WESF Modifications Conceptual Design Report (Project W-135)

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2M
P.O. Box 1600
Richland, Washington 99352

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Abbreviations, Acronyms and Terms

ACDR    advanced conceptual design report
ALARA   as low as reasonable achievable
AoA     analysis of alternatives
AWS     automated welding system
CAP     capital asset project
CD      critical decision
CDR     conceptual design report
CHBWV   CH2M HILL BWXT West Valley, LLC
CHPRC   CH2M Plateau Remediation Company
CMAA    Crane Manufacturers Association of America
CSA     Capsule Storage Area
CSP     Capsule Storage Pad
CSS     Cask Storage System
DBI     design basis input
DCM     design compliance matrix
DOE-HQ  U.S. Department of Energy, Headquarters
DOE-RL  U.S. Department of Energy, Richland Operations Office
DTS     Dry Transfer System
EOCI    Electric Overhead Crane Institute
FDC     functional design criteria
FRD     functions and requirements document
GPP     general plant project
GTAW    gas tungsten arc welding
HLW     high-level waste
HLWCRP  High-Level Waste Canister Relocation Project
HVAC    heating, ventilation and air conditioning
KPP     key performance parameter
Lucas   Lucas Engineering and Management Services, Inc
MCSC    Management of the Cesium and Strontium Capsules
MSLD    mass spectrometry leak detection
MSM     master-slave manipulators
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>NAC</td>
<td>NAC International, Inc.</td>
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<tr>
<td>PEP</td>
<td>project execution plan</td>
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<tr>
<td>SCFM</td>
<td>standard cubic feet per minute</td>
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<td>SIP</td>
<td>Shielded Indexer Plate</td>
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<tr>
<td>SSC</td>
<td>structure, system, and component</td>
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<tr>
<td>TSC</td>
<td>Transportable Storage Canister</td>
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<tr>
<td>TSCB</td>
<td>Transportable Storage Canister Basket</td>
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<tr>
<td>UCS</td>
<td>Universal Capsule Sleeve</td>
</tr>
<tr>
<td>VAC</td>
<td>volts AC (alternating current)</td>
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<tr>
<td>VCC</td>
<td>Vertical Concrete Cask</td>
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<tr>
<td>VCT</td>
<td>Vertical Cask Transporter</td>
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<tr>
<td>WESF</td>
<td>Waste Encapsulation and Storage Facility</td>
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<tr>
<td>WVDP</td>
<td>West Valley Demonstration Plant</td>
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Key Definitions

The following general definitions pertain to the Management of the Cesium and Strontium Capsules (MCSC) Project.

**Ancillary equipment:** Includes all associated or related equipment that is required to fully use and handle Cask Storage System (CSS) components supplied for their intended purpose at Waste Encapsulation and Storage Facility (WESF). This includes, but is not limited to, equipment for transfer of the empty Transportable Storage Canister (TSC) into the Vertical Concrete Cask (VCC); a frame or cradle to upend or position an empty Universal Capsule Sleeve (UCS) for loading and/or remote welding, as well as potential remote weld removal; lifting equipment (e.g., yokes, if used, and slings); test equipment for vacuum testing or Helium detection; seismic restraints, if required; and equipment used for component alignment.

Equipment used for component alignment shall also include any solution-specific designed, fabricated, and delivered specialty WESF cover blocks, as allowed in the statement of work and as may be reviewed and approved by CH2M Plateau Remediation Company (CHPRC). The specialty designed cover block ancillary equipment shall conform and comply with applicable requirements of CHPRC-02622, *Cask Storage System (CSS) Functional Design Criteria (Project W-135)*. Ancillary equipment may also include platforms or man-lift equipment necessary to complete VCC loading activities, miscellaneous pumps, hand tools, relief valves, hydrogen detectors, or other items as may be uniquely necessary for the proposed solution technology. Certain common items (e.g. cranes, man-lifts) may be supplied as buyer furnished equipment by CHPRC, as allowed and agreed in the statement of work and/or contract.

**Automated Welding System:** The Automated Welding System (AWS) is used in G Cell to close and seal the UCS following loading of cesium and strontium capsules.

**Capsule Storage Area:** The Capsule Storage Area (CSA) includes the Capsule Storage Pad (CSP) required for storage of the capsules within the VCC, as well as associated fencing, lighting, and road access. The CSA will include a prepared area around the pad sufficient for CSS operations, and surveillance and maintenance operations. This area may be graded, compacted gravel, or concrete depending upon usage and load requirements. The fencing will be used to limit radiological exposure to non-radiological workers from storage system structures, systems, and components (SSCs) and will provide required physical security. The CSA shall include features to address storm water in a manner that does not interfere with the operation of the CSS (e.g. passive cooling).

**Capsule Storage Pad:** The CSP is the concrete foundation upon which the VCC will be placed for interim storage of the capsules. The storage pad is a component of the CSA and CSS. The CSP shall include features to address storm water in a manner that does not interfere with the operation of the CSS (e.g. passive cooling).

**Cask Storage System:** The CSS is the complete system that provides storage of the capsules for the required interim storage period. The CSS includes capsule loading equipment, transfer equipment, storage system components, and ancillary equipment.

**Dry Transfer System:** The Dry Transfer System (DTS) is a shielded bell housing that will be used to transfer the UCS from the G Cell into the designated Transportable Storage Canister Basket (TSCB)/TSC/VCC integrated unit located in the WESF truck port. The DTS is a component of the Ancillary Equipment package.

**Safety class structures, systems, and components:** Safety class SSCs are defined by 10 CFR 830, “Nuclear Safety Management,” as “the structures, systems, or components, including portions of process
systems, whose preventive or mitigative function is necessary to limit radioactive hazardous material exposure to the public, as determined from safety analyses.”

**Safety significant structures, systems and components:** Safety significant SSCs are defined by 10 CFR 830 as “the structures, systems, and components which are not designated as safety class structures, systems, and components, but whose preventive or mitigative function is a major contributor to defense in depth and/or worker safety as determined from safety analyses.”

**Safety structures, systems and components:** Safety SSCs are defined by 10 CFR 830 to mean both safety class and safety significant SSCs.

**Shielded Indexer Plate:** The Shielded Indexer Plate (SIP) is a device that provides a shielded transfer interface between the DTS and the VCC. The SIP is positioned on top of the VCC and maximizes shielding by providing a pass-through within a shielded housing that is rotated to align with the individual tubes of the TSCB.

**Transfer cask:** A component that provides heat removal, shielding, and physical protection during transfer of a loaded TSC into a VCC or from a VCC into a transportation cask. The transfer cask is typically lifted via lifting trunnions and yoke. A transfer cask is not expected to be used for the MCSC Project but it is a component that could be used for future transportation of the TSC offsite for final disposition or as a recovery action.

**Transfer equipment:** Used to move the loaded VCC from WESF to the CSA. It may also be used to move unloaded VCCs. It includes equipment such as trailers, crawlers, or tow vehicles (including any restraint or tie-downs required to move the VCC) and may include tugs, pushers or tractors used to move any trailer or dolly. SSCs used to protect the VCC from environmental conditions once it leaves WESF shall be included. Transfer equipment does not include temporary lifting yokes, slings, and rigging that are considered ancillary equipment (see also Vertical Cask Transporter [VCT]).

**Transportable Storage Canister:** The TSC is designed to fit inside the VCC for storage and the transportation cask for transportation. The TSC houses the empty or UCS loaded TSCB.

**Transportable Storage Canister Basket:** The TSCB is commonly referred to as a basket. It is designed to house multiple UCS and is placed inside the TSC.

**Transportation cask:** A component that provides heat removal, shielding, and physical protection during offsite transfer of a loaded TSC to an alternate offsite location. The transportation cask is typically licensed in accordance with 10 CFR 71, “Packaging and Transportation of Radioactive Material,” for all Nuclear Regulatory Commission-defined transportation accidents for a list of approved contents. A transportation cask is typically lifted with lifting trunnions and yoke. A transportation cask is not expected to be used for the MCSC Project but it is a component that could be used for future transportation of the TSC offsite for final disposition or as a recovery action.

**Universal Capsule Sleeve:** The UCS is designed to hold standard Cesium/Strontium capsules or Type W capsules. It is a metal cylinder used to confine the capsules in a storage system using a canister/overpack design. It is protected from normal, off-normal, and accident conditions by the TSCB/TSC/VCC integrated overpack package.

**Vertical Concrete Cask:** The VCC is the storage overpack that houses the TSC. Once loaded, the VCC will be transferred to the CSA via the Vertical Cask Transporter. The VCC provides radiological shielding and physical protection for the loaded TSC package.
**Vertical Cask Transporter:** The VCT is part of the Transfer Equipment set of SSCs. It is a wheeled, towed hydraulic lift unit designed to lift and carry a VCC over the grade and road conditions existing at the site along the designated haul path. An aircraft gate tractor is typically provided as the prime mover of the VCT for all onsite cask movements. The VCT interfaces with the VCC via two lifting lug sets bolted to the VCC top plate connected by engagement pins to two lift links on the VCT.
1 Introduction

The Management of Cesium and Strontium Capsules (MCSC) Project will fill the capability gap for interim storage of cesium and strontium capsules currently stored underwater at the Waste Encapsulation and Storage Facility (WESF). The scope of the MCSC Project is consistent with DOE/RL-2012-47, Mission Need Statement for the Management of the Cesium and Strontium Capsules (hereinafter called the Mission Need Statement). The MCSC Project is managed by the CH2M Plateau Remediation Company (CHPRC) in compliance with requirements established by the U.S. Department of Energy, Richland Operations Office (DOE-RL) in the Plateau Remediation Contract (DE-AC06-08RL14788, CH2M HILL Plateau Remediation Company Plateau Remediation Contract).

The approach for managing and controlling all activities necessary to successfully execute all responsibilities inherent to the Plateau Remediation Contract are described in the project execution plan (PEP) PRC-MP-MS-19361, CH2M HILL Plateau Remediation Company Project Execution Plan, which has been approved by DOE-RL. The CHPRC PEP describes the CHPRC project management approach, procedures, and methods that comply with DOE O 413.3B, Program and Project Management for the Acquisition of Capital Assets. The MCSC Project is a CHPRC subproject and will be managed in accordance with the CHPRC PEP.

Lucas Engineering and Management Services, Inc. (Lucas) under CHPRC Subcontract 57805 has prepared the conceptual designs for the WESF Modifications and the Capsule Storage Area (CSA) portion of the MCSC Project Capital Asset Project (CAP). This document is the Conceptual Design Report (CDR) for the WESF Modifications portion of the MCSC Project CAP. Section 1.3 of this CDR provides additional details on the execution structure for the MCSC Project and the relationship of the scope of this conceptual design to the other pieces of the MCSC Project CAP. This CDR has been prepared in accordance with the requirements and guidance provided in PRC-STD-EN-40261, Conceptual Design Report.

1.1 Background

From 1974 to 1985, cesium and strontium was removed from the nuclear waste at B Plant and then encapsulated and stored at the WESF (Figure 1-1). Removal of the cesium and strontium from the underground tanks allowed for improved management of the underground tanks, enhanced isolation of the tank waste, and provided an opportunity for beneficial use of the encapsulated cesium and strontium.

WESF is located adjacent to B Plant in the 200-East Area on the Central Plateau of the Hanford Site. The mission of WESF is the safe and compliant storage of 1,936 cesium and strontium capsules. As of June 2017, the capsules contain approximately 90 million curies. This activity includes the short half-life daughter products barium-137m and yttrium-90.

The capsules are stored underwater in pool cells. The WESF is an aging facility that is being operated beyond its design life. The facility relies on active systems for ventilation, maintaining pool cell water levels, and monitoring the capsules. These systems are becoming more expensive and difficult to operate and maintain.
The planning for the final disposal of the capsules has assumed that they would be shipped to a high-level waste repository. The Yucca Mountain Nuclear Waste Repository, as designated by the Nuclear Waste Policy Act of 1982 1987 amendment, was to be the deep geological repository for spent nuclear fuel and other high-level radioactive wastes.

Federal funding for the Yucca Mountain Nuclear Waste Repository ended in 2011 via an amendment to a Department of Defense appropriations action, passed on April 14, 2011. This left the United States without any disposal option for spent nuclear fuel and high-level wastes (HLW). It also left Hanford in a position of not having a disposal pathway for the capsules, and with the need to store the capsules for the foreseeable future.

Recognizing the need for continued storage of the capsules, DOE-RL prepared the Mission Need Statement (DOE/RL-2012-47). The U.S. Department of Energy, Headquarters (DOE-HQ) approved this Mission Need Statement and Critical Decision 0 (CD-0) on November 5, 2015.

The MCSC Project was created to close the capability gaps identified in the Mission Need Statement (DOE/RL-2012-47). The project will close the capability gaps in a manner that:

- Does not eliminate any capsule disposal alternative.
- Considers the future transfer of the capsules from storage to disposal.
- Incorporates the universal canister system concept developed by DOE-RL for disposal of small waste forms.
- Utilizes the experience and technologies used by the commercial nuclear industry for the storage of spent nuclear fuel.

The CHPRC has the overall responsibility for the successful completion of the MCSC Project and will manage the project in accordance with DOE O 413.3B. The CHPRC will maintain the technical baseline, cost baseline and schedule baseline. The CHPRC is responsible for obtaining the necessary environmental permits and nuclear safety approvals.
1.2 Project Need

A Mission Need Statement (DOE/RL-2012-47) and CD-0 has been approved by DOE-HQ in accordance with DOE O 413.3B. The MCSC Project will address the capability gaps identified in the Mission Need Statement. The statement of mission need is as follows:

- The Hanford Site needs to provide safe, compliant, and cost-effective storage of the cesium-137 and strontium-90 capsules. This storage capability will be necessary until a disposal path for the capsules is established and implemented.

- Fulfillment of this mission need will align management of the capsules with site goals for cleanup of the Central Plateau, including safe management of legacy material and long-term stewardship of the site.

DOE-RL is responsible for the safe, compliant, and cost-effective management of the cesium-137 and strontium-90 capsules. The capsules represent a significant portion of the radioactive materials on the Hanford Site. Storage of the capsules is required until final disposal of the capsules is possible.

It has been assumed that the capsules would eventually be disposed in a national HLW repository. With the elimination of funding for the HLW repository in Yucca Mountain, a disposal pathway for the capsules no longer exists.

The need to store the capsules until a disposal pathway is identified and available represents a capability gap. Other factors that contribute to this capability gap include:

- Continued operation of the WESF systems for an extended period of time will result in increased costs as the equipment ages and becomes more difficult to maintain.

- Cleanup of the B Plant Complex cannot proceed until the capsules are removed from the WESF.

- A Beyond Design Basis Accident would result in a significant risk to the Hanford Site workers and the public.

1.3 Project Description

The MCSC Project will provide the necessary capabilities to close the gaps identified in the Mission Need Statement (DOE/RL-2012-47). The project will provide the capabilities necessary to transfer the capsules from the WESF pool cell to a cask storage system (CSS), which will be located in a new CSA. The CSS will safely and compliantly store the 1,936 capsules until a capsule disposal option is available.

The MCSC Project will be managed in accordance with DOE O 413.3B. The tailoring strategy for 413.3B is described in CHPRC-02264, *MCSC Project Execution Plan for the Management of the Cesium and Strontium Capsules (MCSC) Project (W-135)*. The MCSC Project includes a CAP portion and an expense-funded portion. Figure 1-2 is an illustration of what is included in each of these portions of the project.

The CAP portion of the project includes a Line Item and a General Plant Project (GPP). The Line Item will fund the design and construction of the WESF Modifications necessary to transfer the capsules to the CSS and the GPP will fund the design and construction of the CSA.

The expense funded portion of the MCSC Project will provide design and fabrication of the CSS, as well as start-up and readiness activities. The scope of the MCSC Project does not include the actual transfer of the capsules to the CSA.
The scope of the MCSC Project is described in the functions and requirements documents (FRD), CHPRC-02252, Management of the Cesium and Strontium Capsules Project (W-135) Functions and Requirements Document. The project includes the following major activities to successfully transfer the capsules to a new storage capability:

- Design and fabricate a storage capability that can safely, compliantly, and cost-effectively store the capsules until a disposal pathway for the capsules is available.
- Design and construct the equipment necessary to retrieve, load, and transfer the capsules from the WESF pool cells to the storage capability.
- Design and construct a CSA (including storage pad, fencing, lighting, and road access).
- Design and construct the WESF Modifications needed to support capsule retrieval, loading, and transfer to the storage capability.
- Prepare operational procedures, maintenance procedures, and training.
- Perform operational startup readiness activities.
- Prepare required environmental permits and approvals.
- Prepare safety basis documents and obtain DOE-HQ approval.

1.4 MCSC Project Scope
1.5 WESF Modifications Scope

WESF Modifications include the modifications necessary to support the transfer of the capsules to the CSS. The goal of the project is to utilize as many of the existing WESF systems as possible to complete the capsule transfer. The scope of the modifications have been identified during the conceptual design phase of the project. The modifications include items such as: utility services (electrical, air) to the CSS components in G Cell, canyon, and truck port; increased truck port floor loading capacity; modifications to truck port to accommodate the movement and loading of the CSS cask; and helium supply to G Cell and truck port.

This CDR describes the conceptual design for the required WESF Modifications above and includes the following key elements:

- Truck Port.
- Canyon (includes the 15-ton crane).
- G Cell.

1.6 Analysis of Alternatives

An Alternative Analysis report was prepared for the MCSC Project in accordance with the requirements of DOE O 413.3B and the guidance provided in DOE G 413.3-1, Managing Design and Construction Using Systems Engineering for Use with DOE O 413.3A. The Alternative Analysis was developed using a phased and systematic approach that integrated the Analysis of Alternatives (AoA) Best Practices recommended by the U.S. Government Accountability Office (GAO-15-37, DOE and NNSA Project Management Analysis of Alternatives Could Be Improved by Incorporating Best Practices). This Alternative Analysis was based on the mission need to optimize the design solution taking into account safety, cost, schedule, and the use of proven technology.

A Value Engineering approach was used during development of the Alternative Analysis. The results of the analysis, documented in CHPRC-02828, Alternative Analysis for the Management of the Cesium and Strontium Capsules (MCSC) Project (W-135), were a selection of the alternative for a new commercial dry cask storage system as the best and preferred alternative to meet the capability gap identified in the Mission Need Statement (DOE/RL-2012-47).

1.7 Independent Analysis of Alternatives

Recent changes to DOE 413.3B require DOE to conduct an AoA that is independent of the contractor organization responsible for managing the construction or constructing the capital asset project. DOE 413.3B tailoring strategy addresses this requirement in the following manner:

- The MCSC Project has a project history that acknowledges a number of independent alternatives analyses. These analyses were completed prior to the award of the Plateau Remediation Contract. The transfer of the capsules to dry storage was included as scope in the Plateau Remediation Contract on a funding available basis (contract established in 2008). In addition, dry interim storage of the capsules for an extended period was an evaluated case in DOE/EIS-0391, Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS).

- In consideration of the work having been performed, the existing analyses will be used to satisfy the requirement for a project independent AoA, as comprising an equivalent document, in accordance
1.8 Design Reviews and Approvals

A formal design review was performed of the WESF Modifications conceptual design on May 15, 2017, in accordance with the requirements of PRC-PRO-EN-40264, Formal Design Review. The function of this review team was to perform systematic overall review and evaluation of the design by personnel representing affected disciplines. This process involved a detailed review of design media to verify the following:

- Design inputs are adequately defined (including functions, requirements, and design criteria).
- Design meets all defined requirements and parameters.
- Proof in the functional design verification matrix clearly indicates that the design is adequate to confirm that the requirements meet the performance specification.
- Design is sufficient to proceed to construction and startup.

Design acceptance will be documented through an approved report as a controlled, released engineering document according to PRC-PRO-EN-440, Engineering Documentation Preparation and Control. A design review report will be developed, approved, and issued by the MCSC Project’s Engineering Lead.

At each design stage (conceptual, preliminary, final), a single design review will be performed to review the design for the capital asset portion of the project (the CSA and WESF Modifications). A separate design review will be performed for the CSS design. The reviews will be staffed and chaired by CHPRC personnel with DOE-RL participation.

Additional design verification will be performed in the future as components and systems are received and tested prior to placing structures, systems, and components (SSCs) into operation. Receipt inspections will be performed by qualified inspectors on select SSCs in accordance with PRC-PRO-QA-268, Control of Purchased/Acquired Items and Services. Testing of SSCs will be planned, performed, and documented in accordance with PRC-PRO-EN-286, Testing of Equipment and Systems.

Lucas, in conjunction with the development of the WESF Modifications conceptual design, prepared a Design Compliance Matrix (DCM). The DCM summarily lists the requirements from the functional design criteria (FDC) document, CHPRC-03011, WESF Modifications Functional Design Criteria, and describes by reference where and how this requirement is met by the conceptual design. As this is a conceptual design, there are many of the detailed requirements in the FDC that are either not addressed or only partially addressed during this design phase. The DCM identifies those requirements that are not addressed or only partially addressed in this design phase.

2 Design Selection

The conceptual design for the WESF Modifications presented in this CDR has been developed to meet the requirements as defined in the MCSC Project key requirement documents (CHPRC-02252 and CHPRC-03011). In addition to development of a conceptual design that meets the project requirement documents, the WESF Modifications design is needed to meet the technical interface requirements of the CSS, as well as that of multiple CHPRC and other onsite Hanford services organizations.

Finally, the conceptual design integrated several key lessons learned and design features of the recently completed West Valley Demonstration Project (WVD) High-Level Waste Canister Relocation Project
This is a project that employed the same dry cask storage technology that will be used for the MCSC Project to package and provide extended onsite storage of 275 canisters of vitrified HLW. The following sections provide additional details on the key requirements of the FRD and FDC for the WESF Modifications; how the design activities of the CSS and CSA conceptual designs have been integrated with that of the WESF Modifications; how the integration of interfacing with Hanford organizations was met; and how the project design, construction, and operational experience from the WVDP HLWCRP were integrated into the WESF Modifications design.

2.1 Summary of Functions and Requirements Document/Functional Design Criteria

The following sections provide at a summary level the key requirements for the WESF Modifications design as defined in the FRD and FDC.

2.1.1 Functions and Requirements Document

The FRD defines the top-level functional requirements for the MCSC Project, summarized in the following:

- The MCSC Project shall have the capability to transfer all 1,936 capsules from WESF to the CSA within a 52-week period, following successful completion of system startup and readiness review. This includes all activities necessary to retrieve and inspect the capsules, load the capsules into the canisters, close the canisters, transfer the canisters to the CSA, and place the canisters in the storage overpacks at the CSA.

- The process to move canisters out of WESF shall be designed as a clean operation with no contamination external to the package the canisters are in when they leave WESF.

- The MCSC Project shall interface with existing Hanford Site utilities and infrastructure, as needed, to support construction, capsule transfer operations, and long-term storage operations. Existing systems at WESF shall be used to the maximum extent possible to distribute required utilities (e.g., water, electricity, and sanitation).

- WESF Modifications and equipment used within WESF shall have a minimum design life of 5 years or be designed for ease of replacement. All systems and equipment provided shall be designed, to the maximum extent practicable, to provide a minimum 5-year maintenance-free service life.

- The MCSC Project shall be designed to limit occupational radiation exposures in accordance with the requirements of 10 CFR 835, “Occupational Radiation Protection Program,” and CHPRC-00073, CH2M HILL Plateau Remediation Company Radiological Control Manual.

- The MCSC Project shall comply with the requirements of 10 CFR 830, “Nuclear Safety Management” and DOE-STD-1189-2008, Integration of Safety Into the Design Process, as implemented by PRC-PRO-NS-700, Safety Basis Development. The specific strategy that will be used to ensure compliance is described in CHPRC-02236, Waste Encapsulation and Storage Facility Management of Cesium and Strontium Capsules (Project W-135) Safety Design Strategy.

2.1.2 Functional Design Criteria

The FDC, CHPRC-03011, is a subset document to the FRD and provides those lower-level design requirements as they pertain to the scope of the WESF Modifications project.

CHPRC’s Key Performance Parameter (KPP) for the WESF Modifications is “Modify the Waste Encapsulation and Storage Facility (WESF) to allow the installation and operation of a Cask Storage System (CSS). The CSS will provide the capability to load Hanford’s cesium and strontium capsules in a
dry storage cask and transfer the loaded casks to the storage area. This KPP is complete when readiness activities are complete and authorization to begin loading capsules is received.

The key requirements to meet this KPP were established in the WESF Modifications FDC and are summarized in the following sections of this CDR.

Note that the WESF Modifications are to a large extent driven by the CSS vendor equipment to be placed in WESF for loading the capsules for storage. The CSS vendor is currently developing conceptual designs for much of this equipment; therefore, design criteria are not well developed for all WESF Modifications. It is anticipated that the design requirements for the WESF Modifications will be refined as the CSS vendor designs are developed, and that refined requirements will be incorporated into the preliminary design.

The WESF Modifications have been broken into the following three general categories:

- Truck Port.
- Canyon.
- G Cell.

These categories are adhered to throughout this report.

### 2.1.2.1 WESF Truck Port

The main function of the Truck Port for the MCSC Project is to receive and stage Vertical Concrete Casks (VCCs) for loading. VCCs will be moved into and out of the Truck Port using an air pallet.

To this end, the Truck Port floor and the concrete apron outside must be capable of supporting a fully loaded VCC on an air pallet without cracking damage. The Truck Port floor must additionally be capable of sustaining an accidental drop of the Dry Transfer System (DTS) while being handled with the 15-ton Canyon crane onto the top of a VCC staged in the Truck Port.

Floor slope and smoothness are critical parameters for air pallet operations. As a result, appropriate specifications have been placed on the Truck Port floor and apron.

The Truck Port requires a new rollup door following completion of Project W-130. A key function performed by the Truck Port door is control of airflow into the Truck Port during periods when the Truck Port is open to the Canyon.

For the MCSC Project, the Truck Port heating, ventilation, and air conditioning (HVAC) system needs to be capable of maintaining acceptable temperatures with the bounding heat load of a fully-loaded VCC staged in the Truck Port while awaiting transport to the CSA.

Physical interfacing of the VCC and Truck Port requires the removal of certain obstacles that interfere with VCC movement into and out of the Truck Port. The interfering items consist of abandoned piping, fire protection system sprinkler piping, and HVAC ductwork. The necessary piping and fire protection system and HVAC ductwork modifications are discussed in this CDR.

Truck Port utility needs to support MCSC Project operations are driven by the CSS vendor equipment and currently include electrical power and compressed gases (high purity helium). No compressed air or water needs have been identified; the CSS vendor will provide a trailered, diesel-powered air compressor to service the air pallet.

Conceptual design specifics applicable to the Truck Port are discussed in Section 4.1.
2.1.2.2 **WESF Canyon**

The primary function of the WESF Canyon with regard to the MCSC Project is supporting the floor loads imposed by MCSC Project-related equipment that must be staged/stored in the Canyon. The Canyon must allow sufficient storage space for the existing G Cell cover block (to be set aside and replaced with a modified cover block for the duration of MCSC Project operations), the DTS on a DTS stand, and the respective lids of VCC and the Transportable Storage Canister (TSC) that sits inside the VCC. The Canyon also must supply needed utilities, consisting of electrical power and compressed air, to the various MCSC Project equipment.

Meanwhile, the existing 15-ton Canyon crane must be capable of lifting and moving the required MCSC Project loads at the required duty cycle. The primary use of the Canyon crane will be movement of the DTS between G Cell and the Truck Port cover block opening for placement of loaded Universal Capsule Sleeves into the TSC/VCC. The Canyon crane also requires an updated camera system with color and pan-tilt-zoom capabilities to support MCSC Project operations.

The Canyon crane also needs to incorporate new engineered features, controls, and/or administrative controls to address and mitigate drop events. The crane does not meet the single-failure-proof criteria required under DOE requirements (ASME NOG-1, *Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)*), or those typically relied on by the CSS vendor for commercial spent fuel storage applications (NUREG-0554, *Single-Failure-Proof Cranes for Nuclear Power Plants*, and NUREG-0612, *Control of Heavy Loads at Nuclear Power Plants*). The crane will not be upgraded due to the relatively short duration of the end-of-life MCSC Project. Any credible load drops from the crane need to be analyzed for risk and consequences and then mitigated as appropriate.

Conceptual design specifics applicable to the WESF Canyon are discussed in Section 4.2.

2.1.2.3 **WESF G Cell**

Cesium and strontium capsules will be retrieved from the WESF Pool Cell Area into G Cell via the Capsule Transfer Chute, then loaded into Universal Capsule Sleeves (UCS) for movement out of G Cell to the TSC/VCC in the Truck Port. The G Cell floor must be capable of supporting the planned equipment loads without exceeding the floor load rating. G Cell must also provide utilities necessary to support MCSC Project operations, including electrical power and instrumentation connections and compressed gas (argon and helium) through cell wall penetrations. The G Cell HVAC system also needs to handle the heat load imposed by MCSC Project operations along with the existing incandescent lighting heat load. It will be necessary to cool the G Cell incoming air from the Canyon to manage the project heat loads.

Existing G Cell equipment that is capable of supporting MCSC Project operations without modification includes the in-cell hoist, the master-slave manipulators (MSMs), and the Capsule Transfer Chute from the Pool Cell Area.

Conceptual design specifics applicable to G Cell are discussed in Section 4.3.

2.2 **Design Integration**

The three primary elements of the MCSC Project; CSS, WESF Modifications, and the CSA; must be integrated technically. An additional complexity to this integration is that the CSS is being designed by NAC International, Inc. (NAC), while the conceptual designs for the CSA and WESF Modifications are being designed by Lucas. Integration and management of the design interfaces began with the development of the project FRD and three FDCs (one each for the CSS, WESF Modifications, and the
CSA). Lucas provided lead authorship on these four project requirements documents. In addition, Lucas has taken the lead for managing the lower-level integration of the three design efforts. The CSS design drives the conceptual designs for the CSA and the WESF Modifications. Lucas has participated in regular interfaces with NAC during development of the CSS conceptual design. Lucas has also participated in design reviews of the NAC design products.

Design Basis Input (DBI) matrices were developed for both the CSA and WESF Mods designs to capture and manage the design interfaces (see Appendix A). The DBI documents the technical inputs used to develop the conceptual design to meet functional requirements. Following are a few key examples of inputs from the CSS contractor to the WESF Modifications (note that CSS inputs to WESF modification are not limited to this short list):

- Size and weight of the VCC for the WESF Truck Port modifications design.
- Truck Port floor smoothness and finish requirements for air pallet operations.
- Utility requirements for the installed CSS components in WESF.
- Heat loads generated by the capsule loading operations in WESF for consideration in any WESF HVAC modifications that may be required.

These inputs and many others have evolved throughout the conceptual design process. The DBI matrix identifies the required design inputs, points out those that were ultimately utilized in the design, and denotes the respective input sources. The DBI also identifies any areas of uncertainty or risk regarding inputs that will require further confirmation or refinement at later design stages.

In addition to technical inputs from the CSS design contractor, the design of the WESF Modifications required technical integration and inputs from multiple on-site organizations. The key on-site technical interfaces for the WESF Modifications were:

- WESF Operations.
- CHPRC Projects, Engineering, and Nuclear Safety organizations.

The required inputs from these organizations that were utilized in the conceptual design of the WESF Modifications are likewise captured and documented in the WESF Modifications DBI.

It is important to note that much of the design input data was provided in the February through April 2017, time frame. As a result, these inputs may not be aligned with those currently in use by the CSS vendor. In many cases, more conservative initial inputs have been retained to ensure that the WESF Modifications conceptual design will ultimately bound the MCSC Project requirements.

### 2.3 WVDP HLW Relocation Project Lessons Learned Integration

A valuable source of input to the conceptual design for the MCSC Project has been the WVDP HLWCRP. The HLWCRP removed 275 canisters of vitrified HLW, 2 evacuated canisters, and 1 debris canister that were being stored in the site’s Main Plant Process Building and relocated them to a new on-site HLW Canister Interim Storage Facility. The relevancy of this project to the MCSC Project is that West Valley utilized a very similar commercial dry cask storage system supplied by NAC, who is also the CSS vendor for the MCSC Project.

