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Revision 0

Evaluation of Transportation Options for Intermediate Non-destructive Examinations

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Gary Hoggard

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The INL is a U.S. Department of Energy National Laboratory
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ACRONYMS

AFC	Advanced Fuel Cycle
ASTM	American Society for Testing and Materials
ATR	Advanced Test Reactor
BEA	Battelle Energy Alliance
BRR	BEA Research Reactor
COC	Certificate of Compliance
CRADA	Cooperative Research and Development Agreement
DOE	Department of Energy
DOT	Department of Transportation
DTC	Dry Transfer Cubicle
FY	fiscal year
GE-HNE	General Electric-Hitachi Nuclear Energy
GTRI	Global Threat Reduction Initiative
HFEF	Hot Fuels Examination Facility
INL	Idaho National Laboratory
MWD	megawatt days
NDE	non-destructive examinations
NRC	Nuclear Regulatory Commission
SARP	Safety Analysis Report for Packaging
VHTR	Very High Temperature Reactor

Evaluation of Transportation Options for Intermediate Non-destructive Examinations

INTRODUCTION

Background

Idaho National Laboratory (INL) shipments of irradiated experiments from the Advanced Test Reactor (ATR) to the Hot Fuels Examination Facility (HFEF) have historically been accomplished using the General Electric Model 2000 (GE 2000) Type B shipping container. Battelle Energy Alliance (BEA) concerns regarding the future availability and leasing and handling costs associated with the GE 2000 cask have warranted an evaluation of alternative shipping options. One or more of these shipping options may be utilized to perform non-destructive examinations (NDE) such as neutron radiography and precision gamma scans of irradiated experiments at HFEF and then return the experiments to ATR for further irradiation, hereafter referred to as "intermediate NDE."

Scope

This evaluation includes transportation options for intermediate NDE using the GE 2000 cask, BEA Research Reactor (BRR) package, Dry Transfer Cubicle (DTC) insert, and the General Electric Model 100 (GE 100) cask. The GE 2000 cask is the only Type B shipping container currently in use for shipments of irradiated material (exceeding Type A quantities) from ATR to HFEF; therefore it is included as one of the four shipping options in this evaluation. Cost and schedule estimates are provided for performing neutron radiography and precision gamma scans of a five-capsule drop-in-type ATR experiment for each transportation option. All costs provided in this evaluation are rough order-of-magnitude costs based on input from knowledgeable vendor employees and individuals at INL facilities.

INTERMEDIATE NDE OPTIONS

GE 2000 Cask

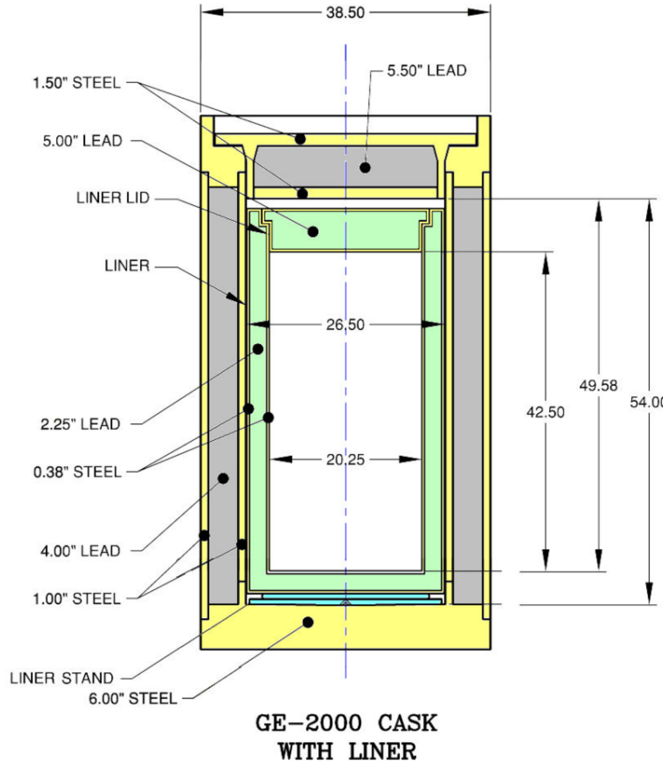
GE 2000 Cask Description

The GE 2000 cask is a steel-encased, lead-shielded, Type B shipping container that weighs approximately 33,550 pounds. It is 72.0 inches in diameter by 131.5 inches tall with a 26.5-inch diameter by 54-inch tall internal cavity and is designed to be loaded and unloaded in wet or dry conditions. Dimensions and a photograph of the GE 2000 cask are provided in Figure 1.

