Geological Disposal

UILW Waste package fire accident conditions

February 2013
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Executive Summary

This Technical Note reviews the severity of the fire accident conditions to which unshielded ILW (UILW) waste packages could potentially be exposed during the operational phase at a geological disposal facility. These fire accident conditions are used as the basis for the assessment of the fire accident performance of UILW waste packages proposed by waste producers. The fire performance of proposed waste packages can be demonstrated through validated computer modelling of waste packages using appropriate thermal properties combined with small-scale active simulant wasteform furnace tests.

This Technical Note considers the severity of potential fire accidents that could befall UILW waste packages. It considers all handling operations between the inlet cell, where they are removed from their protective transport container, and the UILW disposal vaults, in order to justify a reduction in the current assumption that all such accidents should be represented by a fully engulfing fire, resulting from a 1000°C hydrocarbon pool fire of 1 hour duration.

There is still uncertainty in the handling and emplacement equipment for the UILW emplacement route and hence estimates of the available combustible loading. It is recommended that the following fire durations be used as the basis for the assessment of waste package fire accident performance, and included in the guidance that supports the packaging specifications for UILW waste packages.

1. For a GDF constructed in a geological environment defined as higher strength rock or lower strength sedimentary rock:
   - A fully engulfing fire at 1000 °C for a duration of 30 minutes.

   The longest fire duration for a UILW waste package unit is for the package transfer machine in the UILW inlet cell package removal area and the transfer tunnel.

2. For a GDF constructed in a geological environment defined as an evaporite rock:
   - A fully engulfing fire at 1000 °C for a duration of 30 minutes.

   The longest fire duration for a UILW waste package unit is for the package transfer machine in the UILW inlet cell package removal area and the transfer tunnel.

Areas for further work are recommended that could reduce the fire duration for UILW waste package units in a higher strength rock or lower strength sedimentary rock GDF down to 10 minutes. Similarly, further work is identified that could reduce the fire duration for UILW waste package units in an evaporite GDF down to 11 minutes.
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1 Introduction

Within the NDA’s Radioactive Waste Management Directorate (RWMD), the Disposal System Assessments team are responsible for the development and delivery of safety cases to support licensing submissions for the construction and operational phases of a Geological Disposal Facility (GDF). A generic Operational Safety Case (OSC) was produced in 2010 for a non-site specific GDF [1]. It is based on three illustrative geological disposal concept examples and examines the safety aspects of the receipt, handling, emplacement and storage of radioactive waste packages in the GDF.

A key issue for the design of such a facility is to demonstrate that waste packages can be handled and emplaced with no adverse safety impacts to workers or members of the public. This requires that consideration be given to the consequences arising from normal and accident conditions within the facility. This includes the surface facilities, the access drift and separate underground vaults for the different types of waste. The safety performance in each of these locations is published in volume 3 of the 2010 OSC [2].

During the disposability assessment of a proposed waste package design, its fire accident performance is assessed against the requirements specified by the relevant packaging specification [3]. For waste packages containing ILW this includes the requirements that:

“The accident performance of the waste package shall ensure that, in the event of any credible accident during the GDF operational period, the on- and off-site doses resulting from the release of radionuclides from the waste package shall be as low as reasonably practicable and should be consistent with meeting the relevant Basic Safety Levels.”

The packaging specifications include no definition of a ‘credible accident’ but during disposability assessments this is currently assumed to be a fully engulfing fire, resulting from a 1000°C hydrocarbon pool fire of 1 hour duration.

Following on from the publication of the 2010 OSC, RWMD is undertaking a review of the safety case to identify the areas where further design changes, methodology updates, research and data are required to reduce the uncertainties associated with the safety of the facility. One of the key uncertainties in the design and assessment relates to fire accidents during handling of waste packages at a GDF. Currently, pessimistic assumptions are used to assess the performance of waste package handling operations. However to better understand the fire performance of waste packages, the fire conditions need to be more clearly defined.

This Technical Note reviews the fire accident performance requirements for unshielded ILW (UILW) waste packages.

The fire performance of proposed waste packages can be demonstrated through validated computer modelling of waste packages using appropriate thermal properties combined with small-scale active simulant wasteform furnace tests. This Technical Note considers UILW waste package fire accident conditions arising at the:

- Inlet cell;
- Transfer tunnel;
- UILW vault.

