OPERATIONAL ASPECTS OF TRIGA SHIPMENT FROM SOUTH KOREA TO INEEL

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ABSTRACT

A shipment of-"99 irradiated TRIGAZ fuel elements was made from South Korea to the United States in July 1998. The shipment was from two facilities in Korea and was received at the Irradiated Fuel Storage Facility (IFSF) at the Idaho National EnLnneerin2 and Environmental Laboratory (INEEL). Fuel types shipped included aluminum and stainless steel clad standard fuel elements. instrumented and fuel f6flower control elements. as well as FLIP elements and failed fuel elements. %lodes of transport included truck, rail and ship.

INTRODUCTION

The shipment of irradiated TRIGA fuel elements from South Korea to the USA was performed using three NAC-LWT shipping casks specifically configured for TRIGA fuel. The TRIGA fuel included LEU and HEU fuel, aluminum and stainless steel clad fuel. instrumented and fuel follower control rods, as well as failed fuel. All of these fuel types can be shipped, mixed, in the NAC-LWT cask.

Due to facility crane and space limitations new loading equipment was designed and fabricated. This new equipment in conjunction with existing NAC dry transfer equipment was used to load the casks. Failed fuel cans were also designed and fabricated to allow the failed fuel to be transported. New tools were also fabricated to handle the failed fuel and failed fuel cans.

Once loaded. the casks were transported to the IN-EEL by truck. ship and train. The shipping baskets were unloaded and are stored directly with the fuel at the IFSF at INEEL.

FUEL INFORMATION

299 TRIGA fuel elements were shipped from South Korea. The fuel was a mixture of aluminum and stainless steel clad fuel of low and high enrichment. There were instrumented fuel elements and fuel follower control elements (FFCRs). The fuel was located at two sites, the Hanaro site and the Seoul 42 site. Table I gives a brief summary of the fuel element information.

Table 1. South Korean Shipment TRJGA Fuel Data

Quality To Be Shipped			Fuel Information		
Total	Hanaro	Seoul	Element Type	Enrichment	U-235
67	6	61	Standard Aluminum Clad	20%	39 g
2		2	Instrumented Aluminum Clad	20%	39 g
103	84	19	Standard Stainless Clad	20%	39 g
2	1	1	Instrumented Stainless Clad	20%	39 g
4	3	1	Fuel Follower Control	20%	32 g
110	18	92	Standard Stainless Clad (FLIP)	70%	136 g
7	1	6	Instrumented Stainless Clad (FLIP)	70%	135 g
4		4	Fuel Follower Control (FLIP)	70%	112 g
299	113	186	Total Fuel		

Some of the fuel at both sites was failed or damaged. This included a large portion of the stainless steel clad fuel at Hanaro. The fuel had previously been transported to Hanaro, in a cask that was apparently de-watered with unregulated gas. This damage was generally minor in nature and did not breach the cladding. The exception was the FFCRs that have large void spaces in the rods. These rods had rather severe 'crimps' and in several cases the cladding was torn. Several fuel rods were contained in stainless steel cans (pipes) that were only opened prior to loading. Damage to these rods included cracks, ruptures, and compete rod breaks.

The fuel at the Seoul #2 site was that used at both the Seoul #1 and Seoul #2 TRIGA reactors. The fuel was generally in good condition. FFCRs and instrumented rods needed to have the extensions removed. Some were cut and some were dismantled. Two fuel elements were contained in stainless steel cans (pipes). These elements were broken and were placed in a sealed can for transportation

TRANSPORT EQUIPMENT DESCRIPTION

General information on the NAC-LWT package is shown in Table 2. The NAC-LWT shipping configuration for TRIGA fuel consists of five modular stainless steel baskets that stack axially into the cask cavity. The baskets are of three different lengths to accommodate fuel follower control elements up to 45 inches in length. The baskets have seven fuel element positions and are nearly identical to the NAC-LWT MTR basket design except for length.

