Transportation Planning and Execution: Commercial Spent Nuclear Fuel

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Introduction

My name is Robert Jones. I have been in the nuclear field for 31 years. Most of this time I have been associated with the packaging and transportation of radioactive materials, principally spent nuclear fuel. I have designed, licensed, constructed, and tested transport systems. I have directly participated in the shipping of spent fuel. And I have performed studies and assessments of practically every aspect of the movement and storage of spent fuel.

SNF Shipping in the United States

Jim McClure has presented the statistics on spent fuel transportation in the U.S. I find it to be an enviable record. It did not happen by chance. It has come about because those entities and people involved in it are aware of the their responsibility to the public. Since those of us in the business, along with our families and friends, are also members of the public, we take our work very seriously.

There have been roughly 2,600 shipments of commercial spent fuel in this country over the past three decades or so. Although this is not an enormous volume by European standards, it is nevertheless significant. These shipments fall into two general categories: individual and "campaign."

There have been a number of individual shipments where lead test assembly fuel was shipped from a reactor to a laboratory for examination. This is an important part of reactor fuel development.

However, the bulk of the fuel has been shipped in campaigns, where multiple shipments, usually with several casks in service, are scheduled and conducted from one facility to another. Campaigns are conducted to minimize the impact of spent fuel shipping on the shipping and receiving facilities. By blocking out a specific period and maximizing the shipping activity, the facilities are able to mobilize the equipment, personnel, and infrastructure needed for the effort.

Let me illustrate a campaign by describing the Shoreham Fuel Transfer Project.

Shoreham Fuel Transfer Project

The Shoreham Fuel Transfer Project was the shipment of 560 irradiated BWR fuel assemblies from the Shoreham Nuclear Station to the Limerick Nuclear Station. The Shoreham plant was being decommissioned and the 560 assemblies represented the first (and only) fuel core. Due to the low burnup the fuel had energy value and was being shipped to another BWR for continued use. Because the fuel had produced power during Shoreham testing, it had to be shipped in spent fuel shipping casks due to the fission product inventory. Two Model IF-300 railroad shipping casks were used. Transportation was via heavy hauling, barge, and railroad. Total one-way distance was about 400 miles, from the north shore of Long Island to a site 50 miles west of Philadelphia.

The project planning began in 1990 before the selection of the destination at Limerick. Several facilities were considered. In one case, significant planning was performed for that site before it was dismissed in favor of Limerick. Once the final destination was identified the campaign planning took roughly six months although much of the preliminary work had been performed during the planning for the prior candidate site. It is estimated that pre-shipment planning took a minimum of one year. The shipping itself took 9 months, including a 2 month pause for a refueling outage at Limerick. The final close-out was an additional month. The Shoreham campaign then, consisted of::

o All pre-shipping and preparatory activities at both facilities.

o Two IF-300 casks, each carrying 17 BWR assemblies packaged to prevent in-transit damage.

o Shipment by barge from the Shoreham Station to the fossil-fired Eddystone Generating Station on the Delaware River, south of Philadelphia. From there, shipment by dedicated train from Eddystone to the Limerick Generating Station. Total one-way travel distance: roughly 400 miles.

o One barge and one railcar is assigned to each cask and the two casks move in opposition to one another, passing while at sea. The total turnaround time (i.e., outbound loaded-to-outbound loaded) projected at 11 days with a three day headway between casks. This yields two shipments every two weeks. A total of 33 shipments required to move the 560 assemblies.

o Two intermodal transfers required. The first, a roll on/roll-off operation at the Shoreham on-site barge slip. A heavy haul transporter moves the cask/skid from the reactor building to the barge. The second, a lift-on/lift-off operation at Eddystone where a semi-permanent crane installation moves the cask/skid between the barge and the railcar.

o The total campaign expected to take about one year which includes a 2 months refueling outage at Limerick when no fuel will be received. In the month prior to the outage the shipping rate will be adjusted to match certain available "windows" for cask

receipt. A study will be conducted to see if fuel can be received during the outage. It is generally conceded that this period will be "blacked out" for shipping activities.

o All post-shipping demobilization and documentation activities.