It should be noted that the 2010 OSC assumes that UILW waste packages will be protected when overpacked in the transport container such that any release would be negligible for workers or the public. Therefore this Technical Note only develops fire accident conditions for all operations between the inlet cell, where they are removed from their protective transport container, and the UILW disposal vaults.
Section 2 describes the range of UILW waste packages that will be received at a GDF. Section 3 discusses the approaches used by other organisations. Section 4 develops the fire accident conditions at each location along the waste package transfer route. These are reviewed in Section 5 and the conclusions in Section 6 give the recommended fire criteria.

This Technical Note is part of the following iterative cycle in refining the assessment of the performance of waste packages for the GDF operational safety case:

1. Fire criteria based on the GDF designs developed for the 2010 OSC (This Technical Note);

2. Identify needs for additional research;

3. Addendum to the Waste Package Accident Performance Status Report to provide revised fire accident performance release fraction data;

4. Update to the ROSA Toolkit to produce the predicted accident doses to workers and the public;

5. Addendum to the Generic Operational Safety Assessment – Volume 3 Accident safety assessment (To be considered);

6. Review of the GDF design and operations to look at options to reduce the quantities of combustible materials, location of workers and additional engineered barriers;

7. Repeat steps 1-6 to reduce the predicted doses and further improve our safety case for fire accident performance at a GDF.
2 Background

2.1 The range of UILW waste packages

As the disposal concept for higher activity waste is only at a conceptual stage and no specific sites have been identified, the information necessary to develop firm Waste Acceptance Criteria (WAC) for waste packages destined for disposal in a GDF is not yet available. However, to allow the feasibility and safety of the geological disposal concept to be assessed, and to permit the assessment of disposability of packaging proposals for these materials, our approach is to develop generic packaging specifications in order to provide a coherent set of requirements against which packaged waste can be designed and assessed for its suitability for transport and disposal. For waste packages containing ILW these requirements are defined by the Generic Specification for waste packages containing low heat generating waste [3].

For higher activity waste, potentially suitable geological disposal concepts were defined for three generic host rock environments, defined as higher strength rock, lower strength sedimentary rock and evaporites. The Disposability Assessment Process facilitates the manufacture of waste packages now that are compatible with the requirements imposed by each of the distinct periods of long-term management as defined by those concepts.

RWMD has identified a range of waste containers that are suitable for packaging the vast majority of higher activity waste predicted to arise within the UK. The number of container types in the ILW range is limited to the following four for UILW; this being currently considered to be the minimum number which best meets the needs of the UK waste packagers:

- 500 litre drum
- 3 cubic metre box
- 3 cubic metre drum
- Miscellaneous Beta Gamma Waste Store (MBGWS) box.

2.2 Current position and steps taken to identify accurate criteria

The packaging specifications that apply to UILW waste packages (i.e. [3]) require that:

"Under all credible accident scenarios the release of radionuclides and other hazardous materials from the waste package shall be low and predictable.

The waste package should exhibit progressive release behaviour within the range of all credible accident scenarios.

The impact and fire accident performance of the waste package shall comply with the assumptions that underpin the safety cases for transport and the GDF operational period.

The accident performance of the waste package shall ensure that, in the event of any credible accident during the GDF operational period, the on- and off-site doses resulting from the release of radionuclides from the waste package shall be as low as reasonably practicable and should be consistent with meeting the relevant Basic Safety Levels."

It should be noted that these requirements do not quantify the severity of accidents, or the nature of the material released from waste packages. In the 2007 Generic Waste Package
Specification (GWPS) [4] we had defined the fire performance for UILW waste packages as:

“Waste packages should be capable of withstanding a fully engulfing, 1000°C hydrocarbon pool fire of 1 hour duration, with a release of contents that should be no greater than (a quantity defined) for the particular waste package type.”

This prescription of both the fire temperature and duration was to help define the conditions for computer modelling to assess the fire accident performance because it clearly defines the boundary conditions on the outside of the waste package.

