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RADIATION PROTECTION DURING HANDLING OF THE SPENT TRIGA FUEL AT THE MEDICAL UNIVERSITY OF HANOVER

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ABSTRACT

The Medical University of Hanover (MHH) returned its 76 spent TRIGA fuel elements to the United States in the summer of 1999. This paper presents the technical facilities used for handling the fuel elements and the procedure for transferring them from the reactor tank at the MHH to the transport cask with regard to the radiological measures and survey results. It also includes the time scale for both the various steps of the procedure and the entire process.

INTRODUCTION

In 1973 a TRIGA (Training Research Isotope General Atomics) research reactor with a thermal capacity of 250 kW was taken into operation in the nuclear medicine department of the MHH. The reactor has been out of operation since the beginning of 1997, and is to be decommissioned.

The first step towards decommissioning the reactor facility was for the 76 spent fuel elements to be returned to the United States in a GNS 16 transport cask in the middle of 1999. In order to do this the MHH took part in the Department of Energy's "Research Reactor Spent Nuclear Fuel Acceptance Program".

The work within the MHH involved in returning the fuel elements was carried out by the Noell-KRC Energie- und Umwelttechnik GmbH. The GNS 16 transport cask was provided, made ready for transport and shipped by the consortium of the Nuclear Cargo + Service GmbH and the Gesellschaft für Nuklear Service mbH. The mobile loading facility from the research reactor at Rossendorf near Dresden was used for loading the GNS 16 transport cask.

Radiation protection during handling of the fuel elements was ensured by both the MHH and the Noell-KRC company.

TRIGA FUEL ELEMENTS

There were a total of 76 spent TRIGA fuel elements made by the American company General Atomics, 71 with aluminum cladding and 6 with stainless steel cladding.
By using the Origen 2.1 program a total activity of 3.37×10^{13} Bq and a total decay heat of 2.55 W was determined. Average burnup was calculated to be 6.31 MWd/kg.

The fuel elements were inspected by the Lockheed Martin Idaho Technologies Company on behalf of DOE in May 1998. The results of the inspection at the MHH showed that all of the fuel elements were leak-proof and able to be transferred to Idaho National Engineering and Environmental Laboratory (INEEL). Special measures were taken for a total of 15 fuel elements to ensure that they could be safely stored at INEEL (see part 3, inside the reactor facility, no. 3).

PROCEDURE FOR HANDLING THE FUEL ELEMENTS

A completely dry procedure was used to transfer the fuel elements. This required the fuel elements first to be transferred to a special loading unit in one of the dry storage pits in the reactor room and then to be air-dried before loading them into the GNS 16 transport cask. Two types of loading units were used, one for accommodating 6 fuel elements and one for 5 (types A2 and B2).

Handling of the fuel elements at the MHH was divided into two parts, inside and outside the reactor room.

Inside the reactor room the following steps were necessary for removing the fuel elements from the reactor tank and placing them in the transfer cask:

1. Each of the fuel elements was removed from the reactor core or the storage racks individually and pulled into the MHH transport flask which had been placed on the safety platform over the reactor tank. The flask was then moved by means of the reactor hoist and set on the fuel element shutter device, which was located over one of the dry storage pits next to the reactor tank and contained a loading unit in the bottom part (**loading procedure step 1**).
2. The fuel element was then lowered out of the MHH transport flask via the shutter device into the loading unit (**loading procedure step 2**).
   After that the empty transport flask was again positioned over the reactor tank and reloaded. Loading procedure steps 1 and 2 were repeated until the respective loading unit was full of fuel elements and finally all of the fuel elements had been removed from the reactor tank in this manner.
3. The loading channels of the type B2 loading units containing the 15 fuel elements mentioned at item 2 were sealed at the top and bottom with filter stoppers, using a special handling tool in connection with the shutter device.
4. In order to move a full loading unit into the transfer cask, the latter was set on the shutter device using its own hoisting mechanism.
5. Using the transfer cask's hoisting mechanism the loading unit was removed from the shutter device and pulled into the transfer cask (**loading procedure step 3**).
6. In order to remove any residual dampness from the fuel elements the transfer cask, which was still on top of the shutter device, was hooked up to a drying apparatus. Any dampness adhering to the fuel elements was removed from the transfer cask by means of dry air being circulated through a mobile filter unit and directed into the reactor room spent air system.
7. After that the transfer cask with its hoisting mechanism was set in the transfer vehicle so that the transfer cask could be taken to a temporary building, which had been erected adjacent to the MHH radiology building to house the GNS 16 transport cask (**loading procedure step 4**).
   The transfer cask was covered with a protective hood and a partial vacuum of 200 mbar was created in the interior of the transfer vehicle.

8. Finally radiological surveys were done on the transfer vehicle. Both dose rate and contamination measurements were made. (see part 4).
9. After completion of the surveys the transfer vehicle was propelled through the reactor room into the elevator, which in turn took the vehicle to the beginning of the transfer route outside the reactor room.

