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STUDIES AND RESEARCH CONCERNING BNFP:

OPERATIONAL ASSESSMENT OF THE GENERAL ELECTRIC IF-300 RAIL SPENT FUEL CASK

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October 1978

ALLIED-GENERAL NUCLEAR SERVICES
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PREPARED FOR THE
DEPARTMENT OF ENERGY
FUEL CYCLE PROGRAM OFFICE
UNDER CONTRACT ET-78-C-09-1040

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ABSTRACT

This report presents the results of an operational assessment of the General Electric IF-300 spent fuel cask. This packaging system transports current generation, light water reactor (LWR) nuclear fuel assemblies via railroad shipment. The studies were performed at the Barnwell Nuclear Fuel Plant (BNFP) by employees of Allied-General Nuclear Services (AGNS). The work was funded by the Department of Energy during fiscal year 1978 and is categorized in accordance with Sub-Task 1.1 of that contract.

The study basis was prior full-scale tests with the IF-300 system and simulations of fuel unloading operations at the BNFP. Specific tasks and areas of study included: (1) sequential dry-run handling operations under simulated unloading conditions, (2) detailed time and manpower studies, (3) estimates of operator radiation exposure, and (4) a general evaluation of the cask system capabilities as they relate to unloading facility operations. The latter includes suggestions for improvements to equipment, facilities, and procedures. Additionally, general information on the design of the cask and auxiliary equipment, the Certificate-of-Compliance (COC), and a fuel compatibility matrix are included.

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1.0 INTRODUCTION

This report presents an operational assessment of the General Electric IF-300 Nuclear Spent Fuel Cask. This package weighs about 70 tons and is normally transported by rail. The payload is about 3.2 to 3.4 MTU of nuclear fuel [7 pressurized water reactor (PWR) or 18 boiling water reactor (BWR) fuel assemblies]. The cask is fabricated primarily from stainless steel, which comprises the structural containment; and depleted uranium which is the gamma shield material.

The purpose of this report is to present the result of an evaluation of the unloading operations associated with this equipment. The basis of this study is a 50-day operational period utilizing this equipment in 1975 at the Barnwell Nuclear Fuel Plant (BNFP). This was supplemented by recent observation of this equipment at other sites and discussion with equipment users in 1978. The report contains information on operational procedures, operator requirements, unloading times, and projected radiological exposures to the operating area. It is not the intent of this report to present a detailed operations manual. This is available directly from the cask system supplier. However, most of the fuel unloading operations, which correspond in general to fuel loading, are covered in detail.

The methodology used in this study was based solely on the installed equipment at the BNFP with its inherent operational characteristics. It is believed that these would be comparable with an away-from-reactor (AFR) storage site constructed elsewhere. The operational times are based on "typical" conditions with a fifteen percent contingency. Typical conditions are defined as routine operations with no malfunction of either packaging or facility equipment. The radiological exposure estimates are directly correlated to the operations assessment (time, number of operators, and distance from the cask body). The radiation source (nuclear fuel) is assumed to be at the limiting or design conditions noted in the Certificate of Compliance (COC) for the purpose of consistency. In actual expected cases, the operator dose may be considerably lower.

The following study results were obtained relevant to operational requirements and radiological exposure:

Total Plant Turnaround Time	35.5 Hours**
Total Time in FRSS Building	30.8 Hours
Total Man-Hours per Unloading Operation	119.8 Man-Hours
	38.0 Man-Hours/MTU
Estimated Radiological Exposure*	247.0 mrem/unloading
	78.4 mrem/MTU
Average Operator Exposure	13.1 mrem/MTU-Operator

The operational assessment in Section 9.0 presents an overview of design trade-offs and operational improvements. This critique was based upon the opinions of the AGNS operations and engineering staff. These opinions were developed based on prior experience at the BNFP and discussions with people knowledgeable on the current status of the equipment. It is felt that implementation of these recommendations will enhance operations from the standpoint of reduced turnaround time and operational health and safety. The GE IF-300 packaging system is viewed to be workable and has proved itself in service. None of the comments in this critique are meant to imply the contrary.

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*Design basis fuel approximately five months cooling time prior to shipment.

**It was assumed that a contamination barrier was not used when placing the cask into a spent fuel pool.

2.0 SUMMARY DESCRIPTION OF THE CASK

The GE IF-300 is a 140,000-pound cask which has been designed, licensed, and constructed to transport up to 7 PWR type or 18 BWR type light water reactor spent fuel assemblies. The package is designed for shipment by rail or short distance intermodal. Intermodal capability is accommodated by mounting the package on a 35,000-pound skid. This allows the cask to be heavy-hauled to facilities lacking direct rail access. A view of the shipping cask, skid, and rail flat car is presented in Figure 2-1. The cask uses water as a passive coolant within the cask fuel cavity. Dissipation of decay heat from the fuel is by natural convection and radiation from the cask's corrugated outer surface. Under low fuel decay heat conditions, the cask cavity may be shipped dry (air coolant).

A redundant cask auxiliary cooling system is permanently mounted on the transport skid. This cooling skid is not required for license purposes but is utilized to minimize cask body temperatures during shipment to simplify unloading. It operates by blowing air on the cask exterior.

The cask body is fabricated of cylindrical shells. Innermost is a stainless steel inner cavity cylinder surrounded by a depleted uranium gamma shield jacket, outer shell, and the outer corrugated stainless steel body. The cask outer surface, including the cask ends and the external valve boxes, is protected by stainless steel impact fins. Two alternate shielded cask heads are provided for Pressurized Water (PWR) and Boiling Water (BWR) spent fuel assemblies. The short head is used when fuel assemblies up to 169-1/2 inches in length are shipped (PWR fuel). The long head permits shipping of fuel assemblies up to 180 inches (typically BWR fuel). A drawing of the IF-300 Spent Fuel Shipping Cask is shown in Figure 2-2. The quantity, type, and form of allowable LWR spent fuel assemblies using either water or air as the primary coolant are referenced in Section 5.0 and Attachment B of this report. Removable fuel baskets and assembly spacers, which properly position the fuel assemblies and maintain a criticality control, are positioned inside the inner cask cavity. Depending on the needs of the handling facility, the supplier offers a choice of three different cask lifting yokes including a redundant yoke configuration.

