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DEVELOPMENT OF AN OUTLINE OPERATING SYSTEM FOR THE UK MULTI-PURPOSE CANISTER SYSTEM FOR THE STORAGE, TRANSPORT AND DISPOSAL OF SPENT FUEL

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ABSTRACT

The Nuclear Decommissioning Authority (NDA) has established the Radioactive Waste Management Directorate (RWMD) to manage the delivery of geological disposal for higher activity radioactive wastes as required under UK Government policy.

Three illustrative concepts of geological disposal facilities (GDF), corresponding to three generic geological environments - higher strength rock, lower strength sedimentary rock and evaporite rock - have been developed to demonstrate the viability of geological disposal of intermediate level waste (ILW), high level waste (HLW) and spent fuel (SF) in the UK. For the disposal of HLW, AGR spent fuel and PWR spent fuel, a range of standardised canister designs has been developed in 2011-2012.

RWMD now needs to further explore the options for the disposal of PWR spent fuel through the use of Multi-Purpose Canisters (MPC), which, in combination with a range of overpacks, would fulfil the requirements for storage at an interim storage facility, transport to, and uniquely for an MPC system, disposal at a GDF where the MPC must be capable of withstanding external loadings resulting during the post closure phase and, depending upon host geology, maintain containment for a period of 10,000 years or more.

In order to design a MPC and the overpacks, the external constraints and the internal conditions need to be defined. In addition, the operation requirements and the performance requirements of each step of the operation route for the MPC also need to be defined, from which a "bounding set" of operation requirements and performance requirements can be distilled. Based on these requirements, a conceptual design of a MPC and an outline design of the overpacks can then be designed.

The development programme has been organised into three stages:
Stage 1: Development of an outline system within which the MPCs operate
Stage 2: Development of a specification for the design of the MPC and the overpacks
Stage 3: Development of a conceptual design of the MPC and an outline design of the overpacks.

This paper presents the outline operating system as developed from Stage 1 of the programme

1 INTRODUCTION

Work in the UK to support implementing geological disposal of high-heat generating wastes is currently at an early stage of development. A range of possible disposal concepts have been identified, effectively providing a catalogue of concepts for consideration. NDA RWMD is currently evaluating the feasibility of each of these concepts so that well-informed assessment of options can be carried out at appropriate decision points in the future.

In parallel with consideration of the illustrative concepts, RWMD needs to further understand the design concepts for disposal of Spent Fuel (SF), in particular through use of a Multi-Purpose Canister (MPC) to underpin the concept options for disposal of legacy Spent Fuel. In general terms, MPCs are containers that are designed to meet requirements for safe containment of radioactive waste during interim storage and transport. The MPC concept has the advantage that the waste is not directly handled again once it has been placed in the MPC. In particular, spent fuel could be packaged for long term dry storage after a period of cooling in a fuel pond and would not require direct handling for its eventual transport to, and disposal in, a geological disposal facility (GDF).

2 PHASES OF WASTE MANAGEMENT

The MPC System is a series of interactions between the MPC (with its content and overpacks) and the external environment throughout its operating life, in chronological order from upload of SF assemblies to final disposal at a GDF.

Broadly, there are four main components of the System (Figure 1), comprising:

1. Operations at the Nuclear Power Plant (NPP)
2. Storage at the Interim Storage Facility
3. Transport to a GDF
4. Disposal at a GDF (both temporary and final disposal)

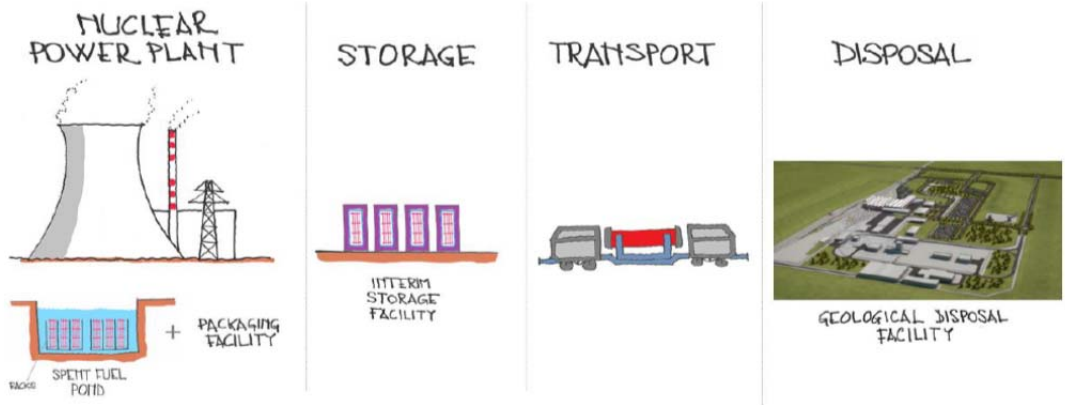


Figure 1 Waste Management Phases for the MPC System

3 MPC SYSTEM COMPONENT OVERPACKS

In all stages the MPC is enclosed within a specific overpack. Different overpacks - Storage Overpack, Transfer Overpack, Transport Overpack and Disposal Overpacks - enclose the MPC throughout its life. The design of each overpack is determined by the specific requirements and constraints of each stage:

- **Transfer Overpack:** would be used to transfer the MPC during operations at the NPP. It provides temporary containment of the MPC when it is transferred from one overpack to another (hence its name).
- **Storage Overpack:** would be used to provide necessary protection to the MPC during the storage stage at the Interim Storage Facility.
- **Transport Overpack:** would be used for transport of the MPC to a GDF via rail/road/sea. Two different versions of the Transport Overpack are envisioned, one for each option (as will be explained in the next section).
- **Transit Overpack at GDF:** would be used to transfer the Disposal Overpack in Option 1 (as will be explained in the next section) as it travels underground at a GDF toward the final disposal location.
- **Disposal Overpack:** it seals the MPC for disposal in a GDF.

4 MPC SYSTEM OPTIONS

It is recognised that options exist with respect to the potential location and timing of packaging the MPC into the Disposal overpack, and each of these will have implications for the MPC system design. For the study five options were considered:

- Option 1: the Packaging Plant for packaging MPCs into Disposal Overpacks is located at a GDF (at surface level). Therefore the MPC is packaged into the Disposal Overpack when it reaches a GDF.
- Option 2: the Packaging Plant for packaging MPCs into Disposal Overpacks is located at the NPP. Therefore the MPC is packaged into the Disposal Overpack at the NPP prior to the transportation to a GDF.
- Option 3: the Packaging Plant is located at a Centralised Facility. Therefore the MPC is packaged in the Transport Overpack for transport to the Centralised Facility and then re-packaged in the Disposal Overpack and another transport Overpack for transportation to a GDF.
- Option 4: the Packaging Plant is located at the NPP and the MPC is packaged in the combined Transport/Disposal Overpack prior to the transportation to and direct disposal in a GDF.
- Option 5: the Packaging Plant is located at the NPP and the Spent Fuel is directly packaged into a Disposal Canister without the need for a MPC.

The advantages and disadvantages associated with each system option are:

- Option 1: The main disadvantages were related to the additional space required at the GDF and the need for a policy change for the GDF in terms of waste arriving in a form suitable for direct transfer and disposal.

- Option 2: The main disadvantage of Option 2 is that it would require the largest Transport Overpack for transport to the GDF, since it needs to accommodate the MPC and the Disposal Overpack, which would result in the smallest MPC (i.e. this option can fit the smallest number of spent fuel assemblies).
- Option 3: In Option 3, the centralised facility would require two separate transport operations in the public domain. In addition, Option 3 would require the largest Transport Overpack for transport to the GDF, since it needs to accommodate the MPC and the Disposal Overpack, which would result in the smallest MPC (i.e. this option can fit the smallest number of spent fuel assemblies).
- Option 4: In Option 4, a single Overpack would be used for both Transport and Disposal. This option would require the package to satisfy both the Transport and disposal design requirements, which would be very onerous. The Overpack would need to have a bolted lid for Transport, but a welded lid for Disposal. There would also be a potential problem if neutron absorber material were required for transport, but needed to be removed for disposal.
- Option 5: In Option 5, where the spent fuel is directly packaged into a Disposal Canister at the NPP, the main disadvantages are related to the large upfront cost and foreclosure of options due to the early use of a fully-sealed Overpack. In addition, Option 5 would require the largest Transport Overpack for transport to the GDF, since it needs to accommodate the MPC and the Disposal Overpack, which would result in the smallest MPC (i.e. this option can fit the smallest number of spent fuel assemblies).

The disadvantages associated with Options 3, 4 and 5 were assessed as being significant disadvantages that outweighed the advantages. Therefore, only Options 1 and 2 were considered for further development.

