Status of Uranium Conversion Plant Decommissioning

D.S. Hwang, K.I. Lee, Y.D. Choi, S.T. Hwang, J.H. Park
KAERI, 150 Deockjin-dong, Yuseong-gu, Daejeon

1. Introduction

KAERI (Korea Atomic Energy Research Institute) constructed a pilot plant for the uranium conversion process for the development of the technologies and the localization of nuclear fuels for HWR (heavy water reactor) in 1982. The final product of the plant was a UO_2 powder of ceramic grade for HWR and its capacity was 100 ton-U/year. After that, a part of the AUC (Ammonium Uranyl Carbonate) process was added and the process was improved for automatic operation. 320 tons of UO_2 powder was produced and supplied to the fabrication plant at KAERI for the fuel of the Wolsong-1 CANDU (Canadian deuterium uranium) reactor. The conversion plant has building area of 2916 m^2 and two main conversion processes. ADU (Ammonium Di-Uranate) and AUC process are installed in the backside and the front side of the building, respectively. Conversion plant has two lagoons, which is to store all wastes generated from the plant operation. Sludge wastes stored 150m^3 and 100m^3 in Lagoon 1 and 2, respectively. Main compounds of sludge are ammonium nitrate, sodium nitrate, calcium nitrate, and calcium carbonate. In early 1992, it was determined that the plant operation would be stopped due to a much higher production cost than that of the international market. The conversion plant has been shutdown and minimally maintained for the prevention of contamination by deterioration of the equipment and the lagoon. In 2000, the decommissioning of the plant was finally decided upon and a decommissioning program was launched to complete the following tasks by 2007: planning and assessment of the environmental impact; decontamination of the pipe, tanks, vessels and equipment for canning or reuse; decontamination of the building for unrestricted reuse, and the treatment of the sludge and the demolition of the lagoon. In the middle of 2004, decommissioning program obtained the approval of regulatory body and decommissioning activities started. In 2004, pre-work was performed as follows: repair of electrical power supply system, inspection and repair of fire alarm and fighting system, installation of ventilation system, radiation management and access control facility, inspection and load testing of crane, distribution and packaging of existing waste, and pre-decontamination of the equipment surface and interior.

This paper introduced briefly decommissioning activities in the first half year of 2006.

2. **Dismantling Activities**

- Dismantling order
  - Area for reuse
  - Most remote room from waste treatment
- Order of dismantling work
  - Disconnecting of pipe, electric wire, etc.
  - Separation of the equipment
  - Cutting into small pieces
  - Grouping of the dismantled pieces for decontamination or packing
  - Decontamination of floor and wall
  - Measurement of remained contaminants
- Kiln area
  - Arranging for temporary radioactive waste storage area
  - Removal of kiln and pipes
  - Concrete decontamination
- Effluent treatment area
  - The use of a lagoon sludge waste treatment area
  - Removal of all installations such as raectors, square mixer, and pipes
  - Filtration area
  - The use of a metallic waste decontamination area
  - Removal of all installations such as tanks and pipes
- AUC production area
  - The use of a sludge treatment preparation and finishing area
  - Removal of all installations such as tanks, pumps, and pipes
- UO_2 storage area
  - The use of a waste drum and free release material carrying out area
  - Removal of all installations such as square mixer and pipes
- Pump and lime mixer area
  - The use of a ventillation area for decontamination and sludge treatment
  - Removal of all installations such as tanks and pumps.
- Drum storage area
  - The use of dismantled waste cutting area
  - Removal of all installations such as tanks, pumps, pipes, and cable
- Workshop area
  - Temporary waste storage area
  - Removal of all installations such as tank, pump, and pipe
- AUC control room
  - Removal of control panel and cable
- Concentration, precipitation, and filtration area
  - Removal of all installations such as tank, pump, pipe, precipitator

• Ventilation facility area
  - Removal of all installations such as fan and duct
• Cutting of dismantled metallic waste
  - The use of a ventilation area for decontamination and sludge treatment
  - Removal of all installations such as tanks and pumps