The shipping cask is transported primarily by rail between the loading and unloading sites. The loading operation consists of moving the enclosure frame (personnel barrier), moving back the air ducts, removing valve box covers, and removing the forward tie-down pins. The cask lifting trunnions can then be installed. A facility crane of about 75-ton capacity or greater, equipped with the suitable lifting yoke, engages the trunnion and raises the cask to a vertical position. A "cap-like" turning fixture which engages the lower portion of the cask permits rotation of the cask. The cask can then be transferred to a handling location where the closure nuts are removed and the cask filled with demineralized water. The cask lifting yoke is again engaged and the cask lifted and submerged in the fuel loading pool. In the fuel pool, the closure head is removed and wet loading of the fuel assemblies is accomplished. While in the pool, it is also possible to change baskets and add fuel spacers. It is necessary to identify individual fuel assemblies. The cask closure head is replaced, and the loaded cask is lifted and transferred to a service area. During the lifting from the pool, a spray of demineralized water is used to rinse the cask exterior. At a dry servicing area the cask closure head is torqued, the pool water is drained from the fuel cavity, and the cavity is refilled with uncontaminated water. Simultaneously, the operators decontaminate the external cask surfaces to levels suitable for shipment.

While the cask surface is being decontaminated, certain peripheral operations can be performed. These include:

- Pressure testing the cask inner cavity and assuring closure seal leak tightness

- Flushing pool water from the cask cavity and replacing with demineralized water

- Sampling of the cask cavity coolant for radioisotopic activity

- Installation of pressure/temperature monitoring.

If aged fuel is shipped and the spent fuel decay heat level is low enough, the cask may be shipped dry. This operation eliminates the requirement for coolant sampling at the loading/unloading site. The loading procedure is modified in that the water coolant is drained from the cask fuel cavity by air pressurization through the closure head vent line. It is also unnecessary to monitor for cavity pressure and temperature as with a wet cask.

The loaded cask is moved by crane to the rail car and the lower end placed into the cask turning fixture. The cask is then lowered into the horizontal shipping position, the lifting trunnions removed, and the cask tied down. The auxiliary cooling system is activated before repositioning the aluminum cage or personnel barrier over the package.

Upon completion of the required site checklists, bill-of-lading, shipping documents, labels, etc., the shipment is ready for transporting to a fuel receiving facility. Fuel assemblies are unloaded using the reverse process plus coolant sampling cooldown if deemed necessary. (This is covered in greater detail in Section 5.0 of this report.)

