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BECHTEL SAIC COMPANY LLC

Project Design Criteria Document

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BSC

1. MGR Project Design Criteria Document

2. QA: QA

Design Criteria
For the Yucca Mountain Project

Complete only applicable items

3. DI (Including Revision Number, if applicable): 000-3DR-MGR0-00100-000-001			
	Printed Name	Signature	Date
4. Originator	H.J. Minwalla	H. Minwalla	3/31/03
5. Checker	See below		
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BSC

1. MGR Project Design Criteria Document (Continued)

2. QA: QA

Design Criteria
For the Yucca Mountain Project

Complete only applicable items

13. Remarks: #5 (from above)		Date	#7 (from above)		Date
T. DiPema E&IC		3/31/03	T. DiPema E&IC		3/31/03
D. Brownson PA		3/31/03	B. Stanley Mechanical		3/31/03
L. Croft ES&H		3/31/03	R. Pernisi Civil/Structural/ Geotechnical		3/31/03
B. Stanley Mechanical		3/31/03	L. Morrison ESF	ESF not included in PDC SLS	3/31/03
T. Frankert Civil/Structural		3/31/03	J. Andersen Mechanical Handling		3-31-03
F. Duan Geotechnical		3/31/03	F. Basamanowicz Plant Design		3/31/03
L. Morrison ESF	ESF not included in PDC SLS	3/31/03	D. Darling Reqs. and Design Support		3/31/03
J. Andersen Mechanical Handling		3-31-03	M. Anderson Spec. Analysis and WP Design		3/31/03
A. Krug Plant Design		3/31/03	J. Cogar Materials and Fabrication Technology		3/31/03
J. Bigbee Reqs. and Design Support		3/31/03	S. Su Nuclear Engineering		3/31/03
M. Anderson Spec. Analysis and WP Design		3/31/03	J. Schmitt Nuclear Engineering		3/31/03
M. Plinski Materials and Fabrication Technology		3/31/03			
N. Kahler Nuclear Engineering		3/31/03			

Design Criteria
Change History

Complete only applicable items

14. DI (Including Revision Number, if applicable):
000-3DR-MGR0-00100-000-001

15. Revision No.	16. Description of Change
00	Initial Issue An impact review per AP-2.14Q, *Review of Technical Products and Data,* is not required since this is the initial issue of the Project Design Criteria Document.
01	The entire Project Design Criteria document is being revised (per Section 5.6 (2) of LP-3.25Q-BSC, Rev. 1, ICN 2, *Design Criteria*) to incorporate additional design criteria, codes and standards, etc. that have been identified since the issuance of Revision 0. Changes from the previous issuance are not uniquely identified with change lines because the entire document has been revised. All revised sections are within the scope of preliminary design efforts necessary to support the license application. An impact review per AP-2.14Q, *Revision of Technical Products and Data,* was not performed since the providers of inputs and checkers of the Project Design Criteria Document, Revision 1, are from the same discipline organizations and comprised of personnel who would have participated in the AP-2.14Q review of the document (Section 5.3 of LP-3.25Q-BSC, Rev. 1, ICN 2, *Design Criteria*), including those from a different discipline or functional organization. Any organization potentially impacted by the Project Design Criteria Document is included in the checking and review process and this checking and review process essentially included aspects of an impact review per AP-2.14Q. An interdisciplinary review per Section 5.3.2 of LP-3.25Q-BSC, Rev. 1, ICN2, *Design Criteria,* was not performed since the disciplines/organizations (that are outside the Repository Design Project organization) providing the input were included as a part of the discipline checking and review performed in accordance with Section 5.3.1 of LP-3.25Q-BSC, Rev. 1, ICN 2, *Design Criteria.* ES&H and PA organizations, which are external to Repository Design Project, were included in Block #5 as Checkers but were not included in Block #7 as Engineering Group Supervisors/Discipline Lead Engineer.

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1. INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of the Project Design Criteria (PDC) document is to provide the design criteria necessary to support the development of preliminary and detailed design. The scope of the PDC includes general discipline design criteria, codes and standards, laws and regulations, design acceptance limits, design load cases, design load combinations, and event sequences. The PDC identifies the appropriate codes and standards for structures, systems, and components (SSCs), which are associated with Quality Levels (for items important to safety and conventional quality) determined from the Q-List prepared in accordance with AP-2.22Q, *Classification Criteria and Maintenance of the Monitored Geologic Repository Q-List*. However, the quality assurance (QA) classification of SSCs based on an approved Monitored Geologic Repository (MGR) System Architecture is currently not available. Therefore, the selection of design criteria, including appropriate codes, standards, etc., is mainly drawn from engineering judgment but will be revised, if necessary, when the Q-list is available. As the design evolves, the PDC will be revised in accordance with the evolving design and Quality Levels provided in the Q-list for MGR systems and subsystems.

The PDC is organized, along traditional discipline lines, and comprised of sections that contain general design criteria or generic discipline design criteria, design load combinations, site conditions etc., and data sheets containing applicable codes and standards for each discipline in the Repository Design Project.

1.2 CODE EFFECTIVE DATE

The U.S. Nuclear Regulatory Commission (NRC) requires, in 10 Code of Federal Regulations (CFR) 63.21(c)(2), that the Safety Analysis Report include information relative to codes and standards that the U.S. Department of Energy (DOE) proposes to apply to the design and construction of the Geologic Repository Operation Area (GROA). The Office of Repository Development (ORD) will select the latest revision of codes and standards in existence at the time of the DOE milestone, Critical Decision-1 (CD-1) (March 2003), which is defined as the point when the project is released to commence preliminary design. Revisions to codes and standards by Standard Developing Organizations from the time period of CD-1 through the license application (LA) design freeze date will be assessed for their impact on the GROA and dispositioned accordingly. Revisions to codes and standards beyond the LA design freeze date will be addressed, as necessary, by the ORD during the NRC review of the LA.

The use of a code or standard that is not endorsed by the NRC requires an adequate technical justification. Appendix B provides technical positions for those codes and standards cited in the Yucca Mountain Review Plan (YMRP) (NRC 2002d) that have not been accepted by the ORD.

1.3 REGULATORY GUIDANCE DOCUMENT APPLICABILITY

NRC regulatory guidance documents such as Regulatory Guides, are generally written by NRC staff to provide applicants and licensees with information such as methods acceptable to the NRC staff for meeting specific parts of the NRC regulations, methods used by the staff in evaluating specific problems or postulated accidents and data needed by the NRC staff in its review of applications for permits and licenses. Regulatory Guides are not substitutes for regulations, and compliance with them is not required.

The statements of consideration in 10 CFR 63 state that "the applicability of regulatory guidance developed for facilities other than a high-level waste repository will need to be considered on a case-by-case basis for applicability to high-level waste disposal at the Yucca Mountain. For the guidance to be appropriate, it should be generally applicable to nuclear facilities with comparable or higher risks to workers and the public than the potential repository at Yucca Mountain site."

The selection of Regulatory Guides provided in Appendix A is based on their applicability to support development of design products for LA-Construction Authorization (CA). Although Regulatory Guides are written for other NRC licensed activities, the ORD will conform to those identified in Appendix A, as applicable, to the development of design products for LA-CA. In a situation where a Regulatory Guide addresses areas that are not applicable to the ORD (single failure criterion, etc.) then the ORD will conform to a Regulatory Guide but with exceptions to those areas that are inapplicable.

1.4 U.S. DEPARTMENT OF ENERGY ORDERS AND STANDARDS APPLICABILITY

DOE HQ O 250.1 provides for the exemption of Office of Civilian Radioactive Waste Management (OCRWM) facilities from certain DOE directives. The exemption applies to DOE directives that overlap or duplicate requirements of the NRC related to radiation protection, nuclear safety (including quality assurance), and safeguards and security of nuclear material in the design, construction, operation and decommissioning of radioactive waste (OCRWM) facilities. Exemptions apply to requirements in directives that overlap or duplicate NRC requirements of the NRC to assure precedence of NRC requirements.

OCRWM facilities include structures, equipment, systems, processes, or activities associated with the acceptance, transportation, storage, and disposal of spent nuclear fuel (SNF) and high-level radioactive waste (HLW) pursuant to the Nuclear Waste Policy Act of 1982, as amended, and NRC regulations, where applicable. Examples include interim storage structures and technologies, repository facility structures, and waste acceptance and transportation activities.

Exemptions do not apply to requirements for which the NRC defers to DOE or does not exercise regulatory jurisdiction.

DOE orders that provide criteria applicable to the non-nuclear portion of the MGR facility will be addressed, as applicable, to the design of the MGR.

1.5 NATIONAL CODES AND STANDARDS APPLICABILITY

DOE O 252.1 requires the use of voluntary consensus standards by the DOE in a manner consistent with Public Law 104-113, *National Technology Transfer and Advancement Act of 1995*, and Office of Management and Budget Circular No. A-119, *Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities*. Public Law 104-113 allows an agency to take exception to specific portions of a voluntary consensus standard if those provisions are deemed to be inconsistent with applicable law or otherwise impractical.

Consensus standards are the product of a Standards Developing Organization operating with openness, balance of interests, due process, an appeals process, and consensus, which represents general agreement but not necessarily unanimity.

The integration of national codes and standards into the NRC regulatory process is achieved through: (a) incorporation of codes and standards by reference in regulations; (b) endorsement of codes and standards in RGs as acceptable methods for implementing regulation; and (c) referencing of codes and standards as technical basis in Standard Review Plans, Technical Specifications, Generic Communications, and Inspection Manuals. Although (a) is the prime example of a mandatory requirement, (b) and (c) are the primary mechanisms for allowing voluntary use of consensus standards by licensees.

10 CFR 63 does not provide prescriptive design criteria but allows the DOE to develop design criteria and demonstrate their appropriateness. Therefore, the DOE has flexibility to use any codes, standards, and methodologies it demonstrates to be applicable and appropriate in MGR design.

When codes or standards are in conflict with each other, the more restrictive code or standard prevails.

1.6 QUALITY ASSURANCE

The PDC is written in accordance with LP-3.25Q-BSC, Rev 1, ICN 2, *Design Criteria* and is subject to the requirements of the *Quality Assurance Requirements and Description* (QARD) (DOE 2002).

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2. ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ADA	Americans with Disabilities Act
AISC	American Institute of Steel Construction
ALARA	as low as is reasonably achievable
ANS	American Nuclear Society
ANSI	American National Standards Institute
ARM	Area Radiation Monitor
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
BSC	Bechtel SAIC Company, LLC
CA	Construction Authorization
CAM	Continuous Air Monitor
CCC	Central Control Center
CCTV	Closed Circuit Television
CCR	Central Communications Room
CFR	Code of Federal Regulations
CMAA	Crane Manufacturer's Association of America
CRWMS	Civilian Radioactive Waste Management System
CQ	Conventional Quality
DCMIS	Digital Control and Management Information System
DP	Differential Pressure
DOE	U.S. Department of Energy
DOE-STD	Department of Energy Standard
EBS	Engineered Barrier System
ECR	Engineering Configuration Room
EMM	Environmental/Meteorological Monitoring
ERDA	U.S. Energy Research and Development Administration
ES&H	Environmental Safety and Health
FC	Frequency Category (seismic)
GROA	Geologic Repository Operations Area
HFS	Human Factors Society
HLW	high-level radioactive waste
HSS	hollow structural shape
HVAC	heating, ventilation and air conditioning

IBC	International Building Code
ICC	International Code Council
ICRP	International Commission on Radiological Protection
ICBO	International Conference of Building Officials
IEEE	Institute of Electrical and Electronics Engineers
I/O	Input/Output
IPC	International Plumbing Code
ITS	important to safety
ISA	Instrument Society of America
ISO	International Standards Organization
LA	License application
LAW	Low Activity Waste
MIL-STD	Military Standard
MGR	Monitored Geologic Repository
mrem	Millirem
NAC	Nevada Administrative Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NPH	Natural Phenomena Hazard
NRS	Nevada Revised Statutes
NRC	U.S. Nuclear Regulatory Commission
NUREG	U.S. Nuclear Regulatory Commission Technical Report
NWPA	Nuclear Waste Policy Act of 1982, as amended
ORD	Office of Repository Development
OSHA	Occupational Safety and Health Administration
PA	Public Address
PC	Performance Category
PCA	Portland Cement Association
pcf	pounds per cubic feet
PDC	Project Design Criteria
PRD	Project Requirements Document
psi	pounds per square inch
QA	quality assurance
QARD	Quality Assurance Requirements and Description Document
QL	Quality Level
RG	Regulatory Guide
RF	Radio Frequency
RRM	Radiation/Radiological Monitoring
RTD	Resistance Temperature Detector
SAR	Safety Analysis Report

SDD	System Description Document
SNF	spent nuclear fuel
SSCs	structures, systems, and components
TBD	To Be Determined
TC	Thermocouple
UCRL	University of California Radiation Laboratory
UL	Underwriters Laboratory
UPS	Universal Power Supply
USGS	U.S. Geological Survey
WLM	Working Level Month
YMRP	Yucca Mountain Review Plan

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3. DEFINITIONS

3.1 *Design*–Specifications, drawings, design criteria, and performance requirements. Also, the result of deliberate planning (e.g., feasibility studies), analysis (e.g., hazard and risk assessment, performance assessment), mathematical manipulation (e.g., sensitivity studies), and design processes (e.g., independent design review).

3.2 *Design Bases*–Statements that refer to design requirements for SSCs and identify why the requirement exists, why it is specified in a particular manner, and why a specified value is used. The design bases provide information that identifies the specific functions performed by the SSCs of a facility and the specified range of values chosen for controlling the parameters that are the referenced boundaries for the design of the SSCs.

3.3 *Design Bases (10 CFR 63.2)*–means that information that identifies the specific functions to be performed by SSC of a facility and the specific values or ranges of values chosen for controlling parameters as reference bounds for design. These values may be constraints derived from generally accepted state-of-the-art practices for achieving functional goals or requirements derived from analysis (based on calculation or experiments) of the effects of a postulated event under which SSCs must meet its functional goals. The values for controlling parameters for external events include:

1. Estimates of severe natural events to be used for deriving design bases that will be based on consideration of historical data on the associated parameters, physical data, or analysis of upper limits of the physical processes involved.

2. Estimates of severe external human-induced events to be used for deriving design bases that will be based on analysis of human activity in the region, taking into account the site characteristics and the risks associated with the event.

3.4 *Design Criteria*–Standards, codes, laws, regulations, general discipline design criteria, event sequences, and hazards that shall be used as a basis for acceptance of design for SSCs to satisfy requirements.

3.5 *Design Input*–Those criteria, parameters, bases, or other design requirements upon which design output documents are based.

3.6 *Design Output*–Drawings, specifications, and other design documents prepared to present the design configuration(s) of SSCs that satisfy design inputs.

3.7 *Design Requirement*–Engineering technical requirements, determined by design processes, that define, for example, the functions, capabilities, capacities, physical size, configurations, dimensions, performance parameters, limits, and setpoints, etc., and are developed and specified by the design authority for SSCs to satisfy the mission design input requirements. The detail design requirements are the result (often iterative) of design processes.

3.8 *Design Verification*–Documented, traceable measures (e.g., design review, alternate calculation, and qualification testing) applied to a design package or technical output by qualified individuals or groups other than those who performed the original design work. These measures verify the technical validity, adequacy, and completeness of a design package or technical output in context with the total design, natural or engineered barrier system, or integrated technical work.

3.9 *Geologic Repository Operations Area (GROA)*–A HLW facility that is part of a geologic repository, including surface and subsurface areas where waste handling activities are conducted.

3.10 *Important to Safety (ITS) (10 CFR 63.2)*–With reference to SSCs means those engineered features of the GROA whose function is:

1. To provide reasonable assurance that HLW can be received, handled, packaged, stored, emplaced, and retrieved without exceeding the requirements of 10 CFR 63.111(b)(1) for Category 1 event sequences; or
2. To prevent or mitigate Category 2 event sequences that could result in radiological exposures exceeding the values specified at 10 CFR 63.111(b)(2) to any individual located on or beyond any point on the boundary of the site.

3.11 *Licensing Basis*–The current effective requirements imposed on the facility, including the requirements at the time the initial license was applied for and granted, together with requirements subsequently imposed. The licensing bases are contained in NRC regulations, orders, license conditions, exemptions, and licensee commitments contained in the Safety Analysis Report (SAR) and other docketed licensee correspondence.

3.12 *Margin*–The difference between the calculated event sequence dose and the prescribed regulatory compliance limit, which provides confidence that the repository design features can adequately protect public health and safety and the environment from any uncontrolled radiological event.

3.13 *Mission Requirements*–Input design demands requested by the owner or client (or imposed by statute or regulation) that identify and define design requirements for performance; functional, operational, and maintenance characteristics; or parameters that the facility SSCs are to be designed to satisfy.

3.14 *Postclosure*–The period of time after permanent closure of the repository system.

3.15 *Preclosure*–The period of time before and during permanent closure of the repository system.

