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CRWMS/M&O

Design Analysis Cover Sheet

Complete only applicable items.

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2. DESIGN ANALYSIS TITLE	
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11. REMARKS

This analysis contains no To Be Verified/To Be Determined design input.
Document prepared in accordance with QAP-3-9 Rev 08.
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1. PURPOSE

This analysis was performed by the Management and Operating Contractor (M&O) Safety Assurance Department to identify and document the internal hazards and preliminary events associated with preclosure operations of the Monitored Geologic Repository (MGR). Internal hazards are those hazards presented by operation of the facility and associated processes. These are in contrast to external hazards which involve natural phenomena and external man-made hazards. The hazard analysis methodology used in this analysis provides a systematic means to identify facility hazards and associated events that may result in radiological consequences to the public and facility worker during the MGR preclosure period. The events are documented in a preliminary events list and are intended to be used as input to the MGR Design Basis Event (DBE) selection process. It is expected that the results from this analysis will undergo further screening and analysis based on the criteria that apply to the performance of DBE analyses for the preclosure period of repository operation. As the MGR design progresses, this analysis will be reviewed to ensure no new hazards are introduced and that previously evaluated hazards have not increased in severity.

This analysis supercedes the analysis of internal hazards and events performed in *Preliminary MGDS Hazards Analysis* (CRWMS M&O 1996). The acronyms used in this analysis are listed in Attachment I.

2. QUALITY ASSURANCE

This analysis is subject to the requirements of *Quality Assurance Requirements and Description*, DOE/RW-0333P (DOE 1998) as determined by Quality Administrative Procedure QAP-2-0, *Conduct of Activities* and the associated Activity Evaluation (CRWMS M&O 1999a) addressing the analysis of MGR hazards. This analysis is performed in accordance with Quality Administrative Procedure QAP-3-9, *Design Analysis*. This analysis does not directly support any construction, fabrication, or procurement activity.

3. METHOD

This analysis is performed utilizing the hazard analysis methodologies described in the System Safety Analysis Handbook (System Safety Society 1997) and addresses MGR internal hazards and associated events that could result in radioactive consequences to the public or facility worker during the preclosure period. The list of preliminary events is generated by applying a checklist of potential generic events (Section 7.3) to each functional area within the repository. A description of the process steps are provided in the following sections.

3.1 DEFINE MGR FUNCTIONAL AREAS

To facilitate identification of MGR hazards, the MGR is divided into functional areas. These functional areas are defined by a specific function and/or physical boundaries of the facility. Division of the MGR into functional areas is based upon the documents listed in Attachment II. MGR functional areas are listed in Section 7.1 and described in Section 7.4.

3.2 DEFINE MGR DESIGN CONFIGURATION AND OPERATIONS

Following the definition of functional areas, facility design configuration and operations within those areas are established and documented prior to hazard identification activities. Functional area design configuration and operations are discussed in Sections 7.2 and 7.4.

3.3 DEVELOP GENERIC EVENTS CHECKLIST

Once the MGR functional areas, design configuration, and facility operations are defined, a list of generic internal events is developed that, if determined to be applicable, could result in radiological consequences to the public or the facility worker. This generic list is not project specific and attempts to identify all potentially hazardous events. The intent is to provide the most comprehensive list to ensure thorough treatment of possible events. The development of generic events shall make maximum use of existing project documents where similar work has been performed. The list of generic events is provided in Section 7.3.

3.4 DETERMINE PROJECT APPLICABILITY OF INTERNAL EVENTS

This portion of the analysis reviews the MGR functional areas, including facility design and operations, to determine the applicability of generic events that could potentially result in radiological consequences.

Specific criteria are developed for each of the generic events to support the applicability determination. If the criteria are satisfied, the generic event has the potential for radiological consequence and specific preliminary events are then identified. It should be noted that potential events producing radiological consequences are not identified in all functional areas.

In addition, a general review of previously performed safety evaluations of repository operations was conducted to determine preliminary events applicable to the MGR. These evaluations included the following:

- *Preliminary Worst-Case Analysis to Support the Conceptual Design of a Potential Repository in Tuff* (Jackson et al. 1983)

- *Site Characterization Plan Conceptual Design Report - Volume 4 Appendices F - O* (MacDougall et al. 1987)
- *Yucca Mountain Site Characterization Project Identification of Structures, Systems, and Components Important to Safety at the Potential Repository at Yucca Mountain* (Hartman and Miller 1991)
- *Preclosure Radiological Safety Analysis for Accident Conditions of the Potential Yucca Mountain Repository: Underground Facilities* (Ma et al. 1992)
- *Preclosure Radiological Safety Evaluation: Exploratory Studies Facility* (Schelling and Smith 1993)

The following approach was used to document preliminary events in Section 7.4.

Area Description: Establishes the baseline description of the functional area of design for the repository. Information will be used to gain understanding of expected use.

Generic Event Category Applicability: Summarizes results from the applicability assessment for each of the following generic events.

- Collision/Crushing
- Chemical Contamination/Flooding
- Explosion/Implosion
- Fire
- Radiation/Magnetic/Electrical/Fissile
- Thermal

Reference: Identifies the preliminary design data used to conduct the analysis.

Preliminary Events: Identifies specific events based on the potential for interaction.

4. DESIGN INPUTS

The basic input used in the performance of this analysis consists of MGR process and design information and includes system description documents, process flow diagrams, mechanical flow diagrams, and a conceptual description of MGR operations. The specific documents are listed in Attachment II of this analysis. Additional design input to this analysis is described in the following sections.

4.1 DESIGN PARAMETERS

Design parameters are not applicable. Design parameters represent the engineering values used in design. This analysis does not perform a design function.