The HLWCRP was completed in November 2016 with the placement of the last HLW canister on the storage pad. CH2M HILL BWXT West Valley (CHBWV) is the site prime contractor at the WVDP site. During the conceptual design for the MCSC Project, there have been multiple exchanges of information between the CHPRC MCSC project team and CHBWV HLWCRP team. This information has included
design and construction information, cost information, and operational inputs. Design information, as well as cost information, have been integrated in the design input basis for multiple aspects of the CSA conceptual design.

The MCSC Project is currently planning on re-utilizing the WVDP HLWCRP Vertical Cask Transporter (VCT) and its associated tug (Figure 2-1) for use on the MCSC Project for transfer of the loaded VCCs to the CSA. CHBWV has provided design and specification information on the VCT and tug to the MCSC Project team for use in the development of this conceptual design. For the WESF Modifications conceptual design, this input was utilized in the design of the apron area outside of the WESF truck port where the empty VCCs are brought to WESF to be loaded, and the loaded VCCs are picked up to be transferred to the CSA.

In addition, the MCSC Project is planning on utilizing an air pallet system to move the VCCs within the truck port. The HLWCRP also used an air pallet to move their VCCs. Inputs from the West Valley project on the operational requirements and characteristics of the air pallet were valuable in the design of the modifications to the truck port floor and its surface finish. Where and how inputs from the HLWCRP project were utilized in the conceptual design of the CSA are cited in this report and in the WESF Modifications DBI matrix.

2.4 Design Options

As discussed in Section 1.6 of this report, the primary analysis of alternatives for the MCSC Project was completed in 2015 with the selection of a commercial dry cask storage system as the option for extended storage of the cesium and strontium capsules. The selection of a CSS provided by NAC was completed in 2016 through a competitive procurement process. The design options examined during conceptual design for the WESF Modifications were limited to alternatives to meet the CSS interface requirements within the WESF. The options examined were those that meet the functional needs of the CSS and the WESF capsule loading operations in a safe and compliant manner while keeping in mind that once the capsule loading and transfer operations are completed the mission of WESF is completed and the facility will
move to decommissioning. Attention was paid to the fact that the capsule loading operations will occur over a period of only one year, and that the MCSC Project is essentially an end-of-life project for WESF. Specifics on the design options chosen to fulfill the MCSC Project requirements with regard to WESF are discussed in Section 4.0 of this report.

3 Design Overview

3.1 Interfaces with Existing Facilities/Systems

Key interfaces for the MCSC Project within WESF take place between the Truck Port, the Canyon, G Cell, and the Pool Cell Area.

The Truck Port will receive and stage VCCs brought to and from WESF via a VCT, to be provided by the CSS vendor. The 200-East roadways and the concrete apron in front of the WESF Truck Port are the primary interfaces between WESF and the outside world.

The Truck Port then interfaces with the WESF Canyon via the Truck Port cover block, which will be removed when a VCC is staged in the Truck Port. The interface with the Canyon consists primarily of the DTS, which moves empty UCSs to G Cell and loaded UCSs to the Truck Port. The Canyon crane also removes and reinstall the TSC and VCC lids while the TSC/VCC are staged in the Truck Port, and installs and removes the shielded indexer plate (SIP) that is used to access individual storage locations within the TSC.

The Canyon and 15-ton Crane interface with G Cell, again via the DTS that moves empty UCSs into G Cell and loaded UCSs back to the Truck Port. The 15-ton Crane is also used to remove the existing G Cell cover block and replace it with a modified cover block to be provided by the CSS vendor. The modified G Cell cover block permits UCSs to be moved into and out of G Cell via the DTS. The modified cover block will be equipped with a shielding door that will be closed to prevent radiation streaming and shine into the Canyon when the DTS is not sitting atop the cover block. A DTS stand will also be located in the Canyon for storage of the DTS when not in use.

G Cell interfaces with various existing WESF utility systems (primarily electrical) via existing or new cell wall penetrations. The UCS Loading Bed, which bears the UCS loading station, Upender and Automated Welding System (AWS), interfaces with the G Cell floor and various utilities (i.e., electrical power, instrumentation, supplemental UCS cooling, compressed helium and argon gases). The AWS control console and power supply for the gas tungsten arc welding (GTAW) system are to be located in the Operating Gallery. The system for evacuating the welded UCS, backfilling it with helium, and then leak checking the weld will also be located in G Cell and will require power and compressed gas service. A water chiller to cool the incoming air to G Cell will be located in the Canyon with cooling coils in the G Cell air inlet duct.

G Cell also interfaces with the Pool Cell Area, where cesium and strontium capsules are currently stored, via the Capsule Transfer Chute. Neither the Pool Cell Area nor the Capsule Transfer Chute will need to be modified, they are fully capable of supporting the MCSC Project in their present operable condition. The CSS vendor has indicated that the G Cell activities and equipment will be designed around the existing capabilities of the in-cell hoist and the MSMs.

The WESF will rely on existing interfaces with Hanford 200-East Area utilities (i.e., the electrical power grid and the water distribution system).
3.2 Nuclear Safety

The MCSC Project will minimize impacts to safety-related systems in WESF. The WESF Pool Cell, where cesium and strontium capsules are stored will be unaffected; capsules will simply be moved from the Pool Cell Area to G Cell via the Capsule Transfer Chute, which also requires no modifications to fulfill its role for the project.

The WESF Truck Port floor will be reinforced to bear the weight of a loaded VCC on an air pallet without sustaining unacceptable cracking. The floor modifications will be designed to not adversely impact the seismic qualification of the 225-B Building.

There are no nuclear criticality safety concerns as the radioisotopes stored at WESF (cesium and strontium) are non-fissile and non-fissionable. No such isotopes will be introduced into the facility during the MCSC Project.

3.3 Operations Integration

WESF Operations has been a critical interface throughout the development of the MCSC Project. Their input was engaged in the development of the project requirement documents, the AoAs, and during the development of this conceptual design. Multiple meetings and email exchanges have been conducted between Lucas, the MCSC Project, and WESF Operations personnel. The WESF Operations personnel have been fully informed as to the scope and duration of the project and the individual processing steps that are planned. Input received from WESF Operations has been incorporated into the conceptual design. Input from the WESF Operations organization will continue to be sought as project preparations evolve.

4 Conceptual Design

WESF Modifications for the MCSC project fall into three primary categories based on location in the facility:

- Truck Port.
- Canyon (includes 15-ton crane).
- G Cell (includes manipulators).

The CDR sections that follow address each of these items and are broken down as appropriate.

Sketches W135-WESF-SK-G-001, W-135 Project WESF Cover Sheet, and W135-WESF-SK-G-002, W-135 Project WESF Drawing Index, in Appendix D provide an overview of the location of WESF with respect to the Hanford 200 East Area.

4.1 Truck Port

The WESF Truck Port must perform the following functions for the MCSC Project:

- Sequentially receive and stage VCCs on an air pallet for loading with cesium and strontium capsules that have been sealed in UCSs.
- Provide utilities to a forced convection TSC cooldown unit.
- Accommodate the decay heat load from cesium and strontium capsules during VCC loading while maintaining ambient air temperature with the allowable limit as determined by the CSS vendor thermal analysis.
Anticipated Truck Port modifications necessary or potentially necessary to meet these MCSC Project needs fall into the engineering disciplines discussed below.

### 4.1.1 Structural/Civil

#### 4.1.1.1 Truck Port Floor Reinforcement

The Truck Port floor requires reinforcement to support a fully-loaded VCC on an air pallet without sustaining unacceptable cracking. A previous WESF floor capacity calculation was performed by Duratek in 2002 (DFSNW-ECAL-215, *Preliminary Evaluation of WESF Floor Capacities*). This analysis evaluated the Truck Port floor, Canyon floor, and the G Cell floor to establish design limits for a potential cask that could be used to move and store the cesium and strontium capsules. This calculation established a design limit of 56,200 lb for a 6-ft diameter cask for the Truck Port floor. A loaded 10-ft diameter VCC with a SIP and the DTS on top has been conservatively estimated at 200,000 lb, well in excess of the previously calculated design limit.

A new analysis of the Truck Port floor was performed (Calculation LEMS-MCSC-17-CAL-001, *WESF Truck Port Slab-on-Grade Loading*, see Appendix B), based upon the current best NAC CSS design information. For this analysis, an additional 10% increase in the estimated loaded weight of the VCC for a weight of 220,000 lb was utilized for consideration of a potential drop accident scenario of the suspended DTS onto the VCC during loading operations. This analysis determined that the existing 8-in. thick reinforced 3,000-psi concrete slab on grade is inadequate to support the bounding 220,000 lb weight of a 10-ft diameter fully-loaded VCC with the SIP and DTS installed on top of the cask.

Options were examined, such as installation of heavy steel plating on top of the existing floor with the joints being welded and ground smooth to meet surface finish requirements. While this is a viable option, the plate thickness would likely need to be relatively high resulting in difficult handing and installation operations. Additionally, a float coat of grout on the existing floor would be required for a level surface on which to lay the steel. The existing floor has a floor drain with slopes to the drain. Thus, the analysis focused on what additional thickness of concrete would need to be poured on top of the existing floor to handle the VCC load without sustaining cracking. A finite element analysis was then run to determine the required thickness of concrete. This analysis determined that an 18-in. slab is required. Note that the WVDP HLWCRP utilized an 18-in. thick concrete slab for the operating apron that carried a load very similar to that of the VCC.

The current Truck Port floor slab was constructed with #4 bars spaced at 12 in. on center each way, top and bottom. It is believed that the bars extend into the Truck Port walls, thus creating potential for cracking or spalling of concrete at the floor wall interface when under load. The recommended Truck Port floor design involves cutting the existing slab along the long axis of the truck port 4 in from each side wall to eliminate this potential stress point and create a true floating slab on grade. This would be followed by roughening of the existing slab with a 0.25-in. amplitude and treating the surface with bonding agent. A new 10-in., 4,000-psi concrete slab would be poured over the existing 11.75-ft strip. A layer of #4 bars, 1.5 in clear of the top face would be placed in the new slab with 12-in. center-to-center spacing each way. The new floor surface needs to be machine-finished smooth and a high-quality epoxy coating applied to meet the surface finish requirements for effective air pallet operations.

Sketch W135-WESF-SK-C-001, *W-135 Project General Arrangement Truck Port Concrete Pad* (see Appendix D), depicts the Truck Port floor structural upgrade. Even with the additional 10 in of floor elevation height, there remains adequate clearance of 2.33 ft of clearance at the Truck Port door and under the Canyon floor.
In addition to the thickening of the floor slab, the Truck Port concrete loading dock ramp will need to be cut back and new stairs cut into the dock.

4.1.1.2 Truck Port Apron Modification
As shown on sketch W135-WESF-SK-C-001, the Truck Port apron will need to be extended and widened to accommodate the VCT and its tug. The apron area will be excavated and the existing apron replaced with a new 60-ft long by 32-ft wide by 18-in. thick reinforced concrete pad shown on the sketch. The new apron, with a total area of approximately 1,900 ft², will match up with the modified Truck Port floor as shown. Like the Truck Port floor, the surface of this apron will need to be machine-finished smooth and an epoxy coating applied for air pallet operation on the apron.

4.1.1.3 Truck Port Floor and Apron Surface Specifications for Air Pallet Usage
As mentioned above, both the Truck Port floor and apron will need to meet air pallet performance requirements. Floor and apron surface deviations must be less than 0.25 in per 10 ft in any direction. Surface inclination must be as near level as possible, with a specification of less than 0.5 in per 80 ft in any direction. In addition, the floor surface must be smooth and non-porous (i.e., epoxy coated or similar) with no cracks or holes. Small gaps may be bridged using duct-taped sheet metal less than 16-gage thickness. These requirements are given in the American Solving literature entitled “Floor Conditions for Air Film Transport” (see Appendix E).

In addition, the floor surface must be maintainable such that it remains suitable for air pallet use over the duration of the MCSC Project. The surface needs to be resistant to significant denting or scratching resulting from normal activities, and/or be readily repairable to accommodate wear and tear.

It is further recommended that bumper guide strips meeting the air pallet supplier’s recommendations be installed down both sides of the truck port floor and apron. These bumper strips would serve as a guide for operations of the loaded air pallet and additionally serve as protection against the loaded pallet moving too close to the edge of the floor slabs and potentially losing lift as a result of air loss.

Compressed air for the air pallet at 450 CFM and 64 psig is anticipated to be provided by a stand-alone, rented air compressor that will be diesel powered. The compressor is assumed to be provided by the CSS vendor and rented as part of the capsule transfer operations, hence is not included as a piece of equipment under the WESF Modifications scope.

4.1.1.4 Truck Port Door Replacement
The Truck Port rollup door is inoperable following completion of Project W-130. It is currently being replaced by a temporary, smaller roll-up door. This door will need to be replaced prior to the commencement of MCSC Project activities. It will be replaced with a door that rolls up on the building exterior providing full usage of the Truck Port door opening and maximum clearance for VCC movement in and out of the Truck Port. The CSS vendor equipment design for the VCC plus air pallet requires a Truck Port rollup door opening of minimum dimensions 124 in (10 ft 4 in) wide by 145.5 in (12 ft 1.5 in).

4.1.2 Mechanical, Piping and Fire Sprinkler System Mods
A variety of unused small diameter piping is attached to the Truck Port walls, most notably the south wall, which may interfere with VCC movement in and out of the Truck Port via air pallet. There is also an overhead section of Fire Suppression System sprinkler piping still in use that provides a crossover from the south to north sides of the Truck Port. Figure 4-1 shows a photograph of the WESF Truck Port south wall and ceiling.
The current above-floor height of the sprinkler piping crossover section is approximately 14.5 ft, which will be reduced to 13 ft 8 in. following the Truck Port reinforcement modification discussed above. The CSS vendor has estimated the height of a VCC on an inflated air pallet at 11.8 ft. This leaves less than 2 ft ceiling clearance above the VCC. Although adequate, subsequent MCSC Project developments, such as the need for a taller VCC, may further reduce the clearance. In addition, Operations personnel may be called upon to perform activities on top of the cask that require greater working room. Also, the CSS vendor (NAC) is designing a ventilation barrier for placement atop the VCC to provide an HVAC seal between the Truck Port and Canyon when the Truck Port access cover block is removed. The operational ramifications of this device are currently unknown; however, it inevitably will require a minimum VCC overhead clearance for installation and removal at the start and finish of VCC loading operations.

Sketch W135-WESF-SK-P-001, *W-135 Project WESF Fire Suppression Piping Modification* (see Appendix D), shows isometric sections of the proposed sprinkler piping modification. The crossover will be relocated to the east end of the truck port, beyond the VCC movement envelope. The existing sprinkler piping along the south wall, along with other piping identified as unused and having no future use, will then be removed.

### 4.1.3 Electrical

Three MCSC Project support items to be located in the Truck Port will require electrical power:

- A temporary cooling system to cool the TSC during the VCC loading evolution.
- A TSC evacuation/helium backfill system for the TSC.
- A helium leak detection system.

These loads are discussed below. All are anticipated to be provided by existing electrical connections in the WESF Truck Port or via a temporary power supply connected to a 480-Volts AC (VAC) welding receptacle in the Service Gallery as discussed in Calculation LEMS-MCSC-17-CAL-006, *Electrical Loads for MCSC Project* (see Appendix B). Section 4.4 of this report provides details on MCSC Project electrical utilities and load planning.
4.1.3.1 TSC Temporary Cooling System

The TSC temporary cooling system has not been specified by the CSS vendor, who will be responsible for providing it. For planning purposes, a portable industrial air conditioning unit with similar capacity to what will be required has been identified. This unit, a MovinCool Classic 60 (see cut sheet in Appendix E), requires 480-VAC, 3-phase power at 9-amps. This load is assumed for the CSS vendor-supplied TSC. The required power will be provided by the temporary power supply and load center connected to the Service Gallery 480-VAC welding receptacle.

4.1.3.2 TSC Evacuation/Helium Backfill System

The TSC evacuation/helium backfill system is to be provided by the CSS vendor. Based on input from CHPRC, it is anticipated to require 480-VAC, 3-phase power at 40-amps plus two 120-VAC, single phase services at 20-amps each. The required 480-VAC power will be provided by the temporary power supply and load center connected to the Service Gallery 480-VAC welding receptacle. The required 120-VAC power will be provided either by existing connections in the Truck Port or through the temporary power supply and load center.

4.1.3.3 TSC Helium Leak Detection System

The helium leak detection system will be used to verify leak tightness of the TSC after each tube has been filled with two USC units. Based on input from CHPRC, this system is anticipated to require one 120-VAC, single phase service at 10-amps. The required 120-VAC power will be provided either by existing connections in the Truck Port or through the temporary power supply and load center.

4.1.3.4 Truck Port Electrical Loads Summary

Table 4-1 lists the anticipated Truck Port electrical loads to support the MCSC Project. See Section 4.4 for further details.

<table>
<thead>
<tr>
<th>Load Description</th>
<th># of Services</th>
<th>VAC</th>
<th># of Phases</th>
<th>Amperage</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSC temporary cooling system</td>
<td>1</td>
<td>480</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>TSC evacuation/helium backfill system, high voltage</td>
<td>1</td>
<td>480</td>
<td>3</td>
<td>40</td>
</tr>
<tr>
<td>TSC evacuation/helium backfill system, low voltage</td>
<td>2</td>
<td>120</td>
<td>1</td>
<td>20</td>
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<tr>
<td>TSC helium leak detection system</td>
<td>1</td>
<td>120</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

TSC = transportable storage canister
VAC = volts AC (alternating current)

4.1.4 Heating, Ventilation, and Air Conditioning

A portion of the K1 HVAC system air duct in the Truck Port must be relocated to the 225B Building exterior for adequate VCC movement clearance in and out of the Truck Port. This existing duct is asbestos covered and its handling, removal and disposal will need to be performed in compliance with CHPRC’s procedures and standards for asbestos control. Sketches W135-WESF-SK-M-001, W-135 Project WESF HVAC Air Flow Diagram, W135-WESF-SK-M-002, W-135 Project WESF HVAC Air Duct Modification, and W135-WESF-SK-M-004, W-135 Project WESF K1 – Duct Modification (see
these sketches in Appendix D), present the changes to be made. Figures 4-2 through 4-4 show the necessary ductwork relocation.

Figure 4-2. Truck Port Interior View of K1 Duct Relocation from Sketch W135-WESF-SK-M-002
Figure 4-3. 225B Building Exterior Views of K1 Duct Relocation from Sketch W135-WESF-SK-M-002
4.1.5 Other

Section 4.2 of this report discusses use of a state-of-the-art integrated camera system on the 15-ton Canyon crane. Such a system offers the ability to incorporate additional remote-viewing cameras to support operations in areas of WESF beyond the Canyon, including the Truck Port. While not a stated requirement for the Truck Port, additional cameras can be specified and added to the WESF Modifications design in subsequent design phases if deemed worthwhile in terms of added safety and operational flexibility.
Appendix E contains information on HoistCam™ camera systems, including the HoistCam™ Director Enterprise Fleet Monitoring Software that supports remote video monitoring and recording capabilities for multiple camera locations.

4.2 Canyon

WESF Canyon items associated with the MCSC Project fall into the following general categories:

- The Canyon deck must be structurally able to meet floor loading imposed by items placed in the Canyon during the MCSC Project.
- There must be sufficient deck space to stage/store large items, including the existing G Cell cover block, the SIP, the DTS on the DTS stand (to be provided by the CSS vendor), and the VCC and TSC lids when removed for loading of UCSs into TSC cells.
- The Canyon must provide utilities (i.e., electrical power and compressed air) necessary to support MCSC Project equipment and operations (see Section 4.4).

In addition, the Canyon crane must be capable of lifting and moving required loads at the required MCSC Project duty cycle. The crane also requires an updated, state-of-the-art camera system to support safe and precise movement of MCSC Project loads.

4.2.1 Structural/Civil

4.2.1.1 Canyon Deck

Calculation LEMS-MCSC-17-CAL-003, Scoping Analysis of Waste Encapsulation and Storage Facility (WESF) Canyon Floor for MCSC Project Equipment Loading (see Appendix B), conservatively estimated the Canyon deck load imposed by the fully-loaded DTS on the DTS stand at 1,500 lb/ft². This is below the recommended live load limit of 2,900 lb/ft² analyzed in SD-WM-DA-034, WESF Floor Loading Analysis for RSI/GE 1500 Casks. The DTS on the DTS stand is anticipated to be the heaviest load that will be placed on the Canyon deck; on that basis, the Canyon deck is able to support all anticipated MCSC Project loads with no structural modifications. Once all items requiring staging or storage in the Canyon have been designed by the CSS vendor, this evaluation will be confirmed during the preliminary design.

The primary Canyon deck modification that may be required is removal of lifting bales from cover blocks of cells A through F, which are now grout-filled and hence permanently out of service. Cutting off the bales level with the Canyon deck will free up laydown space for the VCC and TSC lids, the SIP and the existing G Cell cover block, as well as the DTS/DTS stand. The following is a full estimated listing of items that need to be stored or staged on the Canyon deck:

- DTS/DTS stand.
- VCC lid.
- SIP.
- TSC tube lids and an over-lid, if used per CSS vendor design of the TSC.
- Crane operated electric impact wrench.
- Existing G Cell cover block.
- G Cell air inlet cooling via water chiller (vendor literature in Appendix E).
- Power cart for temporary electrical power connections (vendor literature in Appendix E).
• Scaffolding, if required.
• Fall protection railings for the Truck Port cover block opening when the cover block is removed.

4.2.1.2 Canyon Crane
The Canyon crane is rated at 30,000 lb main hoist capacity. It was designed and supplied as a Moderate Service, Class C crane based on Electric Overhead Crane Institute (EOCI) Specification #61, Specifications for Electric Overhead Traveling Cranes (EOCI 61). EOCI 61 was later superseded by Crane Manufacturers Association of America (CMAA) Specification #70, Specifications for Top Running Bridge & Gantry Type Multiple Girder Electric Overhead Traveling Cranes (CMAA 70). The “Class C (Moderate Service)” crane category was not quantified by EOCI 61. CMAA 70 defines this category as the following:

• Average loading 50% of rated capacity.
• Five to 10 lifts per hour with an average lift height of 15 ft.
• Not over 50% of lifts at the rated crane capacity.

It is anticipated that the MCSC Project crane usage requirements will not exceed the “Class C (Moderate Service)” rating as defined in CMAA 70. The heaviest object to be lifted will be the DTS, which has an estimated fully-loaded weight between 16,450 lb and 22,000 lb. This ranges from 55% to 73% of the Canyon crane’s 15-ton rated capacity. Since the DTS is the heaviest load to be lifted, none of the MCSC Project Canyon crane lifts will be at its rated capacity. Further, the frequency of DTS lifts for transporting UCSs between G Cell and the Truck Port will be less than 10 lifts per hour given the length of time required for cesium and strontium loading into UCSs followed by primary welded closure, evacuation, helium backfilling, helium leak testing, secondary welded closure, and staging in G Cell. Finally, Canyon crane lift heights (anticipated average below 15 ft) will be limited to the minimum height necessary to clear obstacles using engineered and/or administrative controls.

A crane built to EOCI-61 specifications is unlikely to meet current requirements for “single-failure-proof” cranes set forth in ASME NOG-1 or NUREG-0554 and NUREG-0612. However, given that the MCSC Project has a relatively short duration and constitutes an end-of-life project for WESF, Canyon crane replacement or significant component or structural upgrades to meet single-failure-proof requirements are not warranted. The approach for the MCSC Project will be to analyze credible drop accident scenarios for risk and consequences, and to limit crane lift heights with engineered and/or administrative controls.

The CSS vendor will provide an updated time-motion study for MCSC Project operations in WESF, including Canyon crane usage. This time-motion analysis will be available for subsequent project design phases to more closely model the MCSC Project operations and validate usage of the Canyon crane as is.

4.2.1.2.1 Crane Camera System
The existing Canyon crane camera system needs to be updated for improved video quality and safety. The requirements for a new camera system are color imaging, pan-tilt-zoom, and auto-focus capabilities. The new crane camera system is required to provide overhead views of the crane hoist as well as overhead views of the work area in a minimum of two crossing directions. The Canyon length and the Truck Port area above the VCC must be viewable in such a way that direct downward views of the work areas can be achieved for efficiency and safety.

A camera setup from one vendor, HoistCam™, has been identified as a viable candidate. Cameras provided by this vendor attach magnetically to steel crane structures with a safety lanyard; hence, they require no welding or drilling for new mounting brackets and allow multiple cameras to be readily placed
on the crane structure to optimize views of work activities. Cameras may be powered by either batteries or a local power source, which is more desirable to avoid frequent battery recharging. Figure 4-5 shows an example of such a camera in service on a crane block. Appendix E contains information on HoistCam™ camera systems, including the HoistCam™ Director Enterprise Fleet Monitoring Software that supports remote video monitoring and recording capabilities for multiple camera locations.

Figure 4-5. Example of Magnetically-Mounted Crane Camera

Note a state-of-the-art integrated camera system such as this offers the ability to incorporate additional remote-viewing cameras to support G Cell and Truck Port operations. Additional cameras can be specified and added to the WESF Modifications design in subsequent design phases if deemed worthwhile in terms of added safety and operational flexibility.

4.2.2 Mechanical

4.2.2.1 Crane Operated Remote Electric Impact Wrench

The CSS vendor has indicated that a CSS vendor-supplied impact wrench may be used via the Canyon crane for installing and torqueing TSC and VCC lid bolts. Even if these operations do not need to be performed remotely for as low as reasonably achievable (ALARA) concerns, the positioning of the TSC/VCC assembly in the Truck Port 3 to 4 ft below the Canyon deck level may best be performed with a crane-handled impact wrench for personnel safety.
For utility planning purposes, it is assumed this will be an electrically-operated torque wrench requiring no more power than the standard Hanford design typically used for the Plutonium Uranium Extraction Plant connectors. The Hanford wrench torque capacity and electrical power needs are 200 to 650 ft/lb using a 460-VAC, 3-phase service at 1.4-amps (Figure 4-6). Appendix E provides two drawings from HiLine Engineering & Fabrication, Inc. for a remote crane-operated electric impact wrench of their manufacture that has been used with Plutonium Uranium Extraction Plant connectors at the 242-A Evaporator in the 200-East Area.

Figure 4-6. Hanford-Style Remote Crane Operated Electric Impact Wrench

4.2.3 Electrical
The electric impact wrench, the DTS and the SIP will all require electrical power connections, as described above. No electrical requirements have been identified for the modified G Cell cover block.

4.2.3.1 Crane Operated Remote Electric Impact Wrench
As noted above, electrical power requirements for the crane-operated electric impact wrench are 200 to 650 ft/lb using a 460-VAC, 3-phase service at 1.4 amps.

4.2.3.2 Dry Transfer System
Electrical power requirements for the DTS are anticipated to be two 120-VAC, single phase 20-amp services.

4.2.3.3 Shielded Indexer Plate
The SIP is anticipated to require two 120-VAC, single phase 20-amp services.
4.2.3.4 Water Chiller for G Cell Inlet Air Cooling

It is anticipated that a water chiller to cool the airflow into G Cell from the WESF Canyon will be located in the Canyon. This is discussed in the G Cell subject matter under Section 4.3. The chiller will draw its power from the Canyon. As discussed in the section on G Cell modifications, it is anticipated that a packaged chiller unit requiring 230-VAC, 3-phase power will be suitable for this service. This reference package unit draws 8.5 amps in the 3-phase configuration, or 13.6 amps in the single-phase configuration. See Omni-Chill vendor information in Appendix E.

4.2.3.5 WESF Canyon Electrical Loads Summary

Table 4-2 lists the anticipated Truck Port electrical loads to support the MCSC Project. Some or all of these may be serviceable using a portable power cart.

Table 4-2. WESF Canyon Electrical Loads Summary for MCSC Project

<table>
<thead>
<tr>
<th>Load Description</th>
<th># of Services</th>
<th>VAC</th>
<th># of Phases</th>
<th>Amperage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crane-operated remote electric impact wrench</td>
<td>1</td>
<td>480</td>
<td>3</td>
<td>1.4</td>
</tr>
<tr>
<td>Dry Transfer System</td>
<td>2</td>
<td>120</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Shielded Indexer Plate</td>
<td>1</td>
<td>120</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Water chiller for G Cell HVAC inlet air cooling</td>
<td>1</td>
<td>230</td>
<td>3 or 1</td>
<td>8.5 (3 Phase) or 13.6 (1 Phase)</td>
</tr>
</tbody>
</table>

HVAC = heating, ventilation and air conditioning

4.2.4 Compressed Air

In addition to electrical power, the DTS and SIP will both require compressed air service. No compressed air requirements have yet been identified for the modified G Cell cover block.

4.2.4.1 Dry Transfer System

The CSS vendor design of the DTS requires 90-psig instrument air at a minimum 10 standard cubic feet per minute (SCFM) to operate the internal grapple for lifting a UCS.

4.2.4.2 Shielded Indexer Plate

The SIP will require 100-psig instrument air at a yet to be defined CFM.

4.2.4.3 WESF Canyon Compressed Air Load Summary

Table 4-3 lists the anticipated Canyon compressed air loads to support the MCSC Project.

Table 4-3. WESF Canyon Compressed Air Loads Summary for MCSC Project

<table>
<thead>
<tr>
<th>Load Description</th>
<th># of Services</th>
<th>Pressure, PSIG</th>
<th>Flow Rate, SCFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Transfer System</td>
<td>1</td>
<td>80 to 90</td>
<td>10</td>
</tr>
<tr>
<td>Shielded Indexer Plate</td>
<td>1</td>
<td>100</td>
<td>10</td>
</tr>
</tbody>
</table>
Numerous existing instrument air connections that previously served ventilation controls for cells A through F are available in the Canyon to provide the required intermittent air service required.

4.2.5 HVAC

No HVAC-related modifications have been identified for the WESF Canyon other than locating the Canyon-to-Truck Port ventilation barrier on top of the VCC in the Truck Port. This ventilation barrier will be designed by the CSS vendor.

Placement of the G Cell air inlet cooler in the Canyon does not constitute a modification of the K1 HVAC system that services the Canyon.

4.3 G Cell

G Cell is integral to the MCSC Project; this is where cesium and strontium capsules will be loaded and sealed inside UCSs. To support the MCSC Project, the G Cell floor must be structurally able to support the loading imposed by MCSC Project equipment that will be provided by the CSS vendor. G Cell must also provide utilities (primarily electrical power) required by the MCSC Project equipment. The CSS vendor has indicated they are designing the G-Cell equipment around the capabilities of the in-cell hoist, the MSMs, and the Capsule Transfer Chute from the WESF Pool Cell Area; therefore, no modifications to these systems are currently anticipated. Shielded storage tank TK-G7-1 will need to be removed to make room for the CSS vendor equipment to be located in the cell.

The following subsections address required modifications.

4.3.1 Structural/Civil

4.3.1.1 G Cell Floor

Calculation LEMS-MCSC-17-CAL-002, Scoping Analysis of Waste Encapsulation and Storage Facility (WESF) G Cell Floor for MCSC Project Equipment Loading (see Appendix B), conservatively estimated the G Cell floor load imposed by the UCS Loading Bed and an adjacent UCS-Shielded Storage Location (“shield bell”) that will be used to stage a loaded UCS while a second UCS is in process on the Loading Bed. The Loading Bed includes a UCS loading station at one end, an Upender device to reorient a filled USC from horizontal to vertical for welded closure, an AWS, and a UCS evacuation/helium backfill and leak testing system. The in-process UCS is conservatively assumed to be shielded similar to the adjacent UCS shield bell.