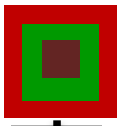
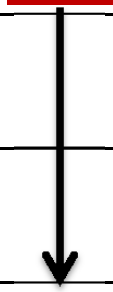
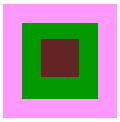
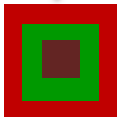
It should also be recognised that the System Options that have been developed are generic systems and therefore do not preclude alternative details or variations on the Systems described.

5 OVERVIEW OF THE PREFERRED MPC SYSTEM OPTION

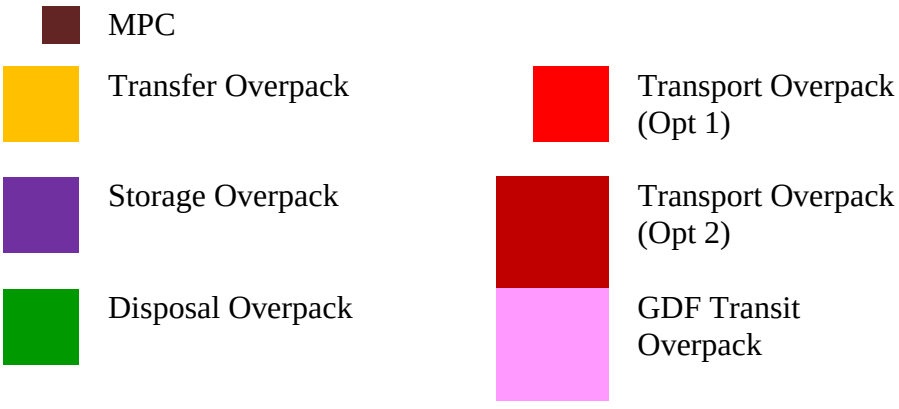
The location of the Packaging Plant for packaging MPCs into Disposal Overpacks has implications on the downstream stages of the System. For instance, in Option 2 the Disposal Overpack must be “nested” within the Transport Overpack for its transport to a GDF and would need to comply with transport regulations. Consequently, Option 2 results in the largest transport container and therefore from an overall size and mass perspective, to comply with UK rail and road transport infrastructure limits, is considered to represent the bounding case.

Table 1 summarises in a schematic way the overpacks that encapsulate the MPC in the various stages of the operation, and any nested configurations, for both Option 1 and Option 2.

Table 1 – Summary of Overpacks in Options 1 and 2

	Option 1 **Packaging at GDF**	**Option 2** **Packaging at NPP**
NPP		
Storage		
Transfer		
Packaging MPC into Disposal Overpack		
Transport		
Transfer		
Packaging MPC into Disposal Overpack		
Underground Transit		
Disposal at GDF		

Key to symbols:



6 MPC SYSTEM OPTION 1

In Option 1, the System consists of 5 phases:

1. Packaging of SF into MPC at NPP
2. Storage at facility adjacent to NPP
3. Transport to GDF
4. Packaging into Disposal Package at GDF
5. Disposal at GDF

6.1 Packaging of SF into MPC at NPP

This Phase consists of two Steps:

1. Loading of the MPC in SF pond in the NPP
2. Canister closing

Note: This is a generic system and does not preclude a dry loading system. However, water may still be required inside the MPC for cooling during the welding of the MPC lid.

6.1.1 Loading of the MPC in SF pond in the NPP

In this Step, SF assemblies are loaded into the MPC following these operations (Figure 2):

- the body of MPC, nested in body of the Transfer Overpack, is lowered into the pond (in the Prep Bay) by the lifting equipment;
- the Prep Bay is flooded;
- the wall between the bays slides off and the body of the MPC, nested in body of the Transfer Overpack, is moved to the Loading Bay;
- underwater, spent fuel assemblies are lifted one by one from the racks and are lowered into the MPC.

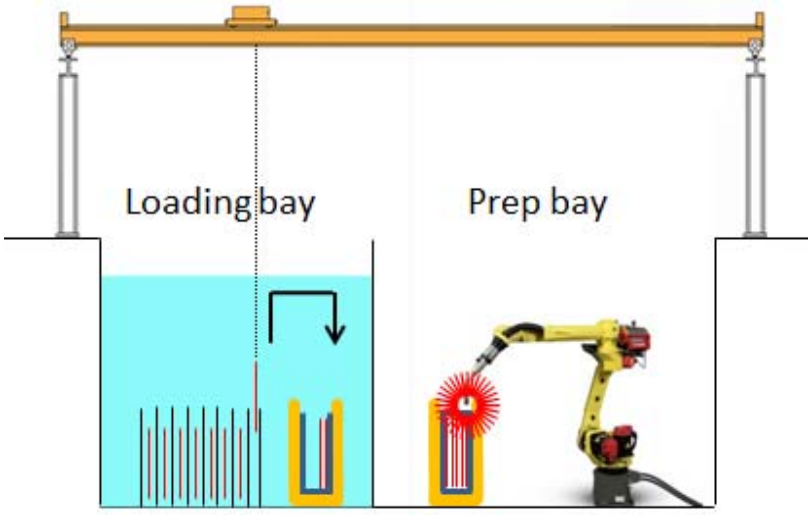


Figure 2 – Packaging of SF into MPC at NPP

6.1.2 Canister closing

The loaded MPC is closed and sealed, according to this sequence of operations:

- the lid is placed on top of the MPC;
- the lid is placed on top of the Transfer Overpack ;
- the Transfer Package (i.e. MPC within Transfer Overpack) is moved back to the Prep Bay;
- the wall between the bays slides back into place;
- the Prep Bay is dewatered;
- the Transfer Overpack lid is removed;
- the MPC lid is machine-welded on;
- welds are checked;
- water is drained from the MPC;
- the MPC is vacuum-dried;
- the MPC is back-filled with inert gas;
- the MPC valve is sealed and the cover plate is welded on;
- the Transfer Overpack lid is bolted on.

At this stage, the SF is sealed within the MPC, which is in turn inside the Transfer Overpack. The Transfer Package is ready to be moved to the Interim Storage Facility.

6.2 Storage at facility adjacent to NPP

This Phase consists of the following Steps:

1. Transfer of the closed MPC to the storage facility adjacent to the NPP and mating with the Storage Overpack
2. Storage in the Storage Overpack
3. MPC is transferred from Storage Overpack to Transfer Overpack
4. MPC + Transfer Overpack is moved to transport terminal

Note: This is a generic system and does not preclude a horizontal storage system or vertical storage units which can accommodate more than one MPC.

6.2.1 Transfer of the closed MPC to the storage facility adjacent to the NPP and mating with the Storage Overpack

The closed MPC is transferred to the storage facility adjacent to the NPP and is mated with the Storage Overpack (Figure 3). This is the sequence of operations:

- the closed Transfer Package is lifted onto the transfer vehicle;
- the transfer vehicle travels to the storage facility;
- in the storage facility, the transfer vehicle moves above the Storage Overpack within the transfer station;
- the Transfer Overpack mates with the Storage Overpack;
- the Transfer Overpack lid is opened;

- the MPC is engaged by the lifting equipment;
- the Transfer Overpack base is opened;
- the MPC is lowered into the Storage Overpack;
- once the MPC is fully lowered, the lifting equipment disengages and is removed;
- the Transfer Overpack is removed;
- the Storage Overpack lid is bolted on.

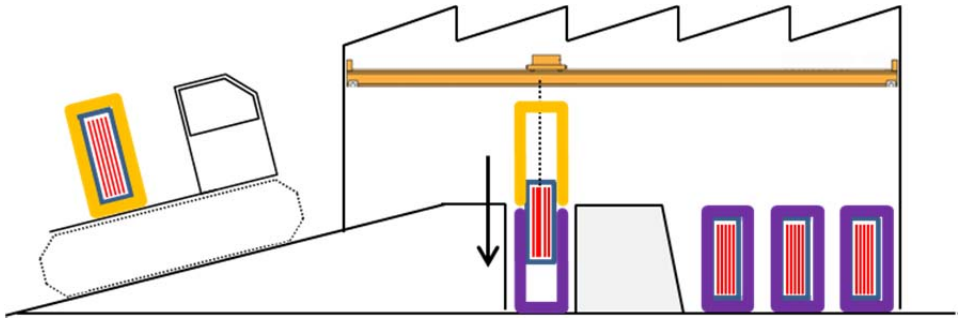


Figure 3 – Transfer of the closed MPC to the storage facility adjacent to the NPP and mating with the Storage Overpack

6.2.2 Storage in the Storage Overpack

The Storage Package (MPC + Storage Overpack) is transferred to the designated storage location at the Interim Storage Facility (Figure 4).

