December 5, 1996

Mr. David M. Dawson
Vice President
Transnuclear, Inc.
Four Skyline Drive
Hawthorne, NY 10532-2120

SUBJECT: SAFETY EVALUATION REPORT - "TN-32 DRY STORAGE CASK TOPICAL SAFETY ANALYSIS REPORT," REVISION 9

Dear Mr. Dawson:

By letter dated November 7, 1996, the Nuclear Regulatory Commission issued its Safety Evaluation Report (SER) for the "TN-32 Dry Storage Cask Topical Safety Analysis Report" (TSAR), Revision 9. SER replacement pages 1-2, 1-3, 2-9, 3-2, 3-3, 4-3, 9-3, 12-3, and 12-5 are enclosed to reflect corrected text. Changes made are indicated by vertical lines in the margin.

If you have any questions regarding this action, please contact Ms. Meg Lusardi at (301) 415-8549.

Sincerely,

Original signed by /s/

Charles J. Haughney, Acting Director
Spent Fuel Project Office
Office of Nuclear Material Safety
and Safeguards

Docket 72-1021 (M-56)

Enclosure: SER revised pages

cc: Mr. J. P. O'Hanlon, VEPCO

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1.3 Review Procedures

Section 1 of the TSAR was examined to verify that the appropriate information, as listed in the above Areas of Review and Acceptance Criteria, was presented. This information is summarized below.

1.3.1 Cask Description and Operational Features

The TN-32 Dry Storage Cask (see Figure 1.2-1 in the TSAR) was developed by TN to store irradiated spent fuel assemblies at an ISFSI. The cask accommodates 32 intact pressurized water reactor (PWR) fuel assemblies. The TN-32 cask body is a right circular cylinder composed of the following components: containment vessel with bolted lid closure, basket for fuel assemblies, gamma shield, pressure monitoring system, weather cover, trunnions, and neutron shield. A general description of the cask and its operational features are provided in TSAR Sections 1.1 and 1.2.

The containment vessel is made of welded cylindrical carbon steel (SA-203, Gr. A or D) 38-mm (1.50-in.) thick, with an integrally welded carbon steel bottom closure. A flange forging is welded to the top of the containment vessel to accommodate a flanged and a bolted carbon steel lid closure. The closure lid uses a double-barrier seal system with two metallic O-rings forming the seal. The annular space between the metallic O-rings is connected to a pressure monitoring system (PMS) placed between the lid and the protective cover. Pressure in the tank of the PMS is maintained above the pressure in the cask cavity to prevent either flow of fission gases out, or air into, the cask cavity, which, under normal storage conditions, is pressurized above atmospheric pressure with helium.

Surrounding the outside of the containment vessel wall is a steel gamma shield (SA-105/516, Grade 70) with a wall thickness of 203 mm (8.0 in.). The bottom end of the gamma shield is made of the same material and has a thickness of 222 mm (8.75 in.). The bolted closure lid provides the gamma shielding at the upper end of the cask body.

Neutron emissions from the stored fuel are attenuated by a borated polyester resin compound neutron shield located on the outside of the gamma shield. The borated polyester is 114-mm (4.50-in.) thick and is encased in aluminum boxes that are 3-mm (0.12-in.) thick, which are held in place by a 13-mm (0.50-in.) thick SA 516 Gr 70 steel shell constructed of two half-cylinders. Neutron emissions from the top of the cask are attenuated by a polypropylene disc 102-mm (4.0-in.) thick and encased in a steel shell 6.35-mm (0.25-in.) thick. There is no neutron shielding provided on the bottom of the cask.

The cask has a cylindrical cavity 1753 mm (69.0 in.) in diameter and 4140-mm (163-in.) long, which holds a fuel basket with 32 compartments, each 221-mm (8.70-in.) square, to hold the fuel bundles. The fuel cavities are formed by a sandwich of aluminum plates, borated aluminum plates, and stainless steel boxes. The fuel compartment stainless steel box sections are attached by a series of stainless steel plugs that pass through the aluminum and poison plates and are fusion-welded to both adjacent stainless steel box sections. The combined wall thickness is 20-mm (0.785-in.) thick. The basket is guided into the cask body and held in place by aluminum rails that run the axial length of the cask body.