The UCS Loading Bed and the UCS staging shield bell currently are in design by the CSS vendor (NAC). Dimensions and weights were estimated from the CSS vendor conceptual drawings shown in Figure 4-7and 4-8 in order to estimate the G Cell floor loading.
MicroShield™ shielding analysis was used to estimate the weight of steel necessary for the shield bells (one on the UCS Loading Bed and one for the adjacent UCS shield bell) based on the six highest-activity cesium capsules and a desired external contact dose rate of 100 mrem/hr. The results of LEMS-MCSC-17-CAL-002 estimate a UCS shield bell weight of 11,500 lb and a UCS Loading Bed weight of 14,100 lb. A single 37-in. square base plate under the UCS shield bell (total base plate footprint of ~9 ft²) and four 27-in. square base plates, one under each of the four corners of the UCS Loading Bed (total base plate footprint of ~20 ft²), will suffice to maintain the resultant floor loading below the recommended G Cell floor live load limit of 1,300 lb/ft² analyzed in SD-WM-DA-034. Thus, although the UCS Loading Bed and adjacent shield bell design will evolve as CSS vendor design work progresses and base plate dimensions to adequately distribute the equipment weight may change, structural modifications to the
G Cell floor will not be necessary because equipment base plate sizes can be adjusted as needed for adequate load distribution.

### 4.3.1.2 Modified G Cell Cover Block with Shielding Door

The modified G Cell cover block necessary to interface with the DTS is in design by the CSS vendor. At this time it is not anticipated that the modified cover block will require any modifications in either G Cell or the Canyon other than a designated Canyon floor storage location if/when it needs to be set aside for G Cell maintenance or to reinstall the original G Cell cover block.

### 4.3.2 Mechanical

#### 4.3.2.1 Automated Welding System/UCS Upender

The AWS and UCS Upender will be part of the UCS Loading Bed. This equipment will be designed and provided by the CSS vendor. While the weight is anticipated to be substantial (estimated 14,100 lb for the Loading Bed with Upender and AWS due to required shielding of the UCS loading station to support personnel entry into G Cell), they can be safely supported on the G Cell floor using base plates of approximately 20 ft² area total to distribute the load (see G Cell floor loading discussion under Section 4.3). The AWS, an automated GTAW unit, will require an Argon gas supply for the GTAW torch arc, along with a compressed air supply at 80-100 psig at 10 CFM.

Electrical, instrumentation, and specialty gases (Helium and Argon) will be supplied to G Cell from the Operating and Service Galleries as appropriate using existing nozzles to the extent practicable. However, it is likely that additional penetrations into G Cell will be required, particularly from the Operating Gallery, as the number of existing penetrations from this side of G Cell are limited. These penetrations are discussed under Section 4.3.5.1.

#### 4.3.2.2 UCS Evacuation/Helium Backfill System

The UCS evacuation / Helium backfill system, to be designed and provided by the CSS vendor, will be integrated with the AWS on the UCS Loading Bed. A bank of compressed gas bottles, including six ultra-high purity Helium bottles with tubing, instrumentation and a gas manifold system, will also be required. The Helium bottles will be located in the Service Gallery with piping / tubing into G Cell via an appropriate cell wall penetration.

#### 4.3.2.3 Helium Mass Spectrometer Leak Detection System

A Helium mass spectrometry leak detection (MSLD) system will be needed to verify welded closure of UCSs. This equipment, to be provided by the CSS vendor, will also be integrated with the AWS on the UCS Loading Bed.

#### 4.3.2.4 G Cell Hoist

The existing G Cell hoist has a 2000 lb lifting capacity. Loaded USC units are estimated to weigh a maximum of 450 lb; therefore, the G Cell hoist is expected to be adequate as-is and requires no modifications.

#### 4.3.2.5 Capsule Transfer Chute

The CSS vendor’s time/motion study estimates that cesium and strontium capsules will need to be transferred from the WESF Pool Cell Area to G Cell at a rate of six capsules per 1.5 hours. The Capsule Transfer Chute and supporting equipment is in good serviceable condition and is capable of supporting this capsule transfer rate with no modifications.
4.3.2.6 Master-Slave Manipulators

The MSMs in G Cell are CRL Model F with an optimal maximum 100 lb lifting capacity, depending on the distance and angle (lever arm) on the manipulator for a given lift. MSMs will be used to load cesium and strontium capsules into UCSs on the UCS Loading Bed and for lightweight tooling/maintenance evolutions. The CSS vendor is aware of the MSM capabilities and limitations and is working to design the MCSC Project G Cell process such that the MSM capabilities envelope will not be exceeded.

4.3.2.7 UCS Shielded Storage Location

A UCS shield bell will be located in G Cell adjacent to the UCS Loading Bed to stage one loaded UCS while a second UCS is in process on the UCS Loading Bed. The intent is to transport two loaded UCSs from G Cell to the Truck Port in rapid succession for loading into a single TSC cell, after which the TSC cell can be closed, evacuated, and filled with helium for thermal considerations. The UCS shield bell is necessary for ALARA purposes to allow personnel entry into G Cell for maintenance and recovery operations in the event of equipment failure while cesium and strontium capsules are present in the cell.

As discussed in LEMS-MCSC-17-CAL-002, the target dose rate is 100 mrem/hr (1 mSv/hr) on surface contact with the UCS shield bell containing a UCS loaded with the six bounding (highest source term) cesium capsules. This mandates a substantial quantity of steel, the presumed shielding material, such that the UCS shield bell will weigh approximately 11,500 lb. A base plate with a footprint area of approximately 9 ft² will be required to uniformly distribute the load over the G Cell floor to less than 1,300 lb/ft² per SD-WM-DA-034.

4.3.2.8 UCS Supplemental Cooling

It is anticipated that the CSS vendor will provide a cooling system for the UCS Shielded Storage Location, and possibly for the shielded UCS loading station on the Loading Bed as well, to prevent cesium and strontium capsules from exceeding temperature limits for the salt contents. Other aspects of the system are unknown at this time; details will be provided by the CSS vendor following their design effort.

4.3.2.9 Tank TK-G7-1 Removal

The current CSS vendor design for G Cell equipment uses essentially the entire available floor space. Therefore, shielded storage tank TK-G7-1, which has no identified future use, will need to be removed from G Cell along with any associated piping as part of the WESF Modifications.

4.3.3 Electrical

Table 4-4 summarizes the anticipated electrical loads for G Cell. These loads are based on CSS vendor input. Much of the custom G Cell equipment for the MCSC Project is not yet designed; therefore, there is a potential that the electrical service needs may vary from those estimated below.
Table 4-4. G Cell Electrical Loads Summary for MCSC Project

<table>
<thead>
<tr>
<th>Load Description</th>
<th># of Services</th>
<th>VAC</th>
<th># of Phases</th>
<th>Amperage</th>
<th>Inside or Outside of G Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS welding machine power supply</td>
<td>1</td>
<td>480</td>
<td>3</td>
<td>30</td>
<td>Outside</td>
</tr>
<tr>
<td>AWS welding console</td>
<td>1</td>
<td>115</td>
<td>1</td>
<td>10</td>
<td>Outside</td>
</tr>
<tr>
<td>AWS welding torch cooling system</td>
<td>1</td>
<td>120</td>
<td>1</td>
<td>20</td>
<td>Inside</td>
</tr>
<tr>
<td>UCS evacuation/helium backfill system, high voltage</td>
<td>1</td>
<td>480</td>
<td>3</td>
<td>40</td>
<td>Inside</td>
</tr>
<tr>
<td>UCS evacuation/helium backfill system, low voltage</td>
<td>2</td>
<td>120</td>
<td>1</td>
<td>20</td>
<td>Inside</td>
</tr>
<tr>
<td>Helium MSLD system</td>
<td>1</td>
<td>120</td>
<td>1</td>
<td>10</td>
<td>Inside</td>
</tr>
<tr>
<td>UCS supplemental cooling&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1</td>
<td>230</td>
<td>1</td>
<td>15</td>
<td>Inside</td>
</tr>
</tbody>
</table>

<sup>a</sup> There may be two UCS Supplemental Cooling systems if the UCS loading station on the Loading Bed is also to have supplemental cooling.

AWS = Automated Welding System
UCS = universal capsule sleeve
VAC = volts AC (alternating current)

4.3.4 Process Air

The most recent conceptual design information from NAC indicates the potential need for process air for operation of capsule loading equipment in G Cell. The H-2-96494 drawings (see Appendix C) show the instrument and process air system at WESF. Drawing H-2-96494 Sheet 2, Flow Diagram Air System, indicates there is a 1” process air header in the Service Gallery that provides process air to the WESF Processing cells. Based on drawing H-2-96494 Sheet 3, Flow Diagram Air System, process air has been historically available in G-Cell through nine cell nozzles (G27, G82, G84, G95, G98, G99, G101, and G102). The WESF process air is maintained at 90 psig, and is supplied by two 275 CFM compressors at pressures up to 100 psig.

Consistent with previous assumptions regarding the state of the G Cell wall nozzles, the conceptual design assumes that a new wall nozzle penetration will be required to provide compressed air to G Cell via the service gallery. This new wall nozzle would be connected to the existing 1” process air header in the Service Gallery.

4.3.5 HVAC

MCSC Project activities in G Cell will generate a significant heat load, with a maximum exceeding 10 kW (10,000 W). This includes the 3 kW base load from G Cell incandescent lighting taken from Drawing H-2-66766, In-Cell Light LF-17 (see Appendix C), 4-kW decay heat from the 12 highest decay heat strontium capsules taken from CHPRC-02248, Estimate of WESF Capsule Decay Heat Values on January 1, 2018, and an estimated 3 kW from the AWS GTAW welding arc (information source discussed in LEMS-MCSC-17-CAL-005, G Cell Heat Balance Calculation for MCSC Project; see Appendix B). LEMS-MCSC-17-CAL-005 documents an evaluation of this heat load, along with the available HVAC airflow through G Cell following completion of Project W-130.
G Cell receives air from the WESF Canyon, which is serviced by the K1 ventilation system. The nominal G Cell air inlet flow rate setpoint is 140 CFM, while the maximum airflow is anticipated to be 300 CFM following Project W-130 completion (CHPRC-02411, *W 130 Project K3N Exhaust System Analysis*). The summer season ambient air temperature in the Canyon is given as 75 °F in VI-11000023, *WESF 225B HVAC System Design Calculations*, which also served as input to the Project W-130 documentation.

A “worst case” evaluated in LEMS-MCSC-17-CAL-005 using the heat loads above, along with the 75 °F inlet air temperature from the Canyon and the nominal 140 CFM airflow rate, indicated that the ambient air temperature in G Cell could rise to 175 °F. The G Cell interior concrete wall temperature would reach 155 °F, which exceeds the 150 °F maximum allowable temperature for concrete given in ACI 349-01, *Code Requirements for Nuclear Safety Related Concrete Structures*.

LEMS-MCSC-17-CAL-005 considered several other cases including some with G Cell airflow greater than 300 CFM, which may exceed the capabilities of the current ventilation system. The calculation ultimately determined the full 300-CFM G Cell inlet airflow rate, if available, will be needed and the inlet air will need to be cooled to 55 °F using a water chiller unit located in the WESF Canyon and a cooling coil located in the G Cell air inlet duct. The required chiller capacity is estimated at 11,500 BTU/hr using a conservatively high 85 °F Canyon air temperature as the basis.

Per Case 4 in LEMS-MCSC-17-CAL-005, the conditions of 300 CFM airflow and 55 °F inlet air temperature result in a G Cell air temperature of 129 °F when all heat loads are present (i.e., lighting, 12 hottest strontium capsules, GTAW torch arc running). However, the previously assumed WESF in-cell operating temperature limit was 120 °F based on VI-11000023. Case 5 in LEMS-MCSC-17-CAL-005 determines that a hypothetical 365-CFM G Cell airflow would be required to drop the in-cell air temperature from 129 °F to 120 °F. The added 65 CFM airflow over and above the 300 CFM maximum airflow rate removes 4,580 BTU/hr additional heat and reduces the G Cell temperature to 120 °F.

Based on the above analysis, it is anticipated that the CSS vendor will need to provide supplemental cooling for the G Cell Shielded Capsule Storage unit discussed above to maintain cesium and strontium capsules in a sealed, staged, and shielded UCS below respective operating temperature limits for the cesium chloride salt and strontium fluoride salt. This supplemental cooling system is expected to have a cooling capacity of approximately 5,000 BTU/hr. Assuming that the heat is rejected outside of G Cell, the added heat removal will reduce the G Cell air temperature to the desired 120 °F, as would the hypothetical added 65 CFM of inlet airflow at 55 °F.

Appendix E contains vendor information on an Omni-Chill Model AC-100A chiller unit that has a cooling capacity of 11,400 BTU/hr, well-matched to the conservatively estimated 11,500-BTU/hr required capacity discussed above. This water chiller will be paired with a 24-in. by 24-in. by 4-in. water cooling coil unit placed ahead of the G Cell HVAC inlet air duct, as shown on Sketch W135-WESF-SK-M-003, *W-135 Project WESF Ventilation Modifications* (see Appendix D).

Note that the 3000 W lighting portion of the G Cell heat load can be reduced by changing to LED lamps, which generate far less heat for a given illumination level.

Further note that LEMS-MCSC-17-CAL-005 does not address loss of ventilation power, possibly during UCS closer welding operations. This is a potential risk that may require further analysis of off-normal conditions related to G Cell cooling during preliminary or final design. Safety SSC requirements, if any, will be identified during preliminary or final design.
4.3.6 Other

This section discusses items relevant to G Cell that do not fall under the preceding topic categories.

4.3.6.1 G Cell Wall Penetrations

Additional penetrations may be needed between G Cell and the Operating Gallery for instrumentation and power connections. MCSC Project planning should include cost and schedule for core drilling such penetrations. Additional penetrations will require mapping the steel reinforcing bar and core drilling the 3 foot thick, high density reinforced concrete shield walls. To prevent shine paths through the nozzles, typical practice is to configure the nozzle penetrations to provide a tortuous path through the nozzle. This is accomplished by placing a through-wall plug in the hole that contains a curved or twisted conduit within a steel and/or high density concrete matrix, and thus requires drilling penetrations through the wall that are larger than the required conduit sizes.

G Cell wall penetrations to be used for support of CSS components will be tested for serviceability prior to use. For the purpose of conceptual design, it is assumed that all G Cell wall penetrations necessary for the MCSC Project will be new in order to provide a bounding cost estimate.

4.3.6.2 In-Cell Cameras

As noted in Section 4.2, a state-of-the-art integrated camera system offers the ability to incorporate additional remote-viewing cameras to support operations in areas of WESF beyond the Canyon. While not a stated requirement for G Cell, additional cameras can be specified and added to the WESF Modifications design in subsequent design phases if deemed worthwhile in terms of added safety and operational flexibility.

Appendix E, Vendor Literature, contains information on HoistCam™ camera systems, including the HoistCam™ Director Enterprise Fleet Monitoring Software that supports remote video monitoring and recording capabilities for multiple camera locations.

4.4 Electrical Utilities

CHPRC-02426, W-130 Project K3N Ventilation Electrical Load Calculation, comprises a recent (2015) evaluation of WESF electrical loads performed in advance of Project W-130. WESF receives electrical power from two 750-kVA transformers. The WESF baseline electrical demand following Project W-130 completion is estimated at approximately 618 kVA.

The WESF electrical one-line drawings shown on Drawing H-2-96643, Sheets 1 through 3, Electrical One Line Diagram MCC-1/ MCC-2/ MCC-3, (see Appendix C), indicate the availability of the following electrical connections available for use by the MCSC Project:

- Three 480-VAC welding receptacles in the Operating Gallery.
- One 480-VAC welding receptacle in the Canyon.
- One 480-VAC welding receptacle in the Service Gallery.

In addition, CHPRC-02424, W-130 Project Construction and Stabilization Electrical Load Calculation, indicates that G Cell convenience receptacles fed from a 20-amp breaker in Lighting Panel E in the Service Gallery is also available to support MCSC Project electrical loads.

It was assumed that all MCSC Project electrical needs will be fed by the normal power bus MCC-1 rather than emergency busses MCC-2 and MCC-3, and that there is sufficient spare capacity available in building electrical panels due to deactivation of WESF Hot Cells A through F.
LEMS-MCSC-17-CAL-006 evaluated and summed the MCSC Project electrical loads. Figure 4-9 shows the electrical load summary from that calculation. The MCSC Project adds a new load of approximately 141 kVA to the existing 618-kVA load for a total of 759 kVA. This is well within the $2 \times 750$-kVA transformer capacity of the WESF electrical power supply from the 200-East Area electrical grid.

**Figure 4-9. MCSC Project Electrical Loads Evaluation Summary from LEMS-MCSC-17-CAL-006**

<table>
<thead>
<tr>
<th>Location</th>
<th>Equipment</th>
<th>Voltage</th>
<th>Phase</th>
<th>Amperage</th>
<th>Phase Factor</th>
<th>kVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>WESF Canyon</td>
<td>Transfer Indexer/Shield Plate</td>
<td>120</td>
<td>1</td>
<td>20</td>
<td>1.000</td>
<td>2.40</td>
</tr>
<tr>
<td>WESF Canyon</td>
<td>Transfer Indexer/Shield Plate</td>
<td>120</td>
<td>1</td>
<td>20</td>
<td>1.000</td>
<td>2.40</td>
</tr>
<tr>
<td>WESF Canyon</td>
<td>Dry Transfer System</td>
<td>120</td>
<td>1</td>
<td>20</td>
<td>1.000</td>
<td>2.40</td>
</tr>
<tr>
<td>WESF Canyon</td>
<td>Dry Transfer System</td>
<td>120</td>
<td>1</td>
<td>20</td>
<td>1.000</td>
<td>2.40</td>
</tr>
<tr>
<td>WESF Canyon</td>
<td>Crane Torque Wrench</td>
<td>460</td>
<td>3</td>
<td>1.4</td>
<td>1.732</td>
<td>1.12</td>
</tr>
<tr>
<td>WESF Canyon</td>
<td>G-Cell Cover Bock Shield Door</td>
<td>120</td>
<td>1</td>
<td>20</td>
<td>1.000</td>
<td>2.40</td>
</tr>
<tr>
<td>WESF Canyon</td>
<td>G-Cell Cover Bock Shield Door</td>
<td>120</td>
<td>1</td>
<td>20</td>
<td>1.000</td>
<td>2.40</td>
</tr>
<tr>
<td>WESF Canyon</td>
<td>G-Cell HVAC Chiller System</td>
<td>230</td>
<td>3</td>
<td>8.5</td>
<td>1.732</td>
<td>3.39</td>
</tr>
<tr>
<td>G-Cell</td>
<td>Welding Machine</td>
<td>480</td>
<td>3</td>
<td>30</td>
<td>1.732</td>
<td>24.94</td>
</tr>
<tr>
<td>G-Cell</td>
<td>Welding Console</td>
<td>115</td>
<td>1</td>
<td>10</td>
<td>1.000</td>
<td>1.15</td>
</tr>
<tr>
<td>G-Cell</td>
<td>Welding Cooling System</td>
<td>120</td>
<td>1</td>
<td>20</td>
<td>1.000</td>
<td>2.40</td>
</tr>
<tr>
<td>G-Cell</td>
<td>Evacuation/He Backfill</td>
<td>480</td>
<td>3</td>
<td>40</td>
<td>1.732</td>
<td>33.26</td>
</tr>
<tr>
<td>G-Cell</td>
<td>Evacuation/He Backfill</td>
<td>120</td>
<td>1</td>
<td>20</td>
<td>1.000</td>
<td>2.40</td>
</tr>
<tr>
<td>G-Cell</td>
<td>Evacuation/He Backfill</td>
<td>120</td>
<td>1</td>
<td>20</td>
<td>1.000</td>
<td>2.40</td>
</tr>
<tr>
<td>G-Cell</td>
<td>He Leak Detection System</td>
<td>120</td>
<td>1</td>
<td>10</td>
<td>1.000</td>
<td>1.20</td>
</tr>
<tr>
<td>G-Cell</td>
<td>UCS supplemental cooling</td>
<td>230</td>
<td>1</td>
<td>15</td>
<td>2.000</td>
<td>6.90</td>
</tr>
<tr>
<td>Truck Port</td>
<td>Evacuation/He Backfill</td>
<td>480</td>
<td>3</td>
<td>40</td>
<td>1.732</td>
<td>33.26</td>
</tr>
<tr>
<td>Truck Port</td>
<td>Evacuation/He Backfill</td>
<td>120</td>
<td>1</td>
<td>20</td>
<td>1.000</td>
<td>2.40</td>
</tr>
<tr>
<td>Truck Port</td>
<td>Evacuation/He Backfill</td>
<td>120</td>
<td>1</td>
<td>20</td>
<td>1.000</td>
<td>2.40</td>
</tr>
<tr>
<td>Truck Port</td>
<td>He Leak Detection System</td>
<td>120</td>
<td>1</td>
<td>10</td>
<td>1.000</td>
<td>1.20</td>
</tr>
<tr>
<td>Truck Port</td>
<td>TSC Cooling System</td>
<td>480</td>
<td>3</td>
<td>9</td>
<td>1.732</td>
<td>7.48</td>
</tr>
</tbody>
</table>

|                      | Total MCSC Project New Load | 140.29 |
|                      | WESF Loads Prior to Project W-130 | 548.50 |
|                      | Change to WESF Load from Project W-130 | 69.80 |
| Estimated Total WESF Load After W-130 and during MCSC Project | 758.59 |

|                      | WESF Canyon Load | 18.90 |
|                      | G-Cell Load      | 74.65 |
|                      | Truck Port Load  | 46.74 |

Overall, MCSC Project electrical loads by WESF area, as estimated in LEMS-MCSC-17-CAL-006, are listed in Table 4-5. (Note that the total electrical loads shown in Figure 4-9 and Table 4-5 are not exactly comparable due to rounding.)
Table 4-5. MCSC Project Electrical Loads by WESF Area

<table>
<thead>
<tr>
<th>Waste Encapsulation and Storage Facility Area</th>
<th>Electrical Load (kVA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canyon</td>
<td>19.5</td>
</tr>
<tr>
<td>G Cell</td>
<td>75</td>
</tr>
<tr>
<td>Truck Port</td>
<td>47</td>
</tr>
<tr>
<td>Total</td>
<td>141.5</td>
</tr>
</tbody>
</table>

4.4.1 Canyon and Truck Port Electrical Load Supply Methodology

The plan for the Canyon and Truck Port electrical loads is as follows:

- Use temporary 480-VAC, 30-kVA transformers (power carts) connected to Canyon welding receptacle WRCPT-225B-CAN-1 (Drawing H-2-96643 zone C4; see red-box on Figure 4-10) to furnish 480-VAC, 240-VAC, and 120-VAC power to MCSC Project equipment located in the Canyon.

- Use similar temporary transformers (power carts) connected to Service Gallery welding receptacle WRCPT-225B-SG-1 (Drawing H-2-96643 zone C4; see red box on Figure 10) to furnish power to MCSC Project equipment in the Truck Port.

Both of these welding receptacles draw from the same 100-amp circuit, as shown on H-2-96643, Sheet 1. Each power cart will draw 36-amps maximum; hence, the 100-amp circuit load limit will not be challenged. Information on power cart options is presented in Appendix E.

Per discussion in LEMS-MCSC-17-CAL-006, Section 4.3, WESF personnel have provided the following three alternatives for powering the total estimated 50-amp, 120-VAC load that will be required to support Truck Port operations:

1. Use an existing 480-VAC, 30-amp receptacle at the outside bridge crane to power outside equipment near the Truck Port via a power cart to supply the 120-VAC loads.

2. Use an existing 480-VAC welding receptacle in WESF Room 113 to feed a power cart in the Truck Port.

3. It may be possible to intercept an existing unused 480-VAC, 175-amp feeder on the WESF roof above the Truck Port, reroute via the Truck Port west wall, install a new 480-VAC receptacle in the Truck Port, and add a power cart to supply the 120-VAC loads.
4.4.2 G Cell Electrical Load Supply Methodology

The plan for the electrical loads in G Cell is as follows:

- Use two of the three available 480-VAC Operating Gallery welding receptacles, WRCPT-225B-OG-1 and WRCPT-225B-OG-2 (Drawing H-2-96643 zone B6-C6; see red box on Figure 4-11), one to power the USC evacuation/helium backfill pump and one to power the AWS GTAW welder. Each of these welding receptacles is on a separate 40-amp circuit. Both are located in close proximity to the hot cells at instrument panels C and F, respectively.

- Core drill one additional electrical nozzle from the Operating Gallery to G Cell for the requisite power cables.

- In-cell power is assumed to be provided from Service Gallery Lighting Panel E through existing spare G Cell nozzles; this needs to be verified and will depend on the final design of the CSS vendor equipment design for G Cell. If Lighting Panel E is not able to support the final design load for CSS equipment in G Cell, an alternate power source in either the Service or Operating Gallery will be used.
4.5 Other

4.5.1 Instrumentation

Instrumentation needs in G Cell are to be determined based on the CSS vendor equipment design. It has been assumed that two additional penetrations will be needed between the Operating Gallery and G Cell (see Section 4.3).

4.5.2 Compressed Air and Specialty Gases

4.5.2.1 Specialty Gases

Specialty gases (i.e., helium and argon) required for MCSC Project operations in G Cell and in the Truck Port will be fed from bottle racks in the Service Gallery. Tubing runs will be installed from the Service
Gallery to the Truck Port and G Cell. The tubing runs into G Cell will use existing Service Gallery nozzle penetrations.

### 4.5.2.2 Compressed Air

All needs other than the air pallet used to move the VCC into and out of the Truck Port can be met by the existing WESF air compressor and distribution system. The air pallet will be supplied by a dedicated trailer-mounted, diesel-run air compressor.

### 4.5.3 High Performance Sustainable Building

The MCSC Project design and construction activities will be performed in compliance with the requirements of DOE O 436.1, *Departmental Sustainability*, and the High Performance Sustainability Building requirements defined in Executive Order 13693, *Planning for Federal Sustainability in the Next Decade*. Applicability of these requirements to the MCSC Project is documented in CHPRC-03260, *MCSC Project (W135) Implementation of Guiding Principles for High Performance and Sustainable Buildings*. The implementation of these requirements for the WESF Modifications design and construction will be developed in later design phases as applicable.

### 5 Design Completion Strategy

This CDR reflects the conceptual nature of the MCSC Project at its present stage specific to the required WESF Modifications. The output of this CDR indicates that all significant modifications to WESF to accommodate the CSS components and their operation have been identified and viable and cost-effective concepts have been developed. The design and engineering path forward will consist primarily of adjustments to the concepts that may be required as the CSS design develops and refinements to the present thinking occur.

Major WESF upgrades beyond those to safely and compliantly conduct the loading operations have been avoided due to the relatively short duration of the loading operations and the fact that it is an end-of-life project for the facility. The below sections identify known remaining risk elements and recommendations for Preliminary and Final Design activities to reduce those risks.

#### 5.1 Identified Risk Elements

The following are areas of design risk that have been identified during this design phase that require mitigation during the following design evolutions for the project:

- When this conceptual design for the WESF modifications was developed, most of the CSS vendor-supplied equipment was in a pre-conceptual state of design. As a result, this CDR incorporates multiple assumptions that will require verification as the CSS vendor design progresses.

- Truck Port Floor – Only visual inspections have been performed on the existing truck port floor slab to access its condition. While the floor appears in good condition, if further physical examination of the floor and its subgrade indicate issues, there remains a risk that it would require complete removal and replacement.

- G-Cell HVAC needs – The heat load analysis performed during this conceptual design were based upon preliminary information provided by NAC on the G-Cell equipment usage and loading operations. LEMS-MCSC-17-CAL-005 does not address loss of ventilation power, possibly during UCS closer welding operations. This is a potential risk that may require further analysis of off-normal conditions related to G Cell cooling during preliminary or final design.
Utility needs in G-Cell and the Canyon for the CSS equipment have been based upon preliminary conceptual design information from NAC. While changes in these are not anticipated to have significant impacts, further definition of these utility needs from NAC will reduce risk.

CSS equipment dimensions and weights were based upon preliminary conceptual design information from NAC. Significant changes in these may impact the WESF Mods, particularly to the Truck Port.

G Cell Utility Service Connections – It has been assumed that the existing utility (electrical, air, instrument) are serviceable. We have identified the need for at least two additional penetrations from G Cell to the Service Gallery will be required. If this assumption is proven wrong through later testing of the service connections, there may need to have additional service penetrations installed.

The analysis of the capacity of existing WESF electrical panels for the utility needs of the CSS equipment was based upon the best information available to us at the time of the design. There is a need to more extensively review the existing available capacity of the existing electrical system at WESF based upon its very latest condition. Until this is done there remains a risk that additional electrical modifications may be required beyond those identified in this conceptual design to meet the system needs.

5.2 Recommendations for Preliminary and Final Design

When this conceptual design for the WESF modifications was developed, most of the CSS vendor-supplied equipment was in a pre-conceptual state of design. As a result, this CDR incorporates multiple assumptions that will require verification as the CSS vendor design progresses. Therefore, the design completion strategy should consider either a revision to this CDR or preparation of an advanced conceptual design report (ACDR) prior to commencing preliminary design. A revised CDR or an ACDR would thus incorporate updated information on CSS vendor equipment, as well as confirm current assumptions. The Preliminary Design phase for the WESF Mods needs to be fully in sync with the CSS design to ensure that the interface requirements for the CSS equipment are fully met with the WESF Mods design.

In addition to this the following additional recommendations are provided to occur during, or prior, to Preliminary Design:

- Perform core drilling of the Truck Port floor and testing of the cores for compressive strength. Additionally, core drill sufficiently into the subgrade material below the existing floor to verify that there are not any subgrade subsidence issues.
- Test and validate the existing G Cell service penetrations for serviceability for the CSS equipment needs.
- Validate the current WESF and B Plant electrical utility loads on the existing panels to validate that there is in-deed sufficient unused capacity to meet the CSS equipment needs.
- Perform further analysis of off-normal conditions related to G Cell cooling during preliminary or final design as appropriate. Safety SSC requirements, if any, will be identified during preliminary or final design.