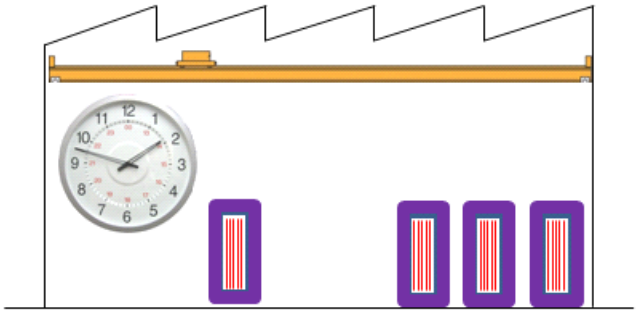


Figure 4 – Storage in the Storage Overpack

6.2.3 MPC is transferred from Storage Overpack to Transfer Overpack

At the end of the storage period, the MPC is transferred into the Transfer Overpack (Figure 5), according to these operations:

- the Storage Package is moved to the transfer station;
- the lid of the Storage Overpack is removed;
- the Transfer Overpack is positioned above and mated with the Storage Package;
- the lid and the base of the Transfer Overpack are opened;
- the MPC is engaged by the lifting equipment;
- the MPC is lifted into the Transfer Overpack;
- the base of the Transfer Overpack is slid back in place;
- the lifting equipment disengages the MPC and is removed;
- the lid of the Transfer Overpack is closed.

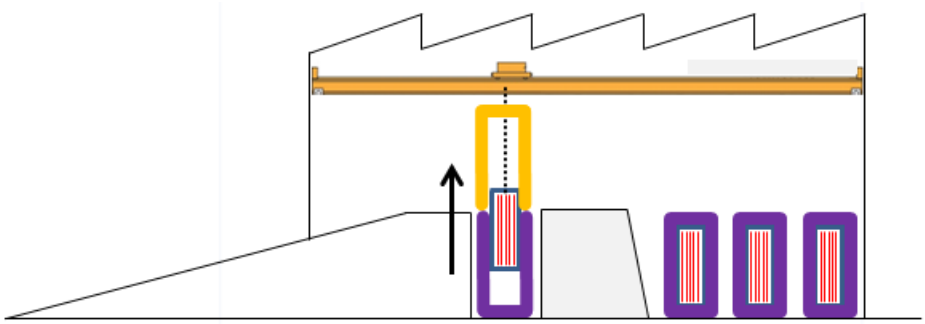


Figure 5 – MPC is transferred from Storage Overpack to Transfer Overpack

6.2.4 MPC + Transfer Overpack is moved to transport terminal

- A crane lifts the Transfer Package onto the transfer vehicle (Figure 6);
- the transfer vehicle travels to the transport terminal.

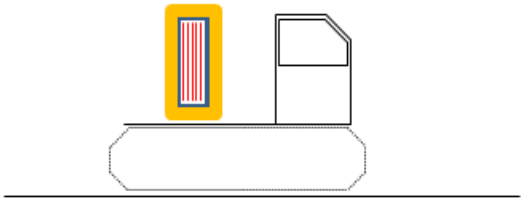


Figure 6 – MPC + Transfer Overpack is moved to transport terminal

6.3 Transport to GDF

This Phase consists of the following Steps:

1. Transfer of the MPC from the Transfer Overpack to the Transport Overpack
2. Loading of the Transport Package to the transport vehicle
3. Transport from the storage facility to the GDF
4. Unloading of the Transport Package from the transport vehicle

Note: This is a generic system and does not preclude the possibility of transportation by road and/or sea.

6.3.1 Transfer of the MPC from the Transfer Overpack to the Transport Overpack

The MPC is transferred from the Storage Overpack to the Transport Overpack (Figure 7) for transport to the GDF, according to this sequence of operations:

- the transfer vehicle is positioned above the pit;
- the Transfer Package is lifted over and mated with the Transport Overpack;
- the Lid of the Transfer Package opens;
- the MPC is engaged by the lifting equipment;
- the Transfer Overpack base is opened by sliding it to one side;
- the MPC is lowered into the Transport Overpack;
- the MPC is disengaged;
- the Transfer Overpack is removed;
- the lid is placed on the Transport Overpack;

- bolts are engaged and tightened;
- the Transport Overpack is back-filled with inert gas;
- Leak test performed.

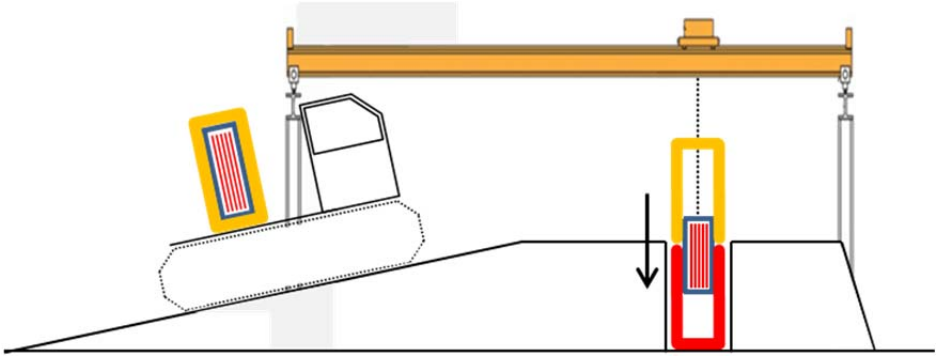


Figure 7 – Transfer of the MPC from the Transfer Overpack to the Transport Overpack

6.3.2 Loading of the Transport Package to the transport vehicle

The Transport Package is loaded onto the transport vehicle (note the rail wagon shown in Figure 8 is illustrative only and does not preclude the use of other types of rail wagon), according to this sequence of operations:

- lifting equipment engages the upper trunnions of the Transport Overpack;
- the Transport Overpack with the MPC is lifted onto the transport frame on the wagon. The lower pair of trunnions of the overpack engage the wagon frame;
- the Transport Overpack with the MPC is lowered to horizontal and secured onto the transport frame;
- lifting equipment disengages;
- impact limiters are fastened to both ends of the Transport Overpack;
- the transport cover is closed.

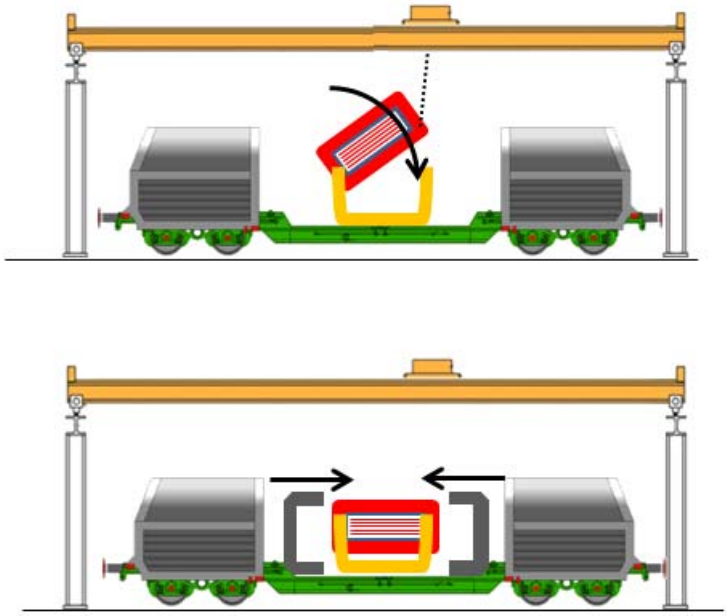


Figure 8 – Loading of the Transport Package to the transport vehicle

6.3.3 Transport from the storage facility to the GDF

The Transport Package travels to the GDF (Figure 9).

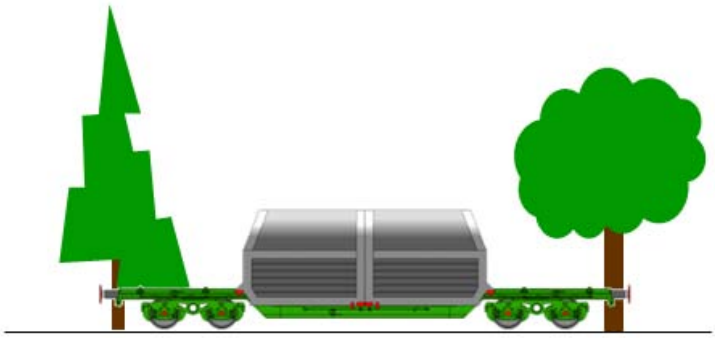


Figure 9 – Transport from the storage facility to the GDF

6.3.4 Unloading of the Transport Package from the transport vehicle

The Transport Package is unloaded from the transport vehicle (Figure 10) according to this sequence:

- the transport cover slides back to expose the Transport Package;
- impact limiters are disengaged from both ends of the Transport Package;
- the lifting equipment engages the upper trunnions of the Transport Overpack;
- the Transport Overpack unlocks from the transport frame, and is raised from horizontal to vertical pivoting about the lower trunnions;
- the Transport Overpack with the MPC is lifted off the wagon.