The GE 2000 cask has a current Certificate of Compliance (COC) issued by the Nuclear Regulatory Commission (NRC), and it is used in compliance with Department of Transportation (DOT) regulations.

History of Use at the INL

Transportation of irradiated experiments from ATR has been primarily performed using the GE 2000 cask. INL personnel are very proficient handling it, and it is currently handled at the INL approximately two to three times per year.



NOTE: Per GE-Hitachi, the additional shield liner is no longer available for use.

Figure 1. GE 2000 cask photograph and drawing.

Availability

Use of the GE 2000 cask requires a lease contract between BEA and General Electric-Hitachi Nuclear Energy (GE-HNE) and is contingent on availability. During 2012, GE-HNE notified BEA that they were no longer leasing the GE 2000 cask; however GE-HNE leased the cask to the INL in 2013 and has tentatively agreed to lease it again in 2014. GE-HNE owns two GE 2000 casks.

Advantages

- Cask handling procedures are in place at ATR and HFEF
- Handling at ATR and HFEF requires no new tools or equipment
- Handling personnel at ATR and HFEF are trained, qualified, and proficient
- NRC licensed, Type B shipping container
- Large internal cavity
- Can be used for off-site shipments.

Disadvantages

- Long lead times to negotiate terms and conditions for a lease
- High lease cost
- May not be available
- Long facility handling time and high labor cost.

Summary

The GE 2000 cask has been the preferred shipping container at the INL to transport Type B quantities of radioactive material from the ATR to HFEF. It is the only Type B container that's currently handled at both ATR and HFEF. The INL continues to attempt to use the GE 2000 cask, pending the implementation of alternative shipping options. Due to the availability concerns associated with the GE 2000 cask, the INL has identified alternative shipping options within last 12 months.

BEA Research Reactor Package

BRR Package Description

The BRR package is comprised of a lead-shielded cask body, payload basket, upper shield plug, closure lid, and upper and lower impact limiters that weighs approximately 26,630 pounds. The cask is a right circular cylinder 77.1 inches tall and 38 inches in diameter (not including the impact limiter attachments and the thermal shield) with a 16-inch diameter by 54-inch tall internal cavity and is designed to be loaded and unloaded in wet or dry conditions. Lead shielding is located between two cylindrical shells, in the lower end structure, and in the shield plug. It utilizes American Society for Testing and Materials (ASTM) Type 304 stainless steel as a primary structural material. Dimensions of the cask and a photograph of the BRR package are provided in Figure 2.

The BRR package has a current COC, issued by the NRC, for transporting specific reactor fuel elements. Use of the BRR package in support of experiment shipments between the ATR and HFEF would require a Transportation Plan or amendments to its current Safety Analysis Report for Packaging (SARP). The Transportation Plan has been determined more feasible and cost-effective than an amendment for shipments within the INL.

History of Use at the INL

The BRR package has not been handled at ATR or HFEF in support of irradiated experiment shipments. It is used to transport irradiated fuel elements from various test and research reactors. Efforts to qualify the package at HFEF are underway and dry-run cask handling has been performed. Analyses are being performed for cask handling at the ATR and dry-runs are scheduled to occur in fiscal year (FY) 2014.

Availability

The primary purpose of the BRR package is to support shipments of irradiated reactor fuels. Planning and coordination with the University Program would be required. To date, there is only one BRR package.

Advantages

- No lease long lead times or costs
- Implementation for cask handling at the INL is underway
- Transportation Plan development is in progress
- Large internal cavity.