Table 2. NAC-LWT Cask Description for TRIGA Fuel

Overall Length	5.08 m
Cavity Length	4.60 m
Overall Diameter	1.12 m
Cavity Diameter	0.34 m
Loaded Weight	23,000 kg
Capacity	120 or 140 Elements
Maximum Enrichment	93%
Heat Rejection	900 or 1050 watts
Maximum Fuel Length	115 cm

A sealed can and a screened can were designed to accommodate failed fuel, Some fuel was canned for transportation purposes and some was canned for INEEL receipt and storage criteria. The transport license requires canning only for fuel with severely degraded cladding, where the geometry of the fuel cannot be maintained. INEEL criteria requires canning of fuel with cladding defects that include localized rips, localized tears, cracks, bulges, or indentations. The NACLWT certificate has no requirements for segregating TRIGA fuel of different types. However, since the baskets are to be stored, INEEL desired segregation of HEU and LEU and aluminum and stainless steel clad elements.

CASK LOADING EQUIPMENT

The shipping facilities were not capable of wet loading the shipping cask directly, so dry and wet transfer systems were used.

Dry Transfer System

The existing NAC Dry Transfer System (DTS) was used in conjunction with newly designed equipment to support the loading operations. NAC finished fabrication of a second system in December 1997 and plans to build a third this year. The system consists of an 8-ton transfer cask, a cask adapter and adapter ring, a carriage assembly, a pool loading assembly, and associated basket grapples and handling tools.

No substantial modifications to the DTS were needed to accommodate loading of TRIGA fuel. A new grapple design was fabricated to allow the longest TRIGA basket to be handled within the DTS transfer cask. Essentially, the MTR grapple was used with the shielding removed and the grapple strength increased to accommodate up to 850 pounds.

ITS Transfer Shield Assembly

The TRIGA FRR site crane capacities servicing the reactor at Seoul #2 was limited to less than five tons. NAC designed and fabricated a top loading Intermediate Transfer System (ITS) transfer shield assembly consisting of an inner and an outer shield. The inner shield has a maximum loaded weight of two tons, provides for draining of the fuel, and has a lid. The outer shield has a maximum weight of five tons (when combined with the inner shield), and provides additional shielding for personnel during operations.

During operations at facilities with reactor service cranes having a capacity between 2 tons and 5 tons, such as Seoul #2, the outer shield is loaded on the existing DTS transfer carriage and placed as close as is practical to the pool. The inner two-ton shield is placed in the pool and loaded with a fuel basket. The lid is placed on the inner shield and the inner shield is lifted from the pool and allowed to drain. The inner shield is then moved and placed in the outer shield. In facilities with reactor service cranes in excess of 5 tons, the inner and outer shields can be lifted and used together in the pool, therefore providing additional shielding during the movement from the pool to the DTS transfer carriage. Following the movement of the fuel to the transfer carriage, the carriage is moved to the cask loading location for mating up with the DTS transfer cask.

An ITS adapter and adapter ring similar in design to the DTS adapters are used to mate the ITS to the DTS cask. The fuel basket is then transferred into the DTS cask. The shipping cask is then loaded using the DTS. A transfer carriage adapter allowed the nested transfer shield to be transported on the existing DTS transfer carriage. This adapter has a drip pan to catch any additional water draining from the nested transfer cask.

ADDITIONAL EQUIPMENT DESCRIPTION

Fuel Cutting Equipment

An underwater saw and underwater shear were developed. The underwater saw was designed to cut fuel follower control rods. instrumented fuel rods, and, of greatest concern, the stainless steel pipes that served as South Korea's failed fuel cans. The saw was of stainless steel construction with an electrical motor that remained above the surface of the pool and was controlled from poolside. The shear was hydraulically operated and was able to cut extensions on instrumented fuel elements and fuel follower control rods. In addition, underwater wrenches were designed and used to unseal the Korean failed fuel cans.

Fuel Handling Tools

Tools for handling intact, cut, and degraded fuel elements and to assist in loading the fuel cans and fuel baskets were also developed. These included a cut fuel handling tool. a debris handling tool, and a station to assist in loading cans.

Cropping fuel removes the handling extension present on fuel follower control rods and instrumented fuel elements. Thus a tool was required to grapple either the top or side of the fuel elements. This tool is based on a proven air actuated clamshell grapple deign that NAC has extensive experience using in North Korea on similar size rods. The grapple is articulated to allow fuel to be picked up from the horizontal position and placed in the vertical position for loading. The handling tool also served as the method for retrieving dropped fuel rods.