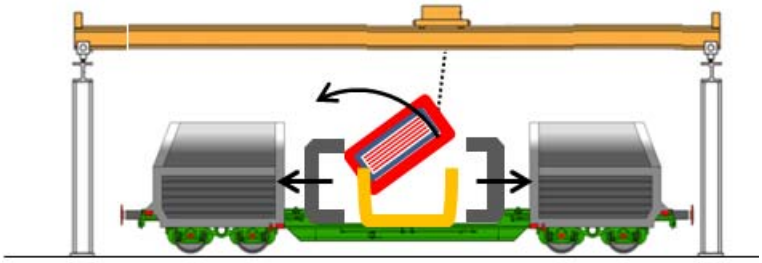


Figure 10 – Unloading of the Transport Package from the transport vehicle

6.4 Packaging into Disposal Package at GDF

This Phase consists of the following Steps:

1. Unloading of the MPC from the Transport Overpack Loading of the Transport Package to the transport vehicle
2. Transfer of the MPC to the Transport Overpack for Disposal Package
3. Closure of Disposal Package and GDF Transit Package

6.4.1 Unloading of the MPC from the Transport Overpack

The MPC is unloaded from the Transport Overpack (Figure 11) – the sequence of operations is as follows:

- the Transport Overpack lid is removed;
- the Transfer Overpack is lifted above and mated with the Transport Overpack;

- the lid of the Transfer Overpack is opened;
- the base of the Transfer Overpack is opened;
- the lifting equipment engages the MPC;
- the MPC is lifted into the Transfer Overpack;
- the base of the Transfer Overpack is closed;
- the lifting equipment disengages the MPC;
- the Transfer Overpack lid is closed;
- the lifting equipment engages the Transfer Package;

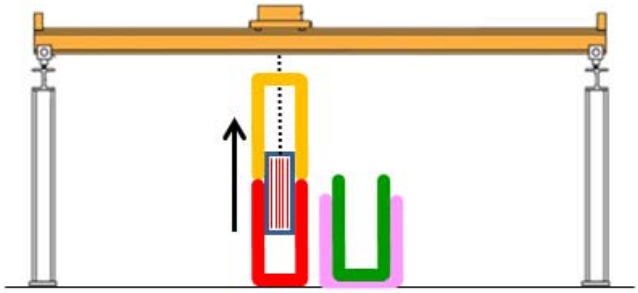


Figure 11 – Unloading of the MPC from the Transport Overpack

6.4.2 Transfer of the MPC to the Transport Overpack for Disposal Package

Via the following operations, the MPC is transferred from the Transport Overpack to the Disposal Package, as shown in Figure 12:

- the Transfer Overpack is lifted over to mate with the Disposal Overpack (green in the figure), which is nested within the GDF Transit Overpack (pink);
- the lid of the Transfer Overpack is opened;
- lifting equipment engages the MPC;
- the base of the Transfer Overpack is opened;
- the MPC is lowered into the Disposal Overpack;
- lifting equipment disengages;
- the Transfer Overpack is removed.

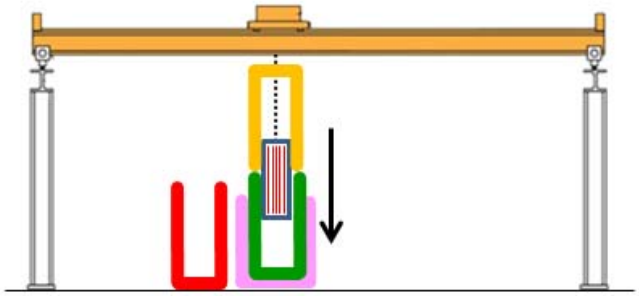


Figure 12 – Transfer of the MPC to the Transport Overpack for Disposal Package

6.4.3 Closure of Disposal Package and GDF Transit Package

In this Step, the Disposal Package (shown in green in Figure 13) is sealed and the GDF Transit Package is closed:

- the Disposal Overpack lid is closed, welded on, inspected and machined;
- a leak test is performed on the Disposal Overpack;
- the lid is placed on the GDF Transit Overpack and is closed.

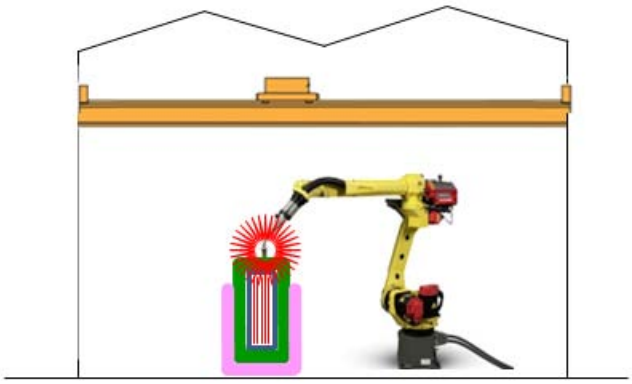


Figure 13 – Closure of Disposal Package and GDF Transit Package

6.5 Disposal at GDF

This Phase consists of the following Steps:

1. Loading of the GDF Transit Package onto the GDF Drift Wagon and transit underground
2. Unloading of the GDF Transit Package from the GDF Drift Wagon
3. Unloading the Disposal Package from the GDF Transit Overpack

6.5.1 Loading of the GDF Transit Package onto the GDF Drift Wagon

In this Step (Figure 14):

- the GDF Transit Package is lowered and secured onto the GDF Drift Wagon frame;
- the GDF Transit Package travels underground to the disposal vault.

Note: This is a generic system and does not preclude transfer of the MPC from the surface facilities to underground vault via shaft access

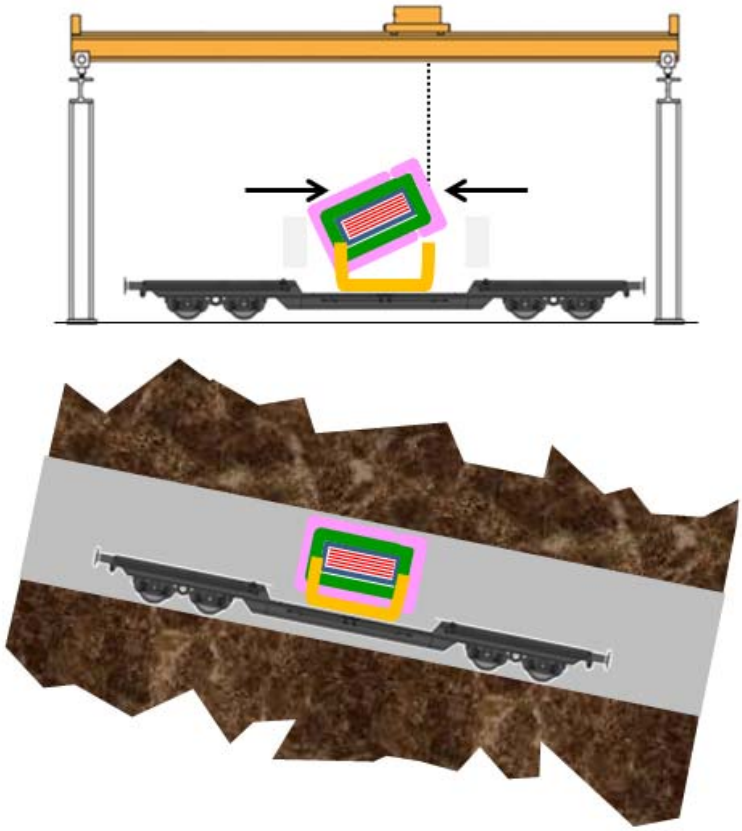


Figure 14 – Loading of the GDF Transit Package onto the GDF Drift Wagon

6.5.2 Unloading of the GDF Transit Package from the GDF Drift Wagon

In this Step (Figure 15):

- the GDF Transit Package is disengaged from the GDF Drift Wagon frame;
- the lifting equipment engages the GDF Transit Package upper trunnions and lifts the Package off the Drift Wagon onto the Disposal Package unloading platform.