The fire criterion defined by the 2007 GWPS were conservatively based and were considered to be severe, particularly in relation to the fire accident conditions prescribed in the IAEA Regulations for transport of radioactive material [5] (30 minute 800°C fully engulfing hydrocarbon pool fire). However, we assigned a temperature of 1000 °C in recognition that the peak temperatures in tunnel fires are often higher than those reported for fires burning in the open air (when underground, the reflection of radiation off tunnel walls and other underground features would increase the fire severity and hence temperature). A longer fire duration of 1 hour has been assumed because access underground is restricted making it more difficult to intervene. It was previously thought that there could be sufficient combustible materials that could sustain fires for a duration of 1 hour [6, 7]. The fire criterion in the GWPS could be considered to be overly pessimistic and it was recognised that an evaluation of the potentially flammable materials and possible ignition sources might enable this requirement to be revised according to the realistic potential for a fire in a GDF.

Based on the 2010 generic GDF designs, Buildings Research Establishment (BRE) in support of RWMD has led a review of the flammable materials in the GDF for all operations between the inlet cell, where they are removed from their protective transport container, and the UILW disposal vaults [8]. The review concentrated on the following areas and operations:

- Inlet cell: lid unbolting, lid removal, shroud location, waste package removal
- Transfer tunnel: load bogie, move to vault
- UILW vault: transfer to crane, locate in vault.

The review identified all the materials in each location. This complements the fault and hazard schedule which identifies locations for fire accidents, but does not quantify the possible scenarios [2, 9]. For each material, the review identified the:

- Possible ignition sources
- Quantity of flammable material (kg)
- Estimated fire duration (min)
- Peak heat release rate (MW)
- Flame impingement (Is the location of the combustible material close enough to make a contribution to the fire?).

With a detailed design, the next step would be to provide an accurate prediction of the thermal loading on the UILW waste packages e.g. to apply finite element modelling (see Box 1). This is not possible at this stage in the GDF design as further details would be

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1 In the 2010 OSC, it is considered that the transport containers provide sufficient protection to prevent any radiological hazard to persons for all credible impact and fire events in a GDF. This includes all movement and handling of the transport container on the surface from the point of receipt, its transfer from lorry or rail wagon to the drift wagon and subsequent transfer via the Drift to the underground reception area.
needed on the ventilation system and certain facilities still have to be designed such as the location of the control rooms and worker positions. As the design develops it is likely that we will review the materials in the GDF to reduce the quantity of flammable material and consider active fire suppression measures, if required.
3 Approach

Some other countries are more advanced in their design of repository and associated safety case for the handling of waste packages underground. A review of the Finnish modelling of transport and repository fire conditions has provided direction to developing an approach appropriate for our stage of the GDF design.

Spent fuel from Finnish nuclear power reactors is planned to be disposed of in a repository to be constructed at a depth between 400 and 600m in the crystalline bedrock at the Olkiluoto site [10]. The total amount of spent fuel to be disposed of is estimated to be at most about 5800 tU. Posiva reviewed the approach in other countries and decided to follow the approach taken by the U.S. Nuclear Regulatory Commission (NUREG), as described in Boxes 1 and 2.

Box 1 NUREG approach to fire modelling

In July 2001 at Baltimore, USA a freight train wagon containing tripropylene (a combustible liquid with a flashpoint of 25 °C) was involved in a tunnel fire accident which burned for about 3 hours before a water pipe burst. As nuclear material is also transported through this tunnel, the U.S. Nuclear Regulatory Commission (NUREG) conducted modelling of a PWR rail transport cask. A fire duration of 7 hours was modelled. The highest temperature at the edge of the fuel bundle was reached 12.7 hours after the end of the fire (546 °C).

NUREG initiated work to simulate the Baltimore tunnel fire in order to estimate the temperatures. The Baltimore tunnel was 2650 m long with a height of 6.7 m and an incline of 0.8%. The tunnel had natural ventilation. The burning pool was modelled as a surface with a temperature of 130 °C and a hydrocarbon vaporisation heat of 300 kJ/kg. The pool fire turned out to be oxygen-limited. Unburnt hydrocarbon blended into the smoke, limiting the fire intensity to 50 MW. The predicted highest flame temperature was about 1000 °C and the wall temperature about 800 +/- 100 °C.