Disadvantages

- Implementation costs are currently unknown.
- University Programs have priority, so cask may not be readily available.
- Cask is usually used and stored in the mid-west or on the east-coast.
- Long facility handling time and high labor cost
- Only one container exists.

Summary

Implementation of the BRR package at the INL is underway and planned to be completed during FY 2014. The Global Threat Reduction Initiative (GTRI) program is currently funding the implementation efforts in support of the reactor conversion program.

BRR Package Figures

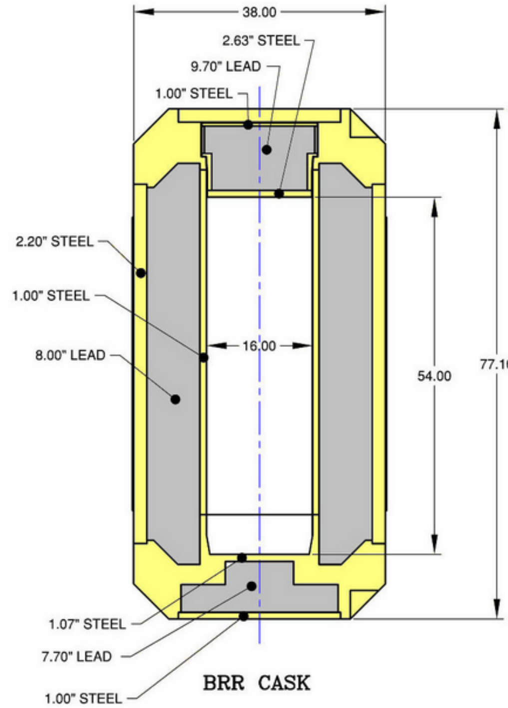


Figure 2. BRR package photograph and cask drawing.

Dry Transfer Cubicle Insert

DTC Insert Description

The DTC insert is constructed of stainless steel with lead shielding and has an empty weight of 4,670 pounds. It is 25.97 inches in diameter by 53.57 inches tall with a 5.5-inch diameter by 46.76-inch tall (w/o extension) internal cavity and is designed to be loaded and unloaded in wet or dry conditions. The shielding is 5.38 inches of lead which provides sufficient dose reduction to allow direct personnel contact during movements. The unit can be used with supplemental tungsten shield inserts for high activity components. The DCT insert could be modified for longer experiments by adding an extension between the body and the lid as shown in Figure 3. Drawings and dimensions of the DTC insert are provided in Figure 4.

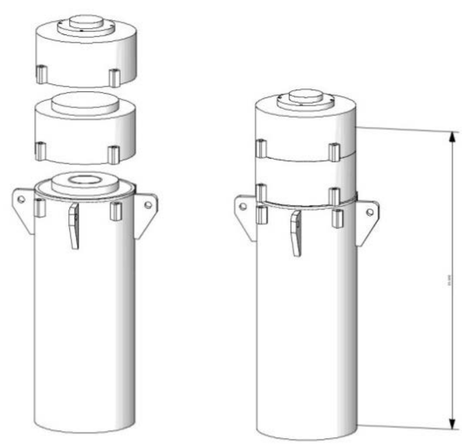


Figure 3. DTC insert with cavity-length extension.

History of Use at the INL

The DTC insert was designed for movement of cut sections of irradiated experiments from the DTC to the canal area for loading into the GE 2000 cask at ATR. One of the two DTC inserts available at the INL is used for these movements when experiments are required to remain dry. Prior use has been in support of the Very High Temperature Reactor (VHTR) Program.

Availability

The DTC insert is Department of Energy (DOE)-owned and requires no lease. Use would require coordination with other programs such as VHTR. There are two DTC inserts (one for dry and the other for wet loading) available at the INL. They are stored at ATR when not in use.

Advantages

- No lease long lead times or costs
- Handling procedures are in place at ATR and HFEF
- INL is currently evaluating the DCT insert as a stand-alone shipping container
- Cavity-length extension may be added for longer experiments
- Stored at the INL.

Disadvantages

- Can’t currently be used as a stand-along shipping package
- Transportation Plan required
- Implementation costs currently unknown.