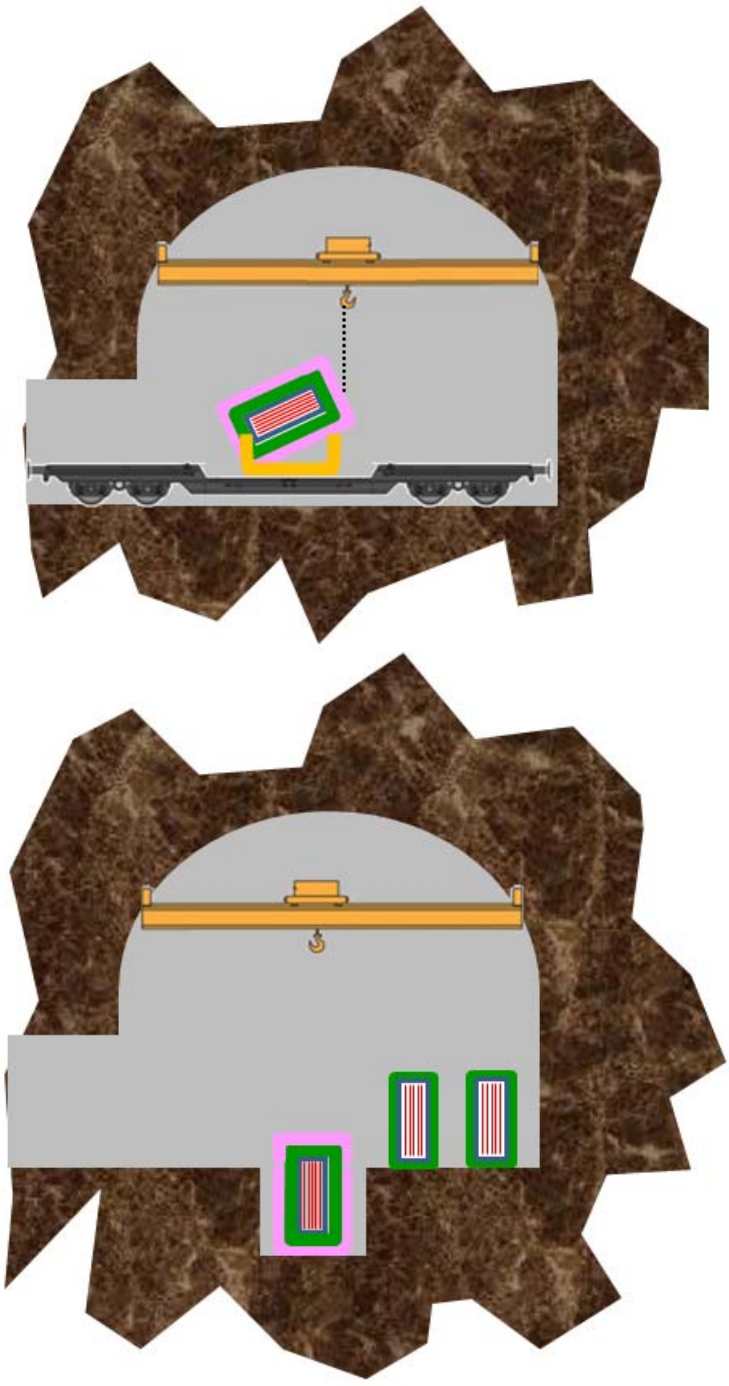


Figure 15 – Unloading of the Disposal Package from the GDF Transit Overpack

6.5.3 Unloading the Disposal Package from the GDF Transit Overpack

The Disposal Package (shown in green in Figure 16) is unloaded from the GDF Transit Overpack (pink); the sequence of operations is as follows:

- the lid of the GDF Transit Overpack is removed;
- lifting equipment engages the Disposal Package;
- the Disposal Package is lifted from the GDF Transit Overpack and is moved to the designated disposal location.

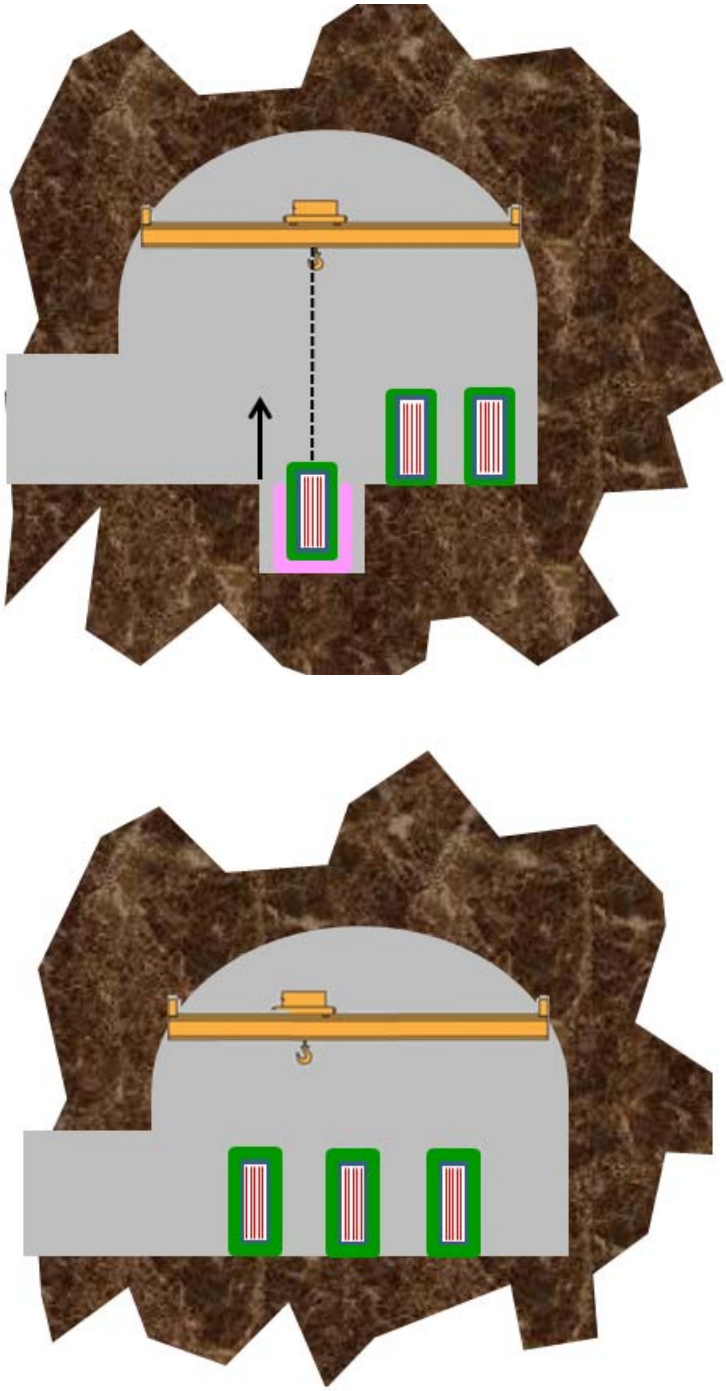


Figure 16 – Unloading the Disposal Package from the GDF Transit Overpack

7 MPC SYSTEM OPTION 2

This section describes Option 2 of the System; the pictorial representation of each step of the System utilises the same symbols described in Table 1.

Option 2 consists of five Phases:

1. Packaging of SF into MPC at NPP
2. Storage at facility adjacent to NPP
3. Packaging into Disposal Package at plant adjacent to NPP
4. Transport to GDF
5. Disposal at GDF

7.1 Packaging of SF into MPC at NPP

In this Step, SF assemblies are loaded into the MPC following these operations (as Figure 17 schematically shows):

- the body of MPC, nested in body of the Transfer Overpack, is lowered into the pond (in the Prep Bay) by the lifting equipment;
- the Prep Bay is flooded;
- the wall between the bays slides off and the body of the MPC, nested in body of the Transfer Overpack, is moved to the Loading Bay;
- underwater, spent fuel assemblies are lifted one by one from the racks and are lowered into the MPC.

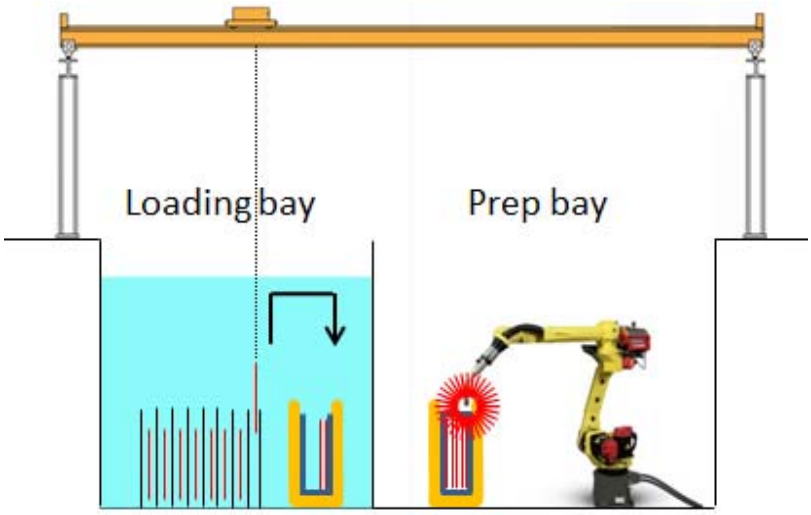


Figure 17 – Packaging of SF into MPC at NPP

At this stage, the SF is sealed within the MPC, which is in turn inside the Transfer Overpack. The Transfer Package is ready to be moved to the Interim Storage Facility.

