THE DEVELOPMENT OF THE TMI-2 FUEL DEBRIS SHIPMENT PROGRAM

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ABSTRACT

As part of the recovery operations at Three Mile Island Unit 2, the nuclear fuel which experienced sever damage, as a result of the accident, was to be shipped to the Department of Energy(DOE). The DOE would provide interim storage of this material until a permanent repository was established. Numerous technical and regulatory problems had to be identified and solved in order to make these shipment. This paper outlines the identification and resolution of the major problem areas as they related to the physical transfer and shipment of the TMI-2 Fuel Debris to the DOE.

INTRODUCTION

On July 20, 1986 the first shipment of TMI-2 Fuel Debris departed Three Mile Island in the NuPac 125-B rail cask. The shipment arrived via exclusive train at the Idaho National Engineering Laboratory five days later for interim storage by the U.S. Department of Energy(DOE). This shipment was a major milestone in the clean up operations at TMI and represented the culmination of years of joint planning on the part of GPU Nuclear, EG&G Idaho, the DOE and regulatory agencies including the NRC and the DOT.

As a result of the accident at TMI-2 in March of 1979, the nuclear fuel, within the reactor vessel, experienced severe damage. The exact extent of this damage was not immediately known but large quantities of both activation products and transuranic materials were spread throughout the plant. After the condition of the plant was stabilized, work began on the decontamination of the facility. The primary objective of this cleanup was to gain access to the reactor vessel so that the nuclear fuel could be removed, packaged, and shipped off site. As a result of written Memoranda of Understandings between the Department of Energy (DOE) and the Nuclear Regulatory Commission (NRC), it was agreed that the DOE would be responsible for the long term storage and eventual disposal of the damage core

Early in the cleanup operations, while still in the plant decontamination phase, DOE and GPU Nuclear began negotiations on a commercial contract to outline their respective responsibilities with regard to this material. At the time little was known about the true condition of the fuel within the reactor vessel. These negotiations tended to be more on the commercial lines than technical in nature. They did, however, establish the operational framework which would guide the future direction of the TMI-2 Fuel Shipping Program. These negotiations ended with the signing of the Damaged Core Contract (DE-SC07-84ID12855) in 1984. This contract assigned specific responsibilities to each of the parties.

- GPU Nuclear would provide all of the equipment and manpower necessary to remove, package, and temporarily store on site the damaged core material.
- GPU Nuclear would provide fuel canisters, packaging, required inspections, loading activities, and other preparations required to assure compliance with all laws and regulations applicable to the shipment of the corematerial.
- DOE would furnish the cask(s) necessary for the transportation of the damaged core material.
- DOE would take physical possession and ownership of the material at Three Mile Island and ship to the DOE facility at INEL
- DOE would provide long term monitored storage within a fuel pool at INEL until the development of a permanent repository at which time the material would be sent for disposal by the DOE.

With the signing of the contract planning began for the shipping of the damaged core.

COORDINATION ACTIVITIES

Schedule constraints combined with the magnitude of the task dictated a close working relationship between the various groups involved in the shipment of the fuel debris. For this reason two groups were established. The first group, which was the TMI-2 Core Shipping Technical Group was responsible for identification and resolution of major technical issues such as hydrogen gas, canister criticality,testing and design requirements, and cask handling design requirements at both INEL and TMI. The second group was the GPUN Fuel Shipping Group. This group was responsible for the development and completion of all on-site tasks necessary for shipment of the fuel debris. As a result, this group was required to coordinated its activities closely with the TMI Core Shipping Technical Group.

Membership on these two groups came for DOE including technical representatives from the various national laboratories, equipment vendors responsible for the

manufacture of the equipment or services and GPU Nuclear. Although not members, the various regulatory agencies like the NRC and the Federal Railroad Administration were also in attendance at most meeting and did provide an input. Numerous individuals were members of both groups. This assured coordination between the groups through good information transfer in the variety of overlapping technical areas. The cooperation and work performed by all the members of both groups can not be over emphasized.

This joint effort between DOE technical representatives, vendor, and GPU did not come to an end when the important technical issues were resolved and implementation began. There still exists a good working relationship between these parties. This helps to ensure the continued success of this campaign.

