APPENDIX A4

STUDY 1 - ALTERNATIVE STORAGE SYSTEMS FOR DUAL PURPOSE CANISTERS

Alternative 4 – Below Grade Vault (C-BGV)

Alternative 4 – Below Grade Vault (C-BGV)

A4-1.0 Description of Storage Alternative

Alternative 4 evaluates the use of below grade, air-cooled vaults to store dual purpose canisters (DPCs). Internationally, air-cooled vaults have been used to store spent nuclear fuel (SNF) and high level wastes from reprocessing plants. In the USA, air-cooled vaults have been used or proposed to store non-LWR SNF. An air-cooled vault design was chosen to house the SNF from the decommissioned Fort St. Vrain (FSV) High Temperature Gas Cooled Reactor.

In this concept, a large shielded structure is constructed that houses an array of storage locations into which DPCs from legacy sites can be placed. It has a large service hall covered by an overhead traveling bridge crane. The floor of this hall is the shield structure covering the air-cooled vault. A shield plug is fitted into the floor over each storage location. Below this shield plug is a seismic restraint system that secures the DPC in a way that prevents movement in the event of a seismic event. The vault area beneath this shield floor is designed to encourage passive air flow around the DPCs. Exhaust stacks on one side of the vault allow the air warmed by the DPCs to escape while air inlets on the other side of the vault draw cool outside air into the building. This natural draft system provides bulk cooling to remove the decay heat from the SNF.

Like all canister-based systems, the DPC is licensed under 10CFR72 (Reference A4-1) for storage and 10CFR71 (Reference A4-2) for transportation. The SNF is placed into a welded sealed metal container, the DPC, which provides the primary confinement boundary for the SNF. The DPC is placed in different overpacks or casks, which provide radiation shielding and physical protection, during canister transportation, transfer, or storage. A typical PWR canister will hold 24 to 37 PWR SNF assemblies and a typical BWR canister will hold 61 to 89 BWR SNF assemblies.

During SNF loading and DPC transfer between the fuel pool and dry storage or shipping, a metal transfer cask provides physical protection and radiation shielding. During transportation, a metal shipping cask protects the DPC from any credible accident that might occur. The casks are metal and provide the confinement boundary for the SNF assemblies. The metal cask is fitted with impact limiting devices for additional protection during transit. The shipping cask must comply with the requirements of 10CFR71.

There are four options of this alternative that are evaluated:

4a. Below Grade Vault, with Integral CHB storing DPCs vertically, C-BGVa

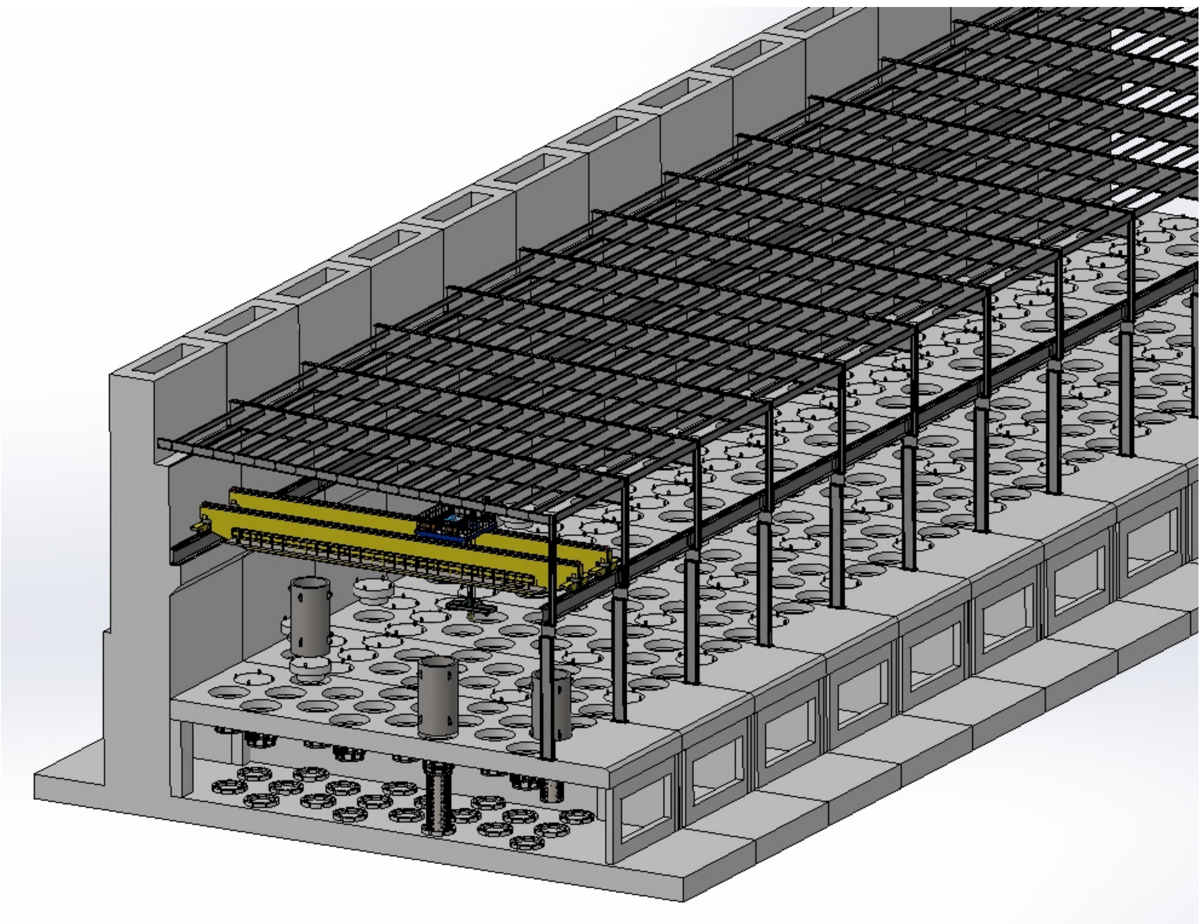
4b. Below Grade Vault, with Integral CHB storing DPCs vertically and horizontally, C-BGVb

4c. Below Grade Vault, with Separate CHB storing DPCs vertically, C-BGVc

4d. Below Grade Vault, with Separate CHB storing DPCs vertically and horizontally, C-BGVd

Figure A4-1 shows a 3D rendering of a conceptual vault design that could store commercial SNF.

Figure A4-1
3D Rendering of a Conceptual Vault



Typically, air-cooled vaults used for the storage of nuclear wastes have stored individual fuel assemblies in vertical storage locations. The ISF air-cooled vaults will need to accommodate DPCs that house many fuel assemblies and it will need to accommodate DPCs designed to be stored both vertically and horizontally. There are two ways of accomplishing this:

1. The horizontal DPCs can be loaded into lifting frames that enable the horizontal DPCs to pick up and stored vertically.

2. The horizontal DPCs can be stored horizontally in a dedicated storage area.

Both of these approaches have disadvantages. The first requires additional handling steps and components and results in the fuel being stored upside down. The second requires a novel approach to air-cooled vaults that is unprecedented in the industry.

Another option considered in this study is the location of the Cask Handling Building (CHB). The CHB can be integral to the storage vault or it can be a separate, standalone structure. The benefit of an integral CHB is that it simplifies operations and eliminates transferring casks between buildings. The disadvantage is that in the event of a need to expand the ISF, the CHB will need to be part of each new vault constructed. This will increase cost and involve not only duplicating the CHB hardware, but also reconfiguring the rail lines on the site to be able to interface with the news CHB location. A standalone CHB eliminates these issues at the cost of an increase in labor, and equipment necessary to transfer DPCs between the CHB and the storage vaults. As will be seen later, the standalone CHB also has an operational throughput advantage.

The DPCs will be removed from these storage systems at the generators' sites and transported to the ISF site by rail. The DPCs will be fitted with the necessary adaptor frames to compensate for any size variations relative to the standard used to size the vault storage seismic restraint system.

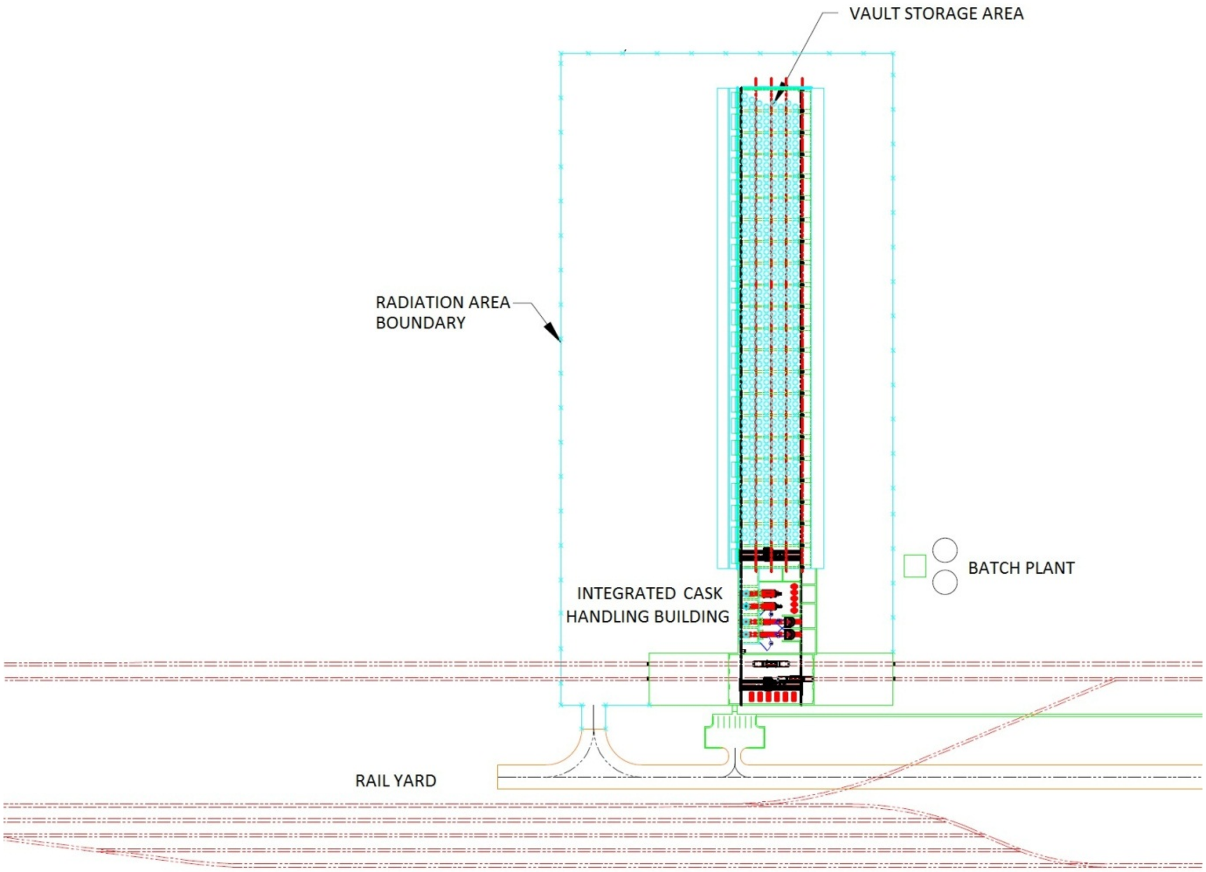
A4-2.0 Concept of Operations

A4-2.1 Facility Layout

The Below Grade Vault alternative has four variants with integral or standalone CHBs and with all vertical or vertical and horizontal storage. **Figure A4-2** shows the Below Grade Vault site layout with integral cask handling building (variation 4a).

The transport casks are delivered to the site by rail. Most likely, the railroad carrier will park the unit train at a siding off site and the ISF dedicated tug will be dispatched to retrieve the unit train. This small locomotive brings the railcars from the mainline siding to the Rail Interchange Siding Yard at the northwest corner of the ISF site.[1] At this point, the unit cars are disconnected and the security detachment who accompanied the shipment is relieved. There is a powered derailer preventing unauthorized rolling stock onto the siding yard without clearance.

Figure A4-2
Conceptual Site Plan of the Below Grade Vault with Integral CHB



The individual transport railcars are moved to the Railcar Security Inspection Area located at the entrance of the ISF protected area. There, site security officers complete the review of the shipping paperwork and perform a thorough check of the rolling stock and the packaging to ensure that there is no contraband on the shipment. The railroad tracks have a powered derailer that is positioned at the gate to the protected area to prevent unauthorized access into the protected area via rail. After the security inspection, the transport cask railcars are

[1] For this study, North is at the top of the figure. The ISF can in fact be situated in any orientation, but for clarity of this description, North is up; East is right; etc.

moved into the SNF Delivery Rail Yard / Staging Area until the Canister Handling Crew is ready for them in the CHB.

The CHB is where the transition from the rolling stock to the storage vault is begun. As a result, it is located near the SNF Delivery Rail Yard / Staging Area. It is accessible by two sets of rails, into a single railbay. The storage vault is constructed on a common foundation with the CHB. For the second variant of the concept, the CHB is centrally located between the different vaults.

Figure A4-3 shows the two configurations of the vault area with integral CHB: BGVa is on the left and BGVb is on the right. It is obvious that BGVb is larger and more complex than BGVa. This is because the horizontal storage layout is much less space efficient than the vertical layout.

Transport casks are brought into the CHB from the staging area via the rollup doors on either the west or the east end of the railbay. Materiel and supplies are brought in via the loading dock on the east side of the CHB. Lifting frames and other necessary adaptors to accommodate odd sized legacy canisters are brought in by truck from the fabrication yard and handled via the railbays. Lifting frames are only required for the all vertical variant. If BGVb is chosen, only adaptors are required to assure that the legacy DPCs are securely located within the vault support internals.

Figure A4-3
Conceptual Plan of the Below Grade Vault with Integral CHB

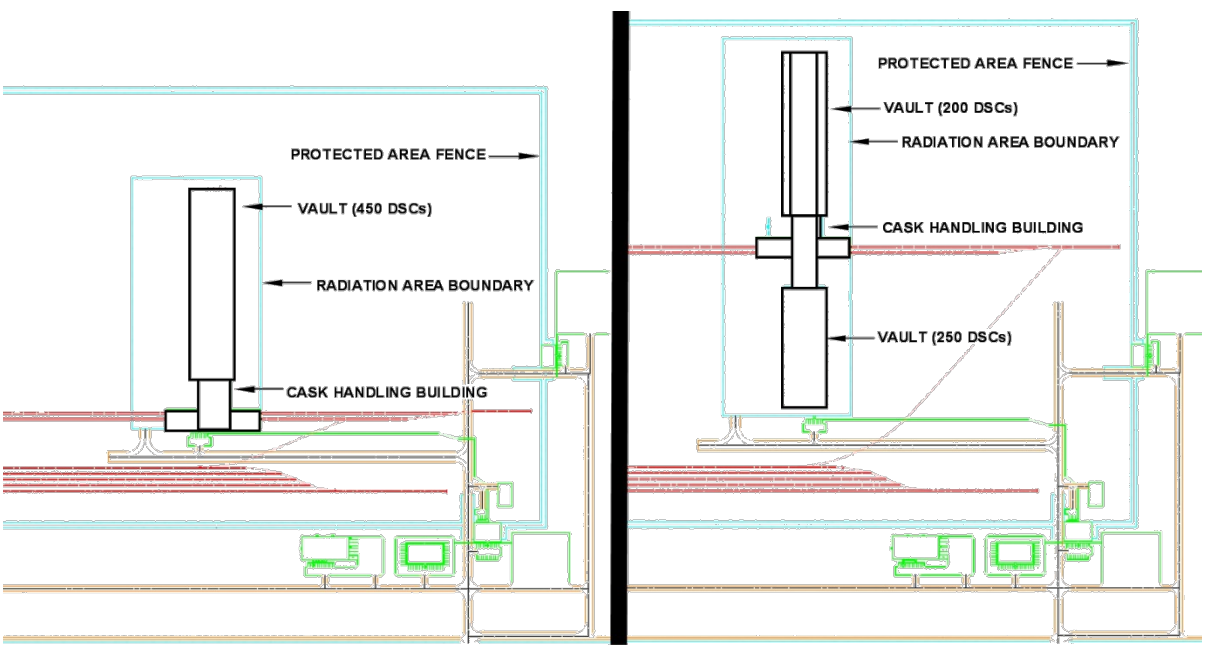


Figure A4–4 shows the ISF site layout for below grade vaults with standalone CHB. As can be seen, the only difference in the layout of the site is the position of the CHB relative to the storage vault. It is also clear that because of the layout, the capital CHB can have two rail bays and independent OTB cranes.

Figure A4-4
Conceptual Overall Site Plan of the Below Grade Vault with Standalone CHB

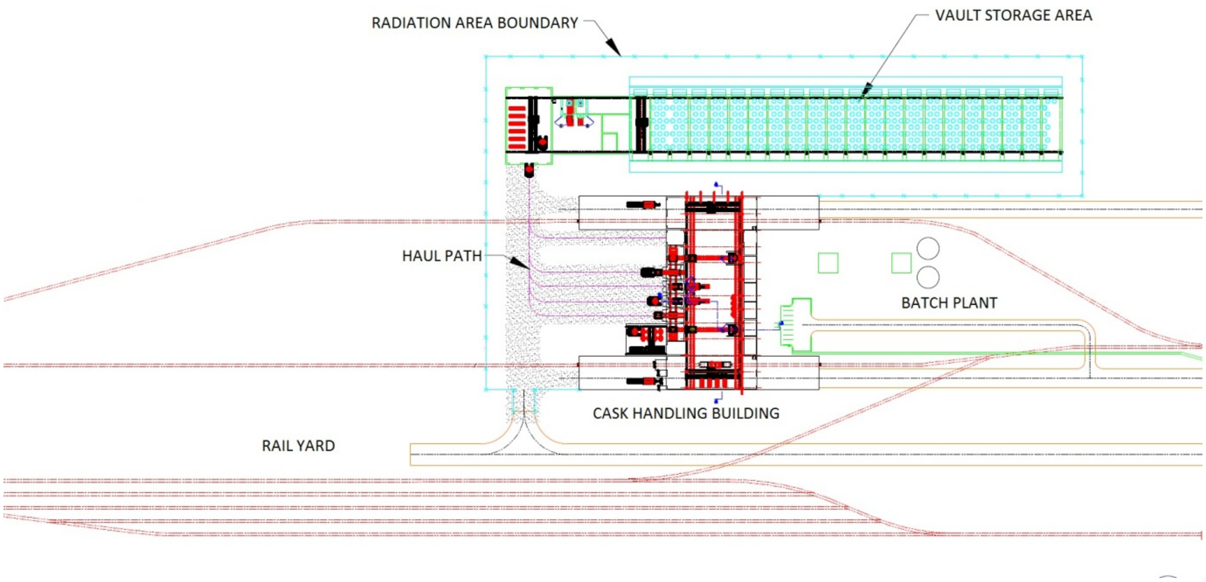
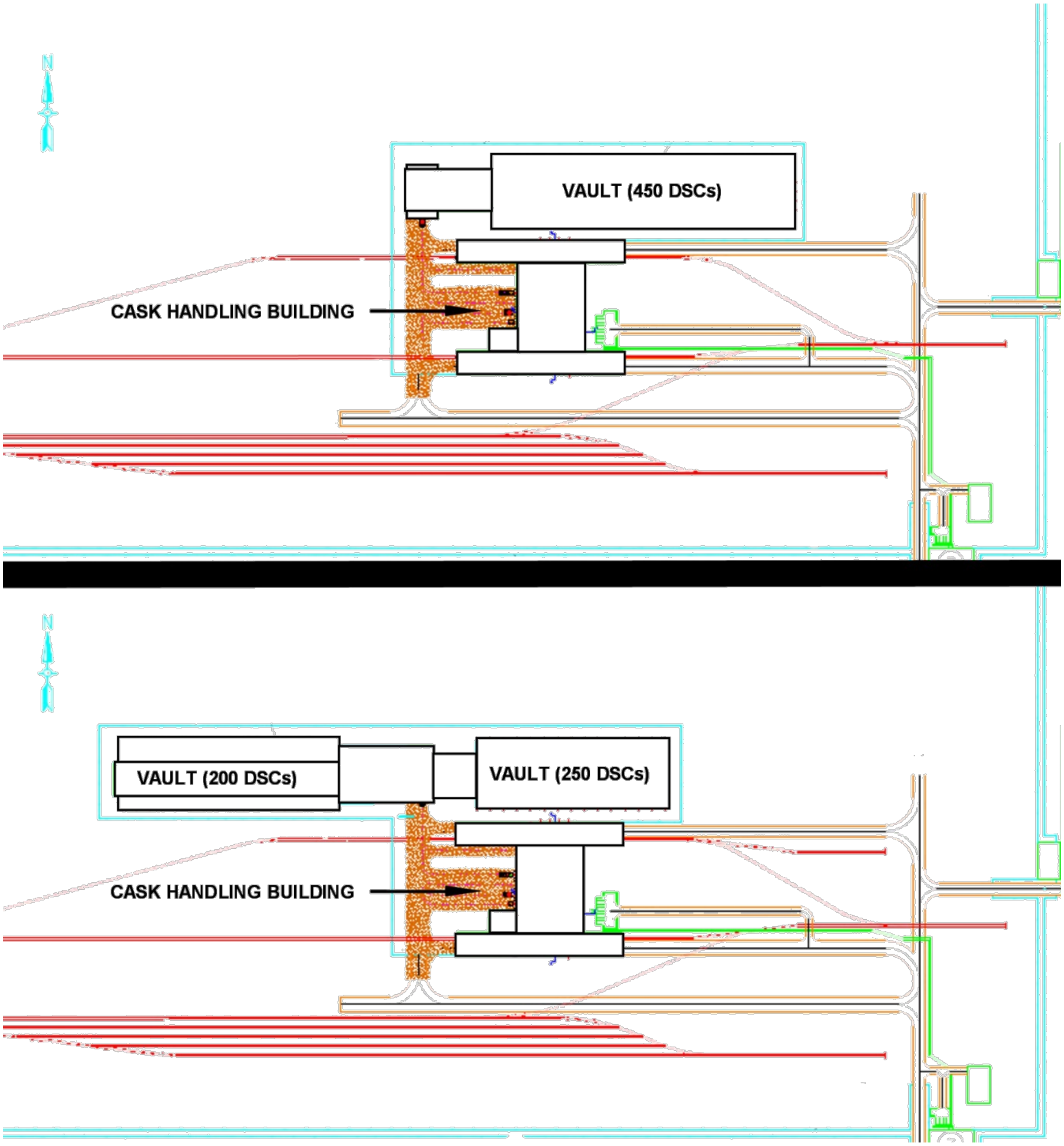


Figure A4-5 shows the two configurations of the vault area with standalone CHB. BGVc is on the top; BGVd is on the bottom. It can be seen from these layouts that the expansion of the site is simplified by this approach and a wide variation of vault configurations could be added giving these variants broad capabilities for expansion.

For any of the variants, personnel entrances and support facilities are located at the southeast corner of the ISF site. These facilities include the ISF Office Building, Warehouse, Security Entrance, parking lots, electrical substation, fire water tanks and pump house, emergency diesel generators and fuel storage tanks, and the ISF Visitor’s Center.

The designs of the BGVc/BGVd variants are significantly impacted by how the DPC is delivered to the Vault Building from the CHB. A simplistic approach is to move the Transport Cask directly from the CHB to the Vault Building where the DPC can be unloaded directly into the appropriate transfer device. This has several drawbacks. First, the cycle time of the ISF is determined by how rapidly the Transport Cask can be unpacked, emptied, and repackaged for shipment offsite.

Figure A4-5
Conceptual Plan of the Below Grade Vaults with Standalone CHB



Moving the Transport Cask to the Vault Building delays the repackaging for shipment and thereby reduces the achievable throughput for the facility. In addition, there are several potential activities that must be performed in order to assure that the DPC is properly placed in storage. Lifting frames and adapters, as appropriate, must be installed on the DPC after it is removed from the Transport Cask. If the transport cask is moved directly from the railbay to the Vault Building, these activities would need to be performed in the vault building. This would require significant material handling capabilities be designed into the Vault Building which would duplicate many of the functions in the CHB. The result would be the construction of both a standalone CHB and a CHB in each Vault Building.

For this reason, this study has assumed the use of a shielded transfer sleeve to transfer the DPC to the Vault Building with whatever adaptor/insert/lifting frame necessary for placement of the DPC into storage. This adds several complex and heavy components to the ISF inventory but it significantly increases the throughput possible. It also concentrates most of the DPC preparation activities in the CHB. This allows for better utilization of the work crews by segregating the types of work into the appropriate buildings.

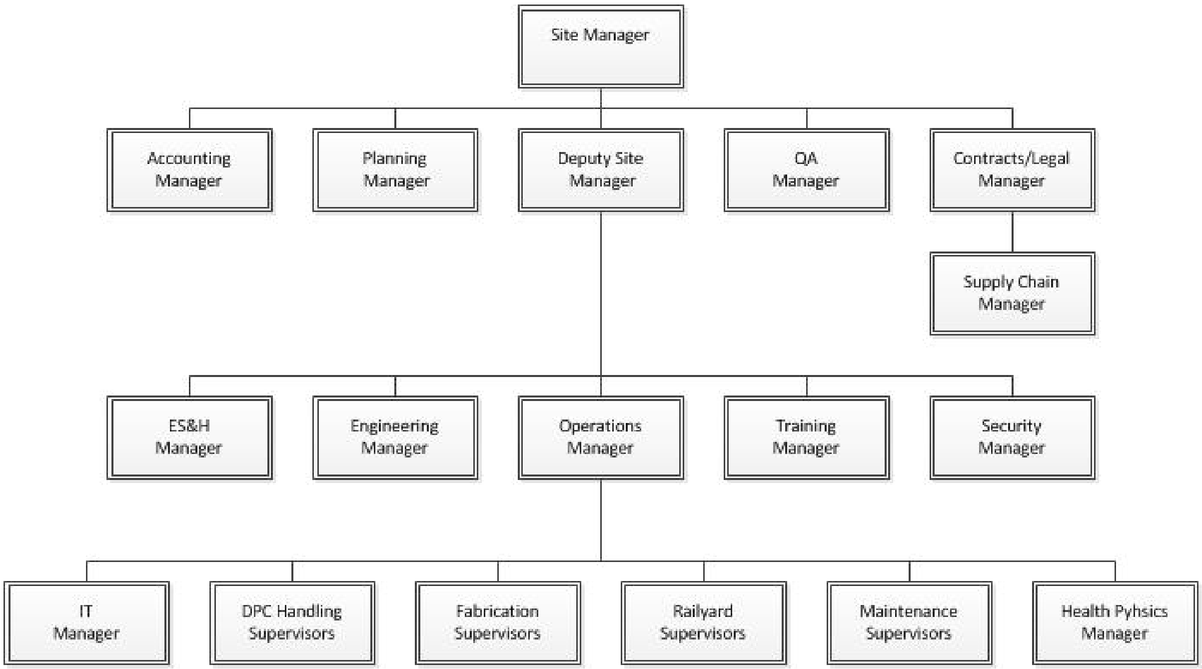
A4-2.2 ISF Operations

The Interim Storage Facility operates on a 24-hour, 7-days a week basis, but Canister Handling operations are limited to a single 8-hour shift, 40-hour work week. This has been done because the logistics issues associated with delivering a large number of transport casks to the site do not warrant around-the-clock Canister Handling operations. It also provides the ability to accommodate surges of work that might be necessary by the simple expedient of adding additional Canister Handling crew shifts. It is assumed that the ISF is operated by an independent contractor so that many of the administrative and Human Resource functions of an organization are not required within the site organization. The costs for these services are covered in the overhead calculation for labor. **Figure A4-6** is the chart of the site organization.

There are two phases to ISF operations: Canister Handling Operations and Storage Facility Surveillance and Maintenance Operations. The Canister Handling Operations are the activities necessary to accept SNF packaged in DPCs from nuclear generators and to place the SNF into interim storage on site. This is a temporary activity lasting only as long as necessary to accept the design basis amount of SNF considered in this study; either 5,000 MTU for the Pilot ISF or 10,000 MTU for the Expanded ISF. This activity lasts only a few years and involves the most labor intensive activities experienced at the ISF. The Surveillance and Maintenance staff specialists are cross trained to enable them to assist in Cask Handling Operations should the need arise. Additional Canister Handling Operations will be necessary at the end of ISF life when the stored SNF is repackaged and shipped to its final destination, whether that is a repository or a recycling facility. However, that effort is not within the scope of this study.