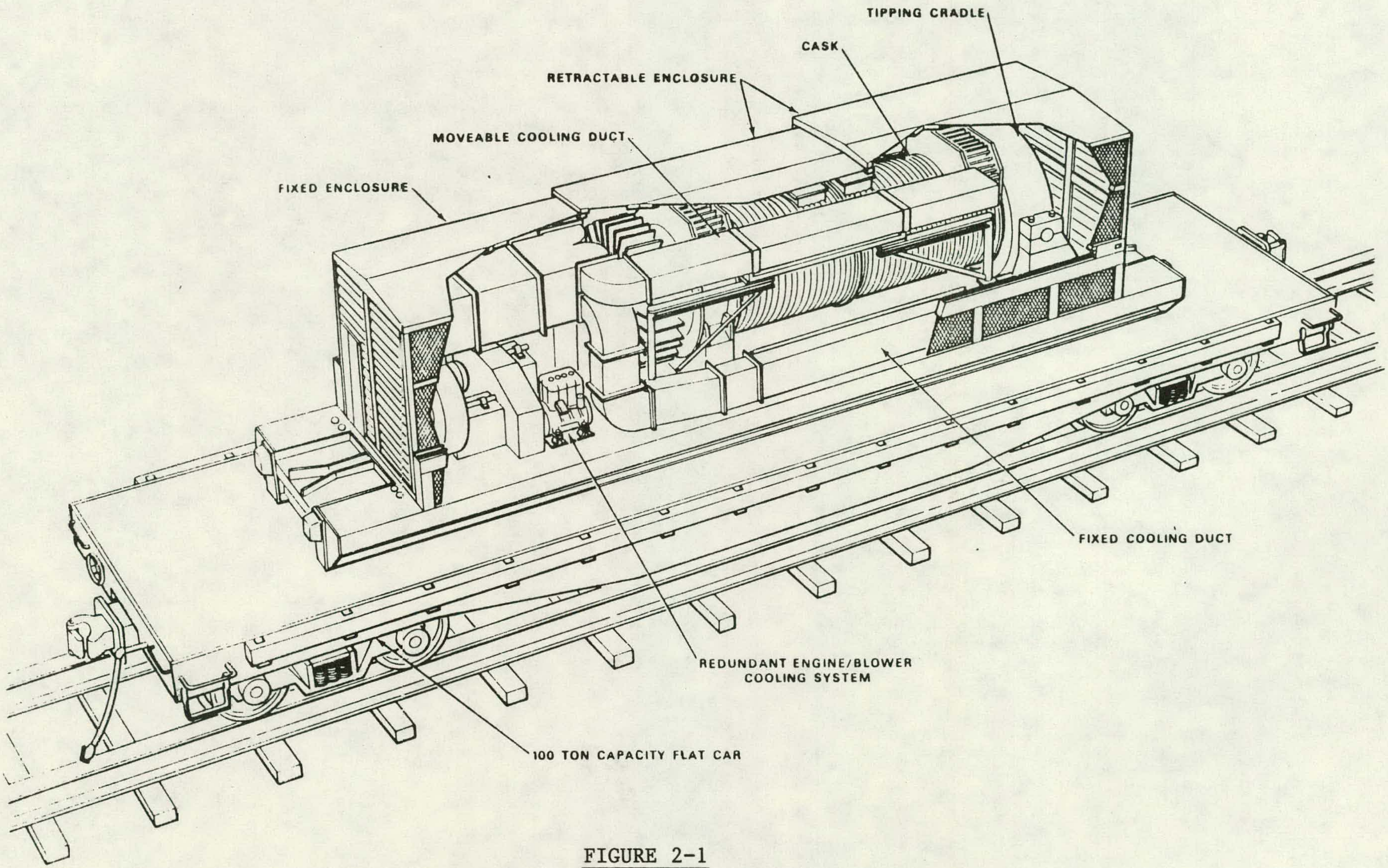

FIGURE 2-1

IF-300 SPENT FUEL SHIPPING CASK, SKID, AND RAIL FLAT CAR

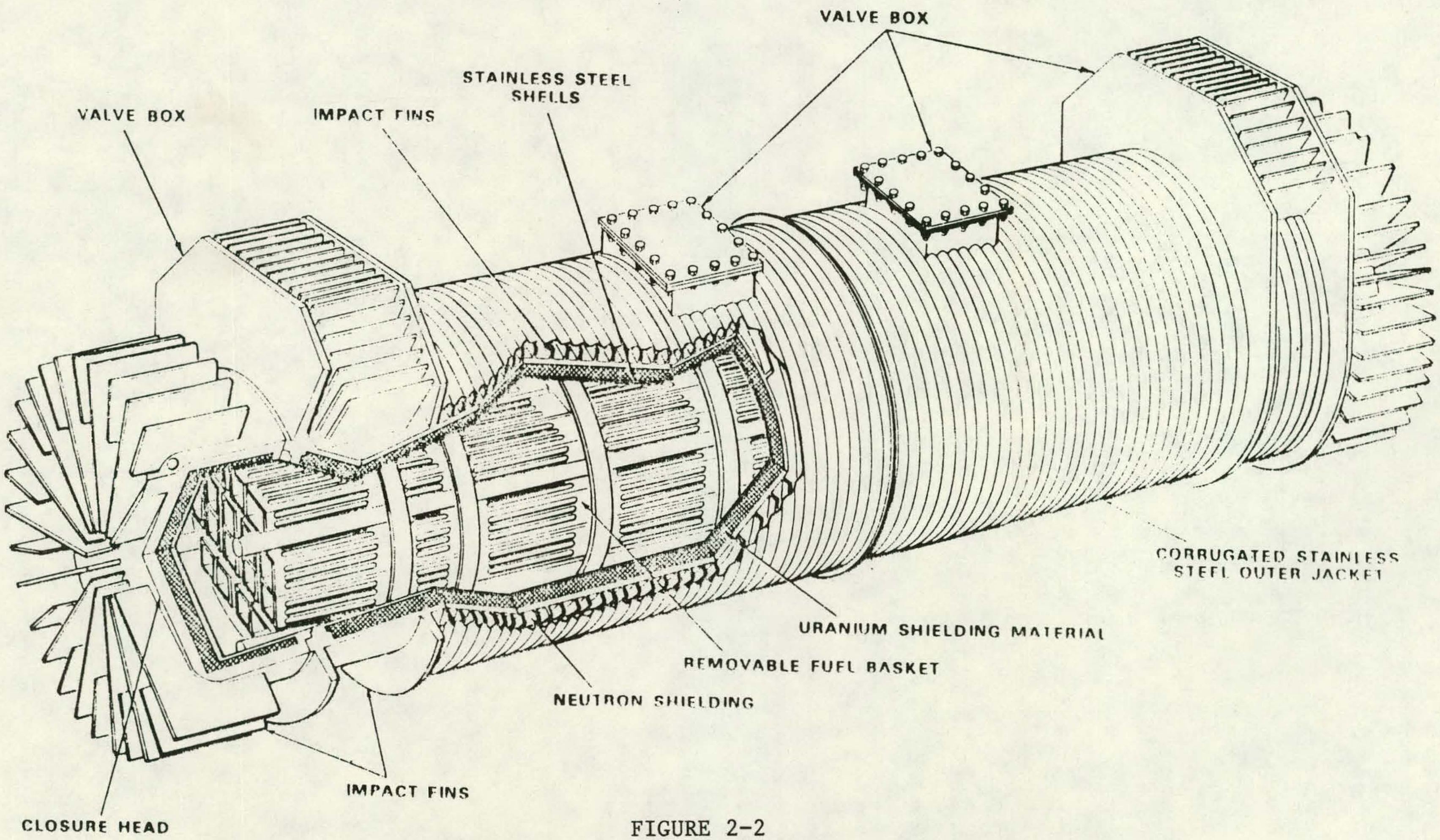

FIGURE 2-2

IF-300 SPENT FUEL SHIPPING CASK

3.0 CASK STATUS AND OPERATIONAL EXPERIENCE

A total of four GE IF-300's were fabricated at the Stearns-Rogers facility in Denver, Colorado, for General Electric (GE). These packages were placed in service in the 1973-75 time period. This package was the first current generation LWR fuel rail cask to be licensed. These casks have seen considerable service in the last two to three years.

Operational shipments to date have primarily been to the GE Spent Fuel Storage Facility in Morris, Illinois. Both BWR fuel and PWR fuel have been shipped.

Carolina Power and Light purchased one of the IF-300's for interstation transport of fuel between the H. B. Robinson Plant, Hartsville, South Carolina, and the Brunswick, North Carolina, Nuclear Plants. The initial shipments were in 1977 and encompassed about 12 round trips. It was necessary to develop a redundant lifting system for these facilities to meet NRC site criteria.

4.0 FUEL COMPATIBILITY

The General Electric Company's IF-300 Spent Fuel Shipping Cask is designed and licensed to transport LWR spent fuel assemblies fabricated by domestic fuel designers with the following limitations. The Certificate of Compliance limits the maximum uranium content per PWR type assembly to 457 kilograms of uranium. PWR fuel fabricators, such as Westinghouse and Babcock & Wilcox, produce assemblies with uranium loadings up to 470 kilograms of uranium. IF-300 spent fuel shipments, using air as a primary coolant, restrict maximum burnups of 19,200 MWd/MTU for BWR type assemblies and 28,500 MWd/MTU for PWR type assemblies. Safety analysis review design criteria are based on maximum fuel pin arrays of 7 x 7 for BWR type and 15 x 15 for PWR type assemblies. All major fuel designers produce assemblies with more individual fuel pins. The IF-300 fuel baskets are large enough to house the newer 8 x 8 (BWR) and 16 x 16 (PWR) assemblies. Table 4-1 describes the design criteria of unirradiated fuel assemblies used by the major domestic manufacturers. Table 4-2 lists the specific capabilities of the IF-300 package system.

TABLE 4-1

FUEL DESIGNERS' DESCRIPTION OF UNIRRADIATED FUEL ASSEMBLIES

FUEL DESIGNER	FUEL-PIN GRID ARRAY	FUEL ASSEMBLY CROSS SECTION (NOMINAL)	ACTIVE FUEL LENGTH (NOMINAL)	ENRICHMENT % U-235 (MAXIMUM)	ASSEMBLY LOADING (NOMINAL)
Westing-house	15 x 15	8.426" x 8.426"	144"	3.5	466
	17 x 17	8.426" x 8.426"	144"	3.5	468
Babcock and Wilcox	15 x 15	8.536" x 8.536"	141" - 144"	3.5	470
	17 x 17	8.536" x 8.536"	141" - 144"	3.5	470
Combustion Engineering	14 x 14	8.180" x 8.180"	136.7"	3.5	395
	16 x 16	8.180" x 8.180"	150"	3.5	438
General Electric	7 x 7	5.438" x 5.438"	144" - 146"	3.0	197
	8 x 8	5.518" x 5.518"	144" - 150"	3.3	200

TABLE 4-2

FUEL COMPATIBILITY MATRIX

CASK	IF-300 Water Coolant	IF-300 Air Coolant
Criticality Basis % Enrichment		
PWR	4.0	4.0
BWR	3.5	3.5
Uranium Content per Assembly (kg)		
PWR	457	457
BWR	197	197
Shielding Study Basis Burnup MWd/MTU		
PWR	35,000	28,500
BWR	35,000	19,200
Power Production kW/kg U		
PWR	40	40
BWR	40	40

(1) The minimum cooling time for each assembly shall be no less than 730 days when air is used as primary coolant.