SPECIAL NUCLEAR MATERIAL (SNM) ACCOUNTABILITY

One of the major concerns that surfaced during contract negotiations was in the area of Special Nuclear Material and other material accountability. This problem was complicated by two major factors. The first and most obvious was the condition of the TMI-2 core. The second was the differences between NRC and DOE requirements in the area of material accountability. These were very complex issues that would require a solution prior to the first shipment and were deferred for later resolution. One area of agreement on this issue was reach and added into the contract. It was agreed that dissolution and chemical analysis would not be required at TMI for material accountability was included.

Under NRC regulations TMI was required to account for all SNM (Pu, U233, U235) in its possession to the nearest gram. NRC rules and regulations established detailed reporting, inventory and transfer requirement by which its licensees accounted for this material. DOE had similar regulations on gram accountability for SNM in its possession. At TMI this accountability was made even more complicated by DOE's requirement to provide gram accountability of additional isotopes that were not accountable under NRC regulations.

This additional accountable material included isotopes such as Americium, Neptunium and others. Some isotopes, like Curium, were accountable not by gram but by microgram. At most reactor plants this would have been a rather straight forward task. The SNM and the other accountable isotopes, for the most part, are contained in the sealed fuel pellets within the fuel rods. Using approved computer programs the amount of these isotopes which are created as a result of the reactors operation could mathematically be determined. This type of mathematical method for activity determination in fuel assembles is widely used and acceptable to both the NRC and DOE.

At TMI-2 this method was not possible. As a result of the accident there was a large amount of damage to the fuel assemblies. This resulted in the release of SNM from the protective cladding and allowed the spread of radioactive material throughout the plant. This made gram accountability difficult if not impossible by normal methods. Due to the problems that would be encountered in determining the quantity of SNM alone, DOE dropped its requirement to provide gram accountability of these other isotopes. This left GPU Nuclear free to concentrate solely on SNM.

The accountability for SNM was not only a problem between GPU and the DOE but it also involved our license requirements with the NRC. As long as the material remained within the confines of the TMI facility accountability and compliance with NRC reporting requirements could be achieved. When the fuel debris began to be shipped to the DOE, this regulatory accountability could no longer be maintained. As a result, the problem of NRC regulatory compliance in this area had to be solved. It was hopped that the solution to the problem from an NRC stand point would also be acceptable to the DOE from a fuel shipping stand point.

Numerous options were presented by the NRC, DOE and others. One of the most popular was "One Core more or less". Under this option GPUN would transfer accountability to DOE as "one" core with no real effort to try and determine the quantity of SNM by gram weight. Another option called for a detailed analysis using experimental equipment to determine the gram quantity of SNM contained in each canister prior to its delivery to the DOE for shipment. Although this type of equipment had been used successfully by the DOE in a laboratory setting, it had not been used in a field setting such as an operating nuclear power facility, nor under the restrictions imposed by such a location. Still another option called for the DOE to do a detailed analysis of each canister after its arrival at INEL. Transfer documentation (DOE/NRC From 741) would be filled out after the fact based on this analysis. As with most operations at TMI the final proposed solution ended as a hybrid of these possible alternatives.

Based on an exemption approved by the NRC in November of 1985 to its regulations contained in 10 CFR Parts 30, 40 and 70, no formal accountability on a gram basis would be required at the time of shipment. TMI-2 would also not be required to submit inventory report on the on hand quantity of SNM. Each shipment would, however, generate a DOE/NRC Form 741 to account for a transfer of the SNM material. This form would be as complete as possible, with all required information which was available entered in its proper location. The DOE/NRC 741 would have a separate Transaction Number for each shipment to control the transfer to the DOE. The DOE/NRC 741 would not, however, contain the gram quantity of SNM. Each form would contain a note stating that "Formal transfer of the total amount of nuclear material in all canisters will be documented at the conclusion of TMI defueling operations".

After defueling operations were concluded, GPUN would then conduct a Post Defueling Survey. The purpose of this survey would be used to determine the total quantity of SNM that was left at TMI-2. This survey would use the available state of the art techniques and both the procedure for conducting the survey along with the survey results

would be approved by the NRC. The results of this survey would establish the quantity of SNM remaining at TMI-2.

Based on TMI's last Physical Inventory Listing (DOE/NRC 742C) the total quantity of SNM on hand at TMI-2 was identified. If the total quantity of SNM that remains at TMI-2, determined as a result of the Post Defueling Survey plus the total quantity of SNM shipped to other licensees and covered by separate DOE/NRC Form 741's plus the total quantity of SNM lost by radionuclide decay is subtracted from the quantity of SNM on hand as of that last Physical Inventory Listing, then the result will be the total quantity of SNM transferred to the DOE as part of the core contract. A consolidated DOE/NRC 741 could than by issued to the DOE which would provide gram accountability for all SNM transferred as a result of these core debris shipments. Based on the NRC's approval of this concept as an exemption to its regulations, the DOE concurred with this method as a solution to the accountability problem.