The Storage Facility Surveillance and Maintenance Operation is the ongoing activity that spans the entire operational lifetime of the ISF. It consists of all the activities necessary to plan, to monitor the performance and aging of the storage systems used to house and cool the SNF, and to provide for the safeguards and security necessary to protect the facility from unwanted intrusions and/or damage. The Surveillance and Maintenance Operations begin immediately upon the commissioning of the ISF and continue until the last DPC has been removed.

Figure A4-6
Typical ISF Organization Chart



During the Canister Handling Operations, many supporting activities need to be performed by the ISF staff. The most directly related to the Canister Handling Activities is the inserts/adaptors that enable the legacy DPCs to fit properly in the cavity enclosure containers. Also, the fabrication of the Horizontal Cask Lifting Frames for the legacy horizontal DPCs cavity enclosure containers need to be produced in order to place horizontal DPCs in the Below Grade Vault system. The steel components for the inserts/adaptors will be fabricated by the original vendor or contractors under the original vendor's control. This is done to preserve the intellectual property. Because there is no shielding in the vault under the operating floor, the lifting lugs or lifting frames with the lifting lugs attached remain on the DPCs in the vault. These lifting lugs are quite elaborate devices and also require quite a lot of effort to fabricate.

The inserts/adaptors/lifting frames will be designed by the legacy DPC vendor to meet the design envelop of the vault seismic restraint system. They are shipped to the site via rail and delivered to the insert/adaptor/lifting frame fabrication yard near the rail entrance to the protected area. After receipt inspection to ensure that the components meet specifications, the site fabrication crew will complete the assembly of the insert/adaptor/lifting frames. Since vault concept uses the original storage canisters, the insert/adaptor/lifting frame Fabrication Crew needs to coordinate closely with the Operations Manager to ensure that the proper vertical storage insert/adaptor/lifting frame prepared far enough in advance of DPC placement. As a result, the insert/adaptor/lifting frame Fabrication Crew needs to be operating well ahead of the SNF acceptance process with a minimum of 30-days after the arrival of the steel components from the manufacturer until the insert/adaptor/lifting frame is ready to be used.

The procurement activities necessary to support the insert/adaptor/lifting frame production must be well ahead of the delivery of the SNF because the lead time for insert/adaptor/lifting frame material sourcing, delivery and final fabrication is on the order of 6 – 12 months. Orders must be placed with the appropriate DPC vendors in time to ensure that there is time fabricate and deliver the necessary components. Ideally, the system should support just-in-time delivery of all necessary insert/adaptor/lifting frame components that they can be used directly by the Canister Handling Crews. However, as a practical matter, the system should allow for buffer storage of these components in order to assure that SNF shipments are not held up by the lack of availability of inserts/adaptors/lifting frames. This means that the Supply Chain Management must identify the correct vendor, the correct model of DPC and the schedule for delivery in order to issue the purchase orders necessary to ensure the flow of material to the site. No shipment of SNF should be undertaken unless there is an appropriate insert/adaptor/lifting frame available on site.

Another major activity at the ISF necessary to support SNF placement is maintenance required for the equipment necessary to perform the heavy lifts and heavy load movements necessary to fulfill the SNF handling function. This includes the OTB crane servicing the railbay, the Vault Crane, the transfer carts, the horizontal transfer fixtures, and the shield sleeve. Cranes, carts and specialty components that handle DPCs need to be single failure proof and inspected and maintained rigorously to ensure operability and safety.

In addition to physical labor, the ISF requires planning and engineering to support operations. As already described, engineering, procurement and insert/adaptor/lifting frame assembly activities need to be well ahead of actual SNF acceptance activities. The timescale of the work necessary to prepare the inserts/adaptors/lifting frames for the storage of SNF requires that the planning and engineering activities be performed nearly a year ahead of the SNF acceptance activities. Engineering activities are required for safety analyses and modifications to processes and materials to support SNF storage. Also, record keeping is required to identify where each DPC originates from, what it contains, the SNF characteristics and where it has been stored. In addition, all material certifications for SNF storage containers and other materials used for SNF handling need to be meticulously maintained for easy retrieval in the future.

Finally, the largest functional activity at the ISF is physical security. The security group needs to actively maintain the security of the site in addition to inspecting all materials coming onto the site. This security function is the largest single group of the organization and is a 24-7 operation. The vault concepts whether below grade or above ground have a significant advantage over other pad-based storage alternatives in this area. Since the DPCs are stored within a reinforced concrete vault that requires special equipment to access, the rest of the site can easily afford two lines over the ISF site in order to locate and to identify intruders. So, while a traditional overpack system might require as many as four security locations to establish the necessary security coverage, the vault concepts can achieve this same requirement with only two. This results in a smaller security force than is needed for other pad-based storage systems. In addition, the IAEA oversight systems would be simplified since a single camera would be able to survey the entire storage area to assure inspectors that no diversion was of potentially strategic materials occurs.

Table A4-1 is a listing of the site organization staff. The organizational staff would be adequate to support the activities at the ISF necessary to support the Canister Handling activities. This staff totals 136 but does not include the Canister Handling crew.

Table A4-1
Site Organization

Position	Staff	Position	Staff
Site Manager	1	Mechanical Engineers	4
Deputy Site Manager	1	I&C Engineers	1
Accounting Manager	1	Electrical Engineers	2
Planning Manager	1	Civil/Structural Engineers	4
QA – Manager	1	Quality Engineers	3
Contracts/Legal Manager	1	Buyers	2
Supply Chain Manager	1	Planners	3
Operations Manager	1	Security	45
ES&H Manager	1	Trainers	2
Engineering Manager	1	Railyard Operators	2
Training Manager	1	Supervisors	4
Security Manager	1	Mechanics	6
IT Manager	1	Electricians	4
DPC Handling Supervisors	1	Facility Operators	16
Fabrication Supervisors	1	IT Technicians	2
Railyard Supervisors	2	Administration Assistants	2
Maintenance Supervisors	2	EMT	1
Health Physics Manager	1	RR Tug Engineers/Brakemen	4
Nuclear Safety Engineers	2	Fabrication Team	5
Health Physicists	2		
		Total	136

A4-2.3 Canister Handling Crew Size

The Canister Handling Operations staff is dedicated to the movement of DPCs around the site. These operations are carried out by dedicated crews who focus on certain areas of the operation. This way, when multiple DPCs are processed each week, a crew learns specialized skills that will improve efficiency. The crews are: 1. the Railbay Crew, and 2. the Cask Transfer Crew.

The Railbay Crew consists of the skilled crafts necessary to prepare the transport cask to be unloaded and later to be reassembled to be shipped back to the generator. These activities include receipt inspection of the as-received package, removal and storage of the impact limiters, removal and storage of the transport cask cover, and removal and storage of the tie-down straps. Then, the Railbay crew rigs the transport cask for lift by the overhead traveling bridge (OTB) crane and, depending on the ultimate storage concept, either places it on the horizontal cask transfer fixture or on the transfer cart in the CHB.

In the case of the alternatives with separate CHB (BGVc/BGVd), as soon as the Transport Cask is removed from the railcar, the Railbay Crew’s supervisor informs the Rail Yard Supervisor to remove the empty railcar and to bring in the next railcar for service. This is done as needed to maintain throughput and to assure that the Railbay Crew is fully engaged throughout the work week. Again, before the transport cask is returned to the railbay, the Railbay Crew will arrange with the Rail yard supervisor to have its original railcar returned to the Railbay.[2] Once the transport cask is returned to the railbay, the Railbay Crew inspects and surveys the cask, rigs it and repositions it back on the railcar, and then reassembles the transportation packaging for shipment offsite. This crew specializes in unloading the transport cask and repackaging empty transport casks.

Due to the design of the alternatives with the integral CHB (BGVa/BGVb), there is no need to shuffle the railcars. The operations for these alternatives are hampered by the availability of the OTB cranes. There are two OTB cranes in the integral CHB concepts, but they divide their duties with one crane working in the railbay and one crane servicing the vault area. The problem arises in the railbay under full operation that the crane is occupied repackaging one railcar while the next transport cask awaits unloading. The vault crane is fully occupied moving DPCs to the vault storage area and cannot alleviate this problem. This problem is relieved somewhat in BGVb, where the vault crane is assisted by the Horizontal DPC Transfer Carts that deliver the DPCs to the storage location enabling the vault crane to move more quickly to the next package. The impact in the railbay is not, in fact, improved because the crane servicing the vault area is paired with the shielded transfer sleeve. This is a

[2] It is assumed that the railcar and the transport cask need to remain paired.

complicated machine with many power feeds and control connections to the crane. It cannot be easily removed and replaced, so the crane servicing the vault area has limited utility for work in the railbay. This is the main constraint on the through put of alternatives BGVa and BGVb.

The designs with separate CHBs have the advantage of two railbays and two OTB cranes totally dedicated to handling the railbay activities. More importantly, the placement of the DPCs in the vault is completely separated from activities in the CHB which enables them to be carried out in parallel with work in the railbay without interference. Transfers of the DPC into the transfer cask are accomplished using a collection of jib cranes, transfer carts, casks and fixtures. When the transfer is completed, a cask transporter picks up the transfer cask and takes it to the vault, where another set of cranes and transfer sleeves are employed to place the DPC into storage. These additional components are the reason that the alternatives with separate CHB are able to have higher throughputs than the alternatives with integral CHB.

The Cask Transfer Crews have to handle both vertical and horizontal storage system DPCs. In the alternatives with integral CHB (BGVa/BGVb), the Transfer Crew works in the CHB and transfers the DPC from the Transport Cask into the shielded transfer sleeve for the vertical-only option (BGVa) and into the shielded transfer sleeve or the horizontal transfer fixture in the case of the vertical and horizontal storage concept (BGVb). This permits the workers to move between packages and perform tasks on either. Their activities include installing lifting frames for horizontal DPCs in BGVa and positioning horizontal DPCs on the transfer fixtures and pushing them onto the Horizontal DPC Transfer Carts in the vaults.

In the alternatives that have separate CHBs (BGVc/BGVd), the Cask Transfer Crews work in the CHB and in the Vault Buildings. The activities in the CHB consist of placing the DPCs into lifting frames and/or adaptors and transferring them into the transfer cask to be hauled from the CHB to the vault building with a transporter. For the BGVc option, a Vertical Cask Transporter (VCT) will be used and for the BGVd option, a combination of VCTs and Horizontal Cask Transporters (HCT) will be used. In the vault building, a separate Cask Handling Crew accomplishes the activities necessary to place the DPCs into storage. This split in the Cask Handling Crew means that the options with separate CHB requires a larger Cask Handling Crew and needs additional precautions to assure that the chain of custody for the DPC is not corrupted.

In BGVb of this alternative, the horizontal DPCs are transferred in the Transport Cask directly over to the transfer fixture in the storage hall. The Transport Cask lid is removed and the cask is rotated down into the horizontal position on the transfer fixture. The transfer port is opened and the Transport Cask is mated to the port collar. A hydraulic ram pushes the DPC onto the Horizontal DPC Transfer Cart inside the shielded storage vault. The Horizontal DPC Transfer Cart then traverses to the storage location and places the DPC on a storage rack. These are all remote actions and the work crew is limited.

In the case of the BGVc and the BGVd alternatives, the Cask Transfer Crew must transfer the DPC from the transport cask into a shielded transfer cask that is transferred to the vault operations bay. There will need to be three shielded transfer casks of each type available for operations. This means that there will need to be at least four of them to ensure a spare for maintenance.

Table A4-2 shows the staffing for each major activity necessary to move DPCs from the transport cask to the storage vault in all four variants. They are grouped by the location of the CHB. The study finds that the differences between the all vertical and the vertical/horizontal vaults do not have a significant impact on crew size. It can be seen in **Table A4-2** that the vaults with standalone CHB's require a significantly larger staff. However, this is mostly due to the fact that the vaults with standalone CHB's are able to process twice as many DPCs into storage per week compared to the vaults with integral CHBs. The positions in **Table A4-2** are described below.

The supervisor is the person in responsible charge of the SNF shipment once accepted by the site. A supervisor is assigned to each transport cask and is responsible for all activities associated with the transfer of the DPC from that transport cask into storage. A separate supervisor may be assigned to oversee and monitor the recycling of Transport Casks when those activities are being conducted in parallel with the DPC placement.

Mechanics are responsible for removing the mechanical fasteners that hold the various cask lids on and the lifting lugs. Riggers are responsible for attaching the lifting devices to casks and for visually monitoring the lifts. Under certain circumstances, rigors and mechanics may be in fact the same people.

Electricians are instrumentation specialists who visually inspect the tamper proof seals on the transport casks and reinstalling them for the reshipment. They also have a role in installing the instrumentation packages to the storage containers in the fabrication crew and attaching the instrumentation to the monitoring systems once the SNF is placed in storage.

Health Physics teams are associated with all DPC handling activities as are QA/QC inspectors.

The Crane Operators are needed for OTB cranes in the CHB and in the Vault Buildings. They also are required for an array of jib cranes and specialized hoists associated with the shielded transfer sleeve and the transfer casks.

The Heavy Equipment operators are the operators of the Omni-loaders that transport the DPCs in their shielded transfer casks from the CHB to the Vault Buildings in options BGVc and BGVd. Because the distance between the CHB and the vault buildings is short, and because the Omni-loaders are only used to deliver the shielded transfer casks between buildings, the ISF only needs two Omni-loaders of each type for operations. Due to the complexity of these machines, one spare Omni-loader of each type is needed.

An observation that can be made from the data in **Tables A4-2 through A4-5** is that the operations in an ISF utilizing a standalone CHB, are much more complex than in the integral CHB designs. This is because it is required to double handle the DPCs in the standalone CHB case. (The DPCs are transferred into a Transfer Cask to transport them into the Vault Building.) In addition, there are more Crane operators and other infrastructure support personnel necessary for the standalone CHB design. However, while there are more operational steps and more complexity the standalone CHB design can process more DPCs per week because of the flexibility of the railbay cranes to function freely.

In order to establish how large the crew sizes are, the table above needs to be used in conjunction with the time motion studies presented in **Section A4-2.6**. Depending on the variant discussed, several shifts a week do not require a full complement of workers for the entire shift. The idled workers will be rotated back to the matrixed workforce for other assignments as necessary. Certain workers such as the crane operator, the Health Physics techs and the QA/QC inspectors are area workers in that they are assigned an area and service the SNF canister only when it is that area. The crane operators use radio remote controllers for the OTB cranes, the shielded transfer sleeve hoists and for jib cranes so that one person could, in fact, operate all of the cranes in a certain area. The mechanics and riggers are task focused and only work on the DPC to accomplish certain activities.

Table A4-2
Basis of Staffing for BGVa

BGVa - Vertical DPCs stored vertically on vault floor		Supervisor	Mechanics	Electricians	Riggers	Operations*	HP	QA/QC	Crane	RR Ops*	Heavy Eq. Operator	Security*	Total Staff	Duration (hrs)
0)	Plan of the Day and Safety Meeting	1	2	2	2	0	2	1	1	0	0	0	11	0.5
1)	Receive transport cask at BGV/AGV	1	2	2	0	1	2	1	0	2	0	2	13	1
2)	Remove impact limiters and place in temporary storage	1	2	0	2	0	2	0	1	0	0	0	8	3
3)	Upend and lift transport cask off of railcar and place on transfer cart	1	0	0	2	0	0	0	1	0	0	0	4	2
4)	Remove transport cask cover using jib crane and set down	1	2	0	2	0	2	0	1	0	0	1	9	1
4a)	Secure the Transport cask and the transfer cart seismically	1	2	0	2	0	0	1	1	0	0	0	7	0.5
4b)	Plan of the Day and Safety Meeting	1	2	2	2	0	2	1	1	0	0	0	11	0.5
5)	Hoist lifting lug to top of DPC and bolt in place	1	2	0	1	0	0	0	0	0	0	0	4	1
6)	Position transfer cart in transfer cell and close shield doors	1	0	0	2	0	0	0	0	0	0	0	3	1
7)	Position shielded transfer sleeve on bridge crane above transfer cell	1	0	0	2	0	0	0	1	0	0	0	4	0.5
8)	Lower hoist, grapple lifting lug, and raise DPC into shield sleeve	1	0	0	2	0	0	1	1	0	0	0	5	1.25
9)	Transfer DPC to vault storage location	1	0	0	2	0	0	0	1	0	0	0	4	2
10)	Remove shield plug above vault storage location	1	0	0	2	0	0	0	1	0	0	0	4	1
11)	Lower DPC into storage position on vault floor	1	0	0	2	0	0	1	1	0	0	0	5	1
12)	Replace shield plug above vault storage location	1	0	0	2	0	2	1	1	0	0	0	7	1
12a)	Turnover to Operations	1	0	2	0	2	2	1	0	0	0	0	8	24
13)	Return Crane to Operating Floor	1	0	0	0	0	0	0	1	0	0	0	2	1
14)	Remove transport cask from transfer cell	1	0	0	2	0	0	0	1	0	0	0	4	1
15)	Install transport cask lid	1	2	0	2	0	2	1	1	0	0	1	10	1
16)	Lift transport cask and transfer to maintenance	1	0	0	2	0	0	0	1	0	0	0	4	1
16a)	Survey and wipedown Transport Cask	1	0	0	0	0	2	0	0	0	0	0	3	1
17)	Lift transport cask, place on railcar, and downend	1	2	2	2	0	0	0	1	0	0	2	10	1
17b)	Plan of the Day and Safety Meeting	1	2	0	2	0	2	1	1	0	0	0	9	0.5
18)	Install impact limiters on transport cask	1	2	0	2	0	0	1	1	0	0	0	7	2
18a)	Plan of the Day and Safety Meeting	1	0	0	0	0	2	1	0	0	0	0	4	0.5
19)	Release railcar for shipment	1	0	0	0	1	2	1	0	2	0	2	9	1

* These categories are loaned to the Cask Handling Crew

Table A4-2
Basis of Staffing for BGVa (Cont'd)

BGVa - Horizontal DPCs stored vertically on vault floor		Supervisor	Mechanics	Electricians	Riggers	Operations*	HP	QA/QC	Crane	RR Ops*	Heavy Eq. Operator	Security*	Total Staff	Duration (hrs)
0)	Plan of the Day and Safety Meeting	1	2	2	2	0	2	1	1	0	0	0	11	0.5
1)	Receive transport cask at BGV/AGV	1	2	2	0	1	2	1	0	2	0	2	13	1
2)	Remove impact limiters and place in temporary storage	1	2	0	2	0	0	0	1	0	0	0	6	3
3)	Upend and lift transport cask off of railcar and downend on transfer fixture	1	0	0	2	0	0	0	1	0	0	0	4	2
4)	Remove transport cask lid	1	2	0	2	0	1	0	1	0	0	1	8	1
4a)	Secure the Transport cask and the transfer cart seismically	1	2	0	2	0	0	1	1	0	0	0	7	0.5
4b)	Plan of the Day and Safety Meeting	1	2	2	2	0	2	1	1	0	0	0	11	0.5
5)	Dock transfer sleeve on horizontal transfer cart with transport cask	1	0	0	2	1	2	0	0	0	0	0	6	1
6)	Push DPC from transport cask into transfer sleeve using ram mounted to fixed rack	1	0	0	2	1	0	0	0	0	0	0	4	1
7)	Decouple horizontal transfer cart from transport cask and close shield door	1	0	0	2	1	2	0	0	0	0	0	6	0.5
8)	Roll horizontal transfer cart onto turntable and rotate 180°	1	0	0	2	1	0	0	0	0	0	0	4	0.5
9)	Roll horizontal transfer cart to upending cell and dock storage/transfer cask on upender	1	0	0	2	1	0	0	0	0	0	0	4	0.5
10)	Push DPC from transfer sleeve into lift frame in storage/transfer cask	1	0	0	2	1	0	0	0	0	0	0	4	1
11)	Unbolt docking collar from storage/transfer cask and undock horizontal transfer cart	1	0	0	2	1	0	0	0	0	0	0	4	1
12)	Upend storage/transfer cask w/ DPC	1	0	0	2	1	0	0	0	0	0	0	4	0.5
13)	Install storage/transfer cask lid using jib crane in upender transfer cell	1	2	0	2	0	2	1	1	0	0	0	9	1
14)	Position shielded transfer sleeve above transfer cell	1	0	0	2	0	0	1	1	0	0	0	5	1
14a)	Secure the shielded transfer sleeve seismically	1	2	0	2	0	0	1	1	0	0	0	7	0.5
14b)	Plan of the Day and Safety Meeting	1	0	2	2	0	2	1	1	0	0	0	9	0.5
15)	Lower hoist, grapple lifting lug and raise DPC into shield sleeve	1	0	0	2	0	0	0	1	0	0	0	4	1
16)	Transfer DPC to vault storage location	1	0	0	2	0	0	0	1	0	0	0	4	2
17)	Remove shield plug above vault storage location	1	0	0	2	0	0	1	1	0	0	0	5	1
18)	Lower DPC and lift frame into storage position on vault floor	1	0	0	2	0	0	1	1	0	0	0	5	1
19)	Replace shield plug above vault storage location	1	0	0	2	0	0	1	1	0	0	0	5	1
19a)	Turnover to Operations	1	0	2	0	2	0	1	0	0	0	0	6	24
20)	Return crane to Operating Floor	0	0	0	2	0	0	0	1	0	0	1	4	1
21)	Install transport cask lid	1	2	0	2	0	2	1	1	0	0	1	10	1
22)	Lift transport cask and transfer to maintenance	1	0	0	2	0	0	0	1	0	0	0	4	1
22a)	Survey and wipedown Transport Cask	1	0	0	0	0	0	0	1	0	0	0	2	1
23)	Lift transport cask and place on railcar	1	2	2	2	0	1	0	1	0	0	1	10	1
24)	Install impact limiters on transport cask	1	2	0	2	0	0	1	1	0	0	0	7	2
25)	Release railcar for shipment	1	0	0	0	1	2	1	0	2	0	2	9	1

* These categories are loaned to the Cask Handling Crew

Table A4-3
Basis of Staffing for BGVb

	BGVb - Vertical DPCs stored vertically on vault floor	Supervisor	Mechanics	Electricians	Riggers	Operations	HP	QA/QC	Crane	RR Ops	Heavy Eq. Operator	Security	Total Staff	Duration (hrs)
0)	Plan of the Day and Safety Meeting	1	2	2	2	0	2	1	1	0	0	0	11	0.5
1)	Receive transport cask at BGV/AGV	1	2	2	0	1	2	1	0	2	0	2	13	1
2)	Remove impact limiters and place in temporary storage	1	2	0	2	0	2	0	1	0	0	0	8	3
3)	Upend and lift transport cask off of railcar and place on transfer cart	1	0	0	2	0	0	0	1	0	0	0	4	2
3a)	Remove railcar from Railbay	0	0	0	0	1	0	0	0	2	0	2	5	1
4)	Remove transport cask cover using jib crane and set down	1	2	0	2	0	2	0	1	0	0	1	9	1
4a)	Secure the Transport cask and the transfer cart seismically	1	2	0	2	0	0	1	1	0	0	0	7	0.5
4b)	Plan of the Day and Safety Meeting	1	2	2	2	0	2	1	1	0	1	0	12	0.5
5)	Hoist lifting lug to top of DPC and bolt in place	1	2	0	1	0	0	0	0	0	1	0	5	1
6)	Position transfer cart in transfer cell and close shield doors	1	0	0	2	0	0	0	0	0	1	0	4	1
7)	Position shielded transfer sleeve on bridge crane above transfer cell	1	0	0	2	0	0	0	1	0	0	0	4	0.5
8)	Lower hoist, grapple lifting lug, and raise DPC into shield sleeve	1	0	0	2	0	0	1	1	0	0	0	5	1.25
9)	Transfer DPC to vault storage location	1	0	0	2	0	0	0	1	0	0	0	4	2
10)	Remove shield plug above vault storage location	1	0	0	2	0	0	0	1	0	0	0	4	1
11)	Lower DPC into storage position on vault floor	1	0	0	2	0	0	1	1	0	0	0	5	1
12)	Replace shield plug above vault storage location	1	0	0	2	0	2	1	1	0	0	0	7	1
12a)	Turnover to Operations	1	0	2	0	2	2	1	0	0	0	0	8	24
13)	Return Crane to Operating Floor	1	0	0	0	0	0	0	1	0	0	0	2	1
14)	Remove transport cask from transfer cell	1	0	0	2	0	0	0	1	0	0	0	4	1
15)	Install transport cask lid	1	2	0	2	0	2	1	1	0	0	1	10	1
16)	Lift transport cask and transfer to maintenance	1	0	0	2	0	0	0	1	0	0	0	4	1
16a)	Survey and wipedown Transport Cask	1	0	0	0	0	2	0	0	0	0	0	3	1
16b)	Reposition Empty Railcar to Railbay	0	0	0	0	1	0	0	0	2	0	2	5	1
17)	Lift transport cask, place on railcar, and downend	1	2	2	2	0	0	0	1	0	0	2	10	1
17b)	Plan of the Day and Safety Meeting	1	2	2	2	0	2	1	1	0	1	0	12	0.5
18)	Install impact limiters on transport cask	1	2	0	2	0	0	1	1	0	0	0	7	2
18a)	Plan of the Day and Safety Meeting	1	0	0	0	0	2	1	0	0	0	0	4	0.5
19)	Release railcar for shipment	1	0	0	0	1	2	1	0	2	0	2	9	1

* These categories are loaned to the Cask Handling Crew

Table A4-3
Basis of Staffing for BGVb (Cont'd)

	BGVb - Horizontal DPCs stored horizontally in racks in vault	Supervisor	Mechanics	Electricians	Riggers	Operations*	HP	QA/QC	Crane	RR Ops*	Heavy Eq. Operator	Security*	Total Staff	Duration (hrs)
0)	Plan of the Day and Safety Meeting	1	2	2	2	0	2	1	1	0	0	0	11	0.5
1)	Receive transport cask at BGV/AGV	1	2	2	0	1	2	1	0	2	0	2	13	1
2)	Remove impact limiters and place in temporary storage	1	2	0	2	0	0	0	1	0	0	0	6	3
3)	Upend and lift transport cask off of railcar and place on transfer fixture	1	0	0	2	0	0	0	0	0	0	0	3	2
3a)	Remove railcar from Railbay	0	0	0	0	1	0	0	0	2	0	2	5	1
4)	Remove transport cask lid	1	2	0	2	0	2	0	0	0	0	1	8	1
4a)	Secure the Transport cask and the transfer fixture seismically	1	2	0	2	0	0	1	1	0	0	0	7	0.5
4b)	Plan of the Day and Safety Meeting	1	0	0	2	0	2	1	0	0	1	0	7	0.5
5)	Dock transport cask with port for transfer cart inside horizontal canister handling area	1	0	0	2	0	0	1	0	0	1	0	5	1
6)	Open port and push DPC through onto transfer cart	1	0	0	2	0	2	0	0	0	1	0	6	1
7)	Close port	1	0	0	2	0	2	0	0	0	1	0	6	0.5
8)	Transfer DPC to horizontal vault storage location	1	0	0	0	0	0	0	0	0	1	0	2	2
9)	Lower Transfer cart to place DPC onto horizontal storage rack	1	0	0	0	0	0	0	0	0	1	0	2	1
9a)	Transfer to Operations	1	0	0	0	2	2	1	0	0	0	0	6	24
9b)	Return Transfer Cart to Transfer Port and Realign	1	0	0	0	0	0	0	0	0	1	0	2	2
10)	Undock transport cask	1	0	0	2	0	0	0	0	0	0	0	3	1
11)	Install transport cask lid	1	2	0	2	0	0	1	0	0	0	0	6	1
11a)	Plan of the Day and Safety Meeting	1	2	0	2	0	2	1	1	0	0	0	9	0.5
12)	Lift transport cask and transfer to maintenance	1	0	0	2	0	0	0	1	0	0	0	4	1
12a)	Survey and wipedown Transport Cask	1	0	0	0	0	2	0	0	0	0	0	3	1
12b)	Reposition Empty Railcar to Railbay	0	0	0	0	1	0	0	0	2	0	2	5	1
13)	Lift transport cask off of transfer fixture and place on railcar	1	2	0	2	0	0	0	1	0	0	0	6	1
14)	Install impact limiters on transport cask	1	2	0	2	0	0	1	1	0	0	0	7	2
15)	Release railcar for shipment	1	0	0	1	1	1	1	0	2	0	2	9	1