5.0 GENERIC UNLOADING PROCEDURE

This section of the report presents a simplified, generalized unloading procedure. The thirty-two steps abstracted in this procedure have been utilized as the baseline for both the time and manpower assessment (Section 6.0) and the radiological exposure study (Section 7.0).

1. Perform the radiological inspection required by DOT and record the results as directed in the approved procedure of the receiver (promptly upon notification of the arrival of the cask system).

2. Perform a system safety inspection as directed by the approved procedure of the receiver and the cask owner. Record results of this inspection as per procedure.

3. Obtain the lock combination and remove the locks. Slide the personnel barrier together to expose the cask.

4. Complete a contamination and radiological survey of the cask.

5. Move to washdown pad, wash, and move unit into unloading bay.

6. Shut down cooling engines if operating and move the air ducts away from the side of the cask.

7. Remove the cask tie-down pins and install the lifting trunnions.

8. Remove the two valve box covers.

9. Using the companion yoke for the cask, rotate the cask to the vertical position, raise it from the rail car, and set it down in the designated work station.

10. Monitor cask temperature and pressure, sample, and obtain results.

11. Attach water flush lines and flush cask interior.

12. Loosen and remove the specified number of head nuts.

13. Attach head slings to the lifting yoke and then, with the yoke suspended over the cask, attach slings to the head. Adjust sling tension using turnbuckles to attain equal strain on each leg for a level lift off.

14. Attach lifting yoke to the cask and move it to the unloading pool. At the pool surface, remove remaining head nuts.

15. Lower cask to set-down position in the unloading area.

16. Remove the yoke, then center the yoke over the trunnions and raise the yoke bringing the head with it. Store and detach head from lift yoke.

17. Operate the fuel assembly grapple from the cask unloading crane working platform. Verify each fuel assembly and transfer it to a preassigned storage location.

18. Reengage cask with the lift yoke and transfer cask to the decontamination area.

19. Replace the head. While torquing the head nuts, observe specifications and sequence.

20. Drain the cask inner cavity. Flush with about two cask volumes of water.

21. Remove fill and drain lines and verify valves are closed.

22. Decontaminate accessible cask surfaces to DOT specifications.

23. Make certain that cask ventilation ducts are moved out of the cask path.

24. Return cask to rail car and remove lifting yoke.

25. Remove lifting trunnions.

26. Install cask tie-down pins.

27. Replace both valve box covers.

28. Return cooling ducts to operating position.

29. Have all radiological inspections and surveys completed and record results.

30. Verify proper placarding and labeling. Close and lock the personnel barrier.

31. Complete shipping papers and trip pack.

32. Sign off by designated individuals for release.

6.0 TIME AND MANPOWER ASSESSMENT

This assessment is correlated directly to the generic procedure presented in Section 5.0. The data were developed based on previous dry-run unloading operations held at the BNFP. A total crew of five (including three operators, one HP technician, and a crane operator) was employed. A supervising engineer monitored the procedure. A 15 percent contingency was utilized based on actual stopwatch time to account for minor delays and the fact that operators would be in anticontamination clothing.

Cask Receiving and Handling Sequence	Estimated Clock Operating Time (Minutes)	Manpower Requirements (Includes 1 HP Technician)
1. Receiving inspection consisting of: Inspecting general conditions, radiation survey, check receiving papers, remove personnel barrier, contamination survey, obtain survey report. Generic procedure Steps 1 through 4.	105	1
2. Move to wash down pad, wash, move unit into unloading bay. Shut down cooling engine. Step 5.	82	3
3. Remove tie-downs, install lifting trunnions, move into T&D pit. Steps 6 through 9.	88	3
4. Check pressure and temperature, sample and obtain results. Step 10.	72	3
5. Connect lines, flush and fill cavity, disconnect lines, loosen head nuts, install protective sleeve. Steps 11 and 12.	247	3
6. Attach yoke and position cask in CUP, remove yoke and head. Steps 13 through 16.	72	3
7. Move canister into position, identify fuel assembly, unload fuel, move canister. Step 17.	176	3
8. Return cask to T&D pit, wash cask, remove water from cask, replace head, remove sleeve, air pressurize cavity to remove all water. Steps 18 through 21.	388	4

Cask Receiving and Handling Sequence	Estimated Clock Operating Time (Minutes)	Manpower Requirements (Includes 1 HP Technician)
9. Perform decontamination, survey and obtain results. Steps 22 and 23.	706	4
10. Return cask to carrier, secure and tie down bolts, replace valve covers, move to parking lot. Steps 24 through 28.	141	3
11. Final survey, install personnel barrier, complete shipping papers. Steps 29 through 32.	72	1
Operating Time	2149 minutes 35:50 hours	

7.0 RADIOLOGICAL EXPOSURE STUDY

A generic study to estimate the maximum radiological exposure to accomplish the turnaround of the IF-300 cask was calculated using the following data. Estimates of the working distances necessary to perform the unloading steps were calculated from previous experience in cask handling and comparing the time and manpower estimates projected by the AGNS Operations Department. The time estimates were also compared with turnaround times actually experienced at other facilities. Dose rate exposure estimates were obtained from the IF-300 safety analysis computer studies (Reference General Electric Maintenance Manual NEDO-10084-1), the maximum allowable dose rates for packages prescribed in 49 CFR 173, and the estimated background radiation anticipated at the fuel handling facility. Table 7-1 is a copy of the time and manpower evaluation estimated by AGNS production personnel.

TABLE 7-1

RADIOLOGICAL EXPOSURE STUDIES
(PER UNLOADING OPERATION)

LOCATION OF SHIPMENT	NUMBER OF PERSONS	ESTIMATED mrem/HR	MINUTES EXPOSURE TIME	EXPOSURE TOTAL mrem
1. Receive rail car and position near FRSS.	4	0.5	30	1
2. Inspect, survey, and remove personnel barrier	2	14	10	5
	1	25	10	4
3. Wash down and move to bay	1	8	8	1
4. Remove tie-downs, install trunnions, and move cask to T&D pit	1	35	20	23
	1	20	8	3
5. Pressure, temperature, and sampling operations	1	20	12	4
	1	40	15	10
6. Cooldown and untorquing head	2	25	165	138
	1	70	12	14
7. Fuel pool handling	1	50	10	8
8. Reassemble and decontaminate	2	8	60	16
	2	2	300	20
				247 mrem

8.0 SPECIAL TOOLS AND ANCILLARY EQUIPMENT

The following information was derived from General Electric Instruction Manual GE192817, November 1973. This equipment is normally supplied by General Electric during a fuel shipping campaign.

