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Section

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of DUKE POWER COMPANY (Amendment to Material License SNM-1773 for Oconee Nuclear Station Spent Fuel Transportation and Storage at McGuire Nuclear Station)	)	Docket No. 70-2623

TESTIMONY OF ROBERT H. JONES

My name is Robert H. Jones. I am the Manager of Transportation Systems, Spent Fuel Services Operation, General Electric Company, with offices at 175 Curtner Avenue, San Jose, California 95125. I was graduated from San Jose State University, San Jose, California in 1966 with a Bachelor of Science degree in Mechanical Engineering. I obtained a Masters degree in Business Administration (MBA) from Santa Clara University, Santa Clara, California in 1969. I am a registered Mechanical Engineer and a Registered Nuclear Engineer in the State of California holding Registration Numbers 14864 and 0876 respectively. I have been employed by General Electric since 1966. My first three years were at General Electric's Vallecitos Nuclear Center where as a Program Engineer and later as a Design Engineer I worked in areas of reactor operations, radiation protection, nuclear safety and reactor fuel performance testing. For the last ten years I have been in the Spent Fuel Services Operation specifically associated with the conceptualization,

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design, analysis, licensing, fabrication, testing and operation of the General Electric IF-300 Irradiated Fuel Shipping Cask. I have maintained and have enlarged my knowledge of nuclear fuel and waste packaging and transportation by participating in numerous industry activities including American National Standards Institute (ANSI) subcommittees, *ad hoc* advisory committees to the U.S. Department of Energy (DOE), and subcommittees of the Atomic Industrial Forum (AIF). I have been involved in numerous national meetings and international symposia relating to the packaging and transportation of radioactive materials, both as a speaker and a session coordinator. I have presented oral and written testimony on spent fuel shipping equipment, safety and logistics to the Interstate Commerce Commission and the Oregon Energy Facilities Siting Counsel.

My current responsibilities require me to keep abreast of developments in nuclear fuel and waste systems such that I have maintained good working knowledge of the equipment which is being proposed or currently used to transport spent nuclear fuel and waste. These systems include consideration of the following:

- Packaging design & technology
- Package testing
- Transportation mode technology
- System logistics & economics
- Fabrication & Quality Assurance
- Regulatory requirements
- Generic industry developments

General Discussion

Regarding packaging, the casks used to transport spent fuel and high level wastes are among the best designed and probably the most accident resistant of all hazardous material containers. This can be illustrated by a series of full-scale vehicle tests, highway and rail, conducted by Sandia where representative casks were subjected to severe accidents under controlled and monitored conditions. The test radioactive material containers survived the simulated accidents without loss of primary containment functioning.(1)

This accident resistant characteristic of shipping casks can be attributed to both the stringent design criteria contained in those Federal Regulations which pertain to packaging and transportation of radioactive materials, 49 CFR 171-177 (DOT) and 10 CFR 71 (NRC), and the quality of packaging design, fabrication, testing and in-service maintenance.

The efforts of industry and government to provide a safe system for the transportation of radioactive materials have been successful. The final environmental statement on the Transportation of Radioactive Material by Air and Other Modes, NUREG-0170, estimates that risk of early fatality from radioactive causes as a result of nuclear material transportation is 100,000 times <u>less likely</u> than being struck by lightning. Surely, this is an acceptable risk considering the benefits provided by nuclear-electric power.

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(1) Proceedings of the 5th International Symposium on Packaging & Transportation of Radioactive Materials, May 7-12, 1978 - Las Vegas, Nev., U.S.A., pgs. 463-471.

Packaging Regulations

In this country the design criteria for spent fuel shipping casks are established by Federal Regulations, NRC and DOT. Conditions of normal transport and accident conditions are defined by law, as well as acceptable normal and post-accident package behavior. It is encumbent upon a licensee to demonstrate to the NRC's satisfaction package compliance with the applicable regulations, both initially and throughout the useful life of the package.

I will not spend time reciting the regulations in detail, but let me summarize the two evaluation conditions:

Normal transport for large casks (10 CFR 71, Appendix A) involves thermal conditions ranging from -40°F shaded to +130°F in full sunlight; a reduced pressure (1/2 atmospheric), expected in-transit vibrations and water spray; a free drop (generally 1 foot for spent fuel casks) onto an unyielding surface; and, a steel bar penetration test. When subjected to these conditions, a package must remain essentially undamaged. No releases of contents or coolant are permitted. No reduction in shielding or criticality control effectiveness is permitted.