* These categories are loaned to the Cask Handling Crew

Table A4-4
Basis of Staffing for BGVc

	BGVc - Vertical DPCs stored vertically on vault floor	Supervisor	Mechanics	Electricians	Riggers	Operations*	HP	QA/QC	Crane	RR Ops*	Heavy Eq. Operator	Security*	Total Staff	Duration (hrs)
0)	Plan of the Day and Safety Meeting	1	2	2	2	0	2	1	1	0	1	0	12	0.5
1)	Receive transport cask on railcar at Cask Handling Building	1	2	2	0	1	2	1	0	2	0	2	13	1
2)	Remove impact limiters and place in temporary storage	1	2	0	2	0	2	0	1	0	0	0	8	3
3)	Upend and lift transport cask off of railcar and place on unloading cell transfer cart	1	0	0	2	0	2	0	1	0	0	0	6	2
3a)	Remove railcar from Railbay	0	0	0	0	1	0	0	0	2	0	2	5	1
4)	Unbolt and remove transport cask lid using jib crane	1	2	0	2	0	2	0	1	0	0	1	9	1
4a)	Secure Transport Cask on unloading cell transfer cart	1	2	0	2	0	0	1	1	0	0	0	7	0.5
4b)	Plan of the Day and Safety Meeting	1	2	0	2	0	2	1	1	0	1	0	10	0.5
5)	Attach lifting lug to top of DPC	1	2	0	2	0	2	1	1	0	1	0	10	1
6)	Position transport cask transfer cart in unloading cell and close shield doors	1	0	0	2	0	2	0	0	0	1	0	6	0.5
7)	Stage empty shielded transfer cask in receiving cell using a transfer cart	1	2	0	2	0	0	1	0	0	1	0	7	0.5
8)	Position shielded transfer sleeve cart over unloading cell	1	0	0	2	0	2	1	0	0	1	0	7	0.5
9)	Lower shield sleeve hoist and grapple DPC lifting lug	1	0	0	2	0	2	0	0	0	1	0	6	0.5
10)	Raise DPC into shield sleeve	1	0	0	2	0	2	1	0	0	1	0	7	1
11)	Position shielded transfer sleeve cart over shielded transfer cask in receiving cell	1	2	0	2	0	2	0	0	0	1	0	8	0.5
12)	Lower DPC into shielded transfer cask, release grapple, and retract hoist	1	0	0	2	0	2	0	0	0	0	0	5	1
13)	Install shielded transfer cask lid using jib crane	1	2	0	2	0	0	1	1	0	0	1	8	1
14)	Place shielded transport cask at CHB floor pick point	1	0	0	2	0	0	0	1	0	0	0	4	1.3
14a)	Secure the Transport cask and the transfer cart seismically	1	2	0	2	0	0	1	1	0	0	0	7	0.5
14b)	Plan of the Day and Safety Meeting	1	2	2	2	0	2	1	1	0	1	0	12	0.5
15)	Pick up shielded transfer cask and transfer to vault using omni-loader	1	0	0	2	0	0	0	1	0	1	0	5	1
16)	Place shielded transfer cart onto transfer cart	1	0	0	2	0	0	0	1	0	1	0	5	0.5
17)	Remove shielded transfer cask cover	1	2	0	2	0	2	1	0	0	0	1	9	1
18)	Position transfer cart in unloading cell and close shield doors	1	0	0	2	0	2	1	0	0	0	0	6	0.5
19)	Position shielded transfer sleeve above transfer cell	1	0	0	2	0	2	0	1	0	0	0	6	0.5
20)	Lower hoist, grapple lifting lug and raise DPC into shield sleeve	1	0	0	2	0	0	1	1	0	0	0	5	1.25
20a)	Secure the Transport cask and the transfer cart seismically	1	2	0	2	0	0	1	1	0	0	0	7	0.5
20b)	Plan of the Day and Safety Meeting	1	2	2	2	0	2	1	1	0	1	0	12	0.5
21)	Transfer DPC to vault storage location	1	0	0	2	0	0	0	1	0	0	0	4	2
22)	Remove shield plug above vault storage location	1	2	0	2	0	2	0	1	0	0	0	8	1
23)	Lower DPC into storage position on vault floor	1	0	0	2	0	2	1	1	0	0	0	7	1
24)	Replace shield plug above vault storage location	1	0	0	2	0	2	1	1	0	0	0	7	1
24a)	Turnover to Operations	1	0	2	0	2	2	1	0	0	0	0	8	24
25)	Return Crane to Operating Floor	0	0	0	0	0	0	0	1	0	0	0	1	1
26)	Remove shielded transfer cask from transfer cell	1	0	0	2	0	0	0	1	0	0	0	4	1
27)	Install shielded transfer cask lid using jib crane	1	2	0	2	0	0	1	1	0	0	1	8	0.5
28)	Place shielded transfer cask at vault floor pick point	1	0	0	2	0	0	0	1	0	0	0	4	0.5
29)	Return shielded transfer cask to CHB using omni-loader	1	0	0	2	0	0	0	1	0	0	0	4	1
30)	Open unloading cell shield doors and position transfer cart under jib crane	1	2	0	0	0	2	0	1	0	0	0	6	1
31)	Install transport cask lid	1	2	0	2	0	0	1	1	0	0	1	8	1
32)	Lift transport cask and transfer to maintenance	1	0	0	2	0	0	0	1	0	0	0	4	1
32a)	Survey and Wipedown Transport Cask	1	0	0	0	0	2	0	0	0	0	0	3	1
32b)	Reposition Empty Railcar to Railbay	0	0	0	0	1	0	0	0	2	0	2	5	1
33)	Lift transport cask, place on railcar, and downend	1	2	0	2	0	0	0	1	0	0	0	6	1
34)	Install impact limiters on transport cask	1	2	2	2	0	0	1	1	0	0	0	9	2
35)	Release railcar for shipment	1	0	0	0	1	1	1	0	2	0	2	8	1

* These categories are loaned to the Cask Handling Crew

Table A4-4
Basis of Staffing for BGVc (Cont'd)

	BGVc - Horizontal DPCs stored vertically on vault floor	Supervisor	Mechanics	Electricians	Riggers	Operations	HP	QA/QC	Crane	RR Ops	Heavy Eq. Operator	Security	Total Staff	Duration
0)	Plan of the Day and Safety Meeting	1	2	2	2	0	2	1	1	0	0	0	11	0.5
1)	Receive transport cask at Cask Handling Building	1	2	2	0	1	2	1	0	2	0	2	13	1
2)	Remove impact limiters and place in temporary storage	1	2	0	2	0	2	0	1	0	0	0	8	3
3)	Horizontally lift transport cask off of railcar and place on transfer fixture	1	0	0	2	0	0	0	1	0	0	0	4	2
3a)	Remove railcar from Railbay	0	0	0	0	1	0	0	0	2	0	2	5	1
4)	Remove transport cask lid	1	2	0	2	0	2	0	1	0	0	1	9	1
4a)	Secure the Transport cask and the transfer cart seismically	1	2	0	2	0	0	1	1	0	0	0	7	0.5
4b)	Plan of the Day and Safety Meeting	1	2	2	2	0	2	1	1	0	1	0	12	0.5
5)	Dock transfer sleeve on horizontal transfer cart with transport cask	1	0	0	2	1	2	0	0	0	0	0	6	1
6)	Push DPC from transport cask into transfer sleeve using ram mounted to fixed rack	1	0	0	2	1	0	0	0	0	0	0	4	1
7)	Decouple horizontal transfer cart from transport cask and close shield door	1	0	0	2	1	2	0	0	0	0	0	6	0.5
8)	Roll horizontal transfer cart onto turntable and rotate 180°	1	0	0	2	1	0	0	0	0	0	0	4	0.5
9)	Roll horizontal transfer cart to upending cell and dock storage/transfer cask on upender	1	0	0	2	1	0	0	0	0	0	0	4	0.5
10)	Push DPC from transfer sleeve into lift frame in storage/transfer cask	1	0	0	2	1	0	0	0	0	0	0	4	1
11)	Unbolt docking collar from storage/transfer cask and undock horizontal transfer cart	1	0	0	2	1	0	0	0	0	0	0	4	1
12)	Upend storage/transfer cask w/ DPC	1	0	0	2	1	0	0	0	0	0	0	4	0.5
13)	Install storage/transfer cask lid using jib crane in upender transfer cell	1	2	0	2	0	2	1	1	0	0	0	9	1
14)	Place transfer cask at CHB floor pick point	1	0	0	2	0	0	0	0	0	1	0	4	0.5
15)	Pick transfer cask and transfer to vault building using omni-loader	1	0	0	2	0	0	0	0	0	1	0	4	1
16)	Lift transfer cask and place on transfer cart	1	0	0	2	0	0	0	1	0	1	0	5	0.5
17)	Remove transfer cask cover	1	2	0	2	0	0	0	1	0	0	0	6	0.5
18)	Roll transfer cart into transfer cell and close shield doors	1	0	0	2	0	0	1	1	0	0	0	5	1
19)	Position shielded transfer sleeve above transfer cell	1	0	0	2	0	2	1	1	0	0	0	7	1
20)	Lower Hoist, grapple lifting lug and raise DPC into shielded transfer sleeve	1	0	0	2	0	2	1	1	0	0	0	7	1
20a)	Secure the Transport cask and the transfer cart seismically	1	2	0	2	0	0	1	1	0	0	0	7	0.5
20b)	Plan of the Day and Safety Meeting	1	2	2	2	0	2	1	1	0	1	0	12	0.5
21)	Transfer DPC to vault storage location	1	0	0	2	0	0	0	1	0	0	0	4	2
22)	Remove shield plug above vault storage location	1	0	0	2	0	2	0	1	0	0	0	6	1
23)	Lower DPC and lift frame into storage position on vault floor	1	0	0	2	0	0	0	1	0	0	0	4	1
24)	Replace shield plug above vault storage location	1	0	0	2	0	0	1	1	0	0	0	5	1
24a)	Turnover to Operations	1	0	2	2	2	2	1	0	0	0	0	10	24
25)	Return Crane to Operating Floor	0	0	0	0	0	0	0	1	0	0	0	1	1
26)	Remove shielded transfer cask from transfer cell	1	0	0	2	0	0	0	1	0	0	0	4	1
27)	Install shielded transfer cask lid using jib crane	1	2	0	2	0	0	1	1	0	0	1	8	0.5
28)	Place shielded transfer cask at vault floor pick point	1	0	0	2	0	0	0	1	0	0	0	4	0.5
29)	Return shielded transfer cask to CHB using omni-loader	1	0	0	2	0	0	0	1	0	0	0	4	1
30)	Open unloading cell shield doors and position transfer cart under jib crane	1	2	0	0	0	2	0	1	0	0	0	6	1
31)	Install transport cask lid	1	2	0	2	0	0	1	1	0	0	1	8	1
32)	Lift transport cask and transfer to maintenance	1	0	0	2	0	0	0	1	0	0	0	4	1
32a)	Survey and Wipedown Transport Cask	1	0	0	0	0	2	0	0	0	0	0	3	1
32b)	Reposition Empty Railcar to Railbay	0	0	0	0	1	0	0	0	2	0	2	5	1
33)	Lift transport cask, place on railcar, and downend	1	2	0	2	0	0	0	1	0	0	0	6	1
34)	Install impact limiters on transport cask	1	2	2	2	0	0	1	1	0	0	0	9	2
35)	Release railcar for shipment	1	0	0	0	1	1	1	0	2	0	2	8	1

* These categories are loaned to the Cask Handling Crew

Table A4-5
Basis of Staffing for BGVd

BGVd - Vertical DPCs stored vertically on vault floor		Supervisor	Mechanics	Electricians	Riggers	Operations*	HP	QA/QC	Crane	RR Ops*	Heavy Eq. Operator	Security*	Total Staff	Duration (hrs)
0)	Plan of the Day and Safety Meeting	1	2	2	2	0	2	1	1	0	0	0	11	0.5
1)	Receive transport cask on railcar at Cask Handling Building	1	0	2	0	1	2	1	0	2	0	2	11	1
2)	Remove impact limiters and place in temporary storage	1	2	0	2	0	0	1	1	0	0	0	7	3
3)	Upend and lift transport cask off of railcar and place on unloading cell transfer cart	1	0	0	2	0	0	0	1	0	0	0	4	2
3a)	Remove railcar from Railbay	0	0	0	0	1	0	0	0	2	0	2	5	1
4)	Unbolt and remove transport cask lid using jib crane	1	2	0	2	0	0	0	1	0	0	0	6	1.3
4a)	Secure Transport Cask on unloading cell transfer cart	1	2	0	2	0	0	1	1	0	0	0	7	0.5
4b)	Plan of the Day and Safety Meeting	1	2	2	2	0	2	1	1	0	1	0	12	0.5
5)	Attach lifting lug to top of DPC	1	2	0	2	0	0	0	1	0	0	0	6	1
6)	Position transport cask transfer cart in unloading cell and close shield doors	1	0	0	2	0	0	1	1	0	0	1	6	1
7)	Stage empty shielded transfer cask in receiving cell using a transfer cart	1	0	0	2	0	0	0	1	0	0	0	4	0.5
8)	Position shielded transfer sleeve cart over unloading cell	1	0	0	2	0	0	0	1	0	0	0	4	0.5
9)	Lower shield sleeve hoist and grapple DPC lifting lug	1	0	0	2	0	2	0	1	0	0	0	6	0.5
10)	Raise DPC into shield sleeve	1	0	0	2	0	2	1	1	0	0	0	7	1
11)	Position shielded transfer sleeve cart over shielded transfer cask in receiving cell	1	0	2	2	0	2	1	1	0	1	0	10	1
12)	Lower DPC into shielded transfer cask, release grapple, and retract hoist	1	0	0	2	0	0	1	1	0	0	0	5	1
13)	Install shielded transfer cask lid using jib crane	1	2	0	2	0	0	0	1	0	0	0	6	1
13a)	Secure the Shielded Transfer Cask and the transfer cart seismically	1	2	0	2	0	2	1	1	0	0	0	9	1
13b)	Plan of the Day and Safety Meeting	1	0	0	2	0	2	1	1	0	0	0	7	1
14)	Place shielded Transfer Cask on CHB floor pick point	1	0	0	2	0	0	0	1	0	0	0	4	1
15)	Pick up shielded transfer cask and transfer to BGV using omni-loader	1	0	0	2	1	2	1	0	0	1	2	10	1
16)	Place shielded transfer cart onto transfer cart	1	0	0	2	0	0	0	1	0	0	0	4	0.5
17)	Remove shielded transfer cask Lid	1	2	0	2	0	2	0	1	0	0	0	8	1
18)	Position transfer cart in unloading cell and close shield doors	1	0	0	2	0	0	0	1	0	0	0	4	0.5
19)	Position shielded transfer sleeve above transfer cell	1	0	0	2	0	0	0	1	0	0	0	4	0.5
20)	Lower hoist, grapple lifting lug and raise DPC into shield sleeve	1	0	0	2	0	0	1	1	0	0	1	6	1
20a)	Secure the Transport cask and the transfer cart seismically	1	0	0	2	0	0	0	1	0	0	0	4	1
20b)	Plan of the Day and Safety Meeting	1	2	2	2	0	2	1	1	0	1	0	12	0.5
21)	Transfer DPC to vault storage location	1	0	0	0	1	0	0	0	2	0	2	6	2
22)	Remove shield plug above vault storage location	1	2	0	2	0	0	0	1	0	0	0	6	1
23)	Lower DPC into storage position on vault floor	1	2	0	2	0	0	1	1	0	0	0	7	1
24)	Replace shield plug above vault storage location	1	0	0	0	1	1	1	0	2	0	2	8	1
24a)	Turnover to Operations	0	0	2	0	2	2	1	0	0	0	0	7	24
25)	Return Crane to Operating Floor	1	0	0	2	0	0	0	1	0	0	0	4	1
26)	Remove shielded transfer cask from transfer cell	1	0	0	2	0	0	0	0	0	0	0	3	1
27)	Install shielded transfer cask lid using jib crane	1	2	0	2	0	0	0	1	0	0	0	6	1
28)	Place shielded transfer cask at vault floor pick point	1	0	0	2	0	0	0	1	0	0	0	4	1
29)	Return shielded transfer cask to CHB using omni-loader	1	0	0	2	0	0	0	0	0	1	0	4	1
30)	Open unloading cell shield doors and position transfer cart under jib crane	1	0	0	2	0	0	0	1	0	0	0	4	1
31)	Install transport cask lid	1	2	0	2	0	0	1	1	0	0	0	7	1
32)	Lift transport cask and transfer to maintenance	1	0	0	2	0	0	0	1	0	0	0	4	1
32a)	Survey and Wipedown Transport Cask	1	0	0	0	0	2	0	0	0	0	0	3	1
32b)	Reposition Empty Railcar to Railbay	0	0	0	0	1	0	0	0	2	0	2	5	1
33)	Lift transport cask, place on railcar, and downend	1	2	2	2	0	0	0	1	0	0	0	8	1
34)	Install impact limiters on transport cask	1	2	0	2	0	0	1	1	0	0	0	7	2
35)	Release railcar for shipment	1	0	0	0	1	2	1	0	2	0	2	9	1

* These categories are loaned to the Cask Handling Crew

Table A4-5
Basis of Staffing for BGVd (Cont'd)

BGVd - Horizontal DPCs stored Horizontally on racks in vault		Supervisor	Mechanics	Electricians	Riggers	Operations*	HP	QA/QC	Crane	RR Ops*	Heavy Eq. Operator	Security*	Total Staff	Duration (hrs)
0)	Plan of the Day and Safety Meeting	1	2	2	2	0	2	1	1	0	0	0	11	0.5
1)	Receive transport cask at Cask Handling Building	1	0	2	0	1	2	1	0	2	0	2	11	1
2)	Remove impact limiters and place in temporary storage	1	2	0	2	0	0	1	1	0	0	0	7	3
3)	Upend and lift transport cask off of railcar and place on Transfer Fixture	1	0	0	2	0	0	0	1	0	0	0	4	2
3a)	Remove railcar from Railbay	0	0	0	0	1	0	0	0	2	0	2	5	1
4)	Remove Transport Cask lid	1	2	0	2	0	2	1	1	0	0	0	9	1
5)	Remove Shield Transfer Cask lid	1	0	0	0	0	2	0	0	0	0	0	3	1
6)	Lift transfer cask, place on transfer fixture, and downend	0	0	0	0	1	0	0	0	2	0	2	5	1
7)	Lift Transport Cask, place on transfer fixture, and downend	1	2	2	2	0	0	0	1	0	0	0	8	1
7a)	Plan of the Day and Safety Meeting	1	2	0	2	0	0	1	1	0	0	0	7	0.5
8)	Push DPC through into transfer cask using hydraulic ram	1	0	0	0	1	2	1	0	2	0	0	7	1
9)	Withdraw Ram and upend Shielded Transfer Cask	1	0	0	2	0	0	0	1	0	0	0	4	1
10)	Install Shielded Transfer Cask lid	1	2	0	2	0	2	1	1	0	0	0	9	1
11)	Lift Shielded Transfer Cask and place Omni-Loader and download	1	0	0	2	0	0	0	1	0	1	0	5	1
12)	Transfer Shielded Transfer Cask to BGV using omni-loader	1	0	0	2	0	0	0	0	0	1	2	6	1
13)	Upend and remove Shielded Transfer Cask from Omni-Loader	1	0	0	2	0	0	0	1	0	1	0	5	1
14)	Place on Transfer Cask one of the vault transfer fixture	1	0	0	2	0	0	0	1	0	0	0	4	1
15)	Remove Shield Transfer Cask lid and downend	1	2	0	2	0	2	0	1	0	0	0	8	1
15a)	Plan of the Day and Safety Meeting	1	2	0	2	1	2	1	1	0	1	0	11	0.5
16)	Open transfer port and dock Shielded Transfer Cask with Collar	1	0	0	2	1	2	1	0	0	0	0	7	1
17)	Push DPC through onto the Horizontal DPC Transfer Cart hydraulic ram	1	0	0	2	1	2	1	0	0	0	0	7	1
18)	Withdraw Ram and close Transfer Port	1	0	0	2	1	2	0	0	0	0	0	6	0.5
19)	Transfer DPC to horizontal vault storage location	1	0	0	2	1	0	0	0	0	0	0	4	2
20)	Lower Transfer cart to place DPC onto horizontal storage rack	1	0	0	2	1	0	0	1	0	0	0	5	1
20a)	Turnover to Operations	1	2	0	2	0	2	1	1	0	1	0	10	24
21)	Return Horizontal DPC Transfer Cast to Transfer Port	1	0	0	2	1	0	0	0	0	0	0	4	2
22)	Undock Shielded Transfer Cask and Upend	1	0	0	2	1	0	0	1	0	0	0	5	1
23)	Install Shielded Transfer Cask lid	1	2	0	2	0	0	0	1	0	0	0	6	1
24)	Lift Shielded Transfer Cask and Place on Omni-Loader	1	0	0	2	0	0	0	1	0	1	0	5	1
25)	Transfer Shielded Transfer Cask to CHB using omni-loader	1	2	0	2	0	0	0	0	0	1	2	8	1
26)	Undock Transport Cask and Upend	1	0	0	2	0	0	0	1	0	1	0	5	1
27)	Install transport cask lid	1	0	0	2	0	0	1	1	0	0	0	5	1
28)	Lift transport cask and transfer to maintenance	1	0	0	2	0	0	0	1	0	0	0	4	1
29)	Survey and wipedown Transport Cask	1	0	0	0	0	2	0	0	0	0	0	3	1
30)	Reposition Empty Railcar to Railbay	0	0	0	0	1	0	0	0	2	0	2	5	1
31)	Lift transport cask and place on railcar	1	2	2	2	0	0	0	1	0	0	0	8	1
32)	Install impact limiters on transport cask	1	2	0	2	0	0	1	1	0	0	0	7	2
33)	Release railcar for shipment	1	0	0	0	1	2	1	0	2	0	2	9	1

* These categories are loaned to the Cask Handling Crew

The results of this effort are summarized in **Table A4-6** below. This staffing estimate is approximate since not all crafts are required for an entire shift. Also, some intermediate steps do not require a certain craft, but in reality, they do not disappear. These interruptions are ignored because they provide opportunities for breaks for the workers and do not materially impact the assessment.

The ISF labor pool will be a matrix structure where necessary craft and managers will be drawn from the site organization staff as necessary to achieve the desired operations. This is an obvious requirement because of the variability in the Canister Handling Crew size by shift in **Table A4-6**.

Based on this study, the site organization staff will need to be increased by a maximum of 28 workers to achieve the desired ISF throughput during the Canister Handling phase of the facility's life cycle for the BGVa/BGVb design. This results in a total ISF staff of 164. A similar analysis for the BGVc/BGVd designs results in the need for an increase of 46 workers for a total ISF workforce size of 182.

Table A4-6
Canister Handling Crew Makeup

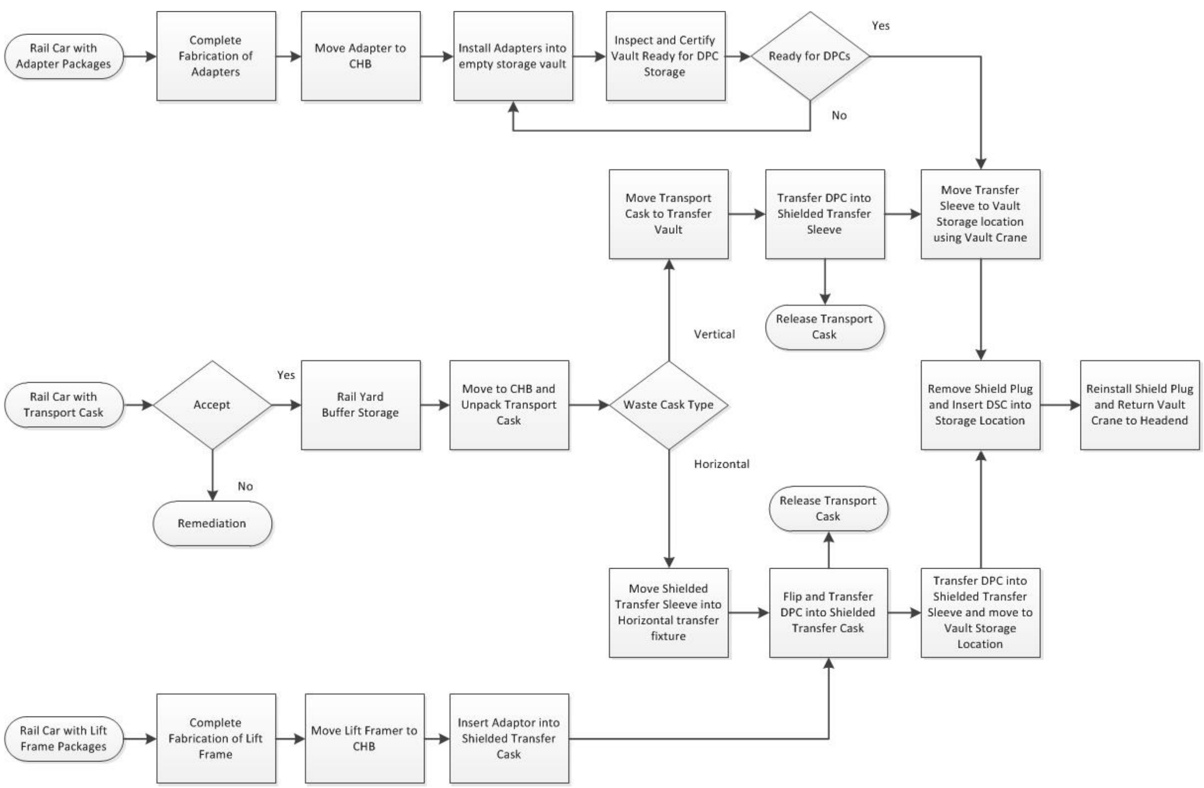
BGVa/BGVb Crew	Shift 1	Shift 2	Shift 3	Shift 4	Shift 5	Average*
Supervisor	1	3	3	1	1	2
Mechanics	2	6	6	2	2	4
Electricians	2	4	2	0	2	2
Riggers	2	6	8	4	2	5
HP	2	4	4	2	2	3
QA/QC	1	2	2	1	1	2
Crane Operator	1	3	3	2	1	2
Heavy Eq. Operator	0	0	0	0	0	0
	11	28	28	12	11	20
BGVc/BGVd Crew	Shift 1	Shift 2	Shift 3	Shift 4	Shift 5	Average*
Supervisor	5	5	5	5	5	5
Mechanics	8	8	8	8	8	8
Electricians	4	4	4	4	4	4
Riggers	10	10	10	10	10	10
HP	8	8	8	8	8	8
QA/QC	5	5	5	5	5	5
Crane Operator	5	5	5	5	5	5
Heavy Eq. Operator	1	1	1	1	1	1
	46	46	46	46	46	46

* To the nearest whole person

A4-2.4 Material Handling Flow Diagram

Figure A4-7 is a representation of the material handling flow for the Below Grade Vault alternative for the ISF with integral CHB. It describes the material flows of the operation. The central flow is the movement of DPCs containing SNF to the site. But equally important to the operations of the ISF are the material flow necessary to support the production of suitable storage insert/adaptor/lifting frames to place the DPCs into after being accepted by the site for storage. The vertical storage adaptors are prefabricated by the vendors and shipped to the site as steel structures packaged to protect them during transit. These adaptors are only required for legacy DPCs that are much smaller than the current DPCs. The need for the adaptor will be part of the licensing basis for the Below Grade Vault design. The site crew will inspect these packages to accept them as undamaged and then will complete the fabrication in accordance with the vendor's specification. For horizontal storage systems, the site fabrication crew needs to complete the fabrication of the lifting frames using the vendor's design and components. Again, the lifting frames need to be designed to fit the legacy DPC to prevent unacceptable clearances.