3.16 *Preclosure Safety Analysis*–A systematic examination of the site; the design; and the potential hazards, initiating events, and event sequences; and their consequences (e.g., radiological exposures to workers and the public). The analysis identifies SSCs that are ITS.

3.17 *Quality Level 1*–QL associated with highest relative risk significance. See AP-2.22Q, *Classification Criteria and Maintenance of the Monitored Geologic Repository Q-List*, Attachment 1, for Important to Safety Screening Criteria.

3.18 *Quality Level 2*–QL associated with medium relative risk significance. See AP-2.22Q, Attachment 1, for Important to Safety Screening Criteria.

3.19 *Quality Level 3*–QL associated with low relative risk significance. See AP-2.22Q, Attachment 1, for Important to Safety Screening Criteria.

3.20 *Conventional Quality*–QL associated with little or no relative risk significance.

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4. FACILITY DESIGN CRITERIA

4.1 GENERAL DESIGN CRITERIA

4.1.1 Generic Design Criteria

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5].
General	Generic*	ANSI Z535.1-1998, ANSI Z535.2-1998, ANSI Z535.3-2002, ANSIZ535.4-1998, ANSI Z535.5-1998, ANSI/ASHRAE/IESNA 90.1-2001, ANSI/ASHRAE 55(55a)-1995, ANSI/ASHRAE 62-1989, ASHRAE 2001, NEMA MG10-1994, SMACNA 1985,SMACNA 1995
		None
		10 CFR 434, Executive Order 13123 (64 FR 30851)
		None
		DOE N 450.4, DOE O 430.2A.

Technical Rationale:

[1] These codes and standards support compliance with requirements of the Project Requirements Document (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21(c)(2)), and PRD-022. Determination of applicable sections of these codes and standards will be determined during the design process and in development of design products.

[2] None

[3] Addressing CFRs supports compliance with requirements in PRD-018/P-019 and PRD-015/P-031.

[4] None

[5] Addressing these DOE orders supports compliance with requirements of PRD-018/P-019. Determination of applicable sections of these DOE orders will be determined during the design process and in development of design products.

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.1.1.1 Energy Conservation Compliance Enforcement

Criteria–Each facility of the MGR shall be designed with the goal of reducing water consumption and energy consumption per gross square foot through life-cycle cost-effective measures.

Technical Rationale–This criteria ensures compliance with 10 CFR 434, *Energy Code for New Federal Commercial and Multi-Family High Rise Residential Buildings*, that provides the minimum standards for energy efficiency goals in the design of new Federal buildings. This document provides design requirements for building envelopes, electrical distribution systems and equipment for electric power, lighting, heating, ventilating, air conditioning, service water heating and energy management. This is also in conformance with DOE Order 430.2A, *Departmental Energy and Utilities Management*, and with Executive Order 13123 (64 FR 30851), *Greening the Government Through Efficient Energy Management*, that provides the goals for reduction of greenhouse gas emissions attributed to the energy use of Federal buildings. Federal buildings include each and every facility in the MGR (surface buildings, underground facilities, and their associated energy-using systems).

4.1.1.2 Design Conditions

Criteria–The ambient (outdoor) and the indoor design conditions as shown in Section 4.8.2 of this document shall be used in the energy conservation calculations.

Technical Rationale–This criterion is based on the applicable comfort criteria in ANSI/ASHRAE Std 55(55a)-1995, including addenda 55a-1995—*Thermal Environmental Conditions for Human Occupancy* and with Subpart C of 10 CFR 434, *Energy Code for New Federal Commercial and Multi-Family High Rise Residential Buildings.* The data provided in Section 4.8.2 of this document is not intended to be all-inclusive and additional data may be obtained from qualified sources to implement the requirement of the Energy Conservation Program.

4.1.1.3 Prescriptive/System Performance Compliance Alternative

Criteria–Each facility of the MGR shall comply with the requirements shown in Table 4.1.1-1, to evaluate the energy efficiency of any building and associated energy-using system to meet the water conservation and energy efficiency goals. This alternative compliance method shall be used where minimum amount of calculation is required to show compliance with the energy conservation requirements.

Table 4.1.1-1. Compliance Minimum Requirements

Minimum Requirement System Description	General Compliance[1]	Mandatory Requirements[1]	Minimum Requirements[2]
Electrical Distribution System	Section 8.1	Section 8.2	Section 434.401.1
Electric Motors	Section 10.1	Section 10.2	Section 434.401.2
Lighting	Section 9.1	Section 9.2	Section 434.401.3
Building Envelope	Section 5.1	Section 5.2	Section 434.402
HVAC Equipment	Section 6.1	Section 6.2	Section 434.403.1
HVAC Systems	Section 6.1	Section 6.2	Section 434.403.2
Service Water Heating Systems	Section 7.1	Section 7.2	Section 434.404

NOTES: [1] ANSI/ASHRAE/IESNA 90.1-2001
[2] 10 CFR 434

Technical Rationale–This criterion is in conformance with Subpart D of 10 CFR 434, *Energy Code for New Federal Commercial and Multi-Family High Rise Residential Buildings*, and also with ANSI/ASHRAE/IESNA 90.1-2001, *Energy Standard for Buildings Except Low Rise Residential Buildings.*

4.1.1.4 Building Energy Cost Compliance Alternative

Criteria–The Building Energy Cost Compliance Alternative method shall be used where greater flexibility is required in the design of energy efficient buildings using an annual energy cost method. The annual Design Energy Cost of the proposed building shall be less than or equal to the annual Energy Cost Budget of a prototype or reference building.

Technical Rationale–This criterion provides an alternative compliance path using the annual energy cost method in accordance with Subpart E of 10 CFR 434, *Energy Code for New Federal Commercial and Multi-Family High Rise Residential Buildings*, and with Section 11 of ANSI/ASHRAE/IESNA 90.1-2001, *Energy Standard for Buildings Except Low Rise Residential Buildings*. It uses energy cost (dollars) to determine compliance rather than units of energy or power such as BTU, kilowatt-hour, or kilowatt and allows the energy use contribution of different fuel sources at different times to be added and compared. This method allows for innovation in designs, materials, and equipment, such as passive solar heating, heat recovery, better zonal temperature control, thermal storage, and other applications of off-peak electrical energy that cannot be adequately evaluated by using other alternative methods.

4.1.1.5 Building Energy Use Compliance Alternative

Criteria–The Building Energy Cost Compliance Alternative method shall be used where greater flexibility is required in the design of energy efficient buildings using an annual energy use method. With this method, a life-cycle cost (LCC) analysis shall be performed of major fuel alternatives and the one with the lowest LCC shall be used in the calculation. The annual Design Energy Use of the proposed building shall be less than or equal to the calculated annual Energy Use Budget of a prototype or reference building.

Technical Rationale–This criterion provides an alternative compliance path using the annual energy use method in accordance with Subpart F of 10 CFR 434, *Energy Code for New Federal Commercial and Multi-Family High Rise Residential Buildings*. The life-cycle cost criteria is in accordance with CFR, which has been identified and is being procured. This alternative method is similar to the Building Energy Cost Compliance Alternative method. The principal difference is that the unit for comparing performance is Btu of energy use instead of dollars of operating cost.

4.1.1.6 Energy Efficiency/Sustainable Design Report

Criteria–An Energy Efficiency/Sustainable Design Report shall be prepared for each building at the end of each design phase of the project to demonstrate that the design complies with the Executive Orders and Federal regulation sustainable design principles for energy efficiency. A performance test report shall be also prepared during the operation phase of the facilities.

Technical Rationale–This criterion is in accordance with DOE Order 430.2A, *Departmental Energy and Utilities Management*. A certificate of compliance is required for new buildings whose total energy consumption is expected to exceed 500 million Btu per year or the building is larger than 10,000 gross square feet and a performance test during the operation phase is required to demonstrates progress towards meeting energy cost and consumption goals, and the greening of the government through efficient energy management.

4.1.1.7 Application for Waiver or Exemption

Criteria–Exemptions from the requirements of the Executive Orders and Federal regulation for energy efficiency shall be obtained by submitting an Application for Exemption to the In-House DOE Energy Management Coordinator for evaluation and approval.

Technical Rationale–This criterion is in accordance with DOE Order 430.2A, *Departmental Energy and Utilities Management*, and with Executive Order 13123 (64 FR 30851), *Greening the Government Through Efficient Energy Management*, that provides the goals for reduction of greenhouse gas emissions attributed to the energy use of the Federal buildings.

4.2 CIVIL/STRUCTURAL/ARCHITECTURAL DESIGN CRITERIA

4.2.1 Civil Design Criteria

4.2.1.1 Civil Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Civil/Structural/ Architectural	Civil*	ANSI/NFPA 407-1990, ASCE 1972, ASCE 7-98, ANSI/AWWA D100-96, AWWA-1990, AREA 1997, ICC/ANSI A117.1-1998, ICC 2000 (IBC), NFPA 22-1998, NFPA 70-2002, NAC 445A, NAC 445B, NFPA 24-1995
		RG 1.59 Rev 2 , RG 1.102 Rev 1
		10 CFR Part 63, 29 CFR 1910, 29 CFR 1926, 28 CFR 36
		NUREG 0800 1987 (NRC 1987)
		DOE Order 420.1, Change 3

Technical Rationale:

[1] These codes and standards support compliance with requirements of the *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21(c)(2)), PRD-022 and *Waste Processing Area Facilities System Description Document* (BSC 2002e). Determination of applicable sections of these codes and standards will be determined during the design process and in development of design products.

[2] These RGs have been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the RGs will be determined during the design process and in development of design products that are impacted by these Regulatory Guides. Addressing these RGs supports compliance with requirements in *Waste Processing Area Facilities System Description Document* (BSC 2002e).

[3] Addressing CFRs and Federal Aviation Administration Advisory Circulars supports compliance with requirements in *Waste Processing Area Facilities System Description Document* (BSC 2002e) and PRD-015/P-015, PRD-015/P-020, PRD-015/P-021 and PRD-005.

[4] This NUREG provide guidance on acceptable methods and approaches that could be utilized in MGR design.

[5] Addressing the DOE Order supports compliance with requirements of PRD-018/P-019. Determination of applicable sections of this DOE Order will be determined during the design process and in development of design products.

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.2.1.2 Site Development

4.2.1.2.1 Site Description

The MGR at Yucca Mountain is located approximately 100 miles northwest of Las Vegas in the State of Nevada. The repository surface facilities are located in distinct operational areas, namely:

- North Portal Operations Area

- South Portal Development Operations Area
- Ventilation Shafts Surface Operations Areas
- North Construction Portal.

Williams, N.H. (2002b), addresses the site development plan for the MGR, which incorporates the necessary civil engineering features and arrangement required to support the surface repository facilities and systems for safe and efficient operations. The site layout is organized around the subsurface accesses and is configured considering owner and radiological exposure boundaries, flood/fault zones, topographic features, and meteorological patterns. In addition, it supports surface and subsurface operations and the required facility and transportation arrangements.

The site layout is designed to maximize preclosure radiological safety and to deter postclosure human disturbance of the MGR. The site layout is also designed to limit impacts to the waste handling operations caused by worst case environmental conditions.

4.2.1.2.2 Surveys and Datum

Criteria–Design documents shall provide for the following:

- Site boundaries
- Site grade
- Datum elevation
- Coordinates (NOTE: Coordinate datums should correspond to Nevada State Plane Coordinate System, Central Zone [NAD 27] for horizontal and NGVD 29 for vertical.)
- Coordinates and elevations of the four operational areas as described in Section 4.2.1.2.1 will be given in a later revision
- Survey control points
- Grid north based on the Nevada State Plane Coordinate System

Technical Rationale–The information presented is required for site description by good engineering practice and shall conform to Nevada State Plane Coordinate System, Central Zone [NAD 27] for horizontal and NGVD 29 for vertical. These data have been used for all previous surveys.

4.2.1.2.3 Subsurface Investigations

Criteria–The information obtained for the subsurface investigations for the MGR has been compiled in the document *Geotechnical Data for a Potential Waste Handling Building and for Ground Motion Analyses for the Yucca Mountain Site Characterization Project* (ANL-MGR-GE-000003, Rev 00) (BSC 2002s).

Technical Rationale–As stated, the information obtained for the subsurface investigations for the MGR has been compiled in the document *Geotechnical Data for a Potential Waste Handling Building and for Ground Motion Analyses for the Yucca Mountain Site Characterization Project* (ANL-MGR-GE-000003 Rev 00) (BSC 2002s). Therefore, it shall be used for this document.

4.2.1.2.4 Site Design Parameters

Criteria

- **Soil Properties**–are defined in reports *Geotechnical Data for a Potential Waste Handling Building and for Ground Motion Analyses for the Yucca Mountain Site Characterization Project*, ANL-MGR-GE-000003 REV 00 (BSC 2002s), and *Soils Report for North Portal Area, Yucca Mountain Project*, 100-00C-WRP0-00100-000-000 (BSC 2002u).

- **Soil Bearing Capacity**–are defined in report *Soils Report for North Portal Area, Yucca Mountain Project*, 100-00C-WRP0-00100-000-000 (BSC 2002u).

- **Groundwater**–The groundwater table is located at a typical depth of 1,260 ft below present ground surface and is over 1,000 ft below the top of bedrock in the North Portal area. Thus, groundwater is not a factor in geotechnical calculations *Soils Report for North Portal Area, Yucca Mountain Project*, 100-00C-WRP0-00100-000-000 (BSC 2002u).

- **Flood**–Flooding and wave action consequences associated with flooding events shall be as identified in *Preliminary Hydrologic Engineering Studies for the North Portal Pad and Vicinity*, ANL-EBS-MD-000060 REV 00 (BSC 2002d).

- **Frost Depth**–The depth of frost penetration for foundation design is as given in Section 6.1.1.

- **Wind and Tornado**–For wind load and tornado load design requirements, see Sections 4.2.2.3.6 and 4.2.2.3.7.

- **Seismic**–For seismic design load requirements see Section 4.2.2.3.8.

- **Environmental Condition**–The design shall provide for the ability to withstand and operate in the extreme outside temperature environment of 2 degrees Fahrenheit to 116 degrees Fahrenheit (Section 6.1.1.5).

- **Precipitation**–See Section 6.1.1.1 for design basis precipitation.

Technical Rationale–The technical parameters given are defined in reports ANL-MGR-GE-000003 (BSC 2000s), 100-00C-WRP0-00100-000-000 (BSC 2002u), ANL-EBS-MD-000060 (BSC 2002d), Sections 6.1.1, 4.2.2.3.6, 4.2.2.3.7, 4.2.2.3.8, and 6.1.1.1 of this document.

4.2.1.2.5 Site Layout

Criteria–The layout shall define the general layout of, routing of, and/or interfaces to the MGR systems as identified in Williams, N.H. (2002b).

Technical Rationale–The general layout, routing, and/or interfaces to the MGR systems is identified in Williams, N.H. (2002b).

4.2.1.2.6 Site Drainage

Criteria–The configuration and grading of pads shall be designed to prevent pooling of water.

- Site drainage shall protect the ramp, ramp portal, shaft, and shaft collar areas from water inflow as a result of the probable maximum flood.
- Site drainage shall contain and route stormwater from natural surface water drainage ways around surface facilities and provide water drainage for systems located on pads.
- Site drainage shall be designed for the runoff accumulated from the storms identified in Section 6.1.1.1.

Technical Rationale–Good engineering practice dictates protection of facilities from probable maximum flood and runoff accumulations.

4.2.1.2.7 Site Slopes and Grades

Criteria

- The nominal grades within pad areas shall be as required to provide proper drainage.
- Fill slopes shall be designed with a slope value no steeper than two horizontal to one vertical.
- The system shall provide for worker safety and maintenance in accordance with 29 CFR 1926, Safety and Health Regulations for Construction.
- The system shall provide for worker safety and maintenance in accordance with 29 CFR 1910, Occupational Safety and Health Standards.

Technical Rationale–Good engineering practice dictates proper drainage as well as practical slope requirements. Safety in construction must conform to federal safety standards.

4.2.1.2.8 Site Barriers

Criteria

- Two separated barriers (provided by the Safeguards and Security System) shall be located along the perimeter of each protected area.

- Physical barriers for vital areas and material access areas within a protected area shall be separated from the physical barriers at the perimeter of the protected area.

- Isolation zones (provided by the Safeguards and Security System) at least 20 ft wide shall be located on both sides of each barrier on the perimeter of the protected area(s).

- The design shall provide secondary containment around all single-walled fuel storage tanks and petroleum, oil, lubricant, and hazardous material storage sites.

Technical Rationale–Security requirements dictate robust perimeter protection of the protected areas. Also required is secondary containment of storage sites containing hazardous materials.

4.2.1.2.9 Other Site Impacts

Criteria–Other site impacts for site development can be due to:

- Impacts on historical and archaeological features
- Impacts on endangered species
- Impacts on the environments.