Accident conditions (10 CFR 71, Appendix B) involve the sequential application of a 30-foot free drop onto an unyielding surface, a 40-inch free drop onto the circular end of a 6-inch diameter bar, exposure to a 1475°F thermal environment for 30 minutes and immersion in 3 feet of water for 8 hours. The drop and puncture tests are applied with the package oriented to produce the maximum damage. When subjected to these accident conditions the package must retain its contents but is permitted to release contaminated coolant of limited activity and certain quantities of fission gas. The dose rate exterior to the cask is permitted to increase somewhat over normal conditions but no reduction in criticality control effectiveness is permitted.

Cask Design, Fabrication and Use

A cask designer has a fundamental goal which is to produce the safest package in full compliance with the applicable regulations. This goal is pursued under a strict quality assurance program (10 CFR 71, Appendix E). The designer utilizes state-of-the-art methods, material and technology to achieve his goal. Not only are sophisticated computer codes employed, but material testing, component testing, scale modeling and full size testing programs are often used to assist the designer.

The fabrication of a cask follows national codes and standards for nuclear service equipment. The quality assurance program utilized for design is continued through the fabrication cycle. NRC performs periodic inspections and audits of fabrication to provide an independent view of that operation. All casks undergo significant non-destructive testing of materials and processes during fabrication, and then are subject to rigorous acceptance tests following fabrication. Completed casks are subjected to a hydrostatic test of the cavity, seal, piping and valves at a pressure which is 50% greater than the design pressure.

Cask shielding continuity is confirmed by gamma scanning, that is, placing a radioactive source within the cavity and measuring the exterior dose rate. Cask heat dissipation capability is measured by placing electric heaters within the cavity to simulate the spent fuel and recording the resultant temperatures. Thermal test measurements are compared to the computer design code predictions. Cask lifting devices are load tested at 150% to 200% of the cask weight. The entire shipping system is given a complete handling demonstration which includes remote removal/replacement of the head, baskets and lifting device from the cask as well as performing the transporter loading/unloading operations. The net result is a high-quality package which fully complies with the design and the appropriate regulations.

Finally, throughout its life a cask must comply with its design bases. To achieve this, cask users follow detailed operating and maintenance plans which are produced by the cask supplier. These plans are periodically revised as operational data are accumulated. Cask suppliers have skilled field service organizations whose function is to train users in the safe operation of the package. Loaded casks are carefully examined and tested prior to shipping. Before each shipment casks are leak checked, tested for external contamination, checked for heat content, measured for external dose rate and examined for mechanical functioning. The transport vehicles are also examined and tested for proper functioning periodically and prior to each shipment. As in the case of design and manufacturing, cask operations are performed in accordance with an approved quality assurance program and are audited by NRC inspectors.

All of the above mentioned phases of cask supply and usage are conducted with exacting attention to safety and in full compliance with applicable laws. The nuclear fuel shipping industry recognizes that it is involved in moving a hazardous commodity and takes that responsibility quite seriously. The excellent safety record of spent fuel shipping discussed later is testimony to the care taken by suppliers, users and carriers.

Cask Details

Spent fuel shipping casks come in a variety of sizes and configurations. There are, however, a number of common characteristics. All current generation casks are about the same length, approximately 18 feet. They are loaded and unloaded from one end while standing vertically in a deep pool of water. Cavity closures are remotely removable and spent fuel is positioned in the cask with some type of interior structure. All casks are transported horizontally and raised to the vertical for loading and unloading through the use of a yoke mounted to the facility crane, and they are equipped with impact energy absorbing devices of one kind or another. Of course, they all comply with NRC and DOT regulations as evidenced by a Certificate of Compliance issued by the NRC.

Casks fall into three categories based on transport mode: legal weight truck, overweight truck and rail. The following table shows the available and near-available casks for shipping current generation LWR spent fuel.

