A STANDARD FOR BARGE TRANSPORT OF TYPE B QUANTITIES OF RADIOACTIVE MATERIALS

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Abstract

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Although barge transportation plays an important role in the general commerce of the United States of America, only two radioactive material shipments have been completed. Despite the underutilization of the past, barge transportation is being considered by the Office of Civilian Radioactive Waste Management of the United States Department of Energy (DOE) as a viable option to augment land modes for the transport of commercial spent fuel and high level wastes. Barges appear to have sufficient potential as a competitive mode for several circumstances to warrant further investigation. The DOE will be relying on a standard for barge transportation of radioactive material which has been issued recently by the American National Standards Institute. The Standard is written particularly for large amounts of radioactivity that will be carried in Type B packagings. Its issuance prior to an immediate need will aid in fostering public confidence that radioactive material shipments by barge can be accomplished in a safe and efficient manner.

INTRODUCTION

In 1825, the Erie Canal was officially opened providing barge service between the Great Lakes and New York City. This event ushered in an era in which barge transportation in the United States has grown from a few simple horse-drawn canal vessels to modern ocean-going barges that carry complete chemical or refining plants pulled by 9000 horsepower tugs. The barges and towboats which ply the inland waterways, Great Lakes and intracoastal and domestic ocean routes are a vital part of the U.S. transportation network, ranking second behind the railroads in the carriage of a broad spectrum of commodities on a total tonnage basis.

There is, however, an interesting commodity distinction between barge transport and the others: with two exceptions, radioactive materials (RAM) have not been transported in the U.S. by barge. This paper first briefly discusses the potential role of barge transportation in the nuclear field and then addresses a major step in the utilization of this mode.

BARGE TRANSPORT NEED AND APPLICATION

A balanced transportation network is one that is flexible enough to permit the shipper to choose among alternatives based on their service, safety and economics. Nuclear shippers in the U.S., particularly those of irradiated fuel, have encountered impediments to the routine movement of these materials by land-based modes. A great deal of effort is currently going into the resolution of these issues which negatively affect the normal land movement of RAM. Though there is optimism over achieving acceptable solutions, the introduction of barges as an alternative transport mode will expand the options of RAM shippers.

The positive attributes of rail and highway transportation of RAM are well known, but those of a barge need some highlighting. Barge transport has several distinct attributes, the most predominant of which is an extremely large carrying capacity. A large deck-cargo barge of dimensions 30.5 meters (100 feet) wide by 122 meters (400 feet) long by 7.6 meters (25 feet) deep can carry approximately 16 300 metric tons (18 000 short tons), which is far greater than the carrying capacity of a number of railroad cars or highway trailers that would occupy that area of barge deck. Another advantageous characteristic is that this mode is essentially unimpeded during transit. Both trucks and trains move at speeds that are much greater than that of barges. However, these land modes are often disrupted by such things as switchyard operations, terminals, traffic and state and local regulations. Barges move steadily along at about 8 to 11 kph (5 to 7 mph), day and night. Barge disruptions are few: waiting at locks on inland waterways or slow running in congested areas. On some routes or in some regions this unimpeded service could be to the shipper's advantage.

Currently only a few agencies, primarily the U.S. Coast Guard, have jurisdiction over water traffic, and the rules and regulations are consistent on a nationwide basis. Thus, requirements that are imposed by state or local jurisdictions such as routing, overweight shipment restrictions, frost laws, wheel loadings and bridge laws and that are notably non-uniform along routes have no counterpart on the water.

Objectivity dictates mentioning some of the disadvantages of barge shipping. Perhaps the most obvious shortcoming is that the number of locations potentially served by barge is quite limited when compared to those with highway access. Another is that barges must be used in conjunction with some other land-based mode. The land segments may be on-site or in the public domain; they may be short or could involve long distances. In any event, all barge shipments are intermodal involving two carrier transfers per one-way shipment. Under the assumption that RAM shipments by barge would be handled by specialized carriers, the cost of barge shipments is high compared to the alternative modes. This is largely due to the number of transfer steps and the low current demand for such service. If barge transport were employed to a reasonable extent in the future, the cost of such service may decline.