7.2 Storage at facility adjacent to NPP

In this Phase the Transfer Package is taken to the Interim Storage Facility for storage using the following Steps:

1. Transfer of the closed MPC to the storage facility adjacent to the NPP and mating with the Storage Overpack

2. Storage in the Storage Overpack
3. MPC is transferred from Storage Overpack to Transfer Overpack
4. MPC + Transfer Overpack is moved to transport terminal

Note: This is a generic system and does not preclude a horizontal storage system or vertical storage units which can accommodate more than one MPC.

7.2.1 Transfer of the closed MPC to the storage facility adjacent to the NPP and mating with the Storage Overpack

The following operations are summarised in Figure 18:

- the closed Transfer Package is lifted onto the transfer vehicle;
- the transfer vehicle travels to the storage facility;
- in the storage facility, the transfer vehicle moves above the Storage Overpack within the transfer station;
- the Transfer Overpack mates with the Storage Overpack;
- the Transfer Overpack lid is opened;
- the MPC is engaged by the lifting equipment;
- the Transfer Overpack base is opened;
- the MPC is lowered into the Storage Overpack;
- once the MPC is fully lowered, the lifting equipment disengages and is removed;
- the Transfer Overpack is removed;
- the Storage Overpack lid is bolted on.

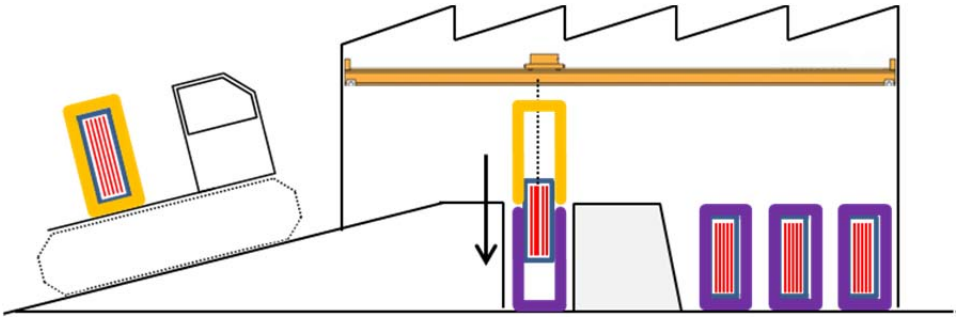


Figure 18 – Transfer of the closed MPC to the storage facility adjacent to the NPP and mating with the Storage Overpack

7.2.2 Storage in the Storage Overpack

The Storage Package (MPC + Storage Overpack) is transferred to the designated storage location at the Interim Storage Facility (Figure 19).

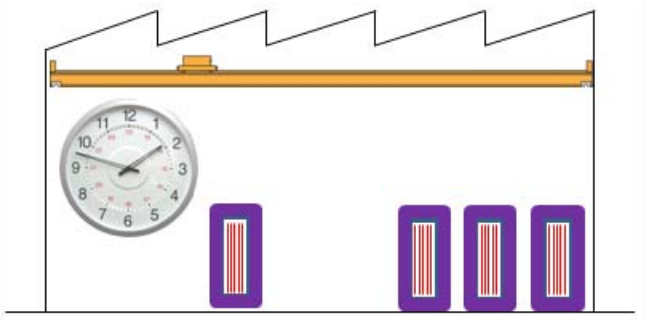


Figure 19 – Storage in the Storage Overpack

7.2.3 MPC is transferred from Storage Overpack to Transfer Overpack

At the end of the storage period, the MPC is transferred into the Transfer Overpack (Figure 20), according to these operations:

- the Storage Package is moved to the transfer station;
- the lid of the Storage Overpack is removed;
- the Transfer Overpack is positioned above and mated with the Storage Package;
- the lid and the base of the Transfer Overpack are opened;
- the MPC is engaged by the lifting equipment;
- the MPC is lifted into the Transfer Overpack;
- the base of the Transfer Overpack is slid back in place;
- the lifting equipment disengages the MPC and is removed;
- the lid of the Transfer Overpack is closed.

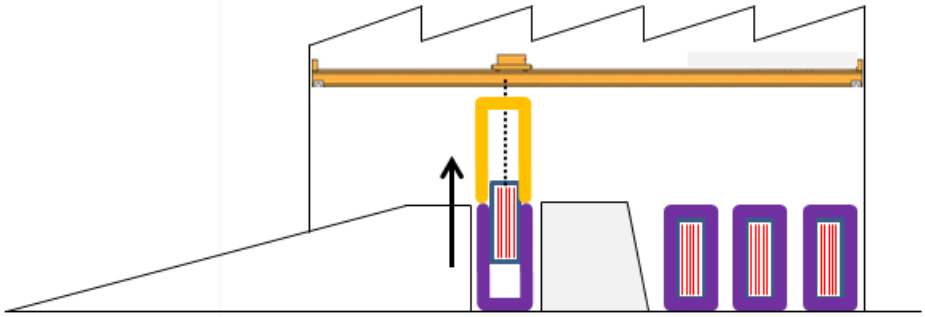


Figure 20 – MPC is transferred from Storage Overpack to Transfer Overpack

7.2.4 MPC + Transfer Overpack is moved to transport terminal

- A crane lifts the Transfer Package onto the transfer vehicle (Figure 21);
- the transfer vehicle travels to the transport terminal.

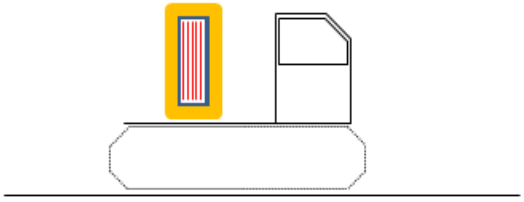


Figure 21 – MPC + Transfer Overpack is moved to transport terminal

7.3 Packaging into Disposal Package at plant adjacent to NPP

At this Phase, Option 2 follows a different path from Option 1, as the MPC heads to the packaging plant where it is encapsulated in the Disposal Overpack.

Figure 22 provides an overview of the Steps at the packaging plant adjacent to the NPP. These are:

1. Transfer of the MPC from the Transfer Overpack to the Disposal Overpack
2. Welding Lid of Disposal Overpack
3. Disposal Overpack is loaded into Transport Overpack

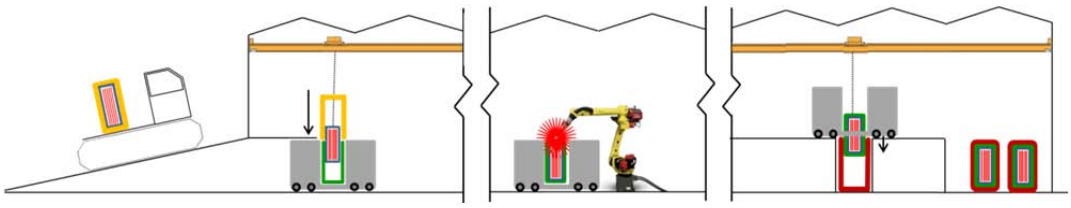


Figure 22 – Packaging into Disposal Package at plant adjacent to NPP

7.3.1 Transfer of the MPC from the Transfer Overpack to the Disposal Overpack

The sequence of operations (Figure 23) is as follows:

- the transfer vehicle is positioned above the Disposal Overpack inside the Conveyor Cart (shown in grey in Figure 23);
- the Transfer Package is lifted over and mated with the Disposal Overpack;
- the lid of the Transfer Overpack opens;
- lifting equipment engages the MPC;
- the Transfer Overpack base is opened by sliding it to one side;
- the MPC is lowered into the Disposal Overpack;
- the MPC is disengaged;
- the Transfer Overpack is removed;
- the lid is placed on the Disposal Overpack.

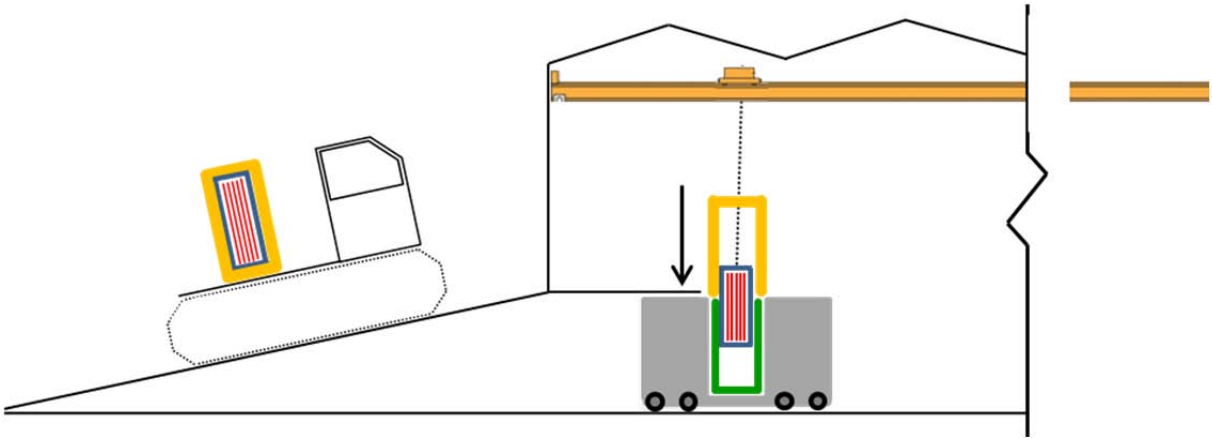


Figure 23 – Transfer of the MPC from the Transfer Overpack to the Disposal Overpack

7.3.2 Welding Lid of Disposal Overpack

The Disposal Overpack is sealed close by welding the lid (Figure 24); operations in this Step are as follows:

- the Conveyor Cart is moved to welding area;
- the lid of the Disposal Overpack is sealed closed by machine-welding, inspected and machined.

