Treatment of Uranium Slugs at the CEA Marcoule site – 12026

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ABSTRACT

The decladding units on the Marcoule nuclear site in southeast France were commissioned in the early 1960s to receive spent fuel cartridge for interim storage in pools and to prepare them for dissolution. After decladding, the uranium slugs were sent to the reprocessing plant for dissolution.

The units were shut down in 1997. All the operational and process equipment was dismantled and transferred to the ANDRA waste repository between 1998 and 2001. During cleanup of the G2-G3 interim storage pool all the internal components (baskets and machinery) mounted on the civil engineering structures were cut up. In November 2007, a UNGG fuel slug in its aluminum cartridge was found at the bottom of the pool. Similarly, while iron slugs (used to control plutonium-producing reactors) were being sorted, five decladded uranium slugs were found between 2006 and 2008.

As the processing facilities had already been dismantled, it was decided to send these fuel cartridges to a laboratory for dissolution. The project was to recover and condition the cartridge and slugs and transport them safely to the laboratory. This required the design of dedicated equipment due in particular to the high dose rate and pyrophoricity hazard. The procedure also required safety clearance by the regulatory authorities for the operations within the facility and for the transport of radioactive materials. The cartridge was dissolved in May 2009, 18 months after it was discovered. Based on the experience acquired, the retrieval of the uranium slugs was completed in March 2011 after a year of preparation.

INTRODUCTION

The decladding units on the Marcoule nuclear site in southeast France were commissioned in the early 1960s to receive spent fuel cartridges for interim storage in pools and to prepare them for dissolution.
Decladding consisted in removing the fuel cartridges from their interim storage canister, withdrawing the magnesium cladding and the graphite core. The structural waste was then stored in dedicated pits and the uranium slugs were placed in a “uranium store” pending dissolution.
Following the shutdown of the decladding units in 1997, all the operational and process equipment was removed and transferred to a repository managed by ANDRA (French National Radioactive Waste Management Agency) between 1998 and 2001.

Since 2001 the facilities have been decontaminated and dismantled, in particular pool G, which was used for reception and interim storage of fuel cartridges from G2-G3, Phenix, and the EDF reactors at St Laurent, Chinon, and Vandellos. The underwater components (baskets and machinery) were cut up by divers and the sludge was vacuumed from the bottom of the pool. In November 2007, while this work was in progress, a UNGG fuel cartridge in its aluminum container was found at the bottom of the pool.
The uranium store in the G1 decladding unit was also used during the operating period to store iron slugs used to control the neutron flux in plutonium-producing reactors. The initial cleanup and dismantling operations in this uranium store consisted in collecting, radiologically characterizing and sorting the iron slugs before transferring them as waste to

the ANDRA repository. While the iron slugs were being sorted, five decladded uranium slugs were found between 2006 and 2008.

As the industrial facilities used for decladding and chemical dissolution had already been dismantled, it was decided to develop and implement specific means for processing and transporting the fuel cartridge and the five uranium slugs.

The objective of this project was to recover and condition the cartridge and slugs individually and transport them safely to the laboratory while avoiding any risk related to the possible presence of uranium hydride.

METHOD FOR UNGG CARTRIDGE

A piece of an aluminum container was discovered in pool G. Further investigation showed that it was a G2-type natural uranium gas-graphite (UNGG) fuel cartridge. As the final load of this type of fuel was received in 1986, the container had been in the pool since its removal from the reactor at least 20 years earlier. The container was temporarily moved aside underwater on a pole-mounted support. The pool, with a volume of 7060 m^3, was filled with water to a height of 8.40 m. In order to continue draining the pool prior to cleanup, it was necessary to remove the cartridge.

Fig 1. Fuel cartridge its interim pool storage canister

This type of cartridge consists of a finned magnesium tube 30 cm long, containing a natural uranium slug. The divers measured a dose rate of 190 mGy/h in contact with the tube (underwater).
Radiological measurements on the fuel cartridge itself ranged from 310 to 500 mGy/h (underwater). A gamma spectrometry scan confirmed that it was a spent uranium cartridge from the G2 or G3 reactor.

The procedure was conducted as follows:
- First, after cutting the aluminum canister underwater, the fuel cartridge was retrieved with a handling pole and placed in a primary container. The primary container was then placed in biological shielding to protect the operators when it was removed from the pool.
- Then the water was removed from the primary container by argon scavenging and the container was pressurized to prevent any contact with air.
- Finally, the primary container (in its biological shielding) was removed from the pool, placed in a transport cask with a Padirac overpack, and transferred to the Marcoule laboratory for dissolution of the fuel cartridge.