As can be seen, a "campaign" is a very complex undertaking. It requires significant planning and ample time for execution.

The Shoreham Project had several features which added to its complexity, the principal one being the use of three modes of transportation. On the other hand, the Shoreham fuel was not classified as spent fuel per Part 73 due to its low burnup, thus some of the in-transit security measures were not as rigorous as would otherwise be imposed. On balance, the Shoreham Project was a good representation of a major shipping campaign between any two commercial nuclear facilities.

Preshipment Planning

1. Project Management Team Assembly

No planning activity can begin without marshalling the team. The initial planning team is a cadre of people who have "been there, done that" experience. There is no substitute for experience. This is not to say that a team cannot start from scratch, however, the learning curve is significant.

2. Routing, Modes, and Equipment

A great deal of planning goes into the assessment of the logistics of the campaign. The early work involves the matching of the reactor site with the appropriate transportation system. Items of concern are: type, characteristics, and quantity of fuel; reactor facility characteristics for cask handling; local transportation infrastructure; cask system characteristics and availability; routing, and proposed campaign schedule. These form the skeleton of the campaign. Options for fulfilling the transportation mission are developed early in the process.

As the planning proceeds, more details are developed about the route and modal alternatives. The process is a carefully balanced one which, through the development of additional data, reduces the options list. Cost is one of the factors considered in the planning. Safety is the underlying consideration, but the rules, regulations, equipment and personnel requirements make every shipment equally safe. A cost consideration example is the total cost of the use of truck casks vs. that of rail casks, where the former are less costly to operate but require more trips than the more costly to operate rail casks.

Route selection is mode-dependent. The DOT regulations prescribes the routes for highway shipping under HM-164 protocols. To date, rail and water routes remain at the discretion of the shipper consistent with other applicable regulations. As the planning

converges on the selected route there are other touch points, one of the most important of which is the route approval by the NRC under the conditions of 10CFR73. This approval is independent of shipping mode.

Federal regulations are not the only route selection consideration, various states have hazmat or radioactive material-specific regulations which are supplementary to those of the Federal government. In some cases the state regulations may be contrary to or more restrictive than the Federal regulations. In the latter cases, Federal regulations may pre-empt those of the state. However, as a practical matter the shipper may choose to obey them and bear the added inconvenience rather than engage in challenging their legality since such challenges can be costly and time consuming. There are instances, however, when the legal issues become so significant that they must be challenged or in some cases a shipper is forced to defend itself.. For instance, in the Shoreham effort, the State of New Jersey attempted to invoke the Coastal Zone Management Act in order to stop shipping along the New Jersey shore. The state sued in Federal Court and the case eventually went to the U.S. Supreme Court (actually twice, in two related arguments) where the court refused to hear it and the lower court's ruling in favor of the shipper was sustained.

3. Facility Requirements

The ability of the reactor facility to support the shipping campaign is an important consideration. This includes both the physical plant as well as the personnel. One of the key items of any investigation is the heavy lifting capability of the shipping facility. NRC guidelines on heavy lifting are contained in NUREG-0612, and in some plants structural or equipment modifications are needed to comply. The cost and feasibility of NUREG-0612 compliance are considerations in cask size selection since a lighter weight unit may be easier to accommodate than a heavier one. This illustrates the need for early planning since modifications to the plant structure or safety-related equipment are time-consuming and often require licensing activity. There are many facility requirements for fuel shipping: air/water services, decontamination, fuel handling equipment, cask processing equipment (e.g., vacuum drying), compressed inerting gases, scaffolding, special tools, etc. Every cask type has it own unique requirements.

Generally a nuclear station has the staffing capability to perform cask preparation, loading, and shipping. If there are unique requirements such as heavy hauling to a railhead or barge slip, then specialists are included in the planning.