4.2 CRITERIA

4.2.1 The MGR shall comply with the applicable provisions of 10 CFR (Code of Federal Regulations) 20, "Standards for Protection Against Radiation." (YMP 1999, Section 3.1.B)

4.3 ASSUMPTIONS

No assumptions are made in this analysis.

4.4 CODES AND STANDARDS

10 CFR 20. Energy: Standards for Protection Against Radiation. January 1, 1999.

Revised Interim Guidance Pending Issuance of New U.S. Nuclear Regulatory Commission (NRC) Regulations (Revision 01, July 22, 1999) for Yucca Mountain. (Dyer 1999)

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6. USE OF COMPUTER SOFTWARE

This analysis uses no software which is required to be controlled in accordance with procedure AP-SI.1Q, *Software Management.*

7. DESIGN ANALYSIS

7.1 MGR FUNCTIONAL AREAS

Based on the documents listed in Attachment II, the following functional areas have been defined to facilitate the identification of the MGR hazards and events associated with preclosure operations. A description of each functional area is provided in Section 7.4.

- Waste Receipt and Carrier/Cask Transport
- Carrier Preparation
- Waste Handling - Carrier Bay
- Waste Handling - Canister Transfer
- Waste Handling - Assembly Transfer
- Waste Handling - Disposal Container Handling and Waste Package Remediation
- Subsurface Transport, Emplacement, and Monitoring
- Site-Generated Waste Treatment - Liquid Low-Level Radioactive Waste
- Site-Generated Waste Treatment - Solid Low-Level Radioactive Waste

7.2 MGR DESIGN CONFIGURATION AND FACILITY OPERATION

Prior to performing MGR hazards analysis, facility design configuration and operations as well as the function of facility SSCs are established. This analysis is based upon the MGR design and functions as established by the documents listed in Attachment II. Attachment II consists of System Description Documents (SDD) in addition to facility process and mechanical flow diagrams.

MGR operations are described by the documents listed in Attachment II. A brief description of operations for each functional area is provided in Section 7.4.

7.3 GENERIC INTERNAL EVENTS CHECKLIST

The development of the generic internal events checklist is based on the following hazard evaluation techniques:

- Energy Analysis (System Safety Society 1997, page 3-77)
- Energy Trace Barrier Analysis (System Safety Society 1997, page 3-79)
- Energy Trace Checklist (System Safety Society 1997, page 3-85)

The generic list is based upon the lists provided in the above three approaches that have been reorganized for convenience and applicability to MGR preclosure operations. The resulting comprehensive checklist contains a series of questions for each generic hazard. Applicability to a functional area of design is determined by a positive (yes) response to all questions.

7.3.1 Collision/Crushing

A. Categories:

1) Uncontrolled Mass/Force—Examples include: excessive velocity or acceleration of mass, inadvertent operation of appendage, failure of primary/secondary structure, tumbling (or tipped-over) mass, uncontrolled robot, or uncontrolled fixed rotating equipment, falls, drops.

2) Protrusions into pathways—Examples include: extended appendages, protruding structural elements, or improperly placed equipment.

B. Applicability to Functional Area of Design:

1) Is kinetic or potential energy present?

2) Can the kinetic or potential energy be released in an unplanned way?

3) Can the release of kinetic or potential energy interact with the waste form?

7.3.2 Chemical Contamination/Flooding (not normally a direct potential threat to the waste form—usually a contributing cause of another threat category)

A. Categories:

1) Reactions—For example: release of chemicals or materials that react with system materials causing system deterioration. The released materials could foster electrolytic/galvanic/stress corrosion or oxidation.

2) Off-Gassing—For example: release of volatile/condensable materials.

3) Venting—Examples include: leaking or venting of materials, gases, or liquids.

4) Debris/Leaks—Examples include: small loose/free parts, flaking, leaking fluids/flooding, or dirt/dust, oxidized materials (e.g., metal rust).

5) Flooding—especially water, leading to potential for criticality.

B. Applicability to Functional Area of Design:

Category 1, Reactions:

1) Are corrosive/reactive chemicals or materials present?

2) Can these chemicals or materials be released?

3) Can the chemicals or materials interact with the waste form?

Category 2, Off-Gassing:

1) Are volatile/condensable materials present?

2) Can these materials be released?

3) Can these materials interact with the waste form?

Category 3, Venting:

1) Is there potential for venting materials in the area?

2) Can the materials interact with the waste form?

Category 4, Debris/Leaks:

1) Is there potential for debris or leaks in the area?

2) Can the debris or fluids interact with the waste form?

Category 5, Flooding

1) Are sources of water present in the area?

2) Is there a potential to release the water?

3) Can the released water interact with the waste form with potential for criticality?

7.3.3 Explosion/Implosion (This event is normally accompanied by shrapnel or other high velocity debris.)

A. Categories:

1) Pressure Energy Release—Examples include: damage/ failure/ rupture of pressurized container/component and release of gases, or implosion of container/vessel/enclosed structural volume.

2) Electrical Energy Release—Examples include faults, arcs, static charge, electrical component failure, battery overcharge or overdischarge, or out of phase source connection.

3) Chemical Energy Release—Examples include: chemical dissociation/reactions, fire internal to confined volumes, adiabatic detonation, or ignition of confined flammable gases.

4) Mechanical Equipment—For example: rotating equipment disintegration due to overspeed.

B. Applicability to Functional Area of Design:

1) Are pressure, electrical, chemical, or mechanical energy present?

2) Can an event occur that results in an explosion or implosion energy release?

3) Can the released energy impact the waste form directly?

7.3.4 Fire

Must have ignition, fuel, and oxidizer sources.