TABLE 1

CASK DATA

Cask Designation	Supplier	Transport Mode	Spent Fuel Capacity, MTU
NFS-4/NAC-1	Nuclear Fuel Services Nuclear Assurance Corp.	L. Wt. Truck	0.5
NLI 1/2	N.L. Industries	L. Wt. Truck	0.5
TN-8/TN-9	Transnuclear, Inc.	O. Wt. Truck	1.5
IF-300	General Electric	Rail	3.5
NLI 10/24	N.L. Industries	Rail	4.7
TN-12*	Transnuclear	Rail	5.5
NAC-3*	Nuclear Assurance Corp.	Rail	5.5

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* Undergoing NRC evaluation

The variations among cask designs are due to designer's preferences and intended service. Gamma shielding materials include steel, lead and depleted uranium; neutron shielding includes water, borated water and solid resin. Cask surfaces, interior and exterior, are generally stainless steel or stainless steel-clad carbon steel; these materials are chosen for their mechanical properties and corrosion resistance. The inner cavity, with its closure, forms the primary containment barrier and is usually the pressure boundary. Surrounding the inner containment is the gamma shielding medium, usually heavy metal such as lead or depleted uranium. Exterior to the gamma shielding is a secondary steel containment which provides protection from puncture and containment of the gamma shielding medium. There are several cask designs where the primary containment, secondary containment and gamma shielding are combined into a single thick-walled all-steel vessel. Exterior to the secondary containment is the neutron shielding, liquid or solid. The liquid shields are retained by a third steel containment. The exterior of the larger casks have fins or other extended surfaces to facilitate heat dissipation.

Casks are equipped with some type of energy absorbing structure, metal or clad-wood which limit the forces on the structure during accident conditions. In some designs these structures are removable for in-plant handling while others are permanently attached. The cask closures are held with high-strength fasteners and sealed with elastomeric or metallic pressure retaining rings. Seal materials are chosen for their durability and resistance to thermal, mechanical and radiation conditions. All cask cavity penetrations are protected from the effects of fire and mechanical damage; valves are of nuclear quality.

Casks must dissipate heat from the contained fuel. The coolants within the cask cavities include air, helium and water. With the exception of the TN-8 and TN-9 casks, all units have the capability of shipping BWR or PWR fuel assemblies, through the use of removable cavity structures.

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The legal weight truck casks weigh about 25 tons and move with a gross vehicle weight (GVW) of about 73,000 pounds. The overweight casks weigh about 40 tons and move with a GVW of approximately 105,000 pounds. Rail casks are in two categories based on the number of axles on the rail car. A four-axle car will carry a cask of 70 or 80 tons, plus its supporting equipment, with a gross weight on the rail of about 260,000 pounds. A six-axle car will carry a 100 ton cask plus supporting equipment and weighs about 330,000 pounds on the rail.

All casks comply with DOT regulations for radiation dose-rates under normal transport conditions, and NRC and DOT regulations for accident dose rates. Table 2 shows these regulatory limits as applied to spent fuel casks.

TABLE 2

DOSE-RATE LIMITS

Condition	Position	Max. Dose Rate
Normal	Package or vehicle surface	200 mR/hr
Normal	6' from vehicle surface	10 mR/hr
Accident	3' from package surface	1000 mR/hr

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In actual practice, casks designed to these limits are well below them due to factors considered in the calculations which cause them to overestimate the dose-rate and the fact that fuel being shipped is generally of lower source strength than the fuel assumed for shield-sizing purposes (e.g. lower exposure or longer cooling times).

Although there are design differences between cask types, the greatest common characteristic is that these are among the highest quality, most accident-resistant containers designed for the movement of hazardous materials.

Sandia Crash Tests Discussion

My familiarity with the Sandia Full Scale Vehicle Testing (FSVT) program comes from my participation on an ad hoc advisory committee to Sandia. All of the truck-mounted casks were formerly owned by General Electric, one was donated to Sandia as a demonstration of GE's support of the program.

The FSVT program was conducted with two objectives, 1) to assess the ability of current analytical and scale modeling methods to predict the behavior of full-size systems under accident conditions and 2) to gain quantitative knowledge of the extreme accident environment by measuring the response of full-size hardware. These tests were not intended to validate current regulatory standards for casks although it is possible to make some comparisons and reach certain conclusions about the relative severities.