4. Emergency Response/Public Outreach

Another route selection aspect is emergency response planning. Somewhat related to this is public outreach. Shippers typically rely on existing infrastructure for emergency response i.e., first responders. Experience shows that the states are generally well-equipped through their emergency management organizations to deal with a host of accidents involving hazardous materials, including radioactive materials. The key to

success is the Transportation Plan and its implementation. The plan is a blue print of the entire campaign, including emergencies. Emergencies are dealt with through contingency plans, shipment tracking, and communications with resources. As an aside, indirectly, emergencies are dealt with in the Transportation Plan by taking the steps necessary to prevent incidents from happening. But we would be unrealistic if we didn't think that the unplanned might occur. It is important to note that emergencies are not necessarily accidents. In deed, most are items where the shipment is delayed due to a malfunction such as a radiator hose failure, a flat tire, or some non-threatening event. Even these are infrequent due to the high level of maintenance applied to the equipment.

As we know, Part 73 calls for notification of the Governor (or designee) of each state traversed at the time of shipment. However, contact is made with the state emergency management organization long before shipping. Information on routes and the nature of the shipments is shared and arrangements are made for cooperation. Usually the Governor's designee for specific shipping notification is either the state police or the emergency management organization. The states are not "surprised" by the shipments.

It is currently not required to perform emergency response training for all responders along the route of travel. The 180(c) provisions of the Waste Act will provide additional training and equipment for responders along transportation routes. In the past the shipper has been willing to voluntarily provide ER information to those agencies that desire it. Often this comes as a request during any public outreach activities. Outreach programs have been selectively used in the past where there may be some local interest. In the Shoreham Project an information day was conducted in a downtown Philadelphia hotel to provide a forum for the public. The railroad portion of the shipments passed close to the downtown area so there was local interest. I know of no time when a shipper has been unwilling to provide the public with information on transportation safety but as a rule massive outreach programs have not been conducted.

Point of fact: outreach is performed to provide the public with information, but it does not contribute to safety. Safety is inherent in the equipment, personnel, rules, regulations, and organization of the campaign. The best information comes from generic programs to generally enlighten the public on the shipment of radioactive materials rather than key it to any particular shipment. However, PR planning within the campaign is necessary to provide the facts to those who are interested such as the media or representatives of the public. Industry does not try to hide the shipments but it feels that little is gained by advertising them. Ask yourself when you have ever been notified of chlorine shipments through your community. Fact is that the nuclear industry probably does more than any other hazmat shipper to provide information to the public.

5. Planning Integration

I have discussed a number of the major items which are considered in campaign planning. These become integrated into a comprehensive plan which all parties involved in the campaign contribute to and abide by. The transportation plan is essentially the campaign

"Bible." In the case of a campaign where there are multiple modes, a separate plan may be written for one particular aspect. In the Shoreham Project, there was a separate Marine Transportation Plan which reflected the unique requirements of the waterborne shipping environment. This was a subset of the master transportation plan.

Pre-Shipping Mobilization

I. Assembly of Equipment and Resources

Using the transportation plan as a basis, the next phase is mobilization. Mobilization has many dimensions from equipment and personnel acquisition to procedures and permits. The transition from planning to implementation is seamless. Generally the same core team that performed the planning also does the mobilization. The team is augmented by disciplines such as: QA, procurement, reactor operations, maintenance, and human resources. The skeleton created by the planning is filled in with the necessary personnel. This is a gradual effort as stages of mobilization are reached. For example, when cask selection is complete, a cask specialist or field engineer is added to the team. In the Shoreham effort, when barge was selected as one transportation mode, a marine engineer was added to the team. When the team is essentially complete, it is a good idea to engage in a team building activity. This was successfully done on the Shoreham Project. Team building is a formal process which allows team members to get to know one another and gives the team problems which require cooperation, especially collective problem solving. The team is often dispersed during shipments, some members in the field and others at the end point facilities. Working together in a coordinated fashion with a common objective, even when at different locations, is what team building is all about.

This mobilization can be fairly time-consuming. It is not uncommon that equipment and facilities require modification and possibly even licensing. In the Shoreham effort, two new cask baskets had to be designed, licensed, and fabricated. A fuel assembly cushioning system internal to the basket had to be designed, qualified, and integrated into the basket. Often the reactor facility or site requires modification. Rail service may have to be extended or perhaps track upgrading performed. A barge slip might be required. Building equipment may require relocation to provide clearance for the cask. There are usually a number of these site-specific changes that must be completed prior to shipping.