3. Decontamination activities

• Installation of decontamination equipment
  - Chemical decontamination with ultrasonic
  - Steam cleaning
  - Electrochemical depolishing
• Decontamination of metallic waste
  - Chemical: 10 wt% nitric acid
  - Chemical decontamination with ultrasonic and steam washing
  - Metallic wastes: plate contaminated with UN, AUC, and UO_2
  - Decontamination goal: alpha < 0.2 Bq/g, beta, gamma < 0.4 Bq/g
  - Plate contaminated with UN, AUC can be decontaminated less than 0.2 Bq/cm^2 of alpha in 10 minutes.
  - Plate contaminated with UO_2 can be decontaminated less than 0.2 Bq/cm^2 of alpha in 60 minutes.

4. Lagoon Sludge Treatment

The lagoon is a series of artificial ponds where all the liquid wastes have gathered. It is located adjacent to the conversion plant building and consists of two ponds. The sludge consists of three different layers; upper layer saturated solution, middle crystalline solid, and bottom deposit. The major compounds of the sludge are ammonium nitrate, sodium nitrate, calcium nitrate, and calcium carbonate. The uranium content of the deposit at the bottom of the lagoon is very high.

• Thermal denitration process
  - Much ammonium nitrate in the sludge
  - Difficulties of an ammonium nitrate decomposition
  - Ammonium nitrate is explosive and is decomposed by evolving a great deal of gas.
  - Preventing explosive problem by a suction of evolved gas for off-gas treatment
  - Two step thermal decomposition with the characteristics of the sludge
  - The first occurred at a low temperature and the second at a high temperature.
  - The low temperature decomposition is due to ammonium nitrate.
  - The high temperature decomposition is due to the sodium and calcium nitrate and calcium carbonate.
• Off-gas treatment
  - A treatment of NOx and ammonia evolved from the thermal decomposition is one of the important processes.
  - Off-gas is treated by using a selective catalytic reduction (SCR) method.
  - Off-gas is treated with three steps, which consists of oxidation catalyst, ammonia SCR, and ethanol SCR.
  - Ammonia evolved from decomposition of ammonium nitrate was oxidized by oxidation catalyst.
  - NOx is treated by ammonia SCR around 300℃.
  - But ammonia must not discharge to atmosphere, so ammonia doesn't over supply.
  - Therefore, NOx was not completely removed because ammonia was not supplied enough.
  - This problem can be solved with ethanol SCR, which use ethanol as a reducing agent.
• Results from basic study
  - Most ammonium nitrate involved in the sludge of each layer is decomposed for 60 minutes at 300℃.
  - Sodium and calcium nitrate started to decompose at around 600℃ and they are decomposed completely by 60 minutes.
  - Alumina is added into the sludge, which involves lots of sodium nitrate, to make a stable form.
  - The residual solid waste consists mainly of $3Na_2O\text{-}7UO_3$, calcium oxide, calcium hydroxide, and $Na_2O\text{-}Al_2O_3$ and these are stable compounds for storage.
  - A volume of the sludge waste can be decreased by over 75 % with the sludge treatment.
• Installation of treatment facilities
  - Furnace: 6 set, W700 X L700 X D700, Max temp. 1000℃
  - SCR facility: oxidation reactor, ammonia SCR reactor, ethanol SCR reactor
  - Sludge transportation: slurry pump, sludge storage container and transportation cart
• Performance test
  - Test 1

    Sludge: Lagoon 2 upper layer solution
    Working volume : 36 L
    Low temp. treatment (AN decomposition): 2 hr
    High temp. treatment (SN, CN decomposition): 1hr
    Residual stabilized solid waste: 3.5 L (90 vol.% removal)
    NOx treatment: removal less than 100ppm
  - Test 2

    Sludge: Lagoon 2 bottom layer sludge
    Working volume: 45 L
    Low & high temp. treatment (AN, SN, CN decomposition): 3 hr
    Residual stabilized solid waste: 35 Kg (25 vol.% removal)
    NOx treatment: removal less than 100ppm