6 References


Appendix A

Design Basis Inputs Matrix
<table>
<thead>
<tr>
<th>Number</th>
<th>System/Area</th>
<th>Input Needed</th>
<th>Value/Data Used</th>
<th>Source</th>
<th>Where Used or Needed</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>WESF Truck Port</td>
<td>VCC Dimensions and Loaded Weight</td>
<td>220,000 lb. 138 inches (11.5 ft) high. 120 inches (10 ft) in diameter.</td>
<td>Weight is from NAC Proposal, conservatively rounded up for design margin. Dimensions from NAC April 2017 design presentation</td>
<td>WESF Truck Port Slab-on-Grade Loading Calculation LEMS-MCSC-17-CAL-001; W135-WESF-SK-C-001</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>WESF Truck Port</td>
<td>Existing Floor Construction Details</td>
<td>Floor is 8&quot; of 3,000 psi concrete, with #4 rebar on 12&quot; centers, each way, each face</td>
<td>EI-2-66421</td>
<td>WESF Truck Port Slab-on-Grade Loading Calculation LEMS-MCSC-17-CAL-001; W135-WESF-SK-C-001</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>WESF Truck Port</td>
<td>Air Pallet specifications</td>
<td>10' x 10' square air pallet, American Solving MLS-48H air pallet rig set using four M1448H air bearings. 360,000 lb rated capacity. Air consumption 435 scfm at 64 psig. Effective lift 3. Lift Area (per bearing) 1369 in² per bearing. Air pallet weight 703 lbs.</td>
<td>American Solving air pallet vendor) &quot;Rig Set Modular Air Bearing System&quot; and &quot;The SOLVING Air-bearing Load Module&quot; vendor brochures</td>
<td>WESF Truck Port Slab-on-Grade Loading Calculation LEMS-MCSC-17-CAL-001; WESF Utility Evaluation in Conceptual Design Report; W135-WESF-SK-C-001</td>
<td>To be added as notes to drawing W135-WESF-SK-C-002. Include in Conceptual Design Report.</td>
</tr>
<tr>
<td>4</td>
<td>WESF Truck Port</td>
<td>Air Pallet required floor specifications</td>
<td>Machine trowled, exoxy treated concrete floor free from marks, pits, cracks, or flaking. Use of thin (~16 gauge) metal, vinyl floor sheeting, or masonite boards with smooth side up over concrete floor are acceptable. (Undulations &lt;25% of diameter of air cushion. Slope &lt;0.2%. Unevenness &lt;0.25&quot; per 10 feet. Floors airtight, expansion joints sealed with rubber-like urethane with shore hardness of ~80.</td>
<td>American Solving brochure &quot;Floor Conditions for Air Lift Transport&quot;</td>
<td>To be added as notes to drawing W135-WESF-SK-C-002. Include in Conceptual Design Report.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>WESF Truck Port</td>
<td>Electrical load requirements for Temporary Cooling System (TCS) in Truck Port</td>
<td>22 kW excess decay heat to be removed from Truck Port. VCC loaded with Sr capsules is bounding.</td>
<td>NAC Proposal value used for conservatism</td>
<td>WESF Electrical Load estimate LEMS-MSCS-17-CAL-006. WESF Utility Evaluation in Conceptual Design Report</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>WESF Canyon</td>
<td>Anticipated contamination levels in the canyon</td>
<td>Loose surface contamination levels &lt;1,000 dpm/cm² No respiratory protection required for a person-shift occupancy</td>
<td>CHPRC data provided 2/14/2017</td>
<td>MCS/SC Operations planning; ALARA evaluation</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Transfer Indexer/Apparatus</td>
<td>Building support system (e.g., power, air, water, ventilation) requirements.</td>
<td>The design of this item is still on-going. However, at a minimum 120VAC, single phase, minimum 20A service (minimum 2 sources) and Clean, oil free, filtered and dry compressed air - minimum 100 psi may be required. The requirements will be updated as the design becomes finalized</td>
<td>CHPRC / NAC input 2/14/2017</td>
<td>WESF Electrical Load estimate LEMS-MSCS-17-CAL-006. WESF Utility Evaluation in Conceptual Design Report</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Dry Transfer System (DTS)</td>
<td>Building support system (e.g., power, air, water, ventilation) requirements.</td>
<td>120VAC single phase, minimum 20A service, minimum two sources. Clean, oil free, filtered and dry compressed air - minimum 80 psi maximum 90 psig, with 10 SCFM flowrate</td>
<td>CHPRC / NAC input 2/14/2018</td>
<td>WESF Electrical Load estimate LEMS-MSCS-17-CAL-006. WESF Utility Evaluation in Conceptual Design Report</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Dry Transfer System (DTS)</td>
<td>Weight and dimensions</td>
<td>22,000 lb loaded DTS weight. This conservatively envelopes Table 4-3 of the NAC Design Specification, which has an estimated DTS empty weight of 16,000 lbs, plus 450 lbs for a loaded UCS, or a total of 16,450 lbs.</td>
<td>22,000 lb loaded weight estimate is based on empty weight of 21,000 lb given on NAC proposal drawing Dry Transfer Systems Hanford Operations plus weight of loaded UCS.</td>
<td>WESF Canyon Floor Loading Calculation LEMS-MSCS-17-CAL-005 for the DTS stand. WESF Canyon Crane Evaluation in Conceptual Design Report</td>
<td>A UCS loaded weight of 500 lbs has also been provided. Verify final UCS weight for preliminary design. Verify final DTS weight and stand dimensions for final design</td>
</tr>
</tbody>
</table>
## WESF Modifications - Design Basis Inputs Matrix

<table>
<thead>
<tr>
<th>Number</th>
<th>System/Area</th>
<th>Input Needed</th>
<th>Value/Data Used</th>
<th>Source</th>
<th>Where Used or Needed</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Modified G-Cell Coverblock</td>
<td>Building support system (e.g., power, air, water, ventilation) requirements.</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>The G-Cell Canyon Coverblock design modification has not yet been finalized. Operation of the moveable shielding door is not known at this time as it has not yet been designed. Will be picked up in preliminary design.</td>
</tr>
<tr>
<td>11</td>
<td>Canyon-Truck Port Isolation Barrier</td>
<td>Critical dimensions and facility interfaces</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>The Canyon-Truck Port Isolation Barrier design has not yet been finalized. Requirements are not available. Will be picked up in preliminary design.</td>
</tr>
<tr>
<td>12</td>
<td>WESF Canyon Crane</td>
<td>WESF Crane specifications</td>
<td>Bridge with top-running trolley, with 15T main hoist capacity and two auxiliary 1T hoists. Class &quot;C&quot; Moderate Service crane under EOCI-61.</td>
<td>Drawing H-2-66727; WESF Division X construction specification (HWS-8951)</td>
<td>Canyon Crane Evaluation in Conceptual Design Report</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>WESF Canyon Crane</td>
<td>WESF Crane camera specifications</td>
<td>Remote cameras are requested to provide overhead views of the crane hoist as well as overhead views of the work area in a minimum of 2 crossing directions to view both the length of the canyon and over the truck port block area such that a direct view downward of the work area can be achieved. Cameras should be color cameras with PTZ and auto-focus capable</td>
<td>CHPRC / NAC input 2/14/2017</td>
<td>Canyon Crane Evaluation in Conceptual Design Report</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>WESF Canyon Crane</td>
<td>Remote impact wrench requirements</td>
<td>A remote operated torque wrench will be used. Torque value has not been determined as the design has not been finalized. Once the design has been finalized, the required torque values will be documented and provided. For purposes of conceptual design, have assumed current Hanford-standard, crane hoist carried impact wrench will be used. 460V, 3 phase, 1.4 amp electrical power required.</td>
<td>CHPRC / NAC input 2/14/2017; HILine Drawing 1402-WRP-0418 and RPP-SPEC-56/192</td>
<td>WESF Electrical Load estimate LEMS-MSCS-17-CAL-006; WESF Utility Evaluation in Conceptual Design Report; Canyon Crane Evaluation in Conceptual Design Report</td>
<td></td>
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<tr>
<td>15</td>
<td>WESF Canyon Crane</td>
<td>Anticipated crane duty cycle</td>
<td>Detailed time and motion study for current CSS design not available. Table 3.3-4 of the NAC proposal implies a duty cycle of 26 hours of crane operations during each week of two-shift operations</td>
<td>CHPRC / NAC input 2/14/2017; NAC CSS proposal</td>
<td>Canyon Crane Evaluation in Conceptual Design Report</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>WESF Canyon Crane</td>
<td>Limit/stop devices requirements for crane lift height</td>
<td>Design requirements not available until CSS equipment design progresses. Table 3.2-2 of the NAC proposal, under &quot;Comments,&quot; notes that &quot;... transfer of the DTS within the canyon is limited to just a few inches of the canyon floor - limiting drop condition (may also install limiting/stop device above a certain height).&quot; Have assumed administrative controls for now.</td>
<td>CHPRC / NAC input 2/14/2017; NAC CSS proposal</td>
<td>None</td>
<td>Revisit need for engineered controls after design details are developed.</td>
</tr>
<tr>
<td>17</td>
<td>Automated Welding System</td>
<td>Automated Welding System description and building support system requirements</td>
<td>A Liburdi Dimetrics AWS will be used in G Cell. The system as identified at this time includes a Gold Track VI power supply, welding console and a camera system. The system is still under development and may change based on the final design of the system. The power supply selected for the AWS requires 480 VAC 30A 3 phase AC for optimum performance. The Welding Console requires 115VAC, single phase, 10A, and dry filtered and dry compressed air (min 80 max 100 psig). Cooling system requires 120VAC, single phase, 10A.</td>
<td>CHPRC / NAC input 2/14/2017</td>
<td>WESF Electrical Load estimate LEMS-MSCS-17-CAL-006; WESF G-Cell HVAC calculation LEMS MSCS-17-CAL-005; WESF Utility and G-Cell HVAC Evaluations in Conceptual Design Report</td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>System/Area</td>
<td>Input Needed</td>
<td>Value/Data Used</td>
<td>Source</td>
<td>Where Used or Needed</td>
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<td>--------</td>
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</tr>
<tr>
<td>18</td>
<td>UCS Capsule Upender / Welding Jig</td>
<td>Building support system (e.g., power, air, water, ventilation) requirements.</td>
<td>Design work for the Universal Capsule Sleeve Upender is still underway. Current preliminary design will require 120VAC, single phase, 10A service and dry, filtered and dry compressed air (min 80, max 100 psig up to 10 SCFM (flowrate) in G Cell</td>
<td>CHPRC / NAC input 2/14/2017</td>
<td>WESF Electrical Load estimate LEMS-MSCS-17-CAL-006. WESF G-Cell HVAC calculation LEMS MSCS-17-CAL-005. WESF Utility and G-Cell HVAC Evaluations in Conceptual Design Report</td>
<td>Confirm estimated weights and dimensions when NAC design details are available</td>
</tr>
<tr>
<td>19</td>
<td>UCS Capsule Upender / Welding Jig</td>
<td>Dimensions and weight</td>
<td>Design work for the Universal Capsule Sleeve Upender is still underway. Weight and dimensions estimated based on NAC concept sketches</td>
<td>NAC design presentation April 2017</td>
<td>WESF G Cell Floor load calculation (LEMS-MSCS-17-CAL-002); WESF G Cell Evaluation in Conceptual Design Report</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>UCS Evacuation/He Backfill System</td>
<td>Building support system (e.g., power, air, water, ventilation) requirements.</td>
<td>The evacuation system will require 480 VAC 3 phase minimum 40A (1 source) and 120VAC single phase minimum 20 A service (2 sources). The Helium backfill system will consist of tubing, instrumentation and gas manifold system supplying Ultra High Purity Helium from a bottle bank of 6 bottles of Ultra High Purity helium to be connected to the manifold. Evacuation and backfill systems will be required in both G Cell and the Truck Port.</td>
<td>CHPRC / NAC input 2/14/2017; NAC design presentation April 2017</td>
<td>WESF Electrical Load estimate LEMS-MSCS-17-CAL-006. WESF G-Cell HVAC calculation LEMS MSCS-17-CAL-005. WESF Utility and G-Cell HVAC Evaluations in Conceptual Design Report</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>He Leak Detection System</td>
<td>Building support system (e.g., power, air, water, ventilation) requirements.</td>
<td>Helium leak detection will be performed using a remote operated MSLD which requires 120VAC single phase10A minimum (1 source). Leak check systems will be required in both G Cell and the Truck Port.</td>
<td>CHPRC / NAC input 2/14/2017; NAC design presentation April 2017</td>
<td>WESF Electrical Load estimate LEMS-MSCS-17-CAL-006; WESF Utility Evaluation in Conceptual Design Report</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>TSC/UCS Cooling System (G Cell)</td>
<td>Building support system (e.g., power, air, water, ventilation) requirements.</td>
<td>The design work is still underway for cooling system. Once the design has become finalized, the requirements will be provided. A cooling system will be required during the sealing and processing activities of the Universal Capsule Shelves and while the Universal Capsule Shelves are waiting to be retrieved by the DTS for transfer to the TSC. The cooling system will be in the G-Cell with heat rejected to the G-Cell area ventilation system. Alternatively, placement of the heat rejection system may be placed in outside of the G-Cell with the necessary lines passed thru existing approved wall penetrations</td>
<td>CHPRC/NAC CD Review meeting, 4/11/2017</td>
<td>WESF Electrical Load estimate LEMS-MSCS-17-CAL-006. WESF G-Cell HVAC calculation LEMS MSCS-17-CAL-005. WESF Utility and G-Cell HVAC Evaluations in Conceptual Design Report</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>TSC/UCS Cooling System (Truck Port)</td>
<td>Building support system (e.g., power, air, water, ventilation) requirements.</td>
<td>The 22kW will be rejected from the TSC while in the Truck Port area. Additionally, capsules will reject heat to the G-Cell area until loaded into the Universal Capsule Sleeve. Once loaded, the capsules will reject heat to the Universal Capsule Sleeve which will reject heat to the cooling system in the G-Cell. The cooling system will reject heat to the G-Cell. Once the Universal Capsule Sleeve has been sealed and processed, the Universal Capsule Sleeve will be loaded into the Dry Transfer System which will reject heat to the surrounding area in the Canyon. Once the DTS has been relocated to the Truck Port, heat will then be rejected to the Truck Port area until the Universal Capsule Sleeve is transferred to the designated TSC Cell. Once sealed, the TSC will receive heat from the Universal Capsule Sleeve and reject that heat to the Truck Port area.</td>
<td>CHPRC/NAC CD Review meeting, 4/11/2017</td>
<td>WESF Electrical Load estimate LEMS-MSCS-17-CAL-006. WESF G-Cell HVAC calculation LEMS MSCS-17-CAL-005. WESF Utility and G-Cell HVAC Evaluations in Conceptual Design Report</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>G Cell Manipulators</td>
<td>UCS dimensions and weight</td>
<td>Current design parameters of the 6 capsule UCS are: Diameter = 6.5&quot; Overall Length/Height = 49 inches Estimated Loaded Weight = 300 lbs (Note - differs from 450lbs provided previously)</td>
<td>CHPRC 2/14/17 responses</td>
<td>None. CSS Vendor equipment to be designed around manipulator capabilities</td>
<td>Verify final UCS weight for preliminary design</td>
</tr>
</tbody>
</table>
### WESF Modifications - Design Basis Inputs Matrix

<table>
<thead>
<tr>
<th>Number</th>
<th>System/Area</th>
<th>Input Needed</th>
<th>Value/Data Used</th>
<th>Source</th>
<th>Where Used or Needed</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>G Cell Manipulators</td>
<td>Anticipated manipulator activities and duty requirements</td>
<td>At a minimum, Manipulators will be used to load the capsules into the Universal Capsule Sleeves. Additional activities that the Manipulators would be used for are still being determined and will depend greatly on the capabilities and reliability of the manipulators. Assume NAC Proposal Table 3.3-4 duty cycle of 30 h/wk.</td>
<td>CHPRC/NAC inputs 2/14/2017; NAC Proposal Table 3.3-4</td>
<td>None. CSS Vendor equipment to be designed around manipulator capabilities</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Pool Cell to G Cell Transfers</td>
<td>Anticipated transfer rates from pool cell area via capsule transfer chute</td>
<td>6-7 capsules per 1.5 h</td>
<td>CHPRC/NAC inputs 2/14/2017; NAC Proposal Table 3.3-4</td>
<td>None. CSS Vendor equipment to be designed around capsule transfer chute capabilities</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>G Cell HVAC</td>
<td>Post W-130 system specifications</td>
<td>Up to 300 CFM (nominal 140 CFM) air supplied from WESF Canyon to G-Cell at 75°F</td>
<td>CHPRC-02411; H-2-836672; VI-11-000023</td>
<td>G Cell Heat Balance Calculation for MCSC Project (LEMS-MCSC-17-CAL-005); WESF G Cell HVAC Evaluation in Conceptual Design Report</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>G Cell HVAC</td>
<td>G Cell concrete thermal conductivity</td>
<td>1.95 (hr-ft²-oF)/BTU</td>
<td>VI-11-000023</td>
<td>G Cell Heat Balance Calculation for MCSC Project (LEMS-MCSC-17-CAL-005); WESF G Cell HVAC Evaluation in Conceptual Design Report</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>G Cell HVAC</td>
<td>G Cell heat sources</td>
<td>6 x 500W incandescent lights. 3 kW arc power for AWS. Approx. 4 kW from 12 strontium capsules</td>
<td>H-2-66766; Stenbacka 2013; CHPRC-02248.</td>
<td>G Cell Heat Balance Calculation for MCSC Project (LEMS-MCSC-17-CAL-005); WESF G Cell HVAC Evaluation in Conceptual Design Report</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>WESF Electrical System</td>
<td>Current loads, and anticipated loads after Project W-130 is completed</td>
<td>WESF Loads prior to Project W-130 = 548.5 kVA; Loads added due to Project W-130 = 69.8 kVA</td>
<td>CHPRC-02424; CHPRC-02426</td>
<td>WESF MCSC Electrical Load Calculation (LEMS-MCSC-17-CAL-006); WESF Utilities Evaluation in Conceptual Design Report</td>
<td></td>
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<tr>
<td>32</td>
<td>WESF Electrical System</td>
<td>Current electrical supply</td>
<td>2 x 750 kVA transformers in Substation C8-S26</td>
<td>CHPRC-02424</td>
<td>WESF MCSC Electrical Load Calculation (LEMS-MCSC-17-CAL-006); WESF Utilities Evaluation in Conceptual Design Report</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>WESF Electrical System</td>
<td>Power distribution system</td>
<td>Location/capacity of lighting panels and welding receptacles</td>
<td>CHPRC-02424; H-2-96643</td>
<td>WESF MCSC Electrical Load Calculation (LEMS-MCSC-17-CAL-006); WESF Utilities Evaluation in Conceptual Design Report</td>
<td></td>
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<tr>
<td>34</td>
<td>WESF Compressed Air System</td>
<td>Compressed air distribution system</td>
<td>Location/capacity of compressed air system outlets</td>
<td>H-2-96494</td>
<td>WESF Utilities Evaluation in Conceptual Design Report (see Slide 51 in presentation)</td>
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<tr>
<td>Number</td>
<td>System/Area</td>
<td>Input Needed</td>
<td>Value/Data Used</td>
<td>Source</td>
<td>Where Used or Needed</td>
<td>Comments</td>
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<td>----------------------------------------------------------------------------------------------------</td>
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<td>----------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------</td>
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<tr>
<td>35</td>
<td>G Cell Service Nozzles</td>
<td>Types of nozzles available</td>
<td>Types of nozzles available, and location (service gallery or operating gallery)</td>
<td>H-2-84586</td>
<td>WESF Utilities Evaluation in Conceptual Design Report</td>
<td></td>
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<tr>
<td>36</td>
<td>WESF G Cell</td>
<td>Floor Loading Limits</td>
<td>Safe live load limit = 1,300 lb/ft²</td>
<td>SD-WM-DA-031</td>
<td>WESF G Cell Floor load calculation (LEMS-MCSC-17-CAL-002); WESF G Cell Evaluation in Conceptual Design Report</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>WESF G Cell Shielded Storage</td>
<td>Dimensions and weight</td>
<td>Design work for the shielded storage location is still underway. Weight and dimensions estimated based on NAC concept sketches and capsule properties</td>
<td>NAC design presentation April 2017</td>
<td>WESF G Cell Floor load calculation (LEMS-MCSC-17-CAL-002); WESF G Cell Evaluation in Conceptual Design Report</td>
<td>Confirm estimated weights and dimensions when NAC design details are available</td>
</tr>
</tbody>
</table>
Appendix B
Calculations

LEMS-MCSC-17-CAL-001, Scoping Analysis of WESF Truck Port Floor for MCSC Project
Equipment Loading .............................................................. B-2

LEMS-MCSC-17-CAL-002, Scoping Analysis of WESF G Cell Floor for MCSC Project
Equipment Loading .............................................................. B-25

LEMS-MCSC-17-CAL-003, Scoping Analysis of WESF Canyon Floor for MCSC Project
Equipment Loading .............................................................. B-49

LEMS-MCSC-17-CAL-005, G Cell Heat Balance Calculation for MCSC Project ............ B-59

LEMS-MCSC-17-CAL-006, WESF Electrical Loads for MCSC Project ..................... B-76
## Calculation Note and Peer Review

### Project: MGSC Project

### Discipline: Structural

### Structure or System: WESF Truck Port Floor

### Subject: Scoping Analysis of Waste Encapsulation and Storage Facility (WESF) Truck Port floor for MGSC Project Equipment Loading

| Completed by: | Date: 6/30/17 |
| Checked by: | Date: 6/30/17 |
| Approved by (Name or Department Manager): | Date: 7/9/17 |

### Distribution:

<table>
<thead>
<tr>
<th>Reason for Revision:</th>
<th>Total number of sheets in this issue: 24</th>
</tr>
</thead>
</table>

**Problem Statement:**
The existing concrete slab-on-grade floor in the WESF Truck Port needs to be evaluated for its ability to sustain the loads imposed by a loaded MGSC Project loaded Vertical Concrete Cast (VCC) loaded on an air pallet. If the existing floor is determined to be unable to sustain the load without unacceptable cracking an evaluation of what modifications to the Truck Port floor can be implemented to sustain the expected load.

**Summary Conclusions:**
The existing 8" concrete slab was determined not to be adequate to sustain the expected loading without unacceptable cracking failure.

An additional reinforced concrete layer of 10" (18" total) poured on top of the existing floor with adequate preparation of the existing floor will be adequate to support the expected loading without unacceptable cracking.

**Design Basis:**
NA – this is not a design basis calculation.
Calculations

Performed by:

Meier
ARCHITECTURE • ENGINEERING

for

Lucas Engineering and Management Services, Inc.
P. O. Box 1350
3160 George Washington Way, SIGMA III Bldg.
Richland, WA 99352

Prepared by: Date: 6/8/17
Reviewed by: Date: 6/8/17
Approved by: Date: 6/9/17
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2.0 REFERENCES ......................................................................................... 3  
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   3.3 Assumptions ......................................................................................... 3  
   3.4 Results of Existing Slab ..................................................................... 3  
   3.5 Results of Existing Slab Analysis .......................................................... 4  
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1.0 PURPOSE AND SCOPE

To determine the adequacy of an existing WESF Truck Port floor concrete slab-on-grade to support the estimated loading of an air-pallet carrying a fully loaded Vertical Concrete Cask (VCC) without sustaining unacceptable cracking. This is a scoping level analysis in support of a conceptual design.

2.0 REFERENCES

ACI 318-14, Building Code Requirements for Structural Concrete, American Concrete Institute, 2014.
ACI 360R-10, Guide to Design of Slabs-on-Ground, American Concrete Institute, 2010.
Ringo, Boyd C., and Robert B. Anderson, Designing Floor Slabs on Grade, 1992.

Drawings:
   a. H-2-66421, Revision 3, Structural, Foundation & Floor Plan, Area 3
   b. H-2-66422, Revision 3, Structural, Sections, Area 3

3.0 PROCEDURE

3.1.1 Purpose

To determine the adequacy of an existing WESF Truck Port 8" concrete slab on grade to withstand loading due to an air pallet carrying a loaded VCC without damage to the existing slab or support structure. If not adequate, identify through analysis modification of the existing slab-on-grade to meet the load requirements.

3.1.2 Inputs

- Future cask weighs 220,000 pounds (This includes an additional 10% allowance on the current estimated weight of 200,000 pounds to account for a potential accidental drop of the Dry Transfer System (DTS) from the canyon hoist on top of the VCC while loading)
- The air pallet weighs 703 pounds
- There are (16) casks to be moved into the TP for loading and then out for transfer to the Capsule Storage Area.

3.1.3 Assumptions

- Concrete is in good/undamaged condition (this is based upon visual inspections of the floor.
- Drawings are accurate of installed conditions
- The air pallet consists of (4) American Solving Inc. ML 48H air-bearings. Each air-bearing is 48" square with a lift area of 1369 in² and a resting area of 558 in². Air pallet measures 10'x10' square, in plan, when assembled. See Attachment B.

Note: These assumptions will need to be verified in later design evolutions of the project.

3.1.4 Results of Existing Slab

Five different methodologies were utilized in this analysis and they are each described in the Attachment to this calculation.
The results of the existing 8" slab are as follows:
- Case I: FAIL
- Case II: PASS
- Case III: FAIL
- Roark’s Method: FAIL
- FEA Analysis: FAIL

3.1.5 Results of Existing Slab Analysis

We have found that the existing 8” concrete slab will likely be damaged during the moving of the casks via the air pallet as proposed. Further precautionary steps should be reviewed and analyzed to prevent damage to the existing slab.

3.1.6 Recommended Next Steps

1. The existing slab should have the edges separated from the side walls to prevent tension stress cracking at the walls. This should be achieved by cutting a straight line 4” from the walls that are 12-5” apart. The cut shall extend the full length of the slab from the door way to the back wall. This will leave a section of slab that is 11’-9” wide.

2. Core samples should be taken and tested to verify the concrete strength. The samples shall be taken from the portion of the slab that is not part of the 11’-9” strip.

3. The surface of the 11’-9” strip shall be roughened with a ¼” amplitude and treated with a bonding agent.

4. A new 10’ 4000 psi concrete slab shall be poured over the existing concrete 11’-9” strip. A layer of #4 bars, 1-1/2” clear of the top face, shall be placed in the new slab with a 12” center-to-center spacing each way.

5. The air-pallets shall be operated in a fashion that keeps the cask centered on the 11’-9” strip. Moving the air pallet to the long edges of the slab shall be avoided.

3.1.7 Results of Remediated Slab Analysis

A Finite Element Analysis (FEA) was performed. The methodology of the analysis was one that is conservative in nature to establish a bounding case for required floor slab thickness. The results of the existing slab are as follows:
- FEA Analysis: PASS

3.1.8 Scoping Calculation Conclusions

We have found that the remediated, 18” total slab thickness, concrete slab-on-grade will be adequate during the operation of the casks via the air pallet as proposed.

3.1.9 Software

- MathCad 15 (independently checked by hand calculations)
- RISA 3D
- CPU: Windows 10 Pro 64-bit, Intel Core i7-4790 CPU @ 3.60 GHz 3.60 GHz, 16.0 GB Ram

Note: No V&V of the software was performed due to these being scoping level calculations and are not a basis of design for Preliminary or Final Design.

4.0 LIST OF ATTACHMENTS

Attachment A – Truck Port Loading Analysis
Attachment B – Air Pallet Information
ATTACHMENT A:
TRUCK PORT LOADING ANALYSIS
A.1 DESCRIPTION

The Truck Port floor is an 8" concrete slab-on-grade with #4 bars spaced at 12" on center each way top and bottom. An air-pallet will be used to move a cask across the floor. The purpose of this calculation is to ensure that the existing floor slab is not damaged during loading. This calculation will compare the demand loads against the cracking strength of the concrete slab to ensure that no damage is accrued during the operation of the air-pallet. The slab is considered unreinforced to ensure the slab is not damaged during operation. Analysis of slab capacity will be determined by several methods and considering different conditions per section A.4.

A.2 EXISTING PROPERTIES

Concrete strength of existing slab-on-grade [Drawings]

\[ f_c = 3000 \text{psi} \]

Modulus of elasticity of existing slab-on-grade [ACI 318]

\[ E_c = 57000 \times \sqrt{f_c} \cdot 1\text{psi} = 3.12 \times 10^6 \text{psi} \]

Modulus of rupture of existing slab-on-grade [PCA]

\[ f_r = 9 \sqrt{f_c} \cdot 1\text{psi} = 492.95 \text{psi} \]

Steel tie and dowel strength [Drawings]

\[ f_Y = 40 \text{ksi} \]

Allowable soil bearing pressure [Drawings]

\[ q_{bp} = 4000 \text{psf} \]

Soil subgrade modulus based on clean gravel (GW/GP) [ACI 300]

\[ k = 300 \text{pci} \]

Thickness of existing slab-on-grade [Drawings]

\[ t_{slab} = 8 \text{in} \]

Stress ratio (for 30 cycles, this is conservative as the actual cycles are 13) [ACI 300]

\[ SR = 0.85 \]

Joint factor (for dowel connections) [PCA]

\[ JF = 1.1 \]

Allowable compressive stress [ACI 318 & PCA]

\[ f_{ec} = \frac{0.85 f_c \cdot SR}{JF} = 1970.45 \text{psi} \]

Allowable tensile stress (working stress) [PCA]

\[ f_{et} = \frac{f_r \cdot SR}{JF} = 380.92 \text{psi} \]
A3 LOADING PROPERTIES

Weight of cask (provided) \( P_{\text{cask}} = 220 \text{kip} \)

Weight of air pallet \( P_{\text{ap}} = 703 \text{lbf} \)

Impact factor (10% of gravity) \( D_I = 1.1 \)

Estimated loaded weight of the air-pallet \( P = (P_{\text{cask}} + P_{\text{ap}})D_I = 242.77 \text{kip} \) USE \( P_T = 245 \text{kip} \)

Loaded square dimension of air pallet \( b_{\text{ap}} = 120 \text{in} \)

Poisson's ratio for concrete [ACI 360] \( \nu = 0.15 \)

Equivalent radius of load \( a = 67.70 \text{in} \)

A4 ANALYSIS

A4.1 CASE I: LOAD CLOSE TO CORNER OF LARGE SLAB

This case considers the load close to a corner of the slab, either at a control/construction joint or at a free edge per the methodology described in ACI 360 in accordance with the Westergaard methodology.

Radius of relative stiffness [ACI 360] \( \ell_R = \left[ \frac{E_c t_{\text{slab}}^3}{12 (1 - \nu^2) k} \right]^{\frac{1}{4}} = 2.16 \text{ ft} \)

Tensile stress at the top surface [ACI 360] \( f_t = \frac{3 P_T}{t_{\text{slab}}^2} \left[ 1 - \left( \frac{a - \nu 2^0.5}{L_T} \right)^2 \right] = -13445 \text{ psi} \)

If \( f_t < f_{\text{ac}} \) "ADEQUATE", "FAIL" = "ADEQUATE"

If \( |f_t| < f_{\text{ac}} \) "ADEQUATE", "FAIL" = "FAIL"

Note, the slab stress is negative representing a compressive stress. The compressive stress exceeds the allowable capacity and is therefore NOT ADEQUATE for this loading condition.
A.4.2 CASE II: LOAD CONSIDERABLE DISTANCE FROM EDGES OF SLAB

This case considers the load near the middle of the slab per the methodology described in ACI 360 in accordance with the Westergaard methodology.

Tensile stress at the bottom surface [ACI 360]

\[
f_{b_{II}} = 0.316 \frac{Pr}{t_{slab}} \left( \log \left( \frac{t_{slab}}{1 \text{ in}} \right)^3 \right) - 4 \log \left( \frac{1.6}{1 \text{ in}^2} + \frac{t_{slab}}{1 \text{ in}^2} - 0.675 \frac{t_{slab}}{1 \text{ in}} \right) - \log \left( \frac{k}{1 \text{ psf}} \right) + 6.48 \]

\[= -1105 \text{ psi} \]

A.4.2 CASE II: LOAD CONSIDERABLE DISTANCE FROM EDGES OF SLAB

if \((f_{b_{II}} < f_{lt}, \text{"ADEQUATE", "FAIL"}) = \text{"ADEQUATE"} \]

if \((f_{b_{II}} < f_{ac}, \text{"ADEQUATE", "FAIL"}) = \text{"ADEQUATE"} \]

Note, the slab stress is negative representing a compressive stress. The compressive stress does not exceed the allowable capacity and is therefore ADEQUATE for this loading condition.

A.4.3 CASE III: LOAD AT EDGE OF SLAB BUT NOT AT CORNER

This case considers the load close to the edge of the slab, either at a control/construction joint or at a free edge, but not near the corner of the slab per the methodology described in ACI 360 in accordance with the Westergaard methodology.

Tensile stress at the bottom surface [ACI 360]

\[
f_{b_{III}} = 0.572 \frac{Pr}{t_{slab}} \left( \log \left( \frac{t_{slab}}{1 \text{ in}} \right)^3 \right) - 4 \log \left( \frac{1.6}{1 \text{ in}^2} + \frac{t_{slab}}{1 \text{ in}^2} - 0.675 \frac{t_{slab}}{1 \text{ in}} \right) - \log \left( \frac{k}{1 \text{ psf}} \right) + 5.77 \]

\[= -3555 \text{ psi} \]

if \((f_{b_{III}} < f_{lt}, \text{"ADEQUATE", "FAIL"}) = \text{"ADEQUATE"} \]

if \((f_{b_{III}} < f_{ac}, \text{"ADEQUATE", "FAIL"}) = \text{"FAIL"} \]

Note, the slab stress is negative representing a compressive stress. The compressive stress exceeds the allowable capacity and is therefore NOT ADEQUATE for this loading condition.
A.4.4 ROARK’S METHOD FOR BEAM ON ELASTIC FOUNDATION

Treat the slab as a beam that spans between walls. The slab is pinned to each wall per the original construction drawings. The following method is per Roark’s Guide Table 8.3 Case 2 with Left Edge Simply Supported and the Right Edge Fixed. The left edge models the connection at the wall and the right edge models the fixed nature of the slab. The figure in Roark’s represents half of the loading, with the other half distributing to the wall. Both cases are checked in the following pages. See Figure A.4.4-1 for the slab and the considered loading.