In anticipation of having to repair or debug equipment or systems, specialists are brought on site or identified for rapid mobilization. A cask field engineer is usually on site for training and overseeing. An inventory of cask and ancillary equipment spare parts must be secured.

Another part of mobilization is organizing for the control of the actual shipping operation: a traffic management function and the facilities and equipment for its implementation.

2. Traffic Management

Traffic management revolves around a focal point, a command or control center. This is usually located at the shipper's facility and is staffed around the clock. It could be incorporated into the reactor control room activities. It integrates the transportation activities, serves as the master location for tracking and communications, and dispatches resources as required to keep the operations moving. Cask loading and preparation for shipment is usually under the control of plant maintenance or plant operations (or a combination of both). Once prepared for shipment, traffic management takes control. Even the empty cask being returned for reloading is controlled by traffic management.

3. Training

Prior to the beginning of shipping "dry runs" are conducted. Some involve the cask itself and are used for personnel training purposes. Others test the traffic management system, especially under off-normal conditions. Communication systems and equipment are tested for effectiveness. All training follows facility requirements.

4. Permits and Approvals

Permits and other regulatory items are secured in the mobilization phase. Route approval is included in this list. The Coast Guard reviewed the Marine Transportation Plan (which included the route) for Shoreham and established a barge and tiedown inspection protocol prior to each shipment. One Shoreham shipping alternative had casks being moved by heavy hauling on public roads which would have required an overweight permit and an escort from the local law enforcement agency. Arrangements for escorts to comply with Part 73 must be arranged. There is a large amount of contracting and scheduling. The project team gets very schedule-conscious in the mobilization phase. All activities are directed at the actual shipping effort.

The cask and fuel records are compared to the Certificate requirements to assure compliance. Sometimes cask annual testing is done early such that it doesn't have to be performed in mid-campaign.

5. Procedures

Since the shipments are initiated at a nuclear facility, all associated activities are under the rules of that plant. This means procedures and safety committee reviews. Resident NRC inspectors observe all these activities. Procedure writing and approval follows strict rules. Input to these comes from sources such as the cask vendor, the carrier, and any other knowledgeable resource. Most cask and fuel handling activities are safety-related and require such controls as sign-offs, independent verifications, etc.

6. Carrier Arrangements

Carrier arrangements are finalized in this phase.

o Highway: For highway shipment there are several specialized carriers that have the properly equipped tractors and qualified drivers. Truck casks generally have a custom-built trailer to integrate with the cask so the carrier only supplies drivers, motive power, and services. These companies have contacts with the resources for complying with Part 73, including escorts, communications and sometimes satellite tracking systems. These are relatively straightforward to arrange.

More difficult to arrange is railroad, barge, and intermodal shipments.

o Railroad: Railroad arrangements may involve several lines, each of which may require contracts and operating rule agreements. These are negotiated tariffs. Railroad shipping casks are designed with their own dedicated railcars. Thus the railroad only provides motive power and "buffer" cars which separate the locomotive and caboose from the cask(s). Some form of escort transportation either a caboose or similar car must be included in the train. The railcask can move in regular freight or dedicated freight; the latter is where only the cask car(s) is in the train along with buffer and personnel cars. All commercial fuel railroad shipments in the last two decades have been made by dedicated train; DOE's future policy has not been finalized. Dedicated train offers greater flexibility and control over the shipment but the cost is high compared to regular freight, roughly $50 per mile plus the tariff cost. Some plans suggest dedicated train service for the loaded shipments and regular freight on the empty return.

o Barge: Barge shipping involves carriers and equipment which must meet the standards of ANSI N14.24 and the Coast Guard. The number of qualified carriers is small. Negotiations are required to get agreement on service, personnel, equipment, insurance, etc. Every barge shipment and some railroad shipments require rigging and heavy hauling, so there is another, and sometimes related, contracting effort. Competitive bidding for rigging services is recommended since there are a number of carriers with these capabilities. Often riggers will team bid the work. One rigging company on the east coast is also a barge operator.

7. Outreach

Outreach programs, as necessary, are conducted during the pre-shipping mobilization period. As stated earlier, these are directed efforts to provide general information to the public and/or to civic groups.