How can barge shipping be applied to the nuclear business? The prospects of moving large spent fuel casks bring into focus nuclear reactor sites even though interim storage facilities and final repositories should also be included. Further, irradiated fuel is only one RAM form which is suitable for barge service. There are a total of 77 plant sites, 50 of which have one or more operating units. Of the 77 sites, 55 (71%) have access to navigable waters either on site or a short distance away, the farthest removed being 10 miles from a water course. This is comparable to the 59 sites (77%) with direct rail access. Also, of the 18 sites without direct rail access, 16 have direct access to a navigable waterway. Of course, all sites have highway access.

Could the barge mode be a direct substitute for the land-based modes? The answer to this is a qualified no. As discussed earlier, barges require land-mode service to make them useful. Next, there are a large number of RAM commodities that are not shipped in the quantities or package sizes that would justify the application of this mode. Further, there are regional circumstances where impediments to land transport are not sufficiently restrictive to impact on transit times. And lastly, there are proposed receiving sites that are far removed from a navigable waterway.

Barge service would appear to be applicable to the following commodities:

- Low level waste in shielded transport casks,
- Spent fuel or high level waste in transport casks,
- Spent fuel in dry storage containments,
- Contaminated equipment in transport packages,
- Decommissioning wastes, hardware and components with or without transport packaging.

The last category could be an extremely productive application of barge transport. The two barge shipments of RAM in the U.S. were (1) a failed steam generator which was shipped from the East Coast to Hanford, Washington via the Panama Canal and (2) a reactor compartment from a dismantled nuclear submarine which was also shipped to Hanford. These successful shipments demonstrated the ability to move very large, contaminated objects by waterborne means.

This brief introductory discussion has not addressed the details of completing a shipping campaign using barge transport. This is where the American National Standard N14.24 is significant.

ANSI N14.24 STANDARD

The notion of domestic barge shipping of spent fuel was first raised in the early 1970's by the then developing U.S. irradiated fuel reprocessing business. Several of the proposed or under-construction plants were located close to navigable waterways. In 1974 , the American National Standards Institute (ANSI) under the N14 Committee formed the N552 Subcommittee on Water Transportation of Irradiated Fuel. The charter of this group was to write a Standard or Guide for the shipper of this material to permit an easy integration of the nuclear, regulatory and maritime requirements; it was to be a 'how-to-do-it' manual on spent fuel shipping by waterborne means. A draft document was produced for N14 approval, however, the effort was suspended until 1982. At that time, the Subcommittee was activated, reconstituted and renumbered N14.24.

The N14.24 Subcommittee changed the focus of the effort somewhat from that of the old N552 group. The commodity carried was broadened from just spent fuel to highway route controlled quantities of RAM. The transport vessels considered were narrowed from barges and self-powered craft to only barges. After several rounds of minor adjustments, including a title change, the N14 Committee accepted the document [1]. It was approved for publication on July 23, 1985 and is now available.

Scope

The Scope of N14.24 reads

> This standard identifies the organizations, equipment, operations, and documentation that are involved in domestic (i.e. between U.S. ports) barge shipments of highway route controlled quantities of radioactive material (RAM) on inland waterways and in coastwise and ocean service. This standard is expected to be most useful to shippers of radioactive material and is written in such a format that it provides them with sufficient information to prepare for, initiate, and complete one or more shipments. Included are requirements pertaining to: selection of barge, towing vessel, and packaging; preparation of certificates and documents; radiological and nonradiological operations; emergency planning; insurance; keeping records; and physical protection of the package.

As can be seen, the N14.24 Standard covers a large number of important topics.

Interface Matrices

Cask/barge operations are divided into four phases: planning, pre-operational, operational and postoperational. Matrices are presented which 1) identify the organizations that participate in each phase, 2) define the role of each organization and 3) assign to each organization a measure of the degree of its responsibility. Organizations include shipper, carriers, regulators and supporting services.

Loading/Unloading

In recognition of the need to perform an intermodal transfer twice in each one-way trip, the Standard discusses requirements for both roll-on/roll-off and lift-on/lift-off operations. Subjects include mooring, tug attendance, inspection of tiedowns and lifting gear, weather restrictions, transfer bridges, rolling equipment specifications and inspections and physical protection. Transfer safety is stressed.

Critical Requirements

Critical requirements are established for the barge, the tow, the package and the tie-downs. Barges for service under this Standard must be designed and constructed to recognized maritime classification society rules, codes and standards. The barges must meet intact stability as well as damage stability requirements which state that, following damage to any one compartment of the barge, the vessel must still meet specified margins of safety and not sink or capsize. The minimum acceptable barge length is 38 meters (125 feet). Minimum set-backs for collision protection are defined for locating the radioactive material package(s) on board the barge. These set-backs are stated in terms of the beam and length of the barge and apply to both inboard and fore/aft stowage locations. Barge construction and materials are also addressed. An adequately equipped barge will be required to carry certain ancillary equipment primarily for accident mitigation measures: emergency position indicating radio beacon, radar reflector, emergency towing wire, air identification marker and a sonic signaling device are specified in the Standard.

