Return of TRIGA fuel from the Medical University of Hanover (MHH) to the United States

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Abstract
The Medical University of Hanover (MHH) returned its TRIGA fuel to the United States in the summer of 1999. This paper deals with the procedure for handling the fuel elements within and outside the reactor facility. It describes the dry loading technology, taking into account the special conditions relevant to the MHH. It also includes the time scale for both the various steps of the procedure and the entire process, as well as the main results of the radiological surveys.

1. Introduction

In 1973 a TRIGA (Training Research Isotope General Atomics) research reactor with a power of 250 kW was taken into operation in the nuclear medicine department of the MHH. The reactor is located in the basement of the radiology building on the grounds of the MHH. The TRIGA reactor was used mainly for producing radiopharmaceuticals with short physical half-lives for use in nuclear medicine diagnosis. In addition, the reactor was used for activation analysis in medical, biological and geological research. The reactor has been out of operation since the beginning of 1997. The reactor is to be decommissioned.

All of the work involved in removing the fuel elements within the MHH 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.

2. Removal of the TRIGA fuel

The first step towards decommissioning the reactor facility was for the spent fuel elements to be returned to the United States in a GNS 16 transport cask in the middle of 1999. The MHH took part in the Department of Energy's (DOE) "Research Reactor Spent Nuclear Fuel Acceptance Program". The return of the fuel elements to the interim storage facility of the Idaho National Engineering and Environmental Laboratory (INEEL) ensued on the basis of the contract concluded between DOE and the MHH on July 1, 1998.

There were a total of 76 TRIGA fuel elements made by the American company General Atomics, 71 with aluminum cladding and 5 with stainless steel cladding.

Using the Origen 2.1 program, the main data for the fuel elements were determined by the first of January 1999 as shown in Table 1 below.

Table 1: Main data for the TRIGA fuel elements of MHH calculated by the program Origen 2.1

total weight of U-235	2776 g
total weight of plutonium	8.85 g
total activity	3.37×10^{13} Bq
total decay heat	2.55 W
average burnup	6.31 MWd/kg
U-235 weight per fuel element	37.87 g maximum
U-235 enrichment per fuel element	19.9% maximum

The fuel elements at the MHH were inspected by the Lockheed Martin Idaho Technologies Company on behalf of DOE approx. one year prior to shipment. The results of the inspection showed that all of the fuel elements were leak-proof and able to be transferred to INEEL. Special measures were taken for a total of 15 fuel elements to ensure that they could be safely stored at INEEL (see No. 3.2).

3. Procedure for handling the fuel elements

3.1 Special conditions with respect to the premises and technical considerations

Due to the location of the reactor in the radiology building it was not possible to bring the GNS 16 transport cask into the reactor room (see fig. 1). The cask had to be loaded outside the reactor facility in a temporary building erected for this purpose. Therefore it was necessary to remove the fuel elements from the reactor tank and load them first into a special transfer cask, which was then moved to the temporary building. In the temporary building the special transfer cask was unloaded using the mobile reloading facility which had been developed for the removal of fuel elements from German research reactors and first used at the Rossendorf research reactor near Dresden. Thus it was possible to load the GNS 16 transport cask using a completely dry loading procedure.

3.2 Fuel element loading units

In order to handle the fuel elements special loading units made of an aluminum alloy were used (see fig. 2). There were two types of loading units, one to accommodate 5 fuel elements (type B2) and one to accommodate 6 fuel elements (type A2). Compared to the A2 type the loading channels of the B2 type loading unit are approx. 2mm larger in diameter in order to accommodate bent fuel elements and filter plugs can be placed at each end. The filter plugs are made of woven stainless steel with a mesh width of 100 µm and serve to hold back particles in accordance with INEEL requirements.

The TRIGA basket in the GNS 16 transport cask can accommodate a maximum of 15 loading units.

Criticality analyses were carried out for both the loading units and for a full basket, not only under normal handling conditions but also in emergency situations. The results showed that the configuration of the fuel elements remained below the critical level under all conditions.