Box 2 Posiva approach to fire modelling

In Finland, the NUREG approach was used by Posiva to model the performance of the Finnish B(U) type transportation cask. The outer casing has a diameter of 0.75 m. Axis-symmetric modelling with a flame temperature of 1000 °C for a 4-hour fire produced an internal temperature of about 400 °C. On cooling the inner temperatures increased to a maximum of 570 °C at 5.3 hours at which point all the temperatures were falling. This is approximately the temperature at which fuel clad damage could occur. Therefore, when the flame temperature is 1000 – 1200 °C, the critical duration of the fire is 2.5-4 hours for the transportation cask and 2-3 hours for the radiation shield.

Modelling was also conducted underground for the canister transportation vehicle. Four combustible substances were identified for the canister handling and deployment vehicle: diesel, tyres, heat insulators and neutron shield. Other materials such as cabling attached to the tunnel walls were not considered. All the combustible materials adjacent to the waste package were considered to burn for a constant rate with a duration of 1 hour except the diesel which was modelled to burn for 30 minutes.
Posiva has developed an approach to demonstrating fire safety appropriate to the design of their facility by building on the IAEA Transport Regulations (modelling a fully engulfing fire at 800 °C for a duration of 30 minutes) and NUREG (testing and modelling of the Baltimore tunnel fire). For a UK GDF it will only be possible to model the fire scenarios underground once features such as the ventilation have been established. Therefore the approach to developing fire scenarios will include the following assumptions:

- The fire will burn freely – the fire is not oxygen-limited;
- All combustible materials that are identified in the BRE review as potentially giving rise to fires that ‘won’t’ impinge on the waste package are considered to not contribute to the fire although they could be part of the initiating event;
- Frequencies of initiating events for individual materials are not considered as part of this Technical Note, as it is assumed that once a fire is initiated in one material it will spread to all the combustible materials in the area;
- All combustible materials that are identified in the BRE review as potentially giving rise to fires that ‘will’ or ‘might’ impinge on the waste package are considered to give rise to an all-engulfing fire;
- The all-engulfing fire will burn with a flame temperature of 1000 °C (with no rise and fall as would be expected with real fires which show clear phases: they develop, are established and then decay);
- The combustible materials will combine to produce an all-engulfing fire which will burn for the duration of the material with the longest time as identified in the BRE review.

For a Pre-Construction Safety Case, we would present similar computer modelling to support our understanding of the performance of waste packages subject to fire conditions. This would be based on a detailed design of a GDF for a specific site and would follow best practice followed elsewhere as described above. The approach described in this Technical Note is consistent with the NUREG and Posiva approaches noting that our design is not as advanced and hence there remain uncertainty in some of the factors that define fire duration and intensity. We have developed a computer modelling capability to predict the consequences of fire accidents on waste packages. It is intended that as our understanding of the detailed design progresses, we will be able to apply the model to take better account of details such as fire growth time – the time taken for the fire to be established.
4 Fire accident conditions appropriate to the GDF

The fault and hazard schedule for a GDF includes UILW waste packages [9]. It is recognised that the majority of the fire Fault IDs in the schedule relate to waste package fires in a variety of different circumstances. These are described in Sections 4.1-4.6. For completeness, Section 4.7 describes a number of additional thermal damage faults and the work to ensure the safety of a GDF.

4.1 Inlet cell – Lid seal unbolting

The BRE review confirms that none of the identified combustible materials could give rise to flame impingement on the UILW waste package unit i.e. there would still be appropriate protection provided by the transport container during the lid seal unbolting stage.

4.2 Inlet cell – Lid removal

The BRE review confirms that several combustible materials in the lid removal area could give rise to fires with flame impingement on the UILW waste package unit. It also confirms that the bogie combustible materials will not impinge on the waste package and have not been included in these calculations of the fire accident conditions (See Table 1).

In the 2010 OSC, this is covered by Fault ID 3.4.4.2 for all fire faults in the lid removal station.

Table 1 Inlet cell – Lid removal

<table>
<thead>
<tr>
<th>Inlet cell: lid removal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OSC ID</strong></td>
</tr>
<tr>
<td><strong>Facility</strong></td>
</tr>
<tr>
<td>Lid removal area</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

4.3 Inlet cell – Package removal

The BRE review confirms that several combustible materials in the package removal area could give rise to fires with flame impingement on the UILW waste package unit. It also confirms that fires arising from bogie combustible materials will not impinge on the waste.
package and have not been included in these calculations of the fire accident conditions (See Table 2).