A protective cover, 9.5-mm (0.375-in.) thick, is bolted to the top of the cask body to provide weather protection for the lid penetrations. The cask cavity surfaces have a sprayed metallic coating of aluminum for corrosion protection. The external surfaces of the cask are painted for ease of decontamination. The neutron shield, PMS, and shield cap are placed on top of the cask after fuel loading and removal from the spent fuel pool.

The cask body has four trunnions that are welded to the gamma shield. Two of these are located near the top of the cylindrical steel forging, spaced 180 degrees apart, and are used for lifting the cask. The remaining two trunnions are 180 degrees apart and located near the bottom of the cask. The lower trunnions are used to rotate the unloaded cask between vertical and horizontal positions. The lifting trunnions have an effective diameter of 220 mm (8.67 in.).

The cask has two containment penetrations: one cask cavity drain, and one cask cavity vent. Both of these penetrations are in the lid. The drain and vent ports are covered by a double-seal bolted closure. The cavity drain line penetrates the closure lid and terminates in the bottom of the cask cavity. This is used to drain water from the cask cavity after underwater fuel loading. It is also used during the drying and helium back-filling of the cask cavity. The drain valve is of the quick-disconnect type and was not analyzed as part of the primary containment system. The cavity vent valve is identical to the drain valve.

The overall dimensions of the cask are 5131-mm (202-in.) long and 2591-mm (102-in.) in diameter. The cask weighs approximately 115.5 tons (230,990 pounds) when loaded.

The cask is designed to store 32 intact fuel assemblies. Each fuel assembly is assumed to have a maximum initial enrichment not to exceed 3.85 w/o U-235 in uranium. Further assumptions limit the fuel to a maximum of 40,000 MWD/MTU burnup, a minimum decay time of 7 years after reactor discharge and a maximum decay heat load of 0.847 kW per assembly for a total of 27.1 kW for a cask. Additional fuel limitations are discussed in Sections 2 and 12 of this SER.

The heat rejection capability of the cask maintains the maximum fuel rod clad temperature below 348°C (658°F), based on normal operating conditions with a 27.1 kW decay heat load, 38°C (100°F) ambient air, and full insolation. The fuel assemblies are stored in an inert helium gas atmosphere.

The cask shielding features of the cask are designed to maintain the maximum combined gamma and neutron surface dose rate to less than 200 mrem/hr, under normal operating conditions.

As discussed in Section 2.3.2.1 of the TSAR, the TN-32 design also provides the capability to detect seal failure through a pressure monitoring system (PMS). The interseal region is filled with helium gas to 5.5 atm. In the event of a seal failure of either the inner or outer lid seal, this gas will leak either into the cask cavity or to the atmosphere, respectively, and an alarm will indicate a drop in pressure. No single seal failure can result in a leak of cavity gas to the atmosphere. Except for the PMS, no other instrumentation or control systems are applicable to the TN-32.

2.3.3.6 Radiation Protection

Section 2.3.5 of the TSAR addresses radiological protection. The principal design features of the TN-32 for exposure control are the inherent shielding capability of the cask and the integrity of the seals at the closure joints. Radiological alarm systems and systems for monitoring effluents and direct radiation are not applicable to the design of the storage cask. In addition to the provisions of ALARA, the use of the TN-32 at an ISFSI must comply with the total dose limits at the site boundary as specified in 10 CFR 72.104(a) and 72.106(b). Because these dose limits depend on site-specific parameters (e.g., total number of casks, cask-array configuration, distance to the site boundary, and radiation from other fuel cycle operations), demonstration of compliance with these requirements is the responsibility of the site licensee. A detailed analysis to illustrate that such compliance can be achieved in principle is presented in Sections 5, 7, and 10 of the TSAR and is discussed in the corresponding sections of this SER.

2.3.3.7 Criticality

Section 2.3.4 of the TSAR establishes a maximum effective multiplication factor of 0.95, including uncertainties and biases, for all credible configurations and environments for the prevention of criticality. A k_{eff} less than 0.95 is achieved by use of geometry and fixed poisons. Fresh fuel composition and 2000 ppm borated water in the cavity are assumed for criticality analysis.