The site layout should be such that these impacts are minimized. The following points shall be considered:

- The layout design shall not require the disturbance of any known archaeological resource unless the disturbance has been specifically permitted in accordance with the applicable programmatic agreement between the DOE and the Advisory Council on Historic Preservation.

- The layout design shall not require the disturbance of any known active desert tortoise (Gopherus agassizii) burrow, pallet, den, watering depression, cover, etc., unless the tortoise is relocated in accordance with the applicable biological opinion to be provided by the U.S. Fish and Wildlife Service pursuant to Section 7 of the "Endangered Species Act of 1973," as amended (16 USC 1531).

- In areas where desert tortoises are not relocated, desert tortoises shall be prevented from entering into areas where MGR activities are being conducted.

Technical Rationale–Conformance with federal requirements for historical and archaeological features is required, as is the protection of endangered species such as the desert tortoise.

4.2.1.2.10 Pollution and Soil Erosion Control

Criteria

- Pollution and soil erosion controls shall be implemented during construction activities to mitigate impacts on air, water, and other environmental resources and to assure compliance with appropriate sections of NAC 445 A, NAC 445B.

- When riprap is required for erosion control, the riprap shall be sound, durable stone with an average bulk density not less than 125 pounds per cubic foot according to a standard, which will be provided later. Stone shall be graded from 12-inches maximum size to 3-inches minimum, as placed vertically. The largest dimension of any riprap stone shall be no longer than three times the vertical dimension.

Technical Rationale–Construction activities are required to be environmentally responsible and in accordance with the NAC 445 A and NAC 445B. Riprap is specified in accordance with good engineering practice.

4.2.1.2.11 Corrosion Potential and Corrosion Control

A. General

Typically, metallic underground installations are prone to corrosion. As identified in the Soils Report, the soil aggressivity to the ferrous metals from Alluvium and engineered fill is determined to be lightly corrosive. However, the *Soils Report for North Portal Area, Yucca Mountain Project*, 100-00C-WRP0-00100-000-000 (BSC 2002u) indicates that there is not enough data to evaluate the degree of soil aggressivity to concrete. Types of corrosion control that may be used are protective coatings and cathodic protection.

B. Cathodic Protection Systems

When buried pipelines require cathodic protection, the systems shall be installed at the same time as the piping system.

The interior of steel water tanks shall be protected by cathodic protection system.

Technical Rationale–The *Soils Report for North Portal Area, Yucca Mountain Project*, 100-00C-WRP0-00100-000-000 (BSC 2002u) identifies the soil aggressivity to be lightly corrosive to ferrous metals. Required cathodic protection is suggested by good engineering practice.

4.2.1.3 Criteria for Design of Civil Works

4.2.1.3.1 Earthwork

Criteria

A. Clearing, grubbing, stripping, demolition, and disposal

- Clearing–The area within the repository boundary shall be cleared of all materials above or at the natural ground surface. Materials to be cleared shall include trees, brush, rubbish, vegetation, and obstructions. However, in certain specified areas, trees and brush may have to be retained and preserved.

- **Grubbing**–The entire area within the limits of clearing shall be grubbed of all stumps and roots.
- **Stripping**–All turf and topsoil shall be stripped from the areas as needed. The approximate depth of stripping shall be 6 inches below the existing ground levels. Turf and topsoil shall be stored for reuse in stockpiles separate from other excavated material.
- **Demolition**–Redundant buildings and structures shall be demolished and all debris removed. All underground structures and chambers shall be removed and the resulting excavation filled with compacted acceptable material.
- **Disposal**–Debris from clearing and grubbing operations shall be removed to designated disposal areas. Burning shall not be permitted.

B. Excavation and backfill

- Temporary and permanent earthwork slopes, excavations, and structural fill shall be in accordance with the requirements of the *Soils Report for North Portal Area, Yucca Mountain Project* 100-00C-WRP0-00100-000-000 (BSC 2002u).
- As a minimum, the cut and fill slopes shall meet the requirements of 29 CFR 1910 and 29 CFR 1926.
- Permanent fill slopes shall be no steeper than 2:1 (horizontal to vertical)
- Temporary side slopes for pool excavations estimated to be 50 feet deep shall be no steeper than 1¼:1 in alluvium and 1:1 in engineered fill. An eight-ft wide (minimum) bench should be constructed at mid depth of excavation.

C. Compaction

All fill, foundation and trench backfill materials, and utility bedding shall be compacted to an in-place density of at least 95 percent of the maximum laboratory dry density as determined by a standard, which has been identified and is being procured.

D. Borrow materials

Borrow material shall be obtained from the Fran Ridge Borrow Area and used in accordance with the *Soils Report for North Portal Area, Yucca Mountain Project*, 100-00C-WRP0-00100-000-000 (BSC 2002u).

Technical Rationale–Earthwork is in accordance with the requirements 29 CFR 1910 and 29 CFR 1926. Compaction required is in accordance with good engineering practice.

4.2.1.3.2 Roadways, Parking Areas, Walkways, and Open Areas

Criteria

A. Road Classification

YMP roads shall be classified as access road, heavy haul loop road, service roads and driveways, surface transporter or waste package transporter areas, parking areas, and construction roads.

- The access road runs from near Gate 510 at U.S. 95 to the Nevada Transportation MGR Facilities.
- Heavy haul loop road connects the access road to the heavy haul onsite rail car transfer.
- Service roads, driveways, and parking areas shall be located in accordance with Site Development Plan layout.
- Surface transporter or waste package transporter areas shall be those as identified in the *Site Development Plan*, Williams, N.H. (2002b), for movement of those types of equipment.
- Temporary construction roads will be utilized when and where necessary to facilitate onsite construction and through site access traffic.

B. Design Parameters

Roads layout and geometry shall conform to Nevada Department of Transportation specifications, which will be identified in a future revision. Design parameters not covered in the Nevada Department of Transportation documents shall be based on Design Guides for Highways and Streets, which has been identified and is being procured.

- Access road shall be designed to be capable of handling heavy haul truck carrying rail shipping cask or legal weight truck.
- Heavy haul loop road shall be capable of handling heavy haul truck carrying rail shipping cask or legal weight truck.
- Service roads, driveways, and parking areas shall be capable of handling legal weight truck.
- Surface transporter paths shall be capable of handling the movement of fully loaded surface transporter.
- Permanent roads and parking areas shall have permanent surface such as concrete or asphalt.

- Construction roads shall be gravel surface designed for loading in accordance with standard which has been identified and is being procured.

- Minimum road width for fire fighting apparatus shall meet the requirements of Section 4.8.1.5.

C. Parking Areas

Parking areas shall have a minimum slope of one percent in the direction of drainage. Parking areas shall be asphalt paved and sized to accommodate a minimum of (to be provided later) vehicles. Handicapped parking shall be provided as a ratio of two percent.

The handicapped parking and the curb ramps for the handicapped shall be marked and dimensioned in accordance with ICC/ANSI A117.1.

D. Site Access

Access to the site shall be via access control points. Once within the site personnel shall walk to their respective work location of the facility.

E. Walkways

Walkways shall be provided for pedestrian traffic from designated parking lots to and around all permanent buildings.

F. Accessibility

The administrative portion of all buildings and adjoining site including parking areas will require handicap accessibility. These buildings and parking areas shall be designed in accordance with ICC/ANSI A117.1.

G. Open Areas

Open areas around building disturbed areas shall be covered with a three-in. layer of 1¼-in. crushed surfacing surface course.

H. Signs and Markings

Signs and markings on pavement shall be provided as necessary in accordance with standards, which has been identified and is being procured.

I. Power Line Clearance

The minimum power line clearance shall be provided in electrical design criteria (Section 4.3).

Standard CAUTION signs shall be placed on both sides of the road where electrical lines cross over roads. Signs shall state the actual clearance from the top of the road to the lowest wire or cable. The sign must be visible at 100 ft away from the overhead lines.

Technical Rationale–Layout of roadways, parking areas, walkways, and open areas are in accordance with the Williams, N.H. (2002b), and with code identified, which is being procured. Roadway design is determined by loading conditions in accordance with good engineering practice. Handicapped accessibility complies with ICC/ANSI A117.1. Minimum clearance of power lines over plant roads will be in accordance with electrical design criteria.

4.2.1.3.3 Railroad Design

Criteria

A. General

The bases for railroad facilities design shall be the criteria in AREA 1997, *Manual for Railway Engineering*.

B. Track Layout

Track layouts shall allow rail movement to be continuous from the interchange yard through the classification yard to the delivery tracks. Each interchange or receiving track shall be designed to accommodate the maximum single delivery. The average number of cars in each classification shall determine the length of classification tracks.

C. Drainage

Track-side drainage swales, drainage ditches, intercepting ditches, culverts, lateral drains, pipe drains, and other drainage facilities shall comply with AREA 1997, *Manual for Railway Engineering*.

D. Structures

The design strength of railroad structures shall not be less than that required for a Cooper E-80 loading, AREA 1997, *Manual for Railway Engineering*.

E. Rail

Rail to be used in new construction or for minor alignment and modifications shall be new or relayer rail. New rail is preferred for new construction.

F. Ties

The use of non-wooden ties shall be allowed, provided the cognizant DOE authority approves the alternative material. Concrete ties shall be used in areas where tie inspection and maintenance entails pavement removal or in locations where track maintenance interferes with other site operations and activities (e.g., railroad and road crossings, paved streets, and paved industrial areas). All wood ties shall be treated with decay-retardant compounds conforming to the requirements of AREA 1997, *Manual for Railway Engineering*. Hardwood ties shall be provided with anti-splitting devices in each end.

G. Joint Bars

Joint bars shall be of the size, shape, and punching pattern to fit the rail.

Compromise Joint Bars–Where new or relayer rail joins rail of lighter weight, compromise joint bars shall be used. Each pair of compromise joint bars shall be of the proper design and dimensions for the rail on which it is applied.

H. Tie Plates

New Rail–Tie plates shall be new with or without ribs. Insulating tie plates shall be used in the vicinity of lighted crossings.

Relayer Rail–Used tie plates in good condition and of the proper size and punching can be used with relayer rail. The size of the used tie plates shall not be smaller than 7½-inches by 10-inches for an 85-pound relayer rail and 7½-inches by 11-inches for a 110-pound relayer rail. Tie plates with or without ribs can be used.

I. Rail Anchors

Rail anchors shall be spaced to comply with AREA 1997, *Manual for Railway Engineering*.

J. Spikes

Six in. by 5/8-in. spikes shall be used for all ties. New track spikes shall be used for both new and relayer rail.

K. Guardrails

Guardrails shall be installed on both sides of all single-track bridges and trestles. Each guardrail shall be 11 in. from the traffic rail and shall extend at least 30 ft beyond each end of the bridge or trestle. One guardrail shall be placed on the outside of each track of double-track bridges or trestles.

L. Road–Railway Grade Crossing

All grade road crossings shall comply with AREA 1997, *Manual for Railway Engineering* and local highway standards.

M. Ballast

The minimum depth of ballast under the ties shall be 8 in. Prepared ballast (stone, gravel, or slag) will be accordance with AREA 1997, *Manual for Railway Engineering*.

N. Turnouts

Turnouts shall comply with AREA 1997, *Manual for Railway Engineering*.

O. Super-elevation

Super-elevation shall not be used on curves where the speed is less than 20 miles per hour except when required by the serving railroad. Super-elevation shall be provided on access or main running tracks where the speed is equal to or greater than 20 miles per hour.

P. Grades

The maximum grade on access lines shall be determined by the tonnage handled in one train unit. An analysis shall be made to design grades below three percent. Grades shall not exceed three percent without approval by the cognizant DOE authority. The design shall be coordinated with the requirements of the serving railroad.

Q. Clearances

Clearances for tangent track shall comply with AREA 1997, *Manual for Railway Engineering*. Side clearances shall be measured horizontally from the centerline of tracks. Side clearances on the outside of curves shall be increased one in. for each degree of track curvature over that shown for tangent track. Side clearances on the inside of curves shall be increased one in. for each degree of track curvature and also three and one halftimes the amount of super-elevation of the high rail.

R. Electrical Grounding

Electrical grounding shall be provided at intervals to preclude development of electrical potentials. Electrical grounding shall include bonding between rail sections, installation of ground electrodes, and connection of spur track with building grounding systems where they are within 25 ft of each other.

Electrical grounding shall comply with the NFPA 70-2002.

Technical Rationale–The bases for railroad facilities design are the criteria in AREA 1997, *Manual for Railway Engineering*, and good engineering practice. Railroad structures are designed for Cooper E-80 loading as a very heavy loading.

4.2.1.3.4 Heliport Design

Criteria

A. **General**

- Planning and design of aviation facilities and the airspace clearances shall comply with FAA Advisory Circular, which has been identified and is being procured.

- Principles and criteria of airfield general site plans are contained in FAA Advisory Circular, which has been identified and is being procured. Heliports shall not be located closer to critical facilities than two times the dimension of the landing pad or three times the rotor diameter of the largest helicopter authorized to land at the heliport.

B. **Site Selection**–The following parameter shall be considered to determine the adequacy of the aviation facility:

Site selection for a heliport or plans for expansions of existing facilities shall comply with FAA Advisory Circular, which has been identified and is being procured.

C. **Aircraft Characteristics**–The design of aviation facilities shall be based on consideration of relevant aircraft characteristics contained in FAA Advisory Circular, which has been identified and is being procured.

D. **Airfield Safety Clearances**–Airfield safety clearances shall comply with clearance criteria and the criteria for determining obstructions to air navigation in FAA Advisory Circular, which has been identified and is being procured.

E. **Fire and Rescue Facilities**–Fire station facilities shall comply with FAA Advisory Circular, which has been identified and is being procured.

F. **Drainage**–Airport drainage systems shall comply with FAA Advisory Circular, which has been identified and is being procured.

G. **Pavements**–Airfield pavements shall be designed in accordance with FAA Advisory Circular, which has been identified and is being procured.

H. **Pavement Markings**–The marking of paved areas at airport and heliports shall comply with FAA Advisory Circular, which has been identified and is being procured.

I. **Storage Facilities for Petroleum, Oil, and Lubricants**–Storage of petroleum, oil, and lubricants shall comply with ANSI/NFPA 407-1990.

Technical Rationale–Heliport design is in accordance with FAA Advisory Circulars that have been identified and are being procured.

4.2.1.3.5 Sanitary Sewer System

Criteria

A. System Design

The system design shall comply with federal and state regulations on water and air pollution and shall be in accordance with Manual, which has been identified and is being procured.

The system shall be designed in accordance with Nevada State Department of Health and Nevada Administrative Code (NAC) requirements for Large Onsite Sewage Systems, which will be identified later. Design the pressure distribution leach fields in accordance with the requirements of the Nevada regulations for onsite sewage systems and the Nevada Design Standards for Large Onsite Sewage Systems.

The system design shall be based on a standard, which has been identified and is being procured.

Quantity of Sanitary Sewage

The rate of sanitary flow shall be calculated on the basis of 15 gallons per person per day for the Administration Building and 35 gallons per person per day for the remainder of the plant facilities, which will be confirmed later.

The rate of sanitary flow for the construction phase shall be calculated on the basis of 10 gallons per person per day for the total population, which will be confirmed later.

B. System Layout

Gravity flow pipelines shall collect and transfer sewage to the septic tanks. Pump stations (dosing tank) shall pump the effluent to the drain fields. A pressurized drain field system shall be used for disposal of the sewage.

The minimum diameters shall be 8 inches for sanitary sewer main lines and 6 inches for laterals.

The minimum grade for various pipes shall be as follows:

Diameter (inches)	Grade (ft per 100 ft)
6	0.49
8	0.33
10	0.24
12	0.19

Manholes shall be located at all junctions and changes of grade or size of mains. Spacing between manholes on the main lines shall not exceed 400 ft. Cleanouts shall be located at dead ends of laterals and where laterals make a horizontal change in direction. The maximum length of sewer lateral shall be 100 ft without a cleanout.

Minimum sewer velocities shall be designed in accordance with Manual, which will be provided later.

Technical Rationale–The sanitary sewer system is designed in accordance with manuals, Nevada State Department of Health, Nevada Administrative Code Requirements, and good engineering practice.

4.2.1.3.6 Storm Drainage System

Criteria–All areas of the YMP shall be designed for storm water runoff, based on the functional requirements of each facility.

- The majority of the site storm water shall be managed in a closed underground drainage system, which exits to a detention pond.
- The storm drainage system shall be designed to handle the flow that is generated by a 25-year storm event and to facilitate firewater runoff.
- The maximum single-source discharge shall be based on average annual precipitation.
- There shall be no process liquid or sanitary sewer contributions to the storm system.
- Building and surface runoff shall be directed toward drainage structures (catch basins) and ditches by sloping the tributary surface area.
- The minimum culverts diameter shall be 18 inches.
- Culverts and pipes shall be designed to accommodate the minimum HS20-44 loading in accordance with code that has been identified and is being procured, unless they are located in the areas of heavy haul truck or the surface transporter or waste package transporter. In these cases, appropriate loading from heavy haul truck or surface transporter or waste package transporter shall be considered.
- Drainage ditches shall be trapezoidal in cross section with minimum bottom width of 3 ft and with minimum side slope of 2:1. Roadway ditches may be "V" shaped.
- Drainage discharge point shall have a riprap in a fan shape to disperse outfall stormwater flow.
- Drainage ditch slopes shall be based on channel velocity, calculated using the "Manning Formula."