![Diagram of considered beam](image)

**Figure A.4.4-1 Considered Beam**

Uniformly distributed load

\[ w = \frac{P_r}{b_{bp}} = 24500 \text{ plf} \]

Thickness of slab

\[ t_y = 8\text{ in} \]

Effective width of slab [Ringo]

\[ b_w = b_{bp} + 2 \cdot t_y = 11.33 \text{ ft} \]

Effective moment of inertia of slab

\[ I_c = \frac{1}{12} b_w t_y^3 = 5803 \text{ in}^4 \]

A.4.4.1 DIRECTION 1

Length of span 1

\[ L_1 := \text{12 ft} + 3 \text{in} \]

Clear distance for span 1

\[ a_1 := \frac{b_{ap}}{2} = 7.25 \text{ ft} \]

Longitudinal distance along span 1 (by manual seeking 9.1 ft determined to produce the greatest tensile stress)

\[ x_1 := 9.1 \text{ ft} \]

Characteristic value for analysis

\[ \beta = \left( \frac{b_{ap}}{4E_c I_c} \right)^{1/3} = 0.33 \left( \frac{1}{\text{ft}} \right) \]

Analysis constant

\[ C_{1-1} := \cosh(\beta L_1) \cos(\beta L_1) = -17.76 \]

Analysis constant

\[ C_{2-1} := \cosh(\beta L_1) \sin(\beta L_1) + \sinh(\beta L_1) \cos(\beta L_1) = -39.46 \]

Analysis constant

\[ C_{3-1} := \sinh(\beta L_1) \sin(\beta L_1) = -21.69 \]

Analysis constant

\[ C_{4-1} := \cosh(\beta L_1) \sin(\beta L_1) - \sinh(\beta L_1) \cos(\beta L_1) = -3.99 \]

Analysis constant

\[ C_{13-1} := \cosh(\beta L_1) \sinh(\beta L_1) - \cos(\beta L_1) \sin(\beta L_1) = 785.66 \]

Analysis constant

\[ C_{81-1} := \cosh[\beta (L_1 - a_1)] \cos[\beta (L_1 - a_1)] = -2.0 \]

Analysis constant

\[ C_{94-1} := \cosh[\beta (L_1 - a_1)] \sin[\beta (L_1 - a_1)] - \sinh[\beta (L_1 - a_1)] \cos[\beta (L_1 - a_1)] = 2.86 \]

Analysis constant

\[ C_{a5-1} := 1 - C_{a1-1} = 1.20 \]

Function 1

\[ F_{1-1} := \cosh(\beta x_1) \cos(\beta x_1) = -9.87 \]

Function 2

\[ F_{2-1} := \cosh(\beta x_1) \sin(\beta x_1) + \sinh(\beta x_1) \cos(\beta x_1) = -8.32 \]

Function 3

\[ F_{3-1} := \sinh(\beta x_1) \sin(\beta x_1) = 1.49 \]
A.4.4.1 DIRECTION 1. CONTINUED

Function 4

\[ F_{A-1} := \cosh(\beta \cdot x_1) \sin(\beta \cdot x_1) - \sinh(\beta \cdot x_1) \cos(\beta \cdot x_1) = 11.31 \]

Function 3a (Note: for \( x < a \), Function equals 0, therefore the only critical sections of \( x \) are for \( x > a \))

\[ F_{A3-1} := \sinh(\beta \cdot (x_1 - a_1)) \sinh(\beta \cdot (x_1 - a_1)) = 0.37 \]

Moment at left end

\[ M_{A1} := 0 \]

Deflection at left end

\[ \gamma_{A1} := 0 \]

Reaction at left end

\[ R_{A1} := \frac{w}{2 \cdot \beta} \left( C_{2A} \cdot C_{a1} - 2 \cdot C_{1A} \cdot C_{a5} \right) \]

Rotation at left end

\[ \theta_{A1} := \frac{w}{4 \cdot E_c \cdot l_c \cdot \beta^3} \left( 2 \cdot C_{3A} \cdot C_{a5} - C_{4A} \cdot C_{a4} \right) \]

Bending moment at \( x \)

\[ M_{A1} := M_{A1} \cdot F_{A-1} + \frac{R_{A1}}{2 \cdot \beta} \cdot F_{Z-1} - \gamma_{A1} \cdot 2 \cdot E_c \cdot l_c \cdot \beta^2 \cdot F_{3-1} - \theta_{A1} \cdot E_c \cdot l_c \cdot \beta \cdot F_{4-1} - \frac{w}{2 \cdot \beta^2} \cdot F_{A3-1} = 401 \text{ kip} \cdot \text{in} \]

Flexural stress at \( x \)

\[ f_{x1} := \frac{M_{x1}}{\frac{2}{l_c}} = 277 \text{ psi} \]

If \( (x_1 < f_{gt}, "\text{PASS}"), "\text{FAIL}" ) = "\text{PASS}"
A.4.4.2 DIRECTION 2

Length of span 2

\[ L_2 := 5\text{ft} + 8\text{in} \]

Clear distance for span 2

\[ s_2 := \frac{b_{ap}}{2} \]

Longitudinal distance along span 2 (by manual seeking. 2.7 ft determined to produce the greatest tensile stress)

\[ x_2 := 2.7\text{ft} \]

Characteristic value for analysis

\[ \beta = 0.33 \text{ft} \]

Analysis constant

\[ C_{1.2} := \cosh(\beta \cdot L_2) \cdot \cos(\beta \cdot L_1) = -2.09 \]

Analysis constant

\[ C_{2.2} := \cosh(\beta \cdot L_2) \cdot \sin(\beta \cdot L_2) + \sinh(\beta \cdot L_2) \cdot \cos(\beta \cdot L_2) = 2.25 \]

Analysis constant

\[ C_{3.2} := \sinh(\beta \cdot L_2) \cdot \sin(\beta \cdot L_2) = 3.01 \]

Analysis constant

\[ C_{4.2} := \cosh(\beta \cdot L_2) \cdot \sin(\beta \cdot L_2) - \sinh(\beta \cdot L_2) \cdot \cos(\beta \cdot L_2) = 4.06 \]

Analysis constant

\[ C_{13.2} := \cosh(\beta \cdot L_2) \cdot \sinh(\beta \cdot L_2) - \cos(\beta \cdot L_2) \cdot \sin(\beta \cdot L_2) = 10.64 \]

Analysis constant

\[ C_{31.2} := \cosh[\beta \cdot (L_2 - a_2)] \cdot \cos[\beta \cdot (L_2 - a_2)] = -0.20 \]

Analysis constant

\[ C_{34.2} := \cosh[\beta \cdot (L_2 - a_2)] \cdot \sin[\beta \cdot (L_2 - a_2)] - \sinh[\beta \cdot (L_2 - a_2)] \cdot \cos[\beta \cdot (L_2 - a_2)] = 2.86 \]

Analysis constant

\[ C_{35.2} := 1 - C_{31.2} = 1.20 \]

Function 1

\[ F_{1.2} := \cosh(\beta \cdot x_2) \cdot \cos(\beta \cdot x_2) = 0.30 \]

Function 2

\[ F_{2.2} := \cosh(\beta \cdot x_2) \cdot \sin(\beta \cdot x_2) + \sinh(\beta \cdot x_2) \cdot \cos(\beta \cdot x_2) = 1.74 \]

Function 3

\[ F_{3.2} := \sinh(\beta \cdot x_2) \cdot \sin(\beta \cdot x_2) = 0.76 \]

Function 4

\[ F_{4.2} := \cosh(\beta \cdot x_2) \cdot \sin(\beta \cdot x_2) - \sinh(\beta \cdot x_2) \cdot \cos(\beta \cdot x_2) = 0.46 \]
A.4.4.2 DIRECTION 2, CONTINUED

Function 3a (Note: for x≤a, Function equals 0, therefore the only critical sections of x are for x>a)

\[ f_{a3\_2} = \sinh \left[ \beta (x_2 - a_2) \right] \sin \left[ \beta (x_2 - a_2) \right] = 0.45 \]

Moment at left end

\[ M_{A2} = 0 \]

Deflection at left end

\[ y_{A2} = 0 \]

Reaction at left end

\[ R_{A2} = \frac{w \ C_{2,2} C_{a4,2} - C_{1,2} C_{a5,2}}{2 \beta C_{13,2}} = 40037 \text{ lb} \]

Rotation at left end

\[ \theta_{A2} = \frac{w \ 2 C_{3,2} C_{a5,2} - C_{4,2} C_{a4,2}}{4 E_c I_c \beta^3 C_{13,2}} = -5.69 \times 10^{-4} \]

Bending moment at x

\[ M_{x2} = M_{A2} F_{2,2} + \frac{R_{A2}}{2 \beta} F_{2,2} - y_{A2} \cdot E_c I_c \beta^2 F_{3,2} - \theta_{A2} E_c I_c \beta F_{4,2} - \frac{w}{2 \beta^3} F_{a3,2} = 795 \text{ kip-in} \]

Flexural stress at x

\[ f_{x2} = \frac{M_{x2}}{\frac{210}{t_0}} = 548 \text{ psi} \]

if \( f_{x2} < f_{\text{st}} \), "PASS", "FAIL" = "FAIL"

A.4.4.3 REACTION AT WALL

The connection at the adjacent walls is made with (1)#4 dowels at 12"c/c. This check ensures that the dowels will not fail due to the reaction at the walls and thereby cause damage.

Area of resisting dowels

\[ A_0 = 0.20 \text{ in}^2 / \text{ft} \quad b_w = 2.27 \text{ in}^2 \]

Max reaction at the wall

\[ R_r = \max \left( R_{A1} , R_{A2} \right) = 40.04 \text{ kip} \]

Allowable shear strength of #4 dowel [AISC]

\[ R_{av} = \frac{6.45 - F_y A_b}{2.0} = 20.40 \text{ kip} \]

if \( R_{av} > R_r \), "PASS", "FAIL" = "FAIL"

A.4.4.4 SECTION CONCLUSION

The long span (span 1) was determined to be ADEQUATE for the loading. The short span (span 2) was determined to be NOT ADEQUATE for the loading. The reaction at the wall was determined to be NOT ADEQUATE for the loading.

A.4.5 FINITE ELEMENT ANALYSIS OF PLATE ON ELASTIC FOUNDATION

RISA 3D is utilized in the following section to more accurately define and analyze the existing slab on grade. A plate model was generated with a refined mesh size of approximately 2" square were used. The supports were modeled as a spring with the soil stiffness of 300 psi being utilized.

Figure A.4.5-1 shows the loading of the 8" slab. Figure A.4.5-2 shows the resulting plate stresses from the analysis.

The maximum stresses in the slab are 1557 psi which exceeds the allowable stress of 380 psi, therefore the slab is shown to be NOT ADEQUATE for the required loading.

Figure A.4.5-1 Slab Loading
A.4.5 FINITE ELEMENT ANALYSIS OF PLATE ON ELASTIC FOUNDATION, CONTINUED

Figure A.4.5-2 Plate Stresses - Max Stress 1557 psi
A.4.6 FINITE ELEMENT ANALYSIS OF REMEDIATED SLAB

Similar to section A.4.5, a revised slab was analyzed to determine what thickness is required to meet the loading requirements. It was determined that an 18" slab is required.

Figure A.4.6-1 shows the center loading of the 18" slab. Figure A.4.6-2 shows the resulting plate stresses from the center loading analysis.
A.4.6 FINITE ELEMENT ANALYSIS OF PLATE ON ELASTIC FOUNDATION, CONTINUED

Figure A.4.6-2 Plate Stresses - Max Stress 384 psi
A.4.6 FINITE ELEMENT ANALYSIS OF PLATE ON ELASTIC FOUNDATION, CONTINUED

Figure A.4.6-3 shows the edge loading of the 18" slab. Figure A.4.6-4 shows the resulting plate stresses from the edge loading analysis. Note that the edge conditions are more sensitive to loadings so the load to be applied was refined to more precisely match the air-pallet's pressure footprint. 1432 nodes were loaded with equivalent forces, but for graphical clarity only load footprint is shown in Figure A.4.6-3. The actual loads are each 172 lbs for the 1432 nodes.

The maximum stresses for the center loading in the slab are 384 psi which exceeds the allowable stress of 360 psi by 1%, therefore the slab is considered to be ADEQUATE for the required loading. The maximum stresses for the edge loading in the slab are 92 psi which does not exceed the allowable stress of 380 psi, therefore the slab is considered to be ADEQUATE for the required loading.

Figure A.4.6-3 Slab Loading at Edge
A.4.6 Finite Element Analysis of Plate on Elastic Foundation, Continued

Figure A4.6-4 Plate Stresses - Max Stress 92 psi
ATTACHMENT B:
AIR PALLET INFORMATION
The SOLVING Air-bearing Load Module

Technical Data

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<th>Load module type</th>
<th>Air-bearing element type</th>
<th>Capacity (lbs)</th>
<th>Air Pressure (psi)</th>
<th>Air consumption (SCFM)</th>
<th>Lifting Height (in)</th>
<th>Lift Area (sq. ft)</th>
<th>Support Area (sq. in)</th>
<th>A (in)</th>
<th>B (in)</th>
<th>C (in)</th>
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1) Air pressure in air bearing element at capacity
2) Actual air consumption depends on the effective load and the floor quality
3) Nominal lifting height = 2 inches at case load
4) Support area with deflated air bearing module
5) Cast aluminum load module / Extruded aluminum load module

Options
- High-lift air bearings
- Polyurethane air bearings for extended life
- Corrosion proof air bearings for offshore market
- Perforated air bearings for theaters and multipurpose halls

Accessories
- Control unit
- Air supply system

AMERICAN SOLVING INC.
6519 EASTLAND PLAZA, UNIT #5
BROOK PARK, OHIO (USA) 44142
ph. 440 234-7373 / fax 440 234-9112
1-800-822-2285
RIG SET MODULAR AIR BEARING SYSTEM

Control Box

Optional (umbilical attached) Hand Pendant

Supply Hose (not included w/ standard Rig Set, available only as optional item).

Air Bearing / Load Module (x4)

Interconnecting Hose (x4)

Typical Rig Set Modular Air Bearing System

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<td>2-3/16</td>
<td>251</td>
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<tr>
<td>MLS-36H</td>
<td>200,000</td>
<td>1</td>
<td>2</td>
<td>63</td>
<td>355</td>
<td>36</td>
<td>2</td>
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<td>434</td>
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<td>1</td>
<td>64</td>
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<td>703</td>
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<td>MLS-60H</td>
<td>560,000</td>
<td>1</td>
<td>1</td>
<td>64</td>
<td>585</td>
<td>40</td>
<td>3</td>
<td>2-1/16</td>
<td>1000</td>
</tr>
</tbody>
</table>

1) As SHH rated capacity
2) These values are for smooth sealed concrete with good "light reflective" quality, some surface deterioration, floor cracks with a max. sum of 1/8" wide and filled expansion joints. (Maximum Air Consumption is dependent on floor condition).
3) Models MLS 8, 12, 15 are shown with both use aluminum top plates and extended aluminum top plates.
4) Contact factory.

AMERICAN SOLVING INC. • 6519 Eastland Plaza • Brook Park, Ohio 44142 • Ph. 800 822-2285 / 440 234-7373 Fax 440 234-9112
**Calculation Note and Peer Review**

<table>
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<th>Rev No.</th>
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**End Use:** Conceptual

**Project:** MCSC Project

**Discipline:** Structural

**Contract No.:** 57605

**Structure or System:** WESF G Cell Floor

**Subject:** Scoping Analysis of Waste Encapsulation and Storage Facility (WESF) G Cell Floor for MCSC Project.

**Equipment Loading**

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<th>Checked by (Questor or Department Manager)</th>
<th>Date</th>
<th>Approved by (Questor or Department Manager)</th>
<th>Date</th>
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<tr>
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**Distribution:**

**Reason for Revision:**

<table>
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**Problem Statement:**

Estimate WESF G Cell floor loading imposed by hardware to be installed for the MCSC Project.

**Summary Conclusions:**

Per SD-WM-DA-031, WESF Floor Loading Analysis for RSI/GE 1500 Casks, the recommended safe live load limit for the G Cell floor is 1300 lb/ft².

Based upon estimated floor loading of planned CSS equipment in G-Cell, floor loading in excess of this limit should be avoidable. See Section 6.0 for a tabulation of results.

**Design Basis:**

NA – this is not a design basis calculation.
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File: LEMS-MCSC-17-CAL-002_R0
Acronyms, Abbreviations and Symbols

CD  conceptual design
Ci  curie
Cs  cesium
DOE  U.S. Department of Energy
DTS  Dry Transfer System
ft  foot (feet)
He  helium
in  inch (inches)
kCi  kilocurie (1000 Ci)
MCSC  Management of the Cesium and Strontium Capsules (Project W-135)
mSv  milliSv (1/1000th Sv)
NAC  NAC International
Sr  strontium
Sv  seivert
TSC  Transportable Storage Canister
UCS  Universal Canister Sleeve
VCC  Vertical Concrete Cask
WESF  Waste Encapsulation and Storage Facility
"  inches
1.0 OBJECTIVE/PURPOSE

1.1 Background

Dry storage of Waste Encapsulation and Storage Facility (WESF) cesium (Cs) and strontium (Sr) capsules has been proposed by the U.S. Department of Energy (DOE) per Project W-135, Management of the Cesium and Strontium Capsules (MCSC). The Cs and Sr capsules will be loaded into Universal Capsule Sleeves (UCSs), six capsules per UCS (or two Type W Cs capsules per UCS, not discussed here because it is bounded by the isotopic inventory of the six-capsule UCS).

New equipment will be installed in G Cell to support the MCSC Project. This equipment consists of a UCS capsule loading bed used for loading, upending, and closure (welding and helium leak testing) of UCSs. Also included in G Cell, per NAC’s current conceptual design (CD), is a “shield bell” sitting beside the capsule loading bed to contain a previously loaded UCS. NAC’s operational intent is to move two UCS units to the WESF Track Port via the Dry Transfer System (DTS) in rapid succession for loading into one cell of the Transportable Storage Canister (TSC) staged inside the Vertical Concrete Cask (VCC). At that point, the filled TSC cell (which holds two UCS units) can be sealed and backfilled with helium (He) for thermal stability while the remaining TSC cells are similarly filled and sealed.

The UCS loading station on the capsule loading bed will consist of a similar shield bell to house the in-process UCS. The two shield bells would allow personnel entry into G Cell in the event of equipment malfunction. The interim goal is to limit ALARA dose rates to 100 mrem/h on contact with the surface of the shield bells containing the UCSs.

1.2 Purpose

This scoping calculation conservatively estimates weights of the UCS capsule loading bed along with the second shield bell for staging a previously loaded UCS, and estimates resulting WESF G Cell floor loading values. Per SD-WM-DA-031, WESF Floor Loading Analysis for RS/AGE 1500 Casks, the recommended safe live load limit for the G Cell floor is 1500 lb/ft². Note that this calculation is based on NAC conceptual drawings from an April 2017 CD status presentation. Design details, i.e., weights and dimensions, are not available at this time.

2.0 INPUT DATA

Inputs to this calculation are as follows:

1. The G Cell hardware design concept is taken from NAC’s April 2017 CD presentation, excerpts of which are shown in Figure 2-1 and Figure 2-2 below. Dimensions are estimated based on measurements taken from these figures.

UCS length and diameter dimensions are taken from NAC Project 80001.01 Drawing 015. See Figure 2-3 and Figure 2-4 below for excerpts from this drawing.

3. The estimated weight of a loaded UCS, 450 lb, is taken from NAC’s Draft Design Specification, an excerpt of which is shown in Figure 2-5 below.

4. The curie (Ci) content of the top six WESF Cs capsules, which totals 191 kilocuries (kCi) is taken from CHPRC-02284 Appendix A, a relevant excerpt of which is shown in Figure 2-6 below.

5. The unit weights of steel tubing and plate assumed to be used for fabrication of the UCS capsule loading bed and floor support pads/plates are taken from the Ryerson Stock List, as follows:
   - The weight per unit length of 6” x 4” x ⅜” rectangular carbon steel tubing is given as 28.43 lb/ft.
   - The weight per unit area of ¼” hot rolled carbon steel plate is given as 20.42 lb/ft².

File: LEMS-MCSC-17-CAL-002_R0
6. The density of carbon steel, 7.82 gm/cm³, is taken from PNNL-15870, Compendium of Material Composition Data for Radiation Transport Modeling.

7. The density of cesium chloride (CsCl) used in this calculation, 3.8 gm/cm³, is taken from WMP-16940, Thermal Analysis of a Dry Storage Concept for Capsule Dry Storage Project, Appendix F, Table F-1. This density is interpolated for 590 K (317 °C, 633 °F), which is the corrosion-based salt/metal interface temperature limit for Cs capsules during interim storage. This density was used for defining CsCl as a custom material in MicroShield®.

8. The dose rate on contact with either shield bell is limited to 100 mrem/h to permit personnel entry without exposure to a high-radiation area (> 100 mrem/h).

Figure 2-1. Isometric View of NAC Concept for G Cell USC Capsule Loading Bed from NAC April 2017 CD Presentation
Figure 2-2. Elevation View of NAC Concept for G Cell Capsule Loading Bed from NAC from April 2017 CD Presentation

Figure 2-3. Cross Sectional View of UCS with Dimensions for MicroShield® Input
Figure 2-4. Cutaway View of UCS Weldment Without Closure Lids with Dimensions for MicroShield® Input
Figure 3-5. Excerpt from NAC Document Design Specification for the Cask Storage System (CSS) for the Management of the Cesium and Strontium Capsules Project (MCSC) at the Hanford Site

<table>
<thead>
<tr>
<th>Table 4-3 Estimated System Operational Weights and Weight Limitations(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hanford MPC-CSS Component / Operational Configuration</td>
</tr>
<tr>
<td>TSC Closure Lid</td>
</tr>
<tr>
<td>UTF (empty)</td>
</tr>
<tr>
<td>UCS (loaded)</td>
</tr>
<tr>
<td>Shielded Indexer Plate</td>
</tr>
<tr>
<td>MPC-CSS VCC (empty w/o VCC Lid)</td>
</tr>
<tr>
<td>VCC Lid</td>
</tr>
<tr>
<td>Loaded MPC-CSS (VCC and TSC) - Ready for Transfer to CSA</td>
</tr>
<tr>
<td>Lift Load to Position TSC Closure Lid on Loaded TSC</td>
</tr>
<tr>
<td>Lift Load to Position VCC Lid on VCC</td>
</tr>
<tr>
<td>Maximum Vertical Cask Transporter (VCT)</td>
</tr>
</tbody>
</table>

(1) Final component, content, and assembly weights shall be developed in a Hanford MPC-CSS weight calculation for use in the final structural and operational analyses. Estimated weights provided for scoping purposes only based on preliminary Design Drawings and preliminary operational sequence.

Figure 2-6. Excerpt from CHPRC-02248, Appendix A, Showing the Top Six Ci Loaded Cs Capsules (Total 191 kCi)

<table>
<thead>
<tr>
<th>WESEF Encapsulation Database System - Cesium Capsules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorted by current capsule wattage</td>
</tr>
<tr>
<td>Outer Capsule ID</td>
</tr>
<tr>
<td>C-1076</td>
</tr>
<tr>
<td>C-1723</td>
</tr>
<tr>
<td>C-906</td>
</tr>
<tr>
<td>C-887</td>
</tr>
<tr>
<td>C-1715</td>
</tr>
<tr>
<td>C-957</td>
</tr>
</tbody>
</table>

File: LEMS-MCSC-17-CAL-002_R0
3.0 ASSUMPTIONS

This analysis makes use of the following assumptions. Assumptions that require subsequent verification as the CSS vendor design progresses are noted as such in italicized parenthesis.

(a) Two shield bells are assumed, one on the floor next to the UCS capsule loading bed and one on the capsule loading bed itself, since both UCS units (one filled and staged, one in-process, both assumed filled with six Cs capsules each for a bounding radioactive source term) would need to be shielded to allow personnel entry into G Cell in the event of equipment malfunction. (Requires subsequent verification of CSS vendor design.)

(b) The collective Cs-117 Ci inventory of the top six WESF Cs capsules, 191 kCi (see Figure 3-6), is assumed to be contained within each shield bell. This conservatively bounds the radioactive source term in the two shield bells in G Cell.

(c) Ba-137m is assumed to be present in secular equilibrium with Cs-137 in the Cs capsules. The secular equilibrium ratio of Ba-137m to Cs-137 is 0.946 (see National Nuclear Data Center website, URL https://www.nndc.bnl.gov/).

(d) The shield bells are assumed to be fabricated of carbon steel. (Requires subsequent verification of CSS vendor design.)

(e) The diameter of the shield bells’ end shields is assumed to be equal to that of the side shield (shield bell body). This configuration prevents direct gamma radiation streaming through shielding areas where the chord length would be less than the calculated required shielding thickness.

(f) The UCS capsule loading bed frame and auxilliary structures are assumed to be fabricated from 6” x 4” x ½” rectangular carbon steel tubing described in the Ryerson Stock List. (Requires subsequent verification of CSS vendor design.)

(g) Floor plates/foot pads for the capsule loading bed are assumed to be fabricated from ½” hot rolled carbon steel plate described in the Ryerson Stock List. (Requires subsequent verification of CSS vendor design.)

(h) The mounting plate for the UCS closure welder (automatic welding system) on the capsule loading bed is assumed to be 3” hot rolled carbon steel plate described in the Ryerson Stock List. (Requires subsequent verification of CSS vendor design.)

(i) The welder is assumed to weigh 250 lb. (Requires subsequent verification of CSS vendor design.)

(j) The radioactive material source term, which consists of the Cs-137/Ba-137m contents of the top six WESF Cs capsules, is assumed to comprise a cylindrical source of the same dimensions as a UCS with regard to length and inner diameter. This conservatively neglects the inner and outer Cs capsules; however, the approximate quantity of steel of which the capsules are comprised is intrinsically added to the shield bell by default when calculating the side and end shield thicknesses necessary to achieve 100 mrem/h on contact.

(k) Because the Cs capsules are fabricated of stainless steel while the shield bells are assumed to be made of carbon steel, the shielding properties of carbon and stainless steels are assumed to be approximately equivalent. This is valid because the carbon steel content of the shield bells far outweighs the stainless steel of the Cs capsules.

(l) Any shield bell cooling jacket structure is neglected; the shield bells are assumed to consist of solid carbon steel. This is acceptable because cooling jacket steel, which would provide additional shielding, is by default added to the shield bell system when calculating the side and end shield thicknesses to achieve 100 mrem/h on contact. Cooling that would run through the shield bell cooling jacket is neglected; however, water, glycol, or a similar coolant would provide minimal shielding and add minimal weight to the overall shield bell structure.

File: LEMS-MCSC-17-CAL-002_R0
(m) The shield bell on the UCS capsule loading bed moves back and forth during the loading and closure evolutions; the bell is at one end during loading, then moves to the opposite end for UCS closure welding and He leak testing. Thus, conservatively assume that floor supports for either end of the capsule loading bed need to handle up to 90% of the total capsule loading bed weight floor without exceeding the G Cell floor 1300 lb/ft² safe live load limit. *(Requires subsequent verification of CSS vendor design.)*

(o) The UCS capsule loading bed is evenly loaded from side-to-side, regardless of the end-to-end load distribution as the shield bell moves back and forth between the USC loading and closure stations. *(Requires subsequent verification of CSS vendor design.)*

Floor loading due to the cart that holds empty UCSs and the loading table in front of the UCS capsule loading bed, shown in Figure 2-1 and Figure 2-2, are neglected in this calculation because their weights are small compared to those of the capsule loading bed and the adjacent shield bell used for loaded UCS staging.

4.0 METHOD OF ANALYSIS

This calculation was performed per the following steps:

1. Shield bell carbon steel side and end shield thicknesses required to limit contact dose rates to 100 mrem/h were determined iteratively using MicroShield®. The "custom material" feature of MicroShield® was used to define the CsCl radioactive source material with a density of 3.8 gm/cm³. *(See Section 2.0, item 7.)* MicroShield® output is documented in Appendix A *(Section 9.1.)*

2. The shielding thicknesses and shield bell UCS cavity dimensions *(sufficient to house a UCS), along with material densities and the estimated UCS weight, were inputted to Mathcad® to estimate the shield bell weight.

3. The unit floor loading was calculated assuming that the shield bell sits upright (on end, i.e., circular load distribution).

4. Since the floor loading thus calculated was greater than twice the recommended G Cell safe live floor load limit of 1300 lb/ft², required dimensions of both round and square support pads were estimated such that the shield bell load would be sufficiently distributed to meet the floor loading limit.

5. The weight of the UCS capsule loading bed with a second shield bell was calculated using dimensions estimated from the NAC CD sketches shown in Figure 2-1 and Figure 2-2. The shield bell length (or height if on end) derived from the MicroShield® side and end shield analysis described in step 1 was used as an approximate scale when estimating dimensions from the NACCD sketches.

6. A minimum load distribution area for the capsule loading bed’s weight was calculated based on the 1300 lb/ft² G Cell safe live floor load limit.

7. The assumption from Section 3.0 item (m) was then applied, i.e., supports for each end of the capsule loading bed conservatively need to safely distribute 90% of the total capsule loading bed weight to accommodate back-and-forth movement of the shield bell during UCS loading and closure. This assumption was used to estimate dimensions for square capsule loading bed support pads (load distribution foot pads) at each corner of the capsule loading bed.

The supporting Mathcad® calculations are documented in Appendix B *(Section 9.2), which contains detailed explanations of the analysis methodology.*
5.0 USE OF COMPUTER SOFTWARE

MicroShield® Version 8.03 was used to estimate required shielding thicknesses for the carbon steel shield bell side and end shields. MicroShield® was run on Lucas computer # ALA42 (Dell Optiplex 380) and has been validated on that machine in accordance with vendor instructions.

Mathcad® Version 15 was used to perform mathematical calculations.

Both MicroShield® and Mathcad® are commercial off-the-shelf software programs.

6.0 RESULTS

Table 6-1 collects and summarizes the results of this calculation.