(1) Cask tie-down pin removal tool (P/N M22-21).

(2) Trunnion hoisting mechanism. Trunnions are removed from the cask during transit and this tool is a special sling used in the removal and repositioning of trunnions.

(3) Lifting yoke - single lift. Fixed "J" hooks.

(4) Tag lines for lifting yoke.

(5) Lifting yoke system for redundant lifting. One yoke serves the two upper trunnions as in conventional lift. The other is equipped with air-driven pins and screws which accomplish mating with upward extensions from a basket in which the cask sits.

(6) Bottom spacer removal tools. One each for PWR and BWR spacers. They differ in their latching schemes in that the former features a threaded attachment and the latter a keyhole for insertion-and-turn attachment.

(7) Flange face shield (P/N M32-17). A sealing surface protective ring, plus handling slings.

(8) Temperature recorder. This one is used to check alarm system when cask is on the car. Probably also can be used for requirement 11(d). Specified for use with type K thermocouple wire.

(9) Yoke adaptor. Used at the Morris unloading pool to avoid immersing the crane block.

(10) Cask set-down plate. Metal or wood; protects cask bottom from having dirt imbedded if set-down location is not clean.

(11) Cask pressure testing system, consisting of:

  (a) Pressure guage, mounted on the branch of a "T" with q.d.'s (quick disconnect fitting) on the other two ends.

  (b) High pressure pump (approximately 200 psig) with inlet and outlet valves, and H.P. hoses with q.d.'s.

  (c) Low pressure hoses with q.d.'s.

  (d) Temperature recorder for type K thermocouple wire hot junction.

(12) Sample valve and container for coolant water.

(13) Head stand for head storage and seal ring isolation. Typically consists of three wooden blocks, 9-inch cubes, arranged 120° apart on a common base.

<u>NOTE</u>: Items 10, 12, and other minor supports, stands, etc., are typically supplied by the utility at the loading facility.

9.0 GENERAL ASSESSMENT OF OPERATIONAL CHARACTERISTICS

The IF-300 spent fuel cask system has been employed successfully for a number of fuel transfers. Experience with this package system comprises the vast bulk of all experience with current generation rail casks. The comments made in this section are not intended to be in the vein of petty criticism. Rather, based on our experience with this system and comparison with other similar equipment, the intent is to highlight areas of possible improvement and to illustrate differences between this system and comparable packages. The IF-300 is a workable system, verified in practice, and there is no intent to present implications to the contrary.

9.1 Package Design Characteristics

The IF-300 packages have been used for fuel transfers over a four-year period. Most of the operational problems have been resolved. This assessment will focus on general areas of operational concern related to the package design.

9.1.1 Specific Areas of Improvement

The following items relate to general areas of long range improvement to the IF-300 packaging system. (These areas are not necessarily unique to the IF-300 but in certain instances are common to most package systems.)

- Decontamination - Handling operations with all current spent fuel casks involve lowering the cask into a contaminated spent fuel pool. Many hours of operational time are expended which impact considerably on the transportation cost of fuel. Additionally, operator radiological exposure is increased. The IF-300, though not unique in this area, requires from 6 to 20 hours of decontaminatin time prior to shipment from both the loading and unloading sites. There are two ways to circumvent this problem:

  (a) Contamination barrier - a plastic or metallic cover which surrounds the body of the cask.

  (b) Dry unloading facility or clean well - the facility design includes a means of unloading the cask without lowering it into a contaminated pool.

  It is felt that a contamination barrier, designed specifically for this package, would offer clear benefits in turnaround time and operator exposure. Its use could lower our estimate of the cask turnaround time by about 10 hours (see Section 6.0).

- Closure Head Torquing - The nature of the closure head seal (GREYLOC) and the torquing/untorquing requirements for the 28 studs result in considerable time being expended in torquing and untorquing the closure head. Based on prior experience, upwards of 3 to 3-1/2 hours is spent at both the loading and unloading site performing these operations. During this procedure, at least two operators are in close proximity to the radiation field of the cask. General Electric has instituted improvements by using a Hy-Shear® torquing system. It is felt that there is room for additional improvement in this area.

- Crud Traps - The design of the cask basket fuel cavity and internals is susceptible to crud (solid radioactive waste from fuel assemblies, etc.) buildup. A means of removing this crud is required. This is of particular importance if maintenance of these areas is required at a later date.

9.1.2 Design Comparisons with Other Casks

The IF-300 has certain design characteristics that vary with other packaging systems being evaluated. This section presents a brief description of these unique characteristics and the relative means:

- Impact Limiter - Most current generation casks employ separate impact protection in the upper and lower head region to cushion the package during the hypothetical 30-foot drop test. The IF-300 employs shock-absorbing fins integral with the cask. This is a distinct handling improvement in that there is no space problem associated with storage of bulky limiters. Additionally, considerable time is saved since there is no need to bolt/unbolt these limiters prior to removing and replacing the cask on the car or trailer. A disadvantage of this concept is the added time required to decontaminate this region of the cask.

- Wet Fuel Cavity - The IF-300 can be shipped with the fuel cavity either water-filled (wet) or air-filled (low decay heat fuel). Wet shipment results in lower fuel temperatures upon arrival at the unloading facility. There is no need to drain the cavity and dry it out. However, the water coolant must be sampled for activity at both the loading and unloading site. There is also a requirement to monitor the coolant temperature and pressure at loading/unloading sites. This operation is dispensed within a dry cask.

- Single Closure Head - Some casks utilize two closure heads in series. The IF-300 has one. This decreases the time involved in handling of closure heads. Alternatively, the rationale for two closures (double containment) is increased safety during shipment and protection of cask service valves.

- Intermodal Capability - The IF-300 shipping package is mounted on a transport skid which in turn is fastened to the rail car. This offers the operator of the loading/unloading facility the capability of receiving this package when the plant site is not serviced by a railroad. A disadvantage is the added shipping weight of the skid which is mounted to the rail car.

- Single Trunnion Pair - Many casks have four lifting trunnions (two pairs) to allow coupling with a redundant lifting system. The IF-300 has a single pair. Since redundant yokes are necessary at many plant sites, this has resulted in equipment for the IF-300 that is more cumbersome (but workable) than those of packaging systems with four trunnions.

9.2 Facility Interface

Unique aspects of the IF-300 cask emphasize certain facility interface conditions. These conditions are crucial to successful operation with this packaging system. Several of the areas common to the IF-300 are noted here:

- Space Requirements - Adequate space within the reactor or auxiliary building is required to accommodate the rail car and to assure proper lifting clearance when removing the cask from the car. Laydown space is also required for placement of auxiliary tools, space for decontamination of the cask exterior, testing of the fuel cavity, and storage of yokes.