These operations required a number of demonstrations and calculations to obtain safety clearance for retrieval and transport of the cartridge. The main safety risk was ignition or explosion of uranium in air. The fuel cladding can be damaged by impact or high burnup in a power reactor. In a confined humid medium the uranium corrosion mechanisms can result in the release of hydrogen gas and the formation of uranium hydride (UH_3) in powder form. Contact with air can then result in autoignition or explosion. Based on the history of this fuel cartridge and its satisfactory visual condition this type of incident was unlikely, but as a security and to avoid this risk, the fuel cartridge was never allowed in contact with air: it was handled underwater, placed in a container filled with argon (inert atmosphere) and discharged underwater in the laboratory.

RESULTS AND DISCUSSION

Step 1

The container was cut underwater to allow more precise measurement, and to remove the fuel cartridge.

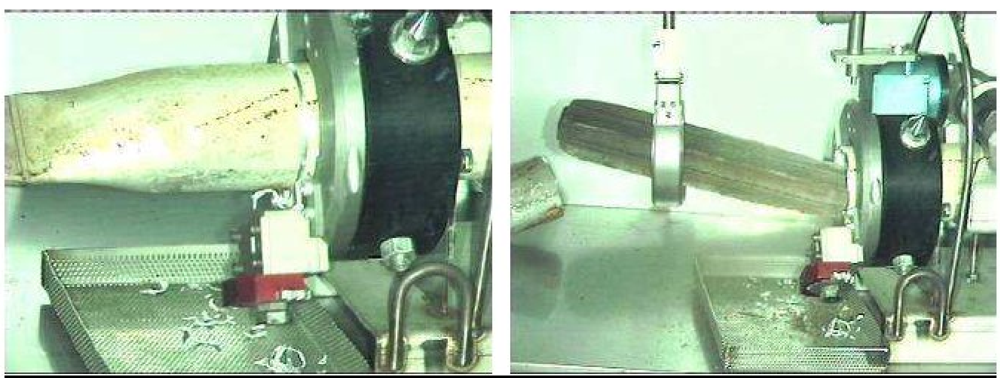

Fig 2. Cutting of the canister underwater and extraction of the fuel cartridge

The fuel cartridge was placed in a primary container surrounded by radiological shielding, by means of handling poles. These operations were carried out remotely underwater by operators assisted by video cameras.

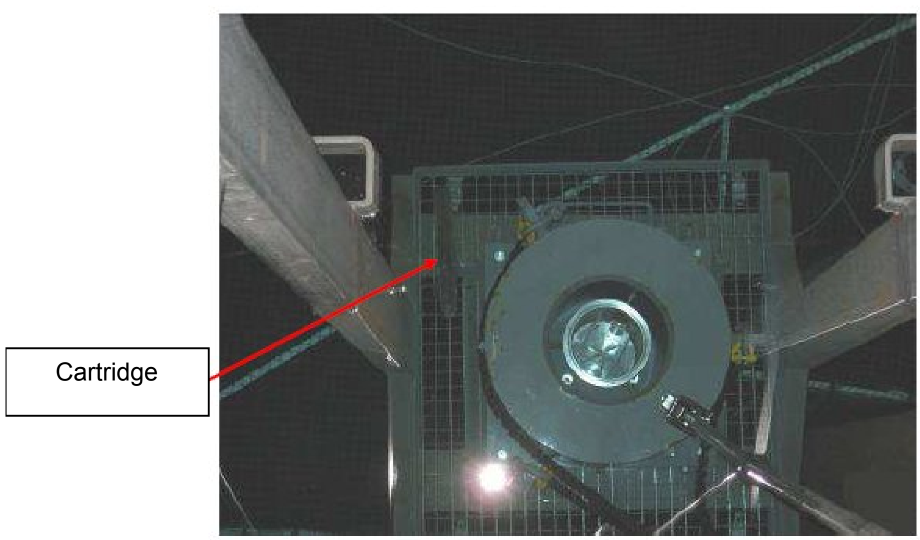

Fig 3. Insertion of the cartridge in the primary container with handling poles

Step 2

Still underwater, by remote manipulation the primary container was inerted with argon via STAUBLI poles.

Fig 4. Closure of the primary container underwater using cameras and connection of STAUBLI poles for inerting the primary container

Step 3

When the primary container (in its radiological shielding) was removed from the pool, it was transferred to a transport cask on a transfer table. The transport cask in its Padirac overpack was then sealed and transferred to the Marcoule laboratory.

Fig 5. transfert de l’emballage primaire dans l’emballage de transport

Equipment was specifically designed for this task:

- a container compatible with the weight and volume limitations of the transport cask, remaining pressurized long enough to allow loading, transport and unloading;
- tools for remote handling, locking and unlocking, with a Staubli coupling for inerting;
- specific biological shielding for transfer of the primary container to the transport cask (130 mm of steel weighing 880 kg). The shielding dimensions corresponded to the radiological characteristics of the fuel cartridge.

CONCLUSION

The project studies began in early 2008 and work was completed about 18 months later in July 2009.

The project was carried out according to the scenario and with the expected results. The technical means and risk management provisions demonstrated their effectiveness and the resulting experience was used for removal of the uranium slugs in 2011.