In order to carry out the dry loading procedure it was necessary to load the fuel elements into the loading unit in a dry storage pit and to circulate dry air around the fuel elements in the loading unit before it could be loaded into the transport cask.

4. Loading the fuel elements

4.1 Timetable

Before loading started a complete step by step dry run was carried out. This included testing all of the handling procedures within and outside the reactor facility. The sequence was practiced following detailed step by step work and survey maps.
After the dry run was concluded the MHH was authorized by DOE on May 14, 1999 to ship the fuel elements to the United States.
Table 2 shows further details with respect to the timetable.

Table 2: Milestones in the process of removing the TRIGA fuel elements from MHH to INEEL

Event	**Time**
dry run	6 days in April and May 1999
permit for fuel handling issued	June 7, 1999
loading of fuel elements begins	June 9, 1999
loading of GNS 16 completed	June 28, 1999
preparation for shipment and sealing of GNS 16	July 6, 1999
GNS 16 leaves MHH	July 9, 1999
ownership of fuel elements passes from the MHH to DOE	August 19, 1999
final unloading of GNS 16 at INEEL concluded	September 9, 1999

The project will be concluded when the authority responsible has approved the lifting of the restricted areas which were required for handling the fuel elements outside the reactor facility. This is expected to take place in the last quarter of 1999.

4.2 Step by step description of the fuel element loading procedure

The handling of the fuel elements was divided into two stages, one within and one outside the reactor facility.

4.2.1 Within the reactor facility

The following steps were carried out within the reactor facility to load and transfer the fuel elements:

Each of the fuel elements was pulled out of 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 with the hoist in the reactor room and set on the fuel element shutter device.
The shutter device was located over a dry storage pit next to the reactor tank, containing a loading unit in the bottom part.

The fuel element was then lowered out of the MHH transport flask via the shutter device into the loading unit. After that the empty transport flask was again positioned over the reactor tank and reloaded.

This loading procedure was 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.

The loading channels of the type B2 loading units containing the 15 fuel elements mentioned at No. 2 were sealed at the top and bottom with filter plugs, using a special handling tool in connection with the shutter device.

In order to load a full loading unit into the special transfer cask, the cask with its own hoisting mechanism was set on top of the shutter device.
Using this hoisting mechanism the loading unit was moved from the shutter device into the special transfer cask (see fig. 3).
This procedure from the time the first fuel element was removed from the reactor tank until the full loading unit was placed in the special transfer cask took about 90 minutes.

In order to remove any residual dampness from the fuel elements the special transfer cask, which was still on top of the shutter device, was hooked up to a drying apparatus. Any dampness clinging to the fuel elements was removed from the special transfer cask by means of dry air being circulated through a mobile filter unit. The air was then pumped into the reactor room spent air removal system. The drying procedure took about 60 minutes.

After the drying procedure was finished, the special transfer cask with a special hoisting mechanism was set in the transfer vehicle in order to move it to the temporary building.
Then the special transfer cask was covered with a protective hood and a partial vacuum of 200 mbar was created in the interior of the transfer vehicle. After that radiological surveys were carried out on the transfer vehicle, whereby the dose rates and contamination levels were measured (screening tests and wipes). No contamination was found during any of these surveys. The maximum dose rate (β,γ) was 100 μSv/h; there was no α or n radiation.

After the surveys were finished, the transfer vehicle was moved by means of a propelling apparatus within the reactor room to the reactor room elevator and taken by elevator to the beginning of the transfer route outside the reactor facility.

4.2.2 Outside the reactor facility

The following steps were necessary for reloading the fuel elements outside the reactor facility:
The transfer vehicle was moved by the propelling apparatus along the transfer route between the reactor facility and the temporary building (see fig. 4).
The protective hood was removed from the transfer vehicle using the crane in the temporary building. After that the special transfer cask with its attached hoisting mechanism was set on the mobile reloading facility also by means of the crane.
The mobile reloading facility had already been placed on top of the GNS 16 transport cask ready for operation.