In the 2010 OSC, this is covered by Fault ID 3.5.4.4, 3.6.4.3, 3.7.4.5 and 3.7.4.6 for all fire faults in the inlet cell.

**Table 2**  
**Inlet cell – Package removal**

<table>
<thead>
<tr>
<th>OSC ID</th>
<th>Standard Hazard 4.3: Fire affecting UILW package unit in Inlet Cell</th>
<th>Fault ID 3.5.4.4: Sustained Fire affecting bare UILW package in Inlet Cell Package Removal Station</th>
<th>Fault ID 3.6.4.3: Sustained Fire affecting bare UILW package in Inlet Cell Monitoring Station</th>
<th>Fault ID 3.7.4.5: Fire affecting bare UILW package in Inlet Cell Stillage Transfer Area</th>
<th>Fault ID 3.7.4.6: Fire affecting bare UILW package in Inlet Cell during transfer to Transfer Tunnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility</td>
<td>Fire hazard</td>
<td>Material</td>
<td>Quantity (kg)</td>
<td>Fire duration (min)</td>
<td>Flame impingement</td>
</tr>
<tr>
<td>Package removal area</td>
<td>Large gaiter (shroud)</td>
<td>Polymer gaiter</td>
<td>10</td>
<td>8</td>
<td>Will</td>
</tr>
<tr>
<td></td>
<td>Manipulator arms</td>
<td>Polymer gaiter</td>
<td>2</td>
<td>4</td>
<td>Might</td>
</tr>
<tr>
<td>Package transfer machine</td>
<td>Hydraulic ram controls, pumps and pipes</td>
<td>Hydraulic fluid and hoses</td>
<td>100 litres</td>
<td>8</td>
<td>Will</td>
</tr>
<tr>
<td></td>
<td>Transfer gantry</td>
<td>Control cabling, motor, gearbox, power cables, buzz bar.</td>
<td>10</td>
<td>23</td>
<td>Might</td>
</tr>
</tbody>
</table>

**4.4 Transfer tunnel**

The BRE review confirms that several combustible materials in the transfer tunnel area could give rise to fires with flame impingement on the UILW waste package unit. It also confirms that fires arising from bogie and tunnel combustible materials will not impinge on the waste package unit and have not been included in these calculations of the fire accident conditions (See Table 3).

In the 2010 OSC, this is covered by Fault ID 4.0.4.4 for all fire faults in the transfer tunnel.
<table>
<thead>
<tr>
<th>OSC ID</th>
<th>Standard Hazard 4.3: Fire affecting UILW package unit in Inlet Cell</th>
<th>Fault ID 4.0.4.4: Fire affecting bare UILW package unit in Transfer Tunnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility</td>
<td>Fire hazard</td>
<td>Material</td>
</tr>
<tr>
<td>Package transfer machine</td>
<td>Hydraulic ram controls, pumps and pipes</td>
<td>Hydraulic fluid and hoses</td>
</tr>
<tr>
<td>Transfer gantry</td>
<td>Control cabling, motor, gearbox, power cables, buzz bar.</td>
<td></td>
</tr>
</tbody>
</table>

4.5 Emplacement vault

The BRE review confirms that several combustible materials in the emplacement vault could give rise to fires with flame impingement on the UILW waste package unit. It also confirms that fires arising from bogie combustible materials will not impinge on the waste package unit and have not been included in these calculations of the fire accident conditions (See Table 4).

In the 2010 OSC, this is covered by Fault ID 5.1.4.7 for all fire faults in the emplacement vault.
### Table 4  Emplacement vault

<table>
<thead>
<tr>
<th>OSC ID</th>
<th>Facility</th>
<th>Fire hazard</th>
<th>Material</th>
<th>Quantity (kg)</th>
<th>Fire duration (min)</th>
<th>Flame impingement</th>
<th>Bounding fire condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gearbox</td>
<td>Lighting and cameras</td>
<td>Oil</td>
<td>20</td>
<td>10</td>
<td>Will</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gearbox</td>
<td>Lighting and cameras</td>
<td>Exposed cables</td>
<td>&lt;1</td>
<td>1</td>
<td>Might</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cables</td>
<td>Lighting and cameras</td>
<td>Exposed cables</td>
<td>&lt;1</td>
<td>1</td>
<td>Might</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grease on rails</td>
<td>Cleaning materials</td>
<td>Grease</td>
<td>1</td>
<td>4</td>
<td>Might</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crane</td>
<td>Cleaning materials</td>
<td>Cleaning / maintenance materials</td>
<td>1</td>
<td>7</td>
<td>Will</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**4.6 Stacker truck (evaporite host rock option)**

For the evaporite host rock option, the BRE review confirms that several combustible materials in the stacker truck could give rise to fires with flame impingement on the UILW waste package unit (See Table 5).