METHOD FOR DECLADDED URANIUM SLUGS

During recovery and characterization of the iron slugs, five decladded uranium slugs were discovered between 2006 and 2008. The slugs were 30 cm long and 3 cm in diameter with a contact dose rate between 160 and 1200 mGy/h (for the most irradiating slug).
They were secured in a shielded container and stored at the bottom of pit M (6 m deep) in the decladding facility. Inside the shielded container the slugs were covered with dry chemical to avoid any risk in case of external aggression.
The project consisted in remotely (due to the high dose rate) recovering each slug individually, placing it in a transport cask and sending it to the Marcoule laboratory for dissolution.

The safety provisions defined for the fuel cartridge were adapted to the context of retrieval and transfer of five uranium slugs to the Laboratory. This required two permits from the French regulatory authorities: one for retrieval in the facility, and one for transport.
The main risk identified in this operation was for the transport cask to be dropped on the shielded container, damaging it and allowing resuspension of contamination with a resulting radiological impact. All the necessary calculations and demonstrations were performed and measures were taken on the site to prevent this risk: it was prohibited to move objects above the shielded container, and a fall-arrest system was used for handling the transport package in the pit.
The fire/explosion hazard arising from uranium was excluded because the interim storage conditions of these slugs were not favorable to the formation of hydrogen gas and uranium hydride powder: the slugs had been stored for more than 20 years in air in the uranium store of the G1 decladding unit. In addition, the fuel was decladded in massive metallic form, and the low burnup could not have caused significant damage to the metal surface.
The five slugs were transported in the same cask as the fuel cartridge.

The operations were conducted as follows:

- All the equipment specifically developed for this task was first installed in pit M.
- The dry chemical was then removed by suction.
- The uranium slugs were recovered and removed individually.

RESULTS AND DISCUSSION

Step1

The following equipment items were specially developed for this task:

- gripper poles and a video pole for remote handling of the equipment and slugs;

- the operator platform with a grid limiting the personnel dose rate to 2 mSv/h, and with hatches for equipment and personnel access to the pit;

Fig 6. Operator platform, seen from above the pit

- a fall-arrest system immobilizing the package in the event of an overhead crane malfunction. The cage is equipped with cables and reels operated by pneumatic actuators.
- a metal frame to position the shielded container and transport package, and a spill tray to transfer the slugs while limiting contamination and ensuring the slug could be recovered if dropped.

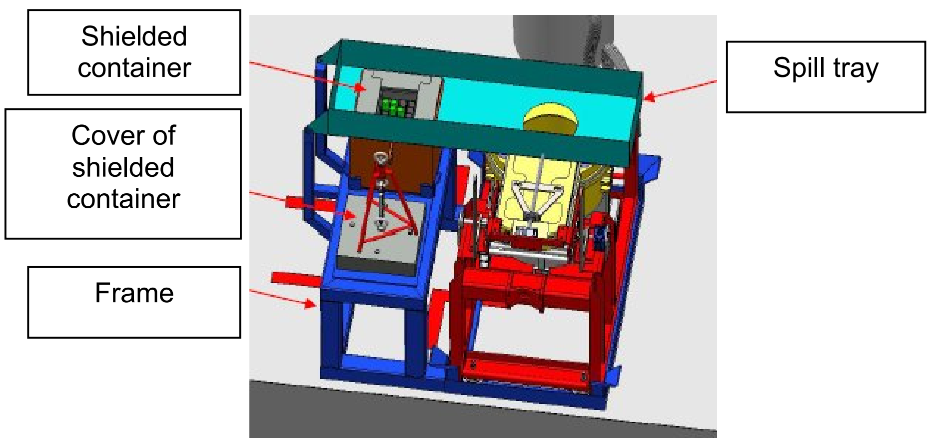

Fig 7. Equipment layout

Step 2

Full-scale tests were performed under inactive conditions to test the reliability of the dry chemical suction recovery system. The principle was to install a fume hood connected to a suction fan around the container to recover the chemical powder when the container was opened, then to vacuum the powder from around each slug.

Fig 8. View of shielded container after vacuuming the dry chemical powder

Step 3

The slug recovery operations were carried out remotely using cameras and handling poles inserted through the roof of the pit, consisting of cast iron radiological shielding.

Fig 9. Retrieval of the first slug with a grippe

Fig 10. Dimensional and radiological measurement of the slug

Once the slug was recovered, radiological measurements were performed to confirm the initial characteristics, then it was inserted in the transport cask through a centering device.

Fig 11. Inserting the slug in its transport cask and raising the package transport out of the pit

CONCLUSION

Based on the experience acquired with the UNGG fuel cartridge, the retrieval of the uranium slugs was completed in March 2011 after a year of preparation.

The decladding units have been shut down since 1997. Fourteen years later, the operators were able to handle a fuel cartridge and uranium slugs in compliance with current safety requirements.
The operation showed that expertise has been conserved for handling UNGG fuel.
Both operations were completed according to their initial scenarios, and can therefore be repeated if the need arises.