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<thead>
<tr>
<th>Parameter Description</th>
<th>Quantitative Result and Units</th>
<th>Comments</th>
</tr>
</thead>
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<tr>
<td>Shield Bell Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shield bell side dose rate on contact</td>
<td>99.98 mrem/h (0.9998 mSv/h)</td>
<td>Iterated shield thickness to achieve as close to 100 mrem/h on contact as possible. Note that MicroShield® gives dose rates in units of mSv/h. The conversion is: 1 mSv/h = 100 mrem/h</td>
</tr>
<tr>
<td>Shield bell end dose rate on contact</td>
<td>100.2 mrem/h (1.002 mSv/h)</td>
<td></td>
</tr>
<tr>
<td>Shield bell side shield thickness</td>
<td>10.5 inches</td>
<td>Carbon steel assumed</td>
</tr>
<tr>
<td>Shield bell end shield thickness</td>
<td>9.9 inches</td>
<td></td>
</tr>
<tr>
<td>Shield bell diameter</td>
<td>27.5 inches</td>
<td></td>
</tr>
<tr>
<td>Shield bell length (or height)</td>
<td>68.8 inches</td>
<td></td>
</tr>
<tr>
<td>Shield bell end area</td>
<td>4.12 ft²</td>
<td></td>
</tr>
<tr>
<td>Shield bell weight</td>
<td>11,500 lb</td>
<td>Shield bell only; no support plate; support plate under bell for load distribution adds ~200 lb</td>
</tr>
<tr>
<td>Unit floor load for shield bell sitting on end</td>
<td>2796 lb/ft²</td>
<td>Exceeds 1300 lb/ft² safe live load limit for G Cell floor</td>
</tr>
<tr>
<td>Minimum shield bell end area support to achieve ≤ 1300 lb/ft²</td>
<td>8.85 ft²</td>
<td></td>
</tr>
<tr>
<td>Required shield bell support plate diameter (if round)</td>
<td>40.3 inches</td>
<td>3/8” plate thickness</td>
</tr>
<tr>
<td>Required shield bell support plate side length (if square)</td>
<td>35.7 inches</td>
<td></td>
</tr>
<tr>
<td>Parameter Description</td>
<td>Quantitative Result and Units</td>
<td>Comments</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Unit floor load with a 42-inch round shield bell support plate</td>
<td>1217 lb/ft²</td>
<td>Acceptable; &lt; 1300 lb/ft²</td>
</tr>
<tr>
<td>Unit floor load with a 37-inch square shield bell support plate</td>
<td>1231 lb/ft²</td>
<td>&quot;</td>
</tr>
<tr>
<td><strong>UCS Capsule loading bed Results</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated capsule loading bed length</td>
<td>14.3 ft</td>
<td>All capsule loading bed dimensions are estimated from NAC conceptual drawings using the calculated shield bell length as an approximate scale.</td>
</tr>
<tr>
<td>Estimated capsule loading bed height</td>
<td>10.0 ft</td>
<td>&quot;</td>
</tr>
<tr>
<td>Estimated capsule loading bed width</td>
<td>3.4 ft</td>
<td>&quot;</td>
</tr>
<tr>
<td>Estimate capsule loading bed weight</td>
<td>14,100 lb</td>
<td>Includes shield bell with loaded UCS inside</td>
</tr>
<tr>
<td>Minimum load distribution area under capsule loading bed to achieve loading of 1300 lb/ft²</td>
<td>10.9 ft²</td>
<td></td>
</tr>
<tr>
<td>Conservatively rounded-up floor area</td>
<td>11 ft²</td>
<td>Ok; &lt; 1300 lb/ft²</td>
</tr>
<tr>
<td>Floor loading for 11 ft² floor area</td>
<td>1283 lb/ft²</td>
<td></td>
</tr>
<tr>
<td>“90%” load distribution area under each end of capsule loading bed</td>
<td>9.9 ft²</td>
<td>Conservatively assumes that each end of the capsule loading bed needs to handle 90% of its total weight as the heavy shield bell moves from the UCS loading station on one end to the welding/closure station on the other end.</td>
</tr>
<tr>
<td>Required area of load distribution (floor support) pad under each corner of the capsule loading bed</td>
<td>4.95 ft²</td>
<td>Assumes capsule loading bed is evenly loaded from side-to-side</td>
</tr>
<tr>
<td>Floor support pad side length (square pads)</td>
<td>27 inches</td>
<td></td>
</tr>
<tr>
<td>Spacing between pads on each end</td>
<td>14.5 inches</td>
<td>Based on estimate capsule loading bed width stated above. This dimension ensures that floor support pads on each end will not overlap/interfere with each other.</td>
</tr>
</tbody>
</table>

7.0 **CONCLUSIONS**

Per SD-WM-DA-031, WESF Floor Loading Analysis for RS/GE 1500 Casks, the recommended safe live load limit for the G Cell floor is 1300 lb/ft².

File: LEMS-MCSC-17-CAL-002_R0
Based upon estimated floor loading of planned CSS equipment in G-Cell, floor loading in excess of this limit should be avoidable provided the CSS equipment is designed with sufficient sized floor plates.
8.0 REFERENCES

1. 30059-S-01 (Draft), Design Specification for the Cask Storage System (CSS) for the Management of the Cesium and Strontium Capsules Project (MCSC) at the Hanford Site, January 2017, NAC International, Norcross, Georgia.


3. NAC Drawing, Project No. 80001.01, Drawing No. 14, Sheet 1, Universal Canister Assembly, 3 Cells, Hanford, April 2016, NAC International, Norcross, Georgia.


9.0 APPENDICES

9.1 Appendix A: MicroShield® Output

9.1.1 MicroShield® Output for Shield Bell Side Shield

Case Summary of UCS Side Shield

<table>
<thead>
<tr>
<th>Date</th>
<th>Run Date</th>
<th>Run Time</th>
<th>Duration</th>
</tr>
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<td>April 17, 2017</td>
<td>3:34:40 PM</td>
<td>00:00:00</td>
<td></td>
</tr>
</tbody>
</table>

Project Info
- Case Title: UCS Side Shield
- Description: Top 6 Cs Capsules (191 kCi)
- Geometry: 7 - Cylinder Volume - Side Shields

Source Dimensions
- Height: 124.46 cm (4 ft 1.0 in)
- Radius: 7.303 cm (2.9 in)

Dose Points
- A
  - #1: 35.146 cm (1 ft 1.8 in)
- X
  - 62.23 cm (2 ft 0.5 in)
- Y
  - 0.0 cm (0 in)
- Z

Shields
- Source: 2.09 x 10^-4 cm^3
- Cs-137: 2.54 cm
- Shield 1: 26.645 cm
- Transition: 0.0 cm
- Air Gap: 0.0 cm
- Wall Clad: 0.69 cm
- Top Clad: 2.032 cm

Material Density
- CsCl: 3.9
- Iron: 7.82

Source Input: Grouping Method - Actual Photon Energies
- Na-22: 1.806 x 10^6
- Cs-137: 5.0 x 10^5

Buildup: The material reference is Shield 1
- Radial: 10
- Circumferential: 10
- Y Direction (axis): 20

Results
- Energy (MeV)
  - 0.0005
  - 0.0318
  - 0.0322
  - 0.0344
  - 0.0665
  - Totals

File: LEMS-MCSC-17-CAL-002_R0
# Dose Equivalent Report

**Program:** MicroShield, Grove Software, Inc.  
**Version:** 8.03  
**Organization:** Lucas EMS  
**Serial #:** 8.03-0000  
**Date / Time:** This case was run on Monday, April 17, 2017 at 3:34:40 PM

**Filename:** E:\ALARA for WESF BURES Side Shield 100 mm TIS OC.txt  
**Case Title:** UCS Side Shield  
**Description:** Top 6 Cs Capsules (191 kCi)  
**Geometry:** 7 - Cylinder Volume - Side Shields  
**Sensitivity:** No

## Results

**Nominal Case**  
**Dose Point #1** (35.1450, 62.23, 0) cm  
**Variable:** Not Applicable

<table>
<thead>
<tr>
<th>Results (Summed over energies)</th>
<th>Units</th>
<th>Without Buildup</th>
<th>With Buildup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photon Fluence Rate (flux)</td>
<td>Photons/cm²/sec</td>
<td>2.678e+003</td>
<td>1.765e+004</td>
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**Effective Dose (ICRP 74 - 1997)**  
**Antero-posterior Geometry** mSv/hr  
2.370e-002  
9.998e-001

File: LEMS-MCSC-17-CAL-002_R0
9.1.2 MicroShield® Output for Shield Bell End Shield

Case Summary of UCS End Shield

<table>
<thead>
<tr>
<th>Date</th>
<th>Run Date</th>
<th>Run Time</th>
<th>Duration</th>
</tr>
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<tbody>
<tr>
<td>April 17, 2017</td>
<td>3:32:11 PM</td>
<td>00:00:00</td>
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</tbody>
</table>

Project Info
- Case Title: UCS End Shield
- Description: Top 6 Cs Capsules (191 kCi)
- Geometry: 8 - Cylinder Volume: End Shields

Source Dimensions
- Height: 124.46 cm (4 ft. 1.0 in)
- Radius: 7.308 cm (2.9 in)

Dose Points
- A: 0.0 cm (0 in)
- X: 151.867 cm (4 ft. 11.8 in)
- Y: 0.0 cm (0 in)

Shields
- Source: 1272.394 m²
- Shield 1: 9.89 in
- Air Gap: 0.727 in
- Wall Clay: 0.8 in
- Top Clay: 7.82

Source Input: Grouping Method - Actual Photon Energies

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<tr>
<th>Nuclide</th>
<th>C1</th>
<th>Bq</th>
<th>μC/μm²</th>
<th>Bq/cm²</th>
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<tbody>
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<td>Ba-137m</td>
<td>1.886e+005</td>
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<td>8.665e+006</td>
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<tr>
<td>Cs-137</td>
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Buildup: The material reference is Shield 1

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<tr>
<td>Circumferential: 10</td>
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<td>Y Direction (axial): 10</td>
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Results

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<th>Activity (Photons/sec)</th>
<th>Fluence Rate MeV/cm²/sec No Buildup</th>
<th>Fluence Rate MeV/cm²/sec With Buildup</th>
<th>Exposure Rate mR/hr No Buildup</th>
<th>Exposure Rate mR/hr With Buildup</th>
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<td>3.812e+04</td>
<td>2.855e+00</td>
<td>1.127e+02</td>
</tr>
</tbody>
</table>

Total: 6.572e+15 | 1.474e+03 | 5.812e+04 | 2.855e+00 | 1.127e+02 |
### Dose Equivalent Report

- **Program**: MicroShield, Grove Software, Inc.
- **Version**: 8.03
- **Organization**: Lucas EMS
- **Serial #**: 8.03-0000
- **Date / Time**: This case was run on Monday, April 17, 2017 at 3:32:11 PM
- **Filename**: E:\ALARA for WESF IIUCS End Shield 100 mrem OC, mc6
- **Case Title**: UCS End Shield
- **Description**: Top 6 Cs Capsules (191 kCi)
- **Geometry**: 8 - Cylinder Volume - End Shields
- **Sensitivity**: No

### Results

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<tr>
<th>Nominal Case</th>
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<th>Variable</th>
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</table>

#### Effective Dose (ICRP 74-1997)

- **Antero-posterior Geometry**: mSv/hr
  - Without Buildup: 2.541e-02
  - With Buildup: 1.002e+00

---

File: LEMS-MCSC-17-CAL-002_R0
9.2 Supporting Mathcad Calculations

**G Cell Floor Load Calcs**

**Calculate Weight of UCS Shield Bell**

Wt of UCS from NAC Design Spec: \( W_{UCS} = 450 \text{ lb} \)

Assume shield bell is carbon steel (CS). Density from PNWL 15870:

\[
P_{CS} = 7.82 \frac{\text{lb}}{\text{in}^3} = 488.19 \frac{\text{lb}}{\text{ft}^3}
\]

Calculate volume and weight of shield bell side shield using dimensions from MicroShield run

\( UCS \) Side Shield 100 mm OC, m36 and given CS density

Subscript definitions: \( \text{IR} \) = inner radius, \( \text{OR} \) = outer radius.

\[
\text{IR}_{side} = 3.24 \text{in} \quad \text{OR}_{side} = 13.73 \text{in} \quad h_{side} = 40 \text{in}
\]

\[
V_{side} = \pi \left( \text{OR}_{side}^2 - \text{IR}_{side}^2 \right) h_{side} = 27426 \text{ in}^3
\]

\[
W_{side} = V_{side} P_{CS} = 7748 \text{ lb}
\]

Calculate volume and weight of shield bell end shields (top & bottom) using dimensions from MicroShield run UCS End Shield 100 mm OC, m36 and given CS density. Assume that diameter of end shield is identical to the side shield OR to prevent gamma streaming.

\[
h_{end} = 9.89 \text{ in}
\]

\[
V_{end} = \pi \cdot \text{OR}_{side}^2 h_{end} = 5863 \text{ in}^3
\]

\[
W_{end} = V_{end} P_{CS} = 1656 \text{ lb}
\]

Weight of shield bell:

\[
W_{bell} = W_{side} + \left( 2 \times W_{end} \right) = 11061 \text{ lb}
\]

Weight of shield bell + loaded UCS:

\[
W_{bell\text{AndUCS}} = W_{bell} + W_{UCS} = 11511 \text{ lb}
\]

*Note that this does not include the weight of a UCS cooling apparatus (jacket, etc.).*
Shield bell overall dimensions:

Diameter: 
\[ d_{\text{bell}} = 2 \cdot OR_{\text{side}} = 27.47 \text{ in} \]

Height (or length): 
\[ h_{\text{bell}} = h_{\text{side}} + 2 \cdot h_{\text{end}} = 61.78 \text{ in} \]

Calculate floor stress if shield bell sits flat on its end on the floor. Area of shield bell end:

\[ A_{\text{bellEnd}} = \pi \cdot OR_{\text{side}}^2 = 4.12 \text{ ft}^2 \]

G Cell floor load due to shield bell sitting flat on floor:

\[ \text{Load}_{\text{UCS, flat}} = \frac{W_{\text{bellAndUCS}}}{A_{\text{bellEnd}}} = 2796 \frac{\text{lb}}{\text{ft}^2} \]

This exceeds the G Cell floor recommended live load limit of 1300 lbs/sq ft from SD-WM-DA-034. Determine a minimum loading area to meet this limit.

\[ \text{LoadLimit} = 1300 \frac{\text{lb}}{\text{ft}^2} \]

\[ A_{\text{min}} = \left( \frac{\text{Load}_{\text{UCS, flat}}}{\text{LoadLimit}} \right) A_{\text{bellEnd}} = 8.35 \text{ ft}^2 \]

Check:

\[ \text{Load} := \frac{W_{\text{bellAndUCS}}}{A_{\text{min}}} = 1300 \frac{\text{lb}}{\text{ft}^2} \quad \text{OK} \]

Calculate minimum dimensions for round and square shield bell supports.

Round support diameter:
\[ d_{\text{round}} = 2 \cdot \sqrt{\frac{A_{\text{min}}}{\pi}} = 3.36 \text{ ft} \quad d_{\text{round}} = 40.29 \text{ in} \]

Square support side length:
\[ L_{\text{square}} = \sqrt{A_{\text{min}}} = 2.98 \text{ ft} \quad L_{\text{square}} = 35.71 \text{ in} \]

Diameter of shield bell from above, for comparison:
\[ d_{\text{bell}} = 27.47 \text{ in} \]

However, adding a base plate adds weight. Estimate slightly larger square and square base plates, add the weight to that of the shield bell + loaded UCS, and recalculate the unit floor load. Assume 1/2" hot rolled carbon steel plate. Unit weight from Ryerson Stock List is:

\[ \text{Unit Weight}_{\text{halfInchPlate}} = 20.42 \frac{\text{lb}}{\text{ft}^2} \]
Let the round plate diameter be 42" and the square plate be 37" per side. Then:

**Round base:**

\[ \text{Area}_{\text{roundBase}} = \pi \left( \frac{42\text{in}}{2} \right)^2 = 9.62 \text{ ft}^2 \]

\[ W_{\text{roundBase}} = \text{Area}_{\text{roundBase}} \times \text{UnitW}_{\text{halfInchPlate}} = 196 \text{ lb} \]

Total\( W_{\text{roundBase}} = W_{\text{bellAndUCS}} + W_{\text{roundBase}} = 11708 \text{ lb} \]

\[ \text{FloorLoad}_{\text{roundBase}} = \frac{\text{TotalW}_{\text{roundBase}}}{\text{Area}_{\text{roundBase}}} = \frac{1217 \text{ lb}}{\text{ft}^2} \quad \text{Ok} < 1300 \text{ lb/sq ft} \]

**Square base:**

\[ \text{Area}_{\text{squareBase}} = (37\text{in})^2 = 9.51 \text{ ft}^2 \]

\[ W_{\text{squareBase}} = \text{Area}_{\text{squareBase}} \times \text{UnitW}_{\text{halfInchPlate}} = 194.13 \text{ lb} \]

Total\( W_{\text{squareBase}} = W_{\text{bellAndUCS}} + W_{\text{squareBase}} = 11705 \text{ lb} \]

\[ \text{FloorLoad}_{\text{squareBase}} = \frac{\text{TotalW}_{\text{squareBase}}}{\text{Area}_{\text{squareBase}}} = \frac{1231 \text{ lb}}{\text{ft}^2} \quad \text{Ok} < 1300 \text{ lb/sq ft} \]

**Conclusion:** Support the shield bell on either a 42" diameter round base or a 37" square base, 1/2" carbon steel plate, to meet the recommended 1300 lb/sq ft G Cell floor live load limit from SD-WM-DA-034.

**Calculate Weight of UCS Loading Bed**

**Approach:** Assume that the UCS loading bed includes a second identical shield bell to provide shielding for a fully-loaded in-process UCS (bounding case) in event of a G Cell entry for equipment repair. Add that weight to the estimated weight of the loading bed frame, upender, and welder.

Dimension and material estimates are based on measurements taken off the two images from NAC's April 2017 PowerPoint presentation. The size of the shield bell estimated above is used as an approximate scale for comparison.

Estimate the loading bed frame dimensions. From the elevation view of the NAC concept drawing, the loading bed frame appears about 2.5 times longer than the horizontal UCS loading shield bell shown on the loading bed, and about 1.75 times taller than the vertical shield bell standing next to the loading bed. Thus:
$L_{\text{bed}} = 2.5 \times h_{\text{bell}} = 14.33 \text{ ft}$

$h_{\text{bed}} = 1.75 \times h_{\text{bell}} = 10.03 \text{ ft}$

The width of the loading bed is estimated at about 1.5 times the shield bell diameter. Thus:

$v_{\text{bed}} = 1.5 \times (2 \times \text{OR}_{\text{side}}) = 3.43 \text{ ft}$

Assume that the primary loading bed frame is made from 6” x 4” carbon steel structural tubing with 1/2” wall thickness. The Ryerson Stock List gives the unit weight of this material as 28.43 lb/ft.

$\text{Unit Wt}_{6x4} = 28.43 \frac{\text{lb}}{\text{ft}}$

There are two lengthwise horizontal frame members, two vertical frame members, and two horizontal cross members. All are assumed to be fabricated from the 6” x 4” x 1/2” thick tubing.

Horizontal lengthwise (HL) frame members:

$W_{\text{HL}} = 2 \times L_{\text{bed}} \times \text{Unit Wt}_{6x4} = 815 \text{ lb}$

Horizontal cross members (HC):

$W_{\text{HC}} = 2 \times v_{\text{bed}} \times \text{Unit Wt}_{6x4} = 195 \text{ lb}$

Vertical frame members (VF):

$W_{\text{VF}} = 2 \times h_{\text{bed}} \times \text{Unit Wt}_{6x4} = 570 \text{ lb}$

There is also a single vertical support (VS) on one side of the loading bed. This may be made of smaller tubing stock, but it is difficult to tell from the drawing, so assume it is also made from the 6” x 4” tubing. Its height measures approximately 1.4 times the shield bell height. Thus:

$L_{\text{VS}} = 1.4 \times h_{\text{bell}} = 8.02 \text{ ft}$

$W_{\text{VS}} = L_{\text{VS}} \times \text{Unit Wt}_{6x4} = 238 \text{ lb}$

The vertical pivot supports (VP) for the USC loading shield bell upender are difficult to size from the drawing, but look smaller than the primary frame members. For simplicity, assume that these pieces are made of the 6” x 4” x 1/2” tubing, but neglect the diagonal supports to compensate for the heavier weight of the vertical pivot support pieces. The vertical pivot supports appear approximately 0.75 times the shield bell height. Thus:

$L_{\text{VP}} = 0.75 \times h_{\text{bell}} = 4.30 \text{ ft}$

$W_{\text{VP}} = 2 \times L_{\text{VP}} \times \text{Unit Wt}_{6x4} = 244 \text{ lb}$

File: LEMS-MCSC-17-CAL-002_R0
The welder mounting plate (WP) attached near the top of the vertical frame members at the "back" of the loading bed appears to be a heavy plate approximately 3" thick. The Ryerson Stock List gives the weight of 3" plate as 122.5 lb/sq ft.

\[ \text{Unit Weight Plate} = \frac{122.5 \text{ lb}}{\text{sq ft}} \]

The horizontal protruding length dimension measures approximately 0.25 times the shield bell height. The width of the plate is estimated at half the width of the loading bed since the vertical support members to which it is attached are "indented" a distance from the lengthwise horizontal frame members. Thus, the plate length and width are estimated as:

\[ L_{WP} = 0.25 \cdot H_{bell} = 1.43 \text{ ft} \]
\[ w_{WP} = 0.5 \cdot w_{bed} = 1.72 \text{ ft} \]

The welder mounting plate weight is:

\[ W_{WP} = L_{WP} \cdot w_{WP} \cdot \text{Unit Weight Plate} = 301 \text{ lb} \]

The weight of the automatic welder (AW) is estimated at 250 lb, since no data is available for weights of Libardi automated welding systems.

\[ W_{AW} = 250 \text{ lb} \]

The estimated total weight of the UCS loading bed, including a shield bell containing a loaded UCS, is:

\[ W_{bed} = W_{UL} + W_{HC} + W_{VF} + W_{VS} + W_{WP} + W_{AW} + W_{bellAndUCS} = 14115 \text{ lb} \]

The minimum area over which this weight must be distributed in order to meet the recommended safe live load limit for the G Cell floor is:

\[ \text{Floor Area} = \frac{W_{bed}}{1300 \text{ lb/ft}^2} = 10.86 \text{ ft}^2 \]

Note that the loading bed's weight will not be evenly distributed over its length due to the variable location of the shield bell. The shield bell will be situated at one end of the loading bed during UCS loading, then moved to the opposite end for UCS closure. Conservatively assume that the end of the loading bed bearing the shield bell at any time exerts 90% of the load on the floor, while the opposite end exerts the remaining 10%. Thus the end bearing 90% of the load is limiting, but floor supports for both ends of the loading bed need to distribute this weight since the shield bell moves back and forth.
Round up the total floor supporting area to 11 sq ft to allow for any weight-adding items, such as steel plates used as foot pads for the loading bed. The total loading bed floor support area thus estimated is:

\[
\text{Floor Area}_{\text{bed est}} = 11 \text{ ft}^2
\]

The floor loading for this area is:

\[
\text{Load}_{11 \text{ sq ft}} = \frac{W_{\text{bed}}}{\text{Floor Area}_{\text{bed est}}} = 1283 \frac{\text{lb}}{\text{sq ft}} \quad \text{OK; } < 1300 \text{ lb/sq ft}
\]

Then the “90%” floor support area required at either end of the loading bed is:

\[
\text{Floor Area}_{\text{end}} = 0.9 \times \text{Floor Area}_{\text{bed est}} = 9.90 \text{ ft}^2
\]

The floor loading is:

\[
\text{Load}_{90\%} = 0.9 \times \frac{W_{\text{bed}}}{\text{Floor Area}_{\text{end}}} = 1283 \frac{\text{lb}}{\text{sq ft}} \quad \text{(Same as above, as it should be)}
\]

Divide this by two to estimate the required area of each floor support (foot pad):

\[
\text{Pad Area}_{\text{end}} = \frac{\text{Floor Area}_{\text{end}}}{2} = 4.99 \text{ ft}^2
\]

Assuming square pads, the side length of each pad under the shield bell end of the loading bed would be:

\[
L_{\text{endPad}} = \sqrt{\text{Pad Area}_{\text{end}}} = 2.22 \text{ ft} \quad \text{L}_{\text{endPad}} = 26.70 \text{ in}
\]

From above, the loading bed width is:

\[
w_{\text{bed}} = 3.43 \text{ ft} \quad w_{\text{bed}} = 41.21 \text{ in}
\]

The two pads on the shield bell end of the loading bed could be centered under the corners of the loading bed with the following dimensions between the inner (facing) edges of the foot pads:

\[
L_{\text{endPad spacing}} = w_{\text{bed}} - L_{\text{endPad}} = 1.21 \text{ ft} \quad L_{\text{endPad spacing}} = 14.51 \text{ in}
\]

This, there would be approximately 9 inches separation between the square pads at either end of the loading bed (they will not interfere with each other).
Calculation Note and Peer Review

Project: MCSC Project
Discipline: Structural
Structure or System: WESF Canyon Floor
Subject: Scoping Analysis of Waste Encapsulation and Storage Facility (WESF) Canyon Floor for MCSC Project Equipment Loading

Completed by: [Signature] Date: 05/04/2017
Checked by: [Signature] Date: 5/9/2017
Approved by [Signature] Date: 5/9/2017

Distribution:

Reason for Revision: NA
Total number of sheets in this issue: 10
Sheets revised, added or deleted: NA

Problem Statement:
Estimate WESF Canyon floor loading imposed by the Dry Transfer System (DTS) and DTS stand.

Summary Conclusions:
The conservatively estimated floor loading is 1500 lb/ft². This is acceptable as it falls below the recommended live load limit of 2900 lb/ft² given in SD-WM-DA-031, WESF Floor Loading Analysis for RSI/GE 1500 Casks.

Design Basis:
NA – this is not a design basis calculation.

File: LEMS-MCSC-17-CAL-003_R0- Canyon Floor Analysis
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1.2 Purpose .................................................................................. 5
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Table 4-1. Summary of Calculation Input Parameters

List of Figures

Figure 2-1. Excerpt of NAC Drawing Showing the Preliminary Universal Canister DT5 Design
Figure 2-2. Excerpt from NAC Document Design Specification for the Cask Storage System (CSS) for the Management of the Cesium and Strontium Capsules Project (MCSC) at the Hanford Site

File: LEMS-MSCC-17-CAL-003_R0- Canyon Floor Analysis
### Acronyms and Abbreviations

<table>
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<tr>
<th>Acronym</th>
<th>Description</th>
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<tr>
<td>Cs</td>
<td>cesium</td>
</tr>
<tr>
<td>DOE</td>
<td>U.S. Department of Energy</td>
</tr>
<tr>
<td>DTS</td>
<td>Dry Transfer System</td>
</tr>
<tr>
<td>ft</td>
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<tr>
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<td>Sr</td>
<td>strontium</td>
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<td>Transportable Storage Canister</td>
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<td>UCS</td>
<td>Universal Capsule Sleeve</td>
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<td>Vertical Concrete Cask</td>
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1.0 OBJECTIVE/PURPOSE

1.1 Background

Dry storage of Waste Encapsulation and Storage Facility (WESF) cesium (Cs) and strontium (Sr) capsules has been proposed by the U.S. Department of Energy (DOE) per Project W-135, Management of the Cesium and Strontium Capsules (MCSC).

The MCSC project will entail placement and use of new equipment in the WESF Canyon. The largest and most massive item will be the Dry Transfer System (DTS). The DTS will be used in conjunction with the 15 ton WESF Canyon crane to singly transport loaded Universal Capsule Sleeves (UCSs) between G Cell and the WESF Truck Port for loading into a Transportable Storage Canister (TSC) situated inside a Vertical Concrete Cask (VCC). The Truck Port lies below the western end area of the WESF Canyon and is accessed via cover block.

The DTS will sit on a DTS stand in the Canyon when not in use. The stand is to be designed by NAC. Assumptions regarding its design are discussed in Section 3.0. Assumptions, since no data is available at the time of this calculation.

1.2 Purpose

This scoping calculation conservatively estimates WESF Canyon floor loading due to the DTS when sitting on the DTS stand, and compares the result against previously analyzed Canyon floor recommended live load limit of 2900 lb/ft^2 given in SD-WM-DA-031, WESF Floor Loading Analysis for RS/GE 1500 Casks.

2.0 INPUT DATA

Inputs to this calculation are as follows:

1. DTS dimensions and the empty weight are taken from the NAC International Drawing Dry Transfer Systems Hanford Operations. Figure 2-1 contains an excerpt from this drawing showing the preliminary Universal Carister DTS design that will be used for the MCSC project. The estimated DTS empty weight of 21,000 lb exceeds the 16,000 lb empty weight given in Table 4-3 of NAC’s Design Specification for the Cock Storage System (CSS) for the Management of the Cesium and Strontium Capsules Project (MCSC) at the Hanford Site (hereafter referred to as the NAC Design Specification for brevity). Since both weights are based on preliminary design information, the heavier weight of 21,000 lb is for conservatism.

2. The DTS will be at maximum loaded weight when it contains a UCS loaded with three Cs or Sr capsules. Figure 2-2 shows Table 4-3 from the NAC Design Specification. The highlighted row gives the estimated loaded UCS weight as 450 lb.

3. The unit weight of steel plating, which is assumed to be used for the DTS stand, is taken from the Ryerson Stock List. See Section 3.0, Assumptions, for further discussion.
Figure 2-1. Excerpt of NAC Drawing Showing the Preliminary Universal Canister DTS Design

(Note: Dimension units shown are inches.)

File: LEMS-MCSC-17-CAL-003_R0- Canyon Floor Analysis
3.0 ASSUMPTIONS

The following assumptions were made for this analysis. Assumptions that require subsequent verification as the CSS vendor design progresses are noted as such in italicized parenthesis.

a) Based on Section 2.0, items 1 and 2, the weight of the DTS containing a loaded UCS is conservatively rounded up for a total assumed loaded DTS weight of 22,000 lb. *(Requires subsequent verification of CSS vendor design.)*

b) At the time of this calculation, no preliminary design data is available for the DTS stand. Thus, the following assumptions are made for the DTS stand construction and dimensions:

i. The base of the stand consists of 1-inch hot-rolled carbon steel plate. From the Ryerson Stock List, 1-inch carbon steel plate weighs 40.84 lb/ft². *(Requires subsequent verification of CSS vendor design.)*

ii. To achieve uniform weight distribution, DTS stand base is assumed to be a rectangular plate that, as a minimum, has length and width approximately equal to the largest vertically-projected dimensions shown in Figure 2-1. *(Requires subsequent verification of CSS vendor design.)*

iii. The overall projected length in the DTS plan view at the top of Figure 2-1 is 5 ft 11 in. Therefore, the length of the DTS stand is estimated at 6 ft. *(Requires subsequent verification of CSS vendor design.)*

File: LEMS-MCSC-17-CAL-003_R0- Canyon Floor Analysis
iv. The outer diameter of the cylinder that comprises the DTS body is given as 26 in. An additional 6 in is added to this figure as an allowance for the observable lateral overhang of unknown parts of the DTS assembly shown in Figure 2-1. (Requires subsequent verification of CSS vendor design.)

v. Based on the above assumptions, the DTS stand base plate is assumed to consist of a rectangular 1 in thick carbon steel plate of rectangular dimensions 72 in (6 ft) by 32 in. (Requires subsequent verification of CSS vendor design.)

vi. The remaining structure of the DTS stand that will be necessary to stably support the DTS in an upright position is assumed to have a weight equal to twice that of the base plate. (Requires subsequent verification of CSS vendor design.)

c) The combined weight of the DTS and DTS stand is uniformly distributed over the assumed footprint of the DTS stand base. (Requires subsequent verification of CSS vendor design.)

d) Assumption (c) (ii) necessitates a related assumption that the WESF Canyon floor area on which the DTS stand will be located is level and flat, i.e., has no significant unevenness (high/low spots), and that the base plate does not flex. Use of a 1-in thick base plate is assumed to negate appreciable flexing.

4.0 METHOD OF ANALYSIS

Table 4-1 summarizes the input parameters used in the analysis that follows.

<table>
<thead>
<tr>
<th>Parameter Description</th>
<th>Quantity and Units</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loaded DTS weight</td>
<td>22,000 lb</td>
<td>Section 2.0, items 1 and 2, with assumed round-up as stated in Section 3.0, item (a)</td>
</tr>
<tr>
<td>Unit area weight of 1-in carbon steel plate</td>
<td>40.84 lb/ft²</td>
<td>Ryerson Stock List and Section 3.0, item (b)(i)</td>
</tr>
<tr>
<td>Dimensions (length and width) of DTS stand base</td>
<td>72 in by 32 in</td>
<td>Section 3.0, item (b)(v)</td>
</tr>
<tr>
<td>Relative weight of DTS stand structure (not including base plate)</td>
<td>2 times base plate weight</td>
<td>Section 3.0, item (b)(vi)</td>
</tr>
</tbody>
</table>

4.1 DTS Stand Base Plate Area

The base plate area is calculated as:

\[
\frac{72 \text{ in} \times 32 \text{ in}}{144 \text{ in}^2/\text{ft}^2} = 16.0 \text{ ft}^2
\]

4.2 DTS Stand Base Plate Weight

The base plate weight is calculated as:

\[
16 \text{ ft}^2 \times 40.84 \text{ lb/ft}^2 = 648 \text{ lb} \approx 650 \text{ lb}
\]

File: LEMS-MCSC-17-CAL-003_R0- Canyon Floor Analysis
4.3 Estimated DTS Stand Weight
The DTS stand weight, including the base and the DTS support structure, is calculated as:

\[ 650 \text{ lb} + \ (2)(650 \text{ lb}) = 1950 \text{ lb} \]

4.4 Total Weight of DTS Plus DTS Stand
The total weight of the loaded DTS plus DTS stand is calculated as:

\[ 22,000 \text{ lb} + 1950 \text{ lb} = 23,950 \text{ lb} \approx 24,000 \text{ lb} \]

4.5 Unit Loading on the WESF Canyon Floor
Taking the results of Sections 4.1 and 4.4, the unit loading on the WESF Canyon floor is calculated as:

\[ \frac{24000 \text{ lb}}{16 \text{ ft}^2} = 1500 \frac{\text{lb}}{\text{ft}^2} \]

5.0 USE OF COMPUTER SOFTWARE
No software other than Microsoft™ Word® was used to prepare this calculation. All numerical calculations were performed with hand calculator.