Ignition Sources—Examples include: electrical faults/shorts, arcs, chemical reactions, hot surfaces, small flames, or catalytic reaction (also see Explosion/Implosion).

Fuel and Oxidizer Sources—Examples include: flammable materials (solids and liquids) and flammable atmospheres (gases), in addition to the presence of an oxidizing environment from ambient atmosphere or other chemical agents (also see Contamination).

A. Categories: Not Applicable

B. Applicability to Functional Area of Design:

1) Are fuel, oxidizers, and ignition sources present?

2) Is there sufficient fuel and oxidizer to sustain fire?

3) Can fire interact with the waste form?

7.3.5 Radiation/Magnetic/Electrical/Fissile

A. Categories:

1) Ionizing—Examples include: radioactive materials, x-rays, or high voltage Radio Frequency (RF) equipment.

2) Non-Ionizing—Examples include: electromagnetic interference, RF, or corona.

3) Magnetic—Examples include: permanent magnets and electromagnetic devices.

4) Nuclear Particles—Examples include: ion/electron beams or radioactive materials.

5) Laser Light—For example: high energy laser beams and accompanying energy forms such as heat.

6) Fissile Material—Examples include uranium-233, uranium-235 and plutonium-239.

B. Applicability to Functional Area of Design:

1) Are radiation/magnetic/electrical energy sources present external to the waste form? Is fissile material present?

2) Is a mechanism present to release radioactive/magnetic/electrical energy?

3) Can the release of radiation/magnetic/electrical energy interact with the waste form? Can fissile material be arranged in a such a manner as to result in criticality?

7.3.6 Thermal (also see Fire above)

A. Categories:

1) Heat—This category accommodates any heat energy source with sufficient energy to have an impact on the waste form.

B. Applicability to Functional Area of Design:

1) Are external heat energy sources present?

2) Can heat energy be released?

3) Can the heat energy affect the waste form?

7.4 EVALUATION OF THE APPLICABILITY OF GENERIC EVENTS TO MGR FUNCTIONAL AREAS

7.4.1 Waste Receipt and Carrier/Cask Transport

Area Description: Transportation casks containing SNF and HLW and associated carriers are received at the repository waste entry point or security gate. The SNF and HLW is contained in casks equipped with impact limiters and personnel barriers. At the security gate, the cask carrier and offsite prime mover are inspected for contraband, sabotage and radioactive contamination. Following inspection, the offsite prime mover is decoupled and an onsite diesel-driven prime mover is used to transport the carrier/cask to the Carrier Preparation Building (CPB). Following carrier/cask preparation in the CPB, the system moves the carrier/cask to the carrier bay of the Waste Handing Building (WHB) for cask unloading.

This functional area is located on the surface at the north portal and consists of security inspection and radiation monitoring equipment, required road and rail systems, and onsite prime movers. The system also transports empty transportation casks and associated carriers from the WHB to the CPB for preparation and on to the repository security gate for dispatch from the site.

Generic Events Applicability:

Collision/Crushing: Yes
Chemical Contamination/Flooding: None identified
Explosion/Implosion: None identified
Fire: Yes - diesel fuel fire
Radiation/Magnetic/Electrical/Fissile: Yes - Radiation, Fissile
Thermal: Yes - see Fire

Reference: CRWMS M&O 1999b, CRWMS M&O 1997a, CRWMS M&O 1997b, Jackson et al. 1983, MacDougall et al. 1987, Hartman and Miller 1991

Preliminary Events:

Collision/Crushing: cask collision, railcar derailment involving transportation cask, overturning of truck trailer involving transportation cask

Fire, Thermal: diesel fuel fire

Radiation: radiation exposure of facility worker

Fissile: criticality associated with cask collision, railcar derailment, or overturned truck trailer and rearrangement of cask internals

7.4.2 Carrier Preparation

Area Description: Transportation casks containing SNF and HLW and associated carriers are delivered to the CPB by the onsite diesel-driven prime mover. Within the CPB, the carrier/cask is prepared for entering the carrier bay of the WHB. The primary operations include:

- Measure external carrier/cask radiation levels
- Remove/retract personnel barriers
- Inspect carrier/cask for radiation contamination
- Measure external cask temperature
- Remove/retract impact limiters

The CPB material handling system also functions to prepare empty carrier/casks for dispatch from the MGR. Specifically the carrier/cask is inspected for radiation contamination and the

impact limiters and personnel barriers are installed. The empty carrier/cask is removed from the CPB for dispatch by the off-site prime mover. The system performs these functions utilizing remotely operated cranes and manipulators, however, some local operator actions may be required.

Generic Events Applicability:

Collision/Crushing: Yes
Chemical Contamination/Flooding: None identified
Explosion/Implosion: None identified
Fire: Yes
Radiation/Magnetic/Electrical/Fissile: Yes, Radiation/Fissile
Thermal: Yes, see Fire

Reference: CRWMS M&O 1999b, CRWMS M&O 1998c, CRWMS M&O 1998d, CRWMS M&O 1997a, CRWMS M&O 1997c, Jackson et al. 1983, MacDougall et al. 1987, Hartman and Miller 1991

Preliminary Events:

Collision/Crushing: handling equipment drops on transportation cask, cask collision

Fire, Thermal: diesel fuel fire

Radiation: radiation exposure of facility worker

Fissile: criticality associated with cask collision and rearrangement of cask internals

7.4.3 Waste Handling - Carrier Bay

Loaded transportation casks and associated carriers are transported from the CPB to the WHB carrier bay by the onsite diesel-driven prime mover (rail and road). Incoming carrier/casks are prepared for waste removal by upending the cask on the carrier, lifting the cask from the carrier and lowering the cask onto a cask transfer cart. The system also functions to load empty transportation casks and non-disposable canisters onto carriers for shipment from the repository. The system performs these functions utilizing remotely operated cranes and manipulators, however, some local operator actions may be required.