Figure A4-7
Canister Handling Material Handling Flow Diagram BGVa[3]



[3] Remediation is not part of this study's work scope and is not addressed other than to note that the packages are not accepted on site regardless of their condition.

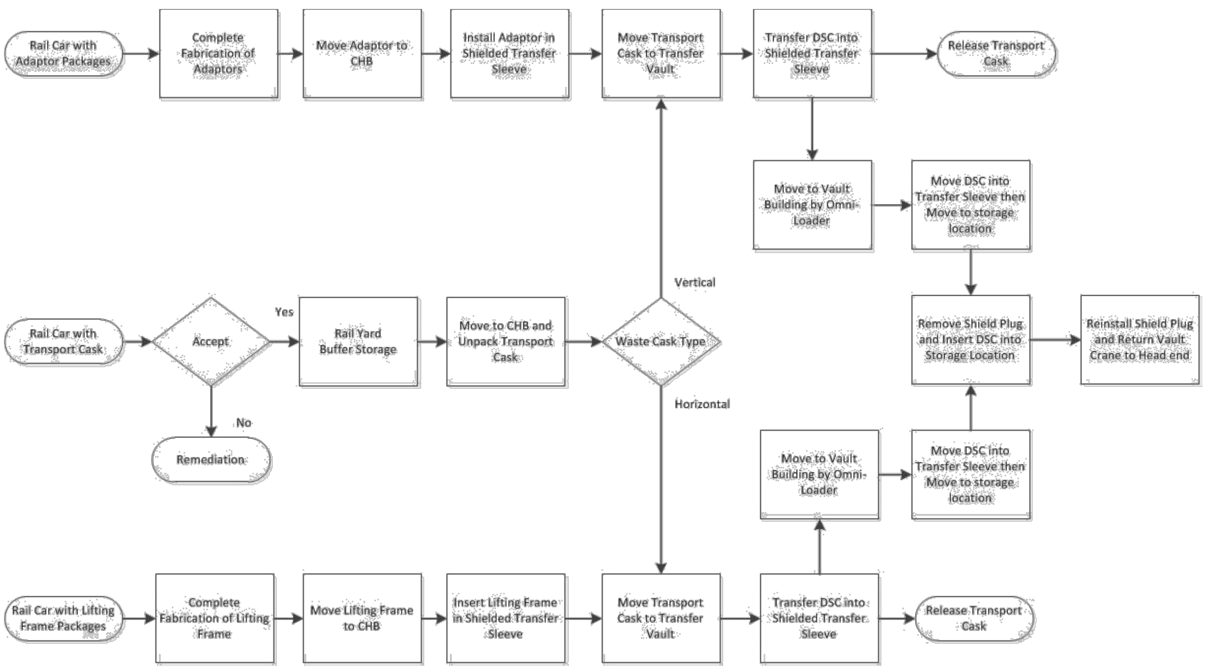
The largest operations challenge for the Below Grade Vault alternative is controlling the supply chain to ensure that the proper adaptor/lifting frame is available to match the DPC being received from the generator. The licensability of the final DPC is based on the conformance of the storage system with the original licensed dry storage system. As described in **Section A4-2.2** above, the preparation time for a storage system is at least a month after receipt of the hardware from the storage system vendor. The time necessary to install the necessary adapters to a bay in the storage vault could be 6 to 12 months after receipt of the components. The lead time for the components could be another 6 to 12 months. Therefore, 18 to 24 months before the receipt of the SNF at the site, the supply chain manager needs to place an order for the necessary storage system adaptor/lifting frame components. This means that the ISF staff needs to know well in advance of delivery what vendor and what model of DPC system is going to be shipped to the site. In addition, each DPC placed in the vault needs to have a lifting lug mated to the DPC or a Lift Frame. Therefore, the coordination of the supply chain for the lifting lug/adaptor/lifting frame fabrication and the SNF storage operations will be the largest management challenge for this design alternative using all-vertical storage.

The second variant uses a horizontal storage vault concept to avoid the need for lifting frames. In Alternatives BGVb and BGVd, the horizontal DPCs are stored in horizontal racks. The Transport Cask or Transfer Cask is picked by the OTB Crane and is placed on one of the four horizontal transfer fixtures.

The cask is lowered into the horizontal position and indexed up against the port in the shield wall and a ram pushes the DPC through the wall onto a Horizontal DPC Transfer Cart inside one of the four halls in the vault. Once the DPC is loaded on the Horizontal DPC Transfer Cart, the cart is moved down to the end of the storage hall. It indexes over a storage cradle and lowers its supports so that the DPC rests on the storage cradle. The Horizontal DPC Transfer Cart is returned to the loading area. This system loads from the far end of the hall to the near end.

Figure A4-8 is a representation of the material handling flow for the Below Grade Vault alternative for the ISF with standalone CHB. These designs are more complex, but are more capable because they provide more space to work on unloading and repackaging Transport Casks in the railbays. This is important to the throughput of the facility because the key to achieving an optimal throughput is to minimize the time it takes to cycle a railcar from receipt to release. Separating the DPC from the Transport Cask early in the process, enables the Railbay Crew to begin the recycling process before the DPC is placed in storage.

Figure A4-8
Canister Handling Material Handling Flow Diagram BGVc



It should be noted that there are no significant differences in the processing times necessary for all-vertical versus vertical/horizontal storage designs. Minor differences in material needed and steps taken aside, the main differences among these designs is the ability to separate the processing of the Transport Casks from the storage of the DPCs. In other words, the options with an integral CHB vs the standalone CHB represent the only significant differences among these options.

A4-2.5 Operations

A4-2.5.1 Operational Sequence

Canister Handling operations are a series of heavy lifts and crane movements that move the SNF in sealed DPCs from the rail head to the storage vault. The operational sequence was benchmarked against ISFSI operations at operating nuclear plants. Although no one has actually performed all of the operations at an ISF, each operation has a precedent established in the nuclear industry. The crew sizes and the durations necessary to perform each activity therefore has basis. This benchmarking provides the underpinning supporting this operational sequence and the Time and Motion analysis the follows in **Section A4-2.6**.

Figure A4-9 shows the high-level schedule for the two storage concepts in Below Grade Vault assuming 8-hour shifts. The operational sequence once the transport cask is accepted into the CHB can be divided into four large blocks:

1. Opening the Transport Cask
2. Moving the DPC into the Transfer device or system
3. Transfer of the DPC to the storage location and
4. Preparing for the turnaround of the Transport Cask.

It should be noted that this is essentially a three shift exercise regardless of the original storage concept used. The return of the Transport Cask is the key to the cycle time in that a new cask cannot be started until the previous one has been removed. Even in the case of horizontal DPCs stored vertically in BGVa of this alternative where the time necessary to install the DPC into its lifting frame forces the delay in the start of the movement of the DPC into storage until the start of the third shift. This is because the DPC needs to be transferred horizontally twice to insert it into its lift frame in the Transfer Cask. This is necessary to avoid storing the fuel upside down in the storage vault. The shielded transfer sleeve removes extracts the DPC in its lift frame from the Transfer Cask in the Upender and the cycle is complete by the end of the third shift.

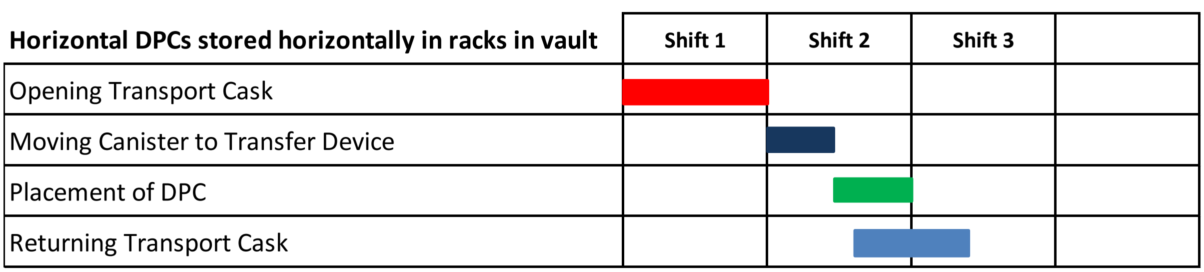
This problem is eliminated by the use of BGVb because the transfer of the DPC into storage is expedited for both the vertical and the horizontal cases. Even so, it takes three shifts. While it is true that another railcar can be started during the third shift, the inability to complete some steps during the shift makes this expedient problematic.

The railcar packaging of the Transport Cask is removed in the railbay using one of the OTB cranes. The impact limiters are removed and the cask cover and hold down straps are removed and stored. The Transport Cask is then upended by the OTB Crane servicing the Railbay and placed on a cart in the vertical orientation. The lid is removed and a lifting lug is bolted onto the top of the DPC. The cart is then moved into the transfer vault. The shielded transfer sleeve is then positioned above the Transport Cask by the other OTB crane. The shielded transfer sleeve hoist grapples the lifting lug and pulls the DPC into the shielded transfer sleeve.

Figure A4-9
High-Level Operational Sequences BGVa/BGVb

All Vertical Storage

Vertical and Horizontal Storage

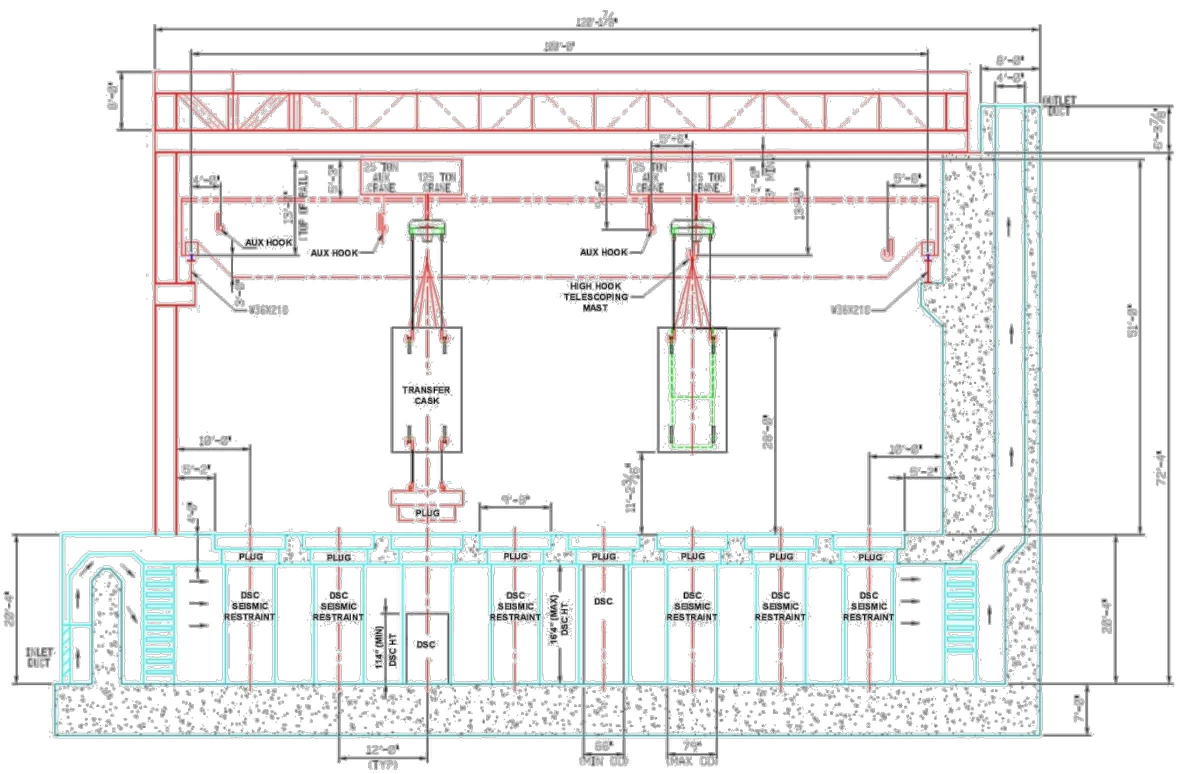


The railcar packaging of the Transport Cask is removed in the railbay using one of the OTB cranes. The impact limiters are removed and the cask cover and hold down straps are removed and stored. The Transport Cask is then upended by the OTB Crane servicing the Railbay and placed on a cart in the vertical orientation. The lid is removed and a lifting lug is bolted onto the top of the DPC. The cart is then moved into the transfer vault. The shielded transfer sleeve is then positioned above the Transport Cask by the other OTB crane.

The shielded transfer sleeve hoist grapples the lifting lug and pulls the DPC into the shielded transfer sleeve.

The OTB crane repositions the DPC over a shield plug in the storage hall. The end-effectors at the bottom of the shielded transfer sleeve grapple the shield plug and the crane lifts the plug out shield floor. The shield plug is placed to one side and the DPC is relocated back over the opening. The DPC is lowered into the lower vault. The DPC is placed on the vault floor under the shield plug. The DPCs are secured laterally in the vault by the DPC Seismic Restraint system that consists of I-Beams embedded in the floor to prevent the DPC from sliding sideways during a seismic event. The top restraint consists of a cage attached to the bottom of the shield operating floor extending down into the vault area far enough to capture the top of the shortest DPC in the industry. For DPCs that are very small in diameter, adaptors are used to minimize the impact against the seismic restraint systems as necessary to avoid damage to the DPCs. **Figure A4-10** shows the relationships of the various components and structures in the air-cooled vault area.

Figure A4-10
Cross-Section of the Storage Vault



Horizontal DPCs are handled in much the same way except the Transport Cask is placed on a horizontal transfer fixture and a hydraulic ram is used to push the DPC into a lifting frame that has been preinstalled inside the shielded transfer sleeve. Once installed, the transfer sleeve is rotated back into the vertical and the lifting lug is attached to the frame securing the DPC within. The shielded transfer sleeve is then picked off of the Transfer Fixture and handled in the same manner as is the case for vertical DPCs.

Lifting lugs attached to the vertical DPCs or to the lifting frames for horizontal DPCs remain in the vault because there is no shielding under the shield floor within a given vault compartment.

The original OTB crane is used to unpack the second railcar in the railbay. So that it can place the second DPC into the operational sequence to prepare it for storage. By staggering the DPC packages, this system can place two DPCs in four shifts. This keeps at least one crane busy in the railbay continuously. However, since there is more work to be done in the railbay than in the vault hall, the crane servicing the vault area is used an average of 2.5 times per week.

In BGVb of this alternative, the only the Horizontal DPCs are handled differently. In this variant, the Transport Cask is lowered onto a horizontal transfer fixture on the lower level of the Horizontal Vault hall. It is rotated into the horizontal and indexed up against a port in the shield wall. The Horizontal DPC is pushed through the port by a hydraulic ram onto a Horizontal DPC Transfer Cart that is located on a rail system inside the shielded area of the vault. Once the DPC is in position, the cart is moved to the far end of the vault to the next available position. Once in position, the mechanism holding the DPC is lowered which positions the DPC in a cradle the holds the DPC seismically. The mechanism is lowered enough to permit the cart to clear the DPC and the cart returns to the port.

There is a maintenance area near the horizontal transfer fixture for the Horizontal Transfer Carts.

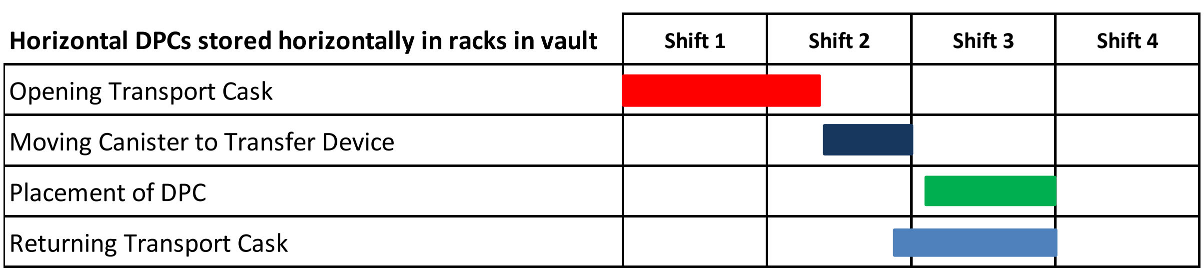
Figure A4-11 shows high-level operational sequence for the Vaults with Standalone CHB. The extra handling necessary to transfer the DPC twice, once in the CHB and once in the Vault Building is obvious. A three shift operation shown in **Figure A4-9** has become a four shift operation. However, it should be noted that the Transport Cask is recycled in three shifts just as in the case of the Integral CHB designs. Further, the fourth shift activities take place in the Vault Building and can be considered to be a parallel activity.

When these sequences are considered in series, this ability to perform work in two places, plus the ability of the CHB in the BGVc/BGVd designs to process more railcars per week make the Vaults with Standalone CHB able to double the throughput of the BGVa/BGVb designs.

Figure A4-11
High-Level Operational Sequences BGVc/BGVd

All Vertical Storage

Vertical and Horizontal Storage



2.5.2 Limits to Operation

Railbay

Operations in the railbay are arguably the most important of the operations at the ISF to determine the throughput. The storage sequence cannot begin until the first railbay activity is completed, and the cycle cannot be completed until the last activity in the railbay is finished. So, railbay activities limit the maximum throughput of the ISF. The vault designs with integral CHB are hampered by the fact that the railbay is serviced by the same crane that services the vault area. This coupled with a single rail bay design significantly reduces the throughput of the vault with integral CHB.

Overhead Traveling Bridge Cranes

The OTB cranes pace the activity in this alternative. Therefore, the more cranes the better the throughput will be. In the BGVa/BGVb designs the cranes must service both the railbay and the vault area. Moreover, these OTB cranes operate on the same tracks. Increasing the number of cranes therefore may not resolve the issue but rather cause a traffic jam in the overhead. The OTB crane servicing the railbay is required to be on station the entire time these activities are taking place. So, having an additional crane servicing the rail bay may not improve the situation because it cannot get past the other crane. This congestion is a major constraint of the vaults with integral CHBs.

Ironically, the vaults with a standalone CHB have solved this problem and even though their operations are significantly more complex than the vault designs with integral CHBs, their throughput is double the throughput of the simpler design.

Canister Transfer Cells

The vertical storage system transfers require canister transfer cells to provide shielding and to simplify operations during the transfer of the DPCs from the transport cask into the shielded transfer sleeve. Each canister transfer vault consists of a door to allow a transport cask on a transfer cart to enter and exit the cell and a transfer port in the roof of the vault to permit the movement of the DPC into the shielded transfer sleeve. Since it is possible that the ISF will process only vertical legacy DPCs for a period of time, it is necessary to have a minimum of two canister transfer cells. These vaults are not required for horizontal DPCs.

Horizontal DPC Transfer Fixture

The Horizontal DPC Transfer Fixture is a novel component for this study. While all of the components of this device are well understood from the legacy horizontal storage concepts, there are no working examples of the horizontal DPC Transfer Fixture in the industry. This device, if successfully designed, may be as fast as the vertical transfer using the transfer vault concept. However, this process is not expected to be simple or automated. One transfer per shift is all that can be projected and if the ISF is receiving only DPCs from a Horizontal Storage legacy site, then there must be two of these devices at least. A third Transfer Fixture may be required to allow for maintenance issues.

In the all vertical storage concepts, BGVa/BGVc, the Horizontal DPC Transfer Fixtures are used to insert the DPC into the lifting frame prepositioned in the shielded Transfer Sleeve. In the vertical and horizontal storage concepts, BGVb/BGVd, these devices are used to push the DPCs onto the Horizontal DPC Transfer Carts in the storage vaults. In the Vaults with Standalone CHB, these devices are used to push the DPCs into the shielded transfer cask to be transported over to the Vault Building.

Horizontal DPC Transfer Carts

The horizontal storage areas of BGVb/BGVd of this alternative are serviced by four Horizontal DPC Transfer Carts. They are “captured” because they are not removable and remain in the storage hall for the life of the facility. These carts are single failure proof devices that must function in a high radiation environment and be extraordinarily reliable and robust. DPCs are extremely heavy and sliding them onto a cart is problematic. If any problem occurs with one of these carts while moving a DPC to its storage position, it will be a difficult problem for the facility and could conceivably limit the storage capacity of the horizontal vault if the problem cannot be remedied.

Transporters

If a separated CHB is used, the vault type ISF will require cask transporters. Transporters are very complex, heavy haul machines. They move slowly at approximately 1 mph and take a long time to move their loads to the storage locations. It takes one and a half shifts from being loaded in the CHB until a transporter returns ready for a second load.

For the BGVc option, since only vertical DPCs will be utilized, then there will need for three VCTs in order not to cause a bottleneck: one VCT to service each railbay and one spare VCT to permit routine maintenance of the complex machinery to ensure continued throughput.

For the BGVd option, VCTs and HCTs are central to the operation of DPC transfer operations. HCTs are more complex than VCTs because they include positioning hydraulics to align the transport cask to the horizontal storage module and a hydraulic ram that pushes or pulls the DPC in or out of the module. Any failure of the HCTs immediately impacts the placement of horizontal DPCs and the throughput of the ISF. The HCT is used for more than one and a half shifts. If the site is processing nothing but horizontal DPCs for a period of time, there would be a need for three HCTs to maintain the ISF throughput. Once again, there may be the need for one or two spare HCTs to ensure that maintenance outages do not impact the ISF throughput.

A4-2.6 Time and Motion Analysis

A4-2.6.1 Methodology

No one has operated a national scale ISF for the dry storage of SNF. For this study, a high-level operational sequence was developed by the concept designers. These high-level activities were then decomposed into their constituent activities. At this level, the activities were generally ones that had been performed by operators at existing nuclear facilities, or that could be estimated by small extrapolations of existing operational experience. Interviews were conducted with several individuals with real, hands-on operational experience with moving SNF to achieve a consensus on the completeness, the durations and the staff size necessary to achieve each of these constituent activities. These were then pieced together to develop a bottom up estimate of durations and crew sizes for each step.

Additional steps were added to recognize the practice of having a “Plan of the Day” meeting and a safety meeting at the start of each shift. Also, steps not envisioned by the facility designers such as HP surveys of the emptied transport casks, and adding seismic restraints to packages containing SNF at the end of a shift were added to allow time for these necessary steps.

Once the operational sequence was developed, the sequences were considered in parallel to determine how many DPCs could be placed per week. Several basic assumptions were made. The first was that a large supply of transport casks on railcars was staged on the site ready for processing. If the ISF rail yard is empty or contains only two railcars during a week, this time and motion study does not apply. The two railcars will be processed and the Canister Handling Crews will be given other duties to fill up the week. So, the first inherent assumption is that the logistics supply chain is adequate to fully challenge the capacity of the ISF. Secondly, this study only considers operations that are already developed and in operation at existing operating nuclear plant experience. No unusual enhancements were considered. The shielded transfer sleeve is a multi-purposed device that is a logical extension of commonly employed devices. If it becomes too complex to design and deploy, t light-duty OTB crane that moves the shield plugs in the storage hall would be a simple expedient to simplify the design challenge. However, this assessment of the Below Grade Vault did not consider automating the transfer or adding a great deal of remote sensors to the area to eliminate personnel exposures. (See A-OPS for these improvements)

A major consideration for the Time and Motion Analysis was that no operation involving the movement of a DPC would be started during a shift if it could not be completed by the end of that shift. This is necessary because the CHB does not operate continuously, so no load would be left hanging or in some other unstable condition that would jeopardize the integrity of the SNF or its confining structures in the event of a design basis event. Abandoning the DPC in mid-operation would leave the canister in a potentially compromised position without qualified canister handling expertise on hand in case of emergency. Furthermore, the DPC was assumed to be secured seismically at the end of each shift.

As stated earlier, this study considers only a single 8-hour shift per week with no overtime. Clearly, the throughput could easily be increased by adding workers and shifts, and indeed that would be a cost effective expedient if additional capacity is desired. However, a working assumption of this study is only a single, 40-hour shift is necessary per week. Based on the certain problems with the logistics of moving SNF to the site, it is considered that this is a reasonable approach.

A4-2.6.2 Conclusion

It was determined that the Below Grade Vault throughput with all of the assumptions is an average of 2.5 full-sized DPCs placed into storage each week. Several observations came out of the Time and Motion Analysis. First, the layout of this concept has placed a great deal of activities in series. A single railbay covered by OTB cranes on a single set of tracks limits the performance of the concept. In addition, the OTB cranes are used to place the DPCs into storage which puts an additional time constraint on the use of the OTB cranes. Most of the activities associated with DPC storage are associated with activities in the railbay. So, optimizing the activities in the railbay results in only a great deal of time where the crane in the vault is idle.

Second, doubling the number of rails in the railbay would have no impact on the throughput unless there additional OTB cranes could be utilized. Even so, the system would result in idle time for cranes either in the railbay or in the vault area. The OTB cranes are the most important device in this concept. Although they are extremely reliable devices, any outage of one of these cranes would have a significant impact on the throughput of this facility.

Third, this concept is easier for the security team to protect because it is concentrated and contained. External threats and internal threats are easier to identify and to defeat than is the case for an external facility.

Finally, this concept is unaffected by weather and other environmental conditions during the loading process. Therefore, DPC placement is not impacted by external conditions so the ISF can be sited anywhere without the throughput being impacted.

Figures A4-12 through A4-15 show the schedules for the Below Grade Vault alternatives. The activities on the Y-axis are the steps necessary to process the DPCs from when they enter the Canister Handling Building until the empty transport cask has been reinstalled on the railcar and removed from the CHB. The time across the top of the schedule is in hours. The red bars are critical path activities; the blue are near critical path activities. It has been assumed that it will take 24-hours of observations of the DPC once stored to accept the package. This activity is show as a green dashed line on this chart but is not really part of the Canister Handling Crew's responsibility. It is the hand-off to ISF Operations for long-term surveillance and safeguards. It will consist of a series of temperature, air flow and radiation measurements over the initial 24-hour period to validate that the expected performance has been achieved.

The schedules in **Figures A4-12 through A4-15** were then placed in series and in parallel to establish the maximum throughput of the ISF. Three separate time motion study scenarios were considered for each variant: all vertical storage, all horizontal storage and a 50-50 mix of vertical and horizontal storage. There are no appreciable differences. **Figure A4-16** shows the work plan for BGVa that reveals the problem with the approach. The Gantt chart bars have been colored to show the equipment used to accomplish the activity. The color coding permits the viewer to easily see when the schedule is causing a conflict in the Vault Building. The OTB cranes in the railbay are saturated with only two and a half DPCs per week. The movement of the DPC takes priority which is why the repackaging of the Transport Cask schedule for DPC#1 has be staggered to permit the unloading of DPC#2 be done on a priority basis. Even though it is possible to start DPC#3 midway through the fourth shift, later issues in the sequence make it inefficient.