- Drainage ditch slopes shall be set such that the maximum velocities are as follows:
  - In clay and/or silty sand, 2.5 ft per second
  - In fine gravel, 5 ft per second
  - In asphalt-lined ditches, 8 ft per second
  - Concrete and riprap-lined ditches, 18 ft per second.
- The Manning coefficient of roughness shall be:
  - 0.013 for concrete-lined ditches
  - 0.033 for riprap ditches
  - 0.025 for gravel-lined ditches
  - 0.009 for PVC piping.
- Quantity of Storm Flows

  Calculation of the surface runoff peak flow rates shall be by the Modified Rational Method as follows:

  Q = Peak discharge in cubic ft per second

  A = Drainage area in acres

  C = Coefficient of runoff

  I = Average rainfall intensity in inches per hour for a given frequency and for the duration equal to the time of concentration.
- Storm management systems for all areas shall be designed for a 25-year, 6-hour storm.
- The coefficient of runoff factor, C, shall be:
  - 0.90 for roofs and impervious pavements
  - 0.50 for graveled areas
  - 0.10 for all other open areas.
- The weighted average of coefficient of runoff factor, C, for sub-areas shall be used in the design.

Technical Rationale–The Stormwater Drainage System is configured and designed according to good engineering practice using the Modified Rational Method for surface runoff.

4.2.1.3.7 Water Supply

Criteria–Potable water mains, 4 inches and larger in diameter, shall be designed in accordance with standards to be provided later. Potable water piping less than 4 inches in diameter shall be designed in accordance with ASTM standard which, has been identified and is being procured.

Cross-connections between the potable and irrigation systems are not recommended. However, if cross-connection control for potable water systems is required, it shall include an approved reduced-pressure backflow preventer and shall be designed in accordance with ANSI/AWWA M14 (1990).

A. Water Demand

The potable water supply systems shall be designed to deliver a peak flow of 2.5 times the average daily demand, plus any special water demands. Construction requirements and permanent operation requirements will be provided later. The water pressure shall have a minimum residual pressure of 30 psi. Water supply systems shall be designed to maintain a normal operating pressure of 40 psi to 100 psi in the water main lines and the service lines. Working pressure for potable water and firewater is 100 psi for the lines from the water tanks to and on the pad. The minimum test pressure is 200 psi.

B. Water Pipelines

Potable pipeline requirements are as follows:

- The material for water mains shall have a minimum pressure rating of 200 psi.
- Water mains shall be a minimum of 4 inches in diameter. Pipes for water mains shall be polyvinyl chloride (PVC) or ductile iron, rated for the maximum pressure encountered. All PVC potable water pipes shall be PVC.
- Service lines shall be a minimum of 1 inch in diameter. Service lines less than 2 inches in diameter shall be connected to the main line by a corporation stop. Service lines 2 inches and larger in diameter shall be connected to the main line by a rigid connection. Service line materials shall be selected on a project-specific requirement basis.
- Underground pressure pipe joints and appurtenances shall have adequate thrust blocks. Above ground pipe joints and appurtenances shall have adequate anchorage systems.
- Underground pipelines shall be installed with at least 36 inches of cover over the piping or at least 12 inches below frost depth, whichever is deeper (NAC 445A). Additional cover shall be provided at roadway crossings in heavy traffic areas, and at railroad crossings.

C. Fire Protection Water Supply

Requirements for fire protection water supply are as follows:

- The water supply system shall supply water to the firewater storage tanks with sufficient flow to fill them in 8 hours (Section 4.8.1.14).

D. Disinfection

Newly constructed potable water mains; mains that have been removed from service for planned repairs or for maintenance that exposes them to contamination, mains that have undergone emergency repairs due to physical failure, and mains that under normal operation continue to show the presence of coliform organisms shall be disinfected in accordance with standard which, has been identified and is being procured.

Technical Rationale–Peak flow requirements for water demand are based on good engineering practice. Potable pipeline requirements and fire protection water supply requirements are also based on good engineering practice.

4.2.1.3.8 Underground Utilities Pipes

Criteria

- Anchor blocks or joint restraints shall be provided for pressure piping systems at all pipe fittings.
- All underground pipes shall be designed for soil loads and traffic loads. Concrete encasement (reinforced) or pipe casings shall be provided at road crossings or other locations as required by load conditions.
- Sewers shall be lower than water mains and separation requirements between sewers and water mains shall be in accordance with NAC 445A.
- Sewer or water main trench widths shall be minimized; however, excavations, trenching, and shoring shall comply with 29 CFR 1926, Subpart P. Pipe bedding specified by the pipe manufacturer shall be in place prior to installation of sewers and water mains.
- General requirements for underground pipelines for fire protection are described in Section 4.8.1.14.
- Piping material for fire protection shall meet the requirements of NFPA 24-2002.

Technical Rationale–Underground utility pipes are designed for pressure loads, soil loads, and traffic loads according to good engineering practice. Separation and configuration of water mains and sewer lines are designed according to good engineering practice. Mains and sprinkler systems for fire lines are configured according to good engineering practice.

4.2.1.3.9 Electrical Duct Bank

Criteria

- All electrical duct banks shall be designed for soil and traffic loads at road and railroad crossings. Traffic loading includes normal HS-20 truck loading and heavy transporter loading where applicable.

- Electrical duct banks shall be located at a depth of 3-foot maximum cover top of duct bank to finish grade surface. Exceptions to the depth requirement shall be permitted for short portions of 10 percent or less of the entire length of the duct bank run.

- The minimum horizontal clearance between adjacent duct banks shall be 2 ft face to face.

Technical Rationale–Electrical duct banks are designed for soil, railroad, truckloads, and ground cover according to good engineering practice.

4.2.1.3.10 Pipe Rack Utilities

Criteria

- Pipe rack utilities shall be designed based on the structural design criteria.

- Foundation design recommendations for isolated spread footings shall be in accordance with structural design criteria and the *Soils Report for North Portal Area, Yucca Mountain Project*, 100-00C-WRP0-00100-000-000 (BSC 2002u).

Technical Rationale–Pipe rack utilities design is based on structural design criteria and soil loads as specified in the *Soils Report for North Portal Area, Yucca Mountain Project*, 100-00C-WRP0-00100-000-000 (BSC 2002u) according to good engineering practice.

4.2.1.3.11 Fencing

Criteria–The YMP Restricted Area perimeter shall be fenced to prevent intrusion into the area. Fencing shall be limited to that required for safety, physical security, and activity control.

- All permanent fences shall be galvanized chain fences. Material shall be in accordance with standard to be provided later.

- Fencing shall be grounded around substations, fuel storage areas, and other hazardous areas.

- The overall fence height, including barbed wire topping, shall be 8 ft nominal.

- Fencing shall be topped with three strands of barbed wire on outriggers. Tension wires at top and bottom shall be used to secure the fence fabric.

- Perimeter fence shall meet security requirements of the site. Posts, bracing, and other structural members shall be located on the inside of secured perimeters.

- Fence shall be 9-gauge, galvanized steel fabric with mesh openings not larger than 2 inches. Outriggers shall be angled outward, away from the security area.

- All posts shall be set in concrete. Concrete foundation shall be designed to withstand any strain or shocks ordinarily brought to bear on the fence.

- Gates shall be double swing, unless called out as roll and slide type.
- Electrical grounding shall be provided for all permanent fencing in accordance with the NFPA 70-2002.

Technical Rationale–Fencing configuration, material, and construction are required for security and good engineering practice. Grounding is in accordance with NFPA 70-2002.

4.2.1.3.12 Yard Fire Protection

To be provided in a later revision

4.2.1.3.13 Field-Erected Tanks and Tank Foundations

Criteria

- Field-erected tanks can be for the purpose of storage of fuel oil, firewater, etc.
- Tanks that contain water for purposes other than fire protection shall meet standard that will be provided later.
- Tanks for firewater storage shall meet the NFPA 22-1998 requirements.
- Tanks for fuel oil or similar material shall meet standard to be provided later.
- Design tanks for the following loading and ambient conditions as provided in the structural design criteria:
  - Roof load (including snow load)
  - Design wind velocity
  - Seismic load
  - Lowest 1-day mean ambient temperature
  - Allowable soil pressure
  - Ambient temperature range.
- Increase the thickness of the various tank elements by the following corrosion allowances for steel tanks:
  - Bottom, 1/8 inch
  - Shell, 1/16 inch
  - Roof plate, 1/16 inch
  - Webs of roof support members, 1/16 inch
- Provide the roof type required for each tank furnished. Use tubular or pipe section columns for supported cone roofs.

- Provide ladders, fittings, and other appurtenances as required. Terminate ladders 1 foot above finish grade.
- Design ladders, ladder safety cages, platforms, and handrails in accordance with Occupational Safety and Health Administration requirements.
- Provide overflow pipes, vents, nozzles, shell manholes, and roof hatches in accordance with the applicable design code.
- Provide liquid-level indicator as required.
- Design supports and fasteners for the liquid-level indicator(s) in accordance with the manufacturer's recommendations.
- Design tank foundations in accordance with accepted design practices. All nozzles 6 in. or less shall be stainless steel. The bottom of central column configuration shall be stainless steel.

Technical Rationale–Field erected tanks and tank foundations shall be designed for loadings specified in the structural design criteria. Firewater storage shall meet the requirements of NFPA 22-1998. Configuration and appurtenances shall conform to good engineering practice and shall meet the requirements of NFPA 22-1998.

4.2.1.3.14 Postclosure Monuments

To be provided in a later revision.

4.2.2 Surface Structural Design Criteria

4.2.2.1 Surface Structural Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Civil/Structural/ Architectural	Structural*	ICC 2000 (IBC), ACI 201.2R-01, ACI 301-99, ACI 318-02/318R-02, ACI 349-01, ACI 530-02/ASCE5-02/TMS 402-02, AISC 1989, AISC 1995, AISC 1997, AISC S303 2000, AISC S341 1997, ANSI A58.1-1982, ANSI/AISC N690-1994, ANSI/ANS-2.8-1992, ANSI/ANS-57.7-1988, ANSI/ANS-57.9-1992, ANSI/ANS-6.4-1997, ANSI/ANS-6.4.2-1985, ANSI/ASHRAE/IES 90A-a-1987, AWS 1.1/D1.1M-2002, ASCE 7-98 2000, ASCE 4-98 2000, ASME NOG-1-2002, ASTM A992/A 992M-02, ASTM A36/A 36M-01, ASTM A53/A 53M-01, ASTM A325-02, ASTM A500-01a Grade B, ASTM F1554-99, ASTM A108-99, ASTM A653/A 653M-01a, ASTM A706/A 706M-01, ASTM A615/A 615M-01b, ASTM A185-01, ASTM A307-00, ASTM A490-02, ASTM D5144-00, IEEE Std 739-1995, MIL-STD-1472E-1996, NFPA 101-2000, UCRL-15673 (Bongarra et al. 1985), CMAA 70-2000
		RG 1.102 Rev 1, RG 1.117 Rev 1, RG 1.122 Rev 1, RG 1.13 Rev 1, RG 1.165 Rev 0, RG 1.29 Rev 3, RG 1.59 Rev 2, RG 1.61 Rev 0, RG 1.69 Rev 0, RG 1.76 Rev 0, RG 1.91 Rev 1, RG 1.92 Rev 1, RG 3.49 Rev 0, RG 3.60 Rev 0, RG 8.8 Rev 3
		10 CFR 20, 10 CFR 63, 10 CFR 73, 29 CFR 1910, 29 CFR 1926 (Sections 750-761), 36 CFR 1191, Appendix A.
		NUREG-0700 1996 (NRC 1996), NUREG-0800 1987 (NRC 1987), NUREG-1567 2000 (NRC 2000a)
		DOE Order 420.1-2000 Change 3, DOE-STD-1020-2002

Technical Rationale:

[1] These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21(c)(2)), PRD-022 and *Waste Processing Area Facilities System Description Document* (BSC 2002e). Determination of applicable sections of these codes and standards will be determined during the design process and in development of design products.

[2] These Regulatory Guides have been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guides will be determined during the design process and in development of design products that are impacted by these Regulatory Guides. Addressing these Regulatory Guides supports compliance with requirements in *Waste Processing Area Facilities System Description Document* (BSC 2002e).

[3] Addressing Code of Federal Regulations supports compliance with requirements in *Waste Processing Area Facilities System Description Document* (BSC 2002e) and PRD-015/P-015, PRD-015/P-020, PRD-015/P-021 and PRD-005.

[4] These NUREGs provide guidance on acceptable methods and approaches that could be utilized in MGR design.

[5] Addressing this DOE Order supports compliance with requirements of PRD-018/P-019. Determination of applicable sections of this DOE Order will be determined during the design process and in development of design products.

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.2.2.2 Categorization of Structures, Systems, and Components

Criteria–The surface facilities in MGR handle large quantities of radioactive and hazardous materials. Natural phenomena hazards (NPH) such as earthquakes, winds, and floods can result in the uncontrolled release of these materials. Consequently, it is necessary to ensure that facility structures are designed to withstand the effects of those natural phenomena events that are postulated to occur during the life of the facility.

To ensure that an adequate level of protection is provided for facility workers, co-located workers, and the public from the potential consequences associated with NPH, a graded approach has been employed in the NPH design of the MGR Facility. Seismic categorization of SSCs Important to Safety (ITS) and conventional quality SSCs designed to International Building Code, ICC 2000, are described in Tables 4.2.2-1 and 4.2.2-2. The seismic design basis summary for various facilities is shown in Table 4.2.2-3. Seismic design inputs are addressed in Section 6.1.3.

Technical Rationale–For structures important to safety (ITS) seismic response is in accordance with site specific information. For conventional quality structures seismic response is in accordance with International Building Code, ICC 2000.

Table 4.2.2-1. Seismic Frequency Categories for FC-1, FC-1A and FC-2 SSCs ITS

Seismic Frequency Category	Earthquake (Annual Probability of Exceedance)	Earthquake (Return Period)	Applicability
FC-2	1×10^{-4}	10,000-year	SSCs Quality Levels ITS is defined by the Pre-closure Safety Analysis to meet dose exposure limits defined in 10 CFR 63. The SSCs are designed to governing codes. Limited inelastic behavior without the loss of function is permitted in the design.
FC-1A	5×10^{-4}	2,000-year	SSCs Quality Levels ITS is defined by the Pre-closure Safety Analysis to meet dose exposure limits defined in 10 CFR 63. The SSCs are designed to governing codes to remain within the elastic limit. Some SSCs as defined in the Preclosure Safety Analysis may need additional verification of meeting the strength requirements with limited inelastic behavior to withstand FC-2 category seismic event.
FC-1	1×10^{-3}	1,000-year	SSCs Quality Levels ITS is defined by the Preclosure Safety Analysis to meet dose exposure limits defined in 10 CFR 63. The SSCs are designed to governing codes to remain within the elastic limit.

Table 4.2.2-2. Seismic Use Group of Conventional Quality SSCs Designed to IBC

Seismic Use Group	Importance Factor I	Nature of Occupancy
III	1.5	SSCs Containing Toxic, Explosive and Hazardous Materials.
II	1.25	SSCs that represent substantial Hazard to Human Life. (Example: Heavy Equipment Maintenance Facility)
I	1.0	SSCs except those listed in Use Group II and III. (Example: Normal Occupancy less than 300 People)

Table 4.2.2-3. Seismic Design Basis Summary for Various Facilities

No.	Facility	Seismic Design Basis*
1	Dry Transfer Facility # 1	
2	Dry Transfer Facility # 2	
3	Remediation Building	
4	Low Level Waste Treatment Building	
5	Transporter Receipt Building	
6	Disposal Container Preparation Building	
7	Surface Aging Facility	
8	Heavy Equipment Maintenance Facility	
9	Switchgear Building	
10	Balance of Plant Facilities	

* To be added later

Table 4.2.2-4 provides a summary of the structural design codes and standards and their applicability for different Quality Level Seismic Category facilities.

The application of the particular code or standard is also summarized in the table. Application of these standards is addressed in more detail in Section 4.2.2.2.