Generic Events Applicability:

Collision/Crushing: Yes
Chemical Contamination/Flooding: None identified
Explosion/Implosion: None identified
Fire: Yes

Radiation/Magnetic/Electrical/Fissile: Yes, Radiation/Fissile
Thermal: Yes, see Fire

Reference: CRWMS M&O 1999b, CRWMS M&O 1998e, CRWMS M&O 1998f, CRWMS M&O 1997a, CRWMS M&O 1997d, Jackson et al. 1983, MacDougall et al. 1987, Hartman and Miller 1991

Preliminary Events:

Collision/Crushing: transportation cask drop, transportation cask slap down, cask collision, isolation door closes on transportation cask, handling equipment drops on transportation cask

Fire, Thermal: diesel fuel fire

Radiation: radiation exposure of facility worker

Fissile: criticality associated with cask collision/drop and rearrangement of cask internals

7.4.4 Waste Handling - Canister Transfer

Transportation casks containing large and small disposable canisters are transferred from the carrier bay to the canister transfer area by means of cask transfer carts. In the canister transfer area, canisters are unloaded from casks, stored as required, and loaded into disposal containers (DC). Empty casks are also prepared for shipment from the MGR. Cask unloading begins with cask inspection, sampling, and lid bolt removal operations. The cask lids are removed and the canisters are unloaded. Small canisters are loaded directly into a DC, or are stored until enough canisters are available to fill a DC. Large canisters are loaded directly into a DC. Transportation casks and related components are decontaminated as required, and empty casks are prepared for shipment from the site.

Two independent and remotely operated canister transfer lines are provided in the WHB. The lines are operated independently to handle disposable canisters and load them into disposal canisters (DCs). Each canister transfer line contains an airlock, cask preparation and decontamination area, and a canister transfer cell. Each cask preparation and decontamination area includes a cask preparation station and a cask decontamination station. Remote handling equipment consists of cask transfer carts, cask preparation manipulators, and equipment required to perform sampling, cask unbolting, lid removal and decontamination. The canister transfer cells include a canister transfer station and DC transfer cart supported by remote handling equipment including a bridge crane (sized to handle the largest canisters), DC loading manipulator, and an array of large/small canister lifting fixtures. A canister staging rack is provided for the accumulation of small canisters in a shielded area.

Generic Events Applicability:

Collision/Crushing: Yes
Chemical Contamination/Flooding: None identified
Explosion/Implosion: None identified
Fire: None identified
Radiation/Magnetic/Electrical/Fissile: Yes, Radiation/Fissile
Thermal: None identified

Reference: CRWMS M&O 1999b, CRWMS M&O 1998e, CRWMS M&O 1998g, CRWMS M&O 1997a, CRWMS M&O 1997j, CRWMS M&O 1997k, Jackson et al. 1983, MacDougall et al. 1987, Hartman and Miller 1991

Preliminary Events:

Collision/Crushing: transportation cask slapdown, DC slapdown, canister drop, canister slap down, canister collision, canister drops onto DC, canister drop on sharp object, canister drop onto another canister at small canister staging rack, shield door closes on transportation cask, shield door closes on DC, handling equipment drops on transportation cask, canister or DC

Radiation: radiation exposure of facility worker

Fissile: criticality associated with small canister staging rack, criticality associated with collision or drop of cask/canister and rearrangement of container internals

7.4.5 Waste Handling - Assembly Transfer

Area Description: Transportation casks containing uncanistered spent fuel assemblies (SFAs) or Dual Purpose Canisters (DPC) are transferred from the carrier bay to the assembly transfer area by means of cask transfer carts. Casks are lifted from the transfer cart and placed into a cask preparation pit. The cask interiors are sampled for radioactivity, vented, cooled down with compressed gas and then filled with water. The cask lid bolts are then detensioned and removed. The cask is lifted and placed in the cask unload pool, where the cask lid is removed and the assemblies are removed and placed directly into a transfer cart or a staging rack. Assemblies contained in a DPC involve the additional steps of removing the DPC from the cask and DPC opening prior to assembly removal. Following assembly removal, empty transportation casks and dual-purpose canisters (DPCs) are removed from the pool and prepared for dispatch from the repository site.

Following removal from the cask/DPC, the SFAs are transferred to the assembly cell (either directly or from the staging rack) by an inclined transfer cart. In the assembly cell, the SFAs are placed in the assembly drying station for water removal and then transferred to Disposal

Containers (DC). The DC is then fitted with a temporary seal, decontaminated, evacuated and backfilled with nitrogen and moved to the DC cell for lid welding.

The system utilizes remotely operated equipment to perform these functions including, a bare fuel assembly transfer machine, fuel assembly grapples, container transfer carts, contamination barriers, inspection instruments, and low level waste removal subsystems.