- Crane Requirements - Obviously the crane must be adequately sized and have sufficient capacity for the cask lifting. A continuing problem is the submerging of carbon steel hoist blocks into the pool. A variety of adapters, covers, etc., have been developed. Two accessories which offer considerable convenience are:

  (a) Rotating Hook - allows turning of the cask while on the hook

  (b) Radio controlled cranes - this offers the operator greater control of the load.

- Adequate Scaffolding - Servicing operations on the cask can be greatly enhanced by using scaffolding specifically designed for the cask. This scaffolding should be rigid and have adequate space to accomplish the various handling requirements including localized decontamination. Proper scaffolding is of particular importance in a large rail cask such as the IF-300 where the effective circumference around the exterior is about 20 feet.

- Underwater Viewing - Replacement of the closure head and loading/unloading operations are difficult when performed under 20 to 40 feet of water. Visual clarity can be greatly enhanced by the use of remote TV cameras.

REPORT NO. AGNS-1040-1.1-28

OPERATIONAL ASSESSMENT OF THE GENERAL ELECTRIC IF-300 RAIL SPENT FUEL CASK

ATTACHMENT A

TRIP REPORT TO GENERAL ELECTRIC, MORRIS, MAY 2-3, 1978

Allied-General Nuclear Services
Post Office Box 847
Barnwell, South Carolina 29812

ATTACHMENT A

TRIP REPORT TO GENERAL ELECTRIC, MORRIS, MAY 2-3, 1978

J. B. Maier; P. N. McCreery; P. F. Highberger

REFERENCES

Sub-Task 1.1 - Spent Fuel Cask Evaluation
Sub-Task 1.2 - Simulated LWR Spent Fuel Receiving
Sub-Task 1.3 - Assessment LWR Spent Fuel Transportation Systems
Sub-Task 1.5 - Fleet Servicing Facility

TRIP REPORT

General Electric uses a three-man crew to unload and store fuels. Utilities loading the fuel casks use four- to six-man crews. Manpower requirements are affected by facility design, administrative procedures, union agreements, and available equipment. Cask turnaround time is influenced by those factors, but affected mainly by inclement weather, job priority at the site, working conditions and workers' attitudes, planning and coordination, and experience in cask handling. The IF-300 can be turned around in 30 hours but averages about 48 hours during a campaign. Recent GE-Morris studies addressing the IF-300 cask handling operations of that facility averaged 140 mrem's per shipment. Annual exposures may average 0.5 manrems/MTU of fuel received and stored. The "hidden costs" are those age-old problems of the reprocessing and fuel storage facilities. Corrosion crud from the fuel elements: as fuel is moved to the storage canisters, corrosion fines shake loose, contaminating the cask basket, cask horizontals and pool. The cask radiation levels increase from crud in the basket, the crud usually restricts draining; drain hoses and basket decontamination become routine exposure problems. The fines increase decon time of the cask. The pool levels increase; additional filtration and back flushing are necessary to maintain water quality and exposure, which in turn increases exposure from the water treatment and filter areas and associated piping. General Electric controls contamination levels at 220α and 2200 β-gamma dpm/100 cm^2 in work areas. The cask decontamination area, water treatment and filter rooms have exceeded control levels.

Specific details developed regarding cask handling:

(1) The time required to drain the cask is two hours.

(2) After draining, the cask is flushed with two volumes (1600 gallons) of water at a throughput rate of 30 gallons per minute. Approximately two gallons of water left in the cask must be forced out by air pressure.

(3) The time interval for head torquing is reduced by using two Hy-Shear® wrenches at their maximum capacity of 700 foot-pounds until just before complete closure is achieved, then torquing only to the specified 375 foot-pounds the last few times around. Wrench failure rate is very high when used at 700 foot-pounds. The median torquing time is about 1.5 hours.

(4) No specific chemical is specified for decontamination. Robinson uses a Turco® cleaning solution. One shift at Morris uses tri-sodium phosphate. Average decontamination time is 20 hours.

(5) The dose at the top of an empty cask with head off and no water in the cavity is about 2 rem per hour. At the bottom of an empty basket, radiation levels as high as 200 rem per hour were recorded.

(6) No estimate is available on the quantity of crud that accumulates in the bottom of the cavity. It does accumulate, it is difficult to remove, and it creates a significant dose rate problem for the cleaning crew.

(7) No significant improvements have been made recently to cask handling. A special tool is now available for handling the heavy extension bolts. This tool resembles miniature ice tongs. New trunnion blocks, with trunnions offset one inch from the cask center line, result in the cask hanging truly vertical from the lifting yoke. The cranes at Morris are now radio controlled; scaffolding far superior to anything available at AGNS was recently installed following a minor (no lost time) accident.

(8) The redundant yoke system is now operative. It is rather complex, with both electrical and air actuated systems. If the set-down area of the pool is not of the same slope as the floor of the decontamination pad (or wherever the initial setup is made), the cask must be lifted from the floor of the pool with the trunnion-engaging yoke before the redundant system will align for engagement.

(9) An average time for either loading or unloading the IF-300 is 48 working hours. Twenty of these hours are for decontamination.

(10) Problem areas, other than those already mentioned, are operator training and head positioning. At the beginning of the head positioning step, there is a significant radiation streaming problem through the main seal, when only two inches of steel provide shielding. In order to mitigate this streaming problem, General Electric has built a metal ring that sits on the closure flange, encircles the cask body, and provides two inches of lead shielding.

(11) Draining the cask presents occasional radiation exposure problems. Lead sheets are sometimes used to reduce exposure, and hoses are discarded when they affect the area dose rate levels.

(13) Water quality at Morris is good; gamma activity averages 5 x 10^{-4} μCi/cc.

(14) They have no algae or bacteria problems. No water treatment for algae except pH maintained at less than 7.

(15) Copies were received of the Master Maintenance, Inspection, and Test Schedule, as well as listings of special and standard tools.

(16) Upon return to Barnwell, ACNS formally requested a copy of the IF-300 Maintenance Manual on letterhead stationery.

(17) AGNS was given a copy of the IF-300 Operating Procedure.

(18) Seal rings can be reused up to 5 times -- possibly as many as 12.

(19) If General Electric or a user damages a sealing surface, that surface must be dressed by Gray Tool Company, an expensive operation. The other two companion surfaces must likewise be dressed to the same diameter.

(20) General Electric has reduced exposure from radioactive cesium deposited in lines by flushing with solutions of stable cesium. Reduction in activity was much greater than expected and unexplained.