Summary

Although the DTC insert shielding is not credited for experiment shipments using the GE-2000 cask, the DTC insert should be implemented for INL on-site shipments after the Transportation Plan has been approved by DOE in 2014. The DCT insert may be shipped in an unshielded overpack which would simplify mating to the HFEF hot cell.

DTC Insert Figures

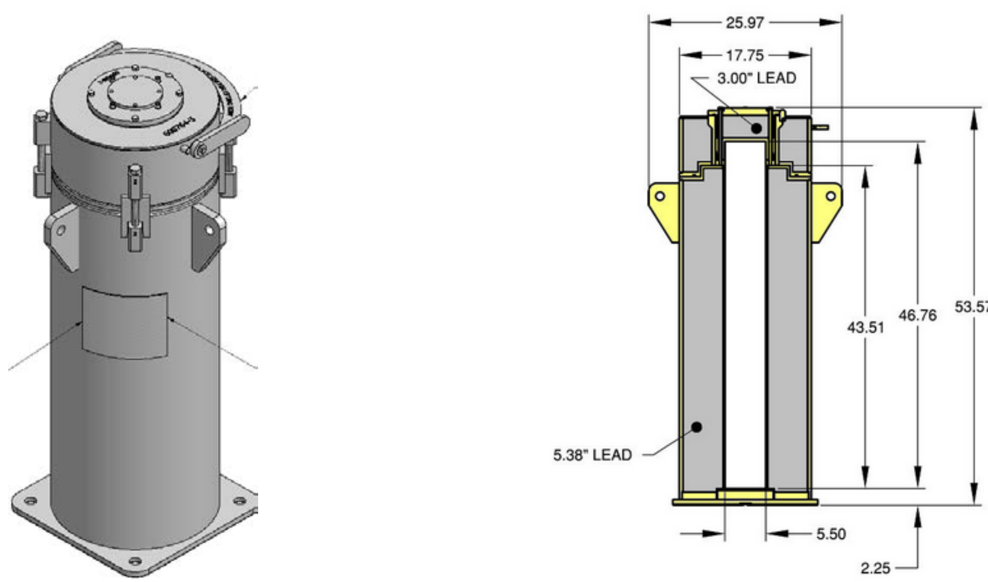


Figure 4. DTC insert drawings.

GE 100 Cask

GE 100 Cask Description

The GE 100 cask is a double-walled, steel-encased, lead-shielded shipping container with a maximum weight of 4,800 pounds. It is 20.25 inches in diameter by 26.875 inches tall with a 7.625-inch diameter by 10-inch tall internal cavity and is designed to be loaded and unloaded in wet or dry conditions. Approximately 5.625 inches of lead surrounds the internal cavity. The cask is equipped with a cavity drain line and lifting device. A drawing and photograph of the GE 100 cask are provided in Figure 5.

The GE 100 cask NRC COC expired October, 2008. Use of the GE 100 cask will require the development of a Transportation Plan to allow shipments between ATR and HFEF.

History at the INL

Prior to 2008, the GE 100 cask was routinely used at the INL to ship irradiated material from ATR to HFEF. The handling tools and equipment previously used are still available.

Availability

The GE 100 cask would need to be purchased from GE-HNE. GE-HNE has two casks available for purchase. Cost for one cask is $220k plus $15k for preparation and transportation fees. If both containers are purchased, the cost is $440k, which includes the preparation and transportation fees. GE-HNE would like to complete any sales of the GE 100 cask(s) by the end of 2013.

Advantages

- No lease long lead times or costs
- Archived cask handling procedures exist at ATR and HFEF
- Handling tools and equipment are available
- Shortest facility handling time and lowest costs
- Would be stored at INL and available when needed
- Transported by a standard, INL-owned, flatbed truck
- Ease of handling due to smaller size.

The intermediate NDE turnaround time (and associated cost) using the GE 100 cask may be minimized by developing a Transportation Plan that would not require the cask to be vacuum dried, back-filled with inert gas, or leak tested. This could reduce the facility handling time to 1-2 days per facility. The project risks associated with this approach would need to be evaluated. The risks associated with this approach are due to residual water that may remain in the cask after gravity draining. Water inside the cask could contribute to corrosion of the experiment and cask, hydrogen generation, and spread of contamination from leakage. Vacuum drying, back-filling, and leak testing would require one additional day at each facility.