6.0 RESULTS
The estimated unit loading on the WESF Canyon floor for the DTS plus DTS stand is 1500 lb/ft². This is below the recommended live load limit of 2900 lb/ft² given in SD-WM-DA-031, WESF Floor Loading Analysis for RSI/GE 1500 Casks, and is therefore acceptable.

7.0 CONCLUSIONS
The WESF Canyon floor will be able to support the DTS plus DTS stand. Note that this conclusion is contingent upon the validity of the assumptions of a level, flat Canyon floor area where the DTS stand will be situated, and no appreciable flexing of the stand’s base plate (see Section 2.0, item (d)).
8.0 REFERENCES

1. 30059-S-01 (Draft), Design Specification for the Cask Storage System (CSS) for the Management of the Cesium and Strontium Capsules Project (MCSC) at the Hanford Site, January 2017, NAC International, Norcross, Georgia.

2. NAC International Drawing, Project No. 80001.01, Drawing No. 16, Sheet 1, Dry Transfer Systems Hanford Operations, April 19, 2016, NAC International, Norcross, Georgia.


Calculation Note and Peer Review

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<tr>
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</table>

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| NA | |
|    | |

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<td>Perform a G Cell heat balance to estimate HVAC air inlet cooling requirements and wall / ceiling concrete temperatures.</td>
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<th></th>
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<tbody>
<tr>
<td>A water chiller capable of removing ~11,000 – 11,500 BTU/h of heat will be required to cool G Cell inlet air such that: (a) G Cell interior concrete wall and ceiling temperatures will not exceed 150 °F per American Concrete Institute concrete temperature range recommendations; and (b) personnel entries into G Cell will be possible for equipment maintenance if necessary.</td>
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Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tr>
<td>BTU</td>
<td>British thermal unit</td>
</tr>
<tr>
<td>Cs</td>
<td>cesium</td>
</tr>
<tr>
<td>CSS</td>
<td>Cask Storage System</td>
</tr>
<tr>
<td>DOE</td>
<td>U.S. Department of Energy</td>
</tr>
<tr>
<td>ft</td>
<td>foot (feet)</td>
</tr>
<tr>
<td>GTAW</td>
<td>gas tungsten arc welding</td>
</tr>
<tr>
<td>h</td>
<td>hour</td>
</tr>
<tr>
<td>HVAC</td>
<td>heating, ventilation and air conditioning</td>
</tr>
<tr>
<td>in</td>
<td>inch (inches)</td>
</tr>
<tr>
<td>MCSC</td>
<td>Management of the Cesium and Strontium Capsules</td>
</tr>
<tr>
<td>NAC</td>
<td>NAC International</td>
</tr>
<tr>
<td>PPE</td>
<td>personnel protective equipment</td>
</tr>
<tr>
<td>Sr</td>
<td>strontium</td>
</tr>
<tr>
<td>UCS</td>
<td>Universal Capsule Sleeve</td>
</tr>
<tr>
<td>WESF</td>
<td>Waste Encapsulation and Storage Facility</td>
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1.0 OBJECTIVE/TURPOSE

1.1 Background

Dry storage of Waste Encapsulation and Storage Facility (WESF) cesium (Cs) and strontium (Sr) capsules has been proposed by the U.S. Department of Energy (DOE) per Project W-135, Management of the Cesium and Strontium Capsules (MCSC). The MCSC Project may entail locating up to 12 Cs or Sr capsules in G Cell at one time, which presents up to ~4000 W of decay heat. Further, a gas tungsten arc welding (GTAW) torch will be used in G Cell as part of an automatic welding system (AWS) to be provided by NAC; the MCSC Project Cask Storage System (CSS) vendor, for closure of Universal Capsule Sveeves (UCSs). The GTAW arc will dissipate considerable energy as heat. Finally, the high-energy G Cell lighting system, required for good visibility of the G Cell interior from the Operating Galley via the cell’s lead glass windows, produces a significant baseline heat load. Other intermittent / miscellaneous heat loads will be minor by comparison and are neglect in this analysis.

1.2 Purpose

This calculation estimates G Cell air and concrete temperatures for various operating scenarios of heat input, HVAC air flow rate, and HVAC inlet air cooling while processing Sr capsules during the MCSC Project. “What-if” scenarios are included to investigate the effects of various G Cell inlet air temperatures on hypothetically required HVAC flow rates to maintain target G Cell air temperatures.

2.0 INPUT DATA

Inputs to this calculation are as follows:

1. Maximum HVAC flow to G Cell from the WESF Canyon is 300 CFM per drawing H-2-836672 in the Project W-130 Mechanical Drawing Set Stamped 7-9-15.
2. The WESF Canyon temperature during summer months is 75 °F per Project W-130 Functional Design Criteria (FDC) CHPRC-02192. This temperature is also noted on page 222 of V1 11000023, WESF 225B HVAC System Design Calculations.
3. The G Cell wall concrete conductive heat transfer resistance is 1.95 ft² °F/ BTU, taken from V1-11000023 and used for consistency with prior analyses.
4. The total G Cell lighting heat load for six 500-W incandescent lights is 3000 W, as given on drawing H-2-66766, Sheets 1 and 2 (500 W/light x 6 lights).
5. The conservatively limiting maximum allowable concrete temperature is 150 °F, taken from ACI 349-01, Appendix A.4, “Concrete temperatures.”
6. The heat capacity of air is 0.24 BTU/lb°F, taken from The Engineering Toolbox website. This value is valid between -100 and +180 °F. See References, Section 8.9, for the applicable URL.
7. The density of air in the temperature range applicable to this analysis is 0.075 lb/ft³, obtained from the 2009 ASHRAE Fundamentals Handbook, Chapter 1, Table 2. This value is for 70 °F, within the range of temperatures applicable to this analysis.
8. The density and heat capacity of water at 60 °F are 62.34 lb/ft³ and 1.000 BTU/lb°F, respectively, taken from The Engineering Toolbox website. See References, Section 8.0, for the applicable URL.
9. The flow rate of water through the water chiller is 2.3 gpm, taken from the Omni-Chill vendor literature in Attachment A (Section 9.1) for the AC-100A chiller unit.

File: LEMS-MCSC-17-CAL-005 Rev 0_170511.docx
10. G Cell dimensions, 16 ft long x 8 ft wide x12 ft high, arc taken from CHPRC-02411, W-130 Project K3N Exhaust System Analysis, Table 1.

11. The natural convective film heat transfer resistance for inside vertical surfaces, 0.68 ft\(^2\) \(\times\) °F \(\times\) h/ BTU, is taken from the 2009 ASHRAE Fundamentals Handbook, Chapter 18, Table 18. This value is applied to the vertical walls of G Cell and neighboring areas (other cells, Operating Gallery).

12. The natural convective film heat transfer resistance for inside horizontal surfaces, 0.92 ft\(^3\) \(\times\) °F \(\times\) h/ BTU, is taken from the 2009 ASHRAE Fundamentals Handbook, Chapter 18, Table 18. This value is applied to the G Cell ceiling and to the WESF Canyon floor above.

13. The conversion from watts to BTU/h is 1 W = 3.41 BTU/h.

14. Decay heat values for the 12 highest thermal power Sr capsules are taken from CHPRC-02248, Appendix B. The capsule ID numbers and heat loads are listed in Table 2-1.

<table>
<thead>
<tr>
<th>Outer Capsule ID</th>
<th>Wattage as of 1/1/2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-458</td>
<td>391</td>
</tr>
<tr>
<td>S-112</td>
<td>361</td>
</tr>
<tr>
<td>S-77</td>
<td>352</td>
</tr>
<tr>
<td>S-86</td>
<td>351</td>
</tr>
<tr>
<td>S-83</td>
<td>339</td>
</tr>
<tr>
<td>S-408</td>
<td>331</td>
</tr>
<tr>
<td>S-94</td>
<td>331</td>
</tr>
<tr>
<td>S-471</td>
<td>339</td>
</tr>
<tr>
<td>S-533</td>
<td>319</td>
</tr>
<tr>
<td>S-1017</td>
<td>313</td>
</tr>
<tr>
<td>S-520</td>
<td>311</td>
</tr>
<tr>
<td>S-88</td>
<td>308</td>
</tr>
<tr>
<td>Total</td>
<td>4038</td>
</tr>
</tbody>
</table>

3.0 ASSUMPTIONS

The following assumptions were made for this analysis. Assumptions that require subsequent verification as the CSS vendor design progresses are noted as such in italicized parenthesis.

a) The bounding capsule decay heat input to G Cell arises from the 12 highest thermal power Sr capsules as of 1/1/2018. This bounding 12-capsule heat load is shown in Table 2-1 above.

b) The sole significant heat sources in G Cell are the lighting, 12 bounding Sr capsules, and the GTA W torch to be used for UCS closure. Miscellaneous other heat sources are intermittent and do not appreciably contribute to cell heating.
c) The UCS evacuation and helium backfill pump is assumed to be located outside G Cell such that it contributes no heat to the cell. Portions of the helium backfill and leak detection system located in G Cell are assumed to remain inactive while the GTAW torch is in use. *(Requires subsequent verification of CSS vendor design.)*

d) The GTAW torch produces 3000 W of heat while in operation. This is an estimated assumed value based on Stenbacka 2013 (see Section 8.0, References). *(Requires subsequent verification of CSS vendor design.)*

e) The welding console that controls the GTAW torch is located outside G Cell such that its heat is dissipated elsewhere. *(Requires subsequent verification of CSS vendor design.)*

f) The minimum HVAC air flow rate through G Cell is 140 CFM. This establishes the bottom end of the range to be considered in this calculation, i.e., 300 CFM max and 140 CFM minimum.

g) The G Cell personnel entry door ("mundoor") is assumed to remain closed to prevent air in- or out-leakage. In any event, the door would be closed for all normal operating conditions when Cs or Sr capsules are present in the cell.

h) The air in G Cell is well-mixed such that the bulk air temperature equals that of the exit air.

i) The temperature of G Cell surroundings is 75 °F, same as the WESF Canyon summer temperature used in the Project W-130 FDC and in Y1 11600023.

Figure 3-1 shows an excerpt from the associated Excel® workbook file listing the assumed G Cell heat sources.

<table>
<thead>
<tr>
<th>G-Cell Heat Sources</th>
<th>Load</th>
<th>Units</th>
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<tbody>
<tr>
<td>Cell Lighting</td>
<td>3000</td>
<td>W</td>
</tr>
<tr>
<td>Capsule Dry Storage Equipment</td>
<td></td>
<td></td>
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<tr>
<td>Welding Machine</td>
<td>8000</td>
<td>W</td>
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<td>Welding Console</td>
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<td>W</td>
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<td>Evacuation Backfill pump</td>
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<td>W</td>
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<tr>
<td>Evacuation Backfill other</td>
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<td>W</td>
</tr>
<tr>
<td>Miscellaneous G-Cell sources</td>
<td>0</td>
<td>W</td>
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<td>Ne Leak Detection System</td>
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<td>W</td>
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<td>Capsules</td>
<td>4037.42</td>
<td>W</td>
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**Figure 3-1. Listing of G Cell Heat Source Assumptions from Excel® Workbook**

### 4.0 METHOD OF ANALYSIS

Calculations are documented in the attached Excel® file. The general approach taken is as follows:

1. Determine G Cell heat transfer parametric inputs (film coefficients, concrete thermal resistance, air density and heat capacity, 12 bounding Sr capsules, G Cell dimensions, etc.) from references as discussed in Section 2.0.

File: LEMS-MCSC-17-CAL-005 Rev 0_170511.docx
2. Build spreadsheet cases with varying parameters for sensitivity study based on a heat balance of G Cell HVAC airflow using the basic equation:

\[ Q = \dot{m}C_p \Delta T \]

Where: 
- \( Q \) = G Cell input heat load, equal to the quantity of heat removed by the HVAC airflow for a heat balance; 
- \( \dot{m} \) = Mass flow rate of air; 
- \( C_p \) = Constant-pressure heat capacity of air; 
- \( \Delta T \) = temperature differential across G Cell, i.e., \( T_{\text{inlet}} - T_{\text{ambient}} \).

3. Use Excel® Goal Seek function to solve for G Cell air temperature when Total Heat Removed equals Total Heat Generated (see cells B42, B43 and B44 in the Cases 1a through Case 10 Worksheets). The sensitivity cases described further down identify the spreadsheet value solved for using Goal Seek.

4. Following a solution for the G Cell air temperature, calculate convection/conduction heat transfer across the inner and outer wall and ceiling convective film layers and the concrete itself to obtain inner and outer concrete surface temperatures based on a surroundings temperature of 75°F.

5. Sensitivity cases are as follows:
   a. Case 1a – Existing G Cell conditions with 3000 W lighting heat load only; minimal 140 CFM airflow into G Cell from WESF Canyon; 75°F entering air temperature; use Goal Seek to solve for G Cell air temperature (cell B7).
   b. Case 1b – Like Case 1a but with 300 CFM airflow into G Cell; use Goal Seek to solve for G Cell air temperature (cell B7).
   c. Case 2 – Add 4038 W Sr capsule heat load and 3000 W G TAW torch heat load; minimal 140 CFM G Cell air inflow; use Goal Seek to solve for G Cell air temperature (cell B7).
   d. Case 3 – Like Case 2 but with 300 CFM G Cell air inflow (corresponds to maximum available airflow through G Cell after Project W-130 is complete); use Goal Seek to solve for G Cell air temperature (cell B7).
   e. Case 4 – Like Case 3 but with G Cell inlet air cooled to 55°F.
   f. Case 5 – Like Case 4 but with the G Cell air temperature constrained to 120°F; use Goal Seek to solve for hypothetical G Cell inlet airflow (cell B6) in excess of 300 CFM as required to maintain this air temperature while still achieving an overall heat balance.
   g. Case 6 – Like Case 5 but with G Cell inlet air temperature of 75°F (i.e., no inlet air cooling); use Goal Seek to solve for hypothetical G Cell inlet airflow (cell B6) in excess of 300 CFM as required to maintain this air temperature while still achieving an overall heat balance.
   h. Case 7 – Like Case 5 but without the 3000 W G TAW torch heat load and with G Cell air temperature constrained to 105°F; use Goal Seek to solve for hypothetical G Cell inlet airflow (cell B6) in excess of 300 CFM as required to maintain this air temperature while still achieving an overall heat balance.
   i. Case 8 – Like Case 6 but without the 3000 W G TAW torch heat load and with G Cell air temperature constrained to 105°F; use Goal Seek to solve for hypothetical G Cell inlet airflow (cell B6) in excess of 300 CFM as required to maintain this air temperature while still achieving an overall heat balance.

File: LEMS-MCSC-17-CAL-005 Rev 0_170511.docx
j. **Case 9** — Like Case 3 but without the 3000 W GTAW torch heat load; use Goal Seek to solve for G Cell air temperature (cell B7).

k. **Case 10** — Like Case 4 but without the 3000 W GTAW torch heat load; use Goal Seek to solve for G Cell air temperature (cell B7).

Table 4-1 below summarizes these sensitivity case descriptions for improved clarity.

6. Last, the Workbook “Chiller Cables” tab contains a brief calculation to conservatively estimate the required performance (BTU/h) for a water chiller to cool the G Cell inlet air. This bounding estimate conservatively assumes that the Canyon air temperature is 85 °F, rather than 75 °F, and that the G Cell inlet air flow is at the maximum post-Project W-130 value of 300 CFM. The required BTU/h chiller performance is based on the water side delta-T, which accounts for heat transfer inefficiencies.

### Table 4-1. Tabulated Description of G Cell Heat Balance Sensitivity Cases

<table>
<thead>
<tr>
<th>Case No.</th>
<th>G Cell Inlet Air Temp (°F)</th>
<th>G Cell Air Inflow Rate (CFM)</th>
<th>Heat Load (W)</th>
<th>G Cell Bulk Air Temperature (°F)</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>75</td>
<td>146</td>
<td>3000</td>
<td>Solved for w/ Goal Seek</td>
<td>Model existing conditions with minimal airflow</td>
</tr>
<tr>
<td>1b</td>
<td>75</td>
<td>300</td>
<td>3000</td>
<td>Solved for w/ Goal Seek</td>
<td>Model existing conditions with maximum airflow following Project W-130 completion</td>
</tr>
<tr>
<td>2</td>
<td>75</td>
<td>146</td>
<td>10,038</td>
<td>Solved for w/ Goal Seek</td>
<td>Model MCSC Project operations with full heat load, no inlet air cooling, minimal airflow</td>
</tr>
<tr>
<td>3</td>
<td>75</td>
<td>300</td>
<td>10,038</td>
<td>Solved for w/ Goal Seek</td>
<td>Model MCSC Project operations with full heat load, no inlet air cooling, maximum airflow</td>
</tr>
<tr>
<td>4</td>
<td>55</td>
<td>300</td>
<td>10,038</td>
<td>Solved for w/ Goal Seek</td>
<td>Model MCSC Project operations with full heat load, inlet air cooled to 55 °F, maximum post-W-130 airflow</td>
</tr>
<tr>
<td>5</td>
<td>Solved for w/ Goal Seek</td>
<td>10,038</td>
<td>Constrained to 120</td>
<td>Model MCSC Project operations with full heat load, inlet air cooled to 55 °F, G Cell bulk air temperature constrained to 120 °F</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Solved for w/ Goal Seek</td>
<td>10,038</td>
<td>Constrained to 120</td>
<td>Model MCSC Project operations with full heat load, no inlet air cooling, G Cell bulk air temperature constrained to 120 °F</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Solved for w/ Goal Seek</td>
<td>7038</td>
<td>Constrained to 105</td>
<td>Model MCSC Project operations with capsule and lighting heat loads only, inlet air cooled to 55 °F, G Cell bulk air temperature constrained to 105 °F</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Solved for w/ Goal Seek</td>
<td>7038</td>
<td>Constrained to 105</td>
<td>Model MCSC Project operations with capsule and lighting heat loads only, no inlet air cooling, G Cell bulk air temperature constrained to 105 °F</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>75</td>
<td>300</td>
<td>7038</td>
<td>Solved for w/ Goal Seek</td>
<td>Model MCSC Project operations with capsule and lighting heat loads only, no inlet air cooling, maximum post-W-130 airflow</td>
</tr>
</tbody>
</table>
5.0 USE OF COMPUTER SOFTWARE

Microsoft® Excel® was used to prepare this calculation.
6.0 RESULTS

6.1 G Cell Heat Balance

Table 6-1 presents the primary calculation results in the format of Table 4-1. The solved values are identified in bold font.

<table>
<thead>
<tr>
<th>Case No.</th>
<th>G Cell Inlet Air Temp (°F)</th>
<th>G Cell Air Inflow Rate (CFM)</th>
<th>Heat Load (W)</th>
<th>G Cell Bulk Air Temperature (°F)</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>75</td>
<td>140</td>
<td>3000</td>
<td>105</td>
<td>Model existing conditions with minimal airflow</td>
</tr>
<tr>
<td>1b</td>
<td>75</td>
<td>300</td>
<td>3000</td>
<td>95</td>
<td>Model existing conditions with maximum airflow following Project W-130 completion</td>
</tr>
<tr>
<td>2</td>
<td>75</td>
<td>140</td>
<td>10,038</td>
<td>175</td>
<td>Model MCSC Project operations with full heat load, no inlet air cooling, minimal airflow</td>
</tr>
<tr>
<td>3</td>
<td>75</td>
<td>300</td>
<td>10,038</td>
<td>141</td>
<td>Model MCSC Project operations with full heat load, no inlet air cooling, maximum airflow</td>
</tr>
<tr>
<td>4</td>
<td>55</td>
<td>306</td>
<td>10,038</td>
<td>129</td>
<td>Model MCSC Project operations with full heat load, inlet air cooled to 55 °F, maximum post-W-130 airflow</td>
</tr>
<tr>
<td>5</td>
<td>55</td>
<td>265</td>
<td>10,038</td>
<td>Constrained to 120</td>
<td>Model MCSC Project operations with full heat load, inlet air cooled to 55 °F, G Cell bulk air temperature constrained to 120 °F</td>
</tr>
<tr>
<td>6</td>
<td>75</td>
<td>528</td>
<td>10,038</td>
<td>Constrained to 120</td>
<td>Model MCSC Project operations with full heat load, no inlet air cooling, G Cell bulk air temperature constrained to 120 °F</td>
</tr>
<tr>
<td>7</td>
<td>55</td>
<td>338</td>
<td>7038</td>
<td>Constrained to 105</td>
<td>Model MCSC Project operations with capsule and lighting heat loads only, inlet air cooled to 55 °F, G Cell bulk air temperature constrained to 105 °F</td>
</tr>
<tr>
<td>8</td>
<td>75</td>
<td>564</td>
<td>7038</td>
<td>Constrained to 105</td>
<td>Model MCSC Project operations with capsule and lighting heat loads only, no inlet air cooling, G Cell bulk air temperature constrained to 105 °F</td>
</tr>
<tr>
<td>9</td>
<td>75</td>
<td>300</td>
<td>7038</td>
<td>122</td>
<td>Model MCSC Project operations with capsule and lighting heat loads only, no inlet air cooling, maximum post-W-130 airflow</td>
</tr>
<tr>
<td>10</td>
<td>55</td>
<td>300</td>
<td>7038</td>
<td>109</td>
<td>Model MCSC Project operations with capsule and lighting heat loads only, inlet air cooled to 55 °F, maximum post-W-130 airflow</td>
</tr>
</tbody>
</table>

Figure 6-1 shows the case results summary from the associated Excel® workbook.
Figure 6-1. G Cell Heat Balance Case Results Summary from Excel® Workbook

<table>
<thead>
<tr>
<th>Case Results Summary</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
<th>Case 5</th>
<th>Case 6</th>
<th>Case 7</th>
<th>Case 8</th>
<th>Case 9</th>
<th>Case 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell Inlet Air Temperature (°F)</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Cell Outlet Air Temperature (°F)</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Operating Gas Wall Temperature OUTSIDE (°F)</td>
<td>82.95</td>
<td>95.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
</tr>
<tr>
<td>Operating Gas Wall Temperature INSIDE (°F)</td>
<td>79.65</td>
<td>92.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
</tr>
<tr>
<td>Operating Gas Elbow (°F)</td>
<td>82.95</td>
<td>95.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
</tr>
<tr>
<td>Operating Gas Elbow (°F)</td>
<td>79.65</td>
<td>92.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
</tr>
<tr>
<td>Operating Gas Outlet (°F)</td>
<td>82.95</td>
<td>95.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
</tr>
<tr>
<td>Operating Gas Outlet (°F)</td>
<td>79.65</td>
<td>92.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
</tr>
<tr>
<td>Operating Gas Outlet (°F)</td>
<td>82.95</td>
<td>95.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
<td>84.85</td>
</tr>
<tr>
<td>Operating Gas Outlet (°F)</td>
<td>79.65</td>
<td>92.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
<td>83.65</td>
</tr>
</tbody>
</table>

File: LEMS-MCSC-17-CAL-005 Rev 0_170511.docx
The results in Figure 6-1 show that it will be necessary to cool the G Cell inlet air to 55°F in order to support personnel entry, if needed for equipment maintenance, and to maintain concrete wall and ceiling temperatures as low as possible for concrete durability.

G Cell operations during the MCSC Project fall into three general categories, each discussed below along with the sensitivity case that most realistically represents it.

1. **No Ongoing MCSC Project Operations in G Cell.** This is best represented by Case 1b which entails only the 3000 W G Cell lighting heat load with 300 CFM air flow. For this minimal heat load case, inlet air cooling to below 75°F is not necessary. The G Cell bulk air temperature remains low at 95°F and the inner concrete wall temperature is similarly low at 91°F.

2. **Full MCSC Project Operations in G Cell.** Case 4, with an inlet air flow of 300 CFM cooled to 55°F and the full heat load of G Cell lighting plus 12 bounding Sr capsules plus the GTAW welding torch (10,038 W total), is the most realistic case for full MCSC operations. The G Cell bulk air temperature rises to nearly 130°F, but this is 20°F below the ACI-recommended concrete temperature limit of 150°F. It is too warm for personnel entry; however, entries would not be made with the AWS in use. Most likely, an entry would be made for the purpose of repairing the GTAW equipment.

3. **“Standby” MCSC Project Operations in G Cell.** “Standby” here is defined as a full 12 bounding Sr capsules in G Cell with the AWS powered down and the Sr capsules shielded to allow personnel entry. Case 10, with 300 CFM air flow into G Cell cooled to 55°F, best represents this situation. The G Cell bulk air temperature is below 110°F and would allow brief periods of personnel entry for maintenance with the appropriate personnel protective equipment (PPE) such as ice vests.

Note that maximum concrete temperatures inside G Cell (“Operating Gallery Wall INSIDE” in Figure 6-1) for all sensitivity cases except Case 2 are below the ACI 349-01 maximum allowable concrete temperature of 150°F. Case 2 is a hypothetical “worst case” that models the minimal 140 CFM air flow rate and includes no cooling of G Cell inlet air; these conditions will not be realized during actual MCSC Project operations.

### 6.2 Water Chiller Calculations for G Cell Inlet Air Cooling

Figure 6-2 shows the water chiller requirements calculation from the associated Excel® workbook. The WESF Canyon air temperature is assumed to be at 85°F for conservatism, 10°F hotter than anticipated. These calculations are based on the chiller vendor literature in Attachment A (Section 9.1).

**Figure 6-2. G Cell Air Inlet Water Chiller Calculation from Excel® Workbook**

<table>
<thead>
<tr>
<th>Chiller Calc</th>
<th>Variables:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Air flow</td>
<td>300 cfm</td>
<td>85°F</td>
</tr>
<tr>
<td>T(air)in.</td>
<td></td>
<td>55°F</td>
</tr>
<tr>
<td>H2O flow</td>
<td>2.3 gpm</td>
<td>0.30747 ft³/s/min</td>
</tr>
<tr>
<td>T(h2o)out.</td>
<td>60°F</td>
<td>62.34 lb/ft²·s @ 60°F</td>
</tr>
</tbody>
</table>

Chiller requirement based on ΔT(air): 0.30747 ft³/s

Chiller performance based on ΔT(water): 11500.43 BTU/hr

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Note that the conservative result of 11,500 Btu/h closely matches the 11,400 Btu/h performance of the Omni-Chill Model AC-100A air cooled water chiller boxed in red on the second page of the flyer in Attachment A. It would also be possible to use a water-cooled water chiller if utility water is readily available in the WEST Canyon where the chiller would most likely be located. In that case, the smallest Omni-Chill water-cooled unit, the AC-100W with a capacity of 16,200 Btu/h, would work. However, assuming that the WEST Canyon air can serve as an adequate heat sink for the rejected heat, use of the air-cooled unit would be simpler.

6.3 Operating Gallery Concrete Temperature for Personnel Contact

There is a potential for facility personnel to sustain pain and burns resulting from contact with hot surfaces, such as the G Cell outer concrete wall in the WEST Operating Gallery. Figure 6-3 shows Table 6 from Chapter 10 of the 2009 ASHRAE Fundamentals Handbook, which gives time vs. temperature data for pain and injury due to hot surface exposure.

Figure 6-3. Pain / Injury Threshold Surface Temperature Limits from 2009 ASHRAE Fundamentals

<table>
<thead>
<tr>
<th>Table 6</th>
<th>Approximate Surface Temperature Limits to Avoid Pain and Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Contact Time 1 s 10 s 1 min 10 min 8 h</td>
</tr>
<tr>
<td>Material</td>
<td>149°F 133°F 124°F 118°F 109°F</td>
</tr>
<tr>
<td>Glass, concrete</td>
<td>136°F 151°F 129°F 118°F 109°F</td>
</tr>
<tr>
<td>Wood</td>
<td>248°F 190°F 140°F 118°F 109°F</td>
</tr>
</tbody>
</table>

Note that the "Operating Gallery Wall Temperature OUTSIDE" results shown in Figure 6-1 (see Section 6.1) for all sensitivity cases are well below the 8-h exposure temperature of 109 °F for concrete in Figure 6-3. Hence, there is no risk of burns to WEST operations personnel due to contact with the Operating Gallery wall in front of G Cell.

7.0 CONCLUSIONS

The MCSC Project capsule packaging activities in G Cell will require inlet air cooling via a water chiller and an appropriate water coil / heat exchanger located in the G Cell HVAC inlet duct. This calculation demonstrates that it is possible to handle the full MCSC Project G Cell heat load as long as (a) the G Cell inlet air is cooled to at least 55 °F and (b) the G Cell air flow rate is maintained at the post-Project W-130 maximum of 380 CFM. This level of air cooling performance also facilitates G Cell personnel entries for equipment maintenance, even with 12 bounding Sr capsules present in the cell, provided that NAC’s G Cell equipment design includes adequate personnel shielding.

The G Cell cooling and air flow specified above will maintain maximum concrete temperatures inside G Cell below the conservative limit of 150°F per ACI 349-01.

An Omni-Chill Model AC-100A, which can provide 11,400 Btu/h of cooling, is a candidate water chiller unit that will provide the necessary G Cell inlet air cooling performance when paired with an appropriately-sized heat exchanger situated in the G Cell air inlet duct. Sizing of this water chiller unit is based on a conservatively high 85 °F WEST Canyon air temperature, compared to the 75 °F expected summer air temperature of the Canyon air that feeds G Cell.

There is no risk of personnel skin burns from contact with the WEST Operating Gallery wall in front of G Cell as the G Cell outside wall temperature will be below the pain / injury threshold identified in the 2009 ASHRAE Fundamentals Handbook.
Note that the 3000 W lighting portion of the GCell heat load can be reduced by changing to LED lamps, which generate far less heat for a given illumination level.

### 8.0 REFERENCES

#### 8.1 Documents and Internet Sites

2. ACI 349-01, Code Requirements for Nuclear Safety Related Concrete Structures (ACI 349-01), February 2001, American Concrete Institute, Farmington Hills, Michigan.
6. Mechanical drawing set to support request for proposal for W-130 project construction, Mechanical Drawing Set Stamped 7-9-15 Revision 0, CHPRC, Richland, Washington.
8. The Engineering Toolbox website for air and water properties, accessed 5/4/2017 at the following URLs:
   - Air: http://www.engineeringtoolbox.com/air-properties-d_156.html

#### 8.2 Computer Files

Supporting Excel® workbook file:

LEMS-MCSC-17-CAL-005 Rev 0_170511-01.xlsx

File: LEMS-MCSC-17-CAL-005 Rev 0_170511.docx
9.0 ATTACHMENTS

9.1 Attachment A: Chiller Vendor Literature

Omni-Chill®
Packaged Chiller Units

If you’re running city or well water through your machinery for cooling — you’re wasting money. With water bills and sewer charges increasing at a rapid pace with no relief in sight, it’s time to consider “closing the loop.” A low maintenance Omni-Chill packaged water chiller recirculates your water through a refrigerant system giving you inexpensive, reliable heat transfer.

Complete systems include integral pumping systems, electrical control panels and full refrigerant safety controls. Standard systems are pre-charged and ready to run. Water cooled and air cooled units are available from 1/2 ton through 200 tons. Options include: non-ferrous construction, casters, hot gas bypass for reduced load operation, emergency backup cooling systems, etc.