REPORT NO. AGNS-1040-1.1-28

OPERATIONAL ASSESSMENT OF THE GENERAL ELECTRIC IF-300 RAIL SPENT FUEL CASK

ATTACHMENT B

CERTIFICATE OF COMPLIANCE NO. 9001

Allied-General Nuclear Services
Post Office Box 847
Barnwell, South Carolina 29812

Form NRC-618
(12-73)
10 CFR 71

U.S. NUCLEAR REGULATORY COMMISSION
CERTIFICATE OF COMPLIANCE
For Radioactive Materials Packages

1.(a) Certificate Number	1.(b) Revision No.	1.(c) Package Identification No.	1.(d) Pages No.	1.(e) Total No. Pa
9001	5	USA/9001/B( )F	1	3

2. PREAMBLE

2.(a) This certificate is issued to satisfy Sections 173.393a, 173.394, 173.395, and 173.396 of the Department of Transportation Hazard Materials Regulations (49 CFR 170-189 and 14 CFR 103) and Sections 146–19–10a and 146–19–100 of the Department of Transportation Dangerous Cargoes Regulations (46 CFR 146–149), as amended.

2.(b) The packaging and contents described in item 5 below, meets the safety standards set forth in Subpart C of Title 10, Code of Federal Regulations, Part 71, "Packaging of Radioactive Materials for Transport and Transportation of Radioactive Material Under Certain Conditions."

2.(c) This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies, including the government of any country through or into which the package will be transported.

3. This certificate is issued on the basis of a safety analysis report of the package design or application—

3.(a) Prepared by (Name and address):

General Electric Company
175 Curtner Avenue
San Jose, California 95125

3.(b) Title and identification of report or application:

GE application dated February 22, March 6 and 12, 1973, as supplemented.

3.(c) Docket No. 71-9001

4. CONDITIONS
This certificate is conditional upon the fulfilling of the requirements of Subpart D of 10 CFR 71, as applicable, and the conditions specified in item 5 below.

5. Description of Packaging and Authorized Contents, Model Number, Fissile Class, Other Conditions, and References:

(a) Packaging

(1) Model number: IF-300

(2) Description

A stainless steel encased, depleted uranium shielded cask. The cask is cylindrical in shape, 64 inches in diameter and a maximum of 210 inches long with maximum cavity dimensions of 37-1/2 inches in diameter by 180-1/4 inches long. Shielding is provided by 4 inches of depleted uranium, 2-1/8 inches of stainless steel and a minimum of 4-1/2 inches of water.

Two closure heads are provided for the shipment of BWR and PWR fuel assemblies. The heads are 304 stainless steel forgings and end plates which encase the 3-inch thick depleted uranium shielding.

The closure heads are secured to the cask body by means of 32, 1-3/4 inch studs. The cask is sealed with a metallic ring gasket.

5. (a) Packaging (continued)

(2) Description (continued)

The cavity is penetrated by a vent line at the top and a drain line at the bottom. These lines are sealed by bellows seal stainless steel globe valves and valved quick-disconnect couplings. The vent line is also equipped with a 375 psig refief valve. All valves are housed in protected boxes on the caks exterior.

Neutron shielding is provided by a liquid-filled, thin-walled, corrugated containment on the cask exterior. This cylindrical structure is separated into two longitudinal compartments, each equipped with two expansion tanks, fill and relief valves. The fill line from each compartment is terminated by a stainless steel globe valve in a protected box (separate from cavity boxes) on the cask exterior. The vent line from each compartment goes to an expansion tank which is provided with a pressure relief valve set at 200 psig.

The cask has two types of fuel baskets which can be interchanged to accommodate various fuels. The PWR basket holds 7 assemblies, the BWR basket hold 18 assemblies.

The cask is shipped horizontally with the bottom supported in a tipping cradle between two pedestals and the upper end resting in a semi-circular saddle; the upper end is pinned to the saddle. The cask supports are welded to the framing of a 37-1/2-foot long by 8-foot wide structural steel skid. The skid also holds the cask cooling system which consists of two diesel engines driving two blowers which discharge into common ducting. Four ducts run the length of the cask and direct cooling air to the corrugated surface. Operation of the auxiliary cooling system is not a requirement of this package approval.

The entire cask and cooling system is covered by a retractable aluminum enclosure. Access to the enclosure is via locked panels in the side and a locked door in one end. Although the IF-300 can be transported for short distances on the highway, its principal mode of transportation is by railroad.

5. (a) Packaging (continued)

(2) Description (continued)

The gross weight of the cask is approximately 140,000 pounds. The skid and other external components weigh approximately 35,000 pounds.

(3) Drawings

The Model No. IF-300 shipping cask is described by the following General Electric Company Drawing No.: 159C5238-Sheets 1 thru 3, Rev. 2; Sheets 4 thru 5, Rev. 4; Sheet 6, Rev. 2; Sheet 7, Rev. 3; Sheet 8, Rev. 3 or 4; and Sheet 9, Rev. 3.

(b) Contents - water as primary coolant

(1) Type and form of material

Irradiated PWR or BWR uranium oxide fuel assemblies. The specific power of each fuel assembly shall not exceed 40 kw/kgU and the burnup of each fuel assembly shall not exceed 35,000 MWD/MTU. The minimum cooling time of each assembly shall be no less than 120 days. Prior to irradiation, the PWR and BWR fuel assemblies have the following dimensions and specifications:

	PWR	BWR
Fuel form	Clad UO_2 pellets	Clad UO_2 pellets
Cladding material	Zr or SS	Zr or SS
Maximum initial U content/assembly, kg	457	197
Maximum initial U-235 enrichment, w/o	4.0	3.5
Maximum bundle cross section, inches	8.75	5.75
Fuel pin array	14x14/15x15	7x7
Fuel diameter, inch	0.380-0.460	0.500-0.600
Fuel pin pitch range, inch	0.502-0.582	0.647-0.809
Maximum active fuel length, inches	144	144

5. (b) Contents - water as primary coolant (continued)

The assemblies may be shipped with or without burnable poison rods or control rods.

(2) Maximum quanity of material per package

Maximum decay heat per package not to exceed 210,000 Btu/hr. Maximum 37,500/Btu/hr/PWR assembly. Maximum 14,600/Btu/hr/BWR assembly.

Seven (7) PWR fuel assemblies, or eighteen (18) BWR fuel assemblies.

Above assemblies to be contained in their respective fuel baskets are shown in GE Drawing No. 159C5238-Sheet 6, Rev. 2.