A stainless steel loading table was fabricated to allow fuel elements and pieces to be examined on the pool bottom. A “dust pan” style retrieval tool was used to pick fuel fragments and debris off of the loading table.

To allow four elements to be loaded in the screened failed fuel can, the can needed to be tilted slightly. A station to hold the failed fuel cans was fabricated for this purpose. The station also was used to stage a single TRIGA fuel element. Tools were designed handle empty and loaded failed fuel cans and to place the lids on the cans. These were simple extension pool tools. A tool was built to remove can lids at the sites A fixture was used to assist in the loading of multiple assemblies into each of the six fuel slots in the baskets. This cruciform shaped fixture (in cross section) was used to provide a lead in for ease of fuel loading and be removed and reused for each fuel slot

FACILITY AND LOADING DESCRIPTION

Hanaro Site

South Korea's newest research reactor is located at the Hanaro site. The fuel shipped, unrelated to the new reactor, was TRIGA fuel from the Seoul #1 and Seoul #2 sites. The fuel was located in a transfer canal for the Hanaro reactor. The Hanaro facility is new and access to the facility is relatively unrestricted. Access to the reactor building was through a roll up door in the rear of the building. The area in the rear of the building is open and provided an adequate staging area for the casks and equipment. Inside the roll up door is a small entry bay (approximately 13m x 6m) that has an overhead hatch (approximately 4.5m x 7m) that provides access to the upper operations area where the pool is located. The facility has a 30-ton crane and the cask was lifted directly from the trailer into the reactor building.

The fuel was stored in a canal (1 m width, 8m length, and 7m depth) next to the storage pool and operations pool for the Hanaro reactor. The operations pool was isolated from the canal and storage pool during the fuel handling operations. Loading was accomplished by using the Dry Transfer System (DTS) with the cask on the operations floor. All operations used the Hanaro overhead crane.

A fuel basket was wet loaded with up to 24 fuel elements and transferred through a shielded funnel directly into the eight-ton NAC DTS transfer cask. The transfer cask was then mated with the shipping cask and the fuel basket loaded into the shipping cask. The first cask was loaded with a single loaded fuel basket containing HEU and four empty baskets. The cask was shipped to Seoul to be loaded with additional HEU. The second cask was loaded with five loaded fuel baskets and sent to Seoul to be staged with the remaining casks.

Seoul Site

Access to the Seoul #2 reactor building is limited by a narrow, partially paved access road from the parking lot to the building equipment door. In addition, the facility crane capacity was less than five tons and the shipping cask or DTS cask could not be handled inside the facility. The casks were set up outside of the building and a portable crane was used to handle the casks and DTS.

The specially designed ITS transfer shield was used to accomplish the loading. Each basket was wet loaded into the transfer shield. The transfer shield was the mated to the, dry transfer cask using_an outside portable crane and the basket transferred to the dry transfer cask. The cask was then loaded in a similar manner as at the Hanaro site.

SHIPMENT

After loading, all three casks were staged at the Seoul #2 site for transport to the port of Inchon. The casks and loading equipment were loaded on exclusive use charter vessel, the Blue Bird, and transported to the United States. The voyage lasted approximately 20 days with the vessel steaming at flank speed nearly the entire time. The vessel arrived at the 12 mile marker outside of San Francisco around 09:00 on July 21. The vessel and containers were inspected and proceeded toward the Concord NWS around noon. The vessel was under coast guard escort during the journey from the 12-mile marker to the NWS.

The vessel arrived at the pier and after another inspection, unloading commenced. The three casks, in ISO containers were transferred to railcars on a dedicated train. The containers were inspected by the NRC, DOE and state agencies for compliance with regulations. The train had two cabooses to accommodate up to 8 persons that traveled with the train. The train departed for INEEL. The ship was transferred to another pier outside of the NWS and the cask loading equipment was unloaded and returned to NAC by truck.

The train arrived at INEEL without mishap, with much news coverage, and without a lot of concern by citizens. The containers were loaded to trucks and moved to the IFSF for unloading. Unloading was accomplished remotely in the IFSF fuel-handling cave. Fuel transportation baskets were unloaded from the casks and stored directly at the facility. After unloading the empty casks were returned to NAC by

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