Disadvantages

- Container purchase required
- Expired COC
- Transportation Plan required
- Procedure revisions, personnel training, and dry-runs required
- Smaller cavity dimensions

- Annual maintenance required
- Annual Transportation Plan review required.

Summary

The GE 100 cask is a desirable candidate for shipments between ATR and HFEF due to reduced cost per shipment and ease of handling and transportation. There are other Programs at the INL interested in the GE 100 cask that may be able to share costs.

GE 100 Cask Figures

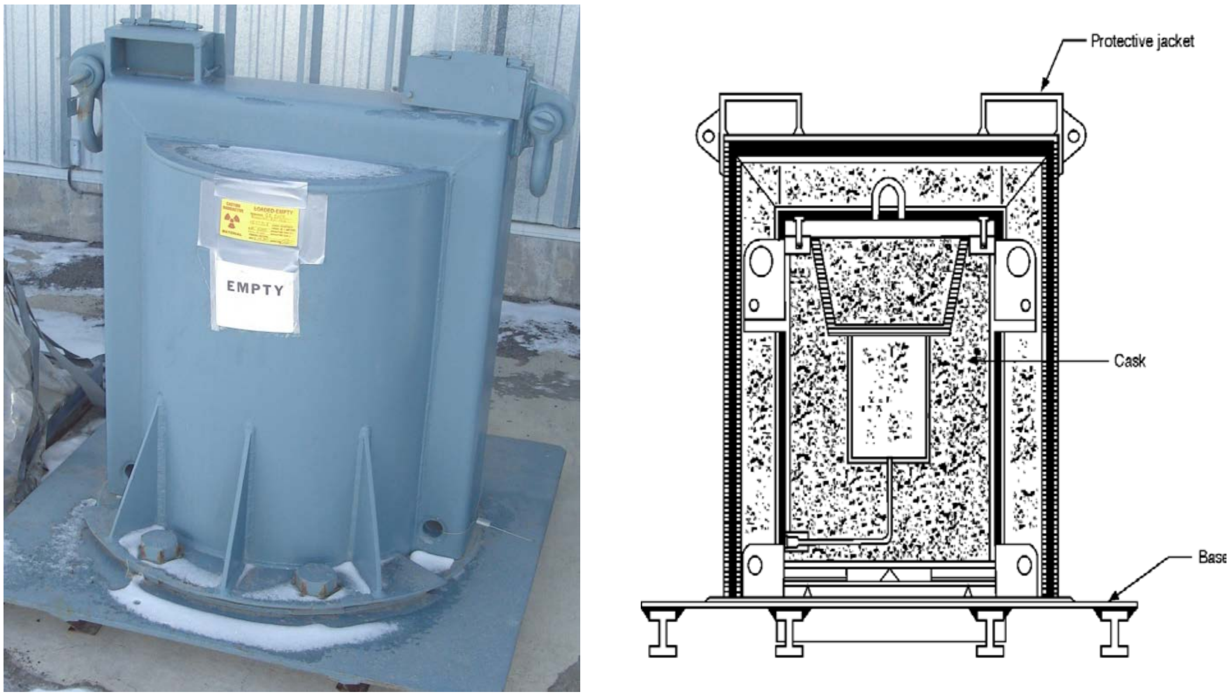


Figure 5. GE 100 cask photograph and drawing.

CONCLUSIONS

Intermediate NDE is feasible using any of the four containers in this evaluation based upon anticipated shipping activities and decay heat and source term calculations for Advanced Fuel Cycle 4B (AFC-4B) experiment after one year of irradiation of approximately 228 megawatt days (MWD). A minimum of 28 days of cool down would be required prior to loading the experiment for shipment to HFEF. The calculated decay heat should be within the limits for all four shipping containers provided in Table 1. Actual decay heat limit values are being determined for the BRR package and the DTC insert, however these limits are expected to be much higher than the AFC-4B values. Confirmation that the activity and decay heat are within a selected container's bounding parameters will be required using the as-run analysis for an experiment.