Generic Events Applicability:

Collision/Crushing: Yes
Chemical Contamination/Flooding: Yes, Flooding
Explosion/Implosion: None identified
Fire: Yes
Radiation/Magnetic/Electrical/Fissile: Yes, Radiation/Fissile
Thermal: Yes

Reference: CRWMS M&O 1999b, CRWMS M&O 1998e, CRWMS M&O 1998h, CRWMS M&O 1997a, CRWMS M&O 1997e, CRWMS M&O 1997f, CRWMS M&O 1997g, CRWMS M&O 1997h, CRWMS M&O 1997i, Jackson et al. 1983, MacDougall et al. 1987, Hartman and Miller 1991

Preliminary Events:

Collision/Crushing: transportation cask drop, transportation cask slap down, cask collision, spent fuel assembly (SFA) drop onto pool floor, SFA drop onto SFA staging rack, SFA drop onto assembly cell floor, SFA drop onto assembly dryer, SFA drop onto DC, SFA collision, loaded SNF assembly basket drop onto pool floor, loaded SNF assembly basket drop onto SFA staging rack, loaded SNF assembly basket drop onto assembly cell floor, loaded SNF assembly basket drop onto assembly dryer, loaded SNF assembly basket collision, uncontrolled descent of loaded incline basket transfer cart

Flooding: uncontrolled pool water draindown/fill resulting in flooding

Fire, Thermal: SNF overheating due to loss of pool water resulting in excessive clad temperature and possible zircalloy cladding fire, SNF overheating in an assembly transfer basket or dryer resulting in excessive clad temperature and possible zircalloy cladding fire

Radiation: uncontrolled pool water draindown/fill resulting in flooding and radioactive contamination of adjoining WHB areas, increased radiation levels in the assembly transfer area and potential uncovering of fuel assemblies, radiation exposure of facility worker

Fissile: criticality associated with cask collision/drop and rearrangement of cask internals, criticality associated with SFA staging rack, criticality associated with misload of assembly dryer, criticality associated with misload of disposal container

7.4.6 Waste Handling - Disposal Container Handling and Waste Package Remediation

Area Description: Within the DC handling area, empty DCs are prepared for loading, DCs are transferred to and from the assembly and canister transfer systems, the DC lids are welded, and waste packages (WPs) are temporarily stored. WPs are also loaded into the waste package transporter and transferred to and from the waste package remediation system. DCs consist of the container barriers, spacing structures or baskets, shielding integral to the container and packing contained with the container. The WP consists of the DC and waste form(s) after the outer lid welds are completed and accepted.

The process begins with empty disposal container preparation, which includes staging the DCs, installing collars, tilting the DC upright and outfitting the container, and transferring it to DC transfer operations. DC transfer operations include staging DC lids for the weld stations, and transferring the DCs to/from the assembly or canister transfer systems for loading/welding. The DC welding operation receives loaded DCs directly from the waste handling lines or from interim lag storage for welding. The welding operations include mounting the DC on a turntable, removing lid seals, and installing and welding the inner and outer lids. The weld process for each lid includes non-destructive examination. Following examination and weld acceptance, the container is called a waste package and is either staged or transferred to a tilting station. At the tilting station, the WP is tilted to horizontal, the collars are removed, and the WP is transferred to WP transporter loading operations. The WP transporter loading operations include survey and decontamination, and lifting and loading the WP into the waste package transporter. DCs that do not meet the welding examination criteria are transferred to the waste package remediation system for inspection or repair.

The DC handling area is contained within the WHB and includes areas for empty DC preparation, welding, staging, loaded WP staging, WP transporter loading, and the associated operating galleries and required equipment maintenance areas. The empty DC preparation area is located in an unshielded structure.

Disposal container handling equipment includes a DC/WP bridge crane, tilting station, and transfer carts. The welding area includes DC/WP welders, staging stations, and a tilting station. Welding operations are supported by remotely operated equipment including transfer carts, a bridge crane and hoists, welder jib cranes, welding turntables, and manipulators. WP transfer includes a transfer/decontamination and transporter load area. The operations are supported by a remotely operated horizontal lifting system, decontamination system, decontamination and inspection manipulator, and a WP horizontal transfer cart. All handling operations are supported by a suite of fixtures including yokes, lift beams, and lid attachments. Remote equipment is designed to facilitate decontamination and maintenance, and interchangeable components are provided where appropriate. Set-aside areas are included as required for fixtures and tooling to

support off-normal and recovery operations. Semi-automatic, manual, and backup control methods support normal, maintenance, and recovery operations.

Generic Events Applicability:

Collision/Crushing: Yes
Chemical Contamination/Flooding: None identified
Explosion/Implosion: None identified
Fire: Yes
Radiation/Magnetic/Electrical/Fissile: Yes, Radiation/Fissile
Thermal: Yes

Reference: CRWMS M&O 1999b, CRWMS M&O 1998e, CRWMS M&O 1998i, CRWMS M&O 1998j, CRWMS M&O 1997a, CRWMS M&O 1997l, CRWMS M&O 1997m, CRWMS M&O 1997n, CRWMS M&O 1997o, Jackson et al. 1983, MacDougall et al. 1987, Hartman and Miller 1991

Preliminary Events:

Collision/Crushing: WP drop, WP slap down, WP drop onto sharp object, WP collision, equipment drops onto WP, DC drop, DC slap down, DC drop onto sharp object, DC collision, handling equipment drops on DC

Fire, Thermal: fuel damage by burn through during welding process, SNF overheating in a DC resulting in excessive clad temperature and possible zircalloy cladding fire

Radiation: radiation exposure of facility worker

Fissile: criticality associated with the DC/WP staging area, criticality associated with collision or drop of DC/WP and rearrangement of container internals

7.4.7 Subsurface Transport, Emplacement, and Monitoring

Area Description: The waste emplacement system transports the loaded and sealed WP from the WHB to the subsurface emplacement area. This system operates on the surface between the north portal and the WHB, and in the underground ramps, access mains, and emplacement drifts. This system accepts the WP onto a reusable rail car, moves the WP into the shielded transporter, transports the WP to the emplacement area, and emplaces the WP in the emplacement drift. The operation cycle is completed when the transport equipment returns to the surface WHB to receive another WP.