FUEL SHIPPING CASK

As part of the Core contract the DOE was responsible for providing the shipping cask that would be used to transport the damaged core from TMI to INEL. In the early phase, information on all currently licensed fuel casks was obtained to determine which was suitable for TMI shipments. During this investigation both commercial and DOE's casks were examined as well as casks designed for both highway and rail transport. Although DOE responsibility, GPU Nuclear was directly involved in this examination. What resulted from these examinations was the development of a new cask designed solely of the shipment of TMI Fuel Debris. This new fuel cask was the NuPac 125B Fuel Cask[USA/9200/B(M)F].

The NuPac 125B is a 160,000 pound rail cask designed to transport a maximum of seven (7 ea.) specially design B&W canisters containing TMI fuel debris. Each canister was authorized a maximum of 100 watts and a gross weight not to exceed 2,940 pounds. The two main characteristics which aided in the development and licensing of this cask were an over conservative design and the limiting of its use. These two characteristics were important in reducing the licensing and review time for this cask. The cask license was very restrictive.

As a result, the only material that needed to be evaluated was TMI-2 core debris packaged in B&W designed canisters. No other contents was authorized for this cask. An example of the over design can be seen in the area of radiation shielding. The highest contact radiation reading on the cask surface to date has been 2.5 millirem. DOT regulations authorize a contact radiation reading of up to 200 millirem for open transport.

An additional area of conservatism was the administrative restriction placed on shipments by the NRC as part of the cask license. The certificate required that all shipments of the cask be classified as Fissile Class III and authorized only one package per vehicle. This administrative requirement made certain documentation requirements to show compliance with DOT regulations much easier because such items as fissile class, radioactive label and transport index could be mandated in an operational procedure and require no additional justification. Since the CofC for the cask required a Fissile III classification, no fissile class determination was needed. By being a Fissile Class III shipment a Radioactive Yellow III label was required regardless of the radiation level at the surface or the transport index. By mandating only one package per vehicle, the NRC required the use of a transport index of 50 for all packages. Since the transport index is either the number expressing the maximum radiation level in millirem per hour at one meter from the package or the number obtained by dividing 50 by the allowable number of packages per vehicle which ever number is greater, the transport index would always be 50. Since the cask would require a Yellow III label, for all shipments the rail car would require placarding with a radioactive placard.

SHIPMENT DOCUMENTATION

As part of the contract between DOE and GPU Nuclear, the DOE would be responsible of providing the cask, accepting title to the fuel debris at Three Mile Island and shipping the material to INEL. GPU Nuclear would be responsible for loading the cask and presenting the DOE with a safe and legal shipment. This arrangement is similar to the way the Nuclear Waste Policy Act of 1982 is worded. DOT regulations are vary specific on just what responsibilities the shipper of radioactive material must perform. Further more since the DOE is not a licensee of the NRC it is exempt from NRC rules and regulations. Since the DOE was the shipper of these shipment it may logically be assumed that the DOE would be responsible for full regulatory compliance with all applicable DOT regulations and that the requirements of the NRC were not applicable. All though this may appear logical it was not in reality the case. GPU Nuclear had full and complete responsibility to ensure that each shipment was in full compliance with both the DOT and NRC applicable regulations. For any DOT or NRC regulatory violations found, the NRC would take enforcement action against GPU Nuclear.

The NRC took this position because of the wording of its regulations. Although DOT specifically lists certain responsibilities as belonging to the "shipper" this word does not appear in NRC regulations. The licensee who delivers to the carrier radioactive material for shipment is in NRC regulations responsible for regulatory compliance of both DOT and NRC regulations. What in reality happened was that GPU Nuclear developed a complete shipment package just as though GPU Nuclear were shipping the material. This package included all of the backup documentation which was required to verify regulatory compliance. The representative of the DOE would sign the GPU Nuclear Shipping Papers as the material being received. The representative of the DOE would than place a Government Bill of Laden as a cover sheet to our shipping paper package to act as the government shipping papers.