The most cost-effective container for shipments between ATR and HFEF is the GE 100 cask due to its small size, ease of handling, and quick turnaround time. Use of the GE 100 cask would require purchasing the container, developing a Transportation Plan, updating existing procedures, training, and dry-runs. The estimated cost for these activities is $515k as shown in Table 1. The estimated time to complete these is 9-12 months.

Table 1. Shipping container comparison.

	GE 2000 Cask	BRR Package	DTC Insert	GE 100 Cask
Ownership	**GE-HNE**	**DOE**	**DOE/INL**	**GE-HNE**
Weight (lb)	23,550	26,630	4,670	4,800
Outer Dimensions (inches)	72 in. dia. 131.5 in. tall	38 in. dia. 77.1 in. tall	25.97 in. dia. 53.57 in.tall	20.25 in. dia. 26.875 in. tall
Cavity Dimensions (inches)	26.5 in. dia. 54 in. tall	16 in. dia. 54 in. tall	5.5 in. dia. 46.76 in. tall (w/o extension)	7.625 in. dia. 10 in. tall
Decay Heat Limit (Watts)	<600	TBD	TBD	<400
U-235 Limit (grams)	<500	TBD	TBD	<350
Usable at INL	Yes	FY 2014	FY 2014	No
Availability	Limited/none	Limited (GTRI)	Limited (VHTR)	Potentially unlimited
Storage Location	GE-HNE	Mid-west/east coast	ATR	GE-HNE Potentially INL
Transportation Plan Required	No	Yes	Yes	Yes
Facility Handling Time (days)	5	5	TBD	1-2[1]
Procurement Cost	N/A	$500k	$0	$235k
Implementation Cost	$0	Unknown	Unknown	$280k
Facility Handling Cost	$75−$100k	$75−$100K	TBD	$25k
Annual Maintenance Cost	$0	Unknown	Unknown	$70k

NOTE: Assumes the cask will not need to be vacuum dried, back-filled with inert gas, or leak tested.

Table 2 shows the cost per shipment for each of the intermediate NDE options. A single intermediate NDE with the GE 2000 cask almost cost as much as the implementation cost plus the cost of a shipment with the GE 100 cask. In addition, the turnaround time for the GE 100 cask is less than typical ATR cycles which can last 50 to 60 days. Therefore, there would be minimum impact to the MWD of irradiation for the experiment since the intermediate NDE could be completed without missing more than one ATR cycle. Enhanced coordination efforts will be necessary to ensure ATR and HFEF can accomplish this quick turnaround.

Table 2. Intermediate NDE Options.

	GE 2000 Cask	BRR Package	DTC Insert	GE 100 Cask
Cost/Intermediate NDE				
Lease Cost	$215K	$0	$0	$0
Facility Handling Cost	$300K	$300K	TBD	$75K
Neutron Radiography[1]	$200K	$200K	$200K	$200K
Gamma Scan	$100K	$100K	$100K	$100K
TOTAL	$815K	$600K	>$300K	$375K
Turnaround Time				
Cooldown[2] (days)	28	28	28	28
ATR (days)	5	5	TBD	1–2
HFEF (days)	5	5	TBD	1–2
Radiography (days)	5	5	5	5
Gamma Scan (days)	5	5	5	5
HFEF (days)	5	5	5	1–2
ATR (days)	5	5	5	1–2
TOTAL (days)	58	58	>48	≤46

NOTE 1: Includes analyses and reporting. Two azimuthal rotations for radiography.

NOTE 2: Base upon AFC-4B decay heat and source term after 228 MWD.

Based upon this evaluation the best option for intermediate NDE is to procure and implement the GE 100 cask for $515K which will take 9–12 months. After that, intermediate NDE (neutron radiography and gamma scan) for a typical five capsule experiment would cost $375K and take 46 days or less. The intermediate NDE does not include examinations to measure fission gas in this evaluation. These capabilities are currently being developed and may be utilized in future intermediate NDE. An annual maintenance cost of $70K will also be required.