Table 4.2.2-4. Applicability of Design Codes and Standards

Title	Applicability	ITS SSCs (SeismicFC-1, FC-1A, and FC-2)	Conventional Quality SSCs (IBC Seismic Use Group)
ICC-2000 International Building Code	Seismic Design		X
ASCE 4-98 Seismic Analysis of Safety-Related Structures	Seismic Analysis	X	
ACI 349-01 Code Requirements for Nuclear Safety-Related Concrete Structures	Design of Concrete Structures	X	
ACI 318-02/318R02 Building Code Requirements for Structural Concrete	Design of Concrete Structures		X
ANSI/AISC N690-1994 Steel Safety-Related Structures for Design, Fabrication and Erection	Design of Structural Steel	X	

Table 4.2.2-4. Applicability of Design Codes and Standards (Continued)

Title	Applicability	ITS SSCs (SeismicFC-1, FC-1A, and FC-2)	Conventional Quality SSCs (IBC Seismic Use Group)
AISC-1997 Manual of Steel Construction, Allowable Stress Design	Design of Structural Steel		X
AISC S341-1997 Seismic Provisions for Structural Steel Buildings	Seismic Detailing of Structural Steel (Part III)	X	X
ICC-2000 International Building Code	Minimum Live Loads	X	X
ICC-2000 International Building Code	Wind Load Design Methodology	X	X
ICC-2000 International Building Code	Snow Load Design Methodology	X	X
Code identified, being procured	Design of Steel Deck	X	X

4.2.2.3 Design Loads

SSCs shall be designed for the loads prescribed in this document and as supplemented by any additional criteria for the project.

4.2.2.3.1 Dead load (D)

Criteria–Dead loads are loads that remain permanently in place.

Technical Rationale–Standard structural terminology.

4.2.2.3.2 Live Load (L & L_r)

Criteria–Live loads (L) are those loads produced by the use and occupancy of a building or other structure. Live loads on a roof (L_r) are those produced (1) during maintenance by workers, equipment, and materials and (2) during the life of the structure by movable objects such as temporary equipment. Also considered as live loads are the dynamic effects of operating equipment (such as cranes and pumps).

Live loads on roofs shall be as stipulated in ICC 2000.

Technical Rationale–Standard structural terminology. Using International Building Code is good engineering practice.

4.2.2.3.3 Snow Load (S_N)

Criteria–Snow load shall be obtained from Section 6.1.1.1.

Technical Rational–Using International Building Code is good engineering practice.

4.2.2.3.4 Ash Load (A)

Criteria–Based on Section 6.3.3.52 of *MGR External Events Hazards Analysis* (CRWMS M&O 2000a), it is determined that potential ash load is 18.14 lbs/ft^2. This is lower than typical roof live load of 20 lbs/ft^2 specified in building code. Hence, roof loading due to ash fall is screened from further consideration.

Technical Rationale–Ash load is screened from further consideration because its potential load from CRWMS M&O 2000a is less than that specified as typical in building code.

4.2.2.3.5 Lateral Earth Pressure (H)

Criteria–Every foundation wall or other wall serving as a retaining structure shall be designed to resist (in addition to the vertical loads acting on it) the incident lateral earth pressures and surcharges. The minimum surcharge load shall be 300 lbs/ft^2 for normal vehicular traffic. Dynamic lateral earth pressures increment due to design basis earthquake shall be computed for FC-1, FC-1A and FC-2 structures from the soil–structure interaction analysis. At rest lateral earth pressure shall be used in the design of structures. Active lateral and passive earth pressures, as appropriate, shall be used in the stability evaluation of structures. Any hydrostatic pressure shall correspond to maximum probable groundwater level.

Technical Rationale–Surcharge load listed is in conformance with good engineering practice.

4.2.2.3.6 Wind Load (W)

Criteria

- For all structures the wind loads shall be calculated per the provisions of ICC 2000, using extreme wind velocity of 121 mph (*MGR Design Basis Extreme Wind/Tornado Analysis* [CRWMS M&O 1999]).
- Refer to the discussion of wind loads in Section 6.1.1.2

Technical Rationale–Design velocity is result of CRWMS M&O 1999.

4.2.2.3.7 Tornado Loads (W_t)

Criteria

- For structures important to safety, the basic parameters for the tornado loads shall be as follows (CRWMS M&O 1999) and guidance in Regulatory Guide 1.76, Rev 0:
  - Maximum speed—189 mph
  - Pressure drop—0.81 psi
  - Rate of pressure drop—0.30 psi/sec

- Tornado generated missiles shall be either Spectrum I or Spectrum II as defined below:
  - Spectrum I—See NUREG-0800 (NRC 1987), Section 3.5.1.4
  - Spectrum II—See Table 5 of CRWMS M&O 1999

- For conventional quality structures, tornado loads are not applicable.

Technical Rationale–Tornado loads are taken from CRWMS M&O 1999 and Regulatory Guide 1.76, Rev 0. Definition of Spectrum I and II are from NUREG-0800 (NRC 1987), Section 3.5.1.4 and from Table 5 of CRWMS M&O 1999.

4.2.2.3.8 Seismic Loads (E)

Criteria

- For structures important to safety with seismic categories FC-1, FC-1A and FC-2, the seismic load shall be based on the following:
  - Design ground motions shall be in accordance with Acceleration Ground Response Spectra provided in Section 6.1.3.
  - Seismic analysis meets the requirements of NUREG-0800 (NRC 1987), Sections 3.7.1, 3.7.2, and 3.7.3.
  - Damping values shall be in accordance with Regulatory Guide 1.61, Rev 0.
  - Consideration of soil—structure interaction effects.
  - Development of structural/seismic responses (acceleration, moments, shears).
  - Development of Floor Response Spectra (FRS).
- For conventional quality structures, seismic loads shall be based on seismic use groups listed in ICC 2000 (IBC).

Technical Rationale–For structures important to safety seismic response is in accordance with Section 6.1.3, with the analysis meeting the requirements of NUREG-0800 (NRC 1987), Sections 3.7.1, 3.7.2, and 3.7.3. Soil-structure interaction effects shall be considered. For conventional equality structures seismic response is in accordance with ICC 2000 (IBC).

4.2.2.3.9 Thermal Loads (T_o, T_a)

Criteria–The design of structures shall include the effects of stresses resulting from variations in temperatures under Category 1 or 2 event sequences (normal operating conditions and accident scenarios). Structures shall also be designed for movements resulting from the maximum seasonal temperature change. The design shall provide for the lags between air temperatures and the interior temperatures of massive concrete members or structures. The ambient temperature profile provided in Section 6.1.1.5 shall be used in the determination of the thermal loads.

Operating Temperatures, T_o

Internal temperatures at various locations inside the facility structures during normal operating conditions shall be per the Ventilation Design Criteria.

Accident Temperatures, T_a

Internal temperatures at various locations inside the facility structures during accident conditions shall be identified on a case-by-case basis and coordinated with Environmental Safety and Health (ES&H).

Temperature Effects on Structural Elements

- The temperature effects for structural steel elements shall be in accordance with Part 6 of AISC-1997.
- The temperature effects for structural concrete elements shall be in accordance with Appendix A of ACI-349-01.

Technical Rationale–Stresses resulting from thermal loads, both normal operating conditions and accident scenarios, shall be used in the design of both steel and concrete structures in accordance with applicable sections of AISC-1997 and ACI 349-01.

4.2.2.3.10 Creep and Shrinkage Forces

Criteria–Effects of creep and shrinkage shall be included with the dead load as applicable.

Technical Rationale–Standard engineering practice.

4.2.2.3.11 Fluid Load, F

Criteria–The design of structures shall include the effects of stresses resulting from fluid loads. Fluid loads include loads due to weight and pressure of fluids with well defined densities and controllable maximum heights. Fluid loads shall include the effects of horizontal sloshing in accordance with Section 3.5.4.3 of ASCE 4-98.

Technical Rationale–Sloshing shall also be included in addition to normal fluid loads in accordance with Section 3.5.4.3 in accordance with ASCE 4-98.

4.2.2.3.12 Operating Pipe Reactions, R_o

Criteria–Operating pipe reactions include piping reactions during normal, operating, and shutdown conditions.

Technical Rationale–Standard engineering practice.

4.2.2.3.13 Precipitation Levels

Criteria–Design-basis precipitation provided in Section 6.1.1.1.

Technical Rationale–See Section 6.1.1.1.

4.2.2.3.14 Settlement

Criteria–Buildings and structures shall be designed for the total and differential foundation settlements, resulting from the combined static and dynamic loads. The dynamic settlement is due to dissipation of pore pressure and/or redistribution of soil stresses from the effects of a design basis earthquake.

Technical Rationale–Standard engineering practice.

4.2.2.3.15 Flood Load (F_a)

Criteria–The structures shall be designed for the flooding and wave action consequences associated with flooding events identified in *Preliminary Hydrologic Engineering Studies for the North Portal Pad and Vicinity* (BSC 2002d). Loads resulting from flooding and wave action shall be considered to meet criteria of Chapter 4 of DOE-STD-1020-02.

Technical Rationale–Flooding and wave action as identified in BSC 2002d shall meet criteria listed in Chapter 4 of DOE-STD-1020-02.

4.2.2.3.16 Construction Loads on Steel Deck and Framing Supporting Concrete Slabs

Criteria

Steel Deck

Steel deck supporting wet concrete shall be designed for the weight of concrete plus 50 psf uniformly distributed load.

Structural Steel Framing

Steel framing supporting steel deck shall be designed for the following load cases:

- The weight of wet concrete plus a 50 pounds per square foot (psf) uniformly distributed load. A note shall be added to the design drawings stating that no rigging shall be permitted from the steel framing during placement of concrete until the concrete has attained its full design strength.
- A 5,000 lb. concentrated load placed anywhere on the span to maximize moment and shear. The concentrated load is not cumulative and shall not be carried to columns.

Technical Rationale–Construction loads are values used in good engineering practice.

4.2.2.3.17 Drop Load

Criteria–Drop loads shall be treated as live loads with impact. Postulated dropped loads will be evaluated for local damage (for example, penetration, perforation and spalling of a concrete slab) as well as for structural integrity. The acceptability of damage due to the dropped load will be evaluated by the Integrated Safety Management Process (for example, penetration may be acceptable but perforation may not be acceptable due to loss of confinement). The drop load evaluation will be based on the Linderman, R.B.; Rotz, J.V.; and Yeh, G.C.K. 1974. *Design of Structures for Missile Impact*. BC-TOP-9A, Rev. 2. San Francisco, California: Bechtel Power or other similar applicable reference guides.

Technical Rationale–Design *of Structures for Missile Impact*, provides guidance on drop load evaluations.

4.2.2.4 Structural Design Criteria for Structures that are Important to Safety (ITS)

The following design criteria are applicable for ITS structures.

4.2.2.4.1 Reinforced Concrete Design

Criteria–Reinforced concrete structures shall be designed for FC-1 and FC-1A seismic levels in accordance with Strength Design Method of ACI 349-01 for load combinations and acceptance criteria shown in Section 4.2.2.4.4.

The reinforced concrete structures shall be designed or evaluated (based on Quality Level and dose consequences (to be provided later)) for FC-2 seismic levels in accordance with ACI 349-01 to assess the overall structural performance for demonstration that building safety is not impaired with limited inelastic behavior. The Seismic Margin Assessment (SMA) methodology shown in Appendix A of ASCE 4-98 can be utilized for evaluation of reinforced concrete structures for FC-2 seismic levels. Detail seismic design strategy for preclosure SSCs will be provided later.

Technical Rationale–ACI 349-01 is the code for safety-related concrete structures. Therefore, it will be used for concrete SSCs ITS. SMA methodology in Appendix A of ASCE 4-8 is applicable for concrete structures evaluated for limited inelastic behavior at FC-2 seismic levels.

4.2.2.4.2 Structural Steel Design

Criteria–Steel structures shall be designed for FC-1 and FC-1A seismic levels in accordance with ANSI/AISC N690-1994, *American National Standard Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities,* for load combinations and acceptance criteria shown in Section 4.2.2.4.4. Proportioning and detailing for seismic loads shall meet the additional requirements of Part III of AISC 1997.

The steel structures shall be designed or evaluated (based on Quality Level and dose consequences (to be provided later)) for FC-2 seismic levels in accordance with ANSI/AISC N690-1994 to assess the overall structural performance for demonstration that building safety is not impaired with limited inelastic behavior. The SMA methodology shown in Appendix A of ASCE 4-98 can be utilized for evaluation of steel structures for FC-2 seismic level.

Technical Rationale–ANSI/AISC N690-1994 is the code for safety-related steel structures. Therefore, it will be used for steel SSCs ITS. SMA methodology in Appendix A of ASCE 4-8 is applicable for steel structures evaluated for limited inelastic behavior at FC-2 seismic levels.

4.2.2.4.3 Masonry Design

Criteria–Use of masonry shall not be permitted for important to safety structures.

Technical Rationale–Construction difficulties make it difficult to get desired strength in masonry SSCs.

4.2.2.4.4 Load Factors, Load Combinations, and Acceptance Criteria

Criteria

Notations

D = Dead Load

L = Live Load

L_r = Roof Live Load

S_N = Snow Load

E = Earthquake (Seismic) Load resulting from FC-1, FC-1A or FC-2 seismic level definition (corresponding to E_{ss} of Section 9.2 of ACI 349-01 and E_{ss} of Table Q 1.5.7.1 of ANSI/AISC N690-1994.

H = Lateral Earth Pressure Load

T_a = Thermal Loads during Accident Condition

T_o = Thermal Loads during Normal Operating Conditions

F = Fluid Load

F' = Buoyant Force of Design Basis Flood

R_o = Operating Pipe Reaction Load

S = Allowable Stress per Allowable Stress Design Method

U = Required Strength per Strength Design Method

W = Wind Load

W_t = Tornado Load (This includes effects from tornado wind pressure, tornado-created differential pressure, and tornado-generated missiles.)

Y_m= Missile impact equivalent static load on structure generated by drop load and including appropriate dynamic load factor to account for dynamic nature of the load. (In determining an appropriate static load for Y_m, elasto-plastic behavior may be assumed with appropriate ductility ratios, provided excessive deflection will not result in loss of function of any SSCs important to safety).

In the load combinations provided in Section 4.2.2.4.4, the following conditions shall be considered:

A. Where the structural effects of differential settlement, creep, or shrinkage may be significant, they shall be included with the dead load D in all the load combinations. Estimation of these effects shall be based on a realistic assessment of such effects occurring in service.

B. Where any load reduces the effect of other loads, the corresponding coefficient for that load shall be taken as 0.9 if it can be demonstrated that the load is always present or occurs simultaneously with other loads. Otherwise, the coefficient for that load shall be taken as zero.

C. In the load combinations that include Y_m, appropriate dynamic load factor should be used unless a time-history analysis is performed to justify otherwise.

D. In the load combinations that include W_t or Y_m, the corresponding acceptance limits (U, 1.6S or 1.7S) should be satisfied first without tornado missile load of W_t, or without Y_m. When considering these concentrated missile loads, local section strength capabilities may be exceeded provided there will be no loss of function of any SSCs important to safety system.

Technical Rationale–Definitions given are standard structural definitions. Conditions listed are to be used with load combinations are good engineering practice.

Criteria–**Reinforced Concrete Design Load Combinations**—The following load combinations are based on Section 9.2 of ACI 349-01 and Paragraphs II.3.b.(ii) and II.5.a of Section 3.8.4 of NUREG-0800 (NRC 1987).

1. $U = 1.4D+1.7L+1.7L_r+1.4F+1.7H+1.7R_o$
2. $U = 1.4D+1.7L+1.7S_N+1.4F+1.7H+1.7R_o$
3. $U = 1.4D+1.7L+1.7L_r+1.4F+1.7H+1.7R_o+1.7W$
4. $U = 1.4D+1.7L+1.7S_N+1.4F+1.7H+1.7R_o+1.7W$
5. $U = 1.05D+1.3L+1.3L_r+1.05F+1.3H+1.05T_o+1.3R_o$
6. $U = 1.05D+1.3L+1.3S_N+1.05F+1.3H+1.05T_o+1.3R_o$
7. $U = 1.05D+1.3L+1.3L_r+1.05F+1.3H+1.3W+1.05T_o+1.3R_o$
8. $U = 1.05D+1.3L+1.3S_N+1.05F+1.3H+1.3W+1.05T_o+1.3R_o$
9. $U = D+L+L_r+F+H+T_o+R_o+E$
10. $U = D+L+L_r+F+H+T_o+R_o+W_t$

11. $U = D+L+S_N+F+H+T_o+R_o+E$
12. $U = D+L+L_r+F+H+T_a+R_o$
13. $U = D+L+S_N+F+H+T_a+R_o$
14. $U = D+L+L_r+F+H+T_a+R_o+E+Y_m$
15. $U = D+L+L_r+F+H+T_a+R_o+W_t$
16. $U = D+L+S_N+F+H+T_a+R_o+E+Y_m$
17. $U = D+L+S_N+F+H+T_a+R_o+W_t$

Technical Rationale–The design load combinations listed for reinforced concrete are based in Section 9.2 of ACI 349-01 and Paragraphs II.3.b.(ii) and II.5.a of Section 3.8.4 of NUREG-0800 (NRC 1987). These are to be used for SSCs ITS.