Outside the reactor room the following steps were necessary for placing the fuel elements in the transport cask:

1. The transfer vehicle was propelled inside the radiology building along the approx. 80-m-long transfer route from the reactor elevator to the temporary building.
2. In the temporary building the protective hood was removed from the transfer vehicle by means of a crane and the transfer cask with its attached hoisting mechanism was set on the mobile loading facility. The latter had already been positioned on the GNS 16 transport cask ready for operation (**loading procedure step 5**).
3. The loading unit was lowered through the shutters of the mobile loading facility into the appropriate loading position in the basket of the transport cask by means of the hoisting mechanism on top of the transfer cask (**loading procedure step 6**).
4. This procedure was repeated until all 14 loading units were positioned in the transport cask. Altogether there were 10 loading units of type A2 and 4 of type B2 loaded into the transport cask. Each working day one loading unit was loaded with fuel elements in the reactor room, moved to the temporary building and placed in the transport cask.
5. After the whole process was completed, the transport cask was checked for proper loading. Then the transport cask was sealed and checked for tightness, moved out of the temporary building by means of an air cushion transport system and set in the 20-foot container of the transport vehicle by means of a 60-ton mobile crane (**loading procedure step 7**).

RADIOLOGICAL PROTECTION DURING HANDLING OF THE FUEL ELEMENTS

All of the radiological protection measures in connection with planning the procedure and handling the fuel elements were aimed at the following:

• minimizing the dose rate for staff involved
• minimizing the local dose rates
• avoiding contamination and the spread of contamination
• preventing the release of airborne radioactive materials into the environment
• avoiding radioactive fluid waste
• avoiding additional radiation for persons not involved

These principles had also been applied to the technical design of the components used for handling the fuel elements.

Measures for avoiding the spread of contamination

Throughout handling of the fuel elements the following measures in particular were taken to avoid the spread of contamination:

- The floor was covered with protective cloths before any components which had been in contact with water from the reactor tank were set down.
- Extra overshoes were worn in the reactor room and in the temporary building.
- The floor of the transfer route was covered with protective sheeting .
- The individual components were checked to make sure they were free of contamination when they were brought into the control area.

Contamination surveys

During handling of the fuel elements direct surveys were made of adherent and non-adherent contamination and wipes were taken. The survey included:

- The concentration of activity in the air was determined every working day (dust collectors in the reactor room, the temporary building and along the transfer route)
- The concentration of activity in the ventilation bypass in the temporary building was determined every working day
- Wipes and screening tests* were done before the transfer vehicle was moved out of the reactor room and before the GNS 16 transport cask was moved out of the temporary building. Figure 1 shows wipes being taken from the bottom of the GNS 16 transport cask before it was placed in the 20-foot transport container
- Contamination of the floor in the reactor room, along the transfer route and in the temporary building was measured directly
- Persons were checked before leaving the reactor room and the temporary building in order to ensure that they were free from contamination
- Decontolling measurements were made along the transfer route and in the temporary building after the handling of the fuel elements was completed

Two different kinds of wipes were done:

- wipes over an area of 100 cm^2 with a dry test cloth
- wipes over an area of 100 cm^2 with a special test cloth which is suitable for an LSC measuring area, after moistening with a decontamination solution

The wipes were evaluated using the MHH's liquid scintillation counter (LSC) and the gamma spectrometer.

The main results of the radiological surveys were as follows:

- It was confirmed that all of the areas were free of contamination. In particular, there was no alpha contamination.
- There was no airborne contamination at any time.
- The radionuclide Co-60 was identified in the fuel element shutter facility from the water dripping from the fuel elements. Due to the small amounts a quantitative analysis was not possible.
- No contamination was found during decontrolling of the transfer vehicle or the GNS transport cask.
- The control area was removed as a result of the decontrolling surveys done on the transfer route and in the temporary building.

Local dose rates
In order to determine the local dose rates during handling of the fuel elements in the reactor room, along the transfer route and in the temporary building the neutron and gamma radiation were measured. Figure 2 shows the neutron and gamma dose rates being measured on the MHH flask.

Since no neutron radiation was ascertained, all of the data in Table 1 refer to dose rates which originated from gamma radiation.

Table 1: Maximum local does rates during handling of the fuel elements

Place and activity	**Dose rate µSv / h**
Pulling a fuel element into the MHH flask • 1 m away from the fuel element (for approx. 1 sec.) • location of the reactor operator • location of other staff 5 m away	 **1,500** **5** **5**
Surface of the MHH flask • aluminum clad fuel elements • steel clad fuel elements	 **5** **100**
Fuel elements in the fuel element shutter facility • surface • 2 m away	 **20** **0.1**
Transfer cask with 6 aluminum clad fuel elements • surface • 3 m away	 **230** **2**
Surface of the transfer vehicle	**100**
Lowering the fuel element loading unit into the GNS 16 transport cask • at the location of the operating staff • in the air gap between the GNS 16 transport cask and the mobile loading facility (for approx. 1 sec)	 **6** **2000**
Surface of the closed GNS 16 transport cask loaded with the 76 fuel elements	**0.07**
Outside surface of the access door to the temporary building after the GNS 16 cask was loaded with the 76 fuel elements	**0.06**

Exposure to radiation during handling of the fuel elements
During handling of the fuel elements exposure to radiation was measured with official film dosimeters and electronic dosimeters. The electronic dosimeters were evaluated and the results stored each working day.

