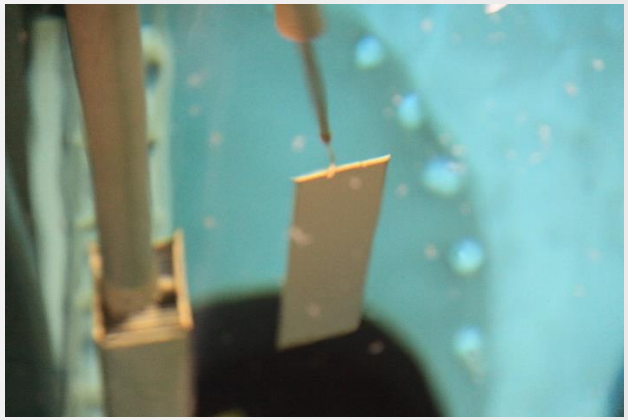
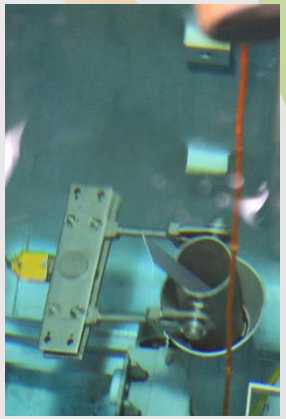
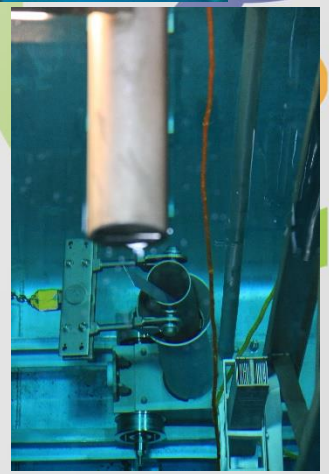
- Prepare Test Fuel Elements U3Si2-Al, namely RI-EBU 1, which contain three Plates Fuel Elements U3Si2-Al with density of 4,8 g U/cc. Three plate fuel element U3Si2-Al are assembled in test fuel element into the groove of side plate No 3, 7 and 19 by inserting.
- Irradiation has been conducted to the test fuel element with the density of 4.8 g U/cc with the irradiation steps as follows:

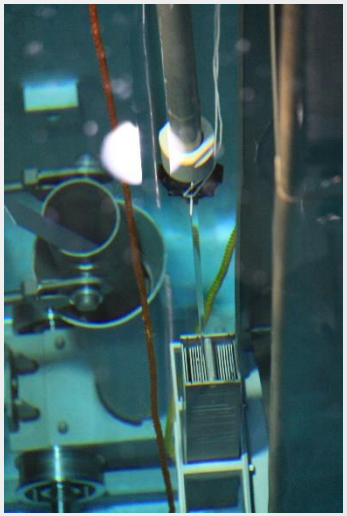
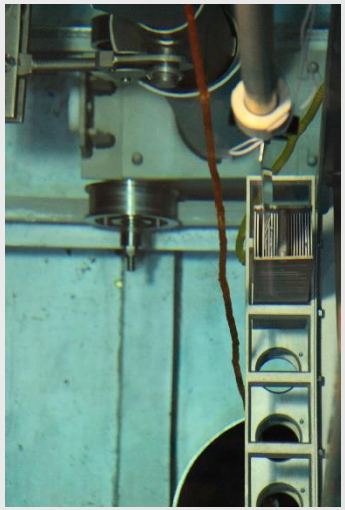
  Irradiation to reach burn up 20%
  - Insert test fuel element RI-EBU 1 to the irradiation position in the reactor core.
  - Irradiate with 15 MW power reactor.
  - After two cycles of reactor operation is completed, take RI-EBU 1 from the reactor core and then place it on a shelf bridge in the reactor pool.
  - Take one plate fuel element in groove 3 then put in the container and transferred to Radio-metallurgy Installation hot cells by transfer cask.
  - Filled groove 3 with a dummy of fuel element by insertion.
  - Enter again the test fuel element RI-EBU 1 to the irradiation position in the reactor core.
  - Irradiation is continued for the next fuel plates to reach burn up 40 & 60 % with the power of 15 MW.