Major items and sub-systems of the waste emplacement system consist of the following:

- A shielded transporter with a reusable rail car for the movement and transfer of the WPs. The transporter requires transport locomotives for movement.

- Transport locomotives for the transporter movement and control functions between the WHB and the subsurface repository.

- A remotely controlled emplacement gantry for the WP emplacement functions in the emplacement drifts. The gantry is self-powered through a direct current third rail system.

- A gantry carrier for gantry transfer between the emplacement drifts and/or to the maintenance facilities. The gantry carrier requires a transport locomotive for the carrier movement and control functions.

The sequence of the subsurface WP handling process is as follows.

The WP, positioned on a reusable rail car, is moved into the shielded transporter at the WHB. A remotely controlled loading mechanism moves the rail car into and out of the transporter. The loading mechanism will be an integral part of the transporter.

A pair of transport locomotives is used to move the transporter from the WHB, into and down the north ramp, into the east or west main, and to the vicinity of the designated emplacement drift. At the pre-selected emplacement drift location, one locomotive is uncoupled to allow the transporter, with the transporter doors facing the drift entrance, to be pushed into the emplacement drift turnout. Before the transporter is pushed into the turnout, the locomotive operators leave the locomotive, and the following functions of the emplacement sequence are performed remotely. Once the transporter is partway in the turnout, the transporter doors and the drift isolation doors open remotely, then the transporter is pushed into contact with the subsurface emplacement transportation system drift transfer dock.

Once the transporter is docked, the unloading mechanism moves the reusable rail car with the WP out of the transporter and onto the rails located on the transfer dock. The emplacement gantry moves into position over the WP, it engages the WP by the skirts at both ends, and raises the WP off the reusable rail car. The gantry carries the WP into the emplacement drift, stopping at a pre-determined emplacement position. The WP is lowered onto permanently installed pedestals. The gantry disengages from the WP and moves back to its waiting position at the transfer dock. These operations are reversible to support moving an emplaced WP to another location.

The transporter retracts the reusable rail car, and is pulled away from the drift entrance doors by a locomotive. The transporter doors and the drift doors are then closed, and the transporter returns to the surface WHB for another transport and emplacement operation. The transporter may also

receive a WP onto the reusable rail car from the emplacement gantry to support moving the WP to another emplacement drift or to the surface WHB.

Following emplacement, the WPs are monitored between the time the WP is emplaced and the time the repository is closed. Concurrent with the emplacement and monitoring of WPs, construction is underway on the development of additional emplacement drifts. Physical separation of emplacement and development activities is provided by isolation air locks. When a predetermined number of newly excavated emplacement drifts are ready for waste emplacement, the isolation airlocks are moved to include the newly developed drifts in the emplacement area.

Generic Events Applicability:

Collision/Crushing: Yes
Chemical Contamination/Flooding: Yes, Flooding
Explosion/Implosion: No
Fire: Yes
Radiation/Magnetic/Electrical/Fissile: Yes, Radiation/Fissile
Thermal: Yes, see Fire

Reference: CRWMS M&O 1999b, CRWMS M&O 1998k, CRWMS M&O 1998l, CRWMS M&O 1998m, CRWMS M&O 1998n, CRWMS M&O 1997m, Jackson et al. 1983, MacDougall et al. 1987, Hartman and Miller 1991, Ma et al. 1992, Schelling and Smith 1993

Preliminary Events:

Collision/Crushing: transporter derailment outdoors, transporter derailment in ramp or main drift, transporter collision with other stationary or moving equipment, WP reusable rail car rolls out of transporter, runaway transporter, rockfall onto transporter, loaded emplacement gantry derailment, WP drop from emplacement gantry, WP/emplacement gantry collision with equipment or another WP, rockfall onto WP, steel set drop onto WP, failure of isolation air locks due to rockfall, equipment collision, or other impacts as a result of development operations

Flooding: flooding from water pipe break originating on development or emplacement sides

Fire, Thermal: fire associated with WP transporter/locomotive or development equipment

Radiation: radiation exposure of facility worker, early or juvenile WP failure and resultant release of radioactive material

Fissile: criticality associated with collision or drop of WP and rearrangement of package internals

7.4.8 Site-Generated Waste Treatment - Liquid Low-Level Radioactive Waste

Area Description: Liquid low-level radioactive wastes (LLW) are piped to the waste treatment building for processing. Liquid waste is treated by filtration, evaporation and ion exchange. Water meeting the requirements for reuse is recovered. Following pH adjustment, non-recyclable liquid is solidified and packaged in drums. The drums are temporarily stored awaiting offsite shipment for disposal.

Generic Events Applicability:

Collision/Crushing: Yes
Chemical Contamination/Flooding: Yes, Flooding
Explosion/Implosion: None identified
Fire: None identified
Radiation/Magnetic/Electrical/Fissile: Yes, Radiation
Thermal: None identified

Reference: CRWMS M&O 1999b, CRWMS M&O 1998o, CRWMS M&O 1998p, CRWMS M&O 1997p - z

Preliminary Events:

Collision/Crushing: handling equipment drops on liquid LLW

Flooding: uncontrolled release of liquid LLW

Radiation: operator exposure to radioactive material.

7.4.9 Site-Generated Waste Treatment - Solid Low-Level Radioactive Waste

Area Description: Solid LLW is shipped to the waste treatment building in drums. The waste consists of combustible and noncombustible job control waste (e.g., protective clothing, rags, wood), ion exchange resin and discarded tools and equipment The waste is treated by shredding, size reduction, compaction, or dewatering as applicable, packaged in drums with a solidification agent and temporarily stored awaiting offsite shipment for disposal.