Criteria–**Structural Steel Design Load Combinations**—The following load combinations are based on Table Q1.5.7.1 of ANSI/AISC N690-1994 and Paragraphs II.3.c.i(a), II.3.c.ii(a), and II.5.b of Section 3.8.4 of NUREG-0800 (NRC 1987).

1. $S = D+L+L_r$
2. $S = D+L+S_N$
3. $S = D+L+ L_r+R_o+T_o$
4. $S = D+L+ S_N+R_o+T_o$
5. $S = D+L+L_r+W$
6. $S = D+L+S_N+W$
7. $S = D+L+L_r+W+R_o+T_o$
8. $S = D+L+S_N+W+R_o+T_o$
9. $1.6\,S = D+L+ L_r+R_o+T_o+E$
10. $1.6\,S = D+L+ S_N+R_o+T_o+E$
11. $1.6\,S = D+L+ L_r+R_o+T_o+W_t$
12. $1.6\,S = D+L+ S_N+R_o+T_o+W_t$
13. $1.6\,S = D+L+ L_r+T_a+R_o$
14. $1.6\,S = D+L+ S_N+T_a+R_o$
15. $1.7\,S = D+L+ L_r+T_a+R_o+E+Y_m$
16. $1.7\,S = D+L+ S_N+T_a+R_o+E+Y_m$
17. $1.7\,S = D+L+ L_r+T_a+R_o+W_t$
18. $1.7\,S = D+L+ S_N+T_a+R_o+W_t$

In load combinations 9 through 18, the stress limit in shear shall not exceed 1.4S in members and bolts.

Technical Rationale–The design load combinations for structural steel are based on Table Q1.5.7.1 of ANSI/AISC N690-1994 and Paragraphs II.3.c.i(a), II.3.c.ii(a), and II.5.b of Section 3.8.4 of NUREG-0800 (NRC 1987). These are to be used for SSCs ITS.

4.2.2.4.5 Stability Criteria for Structures that are Important to Safety (ITS)

Criteria–Structures that are ITS shall be evaluated to demonstrate that the buildings are adequately stable against sliding and overturning effects for the following load combinations:

Load Combination

D + H + W

D + H + E

D + H + W_t

Stability against overturning due to seismic forces shall be evaluated by the "energy approach" (i.e., the factor of safety against overturning shall be calculated as the ratio of potential energy required to cause overturning about one edge of the structure to the maximum kinetic energy in the structure due to the earthquake).

The effect of building sliding due to seismic forces shall be evaluated by the use of "non-linear time-history" approach to demonstrate that any potential building displacements are inconsequential to the structural integrity of the building. However, the commodities (piping, electrical cable, etc.) attached to the building shall be so designed that the commodities shall have adequate factor of safety to withstand the results from the bridge displacements.

Technical Rationale–The listed load combinations for evaluating sliding and overturning are from NUREG-0800 (NRC 1987), *Standard Review Plan*, Section 3.8.5. Resistance against overturning shall be evaluated by "energy approach," and the effect of building sliding shall be evaluated by the use of "non-linear time history."

4.2.2.4.6 Deflection Limits

Criteria

Reinforced Concrete Members

Deflections in reinforced concrete members shall be computed based on cracked section properties. Control of deflections in reinforced concrete members shall be in accordance with Section 9.5 of ACI 349-01.

Structural Steel Members

The deflection requirements shall be in accordance with Section Q1.13 and Comments CQ1.13 of ANSI/AISC N690-1994.

Crane Runway Support Beams and Monorails

The following requirements are used:

- Maximum vertical deflection (loads without impact) = $L_r/600$ (CMAA 70-2000)
- Maximum lateral deflection = $L_r/400$ (CMAA 70-2000).

Steel Deck

The live load deflection shall not exceed (to be provided later).

Technical Rationale–Control of deflections in reinforced concrete members is in accordance with ACI 349-01, while the deflection requirements for structural steel members are in accordance with ANSI/AISC N690-1994. Crane runway deflection is in accordance with CMAA 70-2000.

4.2.2.4.7 Anchorage

Criteria–Anchorage Rods and Concrete Expansion Anchors

Anchorage design for important to safety SSCs shall meet the following:

- Design of anchor rods shall be in accordance with ACI 349-01, Appendix B, Steel Embedments.
- Allowable design capacities of concrete expansion anchors shall be based on the manufacturers' recommendations and shall include a minimum factor of safety of 4 of the mean ultimate capacity. The manufacturers' test data shall be current and shall be approved and published by the International Conference of Building Officials (ICBO).

Technical Rationale–Design of anchor rods for SSCs ITS shall be in accordance with ACI 349-01. Expansion anchors for SSCs ITS shall have test data approved and published by ICBO.

4.2.2.4.8 Story Drift

Criteria–Story drift for important to safety structures shall be as follows:

- Story drift shall be calculated from a dynamic, elastic analysis.
- Calculated drift shall include translational as well as torsional deflections.
- Calculated story drift shall not exceed 0.01 times the story height for structures with contribution to distortion from both shear and flexure. For structures in which shear distortion is the primary contributor to drift, the calculated story drift shall not exceed 0.004 times the story height.

Technical Rationale–Story drift limitations for structures ITS conforms to good engineering practice.

4.2.2.4.9 Foundation Design

Criteria–The foundation design for important to safety structures shall meet the requirements of NUREG-0800 (NRC 1987), Section 3.8.5.

Technical Rationale–The foundation design for ITS structures shall meet the requirements of NUREG-0800 (NRC 1987), Section 3.8.5.

4.2.2.5 Structural Design Criteria for Conventional Quality Structures

The following design criteria for the conventional quality structures are applicable for seismic use groups listed in ICC 2000 (IBC).

4.2.2.5.1 Reinforced Concrete Design

Criteria–Reinforced concrete structures shall be designed in accordance with ACI 318-02/318R-02.

Technical Rationale–ACI 318-02/318R-02 is standard engineering code for reinforced concrete conventional structures.

4.2.2.5.2 Structural Steel Design

Criteria–Steel structures shall be designed in accordance with the following:

- Allowable Stress Design Method utilizing AISC 1997.
- Detailing for seismic loads shall meet the additional requirements of Table 4.2.2-4.

Technical Rationale–AISC 1997 Allowable Stress Design Method is widely accepted for structural steel design as is detailing requirements as listed in ICC 2000 (IBC).

4.2.2.5.3 Masonry Design

Criteria–Masonry shall be designed in accordance with ICC 2000 (IBC).

Technical Rationale–Masonry is acceptable for conventional structures. Using the International Building Code is good engineering practice.

4.2.2.5.4 Load Factors, Load Combinations, and Acceptance Criteria

Criteria–Notations

D	=	Dead Load
L	=	Live Load
L_r	=	Roof Live Load
S_N	=	Snow Load
E	=	Earthquake (Seismic) Load
H	=	Lateral Earth Pressure Load
T_a	=	Thermal Force

F = Fluid Load
S = Allowable Stress per Allowable Stress Design Method
U = Required Strength per Strength Design Method
W = Wind Load

In the load combinations provided in Sections 4.2.2.5.4.1, 4.2.2.5.4.2, and 4.2.2.5.4.3 the following load conditions shall be considered:

A. Where the structural effects of differential settlement, creep, or shrinkage may be significant, they shall be included with the dead load D in all the load combinations. Estimation of these effects shall be based on a realistic assessment of such effects occurring in service.

B. Where any load reduces the effect of other loads, the corresponding coefficient for that load shall be taken as 0.9 if it can be demonstrated that the load is always present or occurs simultaneously with other loads. Otherwise, the coefficient for that load shall be taken as zero.

Technical Rationale–Definitions given are standard structural definitions. Conditions listed are to be used with load combinations, which are good engineering practice.

4.2.2.5.4.1 Reinforced Concrete Design Load Combinations

Criteria–The following load combinations are based on Section 9.2 of ACI 318-02/318R-02 and Section 1605.2.1 of ICC 2000 (IBC):

1. $U = 1.4(D+F)$
2. $U = 1.2(D+F+T) + 1.6(L+H) + 0.5(L_r \text{ or } S_N)$
3. $U = 1.2D + 1.6(L_r \text{ or } S_N) + (1.0L \text{ or } 0.8W)$
4. $U = 1.2D + 1.6W + 1.0L + 0.5(L_r \text{ or } S_N)$
5. $U = 1.2D + 1.0E + 1.0L + 0.2S_N$
6. $U = 0.9D + 1.6W + 1.6H$
7. $U = 0.9D + 1.0E + 1.6H$

Notes: (a) The load factor on L in load combinations 3, 4, and 5 above shall be permitted to be reduced to 0.5 except for garages, areas occupied as places of public assembly, and all areas where L is greater than 100 lbs/ft^2.

(2) The load factor for H shall be zero in load combinations 6 and 7 if structural actions due to H counteracts that due to W or E. Where lateral earth pressure provides resistance to structural actions from other forces, it shall not be included in H but shall be included in the design resistance.

Technical Rationale–The design load combinations listed for reinforced concrete are based on ACI 318-02/318R-02 and Section 1605.2.1 of ICC 2000 (IBC). These are to be used for conventional SSCs.

4.2.2.5.4.2 Structural Steel Design Load Combinations

Criteria–The following load combinations are based on ICC 2000 (IBC), Section 1605.3.2:

1. $S = D+L+L_r$
2. $S = D+L+S_N$
3. $S = 0.75(D+L+1.3W)$
4. $S = 0.75(D+L+S_N/2+1.3W)$
5. $S = 0.75(D+L+S_N+0.65W)$
6. $S = 0.75(D+L+S_N+E/1.4)$
7. $S = 0.75(0.9D+E/1.4)$

Exception: Crane hook loads need not be combined with roof live load or with more than three-fourths of the snow load or one-half of the wind load.

Note: For anchorages against overturning, uplift, and sliding, where portions of resistance is provided by dead load, only 2/3 of minimum dead load likely to be in place during design wind event shall be used.

Technical Rationale–The design loads combinations listed for structural steel are based on ICC 2000 (IBC), Section 1605.3.2. These are to be used for conventional SSCs.

4.2.2.5.4.3 Masonry Design Load Combinations

Criteria–The load combinations and acceptance criteria for masonry design shall be in accordance with Chapter 21 of ICC 2000 (IBC).

Technical Rationale–This is good engineering practice.

4.2.2.5.5 Stability Criteria for Conventional Quality Structures

Criteria–Conventional quality structures shall be evaluated to demonstrate that the buildings are adequately stable against sliding and overturning effects for the following load combinations:

Load Combination

$D + H + W$
$D + H + E/1.4$

Technical Rationale–The load combinations listed conform to good engineering practice.

4.2.2.5.6 Deflection Limits

Criteria

- Reinforced Concrete Members

  Control of deflections in reinforced concrete members shall be in accordance with Section 9.5 of ACI 318-02/318R-02.

- Structural Steel Members

  The deflection requirements shall be in accordance with Section L3 and commentary Section L3 of AISC 1989.

- Crane Runway Support Beams and Monorails

  The allowable deflection of runway support beams and monorails shall be in accordance with the requirements of Section 4.2.2.4.6 of this criteria.

- Steel Deck

  The allowable live load deflection of steel deck shall be in accordance with the requirements of Section 4.2.2.4.6 of this criteria.

Technical Rationale–Deflection limits for reinforced concrete members are in accordance with Section 9.5 of ACI 318-02/318R-02. For structural steel members the deflection limits are in accordance with Section L3 and commentary Section L3 of AISC 1989. For crane runways and steel deck the deflection limits are the same for conventional SSCs as for SSCs ITS.

4.2.2.5.7 Anchorage

Criteria–Anchorage design of PC-2 and PC-1 SSCs shall meet the following:

- Design of anchor rods shall be in accordance with Cook, R.A. 1999, *Strength Design of Anchorage to Concrete*. Portland Cement Association (Cook 1999).
- Allowable design capacities of concrete expansion anchors shall be based on the manufacturers' recommendations. The manufacturers' test data shall be current and shall be approved by the ICBO.

Anchorage of Conventional Quality Concrete and Masonry Walls:

- The anchorage of the walls shall be capable of resisting the largest of the horizontal forces specified in Sections 1604.8.2 and 1620.2.0 of the ICC 2000 (IBC). Walls shall be designed to resist bending between anchors where the anchor spacing exceeds four ft. Anchors in masonry walls of hollow units or cavity walls shall be embedded in a reinforced grouted structural element of the wall.

Technical Rationale–Design of anchor rods is in accordance with Cook, R.A. 1999, which conforms to good engineering practice. Anchorage of walls are based on the largest of forces specified in Sections 1604.8.2 and 1620.2.0 of the ICC 2000 (IBC).

4.2.2.5.8 Story Drift

Criteria–Story drift for PC-2 and PC-1 structures shall be based on the provisions of Section 1617.3 of the ICC 2000 (IBC).

Technical Rationale–Story drift for conventional structures conform to Section 1617.3 of ICC 2000 (IBC), which is good engineering practice.

4.2.2.5.9 Foundation Design

Criteria–Foundation design for the PC-2 and PC-1 structures shall be in accordance with Chapter 18 of the ICC 2000 (IBC).

Technical Rationale–Foundation design for conventional SSCs shall be in accordance with Chapter 18 of ICC 2000 (IBC).

4.2.2.6 Materials

4.2.2.6.1 Structural Steel

Criteria–Structural steel material designation is identified in Table 4.2.2-5.

Technical Rationale–Structural steel material as identified in Table 4.2.2-5 conforms to what is considered as good engineering practice.

Table 4.2.2-5. Structural Steel Material Designation

Section(s)	ASTM	F_y (ksi)	F_u (ksi)
W-shapes	A992/A 992M-02	50	65
M-shapes	A36/A 36M-01	36	58
S-shapes	A36/A 36M-01	36	58
HP-shapes	A36/A 36M-01	36	58
Channels	A36/A 36M-01	36	58
Angles	A36/A 36M-01	36	58
Structural Plate	A36/A 36M-01	36	58
Structural Tees	(per source of split section)		
Steel Pipe	A53/A 53M-01	35	60
Round HSS	A500-01a Grade B	42	58
Square & Rectangular HSS	A500-01a Grade B	46	58
Anchor Rods	F1554-99	36/55	58/75
Welded Studs	A108-99	*	*
Steel Deck (Galvanized)	A653/A 653M-01a	33	*
Stainless Steel Plates	*	*	*

* To be added later

4.2.2.6.2 Concrete and Reinforcing

Criteria

- Concrete: Compressive Strength, $f'_c = 4000$ psi, minimum.
- Reinforcing Steel shall comply with ASTM A706/A706M-01, *Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.* ASTM A 615/A615M-01b, *Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement*, Grade 60 reinforcement shall be permitted if:

  A. The actual yield strength based on mill tests does not exceed the specified yield strength by more than 18,000 psi (retests shall not exceed this value by more than an additional 3,000 psi).

  B. The ratio of the actual ultimate tensile strength to the actual tensile yield strength is not less than 1.25.

- Welded Wire Fabric: ASTM A185-01, Standard Specification for Steel Welded Wire Fabric, Plain for Concrete Reinforcement.

Technical Rationale–Compressive strength specified is reasonable for the area of use. Either ASTM A706/A706M-01 or ASTM A615/A615M-01b may be used for reinforcing steel providing ASTM A615 meets the requirements stated for ductility.

4.2.2.6.3 Masonry

Criteria–All masonry shall be composed of grouted hollow concrete units and shall have a minimum compressive strength, f'_m, of 1,500 psi. The minimum compressive strength shall be reduced by 50 percent, unless special inspection requirements are specified for the construction of masonry elements.

Technical Rationale–Requirements given conform to good engineering practice.

4.2.2.6.4 Structural Bolting Materials

Criteria–Structural bolting shall be limited to the following:

- ASTM A325-02, *Standard Specification for Structural Bolts, Steel, Heat Treated 120/105 ksi Minimum Tensile Strength* with standard that has been identified and is being procured.
- ASTM A490-02, *Standard Specification for Structural Bolts, Alloy Steel Heat-Treated, 150 ksi Minimum Tensile Strength* with standard that has been identified and is being procured.

Structural connections shall be Bearing Type connections except where Slip Critical connections are essential (such as load reversal). Sizes for structural bolting material should be limited to 7/8-inch diameter for all ASTM A325-02 bolts or 1-1/8-inch diameter for ASTM A490-02 bolts.

Bolting of members that are not considered to be part of the main building structure (i.e., stair or platform connections) may utilize ASTM A307-00, *Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength*, bolts. The maximum size of ASTM A307-00 bolts shall be ¾-inch diameter.

Technical Rationale–Either ASTM A325-02 or ASTM A490-02 bolts may be used for structural steel connections depending on the size of the forces being resisted. Limiting the size for each negates the possibility of using the wrong strength bolt in any connection. ASTM A307-00 bolts are sufficient for the application given.

4.2.2.6.5 Welding Material

Criteria–Welding electrodes shall be E70XX (AWS D1.1/D1.1M-2002).

Technical Rationale–The welding electrodes specified are commonly used in steel construction.