2.3.3.8 Operating Procedures

The TN-32 is designed to be loaded and unloaded in a fuel storage pool. Dry loading and unloading are not addressed in the TSAR. General operating procedures are addressed in Section 8 of the TSAR.

Operational features of the cask to minimize radioactive wastes and facilitate decommissioning are also presented in Sections 1.2.2 and 2.4 of the TSAR.

2.3.3.9 Acceptance Tests and Maintenance

Section 9 of the TSAR addresses testing and maintenance requirements for the TN-32. The evaluation of these requirements is presented in the corresponding section of the SER.

3.2.3 The spent fuel cladding must be protected during storage against degradation that leads to gross ruptures, or the fuel must be otherwise confined such that degradation of the fuel during storage will not pose operational safety problems with respect to its removal from storage. [10 CFR 72.122(h)(1)]

3.2.4 Storage systems must be designed to allow ready retrieval of spent fuel waste for further processing or disposal. [10 CFR 72.122(l)]

3.2.5 The cask must be designed and fabricated so that the spent fuel is maintained in a subcritical condition under all credible conditions. [10 CFR 72.236(c) and 72.124(a)]

3.2.6 The cask and its systems important to safety must be evaluated, by appropriate tests or by other means acceptable to the Commission, to demonstrate that they will reasonably maintain confinement of radioactive material under normal, off-normal, and credible accident conditions. [10 CFR 72.236(l)]

3.2.7 Structural systems and components important to safety must be analyzed and evaluated to assess their adequacy for protecting the health and safety of the public. [10 CFR 72.24(d)]

3.3 Review Procedures

3.3.1 Structural Design

3.3.1.1 Structural Design Features

Section 1 of this SER provides a complete description of the cask. The structural components of the TN-32, as discussed in Section 3.1.1 of the TSAR, include: cask body consisting of a containment vessel and gamma shielding, the basket, the trunnions, and the neutron shield outer shell. All drawings, figures, and tables describing structural features are sufficiently detailed.

3.3.1.2 Structural Design Criteria

Section 3.1.2 of the TSAR provides a discussion of the TN-32 structural design criteria, which supplements information presented in Section 2. These criteria can be divided into several categories: load conditions, stress categorization, allowable stress limits for ductile failure, and buckling.

Section 3.1.1 of the TSAR specifies that the TN-32 containment is designed, fabricated, examined, and tested in accordance with the requirements of Section III, Subsection NB of the ASME Boiler and Pressure Vessel Code (B&PVC) [1]. The containment boundary consists of the inner shell and bottom plate, shell flange, lid outer plate, lid bolts, penetration cover plates, and bolts. The containment boundary welds are full penetration welds examined volumetrically by radiograph. These welds are also liquid penetrant or magnetic particle examined. Gamma shield welds are examined in accordance with Section III, Subsection NF. Seal welds are examined in accordance with Section V of the ASME Code. Stainless steel overlay welds are also examined per Section V of the ASME Code. Lifting devices are designed in accordance with ANSI N14.6 [2] requirements for lifting operations. In addition, a principal structural design criterion is established that confinement must be maintained under accident conditions.

All metals used in the primary confinement boundary are Class 1 metals and comply with specifications listed in the B&PVC Section II, Part D, Table 2A. These metals are weldable as required in the B&PVC, Section IX. Metals for bolts comply with the requirements of specifications listed in the B&PVC Section II, Part D, Subpart 1, Table 4. Other metals for components important to safety comply with the requirements of specifications in Section II, Part A or B.

The staff agrees with the use of the provisions of Section III of the ASME Boiler and Pressure Vessel Code for stress categorization and for the determination of allowable stress limits for ductile failure. Section III specifies requirements for nuclear power plant components and its use is consistent with Regulatory Guides 3.60 [3] and 7.6 [4]. Tables 3.1-2 to 3.1-5 of the TSAR list the allowable stress limits for TN-32 containment vessel, containment bolt, non-containment structure, and basket stress limits.

Section 3.1.2.3 of the TSAR discusses the fuel basket structure design criteria under both Level A and Level D service conditions. Individual fuel compartment wall panels are evaluated against buckling load using the provisions of both the ASME Code rules for component supports and B96.1 [5].