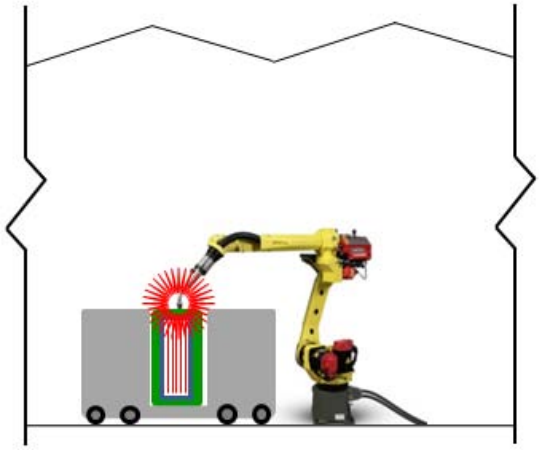


Figure 24 – Welding Lid of Disposal Overpack

7.3.3 Disposal Overpack is loaded into Transport Overpack

To load the Disposal Overpack into the Transport Overpack (Figure 25), the following sequence is adopted:

- the Conveyor Cart moves over the pit;
- lifting equipment engages the Disposal Package;
- the Disposal Package is lowered into the Transport Overpack through the base of the Conveyor Cart;
- Lifting equipment disengages;
- the Conveyor Cart moves away;
- the lid of the Transport Overpack is closed and bolted;
- the Transport Overpack is back-filled with inert gas;
- a Leak Test is performed;
- lifting equipment engages the Transport Overpack;
- the Transport Overpack is lifted out of the pit and is moved into the holding bay.

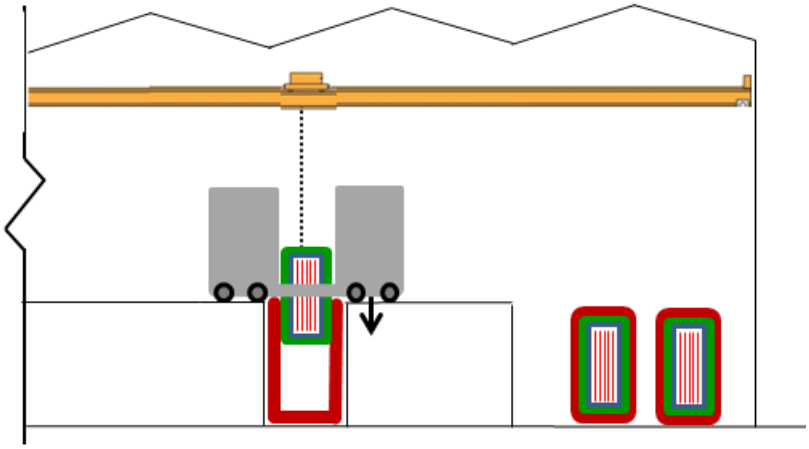


Figure 25 – Disposal Overpack is loaded into Transport Overpack

7.4 Transport to GDF

This Phase consists of the following Steps:

1. Loading of the Transport Package to the transport vehicle
2. Transport from the packaging plant to a GDF
3. Unloading of the Transport Package from the transport vehicle

Note: This is a generic system and does not preclude the possibility of transportation by road and/or sea.

7.4.1 Loading of the Transport Package to the transport vehicle

The Transport Package is loaded onto the transport vehicle (note the rail wagon shown in Figure 26 is illustrative only and does not preclude the use of other types of rail wagon), according to this sequence of operations:

- lifting equipment engages the upper trunnions of the Transport Overpack;
- the Transport Overpack is lifted onto the transport frame on the wagon. The lower pair of the Overpack trunnions are engaged with the transport frame;
- the Transport Package is lowered to horizontal and secured onto the transport frame;
- lifting equipment disengages;
- impact limiters are fastened to both ends of the Transport Overpack;
- the transport cover is closed

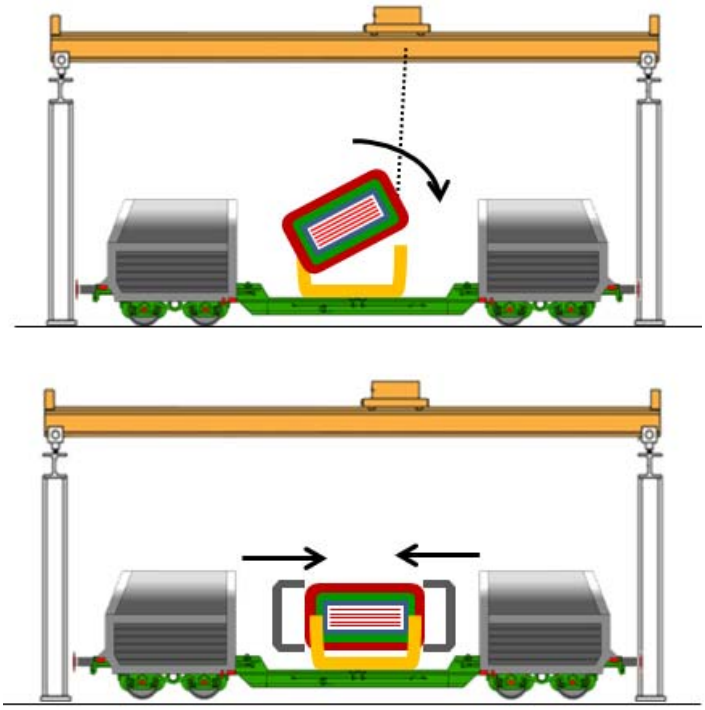


Figure 26 – Loading of the Transport Package to the transport vehicle

7.4.2 Transport from the packaging plant to a GDF

The Transport Package travels to a GDF (Figure 27).

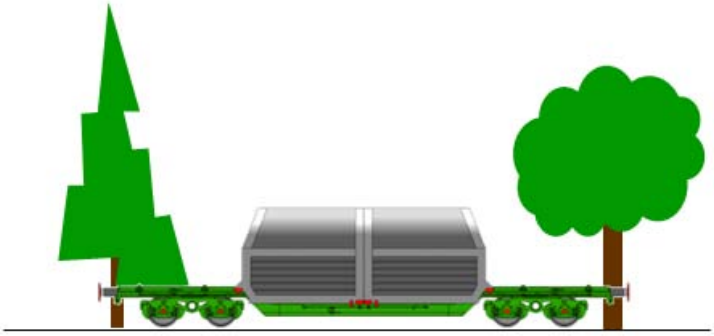


Figure 27 – Transport from the packaging plant to a GDF

7.4.3 Unloading of the Transport Package from the transport vehicle

After transport to a GDF, the Transport Package is unloaded from the transport vehicle (Figure 28) using these operations:

- Transport cover slides back to expose Transport Package
- Transport Frame is disengaged from the transport vehicle
- Lifting equipment engages with Transport Frame
- Transport frame with Transport Package is lifted off the transport vehicle

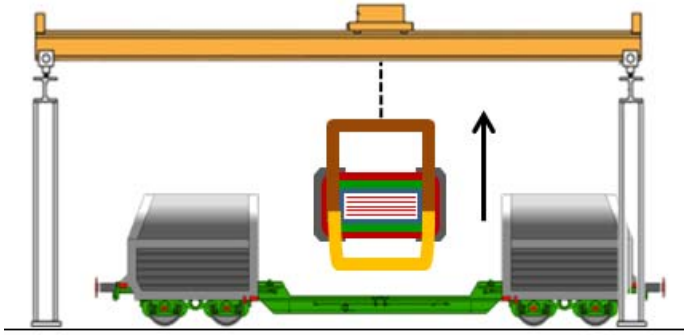


Figure 28 – Unloading of the Transport Package from the transport vehicle

7.5 Disposal at GDF

This Phase consists of the following Steps:

1. Loading of Transport Package onto GDF Drift Wagon and transit underground
2. Unloading of Transport Package from the GDF Drift Wagon
3. Unloading of Disposal Package from Transport Overpack
4. Disposal of Disposal Package

7.5.1 Loading of Transport Package on GDF Drift Wagon

The Transport Package, along with the transport frame, is loaded onto the GDF Drift Wagon (Figure 29), following this sequence of operations:

- the transport frame, with the Transport Package, is lowered and secured onto the GDF Drift Wagon;
- the Transport Package travels underground.