Generic Events Applicability:

Collision/Crushing: Yes
Chemical Contamination/Flooding: None identified
Explosion/Implosion: None identified
Fire: Yes
Radiation/Magnetic/Electrical/Fissile: Yes, Radiation
Thermal: Yes - see Fire

Reference: CRWMS M&O 1999b, CRWMS M&O 1998o, CRWMS M&O 1998p, CRWMS M&O 1997aa - hh

Preliminary Events:

Collision/Crushing: solid LLW drop, handling equipment drops on solid LLW

Fire, Thermal: fire involving combustible low-level waste

Radiation: operator exposure to radioactive material

8. CONCLUSIONS

This analysis determines preliminary internal MGR events based upon the best available MGR design information. As the MGR design progresses, this analysis will be used as a basis for future hazards analysis performed to identify changes in the hazards posed by the facility and the introduction of new hazards. The results of this analysis are used as input to MGR design basis event selection process. A summary of the preliminary internal events identified for each MGR functional area is provided in the following sections.

8.1 WASTE RECEIPT AND CARRIER/CASK TRANSPORT

Collision/Crushing: cask collision, railcar derailment involving transportation cask, overturning of truck trailer involving transportation cask

Fire, Thermal: diesel fuel fire

Radiation: radiation exposure of facility worker

Fissile: criticality associated with cask collision, railcar derailment, or overturned truck trailer and rearrangement of cask internals

8.2 CARRIER PREPARATION

Collision/Crushing: handling equipment drops on transportation cask, cask collision

Fire, Thermal: diesel fuel fire

Radiation: radiation exposure of facility worker

Fissile: criticality associated with cask collision and rearrangement of cask internals

8.3 WASTE HANDLING - CARRIER BAY

Collision/Crushing: transportation cask drop, transportation cask slap down, cask collision, isolation door closes on transportation cask, handling equipment drops on transportation cask

Fire, Thermal: diesel fuel fire

Radiation: radiation exposure of facility worker

Fissile: criticality associated with cask collision/drop and rearrangement of cask internals

8.4 WASTE HANDLING - CANISTER TRANSFER

Collision/Crushing: transportation cask slapdown, DC slapdown, canister drop, canister slap down, canister collision, canister drops onto DC, canister drop on sharp object, canister drop onto another canister at small canister staging rack, shield door closes on transportation cask, shield door closes on DC, handling equipment drops on transportation cask, canister or DC

Radiation: radiation exposure of facility worker

Fissile: criticality associated with small canister staging rack, criticality associated with collision or drop of cask/canister and rearrangement of container internals

8.5 WASTE HANDLING - ASSEMBLY TRANSFER

Collision/Crushing: transportation cask drop, transportation cask slap down, cask collision, SFA drop onto pool floor, SFA drop onto SFA staging rack, SFA drop onto assembly cell floor, SFA drop onto assembly dryer, SFA drop onto DC, SFA collision, loaded SNF assembly basket drop onto pool floor, loaded SNF assembly basket drop onto SFA staging rack, loaded SNF assembly basket drop onto assembly cell floor, loaded SNF assembly basket drop onto assembly dryer, loaded SNF assembly basket collision, uncontrolled descent of loaded incline basket transfer cart

Flooding: uncontrolled pool water draindown/fill resulting in flooding

Fire, Thermal: SNF overheating due to loss of pool water resulting in excessive clad temperature and possible zircalloy cladding fire, SNF overheating in an assembly transfer basket or dryer resulting in excessive clad temperature and possible zircalloy cladding fire

Radiation: uncontrolled pool water draindown/fill resulting in flooding and radioactive contamination of adjoining WHB areas, increased radiation levels in the assembly transfer area and potential uncovering of fuel assemblies, radiation exposure of facility worker

Fissile: criticality associated with cask collision/drop and rearrangement of cask internals, criticality associated with SFA staging rack, criticality associated with misload of assembly dryer, criticality associated with misload of disposal container

8.6 WASTE HANDLING - DISPOSAL CONTAINER HANDLING AND WASTE PACKAGE REMEDIATION

Collision/Crushing: WP drop, WP slap down, WP drop onto sharp object, WP collision, equipment drops onto WP, DC drop, DC slap down, DC drop onto sharp object, DC collision, handling equipment drops on DC

Fire, Thermal: fuel damage by burn through during welding process, SNF overheating in a DC resulting in excessive clad temperature and possible zircalloy cladding fire

Radiation: radiation exposure of facility worker

Fissile: criticality associated with the DC/WP staging area, criticality associated with collision or drop of DC/WP and rearrangement of container internals

8.7 SUBSURFACE TRANSPORT, EMPLACEMENT, AND MONITORING

Collision/Crushing: transporter derailment outdoors, transporter derailment in ramp or main drift, transporter collision with other stationary or moving equipment, WP reusable rail car rolls out of transporter, runaway transporter, rockfall onto transporter, loaded emplacement gantry derailment, WP drop from emplacement gantry, WP/emplacement gantry collision with equipment or another WP, rockfall onto WP, steel set drop onto WP, failure of isolation air locks due to rockfall, equipment collision, or other impacts as a result of development operations

Flooding: flooding from water pipe break originating on development or emplacement sides

Fire, Thermal: fire associated with WP transporter/locomotive or development equipment

Radiation: radiation exposure of facility worker, early or juvenile WP failure and resultant release of radioactive material

Fissile: criticality associated with collision or drop of WP and rearrangement of package internals

8.8 SITE-GENERATED WASTE TREATMENT - LIQUID LOW-LEVEL RADIOACTIVE WASTE

Collision/Crushing: handling equipment drops on liquid LLW

Flooding: uncontrolled release of liquid LLW

Radiation: operator exposure to radioactive material.