Figure A4-12
Time Motion Schedules for Below Grade Vault - BGVa

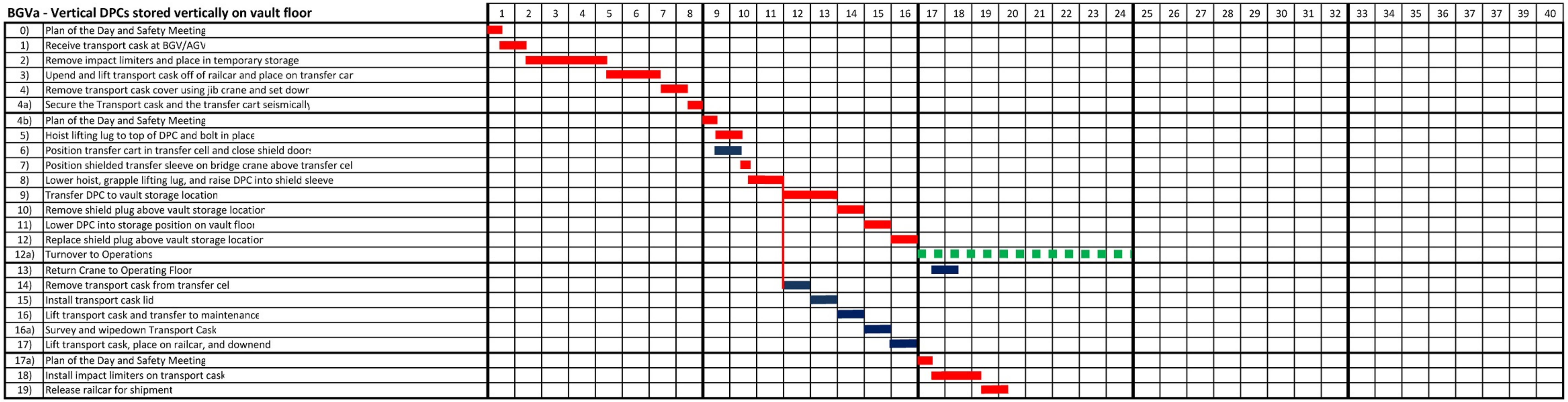


Figure A4-12
Time Motion Schedules for Below Grade Vault - BGVa (Cont'd)

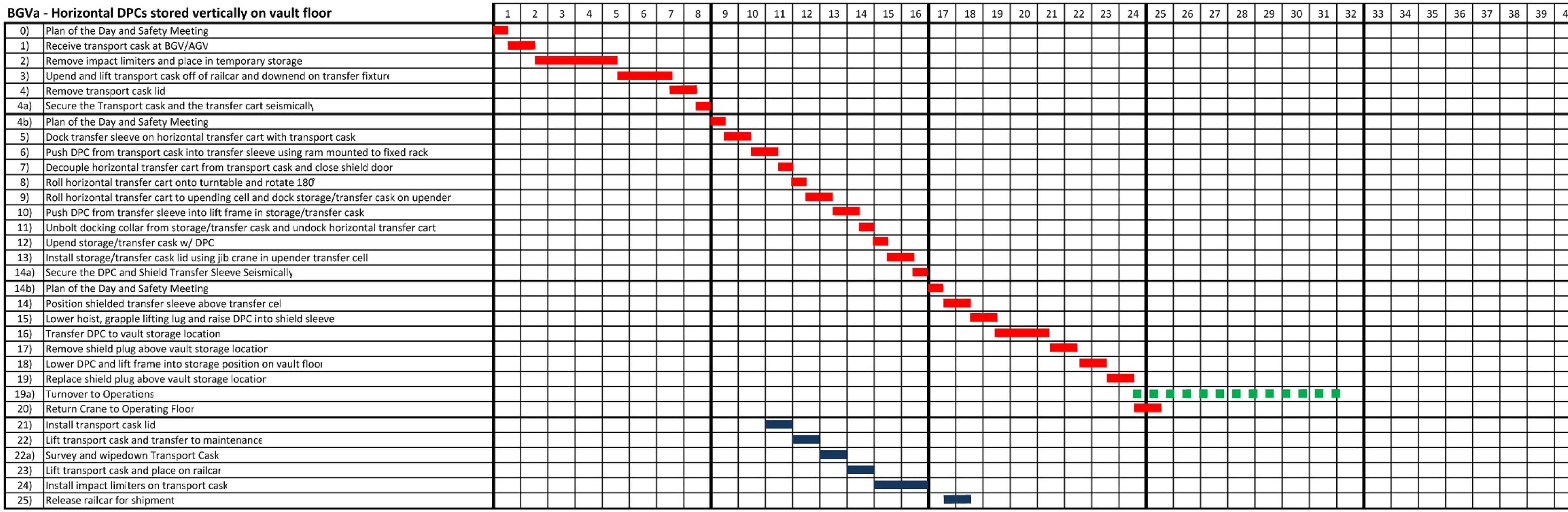


Figure A4-13
Time Motion Schedules for Below Grade Vault – BGVb

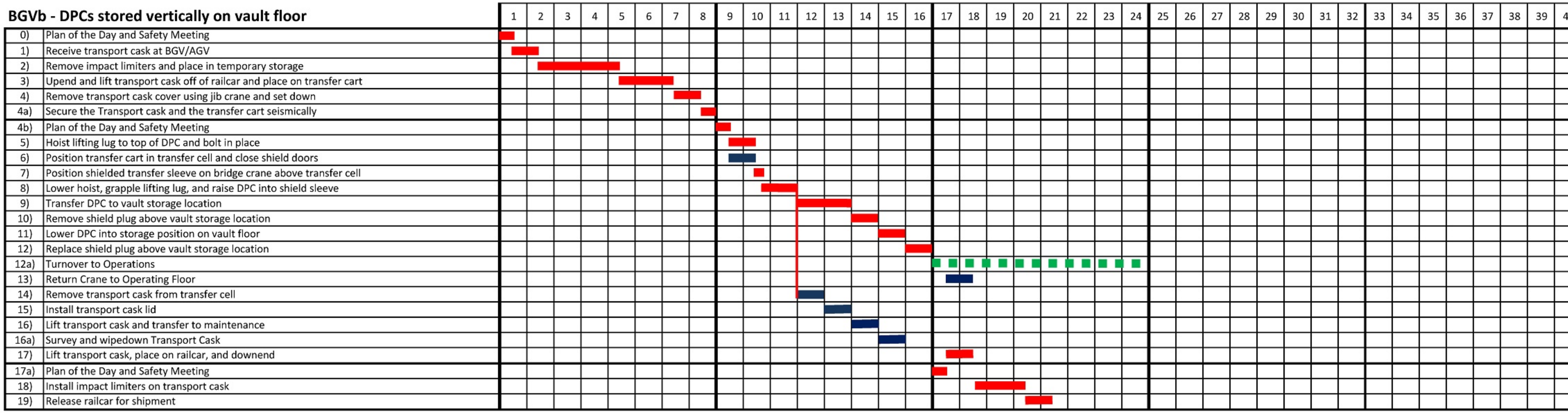


Figure A4-13
Time Motion Schedules for Below Grade Vault – BGVb (Cont'd)

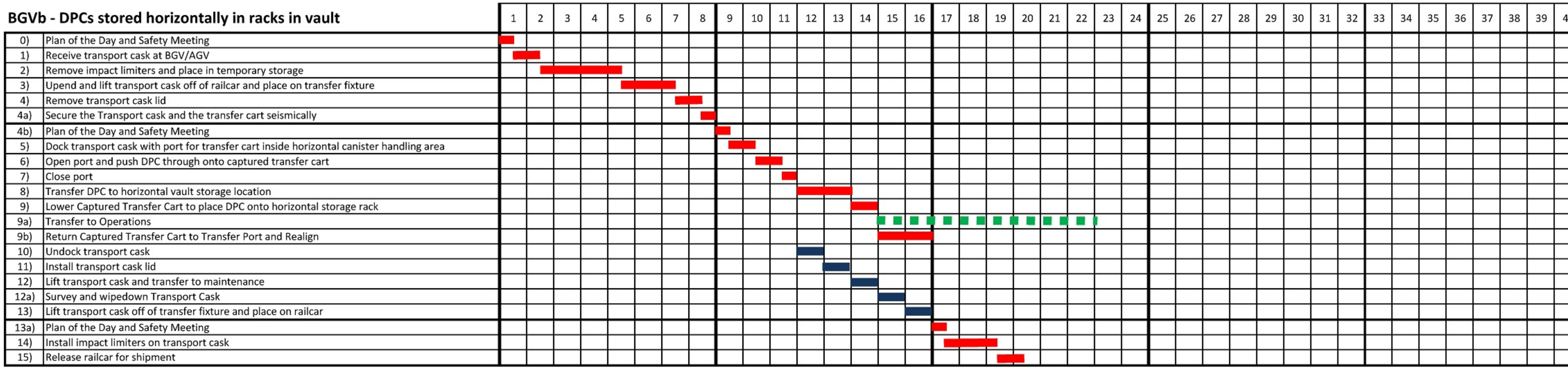


Figure A4-14
Time Motion Schedules for Below Grade Vault – BGVc

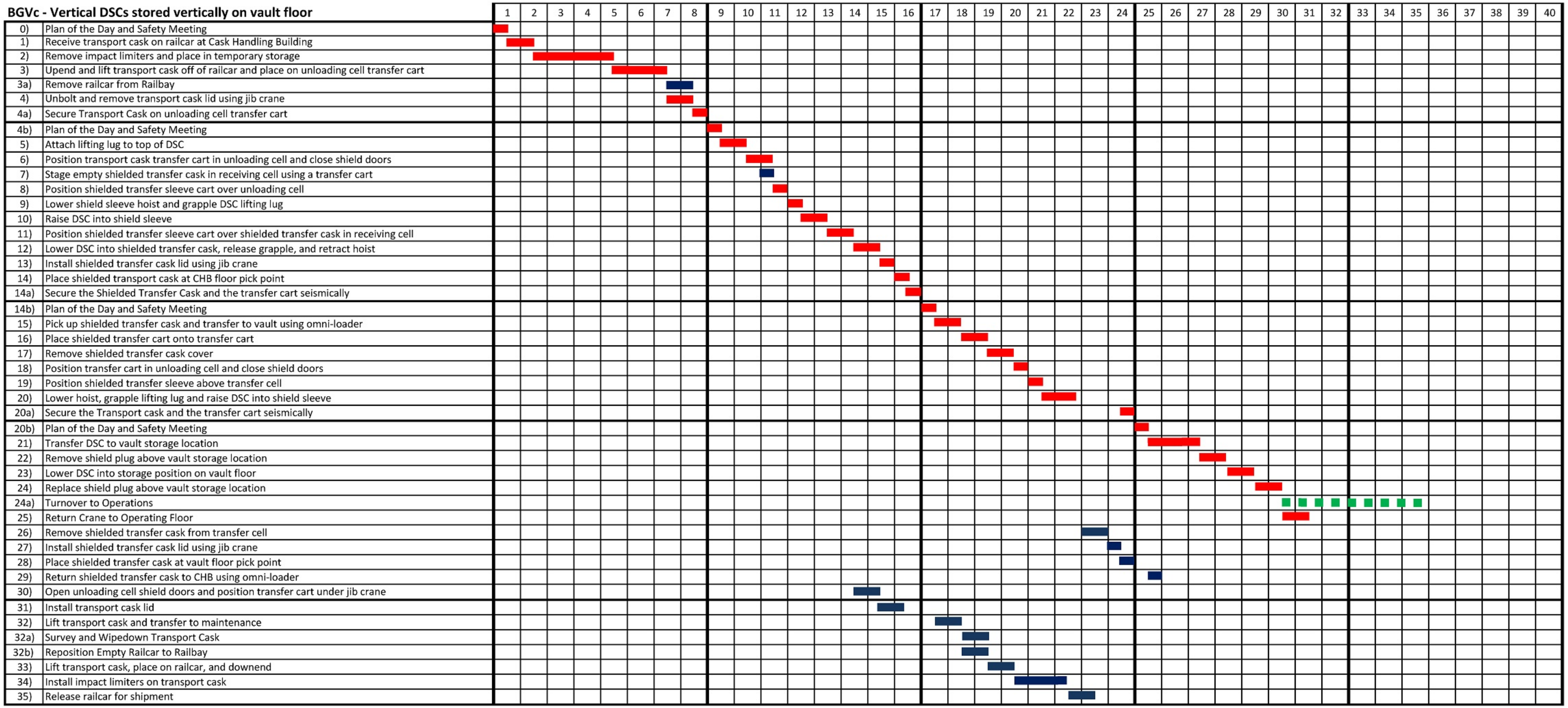


Figure A4-14
Time Motion Schedules for Below Grade Vault – BGVc (Cont'd)

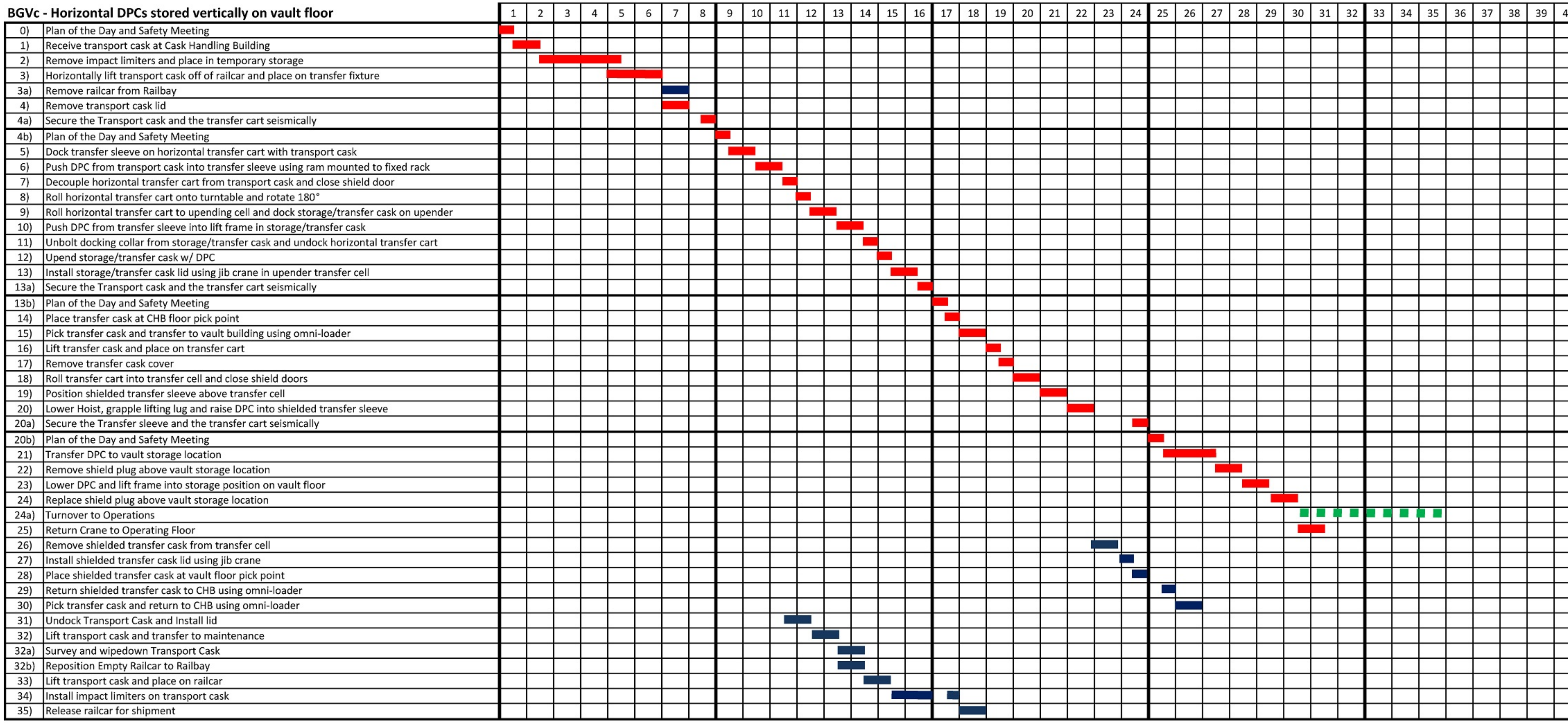


Figure A4-15
Time Motion Schedules for Below Grade Vault – BGVd

Step	BGVd - Vertical DPCs stored vertically on vault floor
0)	Plan of the Day and Safety Meeting
1)	Receive transport cask on railcar at Cask Handling Building
2)	Remove impact limiters and place in temporary storage
3)	Upend and lift transport cask off of railcar and place on unloading cell transfer car
3a)	Remove railcar from Railbay
4)	Unbolt and remove transport cask lid using jib crane
4a)	Secure Transport Cask on unloading cell transfer cart
4b)	Plan of the Day and Safety Meeting
5)	Attach lifting lug to top of DPC
6)	Position transport cask transfer cart in unloading cell and close shield doors
7)	Stage empty shielded transfer cask in receiving cell using a transfer car
8)	Position shielded transfer sleeve cart over unloading cel
9)	Lower shield sleeve hoist and grapple DPC lifting lug
10)	Raise DPC into shield sleeve
11)	Position shielded transfer sleeve cart over shielded transfer cask in receiving cel
12)	Lower DPC into shielded transfer cask, release grapple, and retract hoist
13)	Install shielded transfer cask lid using jib crane
13a)	Secure the Shielded Transfer Cask and the transfer cart seismically
13b)	Plan of the Day and Safety Meeting
14)	Place shielded transfer cask at CHB floor pick point
15)	Pick up shielded transfer cask and transfer to vault using omni-loader
16)	Place shielded transfer cart onto transfer cart
17)	Remove shielded transfer cask cover
18)	Position transfer cart in unloading cell and close shield doors
19)	Position shielded transfer sleeve above transfer cel
20)	Lower hoist, grapple lifting lug and raise DPC into shield sleeve
20a)	Secure the Transport cask and the transfer cart seismically
20b)	Plan of the Day and Safety Meeting
21)	Transfer DPC to vault storage location
22)	Remove shield plug above vault storage location
23)	Lower DPC into storage position on vault floor
24)	Replace shield plug above vault storage location
24a)	Turnover to Operations
25)	Return Crane to Operating Floor
26)	Remove shielded transfer cask from transfer cel
27)	Install shielded transfer cask lid using jib crane
28)	Place shielded transfer cask at vault floor pick point
29)	Return shielded transfer cask to CHB using omni-loader
30)	Open unloading cell shield doors and position transfer cart under jib crane
31)	Install transport cask lid
32)	Lift transport cask and transfer to maintenance
32a)	Survey and Wipedown Transport Cask
32b)	Reposition Empty Railcar to Railbay
33)	Lift transport cask, place on railcar, and downend
34)	Install impact limiters on transport cask
35)	Release railcar for shipment

Figure A4-15
Time Motion Schedules for Below Grade Vault – BGVd (Cont'd)

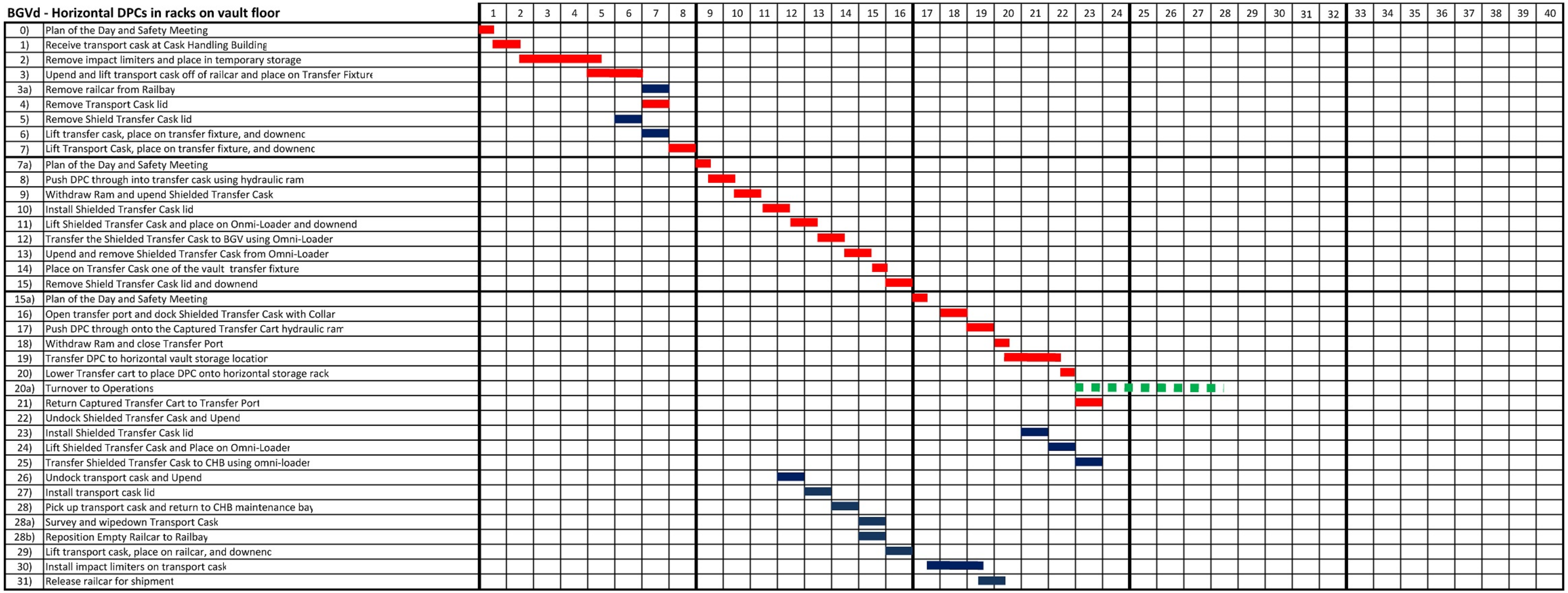


Figure A4-16
Typical Work Plan for Below Grade Vault With Integral CHB

	Week 1					Week 2				
	Shift 1	Shift 2	Shift 3	Shift 4	Shift 5	Shift 1	Shift 2	Shift 3	Shift 4	Shift 5
Rail #1	Transport Cask #1 Unload	DPC #1 Transfer to Vault	Transport Cask #1 Reload		Transport Cask #3 Unload	DPC #3 Transfer to Vault	Transport Cask #3 Reload		Transport Cask #5 Unload	DPC #5 Transfer to Vault
Rail #2		Transport Cask #2 Unload	DPC #2 Transfer to Vault	Transport Cask #2 Reload		Transport Cask #4 Unload	DPC #4 Transfer to Vault	Transport Cask #4 Reload		Transport Cask #6 Unload

	Week 3					Week 4				
	Shift 1	Shift 2	Shift 3	Shift 4	Shift 5	Shift 1	Shift 2	Shift 3	Shift 4	Shift 5
Rail #1	Transport Cask #5 Reload		Transport Cask #7 Unload	DPC #7 Transfer to Vault	Transport Cask #7 Reload		Transport Cask #9 Unload	DPC #9 Transfer to Vault	Transport Cask #9 Reload	
Rail #2	DPC #6 Transfer to Vault	Transport Cask #6 Reload		Transport Cask #8 Unload	DPC #8 Transfer to Vault	Transport Cask #8 Reload		Transport Cask #10 Unload	DPC #10 Transfer to Vault	Transport Cask #10 Reload

NOTES:

1. The highlighted boxes show the critical path activity in the Railbays. Note that work is always on going in the railbays.
2. The cycle is three shifts plus an idle shift to allow for processing two railcars at once. So, the cycle is four shifts long.
3. This process is the same for BGVa/BGVb options, i.e., all vertical, all horizontal or a mix.
4. The ISF can process 10 DPCs in four weeks; averaging 2.5 a week.

Figure A4-16
Typical Work Plan for Below Grade Vault (Cont'd)
With Standalone CHB

	Week 1					Week 2				
	Shift 1	Shift 2	Shift 3	Shift 4	Shift 5	Shift 1	Shift 2	Shift 3	Shift 4	Shift 5
Railbay #1	Transport Cask #1 Unload	DPC #1 Transfer to Vault	Transport Cask #1 Reload		Transport Cask #5 Unload	DPC #3 Transfer to Vault	Transport Cask #3 Reload		Transport Cask #9 Unload	DPC #9 Transfer to Vault
Railbay #1		Transport Cask #2 Unload	DPC #2 Transfer to Vault	Transport Cask #2 Reload		Transport Cask #6 Unload	DPC #6 Transfer to Vault	Transport Cask #6 Reload		Transport Cask #10 Unload
Railbay #2	Transport Cask #3 Unload	DPC #3 Transfer to Vault	Transport Cask #3 Reload		Transport Cask #7 Unload	DPC #7 Transfer to Vault	Transport Cask #7 Reload		Transport Cask #11 Unload	DPC #11 Transfer to Vault
Railbay #2		Transport Cask #4 Unload	DPC #4 Transfer to Vault	Transport Cask #4 Reload		Transport Cask #8 Unload	DPC #8 Transfer to Vault	Transport Cask #8 Reload		Transport Cask #12 Unload

	Week 3					Week 4				
	Shift 1	Shift 2	Shift 3	Shift 4	Shift 5	Shift 1	Shift 2	Shift 3	Shift 4	Shift 5
Railbay #1	Transport Cask #9 Reload		Transport Cask #13 Unload	DPC #13 Transfer to Vault	Transport Cask #13 Reload		Transport Cask #17 Unload	DPC #17 Transfer to Vault	Transport Cask #17 Reload	
Railbay #1	DPC #10 Transfer to Vault	Transport Cask #10 Reload		Transport Cask #14 Unload	DPC #14 Transfer to Vault	Transport Cask #14 Reload		Transport Cask #18 Unload	DPC #18 Transfer to Vault	Transport Cask #18 Reload
Railbay #2	Transport Cask #11 Reload		Transport Cask #15 Unload	DPC #15 Transfer to Vault	Transport Cask #15 Reload		Transport Cask #18 Unload	DPC #18 Transfer to Vault	Transport Cask #18 Reload	
Railbay #2	DPC #12 Transfer to Vault	Transport Cask #12 Reload		Transport Cask #16 Unload	DPC #16 Transfer to Vault	Transport Cask #16 Reload		Transport Cask #20 Unload	DPC #20 Transfer to Vault	Transport Cask #20 Reload

NOTES:

1. The highlighted boxes show the critical path activity in the Railbays. Note that work is always on going in the railbays.
2. The railcars are removed after the work crews are done with them and replaced by the next railcar to be processed.
3. The cycle is three shifts plus an idle shift to allow for processing two railcars at once. So, the cycle is four shifts long.
4. This process is the same for all BVGc/BGVd options, i.e., all vertical, all horizontal or a mix.
5. The ISF can process 20 DPCs in four weeks; averaging 5 a week

When the schedules in **Figure A4-16** for the Vaults with a Standalone CHB were considered in series and using two railbays and staggered railcar unloading and repackaging, it was demonstrated that both of these designs were capable of placing five DPCs into storage each week. Once again, the differences between the all vertical, or the vertical/horizontal design were not significant. Since DPCs contain about 11.1 MTU each, 2.5 DPCs per week is equivalent to about 1,440 MTU per year, assuming no outages. Five DPCs per week is equivalent to about 2,880 MTU per year.

A4-3.0 Pilot ISF Construction

The Pilot ISF will consist of a number of features and structures that will need to be constructed for the facility to operate. They include:

1. ISF Site (with access road and utilities)
2. Railroad spur and yard
3. Vault with integral Cask Handling Building
4. Protected Area (security boundary, cameras, intrusion detection and lighting)
5. Administration building
6. Security/access control building
7. Warehouse/maintenance facilities

A4-3.1 ISF Site

The Pilot ISF site is assumed to be placed on approximately one square mile of property. Not all of the land will require construction, only the area for the Pilot ISF. An access road and electrical utilities will need to be constructed into the property. The site access road will consist of an asphalt paved 2 lane road from the nearest highway into the ISF. The location of the site will determine if mechanical utilities (domestic water, wastewater, natural gas) can be supplied from local means or if these will need to be self-contained. A remote site requiring self-contained utilities can use water wells or trucked-in tanks of water depending on the underground water capability. Wastewater can be discharged through drain fields. Propane gas can be supplied if no natural gas lines are near the site.

The site will require an Owner Controlled Area (OCA) fence which will likely consist of a chain link fence to discourage trespassers from entering the site and keep animals out. The fence requires minimal construction and establishes a good facility boundary. Just inside the fence a gravel security road can be constructed to enable guard patrols around the site.

The purpose of the OCA is to establish the portion of the property that maintains a level of secured control. Within this boundary, security maintains control and patrols for unauthorized individuals. In addition, 10 CFR 72.106 requires that all SNF storage and handling operations be maintained at least 100 meters from the OCA boundary. All CSF functions are contained within this boundary.

A4-3.2 Railroad Spur and Yard

The Pilot ISF will need railroad tracks from the mainline to receive incoming train consists and prepare for outgoing train consists. A rail portal at the Protected Area boundary and a rail yard near the storage area will also be required.

The purpose for the rail yard is to provide adequate railcar storage for incoming and outgoing SNF train consists, and access to the CHB. The rail yard must be designed to allow flexibility for maneuvering yard switchers, railcars, buffer cars, and escort cars.

It is assumed that the rail yard will consist of at least 4 tracks – 2 tracks to receive inbound trains and 2 tracks for staging outbound trains. The yard includes a runaround track to permit the yard switchers access around the tracks. The yard also includes a lead line and a spur off the lead line accessing the Cask Handling Building.