The Sandia tests may be summarized as follows: The first two full scale vehicle tests involved the head-on collision of a tractor-trailer rig carrying a 25-ton cask into a reinforced concrete wall backed by compacted earth. Impact speeds were 100 km/h (62 mph), and 135 km/hr (84 mph). In both tests the cask remained intact and the contents were retained. It is interesting to note that the cask used in the 100 km/hr test was so undamaged that it was subsequently used in the higher speed test. The third test was a simulated grade-crossing accident where a cask-bearing tractor trailer rig was struck by a diesel locomotive traveling at 130 km/hr (81 mph). The locomotive was literally destroyed but the cask sustained relatively minor damage, retaining its contents and integrity. The fourth test was the impacting of a 100 ton rail car transported cask into the concrete/earth wall at a velocity of 130 km/hr (81 mph). As in the preceding tests the cask sustained minor damage. The last test involved subjecting the crashed rail cask to a pool fire. The fire ranged from 9[illegible]C to 1150°C (1796°F to 2102°F) and lasted 100 minutes. At this time a slight lead leak developed but the cask integrity was not compromised.

The program of course, was more than full-scale testing. As a matter of fact, the crash tests, were the last phase. Computer simulations and scale model studies were performed prior to the full-sized test sequence. In each instance the impact effects on the full-scale system were accurately predicted by the analytical and modeling techniques.

One of the studies conducted by Sandia in support of the FSVT program was an assessment of the probabilities of the various accident scenarios. The following table(2) shows that the likelihood of the least severe test scenario (100 km/hr impact) is once in 70 years. As noted above the cask involved in this test was so undamaged that it was also used in the 135 km/hr impact test. The other tested scenarios are significantly less likely.

Table 3
Accident Probabilities

Accident Scenarios	Approximate Interval* (average number of years between accidents)
100 km/h Truck Impact	70
130 km/h Truck Impact	1000
130 km/h Grade Crossing	4500
115 km/h Special Railcar Impact	5900
130 km/h Special Railcar Impact	18000
Combined 130 km/h Special Railcar Impact and 120 minute Fire	10^6
30 minute Railcask Fire, No Impact	120
60 minute Railcask Fire, No Impact	350
90 minute Railcask Fire, No Impact	450
120 minute Railcask Fire, No Impact	700

* Assuming 11 x 10^6 km transport distance per year.

The Sandia project manager concluded(3) the following about the FSVT program:

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(2) Proceedings of the 5th International Symposium on the Transportation and Packaging of Radioactive Materials, Page 470, May 7-12, 1978, Las Vegas, Nevada.

(3) *Ibid*.

> "...the tests demonstrated that (1) scale modeling (impact only) and analytical techniques can reliably predict the response of spent fuel cask systems in severe impact and fire environments, and (2) spent fuel casks can be expected to retain their radioactive contents even after being involved in extremely severe transportation accidents.... In addition, much information has been gained on the behavior of the cask and transport system in extreme environments."

I would add that although not a program goal, the FSVT generally demonstrated the inherent ruggedness of spent fuel shipping casks designed to Federal regulations.

History of Spent Fuel Shipments

Over two million packages of radioactive materials are shipped annually by air, rail and truck.(4) These shipments include radiopharmaceuticals, power reactor fuels, and radioactive wastes. Transportation of these materials has been safe and secure. To date, there have been no fatalities or serious injuries due to the radioactive nature of these materials.

Spent fuel shipping casks have been involved in very few in-transit accidents, none of which have damaged the transported

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(4) NUREG-0170, FES on Transportation of Radioactive Material by Air and Other Modes, December, 1977.

package beyond superficial levels. General Electric Company's Morris (Illinois) Facility has received approximately 500 shipments of irradiated fuel, mostly by highway cask. The total highway distance traveled is about 2 million kilometers (1.24 million miles) and this was accomplished without an accident. Based on an overall accident rate for hazardous materials motor carriers of 1.06×10^{-6} accidents/kilometer,(5) there should have been two incidents rather than none. The reasons for this better-than-average safety record are greater attention to safety in the inspection and securing of the load and vehicle, and the skills level and training of the drivers. Most casks are moved by carriers specialized in hauling these commodities. The low accident probability coupled with both the care taken in transit and the accident resistant nature of the cask, makes the shipment of irradiated fuel among the safest of any hazardous commodity. This conclusion is supported by the record.

Conclusion

In light of the above I find no technical or institutional reasons why spent fuel shipping should not be viewed as an acceptable activity.

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(5) Ibid.

Dated: June 4, 1979

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