Shipping Activities

The first shipment is always an exciting time. It is what dozens of people, working for months or even years, have been focused on. The cask and its transportation and ancillary equipment are on-site long before the first shipment so that training can occur.

1. Cask Loading and Preparation

Cask loading occurs in the fuel pool. Cask sealing, testing, and decontamination occur within the fuel building or the reactor building. The cask is moved to its transporter and secured. Radiation monitoring occurs throughout the handling process. Preparation for shipment involves final inspections, placement of shipping seals, final radiation surveys, instructions to the carrier, shipping papers in accordance with DOT regulations, and notification of the Control Center to institute the traffic management function.

2. Carrier Arrangements

Carrier arrangement call for the cask to spend a minimum amount of time at the site before moving into the public domain. The whole campaign is scheduled such that near-continuity is maintained. The cask loading and preparation time is reasonably predictable but the "learning curve" is in operation so there needs to be a flexible arrangement with the carrier(s). The Shoreham project, with heavy hauling, barge, and railroad carriers, was a challenge. However, a strong traffic management function and teamwork made this run smoothly.

3. Notoriety

As you know, the times and dates of all shipments cannot be divulged by Part 73, except on a need-to-know basis. However, if there is going to be some notoriety from the press or from any protest organizations, this is when it occurs. Although an infrequent occurrance, and a relatively benign one when it has occurred, the shipper must be prepared to deal with it. In the Shoreham Project, procedures were written to cover actions to be taken in the event of such an event. As an aside, none occurred.

4. In-Transit Activities

Once underway, the shipping proceeds per the procedures. Routes are predetermined. Notifications inform the Governors or their designees of the shipment. The in-transit security measures are implemented. Communications occurs apart from just that required under Part 73. Sometimes satellite tracking is used, although not required. This technology (i.e., TRANSCOM) is being studied for its application in future shipments under the DOE. The carriers all have multiple means of tracking and communicating.

Shipments may or may not have some form of radiological monitoring while underway. The specialized highway carrier drivers usually have and are trained to use radiation

detection instruments. This is not required under the regulations. For the Shoreham shipments we had a radiation technician accompany the loaded shipments on both the barge and railroad segments. This was regarded as more for public relations; we were confident that his presence was not needed for shipping safety. His services were not required in any of the 33 shipments.

5. Off-Normal Events

Occasionally something occurs in-transit that is not in the baseline plan. Weather, road repairs, breakdown, illness, etc. The Transportation Plan covers these through contingency planning. In the Shoreham Project, a hydraulic winch on the towboat blew a line and was unable to reel in the barge for its movement up the Delaware River. Advanced planning had towboats on standby, and when the winch problem arose, the Control Center was notified and a tug was immediately dispatched. The Coast Guard was notified by the control center and responded. Within a few hours the cable had been transferred to the new towboat and the barge proceeded to its destination. For all future shipments, new hydraulic lines were installed on all towboats and the winch inspection program was intensified.

6. Receiving Facility

The receiving of the cask and transporter terminates the Control Center's responsibility for the shipment. The receiving facility unloads and processes the cask, and returns the empty to the originating shipper. The Control Center monitors the empty's progress since the campaign depends on turnaround time. The timing of the empty is as important as that of the loaded.

The shipping phase is a well-orchestrated effort. It involves personnel at the end points as well as along the shipping route. My experience shows it to be very doable. Despite what seems to be a complex system, the planning and training pays off. As said earlier, the safety record of the industry over the past 30 years speaks for itself.

Post-Shipment Demobilization

The old expression about the job not being over until the paperwork is done, certainly holds for spent fuel shipping. NRC regulations have record and record retention requirements for all of the shipping and fuel transfer activities. In addition, any temporary facility modifications must be reversed. The cask and equipment must be returned to its owner. Frequently this involves decontamination and packaging. And finally, contract terms must be reconciled, payments made, etc.