The loading unit was lowered via the mobile reloading facility into the appropriate loading position in the basket of the transport cask by means of the hoisting mechanism on top of the special transfer cask (see fig. 5).
After the loading unit was in position the special transfer cask was removed from the mobile reloading facility by means of the crane, set in the transfer vehicle and returned to the reactor facility with its protective hood.

The transfer and loading 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, taken to the temporary building and placed in the transport cask.

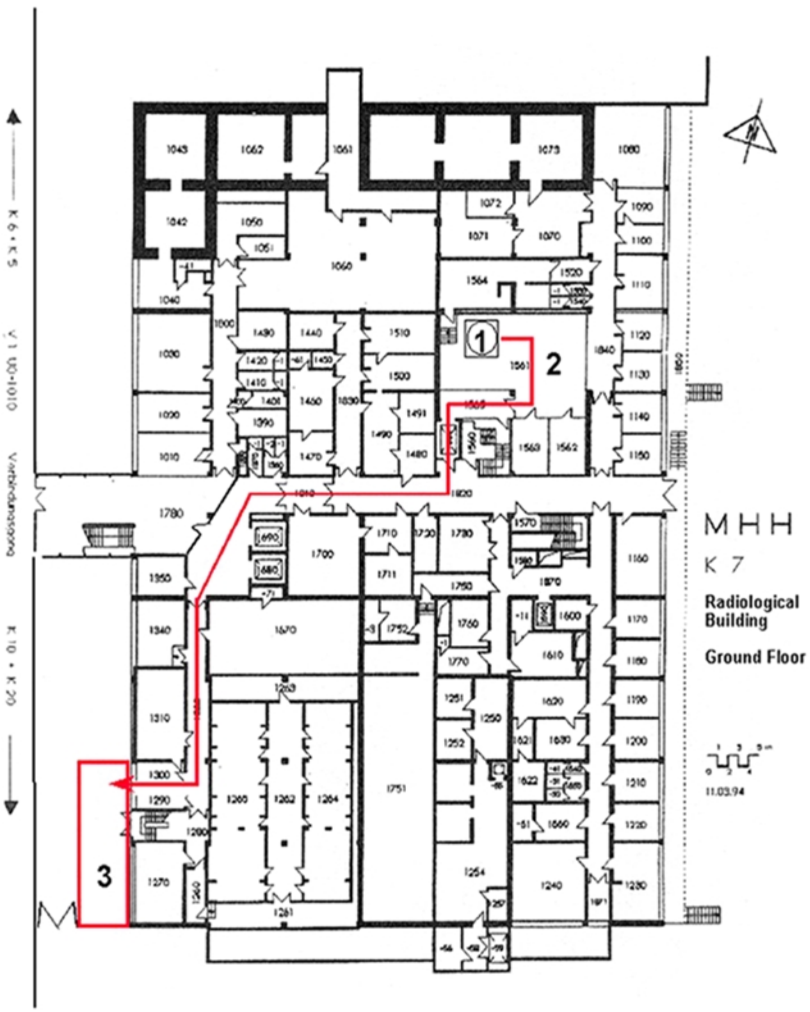
After the entire process was finished, the transport cask was checked to make sure it had been loaded properly.
The transport cask was then sealed and checked for tightness. After that it was made ready for shipment in accordance with transport requirements. Measurement of the dose rates (β,γ) resulted in a maximum of 0.08 μSv/h on the surface of the cask.

The transport cask was then moved out of the temporary building by means of an mobile air cushion transport system and set in the 20-foot ISO-container of the transport vehicle by means of a 60-ton mobile crane (see fig. 6).

After the ISO-container was made ready for shipment the transport cask was released for transport to the port of Esbjerg in Denmark.