3.3.1.3 Weights and Center of Gravity

Section 3.2 and Table 3.2-1 of the TSAR summarize the weights and centers of gravity of the TN-32. The cask weight on the storage pad loaded with fuel is 230,990 pounds. Many of the structural analyses use a cask design weight of 235,000 pounds, which exceeds the loaded cask weight. In the analysis of the stability of the cask, however, a low weight of 228,000 pounds is used. The center of gravity is 92.09 in. above the bottom surface of the cask body.

3.3.1.4 Mechanical Properties of Materials

Table 3.3-1 of the TSAR provides mechanical properties for the cask materials used in the structural evaluation. Table 3.3-2 reports the temperature dependency of the material properties.

The properties of the basket materials (ASME SA-240, Type 304, as well as SB 209, 6061-T6 aluminum), along with their temperature dependencies, are listed in Tables 3.3-4 and 3.3-5.

temperatures of the confinement structural components must not adversely affect the confinement function. The temperature limit, below which the allowable stresses in these components remains invariant with temperature, is 500°F. Fourth, the maximum fuel clad temperature must not exceed the limit that will cause unacceptable degradation of the clad during 20 years of storage. Based on references [1] and [2], the maximum clad temperature limits for fuel cooled a maximum of 7 and 10 years are 658°F (348°C) and 648°F (342°C), respectively, as given in Section 3.5 of the TSAR.

4.3.1.1.2 Accident Conditions

The design criteria for accident conditions given in Section 11.2.5.2 of the TSAR are based on preserving the confinement integrity of the TN-32 storage cask. The maximum temperature limit of the metallic o-ring seals in the confinement vessel closure lid of 570°F must not be exceeded. The maximum cavity pressure must not exceed 100 psig. Based on shielding calculations, the loss of the resin in the neutron shield during a fire does not lead to unacceptable consequences.

4.3.1.2 Design Features

The heat removal system of the TN-32 storage cask is totally passive. No coolants or active cooling systems are utilized. The cask cavity is filled with helium to provide a chemically inert atmosphere as well as to aid in the transport of decay heat from the fuel assemblies to the cask inner wall. The decay heat is transferred from the fuel assemblies to the outer environment by conduction, convection, and radiation.

As discussed in Section 1.2.1 of the TSAR, 32 PWR fuel assemblies are supported in a basket assembly of 304 stainless steel cells separated by 0.5-in. thick 6061-T6 aluminum alloy and 0.040-in. thick borated aluminum plates. The cells are joined by a series of stainless steel plugs that pass through the aluminum plates and are fusion-welded to the stainless steel to form 8.7-in. square compartments for the spent fuel assemblies. The aluminum plate provides the conduction paths for the removal of the decay heat from the assemblies to the cask inner surface. The borated plate provides the necessary criticality control.

The cask body consists of concentric shells. The inner shell, fabricated from ASME SA-203, Grade A or D ferritic steel, is the confinement boundary. The second shell, fabricated from ASME SA-105, SA-560, Gr. 70 or SA-266, Cl. 2 ferritic steel, is a gamma shield. The third shell, that consists of a borated polyester resin compound cast into long slender 6063-T5 aluminum alloy containers, is the neutron shield. The fourth shell, fabricated from ASME SA-516, Grade 70, ferritic steel, encloses the neutron shield. The bottom shield and the bottom confinement plate are made from the same material as the second shell and the inner shell, respectively. The lid is fabricated from ASME SA-350, Gr. LF3 or SA-203, Gr. A or D ferritic steel. The top shield plate is fabricated from ASME SA-105 or SA-560, Gr. 70 ferritic steel.

9.3.1.4 Component Testing

Component testing for the TN-32 consists of testing of the double metallic O-ring seals on the cask lid and all confinement penetrations. The inside metallic O-Ring forms part of the confinement boundary. Upon completion of cask loading, the seals will be leak tested as described in Section 9.3.1.3 above, and/or as described in Section 12.1.2.5 of the TSAR.