8.9 SITE-GENERATED WASTE TREATMENT - SOLID LOW-LEVEL RADIOACTIVE WASTE

Collision/Crushing: solid LLW drop, handling equipment drops on solid LLW

Fire, Thermal: fire involving combustible low-level waste

Radiation: operator exposure to radioactive material

9. ATTACHMENTS

Attachment I Acronym List

Attachment II MGR Design Configuration and Operation

Attachment I Acronym List

CFR	Code of Federal Regulations
CPB	Carrier Preparation Building
CRWMS	Civilian Radioactive Waste Management System
DBE	Design Basis Event
DC	Disposal Container
DOE	U. S. Department of Energy
DPC	Dual-Purpose Canister
HLW	High-Level Waste
LLW	Low-Level Waste
MFD	Mechanical Flow Diagram
MGDS	Mined Geologic Dispoal System
MGR	Monitored Geologic Repository
M&O	Management and Operating Contractor
NRC	U. S. Nuclear Regulatory Commission
PFD	Process Flow Diagram
QAP	Quality Administrative Procedure
RD	Requirements Document
RF	Radio Frequency
SDD	System Description Document
SFA	Spent Fuel Assembly
SNF	Spent Nuclear Fuel
SSC	Structures, Systems, and Components
WHB	Waste Handling Building
WP	Waste Package
WTB	Waste Treatment Building
YMP	Yucca Mountain Site Characterization Project

Attachment II MGR Design Configuration and Operation

Document	Reference
System Description Documents	
Carrier Preparation Building System	CRWMS M&O 1998c
Carrier Preparation Building Materials Handling System	CRWMS M&O 1998d
Waste Handling Building System	CRWMS M&O 1998e
Carrier/Cask Handling System	CRWMS M&O 1998f
Canister Transfer System	CRWMS M&O 1998g
Assembly Transfer System	CRWMS M&O 1998h
Waste Package Remediation System	CRWMS M&O 1998i
Disposal Container Handling System	CRWMS M&O 1998j
Waste Emplacement System	CRWMS M&O 1998k
Subsurface Facility System	CRWMS M&O 1998l
Ground Control System	CRWMS M&O 1998m
Waste Retrieval System	CRWMS M&O 1998n
Waste Treatment Building System	CRWMS M&O 1998o
Site-Generated Radioactive Waste Handling System	CRWMS M&O 1998p
Mechanical Flow Diagrams	
MFD - Waste Handling Overview	CRWMS M&O 1997a
MFD - Carrier/Cask Transport System	CRWMS M&O 1997b
MFD - CPB Material Handling System	CRWMS M&O 1997c
MFD - Carrier/Cask Handling System	CRWMS M&O 1997d
MFD - Assembly Transfer System (Assembly Cask Unloading)	CRWMS M&O 1997e
MFD - Assembly Transfer System (DPC Unloading)	CRWMS M&O 1997f
MFD - Assembly Transfer System (Empty Cask Shipping)	CRWMS M&O 1997g
MFD - Assembly Transfer System (Empty DPC Shipping)	CRWMS M&O 1997h
MFD - Assembly Transfer System (Staging and Loading)	CRWMS M&O 1997i
MFD - Canister Transfer System (Large Canister)	CRWMS M&O 1997j
MFD - Canister Transfer System (Small Canister)	CRWMS M&O 1997k
MFD - DC Handling System (Welding and Staging)	CRWMS M&O 1997l
MFD - DC Handling System (WP Transfer)	CRWMS M&O 1997m
MFD - Empty DC Preparation	CRWMS M&O 1997n
MFD - Empty DC Transfer	CRWMS M&O 1997o
Process Flow Diagrams	
PFD - Liquid LLW Processing (Collection)	CRWMS M&O 1997p
PFD - Liquid LLW Processing (Filtration)	CRWMS M&O 1997q
PFD - Liquid LLW Processing (Evaporation)	CRWMS M&O 1997r
PFD - Liquid LLW Processing (Ion Exchange)	CRWMS M&O 1997s
PFD - Liquid LLW Processing (Treated Water Storage)	CRWMS M&O 1997t

Attachment II MGR Design Configuration and Operation

Document	Reference
PFD - Liquid LLW Processing (pH Adjustment)	CRWMS M&O 1997u
PFD - Liquid LLW Processing (Filling)	CRWMS M&O 1997v
PFD - Liquid LLW Processing (Grouting)	CRWMS M&O 1997w
PFD - Liquid LLW Processing (Mixing & Shipping)	CRWMS M&O 1997x
PFD - Liquid LLW Processing (WTB Floor Drain Collection)	CRWMS M&O 1997y
PFD - Liquid LLW Processing (Vent Treatment)	CRWMS M&O 1997z
PFD - Solid LLW Processing (Initial Sorting & Size Reduction)	CRWMS M&O 1997aa
PFD - Solid LLW Processing (Resin Filtration)	CRWMS M&O 1997bb
PFD - Solid LLW Processing (Shredding)	CRWMS M&O 1997cc
PFD - Solid LLW Processing (Compaction)	CRWMS M&O 1997dd
PFD - Solid LLW Processing (Cement Supply)	CRWMS M&O 1997ee
PFD - Solid LLW Processing (Grouting & Overpack)	CRWMS M&O 1997ff
PFD - Solid LLW Processing (Staging & Shipping)	CRWMS M&O 1997gg
PFD - Solid LLW Processing (Vent Treating)	CRWMS M&O 1997hh
Other Documents	
Monitored Geologic Repository Concept of Operations	CRWMS M&O 1999b