(c) Contents - air as primary coolant

(1) Type and form of material

Irradiated PWR and BWR uranium oxide fuel assemblies. The specific power of each fuel assembly shall not exceed 40 Kw/KgU and the maximum burnup shall not exceed 19,200 and 28,500 MwD/Mtu for BWR and PWR fuel assemblies, respectively. The minimum cooling time of each assembly shall be no less than 120 days. Prior to irradiation, the BWR and PWR fuel assemblies shall have the following dimensions and specifications:

	PWR	BWR
Fuel form	Clad UO_2 pellets	Clad UO_2 pellets
Cladding material	Zr or SS	Zr or SS
Maximum initial U content/assembly, kg	457	197
Maximum initial U-235 enrichment, w/o	4.0	3.5
Maximum bundle cross section, inches	8.75	5.75
Fuel pin array	14x14/15x15	7x7
Fuel diameter, inch	0.380-0.460	0.500-0.600
Fuel pin pitch range, inch	0.502-0.5[illegible]	0.647-0.809

5. (c) Contents - air as primary coolant (continued)

	PWR	BWR
Maximum active fuel length, inches	144	144

The assemblies may be shipped with or without burnable poison rods or control rods.

(2) Maximum quantity of material per package

Maximum decay heat per package not to exceed 40,000 Btu/hr. Maximum 5,725 Btu/hr/PWR assembly. Maximum 2,225 Btu/hr/ BWR assembly.

Seven (7) PWR fuel assemblies, or eighteen (18) BWR fuel assemblies.

Above assemblies to be contained in their respective fuel baskets as shown in GE Drawing No. 159C5238-Sheet 6, Rev. 2.

(d) Fissile Class I

6. The end of life (after irradiation) fuel pin pressure shall not exceed 1,800 psia, at 900°F.

7. The maximum gross weight of the cavity contents shall not exceed 21,000 pounds.

8. (a) For the contents described in 5(b) (water coolant) the cavity fill specifications shall include the following: A 21.0 cu ft cavity air void shall be established for PWR and BWR loadings. These air voids are established when the bulk water temperature is at 100°F for both the PWR and BWR loadings. If less than the maximum number of fuel assemblies is loaded into the basket, a void displacement equivalent to the missing fuel assemblies shall be inserted into the basket. In addition, the licensee shall take sufficient time-temperature-pressure data to show that the cavity pressure will not exceed 346 psig during a 130°F day with no auxiliary cooling. Under freezing conditions, the minimum heat load shall be 36,400 Btu/hr when water is used as the primary cavity coolant.

(b) For the contents described in 5(c) (air coolant) the cavity fill specifications shall include the following: An air void shall be established such that not more than 0.420 cu ft of water (corresponding to a bulk water temperature of 70°F) remains in the cavity for the PWR loading and not more than 0.605 cu ft of water (corresponding to a bulk water temperature of 70°F) remains for the BWR loading. The licensee shall take sufficient time-temperature-pressure data to ensure that the cavity pressure will not exceed 45 psig, and that the average cavity wall temperature will not exceed 210°F during the 130°F day with no auxilary cooling.

9. A determination shall be made for each water coolant shipment (for contents described in 5(b) that the total radioactivity of the primary coolant will not exceed, during the anticipated period of transport, the limits specified in § 71.36(a)(2) of 10 CFR Part 71. This determination shall include monitoring of the coolant and verification of the coolant activity upon arrival of the package at its destination. Records of such determinations shall be maintained for a period of two years after its generation.

10. Prior to each shipment, the licensee shall confirm that the cask is properly sealed by testing as stated in Appendix D4A, GE letter dated August 13, 1973.

11. The cask contents shall be so limited that under normal conditions of transport, 111 times the neutron dose rate plus 11.3 times the gamma dose rate will not exceed 1,000 mrem/hr at three (3) feet from the external surface of the cask.

12. The neutron shielding tanks shall be filled with water during the months of May through October and a 50/50 mixture of ethylene glycol and water during the months of October through May if the total package decay heat is greater than 183,400 BTU/hr (70% of design basis). If the total package decay heat is less than 183,400 BTU/hr the ethylene glycol and water mixture may remain in place all year.

13. In addition the requirements of Subpart D of 10 CFR Part 71, each package prior to first use shall meet all of the acceptance tests and criteria specified in the Thermal Acceptance Procedure of Appendix B4A-2, GE letter dated September 3, 1975. The following item in the Thermal Acceptance Procedure is changed as follows:

    6. Delete second paragraph.

14. The maximum allowable heat load shall be documented for each cask and conspicuously and durably marked on the cask.

15. Each cavity relief valve, typical globe valves, and typical shielding tank (barrel expansion tank) relief valves shall be tested as stated on page B-1-1, GE Letter dated August 13, 1973, with the following exception to the cavity relief valve test: the minimum water flow valve at 10 psi overpressure will be eliminated and the minimum flow valve at 37.5 psi (10%) overpressure will be reduced to 3.0 gpm. Valve testing and maintenance frequency shall be as stated on pages B-1-5 and B-1-6, GE letter dated August 13, 1973 except during periods of cask inactivity. During inactive periods the maintenance and testing frequency may be disregarded provided that the package is brought into full compliance with the requirements of the GE letter of August 13, 1973 prior to the next use of the package. Relief valve cracking pressure tolerance for periodic testing shall be +15, -5 psi at room temperature, repeatable within 1% over 10 test cycles.

16. The cask cavity shall be equipped with a Target Rock 73J pressure relief valve set at a pressure of 375 psig (450°F). The valve is shown in Target Rock Corporation Drawing No. 73J-001, Rev. H.

17. The uranium shielding material shall be separted from all steel surfaces with a minimum cooper thickness of 4-mils.

18. The package shall be procured, fabricated, accepted, operated, maintained, and repaired in accordance with General Electric Company IF-300 Spent Fuel Shipping Cask Quality Assurance Plan Summary, Revison No. 1, February 16, 1973.

19. For casks using air as the primary coolant, the cavity pressure relief valve specified in Item 15 shall be installed and operating during the cooldown prior to unloading.

20. No shutoff valve shall be installed between each neutron shield tank and its respective thermal expansion tank.

21. The package authorized by the certificate is hereby approved for use under the general license provisions of Paragraph 71.12(b) of 10 CFR Part 71. Fabrication under the general license is not authorized.

22. Expiration date: December 31, 1979.

REFERENCES

General Electric Company consolidated application dated February 22, March 6 and 12, 1973, to authorize delivery of radioactive material to a carrier for transport in the IF-300 shipping package.

Supplements dated: August 13 and 27, September 4, December 14 and 26, 1973; January 18 and 28, March 14 and 20, June 7, July 5 and 12, September 3, and December 12, 1974; May 9, September 3, 9, and 23, and November 19, 1975; September 1 and November 16 (DMD-92) and 16 (DMD-93), 1976; and February 1, 1977.

Documentation of maximum package heat load as determined by Item 13 above.

FOR THE NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald

Charles E. MacDonald, Chief
Transportation Branch
Division of Fuel Cycle and
Material Safety

Date: MAR 4 1977

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