Construction of the rail yards will involve excavation, structural fill, potential geotextile materials to maintain soil stability, gradation to establish various elevations to ease railcar movements, heavy steel rail, ties, several rail turnouts, ballast placement, lighting, and other minor railroad related features.

A4-3.3 Storage Area

The storage area resides within the reinforced concrete storage vault. The storage hall above the shielded storage and steel framed structure whose operating floor is at grade elevation. The vault will be a long, open bay approximately 100 ft wide by 800 ft long.

The base of the vault and the operating floor will house a thick reinforced concrete slab approximately 60 inches thick, which will house the DPCs. The C-BGV will utilize a natural cooling method of passing outside air directly across the canisters within the vault and up through the vault's chimney, creating a natural air flow based on the heat generated by the DPCs and the height of the chimney. The vault will be designed to ensure adequate safety and to mitigate the effects of site environmental conditions, natural phenomena, security events, and accidents including stability and liquefaction caused by earthquake conditions over the life of the facility.

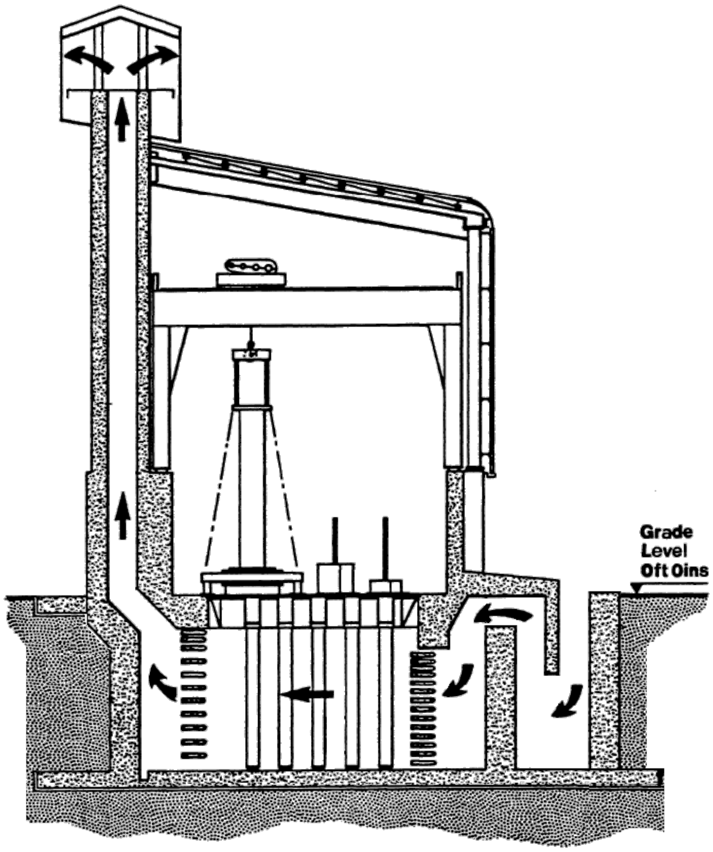
A vault design holds spent fuel in individual DPCs vertically within a concrete structure forming the vault. The DPCs would be transferred from the transportation cask and placed within a cell of the vault with a shield plug placed on top. The tops of the shield plugs would be level and integrated within the operating floor. The vault itself below the operating floor and has a concrete floor that the DPCs rest on and inlet and outlet air cooling ducts. The ceiling of the vault (also the operating floor) would be a composite steel and concrete structure. This ceiling and the floor of the vault would maintain the array of DPCs since they would be sitting within a receiver to ensure no movement during a seismic event, sub-criticality, and efficient cooling.

Cooling air will enter through an inlet vent at grade elevation, pass around a labyrinth to prevent radiation streaming, enter the vault, and exit through the chimney. The passive cooling system is self-regulating, driven by natural buoyancy of warm air, and is naturally immune to partial blockage of the inlet or outlet vents as the air velocity will increase to account for the blockage. This affords the ISF several days to clear the blockage in the unlikely event of a blockage.

Since the vault is a massive concrete structure and the DPCs are stored below grade, there will be little to no radiation dose outside of the vault structure. Even on the operating floor, as long as the shield plugs are in place, there will be less than a 1mrem/hr dose rate.

A typical below grade vault configuration storing up to 5,000 MTHM of shutdown SNF for the Pilot ISF will need to store up to 450 DPCs as shown on **Figure A4-17**.

Figure A4-17
Typical Below Grade Vault Storage System – Elevation View



A4-3.4 Cask Handling Building

The purpose of the CHB is threefold; 1) receive SNF shipments; 2) provide the facilities to offload transport casks from railcars and place them on the horizontal cask transporter for horizontal systems or 3) offload transport casks to a building cell and transfer canisters from the transport casks to storage overpacks for vertical systems. The building is designed to provide physical protection for the canisters and radiation shielding to the workers.

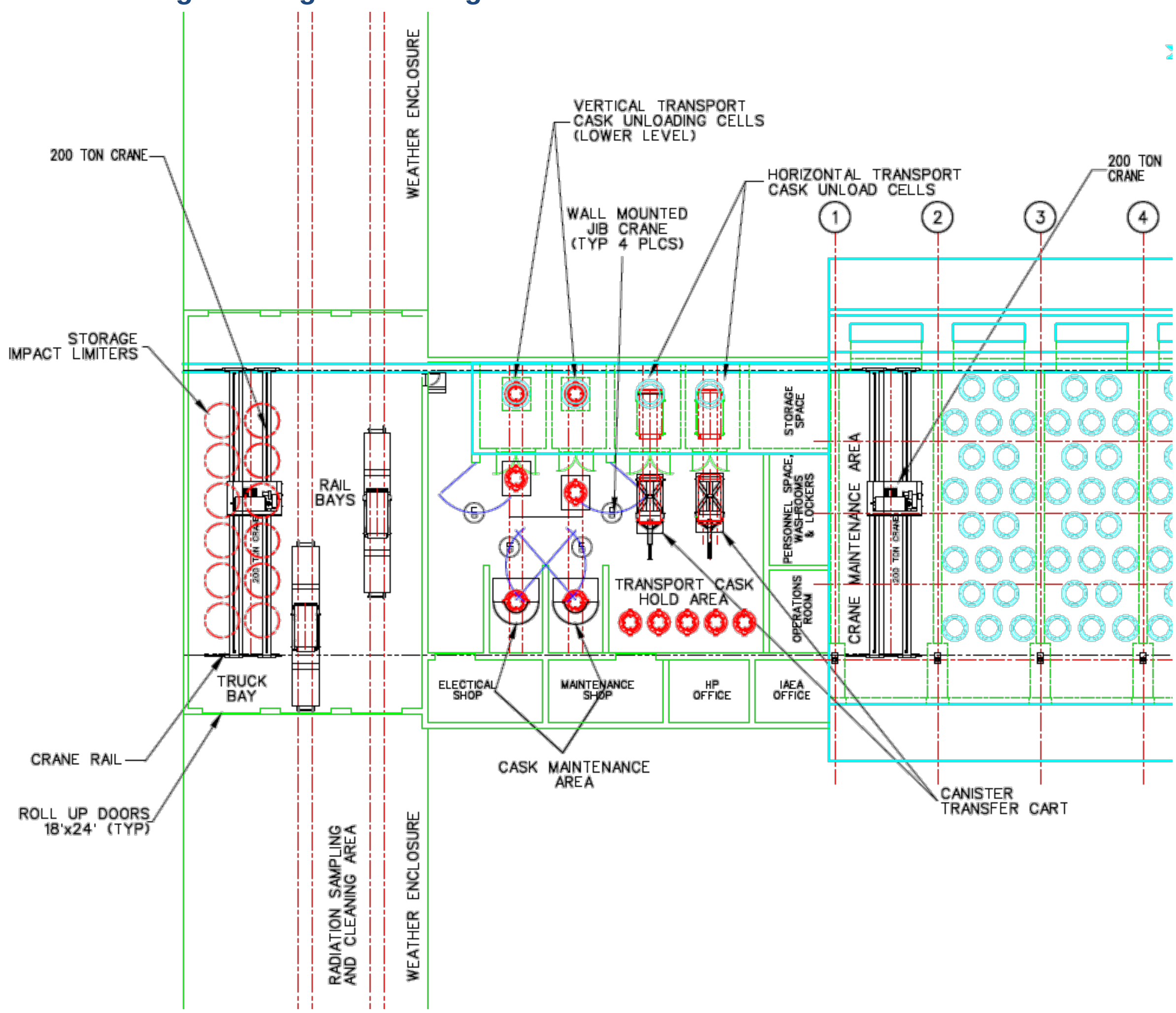
The CHB for this report has been designed with 2 rail bays, 2 truck bays, 4 vertical canister transfer cells, 2 - 200 ton single-failure-proof overhead bridge cranes, laydown area for impact limiters, staging area for transport casks and office area. The CHB would be a reinforced concrete structure with thick walls to protect all SNF casks, canisters, overpacks, and cask-handling equipment from the effects of earthquakes, tornado winds, tornado-generated missiles, fire, and explosions. The throughput would be 3,000 MTHM/yr with one shift per day, 5 days per week.

The building also has a laydown area for impact limiters, staging area for transport casks and office area. The CHB would be a reinforced concrete structure with thick walls to protect all SNF casks, canisters, overpacks, and cask-handling equipment from the effects of earthquakes, tornado winds, tornado-generated missiles, fire, and explosions.

The CHB is designed to provide radiological shielding during canister transfer operations. Four vertical type canister transfer cells with reinforced concrete walls shield workers from dose intensive operations.

Figure A4-18 shows a plan view of the CHB for the a vault using an integral CHB.

Figure A4-18
Cask Handling Building for an Integral CHB



A4-3.5 Protected Area

The PA is an area within the OCA large enough to encompass the ISF rail yards, CHB, and C-BGV. The PA consists of two physical barriers: (1) a security fence and (2) a nuisance fence separated by a 20-foot wide isolation zone. Within the isolation zone is an intrusion detection system that provides ground surveillance to detect any unauthorized entry into the PA. Assessment of unauthorized intruders is provided by illumination along the PA perimeter and throughout the storage area and a CCTV system, consisting of both fixed and pan-tilt-zoom cameras to monitor activities around the PA boundary from the security building.

The PA is surrounded by a passive vehicle barrier system (VBS) that is constructed of large concrete blocks to prevent any vehicles from getting near the PA boundary. The VBS is physically placed at a distance so that a pressure wave from a vehicle-born improvised explosive device cannot affect the storage containers or cask handling activities. Active VBSs are placed at large gates that accommodate railcars loaded with SNF transport casks or vehicles to prevent any unauthorized entry. These VBSs can be lowered once the railcar or vehicles are inspected and cleared for entry.

Security equipment is typically powered from normal off-site power supplies. However, in the event of a loss of off-site power, an Uninterruptable Power System (UPS) consisting of batteries would be used to provide seamless power to all electronic security equipment. The UPS and site lighting would be backed up by an emergency diesel-powered generator located within the PA.

Bullet resistant enclosures would be situated at strategic locations within the PA to provide protected locations for security force personnel during a security event.

A4-3.6 Overpack Fabrication Area

An overpack fabrication area will not be required for the C-BGV system since concrete overpacks are not utilized; all canisters are stored in a common vault.

A4-3.7 Concrete Batch Plant

Since a large amount of concrete will need to be supplied for construction of the C-BGV structure and foundation, the ISF would include a site concrete batch plant during the Pilot and Expansion construction phases. In addition to the batch plant, the ISF would need to include equipment associated with concrete supply operations such as concrete trucks, concrete pumper trucks, mobile cranes, backhoes for excavation, front-end loaders and dump trucks for moving soil, compaction equipment, powered concrete tools and small concrete finishing tools during the construction phase(s). Once all construction has been completed for the ISF, this equipment may be removed from the site.

A4-3.8 Site Support Buildings

The Pilot ISF will need to include a number of support buildings. An administration building will need to be constructed to house managers, admin staff, engineers, document storage, licensing records, health physics personnel, radiological records, training rooms, etc.

A security/access control building will need to be constructed to house security personnel, security managers, the Central Alarm Station, safeguards information, etc. The building can be sited at the Protected Area boundary to provide access control for personnel entering the storage area. This most likely would include a badging station, explosion detectors, metal detector to monitor persons entering the secured area, x-ray machines to monitor materials brought onsite, and turnstiles delineating the PA boundary.

A warehouse/maintenance building will need to be constructed to stockpile materials shipped to the ISF for construction, inspection equipment, general supplies, etc. This structure could also double as a maintenance building for general maintenance activities as well as transporter and canister handling equipment maintenance.

The ISF would also include a number of other features such as fire protection, potable water, sanitary drains, electrical power and distribution, and communications.

A4-4.0 Expansion to the Expanded ISF

A4-4.1 Storage Area Impact

The Expanded ISF would store up to 10,000 MTHM, which includes the 5,000 MTHM from the Pilot ISF storage area plus an additional 5,000 MTHM. The expanded ISF would need to double the storage area size, ie, two vaults.

The Pilot ISF has 1 vault building. The expanded ISF will need an additional vault building that will be constructed adjacent to the rail bay so that both buildings can share a common rail bay and material handling equipment.

Electrical power would be similar to the Pilot ISF with some increases to account for the additional security and temperature monitoring equipment. The Uninterruptable Power System (UPS) and security backup emergency diesel-powered generator should not need to be modified as they should be sized to account for the expanded ISF during the Pilot ISF construction.

A4-4.2 Increased Throughput Impact

The CHB constructed for the Pilot ISF has a throughput capacity of 3,000 MTHM/yr which may be adequate for an Expanded ISF. Even if the throughput requirements are increased to 4,500 MTHM/yr, the CHB would not need to be enlarged. Rather, adding a second shift would effectively double the throughput of the building to 6,000 MTHM.

Alternatively, adding weekend shifts but still maintain only 1 shift per day would effectively increase the CHB throughput to 7 canister transfers per week or 364 canisters per year. This translates into approximately 4,200 MTHM/yr, which is short of the 4,500 MTHM but may still be adequate depending on the shipment rates. Expansion to the expanded ISF beyond a capacity of 10,000 MTHM will require an additional, separate C-BGV building and time and motion analysis to determine the throughput rate necessary to remove canisters from reactor sites.

To expand the Pilot ISF, the rail yards, Administration Building Warehouse/Maintenance Building, Security/Access Control Building and other site infrastructure utilities may not require many modifications. Backup electrical power service for illumination and security of the SNF storage area, additional security guards, increased CCTV and intrusion detection equipment are a few modifications that may be required to accommodate the expanded ISF. For example, these additions may require a larger Security/Access Control Building for the additional security personnel as well as a larger CAS for the increased CCTV coverage. However, if the Pilot ISF is designed with the understanding of the expanded ISF that doubles the vault storage area, then these items could easily be included in the initial design.

A4-4.3 Modular Expansion Impact

For vault storage, the only modular construction would be the construction of an additional, attached vault. No other changes in the ISF would be modular type design.

A4-5.0 Performance of Structures, Systems and Components

A4-5.1 Structural and Seismic Evaluation

Structural evaluations of storage alternatives must be performed to demonstrate compliance with the applicable requirements given in 10CFR72, sections 72.122 and 72.236. These sections specify structural performance requirements for facilities and storage systems to maintain the confinement, subcriticality, radiation shielding, and retrievability of the SNF under normal operations, off-normal conditions, accident scenarios, and design basis natural phenomena conditions. For all dry canister storage systems associated with the shutdown NPP's, the DPC is designated as the confinement boundary. The types of structural loading that the DPC must be qualified to withstand at the ISF include deadweight, internal pressure, and thermal expansion under normal and off-normal environmental conditions, handling loads, drops and tip-over events, explosive overpressure events, and design basis natural phenomena events including fires, floods, tornado winds, and earthquakes. NUREG-1536 (Reference A4-3) provides guidance for the types of structural modeling, structural analysis methods, NRC-approved design codes and standards for different storage system components, loading conditions and combinations, and acceptance criteria for performing the structural analyses required to meet the functional requirements described above.

Structural evaluations of the below grade meet the requirements described above will be performed and documented in safety analysis reports accepted by the NRC during licensing. The environmental, accident and natural phenomena loading conditions, structural models, material properties, and displacement, force, and stress-strain results documented in these evaluations are used as a basis of comparison, to make judgments regarding the seismic performance of storage and transportation systems under the general loading conditions defined for the Pilot and Expanded ISFs.

The below and above ground vaults are long, narrow concrete structures, which house bare DPCs inside ventilated, shielded concrete storage bays. The design of the two vaults are identical, except the above ground vault has the top of its base slab located at grade, and the below grade vault has the top of the operating floor located at grade. The seismic response of the below grade vault will be enveloped by that of the above ground vault, due to the building embedment. Parametric studies of similar structures indicate that partial embedment on the order of 0.2 times the building width reduces the peak seismic demands by as much as 67%. Therefore, the results from the seismic analysis of the above ground vault will be used as representative of the seismic performance of the below grade vault, accounting for the reduced demand by decreasing the reinforcing bar by 10%. Also, there are five optional floor plans for each vault, which are differentiated based on storage orientation (all vertical, all horizontal, and both vertical and horizontal) and transport cask unloading location (integral to vault, and in a separate CHB). In order to limit the number of evaluations to something manageable, the vault with the highest projected cost - the above ground vault with all vertical storage and a separate CHB for cask unloading – will be seismically evaluated, and the results will be used to develop the base cost estimate. Approximate costs for other options will be determined by accounting for the design differences between options, where significant.

A4-5.2 Thermal Evaluation

Thermal evaluations of storage alternatives must be performed to demonstrate compliance with the applicable requirements given in 10CFR72, sections 72.122 and 72.236. The basic thermal performance requirement is for the storage system to provide adequate passive cooling capacity to maintain the temperatures of storage system materials below their allowable limits. NUREG-1536 provides guidance for the types of thermal modeling, the basic heat transfer considerations, the environmental conditions and accident scenarios, and temperature acceptance criteria for the fuel cladding that the thermal evaluations must address.

Thermal evaluations of the vault storage meet the requirements described above and will have been performed in Safety Analysis Reports accepted by the NRC during the licensing process. The environmental conditions, thermal models, and temperature results documented in these evaluations are used in this report as a basis of comparison, to make judgments regarding the thermal performance of storage and transportation systems under the conditions defined for the Pilot and Expanded ISFs.

In the below grade vault, vertical DPCs and horizontal DPCs in lift frames are stored standing up on the base slab which forms the floor of the vault. The vault storage area is isolated from the occupied portions of the building one floor above by the five foot thick operating floor. Shield plugs in the operating floor can be removed to provide access for placement and retrieval of DPCs using an overhead crane, but when installed, isolate the atmosphere in the vault storage area from the area above the operating floor. The vault storage area is separated into individual bays which span the width of the building by concrete walls which isolate one bay from the next. A concrete stack runs the length of the storage area along one side of the building. Each bay has an air intake on one side of the building and is open to the stack on the other side. When DPCs are placed in a bay and the shield plugs are re-installed, the decay heat from the DPCs warms the air in the bay which exhausts upward through the stack. The air exiting the stack is replaced by air flowing into the bay through the air intake on the opposite side of the bay. Thus, a self-sustaining cross flow develops which passively removes the decay heat from the bay. The amount of airflow through the bay is a function of the heat generated in the bay, the stack height and flow area, and the frictional losses along the flow path. Since the stack height and flow area are fixed parameters, the airflow reaches an equilibrium state where the differential pressure due to the stack effect is balanced by the frictional losses along the flow path. After equilibrium is reached, the flow is self-regulating, in that any decrease in the decay heat generated will reduce the driving pressure due to the stack effect, which reduces the flow and associated frictional losses until the system reaches a new equilibrium state at a lower value of flow. Therefore, the thermal performance of a vault is evaluated by determining if the decay heat generated induces sufficient airflow to maintain DPC temperature limits within their allowable values.

A preliminary natural convection computational fluid dynamics (CFD) analysis of the proposed design for the vault has been performed to verify whether or not the vault design meets required thermal performance criteria. This preliminary CFD analysis is based on the conceptual design and does not address all of the environmental extremes and DPC configurations. Therefore, a detailed CFD based on the final vault design and environmental conditions (including various wind speeds/directions, extreme temperatures, tornados, hurricanes, etc.) will be performed during the design phase of the ISF. In the analysis, a thermal model of a representative section through a vault bay was developed, including the air intake, the vault storage area with the base slab below and operating floor above, a row of (8) DPCs, and the exhaust stack. Appropriate (symmetric) boundary conditions were coded along the cut faces of the model. Adiabatic boundary conditions were coded on concrete surfaces, which is a good first approximation since concrete is a rather poor conductor of heat. Each DPC was assigned a decay heat generation rate of 25kW, which is conservative with respect to the maximum heat load for SNF from any shutdown plant. The heat from each DPC was distributed to the model as a uniform heat flux over the DPC sides and top. This uniform distribution is conservative compared to the actual DPC heat flux distribution, where a shield plug at the top of the DPC blocks almost all heat transfer through the top, directing it preferentially out the sides. The environmental temperature considered in the analysis was the extreme accident temperature of 120°F, given in section.

The CFD solver calculated the steady-state temperature distribution, the airflow rates, and the heat fluxes throughout the model, based on the input geometry, the constitutive properties of air, and the applied heat loading described above. Both convection and radiation heat transfer mechanisms were considered in solving the model. Temperature contour plots of the model were generated, as well as tabular results, including the projected maximum centerline cladding temperature, maximum stainless steel temperatures, and maximum concrete temperatures. These results are discussed in the following sections.

A4-5.3 Radiological Evaluation

The exposures to radiation for the workers at the ISF were based on the time and motion study and the assumed average dose rates from the DPCs stored at the site and are shown on **Tables A4-7 through A4-10.** They summarize the radiological dose results of this analysis for the vertical and for the horizontal storage concepts as shown in **Table 6.4.4.2 of Section 6.4.** For the detailed radiological information, see **Appendix D-4**. The doses are based on an approximate average design base fuel that could be present at the ISF. The design base dose values are used to evaluate each alternative storage method and provide an accurate comparison between alternatives. Note that after the DPC has been placed in storage, it is assumed that the dose rate to workers in the cask handling areas is near background levels and have a negligible contribution.

Table A4-7
Radiological Dose Per DPC to Worker by Category for C-BGVa

Storage Alternative	Craft						
	Mechanics	Riggers	Health Physics	Operators	Security	Quality	Totals
Vertical	72	42	46	0	11	3	**173**
Horizontal	53	66	50	0	9	0	**178**

* To the nearest whole person

Table A4-8
Radiological Dose Per DPC to Worker by Category for C-BGVb

Storage Alternative	Craft						
	Mechanics	Riggers	Health Physics	Operators	Security	Quality	Totals
Vertical	72	42	46	0	11	3	**173**
Horizontal	56	38	42	0	3	1	**141**

* To the nearest whole person

Table A4-9
Radiological Dose Per DPC to Worker by Category for C-BGVc

Storage Alternative	Craft						
	Mechanics	Riggers	Health Physics	Operators	Security	Quality	Totals
Vertical	92	58	56	0	11	3	**220**
Horizontal	94	75	59	0	20	0	**249**

* To the nearest whole person

Table A4-10
Radiological Dose Per DPC to Worker by Category for C-BGVd

Storage Alternative	Craft						
	Mechanics	Riggers	Health Physics	Operators	Security	Quality	Totals
Vertical	92	58	56	0	11	3	**220**
Horizontal	110	75	59	0	16	0	**260**

* To the nearest whole person

These radiation doses represent maximum doses per DPC processing activities and are anticipated to decrease with operating experience.

A4-5.4 Design Life, Aging and Maintenance Evaluation

Currently, storage systems may be designed for 40 to 100 years but are only permitted to be licensed for a period of up to 40 years. Prior to February 16, 2011, when 10 CFR 72.42, Duration of License; Renewal (for specific licenses) and 10 CFR 72.240, Conditions for Spent Fuel Storage Cask Renewal (for CoCs for general licenses) were revised to permit 40 year license durations, licenses and CoCs for storage systems had a duration of 20 years. Therefore, most of the storage systems currently in place at ISFSIs are only licensed for 20 years. In order to renew the license and extend the storage license, NUREG-1927, Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance (Reference A4-4) requires that an applicant demonstrate that the effects of aging will be adequately managed so that the intended safety function(s) of SSCs identified in the scope of license renewal will be maintained consistent with the current licensing basis for the period of extended operation. The NRC requires that an Aging Management Review (AMR) be performed that consists of identifying ISFSI components relied on for safety, susceptible materials in those components, environments to which susceptible materials are exposed, aging effects, and development of an aging management program to manage aging effects and protect against degradation of age-sensitive components (such as by performing inspections of age-sensitive components and replacing components that have a life expectancy of less than the license renewal period being requested in the anticipated environment). For purposes of this section, it is assumed that the original license has a duration of 20 years and a 40 year license extension is requested, so the licensee will need to demonstrate the in-scope component materials will withstand the anticipated environment for a total of 60 years, or provide a plan for replacing age-sensitive components at acceptable analyzed intervals. If the initial license was for a 40 year duration, and a 40 year license extension is requested, then the licensee would need to demonstrate the in-scope components are acceptable for 80 years in the storage environment.

The AMR identifies susceptible materials of subcomponents in the in-scope SSCs that are exposed to environments that could cause age-related degradation. The functions required to be performed by the individual subcomponents of these in-scope SCCs (determined in previous section) are identified in applicable tables in this AMR section of the application for ISFSI license renewal.

The NRC's Draft Revision 1 of NUREG-1927, Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel (Reference A4-5) explains the purpose of the AMR as follows:

> "The purpose of the aging management review (AMR) is to assess the proposed aging management activities (AMAs) for structures, systems, and components (SSCs)

determined to be within the scope of renewal. The AMR addresses aging mechanisms and effects[1] that could adversely affect the ability of the SSCs (and associated subcomponents) from performing their intended functions during the period of extended operation. The reviewer should verify that the renewal application includes specific information that clearly describes the AMR performed on SSCs within the scope of renewal."

Footnote 1 in this quotation states: "In order to effectively manage an aging effect, it is necessary to determine the aging mechanisms that are potentially at work for a given material and environment application. Therefore, the aging management review process identifies both the aging effects and the associated aging mechanisms that cause them."

The license application needs to include an Aging Management Review (AMR) that is comprised of four major steps that are summarized as follows:

1) Identification of In-Scope Subcomponents Requiring AMR

Structures, Systems and Components (SSCs) within scope of the aging evaluation are identified as those that are 1) classified as important to safety (ITS), and 2) classified as not important to safety but whose failure could prevent an ITS function from being fulfilled. SSCs within scope are determined based on review of the ISFSI Materials License, ISFSI SAR, ISFSI Tech Specs, NRC's SER for the ISFSI and docketed licensing correspondence related to the ISFSI.

2) Identification of Susceptible Materials and Applicable Environmental Conditions

For the subcomponents of in-scope SSCs that require AMR, the next step is identification of materials of construction susceptible to aging and the environments (e.g., temperature, pressure, radiation, wet vs. dry, etc.) that these materials normally experience.

3) Identification of Aging Mechanisms and Effects Requiring Management

Aging mechanisms potentially at work on susceptible materials in given environments (corrosion, cyclic stress fatigue, radiation embrittlement, etc.) are determined. Aging effects (manifestation of aging mechanisms) of material / environment combinations are compiled from industry and plant operating experience through use of industry standards and reference materials, including metallurgical literary references. During this process, the question is asked, are the potential aging effects credible given the identified materials and environmental conditions of storage?

4) Determination of Activities Required to Manage Aging Effects (Aging Management Program)

The final step in the AMR process involves the determination of activities necessary to manage the effects of aging. If the aging review determines that certain materials may not be able to support a 60 year life in the environment that they are normally exposed to, then an Aging Management Program needs to be established for those subcomponents to extend the life of the storage system to 60 years (such as by performing inspections of vulnerable subcomponents to determine their continued adequacy, or replacing the associated subcomponent at specified intervals).

Each of the four above steps of the AMR process are discussed in more detail in the following paragraphs.