4.2.2.6.6 Structural Analysis/Design Material Properties

Criteria–The following values are to be used in analysis of steel and concrete structures:

Steel:	Modulus of Elasticity	$E = 29 \times 10^6$ psi
	Poisson's Ratio	$\nu = 0.3$
Concrete (4000 psi):	Modulus of Elasticity	$E = 3.834 \times 10^6$ psi (see note)
	Poisson's Ratio	$\nu = 0.17$

NOTE: In lieu of the above value for E, the modulus of elasticity for concrete may be determined in accordance with Section 8.5 of ACI 318-02/318R-02.

For purpose of design calculations, the following material density values shall be used:

Concrete:	150 pounds per cubic ft (pcf)
Steel:	490 pcf

Technical Rationale–The values given for steel and concrete are commonly used in engineering practice.

4.2.2.6.7 Geotechnical Design Parameters and Foundation Design Recommendations

Criteria–Geotechnical Design Parameters

The geotechnical design parameters provided below in Table 4.2.2-6 and Table 4.2.2-7 will be provided later.

Table 4.2.2-6. Summary of Static Modulus Values*

Material	Moist Density (pcf)	Mean Friction Angle (degree)	Elastic Modulus (E) (ksi)	Constant of Horizontal Subgrade Reaction (n_h) (pci)	Coefficient of Subgrade Reaction (K_{s1}) (pci)	Vertical Modulus of Subgrade Reaction (K) (pci)
Muck						
Engineered Fill						

pci = pounds per cubic inch

*To be provided later

Table 4.2.2-7. Summary of Friction and Lateral Earth Pressure Coefficients*

Material	Moist Density (pcf)	Mean Friction Angle (degree) (θ)	Mean Friction Coefficient (δ)	Recommended Design Friction Coefficient (δ)	Mean Active Earth Pressure Coefficient (K_a)	Mean At-Rest Earth Pressure Coefficient (K_o)	Mean Passive Earth Pressure Coefficient (K_p)
Muck							
Engineered Fill							

*To be provided later

Foundation Design Recommendations

To be provided in a later revision.

4.2.3 Architectural Design Criteria

4.2.3.1 Architectural Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5].
Civil/Structural/ Architectural	Architectural *	ANSI/ASHRAE/IESNA 90.1-2001, ANSI/NFPA 220 1992, ASTM E 84-98, ICC 2000 (IBC), ICC/ANSI A117.1-1998, FM Global 2001, ICC 2000 (IPC), NFPA 10-2002, NFPA 101-2000, NFPA 801-98.
		None
		29 CFR 1910, 28 CFR 36
		None
		DOE-STD-1066-99

Technical Rationale:

1 These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros, 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21 (c)(2)), PRD-022 and *Waste Processing Area Facilities System Description Document* (BSC 2002e). Determination of applicable sections of these codes and standards will be determined during the design process and in development of design products.

2 None

3 Addressing Code of Federal Regulations supports compliance with requirements in *Waste Processing Area Facilities System Description Document* (BSC 2002e) and PRD-015/P-015, PRD-015/P-020, PRD-015/P-021 and PRD –005.

4 None

5 Addressing the DOE Standard supports compliance with requirements of PRD-018/P-019. Determination of applicable sections of this DOE Standard will be determined during the design process and in development of design products.

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.2.3.2 North Portal Facilities

4.2.3.2.1 Main Facilities in the North Portal

The main North Portal facilities are comprised of the following:

A. Dry Transfer Facility 1

This is a reinforced concrete structure with steel superstructure that is required for the following functions:

- Handling wastes to transfer from shipping casks to waste packages
- Finishing waste packages for emplacement.

B. Dry Transfer Facility 2

This is a reinforced concrete building that is required for the following functions:

- Handling wastes to transfer from shipping casks to waste packages

- Finishing waste packages for emplacement.

C. Remediation Building

This is a reinforced concrete waste transfer facility that is required for the following functions:

- Support processing off-normal fuel and interim storing assemblies that are too hot for dry storage.

D. Low-Level Waste Building

Information to be provided later.

E. Transporter Receipt Building

This is a sheet metal clad building over a structural steel framework. The function of this building is for:

- Receipt of spent nuclear fuel casks from various offsite sources
- Remove impact limiters
- Rotate shipping cask from horizontal shipping position to vertical orientation.

F. Disposal Container Preparation Building

This is a sheet metal clad building over a structural steel framework. The function of this building is for:

- Preparing the storage casks for receiving spent nuclear fuel.

G. Surface Aging Facility

Information to be supplied later.

H. Heavy Equipment Maintenance Facility

Information supplied later.

I. Switchgear Building

Information supplied later.

J. Central Warehouse

Information supplied later.

K. Central Crafts Shop

Information supplied later.

4.2.3.2.2 Balance of Plant Facilities

A. Site Access Control Facility

The Access Control Facility provides space for security personnel and equipment needed to control the main gate and monitor traffic entering and exiting the MGR facilities. The building will be a prefabricated modular facility.

B. Emergency Operations Center

To be supplied later by ES&H

C. Administration Building

- The Administration Building is an office building housing the daily engineering, operations management and administrative activities of the MGR project.
- The building shall be multi-story steel frame structure with tilt-up concrete panels or precast concrete panels for the exterior walls, with an insulated metal roof rated R-24 or approved equal over "Z" purlins. The building shall have an "industrial image" that is consistent with the overall MGR site image.

D. Motor Pool/Vehicle Maintenance Building

Information to be supplied later.

E. Refueling Station

Information to be supplied later.

F. Warehouse

Information to be supplied later.

G. Craft Repair Shop

Information to be supplied later.

H. Equipment Repair Shop

Information to be supplied later.

4.2.3.3 Criteria for Design of Architectural Works

4.2.3.3.1 General Considerations

Criteria–Design and construction of the surface facilities for MGR shall incorporate standard materials and practices appropriate for the specific building type facilitating a 50-year operational design life. The design shall be defensible in terms of scope, cost, and appearance. Appropriate defensible design is:

- Well planned
- Effective in function
- Simple in form
- Cost-effective
- Constructable
- Adaptable and durable over time
- Clean in appearance
- Maintainable.

A. Architectural Design Philosophy

Design of the facilities shall reflect design characteristics developed for the MGR project complex. Facilities shall be a neutral color that will minimize the visual or aesthetic impact on the surrounding environment. Design elements (coordinating facilities within the complex) shall be incorporated in the design of all structures. These elements include:

Exterior Materials

Exterior materials on the facilities shall include variations of material types such as precast concrete, reinforced cast-in-place concrete, concrete masonry units or metal siding per ICC 2000 (IBC).

Roofing

Roofing for facilities without parapets shall be metal with double slope and center ridge, 1 inch per foot slope per ICC 2000 (IBC), light gray in color, old town gray or approved equal unless otherwise noted. All roofs shall incorporate fall protection tie off points

Exterior scupper and downspouts shall be in a color (to be supplied later) or approved equal.

Interior Finishes and Wall Types

Selection of interior finishes and wall types shall provide for durable, easily cleaned surfaces. Finish types and colors shall be standardized throughout the project facilities depending on specific area function. Determination of wall types shall be based on fire protection requirements, function, durability, shielding, and other factors.

Component features of these elements including color, profile, design, and textures shall be similar throughout the project complex.

Selection of material products, product salient features, sizes, and manufacturers (where necessary) shall be consistent for ease of procurement and maintenance. Of particular importance are siding systems, roofing systems, interior finish materials, doors and hardware or keying, signage, elevators platforms, handrails, and plumbing fixtures. Durable materials shall be selected for those interior and exterior areas subject to equipment movements and operations of potential impact.

B. Occupant Load

Building occupant loads for determination of egress shall be based on NFPA 101-2000. See Section 4.8.1.12.

Occupancy loads shall be based on actual operational staffing levels for the Storage and Special Purpose Industrial Facilities. Fixture counts for all other facilities shall be based on the occupant load as determined by their respective occupancy type defined in the ICC 2000 (IBC).

C. Codes and Standards

The facilities shall be designed in accordance with Industry Codes and Standards referenced in Section 4.2.3.1.

Provisions for egress are described in Section 4.8.1.12. Standards governing non-egress requirements shall be in accordance with 29 CFR 1910, *Occupational Safety and Health Administration* (OSHA) (Subpart D).

Technical Rationale–Architectural Design Philosophy represents general good practice in approaching architectural features for types of buildings to be constructed on this site. Occupancy loads for determination of life safety means of egress are based on pertinent sections of NFPA 101-2000. Occupancy loads for determining plumbing fixture counts shall use applicable sections of either ICC 2000 (IPC) or ICC 2000 (IBC) as required. Provisions for egress shall be as stated in NFPA 101-2000 and DOE Standard 1066-99. Non-egress requirements shall be in accordance with 29 CFR 1910.

4.2.3.3.2 Types of Occupancy and Construction

Criteria–The MGR facilities shall be designed based on occupancy and construction types identified in the ICC 2000 (IBC).

A. International Building Code Occupancies

Occupancies for building design are based on the requirements of the ICC 2000 (IBC), Chapter 3, "Use and Occupancy Classification." The code analyses indicated in this section will be issued at a later date.

International Building Code occupancy types determined for each facility are listed below.

North Portal Facilities	IBC Occupancy Type
Dry Transfer Facility 1	Group F-2

North Portal Facilities	IBC Occupancy Type
Dry Transfer Facility 2	Group F-2
Remediation Building	Group F-2
Low-Level Waste Building	Group F-2 Group S-2
Transporter Receipt Building	Group F-2
Disposal Container Preparation Building	Group F-2
Heavy Equipment Maintenance Facility	Group S-2
Switchgear Building	Group F-2
Central Warehouse	Group S-1, S-2
Central Crafts Shop	Group B Group S-1, S-2
Site Access Control Building	Group B
Medical/Emergency/Security	Group B
Administration Building	Group B
Motor Pool/Vehicle Maintenance Building	Group S-1
Other Facilities	

B. Life Safety Code Occupancies

Occupancies for determination of life safety fire egress requirements shall be based on the classifications defined in NFPA 101-2000, *Life Safety Code*, Chapter 6, "Classification of Occupancy and Hazard of Contents." Industrial occupancies are further classified by NFPA 101, Chapter 40, "Industrial Occupancies," depending on hazard level and operations.

Specific occupancies are determined by Life Safety Code Analysis prepared for the MGR facilities. The code analyses to be indicated in this section will be provided at a later date.

C. Types of Construction

Determination of types of construction used for building design shall be based on the requirements of the ICC 2000 (IBC), Chapter 5, "General Building Heights and Areas," and in Table 503, "General Height and Building Area Limitations." Types of construction used for design of the MGR facilities are further defined in ICC 2000 (IBC) Chapter 6, "Types of Construction." Specific building elements requiring fire-resistive construction per Tables 601 and 602 may be modified by approved construction equivalencies prepared for the MGR project.

Specific types of construction are determined by individual building code analyses prepared for the MGR facilities. The code analyses indicated in this section will be issued at a later date.

North Portal Facilities	IBC Construction Type
Dry Transfer Facility 1	
Dry Transfer Facility 2	
Remediation Building	
Low-Level Waste Building	
Transporter Receipt Building	
Disposal Container Preparation Building	
Aging Pads	
Heavy Equipment Maintenance Facility	
Switchgear Building	
Central Warehouse	Type IIB
Central Crafts Shop	Type IIB
Balance of Plant Facilities	
Site Access Control Building	
Emergency Operations Center	Type IIB
Administration Building	Type IIA
Motor Pool/Vehicle Maintenance Building	Type IIB
Other Facilities	

Information supplied later.

Technical Rationale–The ICC 2000 (IBC) Occupancy Type and the ICC 2000 (IBC) Construction Type are listed by comparing building functions and building configurations with parameters as given in ICC 2000 (IBC).

4.2.3.3.3 Means of Egress

Criteria–Means of egress for all facilities shall comply with the requirements identified in NFPA 101-2000, *Life Safety Code*, Chapter 7 or the applicable section for the specific building occupancy type. This is also discussed in Sections 4.2.3.3.1c, 4.2.3.3.2b and 4.8.1.12.

A maximum travel distance of 75 ft as defined by NFPA 101-2000, Section 7.6.2, shall be allowed to the next confinement barrier in areas of facilities where accidental breach of a primary confinement system could expose personnel to radioactive material per DOE Standard 1066-99. The 75-ft travel distance may be exceeded (based on building occupancy requirements) in areas not normally occupied by personnel where plant equipment alone is located.

Stairs and ladders provided for fire egress and equipment access shall be designed to criteria as included in NFPA 101-2000. Design requirements include all features of stairs, ladders, and alternating tread devices such as rise, run, width, landings, maximum landing obstruction, guardrails, handrails, and toe boards.

Technical Rationale–Means of egress comply with requirements of NFPA 101-2000 and DOE Standard 1066-99. Ladder and stair configurations are referred to Table 1, which also identifies 29 CFR 1910 for requirements.

4.2.3.3.4 Fire Protection

Criteria–Buildings shall be designed in accordance with required fire barriers and noncombustible or fire-resistive construction materials as described in the fire hazard analysis and in Section 4.8.1.19.

A. Fire Barriers

Fire barriers are described in Section 4.8.1.19.

B. Interior Finishes

Exposed interior wall and ceiling finish materials and any factory installed facing material shall have a UL-listed or FM-approved flame spread rating of 25 or less and smoke developed of 50 or less as tested per standard to be provided later.

Interior finishes in areas processing or storing radioactive materials shall be limited combustible as required by NFPA 801-98.

Technical Rationale–Fire barriers shall be in conformance with applicable sections of ICC 2000 (IBC), NFPA 101-2000, and NFPA 801-98.

4.2.3.3.5 Energy Conservation

Criteria–All facilities shall be designed in accordance with the energy conservation requirements set forth in ANSI/ASHRAE/IESNA 90.1-2001. Other energy conservation measures shall include the following items:

- Exterior windows in air-conditioned buildings shall meet shading coefficient requirements by means of tinted insulated glass.
- Personnel, equipment, and vehicular exterior access doors in air-conditioned buildings shall be insulated.
- Exterior openings shall be adequately weather-stripped to minimize air leakage.
- Exterior insulated metal siding walls shall be double caulked to minimize air leakage.
- Vestibules shall be provided at all building entrances of occupied buildings to serve as airlocks and to maintain positive or negative air pressure as appropriate. Allowable infiltration and exfiltration shall comply with ANSI/ASHRAE/IESNA 90.1-2001, except where building or process operations require more stringent provisions to maintain differential pressure.

Technical Rationale–Good engineering practice are used in addition to ANSI/ASHRAE/IESNA 90.1-2001 requirements to produce the maximum energy conservation.

4.2.3.3.6 Accessibility

Criteria–The Administrative portion of all buildings and adjoining site areas, including parking and building access shall be designed to comply with ICC/ANSI A117.1-1998 and applicable provisions of the Americans with Disabilities Act.

Technical Rationale–Accessibility is required for the Administration Building facilities in accordance with applicable provisions of ICC/ANSI A117.1 and Americans with Disabilities Act.

4.2.3.3.7 Building Envelope

Criteria–Exterior walls shall be composed of cast-in-place concrete, tilt-up concrete panels, precast concrete, or prefinished metal siding as described below.

- Cast-in-place concrete
  - Dry Transfer Facility 1
  - Dry Transfer Facility 2
  - Remediation Building
  - Transporter Receipt Building
  - Surface Aging Facility
- Precast Concrete/Tilt-up Concrete Panels
  - Disposal Container Preparation Building
  - Aging Pads
  - Heavy Equipment Maintenance Facility
  - Site Access Control Building
  - Emergency Operations Center
  - Administration Building
  - Motor Pool/Vehicle Maintenance Building.
- Prefinished Metal Siding
  - Switchgear Building
  - Central Warehouse
  - Central Crafts Shop
  - Low-Level Waste Building

Roof systems shall be prefinished metal or single ply. Metal roofs installed on cast-in-place concrete facilities shall be standing seam. Roof drainage systems with exterior downspouts and overflow scuppers shall be provided for all high roofs over 50 ft above grade. All other facility roofs may be drained by use of exterior scuppers or gutters and downspouts with concrete splash blocks. Roof drainage systems shall be sized to accommodate rainfall criteria per Section 6.1.1.1.

System components including penetrations, flashing, accessories, doors, and windows shall be sealed for air and water infiltration and fire rated where required. Energy conservation design and construction shall be provided per Section 4.2.3.3.5.

Exterior walls shall have fire resistance and opening protection, as required, in accordance with the ICC 2000 (IBC). These IBC requirements include the requirements given in Tables 601 and 602 in addition to those given in Section 704.

Exterior wall, door, louver assemblies, and exterior roof systems shall be designed to withstand wind and wind-driven missile design loads as specified in the MGR Structural Design Criteria on a facility-by-facility basis.

Technical Rationale–The building envelopes are configured according to good architectural and structural practices. They comply with energy conservation and are fire resistant, and resistant to high wind and wind-driven missiles.