The 17 persons involved in handling the fuel elements were monitored with these dosimeters. Of this group 13 persons participated constantly in handling the fuel elements.

In addition the electronic dosimeters were also used for visitors, representatives from the authorities and experts. Exposure to radiation for these persons amounted to a maximum of 1 µSv per day and person.

The following dose rates were determined during handling of the fuel elements:

Collective dose rates

• for a total of 17 persons involved	655 manµSv
• for 13 persons constantly involved	623 manµSv
• for 4 persons not constantly involved	32 manµSv

Individual dose rates

• maximum total dose rate for one person constantly involved	122 µSv
• highest daily dose rate for one person constantly involved	16 µSv
• average daily dose rate for one person constantly involved	3.5 µSv

The collective dose rates for the groups of persons involved in handling the fuel elements are shown in Table 2.

Table 2: Collective dose rates for the groups of persons involved in handling the fuel elements

Group of persons	Number of persons	Collective dose rate manµSv
MHH		
reactor operators	4	65
radiation protection staff	2	100
Noell-KRC company		
operating staff	4	350
radiation protection staff	2	105
DOE	1	12

TIMETABLE

Before the actual work began a complete dry run of all the steps was carried out. The handling procedures both inside and outside the reactor room were tried out. The timetable was practiced on the basis of detailed plans for the sequence and survey maps.

Table 3 contains the details of the daily timetable for the loading procedure. Table 4 summarizes the most important milestones of the program for returning the fuel elements to the United States.

Table 3: Daily timetable for handling the fuel elements

Activity	Time required
Preparation	approx. 1 hr.
Loading procedure steps 1 and 2	approx. 2 hrs.
Loading procedure step 3	approx. 1 hr.
Drying of the fuel element loading unit in the transfer cask	1 hr. max.
Loading procedure step 4	approx. 1 hr.
Radiological survey of the transfer vehicle	approx. 0.75 hr.
Transport of the transfer vehicle to the temporary building	approx. 0.15 hr.
Loading procedures 5 and 6	approx. 1 hr.

Table 4: Milestones of the return of the fuel elements to the United States

Activity	Time
dry run at the MHH	6 days in April and May 1999
DOE transport permit issued	May 14, 1999
Permit for handling the fuel elements issued	June 7, 1999
Fuel element loading procedure begun	June 9, 1999
Loading of the GNS 16 transport cask completed	June 28, 1999
GNS 16 transport cask prepared for shipping and sealed	July 6, 1999
GNS 16 transport cask released and shipped from the MHH	July 9, 1999
Ownership of fuel elements transferred from MHH to DOE	August 19, 1999
Unloading of GNS 16 transport cask at INEEL completed	September 9, 1999

SUMMARY

In order for the 76 spent fuel elements from the MHH to be returned to the United States in the summer of 1999 a special loading and transfer technology was developed by the Noell-KRC company for handling the fuel elements inside and outside the reactor room. This required the use of special components which were specially developed for the MHH, e.g. the fuel element loading units, the fuel element shutter facility and transfer cask as well as the mobile loading facility from the Rossendorf research reactor.

This technology made it possible to remove the fuel elements from the reactor tank and load them into the GNS 16 transport cask using a completely dry procedure. The integrity and criticality safety of the fuel elements was thus guaranteed during each step in the handling procedure.

There was no contamination in the reactor room, the temporary building or along the transfer route. The release of radioactive materials either through spent air or waste water was avoided.

Exposure to radiation for all persons involved was considerably lower than the legally permissible values. The total collective dose rate of 623 μSv/h was very low for the 13 people constantly involved in the work. Persons not involved in the procedure were not exposed to any additional radiation.

Daily routine work was not disturbed in the radiology building or in any other MHH buildings during the entire procedure.

A total of 16 working days in the MHH were required for the entire fuel element loading procedure including preparation and shipment of the GNS 16 transport cask. There were no problems. The transport deadline set by DOE was able to be met without any problems, so that ownership of the TRIGA fuel elements could be transferred to the United States on August 19, 1999.

FOOTNOTES

[*] Screening test: surface wipe with a cotton cloth and qualitative check of the cloth for contamination with a contamination monitor.

Fig 1: Wipe being taken from the GNS transport cask

Fig 2: Measuring the neutron and gamma dose rates on the MHH flask