Dry Coolers can meet almost any specification with a standard or custom built cooling package.

Stop wasting valuable fresh water for process cooling. — look into our easy-to-install packaged chiller units today.

One of our knowledgeable application engineers will be ready to assist you in designing a more efficient method of cooling your process. An Omni-Chill® chiller is compact in size, but big in quality and reliability.

Dry Coolers Inc.

Features:
- Air Cooled or Water Cooled Condensers
- Digital Indicating Microprocessor Temperature Controller
- Flow Switch & Low Temp Alarm for Freeze Protection
- High & Low Refrigerant Pressure Indication
- Direct Drive Propeller Fans (Air Cooled Condenser Models)
- Water Regulating Valve (Water Cooled Condensers)
- Crankcase Heater & Suction Line Accumulator
- Filter Drive & Refrigerant (High Volume)
- Insulated Water Lines & Reservoir
- Rugged Steel Housing — Removable for Easy Access
- Pre-Charged & Pre-Wired for Easy Installation

File: LEMS-MCSC-17-CAL-005 Rev 0_170511.docx
Three Good Reasons to get an Omni-Chill Process Chiller—Quality Features, Industrial Specs, and Low Price

![Diagram of an Omni-Chill Process Chiller]

### Table: Model Specifications

<table>
<thead>
<tr>
<th>Model</th>
<th>HP</th>
<th>BTU/H</th>
<th>Chilled Water GPM</th>
<th>Total FLA</th>
<th>Condenser Water GPM</th>
<th>Connections</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC-100A</td>
<td>1</td>
<td>11,400</td>
<td>1/2</td>
<td>2.3</td>
<td>13.6</td>
<td>8.5</td>
<td>—</td>
</tr>
<tr>
<td>AC-150A</td>
<td>1.5</td>
<td>16,800</td>
<td>2/4</td>
<td>3.6</td>
<td>21.3</td>
<td>16.5</td>
<td>—</td>
</tr>
<tr>
<td>AC-200A</td>
<td>2</td>
<td>21,000</td>
<td>2/4</td>
<td>4.8</td>
<td>24.0</td>
<td>15.2</td>
<td>7.8</td>
</tr>
<tr>
<td>AC-300A</td>
<td>3</td>
<td>33,000</td>
<td>3/4</td>
<td>6.7</td>
<td>40.8</td>
<td>26.5</td>
<td>13.0</td>
</tr>
<tr>
<td>AC-400A</td>
<td>4</td>
<td>44,000</td>
<td>3/4</td>
<td>12.2</td>
<td>48.6</td>
<td>29.4</td>
<td>20.3</td>
</tr>
</tbody>
</table>

Note: 1 Chiller is 12,000 BTU/hr. Capacities are based on 90°F entering water, 80°F leaving water at 9°F ambient temp. Specifications are subject to change without notice. Please consult factory for detailed prints and performance.

---

** ALSO AVAILABLE **

- Large Central Chiller Systems
- Evaporative Cooling Tower Systems
- Non-Refrigerant Air Cooled Heat Exchangers
- Packaged Pumping Stations and Control Systems
- Closed Circuit Evaporative Coolers

---

3232 Adventure Lane
Orford, MI 48371
1-800-525-8173
Fax (248) 969-3401
www.drycoolers.com

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Calculation Note and Peer Review

Calculation Set No.
LEMS-MSCC-17-CAL-006

End Use: Conceptual

Rev No. 1

Project: WESF II
Sheet 1 of 10

Discipline: Electrical
Contract No. 57305

Structure or System: WESF
Reserved

Subject: WESF Electrical Loads for MCSC Project

Completed by: 
Date 6/15/2017

Checked by: 
Date 6/15/2017

Approved by [To Be Updated]
Date 6/15/2017

Distribution:

Reason for Revision:
Incorporate CHPRC comments on Rev. 0.

Total number of sheets in this issue: 10
Sheets revised, added or deleted: NA

Problem Statement:
Estimate electrical loads at the Waste Encapsulation and Storage Facility (WESF) necessary to support the Management of the Cesium and Strontium Capsules (MCSC) Project (W-135).

Summary Conclusions:
The MCSC Project will impose a new electrical load of approximately 141 kVA to the WESF electrical system. The total WESF electrical load will be approximately 755 kVA during the MCSC Project. This anticipated load is well within the 2 x 750 kVA transformer capacity that feeds WESF. The MCSC loads by WESF area are identified as:
- Canyon – 19.6 kVA
- O Call – 75 kVA
- Truck Port – 47 kVA

Since not all loads will be simultaneously active, only one 750 kVA transformer should be needed at any given time during MCSC Project operations, leaving the remaining transformer as a full capacity backup power source.

Adequate power will be available from the existing substation to support the MCSC project without modifications.

See Section 7.0 for additional conclusions.

Design Basis:
NA – this is not a design basis calculation.

File: LEMS-MSCC-17-CAL-006 Rev 1
## Contents

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Acronyms and Abbreviations

AWS  Automatic Welding System
Cs   Cesium
CSS  Cask Storage System
DOE  U.S. Department of Energy
GTAW gas tungsten arc welding
He   Helium
IEFD Instrument Engineering Flow Diagram
kVA  kilovolt-amps
MCSC Management of the Cesium and Strontium Capsules (Project W-135)
NAC  NAC International
Sr   Strontium
UCS  Universal Capsule Sleeve
WESF Waste Encapsulation and Storage Facility
1.0 OBJECTIVE/PURPOSE

Dry storage of Waste Encapsulation and Storage Facility (WESF) cesium (Cs) and strontium (Sr) capsules has been proposed by the U.S. Department of Energy (DOE) per Project H-135, Management of the Cesium and Strontium Capsules (MCSC). Various WESF modifications are required to support the MCSC Project, one of which is the addition of new electrical loads for the duration of the Project. This calculation estimates the MCSC Project-related electrical loads and tallies them up for comparison against available electrical capacity at WESF. Means of providing electrical power to the projected loads are also discussed.

2.0 INPUT DATA

Inputs to this calculation are as follows:

1. WESF electrical load data from CHPRC-02426
2. Miscellaneous electrical power supply data from CHPRC-02424

3.0 ASSUMPTIONS

The following assumptions were made for this analysis. Assumptions that require subsequent verification as the CSS vendor design progresses are noted as such in italicized parenthesis.

(a) Although no MCSC loads are currently required to have standby power, some loads may be connected to WESF optional standby electrical power busses MCC-2 and MCC-3 (labeled as “Emergency” on H-2-96643, Sheets 2 and 3) if needed for constructability and/or cost savings. However, this calculation assumes that MCSC loads will be preferentially connected to normal power bus MCC-1.

(b) The power source for the Automatic Welding System (AWS) Gas Tungsten Arc Welding (GTAW) torch used for closure of the Universal Capsule Sleeves (UCSs) will be located outside of G Cell in the Operating Gallery. (Requires subsequent verification of CSS vendor design.)

(c) The AWS Welding Console will be located in the Operating Gallery, and will be powered from a standard 120 VAC convenience outlet located there. (Requires verification of CSS vendor design.)

(d) The power source for the UCS Evacuation/Helium (He) Backfill System will be located outside of G Cell in the Operating Gallery. (Requires subsequent verification of CSS vendor design.)

(e) Two separate 120 VAC, 20 amp power sources will be required within G Cell for the Evacuation/He Backfill System, and an additional separate 120 VAC, 10 amp power source will be required in G Cell for the He Leak Detection System. Similar power sources will be required for the Evacuation/He Backfill and He Leak Detection Systems to be installed in the Truck Port. (Requires subsequent verification of CSS vendor design.)

(f) There may be an additional 120 VAC, 10 amp load for a supplemental UCS cooling system in G Cell. (Requires subsequent verification of CSS vendor design.)

(g) Instrument electrical connections between G Cell and the Operating Gallery, separate from power connections, will be required for the Welding Console, Evacuation/He Backfill System, and the He Leak Detection System.

4.0 METHOD OF ANALYSIS

The attached Excel® spreadsheet adds up all new electrical loads to support the MCSC WESF activities as currently understood, and adds this estimate to the existing power loads anticipated at WESF at the conclusion of Project.
W-130. Estimated existing power loads are based on the existing load data summarized in the calculation performed in support of Project W-130 (CHPRC-02426, Rev. 0). The WESF one-line diagram is found on drawing H-2-96643. It is assumed that MCSC Project loads are preferentially connected to normal power bus MCC-1, although optional standby buses MCC-2 and MCC-3 may be used as noted in Section 3.0.

A detailed evaluation of the power available through the three WESF MCCs shown on drawing H-2-96643, Sheets 1, 2 and 3, was not performed for this calculation. Each MCC was sized to support full WESF operations during encapsulation. Current WESF activities draw far less power than these performed during encapsulation; therefore, the low-risk assumption has been made that there is adequate spare capacity within any one of the three MCCs to support MCSC Project loads.

4.1 WESF Canyon

The WESF Canyon equipment shown in the attached spreadsheet represents approximately 14.4 kVA of single phase, 120 VAC load, and 5.1 kVA of 230V/460V 3-phase load. During Project W-130, similar loads were handled using a portable power cart and 30kVA transformer connected to a 480 VAC welding receptacle. Drawing H-2-96643. Sheet 1 indicates the presence of such a receptacle in the WESF Canyon (WRCP-225B-CAN-1, see drawing zone C4), fed from MCC-1.

4.2 G Cell

G Cell operations will require two 480 VAC service lines to support the Universal Capsule Sleeve (UCS) closure Automatic Welding System (AWS) power source and the UCS Evacuation/Hehelium (He) Backfill Systems, both to be provided by NAC, the Cask Storage System (CSS) vendor. In both instances, it is assumed that the power sources will be located outside of G Cell, in the operating gallery, with connections to equipment in G Cell via existing electrical nozzles. Drawing H-2-96643, Sheet 1 indicates that there are three 480 VAC welding receptacles in the Operating Gallery (see drawing zones B4 and C6). Two of these receptacles, WRCP-225B-OG-1 and WRCP-225B-OG-2, are located in close proximity to the hot cells at instrument panels “C” and “F,” respectively, and are each served by a dedicated 480 VAC, 40 amp circuit. The Instrument Engineering Flow Diagram (IEFD) for G Cell, drawing H-2-9456, indicates two electrical nozzles, #295 and #13 (see Sheet 1, drawing zone D8), formerly used “For Capsule Welder Power Supply Ops Gallery.” These nozzles would be used to provide power from 480 VAC power supplies for the AWS and Evacuation/He Backfill systems located in the Operating Gallery.

The Welding Console is assumed to be located in the Operating Gallery, and will be powered from a standard 120 VAC convenience outlet located there.

It is assumed that two separate 120 VAC, 20 amp power sources will be required within G Cell for the Evacuation/He Backfill System, and an additional separate 120 VAC, 10 amp power source will be required in G Cell for the He Leak Detection System. It is further assumed that there may be an additional 120 VAC, 10 amp load for a supplemental UCS cooling system in G Cell. Calculation CHPRC-04242, Section 4.3.2, states that “The panel schedule for the 2-pole, 120/240 volt, 225 ampere rated lighting panel 225B-LP-E indicates that the 20 amp breaker on circuit 31 serves convenience receptacles located in G Cell.” Lighting Panel “E” is in the Service Gallery. Presumably, this lighting panel served more cells that G Cell. With the completion of Project W-130 and the goining of cells A – F, there should be spare breakers available in this lighting panel to support additional loads within G Cell. The G Cell IEFD (H-2-9456) lists unused electrical nozzles #31, #33 and #39 within G Cell (see H-2-9456, Sheet 2, drawing zones D2 – D3) that penetrate into the service gallery as being connected to the electrical wireway. Presumably, these nozzles are able to function as electrical connection points between Lighting Panel “E” and G Cell.

It is also assumed that instrument electrical connections between G Cell and the Operating Gallery, separate from power connections, will be required for the Welding Console, Evacuation/He Backfill System, and the He Leak Detection System. Drawing H-2-67032, (Embended Piping Plan & Sections “G” Cell) shows the following nozzles...
penetrating from G Cell into the Operating Gallery denoted as electrical nozzles: #10, #18, #23, #75, and #81. The G Cell IED (H-2-94596) shows nozzles #10, #18, #23, and #81 as capped off and unused; these nozzles would presumably be available to use as instrument connections.

Although there appear to be spare penetrations available between G Cell and the Operating Gallery and Service Gallery, the condition of these penetrations is unknown. Therefore, planned WESF Modifications should anticipate the need to core drill and install additional electrical/instrument penetrations into G Cell.

4.3 **Truck Port**

Drawing H-2-96643, Sheet 1, shows a 480 VAC welding receptacle located in the Service Gallery (WRCPT-225B-5G-1, see drawing zone C4). This receptacle is on the same 100 amp circuit as WESF Canyon welding receptacle. Based on the analysis performed in CHPRC-02424, a 30 kVA power cart attached to the WESF Canyon welding receptacle will draw 36 amps at 480 VAC. The Truck Port cooling system and the Truck Port Evacuation/He Backfill system will draw 49 amps at 480 VAC, or a total load of 85 amps on this circuit. Thus, there should be adequate capacity on this welding receptacle circuit to provide power to a cooling system and Evacuation/He Backfill system located in the Truck Port if it is acceptable to connect the cooling system to the normal power bus.

Truck Port operations will also require approximately 6 kVA of 120 VAC power at 50 amps total. Lighting Panel E was initially considered for this load, but WESF personnel have indicated this is not a suitable choice because existing 120 VAC receptacles are not sufficient to support the total 50 amp load, and installing new conduit to the Truck Port from Panel E would likely be difficult and not cost effective. WESF personnel state that three alternatives to using Panel E, based on Project W-130 experience, are as follows:

1. Use an existing 480 VAC, 30 amp receptacle at the outside bridge crane to power outside equipment near the Truck Port via a power cart to supply the 120 VAC loads.
2. Use an existing 480 VAC welding receptacle in WESF Room 113 to feed a power cart in the Truck Port.
3. It may be possible to intercept an existing unused 480 VAC, 175 amp feeder on the WESF roof above the Truck Port, re-route via the Truck Port west wall, install a new 480 VAC receptacle in the Truck Port, and add a power cart to supply the 120 VAC loads.

5.0 **USE OF COMPUTER SOFTWARE**

Microsoft® Excel® was used to prepare this calculation.
6.0 RESULTS

The WESF electrical load calculations and results are shown in Figure 6-1.

**Figure 6-1. Excel® Worksheet Excerpt Showing Calculations and Results**

![Image of Excel worksheet excerpt]

File: LEMS-MCSC-17-CAL-006 Rev 1
7.0 CONCLUSIONS

The results shown in Figure 6-1 indicate that the total WESF electrical load during MCSC Project operations, conservatively estimated, will be approximately 759 kVA. The MCSC project is anticipated to add approximately 141 kVA of electrical load to the existing WESF facility loads following the completion of Project W-130.

Actual instantaneous demands during MCSC Project operations will be less than 759 kVA, and likely below 750 kVA, because not all loads will be active at the same time. Given that WESF is supplied from two 750 kVA transformers, only one transformer should be needed at any given time during MCSC Project operations, leaving the remaining transformer available as a full capacity backup power source. Thus, adequate power should be available from the existing substation to support the MCSC project without modifications.

Electrical upgrades to support the WESF modifications will be limited to connecting loads to existing receptacles or wireways located nearby.

To the maximum extent possible, temporary construction connections would be used. Some minor surface conduit, receptacle or junction box mounting, and wire pulling may be required for wire routing into and out of G-Cell.

Items that should be verified by a field walkthrough include:

- Identification of MCSC Project loads that may be advantageously fed from optional standby power busses MCC-2 and MCC-3 for constructability and/or cost savings.
- Actual location of 480 VAC welding receptacles in the service gallery, operating gallery, WESF Canyon, Room 113, and at the outside bridge crane.
- Current configuration, as well as the condition, of electrical and instrument nozzle connections into G-Cell. Potential differences between the information shown on H-2-94506 and other WESF electrical drawings need to be identified and resolved via walkdown.
- Capacity available in WESF Lighting Panel “E” after conclusion of Project W-130.
8.0 REFERENCES

8.1 Documents


8.2 Computer Files

Supporting Excel® workbook file:

MCSC Project WESF
Electrical Load Estimate_170614.xlsx

File: LEMS-MCSC-17-CAL-006 Rev 1
Appendix C

Hanford Site Drawings

H-2-66766 Sheet 1, In-Cell Light LF-17 ................................................................. C-2
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H-2-96643 Sheet 1, Electrical One-Line Diagram MCC-1 ................................. C-4
H-2-96643 Sheet 2, Electrical One-Line Diagram MCC-2 ................................. C-5
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Appendix D
MCSC Project Sketches

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W135-WESF-SK-P-001, W-135 Project WESF Fire Suppression Piping Modification ............... D-9
General Site Drawings

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NOT FOR CONSTRUCTION
Appendix E
Vendor Literature

American Solving, Inc. Literature, “Floor Conditions for Air Film Transport” ......................... E-2
MovinCool Classic 60 Cut Sheet ......................................................................................... E-7
HiLine Engineering & Fabrication, Inc., Drawings for Crane Operated Electric Impact Wrench ...... E-9
HoistCam™ Magnetically Mounted Crane Camera Literature ............................................... E-11
Omni-Chill Packaged Chiller Unit Literature ...................................................................... E-13
Power Cart Literature ........................................................................................................ E-15
FLOORS FOR AIR BEARING TRANSPORT
In order to reap the full benefits of air bearing transport one must pay attention to the properties of the floor surface. A correctly chosen floor will pay dividends in terms of low operating cost and easy handling. An unsuitable surface could lead not only to high traction forces due to friction but also to high air consumption and excessive wear of the air bearing. An inclination or undulation of the floor will also increase the required traction power which might call for the use of powered drive units.

“The floor surface is one part of the Air Bearing system”

When connected to a compressed air supply, the following sequence of events take place.

(Air bearing and Load Module shown with a “cut-out” to illustrate air flow)

The circular reinforced rubber bellows inflates & fills the gap between the mounting plate and the floor.

As the pressure increases, the mounting plate lifts off of the floor surface.
(arrows indicate air flow)

When the pressure in the bellows is higher than the counter pressure of the load, the air flows out from the bellows forming a thin air film on which the load floats practically friction-free.

In order to fully understand the necessity of operating on a proper floor surface, one must understand how an Air Bearing works. The illustration (Left) displays the technology and as to how the thin air film is formed under each Air Bearing/Load.

An ideal Air Film System floor is even and airtight with a smooth surface. most floors in modern plants meet these demands and are in most cases ground, surface-treated floors, the joints being filled with an elastic composition.

The following are Floor Condition Goals when considering an Air Film System:

- The floor surface should be airtight as to enable forming of a load-bearing air film between the floor and the load carrier.

- The floor surface shall be smooth as to minimize the air consumption and the friction.

- The floor surface must be even (without inclinations) so that the load does not glide away because of low friction.

For more information contact:

American Solving, Inc.
6511 Eastland Plaza, Unit #9
Brook Park, OH, USA 44142
Ph. 800 822-2285
FLOORS FOR FREQUENT USE

The floor should be smooth, non-porous and level. A machine troweled, epoxy treated concrete floor is ideal - however the job should be carefully done without marks, pits, cracks, flaking or messy painting.

Most modern floors in new plants meet these demands, if not it is normally possible to achieve a good result through the use of suitable fillers and epoxy paint. The illustrations (below) display the allowed maximum undulations and inclinations.

Please refer to other sections of this manual on means of achieving these guidelines if your floor is currently not suited.

SMOOTHNESS

Section through a bearing showing the pressure chamber and the thin (0.005") air film on which the load rides. One can easily appreciate why sharp, protruding grains must be avoided. Cracks or holes in the floor will make the pressure disappear.

UNDULATIONS

Due to their elasticity, the Air bearing adjust to minor unevennesses. The level differences should, however, not be more than 2% of the diameter of the air cushion.

INCLINATION

The floor inclination should be kept within certain limits for safe handling of the goods. You cannot escape gravity - it is heavy going uphill and easy downhill.
Unevenness of Floor Surface

Undulations:
- Allowed deviation: 1/4” per 10 feet
- Inclination: 1/2” per 80 feet

A long undulation on the floor surface can be considered as inclination. The load floating on the air film tends to guide away towards the lowest spot of the floor because of low friction. The force required to keep the load in position can be calculated as below:

\[ F = \tan \alpha \times G \]

Non-airtight floors

On a non-airtight surface, the air cushions may lose so much air that the pressure is not adequate for lifting the load, i.e., to form the load-bearing air film. A normal concrete floor without surface-treating is porous and lets the air pass through. Also, airtight floors can contain joints, holes, and cracks, which can easily be filled or covered with tape.

Joints

The expansion joints shall be filled with an elastic composition. The best material is a rubber-like urethane composition, the shore hardness being approx. 80 in order to be able to fill the joint properly, a joint width of approx. 3/8” is recommended. The joint composition can preferably be slightly above the floor surface. (See illustration below)

FILLED EXPANSION JOINTS

Old Floors

It is often necessary to improve the floor surface with filling composition. Grinding is sometimes needed for binding the composition to the surface.
FLOOR SMOOTHNESS

The floor smoothness is a matter of great importance when judging a floor’s suitability for air bearing transport. Although there are a number of measuring devices available on the market there is a lack of universal norms. In the last resort, one is left to make a visual evaluation.

Normally one cannot operate on the following surfaces:
- Tarmac
- Dirt Roads
- Metal Grilles
- Checker Plate

Note: If you must temporarily drive on such surfaces, cover with sheet metal or similar (see info on this topic later in this packet)

One can, however, operate on poured asphalt with good surface finish.

FLOOR COVERING FOR OCCASIONAL TRANSPORT

Occasional or infrequent transport of heavy equipment on surfaces not suited for air bearing transport can still be carried out if one covers the floor with, for example, sheet metal (<16 gauge), vinyl floor sheeting or masonite board (smooth side up). Any cracks, pot holes, drains, cable ducts, etc. must be covered and filled with e.g., wet sand or plaster.

![Diagram of sheet metal and masonite coverage](image)

STEPS

Air Bearings have a limited ability to negotiate steps and sharp ramps. For example: an Air Bearing with a diameter of 36” cannot travel either up or down from the edge of a piece of sheet metal 0.12” thick (the equivalent of 11 gauge sheet metal). The sharp edge cuts through the air film and the membrane rubs against the edge.

Steps will, apart from friction, also lead to the loss of air. The size of steps that can be handled depends in practice on the size of the Air Bearing and the pressure used. Large, low pressure bearings with lift can negotiate higher steps than small Air Bearings using high pressure. The height of a step should, generally speaking, not exceed the demands on flatness given earlier. One should always try to even out steps in order to achieve a smooth slop or ramp.
Large Gaps

When large cracks, gaps or area’s between two surfaces (such as door jam’s or loading docks) need to be crossed, one can use the method illustrated on the right.

This maneuver is referred to as “walking”. The illustration shows the walking method being done with four air bearings, however, six air bearings can perform this maneuver much easier.

FLOOR LOADING

It is obvious that the floor must be strong and rigid enough to carry the load. Compared to wheeled transport there is, however, a great advantage in using air bearings. Below the pictures illustrate the much better load distribution when using air bearings which leads to lower demand on the floor strength compared with wheeled transport.

The floor load is very small in air cushion transports due to the big air cushion surface, elasticity and minor dead weight when compared with equipment on wheels. Easily damaged floors such as parquet, linoleum, clinker and surfaces with floor heating are not damaged during air film transports.
For larger applications, the MovinCool Classic 60 can create flexible, mobile or temporary cooling in factories and warehouses. Using multiple T-section drops, you can customize an adaptable cooling solution for your manufacturing or assembly lines. Add casters to the unit and you can move the cool air as your assembly or process line changes.

By cooling only the area that needs it, the Classic 60 saves you money while protecting people and equipment and speeding up processes.

- Inexpensive to use, operate for as little as 35 cents per hour
- 60,000 Btu/h cooling capacities to handle any hot spot
- Half the cost of central air conditioning, no costly installation is necessary
- Handles temperatures up to 115°F, provides cooling in the hottest environments
- Rugged design, proven durability since 1962
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All specifications subject to change without notice.

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HoistCam™ Pan-Tilt-Zoom (PTZ) HC190

The HoistCam™ HC190 from Nautus is a rapidly deployable pan-tilt-zoom (PTZ) wireless night/day camera platform. HoistCam places the eyes of the crane operator anywhere on the job. Safety is increased, and efficiency improved by making instant visual information available to those who need it.

Adjustable View from Crane Operator's Cab with Joystick

FEATURES
- Weatherproof camera with magnetic mount, built-in battery, wireless transmitter and camera
- 2.4GHz directional wireless antenna and receiver
- Base magnets to mount to any magnetic surface
- Joystick and 9.7" display with heavy duty RAM® suction cup mount
- Impact resistant polycarbonate armored dome
- Rechargeable battery; Run-time from 8 to 24+ hours
- Storage temperatures between -10°C to +55°C
- Operating temperatures between -10°C to +55°C
- Safety lanyard and rugged transport case
- Dimensions: 10" x 8" x 7" (with camera)
- Weight: Approximately 14lbs

OPTIONAL FEATURES
- Battery pack for camera
- Remote monitoring and recording with HoistCam Director with Windows, Android or iOS devices
- U-bolt or permanent display mount
- Remote power key FOE for battery management
- Custom integration also available

Ask about available customization options specific to your crane application

Day/Night Vision HoistCam PTZ Camera and Safety Lanyard (HC190)

Rugged Transport Case for Rapid Deployment

©2018 Nautus, LLC. HoistCam™ is a trademark of Nautus. Nautus, LLC is constantly developing product improvements. We reserve the right to modify product design and specifications without notice and without incurring any obligations.
HoistCam™ Director Enterprise Fleet Monitoring Software

Monitor your fleet of HoistCam construction, industrial or marine equipment with the HoistCam™ Director enterprise fleet monitoring software. Compatible with all types of cranes such as tower, crawler, mobile and overhead cranes.

www.HoistCam.com

FEATURES
- Instant access to real-time video from anywhere in the world.
- Remotely view and collaboratively manage hundreds of job sites or equipment operations.
- GPS recording, geofencing and playback with map overlay.
- Search recordings by specific date, time or alarm condition.
- Record, store and archive video feeds to hard drive, SD-card or centralized server.

BENEFITS
- Increase productivity by using real-time video to deploy or redeploy major assets.
- Align written assessments with current real-time visual comparisons.
- Allocate time and travel resources based on heightened awareness of job site status.
- Visually compare operations across all sites through a single point of view.
- Quickly access operations and incident data while promptly addressing and eliminating confusion.
- Collaboratively manage work flow and share information within the organization.

KEY CONSIDERATIONS
- Licensing:
  - Basic License – one concurrent user and MDVR at no additional cost.
  - Enterprise License – support for multiple concurrent users, MDVRs and remotely accessible recordings.
- Cellular, WiFi or Ethernet communication
- Site Tracker Services – customized reporting based on analysis of job site on safety, logistics and more
- In-house or HoistCam hosted centralized servers
- Support for Microsoft Windows® 7 and 8
- Coming Soon: Mac, IOS® (iPhone® and iPad®) and Android
Omni-Chill®

Packaged Chiller Units

If you’re running city or well water through your machinery for cooling — you’re wasting money. With water bills and sewer charges increasing at a rapid pace with no relief in sight, it’s time to consider “closing the loop.” A low maintenance Omni-Chill packaged water chiller recirculates your water through a refrigerant system giving you inexpensive, reliable heat transfer.

Complete systems include integral pumping systems, electrical control panels and full refrigerant safety controls. Standard systems are pre-charged and ready to run. Water cooled and air cooled units are available from 1/2 ton through 200 tons. Options include: non-ferrous construction, casters, hot gas bypass for reduced load operation, emergency backup cooling systems, etc. Dry Coolers can meet almost any specification with a standard or custom built cooling package.

Stop wasting valuable fresh water for process cooling. — look into our easy-to-install packaged chiller units today. One of our knowledgeable application engineers will be ready to assist you in designing a more efficient method of cooling your process. An Omni-Chill chiller is compact in size, but big in quality and reliability.

Dry Coolers Inc.

FEATURES

· Air Cooled or Water Cooled Condensers
· Digital Indicating Microprocessor Temperature Controller
· Flow Switch & Low Temp Alarm for Freeze Protection
· High & Low Refrigerant Pressure Indication
· Direct Drive Propeller Fans (Air Cooled Condenser Models)
· Water Regulating Valve (Water Cooled Condensers)
· Crankcase Heater & Suction Line Accumulator
· Filter Drier & Refrigerant Sight Glass
· Insulated Water Lines & Reservoir
· Rugged Steel Housing — Removable for Easy Access
· Pre-Charged & Pre-Wired for Easy Installation
Three Good Reasons to get an Omni-Chill Process Chiller—Quality Features, Industrial Specs, and Low Price

Model AC-300A shown with side panels and top removed and optional casters.

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<th>CONDENSER WATER GPM</th>
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<th>WEIGHT</th>
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</table>

Note: 1 Chiller Ton = 12,000 Btu/hr. Capacities are based upon 60°F entering water, 90°F leaving water at 95°F ambient or 85°F chilled water. Specifications are subject to change without notice. Please consult factory for certified prices and performance.

ALSO AVAILABLE

Large Central Chiller Systems
Evaporative Cooling Tower Systems
Non-Refrigerant Air Cooled Heat Exchangers
Packaged Pumping Stations and Control Systems
Closed Circuit Evaporative Coolers

Dry Coolers
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Oxford, MI 48371
1-800-525-8173
Fax (248) 969-3401
www.drycoolers.com

Bulletin ACU-150 9/94
Power Carts

Hazardous and Non-hazardous

Solutions designed for industrial and hazardous applications
Plant turnarounds can be complex, chaotic, and costly events. During your next shutdown, turn to Eaton’s Crouse-Hinds for safe, reliable electrical power equipment that ensures efficient and successful operations.
- UL1640 compliant
- 2-wheel, 4-wheel, and skid options
- Standardized cart sizes reduce lead times and eliminate potential on-site placement issues
- Hazardous area power carts eliminate need for time-consuming area declassification and equipment monitoring

2-Wheel Power Carts

Technical Specifications

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Hazardous</th>
<th>Specifications</th>
<th>Industrial Non-Hazardous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Primary Current: 100A</td>
<td>Max Secondary Current: 223A</td>
<td>Max Primary Current: 100A</td>
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Compatible Components

<table>
<thead>
<tr>
<th>Receptacles</th>
<th>Transformers</th>
<th>Panelboards</th>
<th>Compatible Components</th>
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</thead>
<tbody>
<tr>
<td>ENR</td>
<td>7.5 kVA</td>
<td>LUB 12 circuit</td>
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<tr>
<td>CPS</td>
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<td>CPS</td>
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<td>CES</td>
<td>10 kVA</td>
<td>Disconnects</td>
<td>CPS</td>
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<td>FSC/UC</td>
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Cart/Skid Sizes

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<tr>
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<th>Hazardous</th>
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9P Power Carts

Hazardous and Non-hazardous

4-Wheel Power Carts and Skids

Design Features
- Removable roof
- Lifters
- Durable & Robust Carbon Steel Frame
- Perforated Confinement Tubs
- Enclosed Design Protects Components
- Casters, Pneumatic, Semi-Pneumatic, or Solid Rubber Wheel Options

Technical Specifications

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Hazardous</th>
<th>Industrial Non-Hazardous</th>
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<tbody>
<tr>
<td>Max Primary Current: 100A</td>
<td>Max Secondary Current of Main: 100A</td>
<td>Max Secondary Current of Main: 225A</td>
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<tr>
<td>Max Secondary Voltage: 480V</td>
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<table>
<thead>
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<th>Compatible Components</th>
<th>Transformer Types</th>
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<tr>
<td>FNGC</td>
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<td>Panelboards</td>
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Cart/Skid Sizes

<table>
<thead>
<tr>
<th>Cart/Skid 1</th>
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Crouse-Hinds by E-H