A4-5.4.1 Aging Management Review (AMR)

Identification of In-Scope Components Requiring AMR

During this first step in the AMR process, the in-scope SSCs are further reviewed to identify and describe the subcomponents that support the SSC intended function. Intended functions of interest in the AMR are sub-criticality control, pressure boundary integrity (confinement of fission products), heat transfer, structural support (protection against environmental phenomena) and shielding. The subcomponents and associated intended functions are identified by reviewing the applicable current licensing basis (CLB) documentation sources.

SSCs and associated subcomponents within the scope of renewal fall into the following scoping categories:

(1) They are classified as important to safety (ITS), as they are relied on to do one of the following functions:

i. Maintain the conditions required by the regulations, specific license, or CoC to store spent fuel safely;

ii. Prevent damage to the spent fuel during handling and storage; or

iii. Provide reasonable assurance that spent fuel can be received, handled, packaged, stored, and retrieved without undue risk to the health and safety of the public.

These SSCs ensure that important safety functions are met for (1) confinement, (2) radiation shielding, (3) sub-criticality control, (4) heat-removal capability, (5) structural integrity, and (6) retrievability of the spent fuel.

(2) They are classified as not important to safety but, according to the design bases, their failure could prevent fulfillment of a function that is important to safety.

Subcomponents that perform or support any one of the identified intended functions will require an AMR. Those components that do not support an intended function can be excluded from further evaluation in the AMR with supporting justification. The SSCs within the scope of renewal are screened to identify and describe the subcomponents with intended functions. It should be recognized that SSC subcomponents may degrade by different modes, or have different criteria for evaluation from the overall component (i.e., different materials or environments). SSC subcomponents may also have different performance requirements for support of safety functions.

Typically, the application for ISFSI license renewal tabulates the results of the AMR, including a listing of subcomponents and the intended function provided by each subcomponent, material group, environment, aging effects requiring management and aging management activity required. The AMR results tables also identify subcomponents that did not support the SSC intended function and are not subject to AMR, with justification for their exclusion.

Identification of Materials and Environments

The second step of the AMR process requires the identification of materials of construction and the environments to which these materials are exposed, for the in-scope ISFSI subcomponents that require an AMR. Environmental data may include: temperature, wind, relative humidity, relevant atmospheric pollutants and deposits, exposure to precipitation, marine fog, salt, or water exposure, radiation field (gamma and neutron), the service environment (e.g., embedded, sheltered, or outdoor), and gas compositions (e.g., external: air; internal: inert gas such as helium).

The environments to which components are exposed play a critical role in the determination of potential aging mechanisms and effects. A documentation review is required to quantify the environmental conditions to which the in-scope ISFSI SSCs are continuously or frequently exposed (conditions known to exist on a recurring basis). As noted in the next section, normal operating conditions are evaluated and not accident conditions.

The storage system FSAR is typically used to determine the intended functions and materials of construction for cask subcomponents that are in-scope of ISFSI license renewal. Additional documentation, drawings and technical reports should also be reviewed during the AMR process as required to obtain clarifications of the intended materials of construction and functions performed by in-scope ISFSI subcomponents.

The specific materials of construction for the cask and fuel assembly subcomponents requiring aging management review are identified and evaluated for the renewal period.

Identification of Aging Mechanisms and Effects Requiring Management

The third step in the AMR process is to identify the aging mechanisms and effects requiring management. A Material Aging Effects Report (MAER) is typically prepared for the storage system in question. This report needs to include aging mechanisms and effects that theoretically occur as well those that have actually occurred based on industry operating experience and the ISF operating experience for the appropriate material and environmental conditions. Aging effects are presented in this report in terms of material / environment combinations.

The environments considered in the evaluation are the environments that the subcomponents normally experience. Environmental stressors that are conditions not normally experienced, such as accident conditions, or that may be caused by a design problem, are considered event-driven situations and are not characterized as sources of aging. Such event-driven situations would be evaluated at the time of event, with corrective actions taken as necessary.

To effectively manage an aging effect, it is necessary to determine the aging mechanisms that are potentially at work for a given material and environment application. Therefore, the AMR process needs to address both the aging mechanisms as well as the aging effects. Selective mechanisms are only applicable under certain environmental conditions, such as high temperature or moisture. The identified aging mechanisms need to be characterized by a set of applicable conditions that must be met for the mechanism to occur and/or propagate. The application for ISFSI license renewal should identify aging effects based on the aging mechanisms potentially at work in given environments on susceptible subcomponent materials (e.g., general corrosion of carbon steel, stress corrosion cracking and crevice and pitting corrosion of stainless steel, cyclic stress fatigue, radiation embrittlement, boron depletion of neutron absorber due to neutron flux, etc.). Aging effects (manifestation of aging mechanisms) of material / environment combinations are compiled from industry and plant operating experience through use of industry standards and reference materials, including metallurgical literary references. The majority of aging mechanisms will be extracted from industry documents (including NRC and EPRI) for the applicable material/environmental combinations. For instance, the EPRI Dry Cask Characterization Project final report (Reference A4-6) is a primary source for fuel assembly and dual purpose canister internals aging mechanism evaluations. During the process of identifying aging effects the question is asked, are the potential aging effects credible given the identified materials and environmental conditions of storage?

Appendix D, Table D-1, of NUREG-1927 lists potential aging effects and possible aging mechanisms that should be considered. This information is also available from a table in Appendix C to NUREG-1557 (Reference A4-7). Section 3.4 of the NRC's Draft Revision 1 of NUREG-1927 lists the following sources of information that should be used to identify applicable aging mechanisms and effects:

- site maintenance, repair, and modification records;
- corrective action reports, including root cause evaluations;
- lead system inspection results (see Appendix C);
- maintenance and inspection records from ISFSI sites with similar SSC materials and operating environments;
- industry records;
- applicable operating experience outside the nuclear industry;
- applicable consensus codes and standards;
- NRC reports;
- other applicable guidance for determining if an aging mechanism or effect should be managed for the period of extended operation.

Section 3.4 of the NRC's Draft Revision 1 of NUREG-1927 gives the following examples of potential aging mechanisms and effects that may be identified by reviewing the above sources of information:

> "(1) cracking or loss of strength as a result of cement aggregate reactions in the concrete, (2) cracking or loss of material as a result of freeze-thaw degradation of the concrete (requires the presence of moisture combined with temperatures below freezing), (3) reinforcement corrosion and concrete cracking as a result of chloride ingress, (4) accelerated corrosion of steel structures and components and stress corrosion cracking of austenitic stainless steels as a result of atmospheric deposition of chloride salts."

Other possible aging effects are settlement, change in dimension and change in material properties. The applicant for renewal of an ISFSI specific license is not required to take further action if an SSC is determined to be within the scope of renewal but is found to have no potential aging effects for the period of extended operation.

The AMR defines two methods for addressing potential aging mechanisms and effects: TLAA and AMP, both of which are discussed below.

Time-Limited Aging Analyses to Identify Aging Effects

Time-Limited Aging Analyses (TLAAs) are calculations performed to evaluate the life of subcomponents of interest. TLAAs are defined in Section 3.5 of the NRC's Draft Revision 1 of NUREG 1927, as those licensee calculations and analyses that meet all of the following criteria:

1. Involve SSCs important to safety within the scope of the specific-license renewal, as delineated in Subpart F of 10 CFR Part 72;
2. Consider the effects of aging;
3. Involve time-limited assumptions defined by the current operating term;
4. Were determined to be relevant by the specific licensee or certificate holder in making a safety determination;
5. Involve conclusions or provide the basis of conclusions related to the capability of SSCs to perform their intended safety functions (analyses that do not affect the intended functions of the SSCs are not considered TLAAs); and
6. Are contained or incorporated by reference in the design bases.

The defined operating term should be explicit in the analyses. Simply asserting that the SSC is designed for a service life or ISFSI life is not sufficient. The assertions must be supported by a calculation, analyses, or testing that explicitly include a time limit.

Examples of TLAAs described in the past applications for license renewal are: 1) cracking of the dual purpose canister (DPC) shell due to fatigue from thermal cycling; 2) change in material properties of epoxy seal in DPC penetration (for temperature monitoring) due to exposure to ionizing radiation; and 3) canister basket poison plate depletion of boron due to increase in neutron exposure for 60 year life of ISFSI; change in properties of boron-polyethylene front access cover plate due to increased radiation exposure over 60 year life of ISFSI.

Operating Experience Review for Process Confirmation

Typically, the potential aging effects for the ISFSI material and environment combinations are compiled from common industry and plant operating experience through the use of accepted industry standards and reference materials, including various metallurgical literary references relating specific materials and environments to aging effects and mechanisms.

A further review of industry and plant specific operating experience for the ISFSI should also be performed in order to confirm the applicability of previously identified potential aging mechanisms/effects and to identify any aging effects not previously addressed.

The application for ISFSI license renewal will need to address the various observations resulting from ISFSI operating experience with the storage systems. This information should address items specific to the subcomponents. As an example; Dominion identified corrosion of lid bolts and outer metallic lid seals on some of the TN-32 casks stored at the Surrey ISFSI. The corrosion was most prevalent on the down-slope side of the cask lid. As part of the investigation, the bolt torque was checked and it was determined that there had been no torque relaxation. The corrosion of the lid bolts and outer metallic seal was the result of external water intrusion in the vicinity of the lid bolts and outer metallic seal. It was determined that the connector seal for the electrical connector in the cask protective cover was leaking due to improper installation of the connectors. Therefore, this degradation was not related to aging.

Activities Required to Manage Aging Effects (Aging Management Program)

The fourth and final step in the AMR process involves the determination of the aging management activities or Aging Management Programs (AMPs) to be credited or developed for managing the effects of aging. Section 3.6 of Draft Revision 1 of NUREG-1927 states the following regarding AMPs:

> "Aging management programs (AMPs) monitor and control the degradation of SSCs within the scope of renewal so that aging effects will not result in a loss of intended functions during the period of extended operation. An AMP includes all activities that are credited for managing aging mechanisms or effects for specific SSCs. An effective AMP prevents, mitigates, or detects the aging effects and provides for the prediction of the extent of the effects of aging and timely corrective actions before there is a loss of intended function."

> "Aging management programs should be informed, and enhanced when necessary, based on the ongoing review of both site-specific and industry-wide operating experience. Operating experience provides direct confirmation of the effectiveness of an AMP and critical feedback for the need for improvement. As new knowledge and data become available from new analyses, experiments, and operating experience, licensees and CoC holders should revise existing AMPs (or pertinent procedures for AMP implementation) to address program improvements or aging issues."

Section 3.6.1 of the NRC's Draft Revision 1 of NUREG-1927 indicates that an AMP should contain the following elements:

1. Scope of Program,
2. Preventive actions,
3. Parameters monitored or inspected,
4. Detection of aging effects,
5. Monitoring and trending,
6. Acceptance criteria,
7. Corrective actions,
8. Confirmation process,
9. Administrative controls, and
10. Operating experience.

To the extent practical, existing ISFSI programs and/or activities are credited for the management of aging effects that could cause a loss of component intended function during the license renewal period. If the aging review determines that certain materials cannot support the required life in the environment that they are normally exposed to, then an AMP needs to be established for those subcomponents to extend the life of the storage system for the duration of the license renewal period (such as by performing inspections of vulnerable subcomponents to determine their continued adequacy, or replacing the associated subcomponent at specified intervals). The application for ISFSI license renewal will need to discuss development of AMPs to address subcomponents whose materials are susceptible to age-related degradation. AMPs for ISFSIs typically include visual inspections of cask external surfaces to look for signs of deterioration due to corrosion (general corrosion for carbon steel subcomponents due to moist atmospheric environments, and crevice and/or pitting corrosion for stainless steel surfaces that are subject to wetting), and monitoring area radiation levels, airborne and smearable contamination levels at selected areas of the ISFSI. Increased radiation / radioactivity levels could indicate reduction in shielding, breach of the SFA cladding or loss of cask confinement. Inspection intervals are established at frequencies that provide confidence the subcomponents of interest will not experience age-related adverse effects that could prevent them from performing their intended functions.

A4-5.5 Postulated Accident Evaluation

The accident descriptions to follow refer to "Design Event" levels given in ANSI/ANS 57.9, "Design Criteria for an Independent Spent Fuel Storage Installation (Dry Storage Type)" (Reference A4-8). As explained in NUREG-1567, "Standard Review Plan for Spent Fuel Dry Storage Facilities" (Reference A4-9): "Off-normal events are those expected to occur with moderate frequency or once per calendar year. ANSI/ANS 57.9 refers to these events as Design Event II. Accident events are considered to occur infrequently, if ever, during the lifetime of the facility. ANSI/ANS 57.9 subdivides this class of accidents into Design Event III, a set of infrequent events that could be expected to occur during the lifetime of the ISFSI, and Design Event IV, events that are postulated because they establish a conservative design basis for SSCs important to safety. The effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches, are considered to be accident events."

Section 15.4 of NUREG-1567 identifies acceptance criteria for accidents, including the following:

> Criticality: 10 CFR 72.124(a) requires that the spent fuel must be maintained in a subcritical condition (i.e., keff ≤ 0.95), and at least two unlikely, independent and concurrent or sequential changes must be postulated to occur in the conditions essential to nuclear criticality safety before a nuclear criticality accident is possible (double contingency).
>
> Confinement: 10 CFR 72.128(a)(3) requires that the systems important to safety must be evaluated, using appropriate tests or by other means acceptable to the Commission, to demonstrate that they will reasonably keep radioactive material confined under credible accident conditions. NUREG-1567 states that “A breach of a confinement barrier is not acceptable for any accident event.”
>
> Retrievability: 10 CFR 72.122(l) requires that “Storage systems must be designed to allow ready retrieval of spent fuel, high-level radioactive waste, and reactor-related GTCC waste for further processing or disposal.” The definition for Important to Safety SSCs in 10 CFR 72.3 includes those features whose function is to “provide reasonable assurance that spent fuel, high-level radioactive waste, or reactor-related GTCC waste can be received, handled, packaged, stored, and retrieved without undue risk to the health and safety of the public.”
>
> Instrumentation: 10 CFR 72.122(i) states in part: “Instrumentation systems for dry storage casks must be provided in accordance with cask design requirements to monitor conditions that are important to safety over anticipated ranges for normal conditions and off-normal conditions. Systems that are required under accident conditions must be identified in the Safety Analysis Report.”
>
> Radiological Dose: 10 CFR 72.104 requires that for off-normal events, annual dose equivalent to any individual located beyond the controlled area must not exceed 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ as a result of exposure to planned discharges to the general environment, direct radiation from operations of the ISFSI, and cumulative radiation from uranium fuel cycle

operations in the area. 10 CFR 72.106(b) requires that any individual located at or beyond the nearest controlled area boundary must not receive a dose greater than 5 rem to the whole body or any organ from any design basis accident.

A4-5.5.1 Earthquake

An earthquake is classified as a natural phenomenon Design Event IV as defined in ANSI/ANS-57.9. Earthquakes are associated with faults in the upper crust of the earth's surface. SSCs classified as Important to Safety are required to be designed to resist the effects of the design basis ground motion in accordance with the requirements of 10 CFR 72.122(b).

10 CFR Part 72.103, "Geological and Seismological Characteristics for Applications for Dry Cask Modes of Storage on or after October 16, 2003," gives requirements for determining Design Earthquake Ground Motion (DE) at sites for spent fuel storage, and NRC Regulatory Guide 3.73 "Site Evaluations and Design Earthquake Ground Motion for Dry Cask Independent Spent Fuel Storage and Monitored Retrievable Storage Installations" (Reference A4-10) provides guidance on applying the rules in Part 72.103 to arrive at an acceptable DE that satisfies the requirements of Part 72. In general, Part 72.103 allows use of a standardized DE described by an appropriate response spectrum anchored at 0.25 g for sites in non-seismically-active areas east of the Rocky Mountain Front and requires a seismic evaluation elsewhere. For the ISF, a probabilistically-derived horizontal ground acceleration design value of 0.75 g is used to provide a bounding value for all potential ISF sites.

Depending on the specific storage system, the acceptance criteria for seismic design may include some or all of the following:

i. The loaded overpacks will not impact each other during the DE event.

ii. The loaded overpack will not slide excessively.

iii. The loaded overpack will not tip over.

iv. The confinement boundary will not be breached.

A4-5.5.2 Tornado Winds and Missiles

The storage system is designed to withstand loads associated with the most severe meteorological conditions, including extreme winds, pressure differentials, and missiles generated by a tornado. The extreme design basis wind is derived from the design basis tornado. Extreme wind is classified as a natural phenomenon Design Event IV as defined in ANSI/ANS-57.9. The design basis tornado loading is defined for a given region (identified in NRC Regulatory Guide 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants" (Reference A4-11). It is conservatively assumed that Region I design basis tornado loading applies to the ISF. The design basis tornado wind loading for this region is defined as a tornado with a maximum wind speed of 230 mph and a 1.2 psi pressure drop occurring at a rate of 0.5 psi/sec.

In addition, the ISF is designed to withstand the effects of tornado-generated missiles that could be created by the passage of the tornado as identified in Regulatory Guide 1.76, Rev. 1, and discussed in Sections 3.3.2 (Tornado Loadings) and 3.5.1.4 (Missiles Generated by Extreme Winds) of NUREG 0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, (Reference A4-12). Tornado-driven missiles, identified in the following table, are assumed to impact a storage system in a manner that produces maximum damage. Regulatory Guide 1.76, Rev. 1, identifies the following design basis missiles for Region I:

Missile Description	Total Mass (lbs)	Velocity (mph)
Automobile	4000	92
Schedule 40 Pipe (6. 625 inch-diameter), 15 ft long	287	92
Solid Sphere (1-inch-diameter)	0.147	17.7

Alternatively, there are other spectrums of tornado missiles that have been accepted by the NRC (for which spent fuel storage systems have been qualified) that could be reviewed for potential use at the ISF.

The combination of tornado winds with the most massive missile, a 4,000 lb automobile traveling at 92 mph, needs to be evaluated in accordance with Section 3 of NUREG-0800, since it tests storage system stability. The wind tip-over moment is applied to the cask at its maximum rotation position following the worst-case missile strike. The schedule 40 pipe missile tests the capacity of the storage system to resist penetration, and the small solid steel sphere missile tests barrier openings. Canister tip-over potential and reduction in shielding from tornado-borne projectile strikes are evaluated.

A4-5.5.3 Flood

Flooding is classified as a natural phenomenon Design Event IV as defined in ANSI/ANS-57.9. 10 CFR 72.122(b)(2) requires that SSCs Important to Safety must be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, lighting, hurricanes, floods, tsunami, and seiches, without impairing their capability to perform safety functions.

The probable maximum flood (PMF) is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions.

Other potential sources of flooding considered include effects from an upstream dam breach, seismically induced flooding due to landslides in the site area, occurrence of the PMF with superposition of wind-wave activity on nearby water bodies, flooding due to tsunamis and ice conditions, and flooding from local intense precipitation.

The storage system is designed to withstand severe flooding, including pressure and water forces associated with deep and moving flood waters. Resultant loads on the storage system consist of buoyancy effects, static pressure loads, and velocity pressure due to water velocity. The flood is assumed to deeply submerge the storage system without the canisters collapsing, buckling, or allowing water in-leakage under the hydrostatic pressure from the flood; and, where applicable, without sliding and cask tip-over occurring. Full blockage of the air inlets by submergence in water is addressed by emergency action planning based on the individual storage device's capabilities. For more information on blockage of air inlets, refer to "Loss of Cooling Accident."

A4-5.5.4 Fire

Fire is classified as a human-induced Design Event IV as defined in ANSI/ANS-57.9. The storage system must withstand elevated temperatures due to a fire event. Credible fires from various sources such as buildings, fuel spills, and other combustible materials are analyzed for heat flux using standard analysis techniques from NFPA and compared with acceptance criteria for the storage system. Possible effects from wildfires are also evaluated, addressing fire magnitude, duration, propagation, and heat generation.

Fires analyzed include those that could occur during transfer operations and those affecting stored fuel. Canister integrity during smaller fire events is qualified by heat flux comparison with a bounding fire for which an approved canister analysis has been performed. Fires affecting structures in which transfer operations and storage of fuel occur have been analyzed to ensure continued reliability.

Based on the analyses, the canister storage and transfer systems meet the general design criteria of 10 CFR 72.122(c), which states that SSCs Important to Safety must be designed and located so that they can continue to perform their safety functions effectively under credible fire exposure conditions. A fire at the ISF (or a wildfire adjacent to the ISF Protected Area) would not cause a radioactive release, even if no credit were taken for firefighting by personnel or for automatic fire detection/suppression systems.

A4-5.5.5 Explosion

Explosion is classified as a human-induced Design Event IV as defined in ANSI/ANS-57.9. The ISF storage system must withstand loads due to an explosion. Potential onsite (internal and external) and offsite explosions are investigated.

NRC Regulatory Guide 1.91, "Evaluations of Explosions Postulated to Occur on Transportation Routes near Nuclear Power Plants" (Reference A4-13) provides guidance for calculating safe distances from transportation routes, based on calculated overpressures at various distances created by postulated explosions from accidents. The Regulatory Guide indicates that overpressures which do not exceed 1 psi at the storage site would not cause significant damage and states:

> under these conditions, a detailed review of the transport of explosives on these transportation routes would not be required.

In lieu of the 1 psi overpressure selected in the Regulatory Guide, the overpressure for which the storage system is qualified (e.g., 3 psi, 5 psi, 10 psi) is used to determine the safe standoff distance from the source of the potential explosion.

There are no credible internal explosive events since the canister is comprised of non-explosive materials, it is filled with an inert gas, and materials are compatible with the operating environment. Likewise, the mandatory use of the protective measures at the ISF site to prevent fires and explosions and the absence of any need for an explosive material during canister loading, transfer, and unloading operations eliminates the scenario of an onsite explosion as a credible event, except during canister movement, which requires investigation of any nearby onsite-specific potential explosive sources.

Any design basis overpressure from an offsite explosion (e.g., from a truck, rail car, barge, fuel storage tank, munition depot, chemical processing plant, petroleum refinery, natural gas facility, etc.) must be investigated and, if credible, analyzed.

Based on the analyses, the canister storage and transfer systems meet the general design criteria of 10 CFR 72.122(c), which states that SSCs Important to Safety must be designed and located so that they can continue to perform their safety functions effectively under credible explosion exposure conditions.

A4-5.5.6 Canister Drop Accident

NUREG-1567 considers both off-normal cask drops and more severe cask drop accidents. With regards to an off-normal event involving a cask drop that is less than the design allowable lift height, Section 15.5.1.1 of NUREG-1567 states:

The drop of the confinement cask at less than design allowable height is one of the hypothetical off-normal scenarios that the applicant must evaluate. The evaluation must show that the cask integrity and fuel spacing geometry are not compromised if the cask is dropped from a relatively low height. It must also show that the cask will continue to store fuel safely after such a drop.

For accident conditions, the hypothetical drop of a storage canister is classified as Design Event IV as defined by ANSI/ANS-57.9.

With regards to a cask drop accident, Section 15.5.2.2 of NUREG-1567 identifies the key items to be evaluated assuming a cask drop, including decelerations, evaluation of calculated stress intensities against the allowable stresses identified in the applicable code, evaluation of buckling stability for each component of the cask confinement subjected to compressive loading, and evaluation of deformation of cask internal members that could contribute to fuel assembly spacing geometry (for criticality concerns). While this guidance may apply to transport casks that do provide a confinement boundary, it may not be directly applicable to the transfer casks that are used to transfer canisters from transport casks to storage overpacks. In addition, in the event the spent fuel cask handling systems meet the NRC criteria for “single-failure-proof” (discussed in Section 9.1.5 of NUREG-0800, "Overhead Heavy Load Handling Systems”), the NRC does not require a cask drop accident to be postulated nor its consequences to be analyzed.

Within the alternative storage systems, there are two basic drop situations, with certain potential drop accidents that necessitate analysis and/or operational restrictions, as identified below:

(1) Handling inside the transport cask receiving structure and canister transfer facility:

- A drop of the transport cask with its impact limiters removed prior to being handled by the single-failure-proof crane requires analysis and operational restrictions.
- Transport cask drop accidents (other than above) and transfer cask drop accidents are precluded by the use of a single-failure-proof handling system, consisting of an overhead crane whose main hoist meets the NRC criteria for a single-failure-proof crane (i.e., NUREG-0554, "Single-Failure-Proof Cranes for Nuclear Power Plants," (Reference A4-14) or ASME NOG-1, "Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)" (Reference A4-15)).

(2) Handling outside the transport cask receiving structure and canister transfer facility (i.e., during cask transfer to the storage area):

- For some transport systems, it is required to assume a cask drop and, therefore, the lift height is limited to a height that has been fully analyzed for the assumed cask drop accident (e.g., TransNuclear transfer casks and NAC storage casks).

- For other systems (e.g., Holtec Vertical Cask Transporter), the lifting apparatus is required to meet ANSI N14.6 "American National Standard for Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10 000 Pounds (4500 kg) or More" (Reference A4-16) criteria for allowable stresses and to have redundant drop protection features. For these systems, no height restriction is required for cask transfer.

- For potential drops when a canister is being handled, lifts of canisters loaded with spent nuclear fuel are performed using single-failure-proof equipment and lifting devices that comply with the stress limits of ANSI N14.6 and have redundant drop protection to render an uncontrolled lowering of the payload non-credible, so a canister drop accident need not be postulated.

A4-5.5.7 Loss of Cooling Accident (LOCA)

The various spent fuel storage system alternatives all use passive air cooling of the dry storage canisters. The cooling air flow is driven by natural convection with cool air at ambient temperature entering the canister storage area near the bottom of the canister(s), rising as it is heated by the relatively hot outer surface of the canister(s), and exiting the canister storage area by outlet vents above the canisters.

It is credible that various types of debris or materials such as plastic sheets could blow into the canister storage area and block some of the air vents, thus reducing air flow and causing canister temperatures and spent fuel cladding temperatures to increase. Complete blockage of the air inlet ducts is classified as a Design Event IV accident condition as defined by ANSI/ANS-57.9. In addition, partial blockage of the cooling air vents is also analyzed as an off-normal condition, such as by assuming that one-half of the area of the air inlet vents is blocked. Thermal analyses are required to be performed to determine storage system temperatures, including canister and spent fuel cladding temperatures. The resulting temperatures are compared with the applicable temperature limits for off-normal (partial vent blockage) and accident or faulted conditions (complete blockage of air inlets).

Typically, the thermal analysis of partial blockage determines final steady-state temperatures of the storage system that result from the reduced air flow rates and these are compared to the maximum allowable temperatures of the various components to demonstrate the storage system can acceptably withstand this partial blockage with no operator actions.

For the accident condition involving postulated complete blockage of the air inlet vents, a transient thermal analysis is performed that determines the time at which temperatures of storage system components that are classified as Important to Safety exceed their maximum allowable temperatures for accident conditions, such as spent fuel cladding, canister confinement or canister basket material temperatures. This time is then used to establish a conservative required frequency of inspection or temperature monitoring of the storage system that ensures temperature limits will not be exceeded. This inspection frequency is then incorporated into the Technical Specifications that govern operations of the spent fuel storage facility. With regard to this inspection frequency requirement, Section 6.5.1.1 of NUREG-1567 recommends the following paragraph be incorporated into the Technical Specifications, based on results of the accident analysis that assumes complete blockage of air inlet vents:

> Surveillance requirement: Periodic surveillance will be performed to ensure that there is no blockage of cooling air flow in the heat removal system. This surveillance [typically based on the minimum time for stored material cladding or other material Important to Safety (e.g., shielding) to reach a threshold temperature in the event of a complete blockage occurring immediately following the prior surveillance.

Surveillance of cooling air vents for blockage can either be performed by visual inspection of the air inlet and outlet vents or by checking temperature readings of the temperature monitoring system to verify temperatures for each storage system are within allowable limits. ISFSIs frequently use temperature detectors mounted in the outlet vents to assess the performance of the natural convection air cooling system, since blockage of cooling air vents will result in reduced airflow with consequent increased air outlet temperatures. For ISFSIs with a relatively large number of storage systems, temperature monitoring is used to ensure worker doses are ALARA, since significant dose can be accrued by workers performing routine inspections of storage system air vents (typically, daily inspections are required), which requires the inspector to be in the near vicinity of the spent fuel storage systems.