In the 2010 OSC, stacker truck emplacement in the evaporite host rock option has not been directly assessed.
Table 5  Stacker truck (evaporite host rock option)

<table>
<thead>
<tr>
<th>OSC ID</th>
<th>Standard Hazard: To be identified</th>
<th>Fault ID: To be identified</th>
<th>Facility</th>
<th>Fire hazard</th>
<th>Material</th>
<th>Quantity (kg)</th>
<th>Fire duration (min)</th>
<th>Flame impingement</th>
<th>Bounding fire condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive</td>
<td>Transmission Oil 25 litres</td>
<td>Fully engulfing fire at 1000 °C for a duration of 11 minutes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydraulic hoist</td>
<td>Hoist Hydraulic fluid and hoses 140 litres</td>
<td>Will</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>Trim GRP, plastics 7</td>
<td>Might</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.7 Additional thermal damage faults

The fault and hazard schedule for a GDF includes UILW waste packages. It is recognised that the majority of the fire Fault IDs in the schedule relate to waste package fires in a variety of different circumstances. This Technical Note focuses on these fire accidents.

The fault and hazard schedule has also identified a number of thermal initiating events that are not possible to define in sufficient detail at the generic design stage. These thermal damage faults have not been included in this review as they require further work before predictions can be made for the safety of a GDF to these faults. Once a site is identified, with a detailed design, then it would be possible to determine the safety of a GDF to aircraft crash and overheating. These are discussed below.

**Aircraft crash**

For an aircraft crash, the probability of occurrence is related to the location of the site and the layout of the site. The distance from airfields and flight corridors are factors that need to be considered. Usually, civil aviation is considered separately from military flight patterns. Similarly to other large sites, each surface building would be considered systematically in turn, to determine the probability of a fire and the possible number of waste package units involved in an incident. The safety case will be developed further at the scheme design stage.

**Overheating**

For overheating, it is our intention to understand the quantity of excessive inventory that could give rise to an increase in waste package temperature, provide a high level of safety assurance and safety systems. The aim is to design out overheating from detailed consideration in our OSC. The safety case will be developed further at the scheme design stage.
5 UILW waste package unit fire accident conditions

The results of this review, of the GDF design and the combustible material characterised by BRE, demonstrates that none of the locations in the GDF for UILW waste package units will be subject to a fire approaching the current conditions of a fully engulfing fire at 1000 °C for a duration of 1 hour. Fire accident conditions for each of the GDF locations have been developed and are summarised in Table 6.

Table 6 UILW waste package fire accident conditions for each of the GDF locations

<table>
<thead>
<tr>
<th>Location</th>
<th>Fire conditions: 1000 °C fully engulfing fire for a duration of (minutes):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility</td>
<td>Area</td>
</tr>
<tr>
<td>Inlet cell: lid removal</td>
<td>Lid removal area</td>
</tr>
<tr>
<td>Inlet cell: package removal</td>
<td>Package removal area</td>
</tr>
<tr>
<td>Package transfer machine</td>
<td>Package transfer machine</td>
</tr>
<tr>
<td>Transfer tunnel</td>
<td>Package transfer machine</td>
</tr>
<tr>
<td>Emplacement vault</td>
<td>Crane</td>
</tr>
<tr>
<td>Stacker truck (evaporite host rock option)</td>
<td>Drive</td>
</tr>
<tr>
<td></td>
<td>Hydraulic hoist</td>
</tr>
<tr>
<td></td>
<td>Other</td>
</tr>
</tbody>
</table>

This Technical Note identifies several facility areas where the GDF safety case could be improved by using significantly reduced fire accident consequences for UILW waste package units. The outputs of this Technical Note identify combustible material fire durations for assessing the fire accident performance to enable predicted release fractions to be provided.

It is recommended that the following fire durations be used as the basis for the assessment of waste package fire accident performance, and included in the guidance that supports the packaging specifications for UILW waste packages.