Result & Discussion

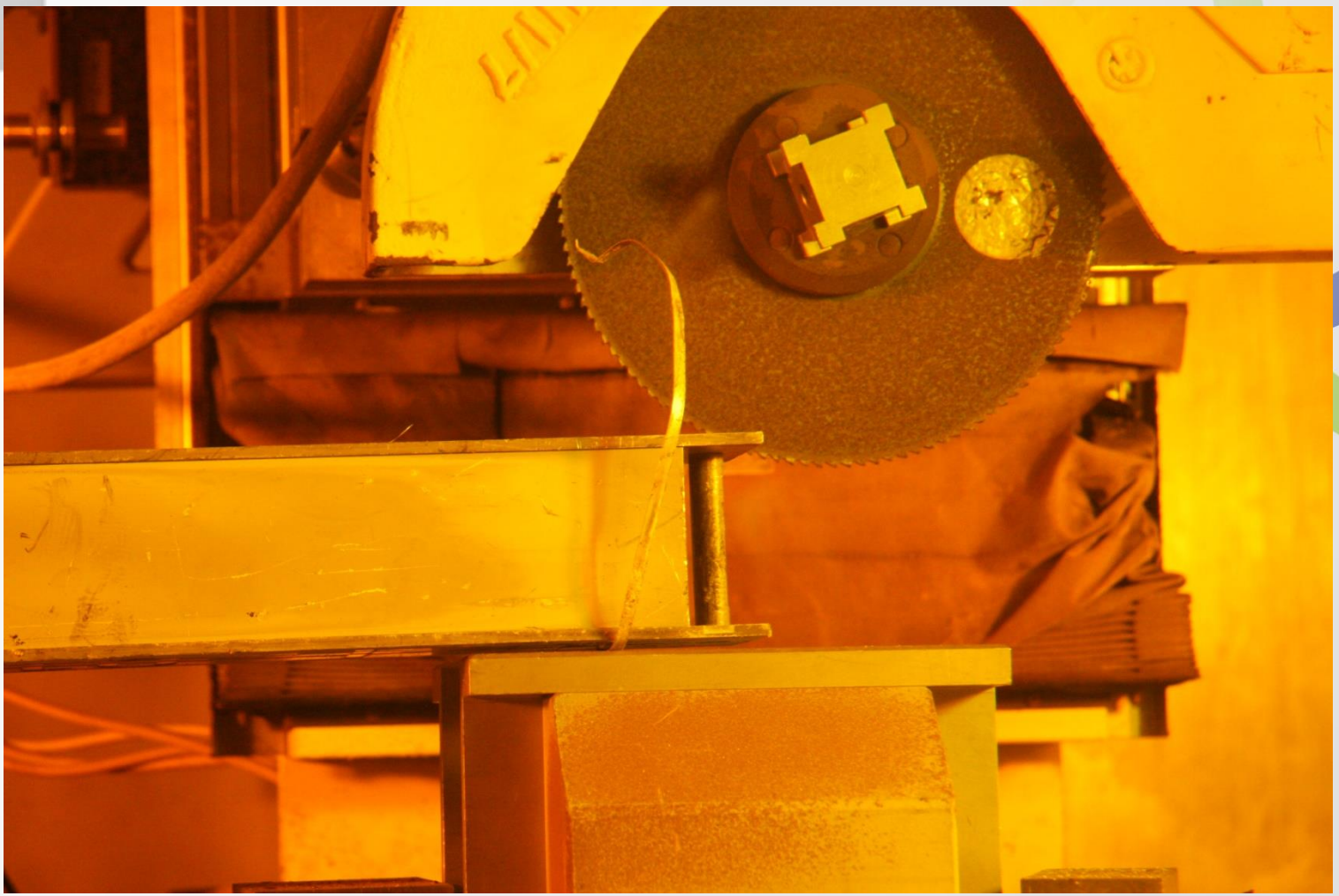
- Test fuel elements with a density of 4.8 g U / cc have been fabricated with the full size as fuel element used in the RSG-GAS reactor.
- In the fabrication, three plates of fuel elements are assembled by without doing swag-roll, just inserted into the groove in the two side plates of test fuel element.
- The 18 plates of dummy fuel elements are assembled in a test fuel element by insertion into the groove in the two side plates of the test fuel element and performed swag-roll.
- Wide groove in the side plates for the insertion of the fuel element plate slightly widened from 1.43 mm of normal size to 2.00 mm.
- The size of three plates of the fuel element is longer than the normal size of fuel element, i.e., about 5 mm longer.
- At the top of the 3 plates fuel elements, each fitted with wire to make it easier in the process of taking plates fuel elements from the existing test fuel element in the reactor pool.
- Three plates fuel elements with U density of 4.8 g / cc has been irradiated safely with burn-up up to 60%.
- Fuel plate is directly take out from the test fuel element bundle in the reactor pool and transfer to the hot cell by transfer cask.
- With this technique, it doesn't need to use dismantling machine to cut fuel bundle to take out the fuel element in the hot cell.




Process transfer of fuel plate by transfer cask.



Process of dismantling fuel bundle

CONCLUSSION

- The assembly of fuel elements in the fuel bundle are not using swag-roll.
- By this technique, irradiated fuel elements could be removed from the fuel bundle directly from the reactor pool.
- With this technique, we do not need dismantling machine to cut off the fuel bundle to take out the fuel elements in the hot cell.
- With this technique we can irradiate 3 samples of the fuel plates with different burn up easily and quickly.
- With this technique we can also doing the process of transfer of nuclear fuel from research reactors to the hot cell laboratory with more simple.
- By not doing dismantling process in the hot cells, it could reduce waste come from the cutting of fuel bundle in hot cells.