5. Final comments

The loading and transfer technology used offers the advantage of dry handling of spent fuel elements, resulting in no contamination in the reactor room or in the temporary building or along the transfer route. No radioactive material was released into the environment, in particular radioactive waste water was avoided. The total collective dose of 623 μSv for all persons was very low for 13 people (personnel carrying out and supervising the procedure). Daily routine work was not disturbed in the radiology building or in any other MHH buildings. Persons not involved in the procedure were not exposed to any additional radiation.
Altogether the procedure chosen for removing the TRIGA fuel proved to be the optimal solution under the existing conditions at the MHH.



1 Reactor
2 Reactor area
3 Temporary building

Fig. 1: Route to be taken by Fuel Elements

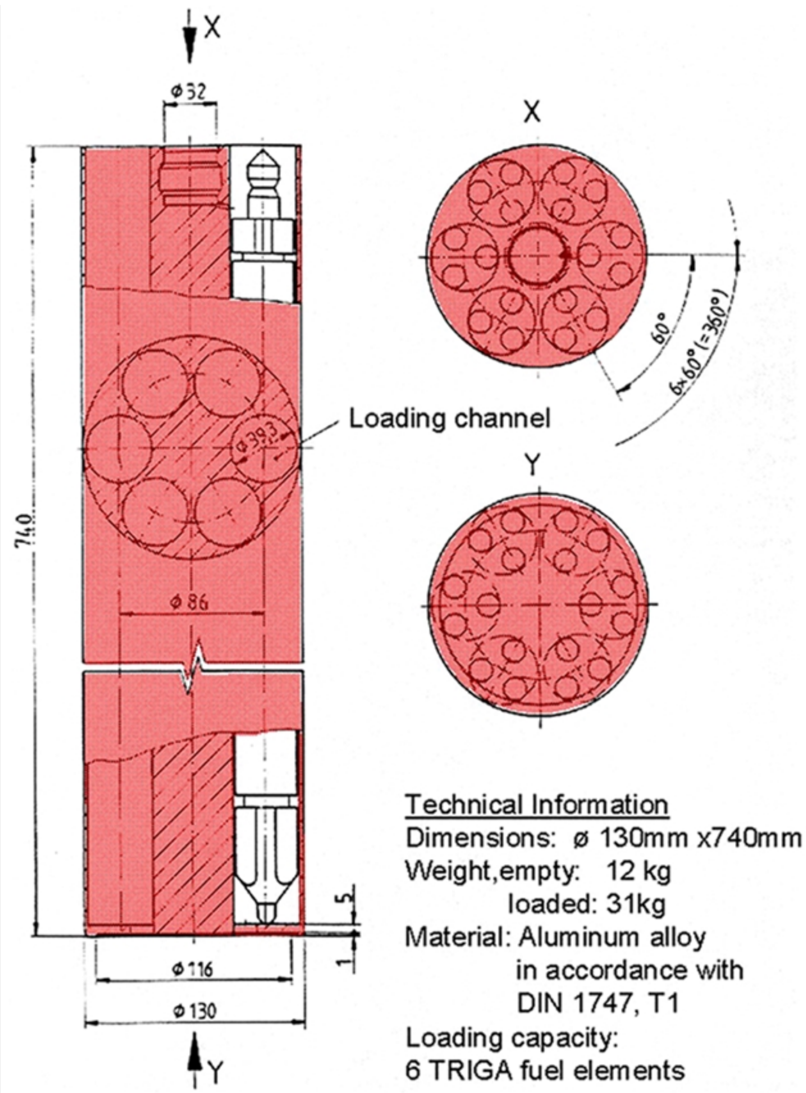


Fig. 2: Loading Unit for 6 Fuel Elements

Fig. 3: Special transfer cask with its hoisting mechanism on top of the shutter device

Fig. 4: Transfer vehicle with propelling apparatus on the route between reactor area and temporary building

Fig. 5: Special transfer cask with its hoisting mechanism on the top of the transport cask GNS 16

Fig. 6: Transport cask GNS 16 in the bottom impact limiter in the ISO - container