1. For a GDF constructed in a geological environment defined as higher strength rock or lower strength sedimentary rock:
   - A fully engulfing fire at 1000 °C for a duration of 30 minutes – this is a ‘rounded’ and conservative number based on the predicted 23 minute duration for a fire in the inlet cell package removal area and the transfer tunnel for the package transfer machine. Lower fire durations are estimated for the inlet cell lid removal area and the emplacement vault.

2. For a GDF constructed in a geological environment defined as an evaporite rock:
• A fully engulfing fire at 1000 °C for a duration of 30 minutes – this is again a conservative approach based on the predicted 23 minute duration for a fire in the package transfer machine.

5.1 Design iteration for UILW waste package fire accident conditions

For a GDF in a higher strength rock or lower strength sedimentary rock, it is recommended to conduct a design iteration to understand the measures that could be taken to reduce the combustible materials and hence fire loading associated with:

• Hydraulic fluids and hoses (8-11 minutes)
• The gantry of the package transfer machine, which transfers waste package units from the inlet cell package removal area to the transfer tunnel, contains cabling, electric motor, gearbox and bus bar (23 minutes).

If both of these areas can be reviewed and action taken to reduce the combustible material or the direct contact with the waste package unit then the predicted fire duration can be reduced to no more than 10 minutes in any of the UILW waste package handling areas.

For a GDF in an evaporite host rock, it is recommended to conduct a design iteration to analyse the design of the stacker truck and its associated combustible materials. Because of the location of the combustible materials, it is likely that the flame impingement is from one side only.
6 Conclusions

A review has been conducted of the combustible materials associated with the UILW vault waste package unit emplacement route in a GDF. It is recommended that these reduced fire accident conditions for UILW waste package units are submitted through change control. Once completed a design iteration should be conducted to identify the measures that could be taken to reduce the combustible materials and hence the fire loading. The recommendation will have implications for the packaging specifications, the assessment of waste package fire accident performance and the 2010 OSC:

6.1 Recommended revision to the OSC

For the DSSC it is recommended that the fire durations identified in Table 6 are applied to the safety case for the different areas in the UILW waste package emplacement route. The task to revise the documentation would include:

- Calculation of the waste package fire release fractions (Research to assess and potentially provide revised data in an Addendum to the Waste package accident performance status report [7])
- Update to the fault and hazard schedule (Assessments to consider an extension to the Fault and Hazard Schedule to include the evaporite host rock option)
- Revision to the dispersion models used in the OSC (Assessments to produce an addendum to the current 2010 OSC [2])
- Update to the ROSA Toolkit to support the OSC and the Disposability Assessment Process (Assessments to produce an updated version of the Methodology, User guide and Validation reports)
- Revision to the safety case for workers and the public doses in the OSC (Assessments to produce an addendum to the current 2010 OSC [2]).

6.2 Recommended revision to the guidance that supports the packaging specifications

There is still uncertainty in the handling and emplacement equipment for the UILW emplacement route and hence estimates of the available combustible loading. It is recommended that the following fire durations be used as the basis for the assessment of waste package fire accident performance, and included in the guidance that supports the packaging specifications for UILW waste packages.

1. For a GDF constructed in a geological environment defined as higher strength rock or lower strength sedimentary rock:
   - A fully engulfing fire at 1000 °C for a duration of 30 minutes.
   The longest fire duration for a UILW waste package unit is for the package transfer machine in the UILW inlet cell package removal area and the transfer tunnel.

2. For a GDF constructed in a geological environment defined as an evaporite rock:
   - A fully engulfing fire at 1000 °C for a duration of 30 minutes.
   The longest fire duration for a UILW waste package unit is for the package transfer machine in the UILW inlet cell package removal area and the transfer tunnel.
6.3 Recommended timing

Sections 6.1 and 6.2 confirm the resources required to implement the recommended reduction in fire conditions for UILW waste package units. If the changes are agreed and formally approved for UILW fire conditions in the 2012/13 financial year, then the actions to implement the change control could be completed in the 2013/14 financial year leading to an addendum to our OSC. The timescales may need to be extended if detailed calculations are required by Research to develop revised RFs.

This would formalise the approach that would need to be undertaken for the other SILW and DCIC waste package types.
References