Because of the high visibility of these shipments, a great deal of preparation was devoted not only to the proper and complete documentation but also to the concurrence of the

various regulatory agencies at both the federal and state levels. As a result of a joint effort on the part of GPU Nuclear and EG&G Idaho, Inc.,DOE's agent, detailed procedures were developed to ensure that all shipments were made in total compliance with all applicable rules and regulations. These detailed procedures identified each regulatory requirement that needed to be met. Once identified, the procedures outlined how the shipments met the regulatory requirement and how that compliance would in fact be documented.

Besides causing problems in SNM accountability, the condition of the core also caused problems in such areas as curie content, thermal wattage determination, and other shipping calculations. To ensure proper regulatory compliance it was decided to use a worst case approach in handling these areas. To determine the total activity for each shipment a conversion factor was developed based on the net weight of each canister. Conversion factors were not new to TMI. This was, however, the first one that used net weight. Most of the conversion factors at TMI were based on radiation levels but this was not a reasonable approach for the fuel canister due to the inability from an operational standpoint to take a good, reliable radiation profile. A radiation profile system was installed to be used as a check but was plagued with operational problems. Conversion factors based on weight were also used to determine thermal wattage. Each canister was limited to less than 100 thermal watts based on the cask Certificate of Compliance.

In determining total activity no attempt was made to determine an activity by isotope in each package. DOT regulations require only that the total activity and the name of each isotope be identified. Determining the activity per isotope is usually used in determination of the required packaging and other radioactive material quantity designations. To comply with the regulatory requirement to list the name of each isotope in the shipment, TMI developed a standard letter that went with each shipment. This letter listed each isotope that was contained in the Orign Computer Code based on TMI-2's power history and length of decay. The letter was signed by the same individual that made the required DOT certification on the shipping papers delivered to DOE by GPU.

Since the activity per isotope was not determined, shipping quantity was determined by a worst case determination. DOT regulation authorizes that when the total activity is known but the activity of each isotope is not known then the shipper will apply the total activity to the most restrictive isotope known to be present. In the case of the TMI fuel shipments, the most restrictive A2 value was .002 curies. As a result when the total activity in the package exceeded six (6) curies(3,000 X .002 curies) the shipment was a Highway Route Controlled Quantity. This had little effect since any package which contained more that 30,000 curies, regardless of the A2 calculation, was automatically a Highway Route Controlled Quantity. It was believed that all shipments would exceed this 30,000 curie level.

Because these shipments were being sent by rail instead of highway this classification had little effect on these shipments. The only real effect was that the shipping papers had to be annotated "HIGHWAY ROUTE CONTROLLED QUANTITY". Since these shipments were by rail no special routing or drivers' training was required. Even the special background behind the placards required for highway shipments is not required for rail shipments. The Radioactive Yellow III labels which are required for all Highway Route Controlled packages were already required because the cask Certificate of Compliance required the shipment to be made as a Fissile Class III which also requires the Radioactive Yellow III labels.

One area of regulatory compliance did cause some early concern on the part of GPU Nuclear. That was in the area of advanced notification of these shipments to the states through which they would travel. The NRC established detailed notification requirements in 10 CFR Part 73.27 for its licensees to follow. These requirements identified, in detail, who, when, and how notifications would be made. The DOE on the other hand had established notification requirements which are outlined in DOE Orders 5632.1 and 5632.2. These notification requirement are vastly different from those of the NRC. Under the DOE regulations shipments of fuel debris from TMI-2 would not receive the same advanced notification requirements as they would under NRC regulations.The DOE planned to follow its requirements and did not want GPU Nuclear making any notifications. 10 CFR 73.27 offered GPU a way to comply with NRC requirements, while allowing DOE to provide all advanced notification. GPU Nuclear would comply with its responsibilities as the deliverer of the material to the carrier in the area of advanced notification by receiving written certification the advanced notification would be performed in accordance with DOE Order 5632.1 from the DOE.

Each area of DOT and NRC regulations were reviewed and a compliance method was identified that would provide for the appropriate written documentation. Numerous checklists and instructions were developed to provide all personnel in every area with the appropriate quantitative and qualitative guidance needed to ensure compliance. This effort culminated in the development and approval of a TMI-2 Departmental Administrative Procedure 4231-ADM-4450.04 entitled "Shipment and Transfer of the TMI-2 Fuel Canisters to the DOE". A great deal of time and effort went into the development of this procedure on the part of many people in GPU Nuclear, and EG&G Idaho,Inc. It was reviewed and concurred with by the DOE, NRC and the Federal Railroad Administration for the DOT. Its value has been shown by the more than 34 shipments of core material that have been made so far without any material problems.