There are no valves that perform a safety-related function on the TN-32. The TN-32 design incorporates quick-disconnect couplings for ease of draining and venting. These quick-disconnect couplings do not perform a safety-related function nor are they part of the confinement boundary.

9.3.1.5 Shielding Tests

The acceptance criteria for shielding integrity includes qualification testing of the personnel and procedures used for the mixing and pouring of the polyester resin used for neutron shielding. Qualification testing further includes verification that the required chemical composition and densities are achieved and that the processes are performed in a manner that will prevent the inclusion of voids.

Additional surveillances will be performed after loading to ensure that the radiation dose limits will not be exceeded for each cask.

9.3.1.6 Thermal Acceptance

The analyses performed to ensure that the casks are capable of performing their heat transfer functions are presented in Chapter 4 of the TSAR. The analyses were performed using conservative assumptions for the design basis fuel. Staff accepts this analysis and no thermal tests are required.

9.3.2 Maintenance Program

The TN-32 does not require routine or periodic maintenance during normal storage operations at an ISFSI. The valves and seals selected for use will not require inspection or replacement during normal fuel storage operations.

The pressure transducers/switches used to monitor the confinement seals will be inspected according to site-specific procedures. Two identical pressure transducers/switches are used to assure a functional system through redundancy. The switches are not replaced unless they are malfunctioning.

All the gaskets are designed to maintain their sealing capability until the cask is reopened. If a leak is detected by a drop in pressure in the PMS, the cask could be returned to the spent fuel pool and the appropriate gaskets would be replaced.

12.3.1.2 Radiation Protection

Dose rates on the accessible surfaces (top, sides) of the cask shall not exceed 200 mrem/hr., and shall be compared to the values in Table 5.1-2 of the TSAR to verify proper loading of the fuel and assure the ISFSI site's compliance with 10 CFR 72.104 and 10 CFR Part 20.

Removable contamination on the cask shall not exceed 1000 dis/min/100 cm^2.

The total leak rate of all confinement seals shall not exceed $1x10^{-5}$ std cc/s helium. (See Section 7.3.1 for a description of these three sets of seals.)

A pressure-monitoring system shall be installed on each cask to monitor the pressure of helium in the inter-seal regions. The monitoring system shall be set to alarm if the pressure decreases to 3.2 atm or if the pressure switch fails.

12.3.1.3 Acceptance Testing

Each cask shall be fabricated, tested, and maintained in accordance with the specifications of Section 9 of the TSAR.

12.3.1.4 Operating Procedures

The water in the spent fuel pool shall contain at least 2000 ppm boron during cask loading and unloading operations. Steps shall be taken before loading or unloading the cask to verify the boron concentration.

Before moving the cask to the pad, the cask shall be vacuum dried and successfully dryness tested. Chapter 8 of the TSAR specifies a dryness test of evacuating the cask to a vacuum of 10 mbar or less. The pressure change shall not exceed 3 mbar in less than 10 minutes.

The cask cavity shall be backfilled to an equilibrium pressure of 2.2 atm with helium.

The TN-32 shall not be lifted more than 18 inches when transferring the cask to and from the storage pad as well as when placing the cask on the pad.

For use at a reactor site, all operations, including maintenance of the TN-32, shall also be conducted in accordance with the 10 CFR Part 50 license, technical specifications, programs, and procedures for the site.

12.3.2. Limiting Conditions

The pressure in the inter-seal regions of the TN-32 shall be maintained above 3.2 atm ±5%.

12.3.3. Surveillance Requirements

Surveillance requirements for use of the TN-32 shall be established by the ISFSI operator. These requirements shall include a means to assess the functionality of the pressure monitoring system (PMS).

12.3.4. Design Features

Design features described in the text and license drawings of the TSAR shall not be modified except as permitted by 10 CFR 72.48.

12.3.5. Administrative Controls

Administrative controls shall be established by the ISFSI licensee in accordance with 10 CFR 72.42(c)(5).

12.4 Evaluation Findings

The staff concludes that the operating controls and limits for the TN-32 are in compliance with 10 CFR Part 72 and that the applicable acceptance criteria have been satisfied. The evaluation of the operating controls and limits provides reasonable assurance that the TN-32 will enable safe storage of spent fuel. This finding is based on a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted practices.