Note: This is a generic system and does not preclude transfer of the MPC from the surface facilities to underground vault via shaft access.

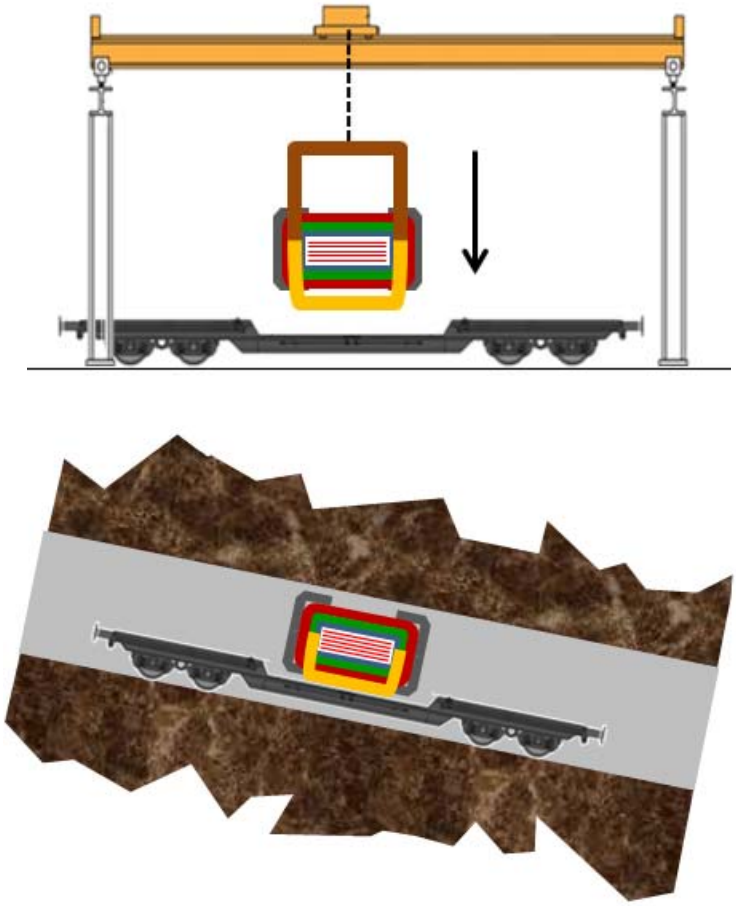


Figure 29 – Loading of Transport Package on GDF Drift Wagon and underground transfer to disposal area

7.5.2 Unloading of Transport Package from the GDF Drift Wagon

The Transport Package is unloaded from the GDF Drift Wagon (Figure 30), according to these operations:

- impact limiters are removed;
- the Transport Package (less impact limiters) is disengaged from the Drift Wagon frame;
- lifting equipment engages the upper trunnions of the Transport Package (less impact limiters);
- the Transport Package (less impact limiters) is lifted to vertical;
- the Transport Package (less impact limiters) is lifted off the transport frame and is lowered onto the Disposal Package unloading platform.

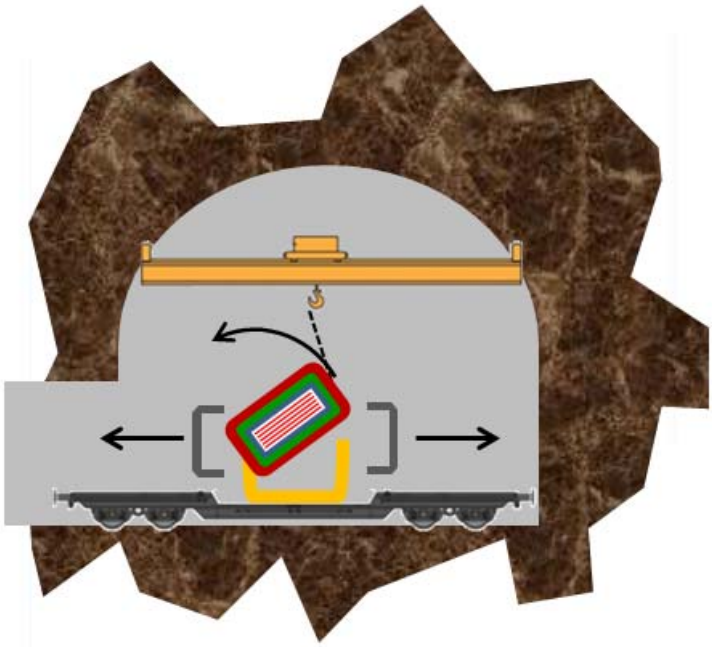


Figure 30 – Unloading of Transport Package from the GDF Drift Wagon

7.5.3 Unloading of Disposal Package from Transport Overpack

The Disposal Package is unloaded from the Transport Overpack (Figure 31), according to this sequence of operations:

- the lid of the Transport Package is removed;
- lifting equipment engages the Disposal Package;
- the Disposal Package is lifted out of the Transport Overpack and onto vault floor level.

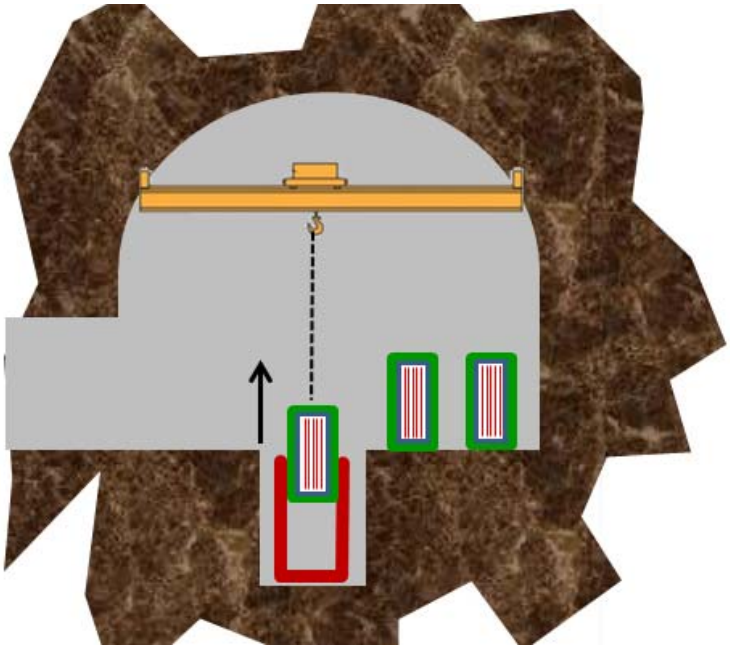


Figure 31 – Unloading of Disposal Package from Transport Overpack

7.5.4 Disposal of Disposal Package

- The Disposal Package is moved to the designated disposal location (Figure 32).

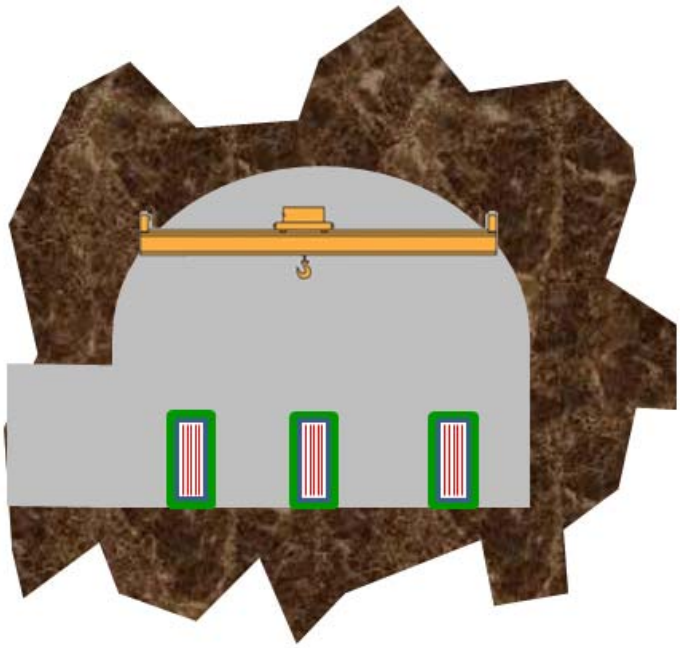


Figure 32 – Disposal of Disposal Package

8 CONCLUSIONS

An outline system in which an MPC can operate in the UK has been established. This enables the design requirements for the MPC and its overpacks to be identified and these will be captured in a design specification. From this, a design concept of the MPC and the overpacks for the UK can be developed.