Discussion Wrap-Up

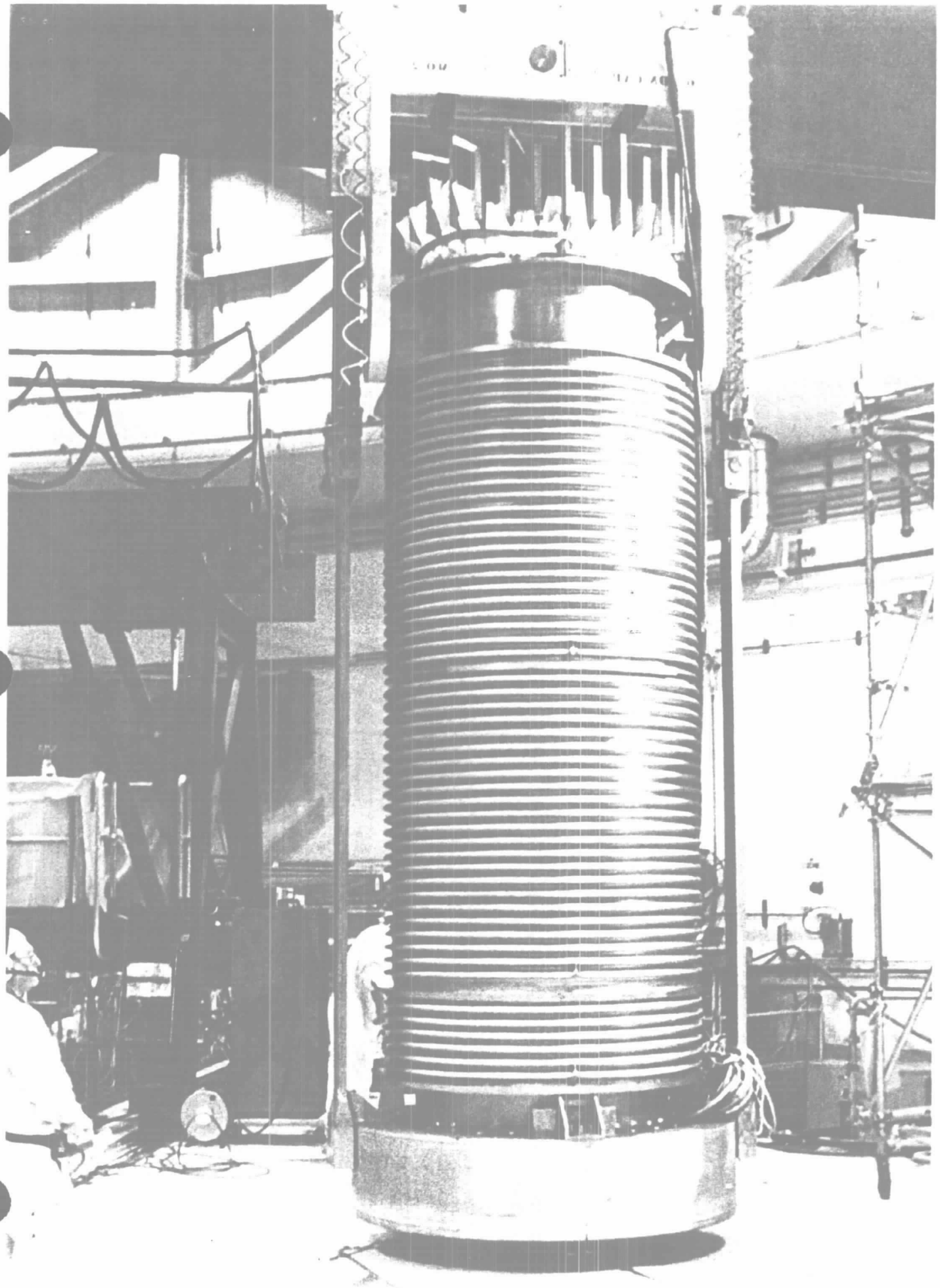
I would like to finish this by giving you the final statistics on the Shoreham Project campaign.