A4-5.5.8 Off-Normal and Extreme Environmental Temperature

Ambient environmental temperatures must be evaluated for periods during which handling operations take place and also for the long time period over which spent fuel storage will occur. The various cask vendors have analyzed their products for intended use typically to cover all ISFSI sites in the continental U.S.

Minimum short-term temperature limitations are specified to ensure a sufficient safety margin against brittle fracture during handling. A typical operational limitation would be around 0°F, so it is likely that operational temperature restrictions imposed for other reasons may be more stringent (e.g., the minimum allowable temperature for crane operation). The lower bound off-normal temperature limit, applicable to long-term storage, is typically about -40°F.

Storage systems are designed for upper bound off-normal temperatures in the range of about 100°F, which is assumed to persist for a sufficient duration to allow the system to reach thermal equilibrium. The accident condition extreme ambient environmental temperature is typically around 125°F. Upper bound limitations are based on analyses that determine the storage system's ability to properly convey heat away from the spent fuel. Extreme environmental temperature is classified as a natural phenomenon Design Event IV as defined in ANSI/ANS-57.9.

A4-5.5.9 Lightning

Lightning is classified as a natural phenomenon Design Event III as defined in ANSI/ANS-57.9. Because a direct lightning strike of a storage SSC is a credible occurrence, the ISF storage system must withstand loads due to lightning, with the canister retaining its confinement integrity, and thereby preventing release of radioactivity. The lightning path to ground will vary, depending on the storage system alternative; but for each alternative, the canister will be protected from the effects of a lightning strike. (For example, for above-ground vertical cask storage, the steel shell of the overpack will convey the lightning to ground and the lightning will not pass through the canister, which is surrounded by the cask steel, so the strike will not affect the canister integrity.) Therefore, no offsite doses would result from this accident.

A3-5.5.10 A4 Alternative Applicability

Each of the previously discussed design basis accidents for each alternative will be slightly different since each of the alternatives' design handles each of the accidents differently. The below list summarizes the applicability of the accidents with regard to Alternative A4 (C-BGV):

1. Seismic (A4-5.5.1)

   The C-BGV will be designed to adhere fully to the requirements discussed in A4-5.5.1. A site-specific seismic analysis will be performed to ensure all components of the C-BGV are qualified for the chosen ISF site's seismic input. Since the vault is underground, the seismic input will be reduced.

2. Tornado Winds / Missiles (A4-5.5.2)

   The C-BGV will be qualified to the NRC's tornado winds and missile criteria as discussed in A4-5.5.2. While the vault itself and the exhaust stack will be required to withstand the tornado wind forces, the building around the vault will employ blow-off panels to reduce the wind forces on the superstructure. The vault structure and exhaust chimney will be analyzed to withstand the design basis tornado missiles as discussed in A4-5.5.2

3. Flooding (A4-5.5.3)

   The C-BGV will comply with all flooding requirements discussed in A4-5.5.3. Flooding is of particular concern with an underground vault system as the air inlet vent is below grade and will thus be required to have a drain system in order to preclude the vent from being completely blocked by water.

4. Fire (A4-5.5.4)

   The C-BGV will comply with all fire protection requirements discussed in A4-5.5.4, including fire sources from nearby buildings, fuel spills, combustibles, and wildfires. This will also include internal fuel spills as the cask handling building will be integral with the vault and will required to be analyzed to ensure the DPCs' shell temperature is not exceeded during a design basis fire.

5. Explosion (A4-5.5.5)

   The C-BGV will comply with all explosion requirements from NRC Reg Guide 1.91 as discussed in A4-5.5.5. Since the vault would be underground, the exposure of the DPCs to an explosion risk is minimal.

6. Canister Drop Accident (A4-5.5.6)

   The C-BGV system will comply with all canister drop requirements from NUREG-1567 as discussed in A4-5.5.6. All material handling systems will be classified as Single-Failure-Proof as and thus not require postulation of a dropped DPC.

7. Loss of Cooling Accident (LOCA) (A4-5.5.7)

   The C-BGV will comply with all LOCA requirements discussed in A4-5.5.7. The C-BGV alternative will use passive air cooling of the DPCs through an underground vault. The cooling air flow is driven by natural convection with cool air at ambient temperature entering the vault near grade level, passing through the vault, and rising as it is heated by the relatively hot outer surface of the canisters, and exiting the vault by outlet vents through a building chimney.

8. Off-Normal and Extreme Environmental Temperature (A4-5.5.8)

   The C-BGV will comply with all off-normal and extreme environment temperature requirements discussed in A4-5.5.8 based on the environmental maximum temperatures at the ISF site.

9. Lightning (A4-5.5.9)

   The C-BGV will comply with all lightning requirements discussed in A4-5.5.9.

A4-5.6 Licensing Evaluation

A4-5.6.1 Overview

10 CFR Part 72 governs ISFSI licensing. There are two options for licensing an ISFSI: (1) a specific license and (2) a general license. However, 10 CFR 72.210 only authorizes the use of a general license at a power reactor site with a 10 CFR Part 50 or 10 CFR Part 52 license. Since it is not anticipated that the ISF would be located at the site of a nuclear power plant, the ISF would be governed by a 10 CFR Part 72 specific license.

The process for obtaining a specific ISFSI license is similar to that for obtaining a license for a fuel cycle facility under 10 CFR Part 70 (Reference A4-17). The applicant submits a License Application (LA) in accordance with 10 CFR 72.16 that includes the information required by 10 CFR 72.22 through 10 CFR 72.28. The primary documents comprising the LA are as follows:

- Safety Analysis Report (SAR) that assesses safety of the storage system and the ISFSI facility (used as basis for NRC preparation of the Safety Evaluation Report)
- Environmental Report (used as basis for NRC preparation of the Environment Impact Statement)
- Proposed Technical Specifications
- Quality Assurance (QA) program
- Decommissioning Plan
- Emergency Plan
- Security Plan

A4-5.6.2 Licensing Process

Upon receipt of the application, the NRC establishes a docket number and reviews the application for completeness. If the application is deemed complete, the NRC prepares and publishes a notice of docketing in the Federal Register (FR). The notice of docketing identifies the site of the ISF and includes either a notice of hearing or a notice of proposed action and opportunity for hearing pursuant to 10 CFR 72.46. 10 CFR 72.46 provides the regulations governing the hearing process with references to 10 CFR Part 2 (Reference A4-18), as appropriate.

The NRC will request a hearing upon the notice of docketing if a statute specifically requires it, or if they believe it to be in the public interest, notwithstanding any requests for hearing submitted by parties who believe they having standing in the licensing action. 10 CFR 2.105(a)(7) specifies that if the NRC is not required by statute to conduct a hearing and does not find that a hearing is in the public interest, a notice of proposed action is instead published in the FR.

The notice of proposed action includes the time frame for any person whose interest may be affected by the proceeding to file a request for a hearing or a petition for leave to intervene if a hearing has already been requested. A request for hearing on a 10 CFR Part 72 License Application must be submitted, with the contentions upon which the hearing would be litigated, within 60 days of the notice of docketing. It is worth noting that if the 10 CFR Part 72 specific license applicant is incorporating design information pertaining to a previously NRC-certified spent fuel storage cask design by reference into the application, any hearing held to consider the application will not include any cask design issues pursuant to 10 CFR 72.46(e).

If any requests for hearing are received on the notice or proposed action, the NRC will establish an Atomic Safety Licensing Board (ASLB) to review the hearing requests and contentions for admittance. For the ASLB to admit a contention and grant a hearing, the requestor needs to have standing in the proceeding per 10 CFR 2.309(d), and at least one contention must meet the criteria in 10 CFR 2.309(f). The NRC may also permit discretionary intervention of someone not having standing under the strict requirements of 10 CFR 2.309(e).

Admitted contentions are litigated through a review of documents submitted by the petitioner and may require court testimony and/or documents to be submitted by the applicant, at the discretion of the ASLB. Hearings would take place after issuance of the Final Environmental Impact Statement (EIS). The ASLB may decide to start the hearings prior to completion of the NRC staff Safety Evaluation Report (SER). A license would not be granted until all hearings are completed and the contentions resolved in favor of the applicant. At that point, the Director of the Office of Nuclear Material Safety and Safeguards would request Commission authorization to issue the license pursuant to 10 CFR 72.46(d). While petitioners may appeal the resolution of contentions in the courts, the license would likely be issued without awaiting resolution of those court appeals.

The NRC reviews the application for a specific license, and generally there are several rounds of requests for additional information.

10 CFR 72.42, Duration of License; Renewal, paragraph (a) states the following:

> Each license issued under this part must be for a fixed period of time to be specified in the license. The license term for an ISFSI must not exceed 40 years from the date of issuance. The license term for an MRS must not exceed 40 years from the date of issuance. Licenses for either type of installation may be renewed by the Commission at the expiration of the license term upon application by the licensee for a period not to exceed 40 years and under the requirements of this rule.

A4-5.6.3 License Application

NUREG-1571, “NRC Information Handbook on Independent Spent Fuel Storage Installations,” (Reference A4-19) summarizes key requirements for a specific license application, as follows:

- Siting Evaluation Factors (10 CFR 72 Subpart E)—The site characteristics, including external, natural, and manmade events, that may directly affect the safety or the environmental impact of the ISFSI.
- General Design Criteria (10 CFR 72 Subpart F)—Applies to the design, fabrication, construction, testing, maintenance, and performance requirements for structures, systems, and components important to safety.
- Quality Assurance (10 CFR 72 Subpart G)—The planned and systematic actions necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily in service as applied to design, purchase, fabrication, handling, shipping, storing, cleaning, assembly, inspection, testing, operation, maintenance, repair, modification, and decommissioning.
- Physical Protection (10 CFR 72 Subpart H)—The detailed plans for ISFSI security.
- Personnel Training (10 CFR 72 Subpart I)—The program for training, proficiency testing, and certification of ISFSI personnel who operate equipment or controls important to safety.

The NRC will review the specific license application and complete an evaluation of potential environmental impacts of the ISFSI in accordance with the National Environmental Policy Act of 1969 (NEPA), as amended (Reference A4-20). The NRC will prepare an EIS in accordance with 10 CFR Part 51 (Reference A4-21). Following its safety review and resolution of comments, the NRC issues a Materials License along with its SER and final

EIS. The SER describes the conclusions of the staff's safety review based on the applicant's SAR and assesses the technical adequacy of the ISFSI and the spent fuel storage system(s).

Safety Analysis Report

The level of effort associated with preparation of the ISFSI SAR for a specific license can be reduced considerably by taking advantage of the permission granted in 10 CFR 72.46(e) to select storage systems with SARs that have been reviewed and approved by the NRC (with Certificate of Compliances [CoC] having been issued for the storage systems), or storage systems that are currently undergoing NRC review per 10 CFR 72, Subpart L. 10 CFR 72.46(e) states: "If an application for (or an amendment to) a specific license issued under this part incorporates by reference information on the design of a spent fuel storage cask for which NRC approval pursuant to subpart L of this part has been issued or is being sought, the scope of any public hearing held to consider the application will not include any cask design issues." With this approach, the NRC will focus its review on site-specific issues and storage system/site interface issues. This helps streamline the specific licensing process. Should the applicant select a storage system that has neither been reviewed and approved by the NRC nor is currently undergoing NRC review, the NRC must review information associated with the proposed spent fuel storage system as part of the specific license application, which would extend the review time.

Detailed guidance as to information that needs to be included in the ISFSI SAR that is submitted with the license application is provided by Regulatory Guide 3.48, "Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation or Monitored Retrievable Storage Installation (Dry Storage)" (Reference A4-22). Additional information to enable the NRC staff review in accordance with NUREG-1567 should also be included in the SAR, along with information from any applicable NRC Interim Staff Guidance (ISG). The SAR for the ISF will need to identify and evaluate each of the storage systems that will be used at the ISF to store SNF. For each individual system, the ISF SAR will need to address the following key topics specified in the NUREG-1567 Standard Review Plan:

- General description of the storage system
- Design criteria
- Structural evaluation
- Thermal evaluation
- Shielding evaluation
- Criticality evaluation
- Confinement evaluation
- Material evaluation

- Operating procedures
- Acceptance tests and maintenance program
- Radiation protection (occupational exposures, public exposures, ALARA measures)
- Accident analyses
- Operating controls (technical specifications)
- Quality assurance
- Decommissioning

The previous topics are addressed in the storage system vendors' SARs that have been approved by the NRC for general and specific ISFSI licenses; these documents can be incorporated by reference into the ISF SAR. It is envisioned that the ISF SAR will have a main body that describes and analyzes the ISF design and generic operations, with a separate appendix that serves as the SAR for each individual storage system. The ISF SAR will benefit in that it will primarily use SNF storage systems that have already been licensed under the provisions of 10 CFR Part 72, Subpart K, and have existing Final Safety Analysis Reports (FSARs) that have been approved by the NRC and can be referenced. A specific revision of the vendors' FSARs would need to be chosen for incorporation into the ISF ISFSI SAR. Changes to the vendors' FSARs thereafter would not automatically be incorporated by reference into the ISF SAR, but would require evaluation by the ISF license applicant for incorporation.

The SAR would include descriptions of the safety analyses and other technical evaluations for the ISFSI in each SAR chapter, incorporating by reference any required information for the storage system designs. The format and content would coincide with the chapters of the SRP in NUREG-1567 and any applicable Interim Staff Guidance documents amending that guidance. Formatting the ISFSI SAR in this manner sets the stage for a more efficient NRC technical review because the SRP establishes the format and content template for the NRC's SER.

Environmental Report

The Environmental Report (ER) that is submitted with the License Application is prepared to address the requirements of Subpart E of 10 CFR Part 72, Siting Evaluation Factors, and Subpart A of 10 CFR Part 51, National Environmental Policy Act - Regulations Implementing Section 102(2), using the guidance provided in NRC NUREG-1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs," (Reference A4-23). The ER contains the following key topics:

- General description of the proposed activities and discussion of need for the facility

- Site interfaces with the environment, including geography, demography, land use, ecology, climatology, hydrology, geology and seismology, historical and cultural features, and background radiation levels.
- Description of the facility, including appearance, construction, operations and effluent control
- Environmental effects of facility construction and operation, including transportation of radioactive material, and effects of decontamination and decommissioning
- Environmental effects of accidents involving radioactive materials, including transportation accidents
- Proposed environmental monitoring programs
- Economic and social effects of facility construction and operation, including cost benefit analysis
- Facility siting (site selection process) and design alternatives
- Environmental approvals including federal, state, and local regulations and permits

As noted above, the NRC will need to prepare a complete EIS for the ISF based on the ER submitted by the licensee, in accordance with 10 CFR Part 51 requirements.

A4-5.6.4 Licensing of Alternative Systems

The approach to licensing of the different alternative systems would be the same as that described above. Key differences involve the information that would be required in the License Application are discussed in the following paragraphs.

Alternative 4, Below Grade Vault Storage

Like C-UGS, the use of a vault does away with pad storage and places each DPC into a large self-contained vault module structure. The ISFSI at the former Fort St. Vrain (FSV) reactor site in Colorado uses the Modular Vault Dry Store (MVDS) system in an above grade vault. The FSV MVDS has a specific license (Materials License No. SNM-2504), so has its own SAR and Technical Specification, with analyses specific to the FSV site. Vaults are designed as robust, hardened reinforced concrete structures. The vaults are typically laid out so that the DPCs can be hung from a concrete floor much like a test tube rack, with a support stool at the bottom of each canister that the canister bottom rests upon. An overhead bridge crane can access the entire vault storage area and provides the means to move DPCs from the unloading point where DPCs are removed from transport casks to the DPCs designated storage position. At the FSV MVDS, a canister handling machine is used for movement of a DPC between the transport cask unload port and the port on the operating floor through which the canister is lowered into its storage vault. Following loading of a DPC into its storage vault, a large shield plug is placed in the port in the operating floor to provide radiation shielding above the top of the canister, to attenuate dose rates so workers can walk across the operating floor and not receive significant doses. Cooling of the DPCs is accomplished by means of passive chimney stack effect from an inlet vent in the front of the vault through the DPC storage area to a chimney where air exits from the back of a vault, with chimney height designed to draw the desired air flow. The entire facility is enclosed with walls and a roof. The vault width is typically limited to the span of the bridge crane and can be of various lengths to accommodate the desired storage capacity.

The below grade vault would be designed so that the operating floor would be at ground level and the DPC storage area would be below grade. The below grade vault positions the DPCs so that direct radiation from the sides of DPCs is shielded by the ground. The vault shields DPCs from view, easing security concerns.

All operations such as DPC offload from a transport cask, DPC transfer from the transport cask to the canister handling machine and from the canister handling machine into the DPC storage vault, are performed within the MVDS structure. Once the railcar enters the facility there are no outdoor operations. A canister transfer facility would not be required since all canister transfer operations are performed inside the vault.

There are significant licensing challenges with C-BGV since vault storage for large commercial DPCs is still conceptual, unlike other storage methods. In order to store 450 DPCs, a vault 100 ft in width would need to be about 800 ft long increasing the complexity of the structure. The canisters (fuel storage containers) at FSV are carbon steel cylinders one-half inch thick, 16 ft long but only 18 inches diameter, so designed for a single column of fuel (which at FSV consists of 6 graphite blocks stacked end-to-end). The FSV canister lid is 1.5 inches thick bolted to the body of the canister by means of 24 one-half inch diameter steel bolts, sealed with double metal O-rings. For this type of canister closure, leakage of the gas inside the canister to atmosphere is a credible event, so the FSV SAR assumes leakage of fission products past the O-ring seals in what is termed the "Maximum Credible Accident in the FSV SAR." For storage of commercial DPCs with their redundant seal welded closure lids, accidents involving leakage of DPCs are not credible and not required to be postulated or analyzed in the ISF SAR.

Canisters stored in the existing FSV vaults do not have the increased performance issues such as weight and thermal loading characteristic of commercial DPCs. Since the performance capability of a vault is unknown, rigorous analyses will need to be performed to show that the DPCs could be safely stored in a vault, the vault could perform as desired, and the results of these analyses described in the ISF SAR. These analyses would include structural, thermal and radiation shielding analyses of the DPCs in vault storage. In addition, it is considered that criticality analyses will be necessary since there is potential for neutrons from one DPC reaching adjacent DPCs due to the relatively close packing of canisters stored in vaults with no intervening materials that would shield and attenuate the neutron flux.

Most DPCs in existing dry fuel storage systems have a much higher heat release rate than the FSV canisters. When canisters were initially loaded into the FSV MVDS, a canister containing average decay heat fuel elements would have 330 watts total decay heat. In contrast, a single commercial DPC could have up to 100 times this heat release rate, or on the order of 33 kW. The thermal study performed by CB&I determined that heat removal using the chimney stack effect for natural convection cooling in a vault is limited to thermal outputs much less than the licensed limits in existing commercial DPC storage methods. DPCs with hotter SNF may not be able to be adequately cooled in a vault which would require longer pool cooling prior to storage. This would need to be addressed in the ISF SAR and the ISF licensing process.

Design and licensing tasks would be extensive and involve significantly more time than the other storage methods. As noted above, the FSV MVDS is operated under a specific ISFSI license and the FSV SAR cannot be referenced under as is the case for FSARs associated with an ISFSI general license. In addition, the NRC has never licensed a vault system for storing large commercial DPCs. The performance characteristics of a vault would need to be licensed as part of the Pilot ISF Specific License which would require considerable development in the ISF SAR costing more NRC review time.

Like C-STD and C-UGS, this vault storage method would involve obtaining a single license for systems owned by four different spent fuel storage system vendors. Therefore, the use of this method could incur proprietary conflicts that could be difficult to resolve, possibly involving legal issues.

Similar to the standardized overpacks in C-STD and the UMAX VVMs in C-UGS, the vault is a one-size-fits-all system that would have to accommodate all the different DPC sizes. Each floor opening would likely be the same diameter which would require some means to keep smaller DPCs secure. This would necessitate design and fabrication provisions for the smaller DPCs such as shims or spacers to ensure they would not rattle around during an earthquake. These features would need to be evaluated in the ISF SAR, reviewed by the NRC and certified in the licensing proceedings.

Like C-STD and C-UGS, the horizontal DPCs cannot be lifted by the lid and would require some type of lifting cage to lift and place into a vertical position, such is used for vault storage. The lifting cage for handling horizontal DPCs in a vertical orientation would need to be addressed in the licensing documentation (i.e., ISF SAR).

A4-5.7 Security Evaluation

The purpose of security at an interim storage facility is to protect the SNF against acts of radiological sabotage and theft or diversion that could lead to an unreasonable risk to the health and safety of the public. The ISF must meet the requirements of 10 CFR 73 (Reference A4-24). In order to accomplish this task the ISF will need to establish and maintain a physical protection system which consists of the following:

- Controlled access
- Visual surveillance
- Detection and assessment of unauthorized individuals
- Adversary response
- Measures to resistance explosive devices

The physical security systems must be designed to protect against loss of control of the ISF.

Controlled Access

Controlled access is maintaining control of a clearly demarcated area and isolation of the material or persons within it. The features at the ISF that afford controlled access include a fenced Owner Controlled Area (OCA) typically established at the property boundaries, vehicular access gates into the property where security personnel can verify the identification and authorization of all persons and vehicles entering the site, a Protected Area (PA) with two physical barriers (fences or structures) designed to thwart physical intrusion, and personnel and vehicle access barriers into the PA. All of these features are required of the ISF regardless of the storage system utilized. However, the area required may vary depending on the storage alternative used thus affecting the OCA and PA boundary distances.

For C-BGV storage, the PA will need to be approximately 250 acres in size which would require a perimeter fence roughly 2- 3 miles in length.

Visual Surveillance

Visual surveillance is establishing security guards around the PA who maintain an unobstructed view of the PA at all times. This may be performed from bullet resistant enclosures (BREs) placed around the PA which are occupied by security guards, closed circuit TV (CCTV) cameras that are viewed by security guards at the Central Alarm Station (CAS) or secondary Alarm Station (SAS) or security guards patrolling the site. BREs are situated at strategic locations within the PA to provide protected locations for security force personnel during a security event.

Vault storage has a major advantage in that few exterior and interior BREs or cameras are required to maintain line of sight around and within the vault storage area. Since all storage is within a secured building, there are very few security risks to the canisters.

Detection and assessment of unauthorized individuals

Detection of unauthorized individuals is maintained by establishing an intrusion detection system that can detect unauthorized penetration through the isolation zone located between the PA boundary fences and tamper devices on doors and equipment that send an alarm to alert security staff when the PA or security equipment is breached. Assessment of unauthorized individual is established by illuminating the PA with sufficient lighting that security guards can adequately determine the nature of the intrusion either visually or by the CCTV system. The intrusion and CCTV systems are monitored continually by security staff at the CAS and SAS.

The pilot or expanded C-BGV storage will not affect the detection and assessment capabilities as the initial PA will encompass the size of the expanded C-BGV.

Adversary Response

Adversary response is the ability to prevent or delay the attempted theft of SNF or radiological sabotage by armed response personnel. Adversary response also includes the ability to provide timely communication to a designated response force such as the local law enforcement agency whenever necessary.

C-BGV storage will not affect adversary response since this is primarily a function of the vault building, security staff and communication equipment.

Measures to resistance to explosive devices

Resistance to explosive devices intended to disable security personnel or radiological sabotage is maintained by establishing engineered barriers that prevent such explosions from damaging SNF storage containers or disabling security personnel. Engineered barriers consist of access points designed to slow the speed of approaching vehicles by turns, speed humps, or a serpentine design and a vehicle barrier system (VBS) made of thick reinforce concrete walls or heavy steel portal gates that are installed at a prescribed distance from the SNF or cask handling activities. The VBS prevents entry of vehicle-borne explosive devices. Its distance from the storage area minimizes the impact of an explosion if one were to occur.

Resistance to explosive devices is also maintained by passing persons through explosive and metal detectors, checking all hand-carried items by X-ray machines and inspecting all vehicles and deliveries by security personnel.

Since the entire system is within a below-grade vault within a secured building, the C-BGV storage system has excellent resistance to high explosion pressure waves. This ability enables the VBS to be placed much closer to the PA which effectively reduces the overall footprint of the PA.

A4-6.0 Summary

In summary, the pros and cons to this alternative, listed from the highest most significant impact to the lowest least significant impact are as follows:

Pros

- Since the DPC storage is effectively indoors, the vault alternative may provide a more controlled environment than other alternatives. The DPCs are stored within the building largely away from the effects of weather (although there is some effect since the cooling air is drawn into the building past the DPCs. The DPCs would likely feel humidity changes during wetter weather and temperature changes between summer and winter).
- All operations such as cask offload, canister transfer from the transport cask to the vault and storage are maintained within the structure with an integral CHB. Once the railcar enters the facility there are no outdoor operations unless a separate CHB concept is used.
- A vault shields DPCs from view, easing security concerns. Also, since the DPCs are stored within a secured building, they are more protected from design basis explosions or unauthorized intrusions. In addition, security staff can observe the entire storage area since the system is all internal to the C-BGV building.
- The below grade vault positions the DPCs so that direct radiation from the sides of DPCs is shielded by the ground.
- Removes the possibility of DPC tipover caused by an earthquake or other postulated accidence since the DPCs are locked into position within the vault.
- Below grade vaults with integral CHBs have inherently lower throughputs than vaults with standalone CHBs, but accomplish this at a significant reduction in capital and operating costs during the cask handling phase of the project. If the throughput is acceptable based on the ability to deliver DPCs to the site, and if expansion of the Pilot ISF is not desired, these designs offer a lower cost approach to storing SNF in vaults. If, on the other hand, it is determined that expansion of the Pilot ISF is appropriate, the follow-on concepts are not forced to follow the same design. In other words, a below grade vault with standalone CHB can be added to the site at a later date to increase throughput or to expand the capacity of the site.

Cons

- Unlike other storage methods, vault storage for large commercial DPCs is still conceptual. Canisters stored in existing vaults do not have the increased performance issues such as weight and thermal loading characteristic of commercial DPCs. Since the performance capability of a vault is unknown, rigorous analyses will need to be performed to show that the vault could perform as desired.

- A vault is a large nuclear structure impacted by potential seismic, construction, cost overrun issues typically associated with large nuclear projects. In order to store 450 DPCs, a vault 100 ft in width would need to be about 800 ft long increasing the complexity of the structure.
- Design time and licensing would be extensive and involve much more time than the other storage methods. The Fort St. Vrain (FSV) vault is a site specific license and cannot be referenced under a General License nor has the NRC licensed a vault system for large commercial DPCs. The performance characteristics of a vault would need to be licensed as part of the Pilot ISF Site Specific License which would require considerable development in the ISF SAR costing more NRC reviewing time.
- Most DPCs in existing dry fuel storage systems are much hotter than the FSV canisters. The study performed by CB&I determined that heat removal using stack effect in a vault is limited to thermal outputs much less than the licensed limits in existing storage methods. Some newer DPCs with hotter SNF may not be able to be adequately cooled in a vault which would require longer pool cooling prior to storage.
- Like C-STD and C-UGS, this storage method needs to obtain a single license for systems owned by four different vendors. Therefore, the use of this method may incur proprietary conflicts that will cost time and money to overcome legal issues.
- The vault is a one-size-fits-all system that would have to accommodate all the different DPC sizes. Each floor opening would likely be the same diameter which would require some means to keep smaller DPCs secure. This would necessitate design and fabrication provisions for the smaller DPCs such as shims or spacers to ensure they would not be battered around during an earthquake.
- Like C-STD and C-UGS, the horizontal DPCs cannot be lifted from the lid and would require some type of lifting cage to lift and place into a vertical position. This is not a difficult task but it would add steps to the canister transfer process and the lifting cage would accrue additional costs.
- Placing horizontal DPCs in a vertical position would require additional analyses. New thermal, structural and shielding analyses would need to be performed to show the horizontal DPCs could be placed in the vertical position without adverse effects.
- In order to store an additional 5,000 MTHM of spent fuel, an entire new vault would need to be constructed attached to the cask handling building. If more than

10,000 MTHM of spent fuel storage is required beyond the expanded ISF, a completely separate vault structure with CHB would need to be constructed.

A4-7.0 References

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