Minimum requirements are also established for the towing vessel. The vessel must be at least twin screw and have at least two propulsion engines, each capable of powering the tow. If in ocean or coastwise service, the tow must have a current Load Line Certificate. Also, for this type of service, the following navigational aids must be provided: radar, LORAN C or SATNAV, magnetic compass and gyrocompass. Towing vessels shall have appropriate and redundant communications equipment.

The Standard recognizes that current U.S. packaging testing conditions do not require submergence to depths greater than 15 meters. The Standard recommends that the route to be traversed by the barge be evaluated for the depth of water to be encountered. The package should then be evaluated to the maximum depth expected during transit. Such a recommendation could potentially exceed U.S. requirements.

A major development within the Standard is the specification of accelerations to which tie-downs or sea fastenings must be designed. The tie-down conditions are subdivided into two categories of dynamic loadings: (1) collision and (2) wave motion. The wave motion accelerations specified are applicable only in the case of ocean service and are not superimposed onto collision accelerations. Collision accelerations are based on existing U.S. Coast Guard requirements for independent tank barges. Two load cases are considered for longitudinal and transverse directions. The tie-downs for the package and any accompanying vehicle shall be designed not to exceed limits specified in the Standard when subjected to 1.5 g acceleration along the longitudinal axis or to 0.5g along the transverse axis. All accelerations are through the center-of-gravity (CG) of the package or package/vehicle combination.

Wave motion accelerations were derived from a detailed sea-state analysis. Two dominant load cases are established for extreme accelerations: 1) head seas and 2) beam seas. Tie-downs must be evaluated for accelerations acting in a vertical longitudinal plane through the package or package/vehicle CG with the following magnitude in head seas:

Longitudinal acceleration = ± 1.4g

Vertical Acceleration:

Dynamic portion = ± 2g
Static portion = 1g (gravity)
Yaw acceleration = 0.1 radians/sec/sec

For beam seas, the analogous requirements are established as:

Transverse acceleration = ± 1.6g

Vertical acceleration:

Dynamic portion = ± 2g
Static portion = 1g (gravity)
Yaw acceleration = 0.1 radians/sec/sec

Detailed tie-down structure stress limits and criteria are given in the Standard.

Other Considerations

The Standard addresses the importance of proper documentation with emphasis on the shipping plan. The shipping plan details the operation in terms of origin and destination, equipment, departure and arrival times, route and alternatives, water depths, weather limitations, communication frequencies, contacts and special instructions on the cargo. This plan is supplemental to the usual shipping papers.

Emergency response and emergency action recommendations are also in the Standard, as is a discussion of insurance requirements, both nuclear and non-nuclear. Some of the text is devoted to discussing personnel requirements for manning the vessel, as well as providing radiological monitoring and physical protection, where required.

A last important consideration addressed by the Standard is postoperations activities. These activities include the retention of the records of the shipment(s) as well as any required restoration of the vessel. The records are those of the actual material transfer operation plus those of radiation exposure and physical protection. Vessel restoration involves radiation surveys and, as required, decontamination. Other restoration actions could include tie-down or rail hardware removal from the deck or repair of minor damage.

CONCLUSION

Although virtually untried for the shipment of RAM, the credentials of and capabilities of barge transportation for certain radioactive materials are too good not to be considered. The existence of the ANSI N14.24 Standard should give prospective nuclear shippers much more confidence in their ability to successfully execute a shipping campaign. Although there are no near-term plans for a major shipping campaign where barges might be used, this mode is being integrated into the long range planning of the U.S. Department of Energy for spent fuel disposal under the Nuclear Waste Policy Act. Having a Standard in place in advance of the need will do much to pave the way for the inclusion of barge transport in the overall transportation scheme. The Standard will also aid in the application of this mode to future decommissioning activities. Water transportation deserves a place in the nuclear transportation arena.

REFERENCE

[1] American National Standard for Highway Route Controlled Quantities of Radioactive Materials - Domestic Barge Transport, ANSI N14.24-1985, ANSI, New York (1985).