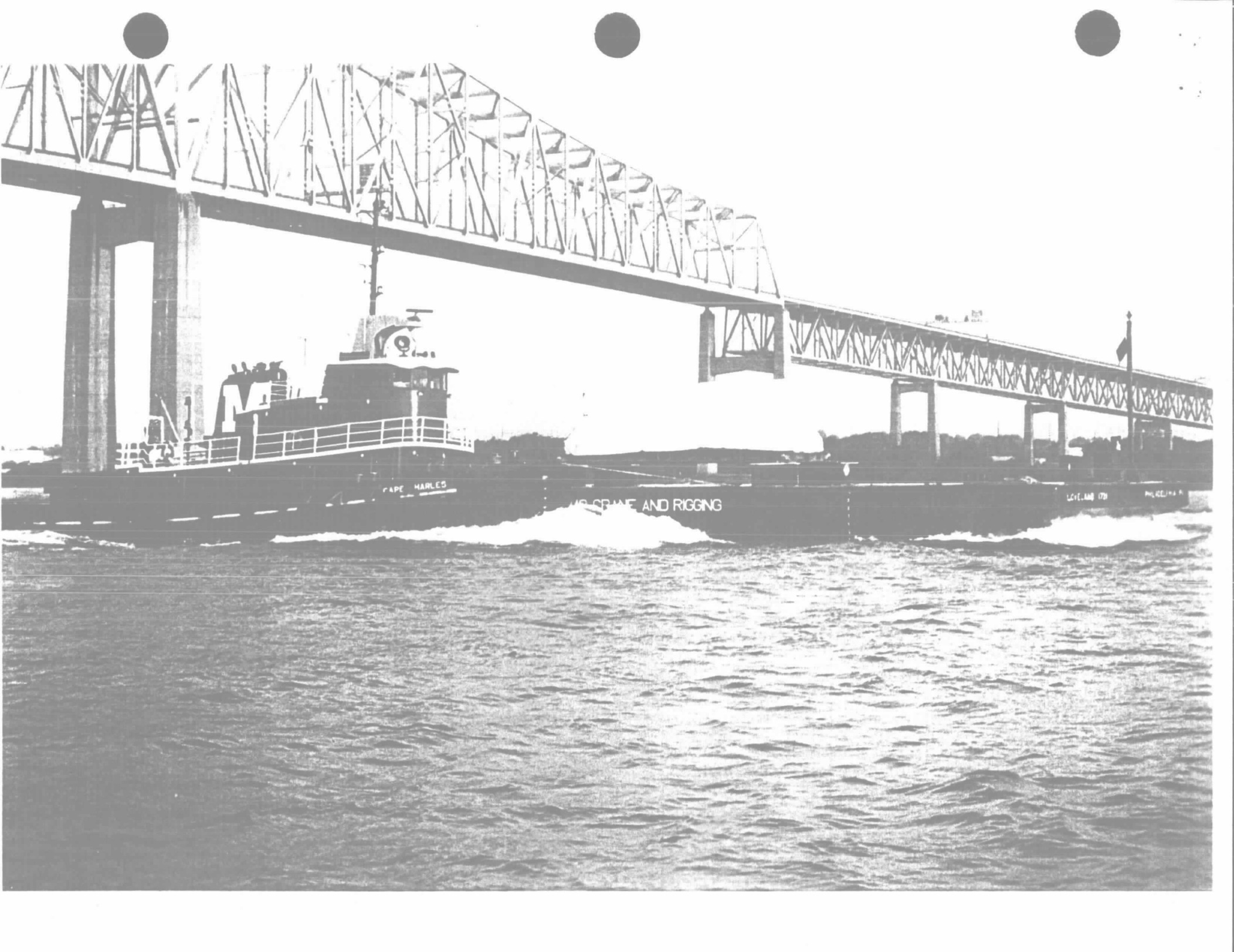
The Shoreham Project:

- Was approximately 4 years in total duration.
- Moved 560 BWR irradiated fuel assemblies (~100 MTU) between two reactors 400 miles apart.
- Moved by heavy hauling, barge, and railroad with two intermodal transfers per direction.
- Used two IF-300 casks shipped separately for a total of 33 shipments.
- Completed the campaign in 9 months
- Had no accidents
- Completed the effort 94 days ahead of the contracted schedule, 6 days ahead of the theoretical schedule, and within budget.

Shoreham pictures to follow.

End

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