4.2.3.3.8 Decontamination, Deactivation, and Decommissioning

Criteria–Interior finishes in areas used for processing or storing radioactive materials and those areas having a possibility of radioactive contamination of wall, ceiling, or floor surfaces shall be non-porous for ease of decontamination per NFPA 801-98, Paragraph 3-8. Special protective coatings shall be used in potentially contaminated areas not provided with stainless steel cladding, areas requiring high durability, or liquid containment areas. Coating type and thickness shall be as determined through analysis on an area-by-area basis.

Technical Rationale–Coating requirements in processing areas or areas where radioactive materials is stored, are non-porous for ease of decontamination.

4.2.3.3.9 Plumbing Fixtures

Criteria–Minimum quantities of plumbing fixtures provided in restrooms, shower areas, and office areas shall be in accordance with the ICC 2000 (IPC). Fixtures include restroom lavatories, water closets, drinking fountains, urinals, showers, service sinks, lunchroom sinks, and health physics lavatories. Number of occupants used for determination of fixture counts shall be as identified in Section 4.2.3.3.1B, "Occupant Load," within this criterion.

Technical Rationale–Minimum quantities of plumbing fixtures are based on previously identified occupancy loads and good engineering practice as provided in ICC 2000 (IBC).

4.2.3.3.10 Security/Access Control

Criteria–Specialty door hardware, windows, surveillance metal detector at entrance of building, and other architectural building features required for MGR facility security shall be addressed and defined during the detailed design phase of the project.

Technical Rationale–The security access/control design features will be provided.

4.2.3.3.11 Penetrations and Seals

Criteria–Design guide requirements responsibilities for penetrations and seals are described in Section 4.8.1.19

Technical Rationale–See Section 4.8.1.19

4.2.3.4 Architectural Material Requirements

4.2.3.4.1 Exterior Walls, Windows, and Louvers

Criteria–Exterior wall and roof system assemblies shall be composed of compatible components of the same manufacturer, where possible. Exterior windows, glass, and glazing shall be selected from manufacturers' standard fabrication and sizes. Exterior metal louver size and construction shall be based on air flow requirements determined by heating, ventilation and air-conditioning (HVAC) and other criteria identified within this document.

A. Concrete Masonry Units

Concrete masonry unit exterior wall construction shall be of medium weight standard block, color, and texture as indicated in Section 4.2.3.3.1A, "Architectural Design Philosophy." Units shall be reinforced, insulated (loose fill insulation), and grout filled in areas requiring wind-driven missile protection.

B. Composite Metal Wall System

The field-assembled composite metal wall panel system shall be provided in locations as described in the typical facility description. The components that make up the composite metal liner panel consist of an exterior metal panel, fiberglass insulation, and interior metal liner panels. Other related system components include flashing, sealant, clips, coping, subgirts, fasteners, panel closure, and gaskets. Minimum R-value for composite wall system shall be R-13.

Exterior panels shall be factory finished, galvanized sheet metal, of color and profiles indicated in Section 4.2.3.3.1A, "Architectural Design Philosophy."

Interior liner panels shall be factory finished, galvanized sheet metal, 24 inches wide flat profile panels with 1-1/2 inch "z" shape subgirts similar to Centria L2-3 or approved equal.

Metal louvers shall be factory finished galvanized sheet metal, 45-degree blades with center baffles and return bend for weather protection and bird screen.

C. Metal Sandwich Wall System

The factory-assembled metal sandwich panel system shall be located on all buildings where noted in the typical facility description. The subcomponents for the metal sandwich panels are similar to the components found on the composite metal wall system. The minimum R-value for exterior wall system shall be R-21.

Exterior panels shall be factory finished, 24 gage galvanized sheet metal, of color and profiles indicated in Section 4.2.3.3.1A, "Architectural Design Philosophy."

Metal louvers shall be factory finished galvanized sheet metal, 45-degree blades with center baffles and return bend for weather protection and bird screen.

D. Entrance Doors, Glass, Glazing, and Exterior Windows

Entry doors shall have insulated glazing and be tempered where required. Window frames shall be thermal break fixed. Glazing shall consist of two lites separated by ½-inch hermetically sealed dehydrated air space, ¼-inch "low E" clear float interior, and ¼-inch tinted exterior similar to PPG "Graylite." Aluminum finish and glazing tint shall be as indicated in Section 4.2.3.3.1A, "Architectural Design Philosophy." Main entry doors to facilities that are accessible to the public shall be storefront type aluminum frames with clear anodized finish.

Exterior windows shall be aluminum frames with clear anodized finish. Main entry doors shall be storefront type aluminum frame with clear anodized finish. Window glazing shall have an exterior lite with a tint similar to PPG "Graylite."

E. Precast Concrete Walls

Information to be provided later.

F. Cast-in-Place Concrete Walls

Information to be provided later.

G. Tilt-up Concrete Panels

Information to be provided later.

Technical Rationale–Architectural material requirements represent good architectural practices in architectural design and configuration.

4.2.3.4.2 Roofing

Criteria–Roof assemblies shall be constructed in accordance with the UL Class B or FM Class I as indicated in the *Guides* that have been identified and are being procured. Roof systems shall use commercial grade materials and consist of compatible components as recommended by the roof manufacturer. Roof application standards shall comply with the guidelines indicated in

Manual, which has been identified and is being procured. Roof insulation for all MGR facilities shall have a minimum resistance value of R-30. Metal roof deck shall comply with FM Class I or UL Class B requirements. Roof access shall be provided to all process building main roofs and other roofs with mechanical equipment by means of ladders, hatches, or stairs complying with OSHA standards. Walkways shall be provided on roofs requiring access and to roof mounted mechanical equipment.

A. Standing Seam Metal Roof System

Main roofs and other roof areas on process facilities above 50 ft shall be a mechanically fastened standing seam metal roof system, minimum ¼-inch per foot slope. System shall include panels, polyisocyanurate rigid insulation, structural deck subpurlins, clips, flashing, roof drain pans, sealant, and accessories providing for a complete system meeting the requirements of this architectural criterion. Roof color shall be neutral as defined in Section 4.2.3.3.1A, "Architectural Design Philosophy."

Manufactured metal buildings shall have metal roof panels, factory finish.

All other roofs shall be single ply roof systems with metal substructure.

B. Metal Roof System

The metal roofing used on all pre-engineered structures listed in the Balance of Facilities scope of work, except the Administration and Access Control buildings, shall consist of roof panels, vinyl scrim fiberglass batt insulation subpurlins, clips, flashing, closure strips, sealant, drainage scuppers or gutters, downspouts, and other related accessories.

C. Single Ply Roof System

Roofing systems for all roof areas that are not indicated above shall be single ply roofing systems. Roof systems include membrane, insulation, vapor barrier, flashing, expansion joints, pedestals and curbs, mechanical equipment curbs, sealant, drainage scuppers or gutters, downspouts, and accessories providing for a complete system meeting the industry standards for roofing applications and the requirements of this architectural criterion.

Single ply roof system shall be a minimum ¼-inch per foot slope consisting of rigid board insulation over metal decking and polyester reinforced thermoplastic polyolefin (TPO) roof ply. Finish color shall be manufacturer's standard gray.

Technical Rationale–The roof systems described represent good architectural practices in architectural design and configuration.

4.2.3.4.3 Doors and Hardware

Criteria–Exterior and interior personnel doors and frames, service doors, and vehicle doors will be provided. Doors for shielding and special doors for operations will be provided by other disciplines.

Exterior door assemblies and roll-up doors including frame shall be designed to withstand wind loads as required in Section 4.2.3.3.7, "Building Envelopes."

Doors and frames for openings in fire-rated barriers shall bear UL and/or FM labels appropriate for each fire-rated wall opening. Design and installation of fire doors shall meet NFPA standards identified in Section 4.8.1.

Doors at ventilation zone boundaries shall have appropriate seals. Pressure equalization devices shall be installed at doors in areas where, under adverse ventilation conditions, normal egress is impaired.

A. Personnel Doors

Exterior doors shall be 1-3/4-inch insulated hollow metal, flush face; 16 gage minimum. Exterior door frames shall be hollow metal steel, 14 gage minimum. Doors shall be provided with lockable entrance hardware, exit or panic hardware where required; weather-stripping, door sweep, threshold, and closer.

Interior doors in operational areas shall be flush face, 1-3/4-inch hollow metal, 18 gage minimum. Doors in office or similar support areas may be solid core wood with wood or laminate veneer. Wire glass vision panels shall be provided where required for visibility. Door frames shall be hollow metal steel, 16 gage minimum. Doors shall be provided with appropriate hardware.

B. Service and Vehicular Doors

Interior overhead coiling service doors shall have interlocking slat roll-up type, top coiling with dust hood, and manual operation. Overhead coiling doors over 100 square ft in area shall be motor operated.

Other overhead coiling service doors and vehicular doors shall be insulated and weather-stripped sliding, overhead sectional, or vertical lift. Overhead coiling doors shall be motorized and designed to specific building seismic and wind requirements identified in Section 4.2.3.3.7, "Building Envelope," and Section 4.2.2, "Structural Design Criteria."

C. Door Hardware

Hardware shall be provided as required for the door function, code, and fire label requirements. Door hardware shall meet ANSI standard which has been identified and is being procured, with brushed chrome finish. Locksets and latchsets for all doors except special doors specified by other disciplines shall have lever handles meeting

ANSI standard, which is being procured. Locksets to be mortise type with removable core. Furnish 6 pin tumbler cylinders with Corbin 59C2-6 keyway for each lockset unless otherwise indicated. Key all locks to match the project master keying system. Hardware shall be UL approved for fire-rated doors.

Technical Rationale–The doors and frames systems described represent good architectural practices in architectural design and configuration.

4.2.3.4.4 Interior Partition Walls

Criteria–Interior partition walls include non-bearing walls consisting of reinforced concrete, reinforced concrete masonry unit, or metal stud with gypsum wallboard construction. Steel studs are C-shaped with punched webs. Walls required for fire barriers shall be UL rated fire-resistive assemblies including penetration protection as required. The UL code has been identified and is being procured.

Partition walls shall either be of 12-inch minimum thickness reinforced concrete construction; 8-inches thick minimum reinforced grout filled concrete masonry units (CMU) or gypsum board on metal studs. Concrete construction shall be used where required for shielding, areas of liquids or bulk materials, or operational durability. Gypsum board walls shall be metal stud with 5/8-inch Type 'X' gypsum board each side, layered as required for fire rating. Gypsum board walls along corridors within process areas shall have hardwood material wainscot to a height needed for moveable equipment protection, 6-foot minimum.

Reinforced concrete masonry unit construction shall be used in bulk materials storage areas and as needed for operational durability.

Full height partition walls with sound insulation shall be provided for computer rooms, reproduction rooms, and around areas separating high noise level areas from occupied areas. Minimum sound isolation requirements for separation of source room from adjacent receiver room are:

- Offices, conference rooms, computer rooms, and restrooms, STC50
- Mechanical room near occupied areas, STC65.

STC (Sound Transmission Class) ratings refer to measurements of specific partition construction for reducing airborne sound according to standard, which has been identified and is being procured.

Technical Rationale–The criteria for interior partition walls is consistent with good engineering practice.

4.2.3.4.5 Flooring

Criteria–Flooring systems include stainless steel liners, special protective coatings, vinyl composition tile, sheet vinyl, ceramic tile, carpet, raised access flooring, and sealed concrete. Where the potential threat of water or liquid damage is possible, floors shall be sloped to a sump or drain.

Decontaminable special protective coatings shall be applied to other process and service floors involving radioactive materials including ventilation areas where contamination classifications are assigned. These special coatings shall extend up the walls to form a base 6 inches high.

Vinyl composition tile with 6-inch rubber base shall be used in lunchrooms, offices, corridors, and other similar spaces where contamination classification is not required.

Sheet vinyl with 6-inch rubber base shall be used in non-contaminated change room area. Ceramic tile floors and wainscot shall be applied in restroom and shower areas, where required.

Chemical resistant floor systems shall be utilized in laboratory areas, as required.

Raised access flooring systems consisting of 24-inch square steel panel modules shall be used in computer areas. Panel finish shall be carpet tile.

Concrete floors with hardener and sealer finish shall be specified in non-radioactive materials usage areas of exposed construction requiring heavy equipment usage such as shops, mechanical and electrical equipment rooms.

Floor finishes shall be rated Class I when tested in accordance with ANSI/NFPA 220-992 and have a critical radiant flux of 0.45 W/sq cm minimum.

The Administration Building shall have carpet with rubber base throughout office, lobbies, and similar areas. Sheet vinyl composition tile with rubber base shall be applied in lunchrooms, workrooms, janitor closets, and similar spaces. Ceramic tile with ceramic tile wainscot shall be used in restrooms.

Technical Rationale–The flooring systems described represent good architectural practices in architectural design and configuration.

4.2.3.4.6 Ceilings

Criteria–Ceilings in non-contaminated areas of occupied facilities including offices, conference rooms, computer rooms, change space rooms, restrooms, and associated lobbies and corridors shall be provided with suspended acoustical lay-in panel system with a 2-foot x 4-foot "Tee" bar grid. Shower areas, and janitor closets shall have painted suspended gypsum board. Finished ceiling heights shall be 9'-0" in offices, corridors, laboratories, and similar areas, 8'-0" in restrooms and shower rooms. Ceiling systems shall be integrated with lighting, partitions, fire sprinklers, HVAC, and related building systems.

All other ceilings in occupied or unoccupied areas shall be exposed construction finished with coatings as described in Section 4.2.3.4.7. These areas include sub-change rooms, storage areas, shops, mechanical and electrical areas, janitor rooms, and similar spaces.

Technical Rationale–The ceiling systems described represent good architectural practices in architectural design and configuration.

4.2.3.4.7 Architectural Finishes

Criteria–Finishes used throughout the MGR facilities shall meet fire-resistive requirements identified in Section 4.2.3.3.4B, "Interior Finishes."

Areas within facilities that contain radioactive materials and processes or have potential of radioactive particulate contamination shall receive special protective coatings selected for the specific area environment. Properties to be considered for Special Protective Coatings (SPCs) are radiation tolerance, chemical resistance (e.g., decontamination process), temperature resistance, flame spread, smoke generation, fire resistance (fireproofing), interior finish (specifically excluding equipment and piping), and potential mechanical abuse. These coatings shall be provided to maintain radioactivity levels from surface contamination, ALARA, and facilitate deactivation and demolition.

In industrial areas without radioactive materials and processes, conventional coatings shall be used to maintain cleanliness and adequate illumination levels for safety and work efficiency.

Offices, conference rooms, corridors, computer rooms, restrooms, and similar spaces shall receive semi-gloss paint finishes or other paint finish, where applicable.

Technical Rationale–The architectural finishes described represent good architectural practices in architectural design and configuration.

4.2.3.4.8 Architectural Specialties

Criteria–Minimum specialties used in MGR facilities shall include visual display boards, projection screens, metal toilet partitions, shower compartments, corner guards, identifying devices, lockers, fire extinguisher cabinets, cubicle curtains, and toilet and bath accessories. Other architectural accessories will be identified during design.

Visual display boards shall be provided in lunchrooms, conference rooms, and other rooms used for meetings. Display boards shall be white dry erase writing surface.

Projection screens shall be provided in main conference rooms. Screens shall be manually operated matte white, or glass bead surface with a 60-inch square screen.

Metal toilet compartments shall be provided at each water closet and urinal screening at each urinal. Toilet compartment shall be baked enamel on steel, floor attached, overhead braced complete with chrome steel hardware and accessories. Urinal screens shall be baked enamel, wall supported, with concealed wall supports and hardware.

Shower compartments shall be provided for each showerhead. Compartments shall include both shower and dressing areas and be baked enamel on steel, floor attached, overhead braced, with integral bench, curtain rod with snap hooks, and heavy plastic curtain. Ceramic tile shower surround may be substituted for metal compartment at shower area. Metal dressing area compartment shall be provided as indicated.

Work clothes storage bins shall be provided in main and sub-change rooms, and laundry storage rooms for the storage of clean work clothing. Bins shall be plastic laminate faces high-density particleboard.

Entry mats shall be provided at the main entrances. Mats shall be recessed with aluminum frame.

Window blinds shall be installed at fixed exterior windows in offices and lunchrooms. Blinds shall be 1-inch horizontal aluminum louvered with full tilt and lift.

Technical Rationale–The fixed equipment described represent good architectural practices in architectural design and configuration.

4.2.3.4.10 Conveying Equipment

Criteria–Conveying equipment includes personnel elevators, freight elevators, and dumb waiters. Size of conveying equipment shall be determined on a facility basis depending on need and function including dimensions and load requirements.

Technical Rationale–As stated, conveying equipment shall be determined on a facility need basis.

4.2.3.4.11 Plumbing Fixtures

Criteria–Plumbing fixtures include water closets, urinals, restroom lavatories, showers, service sinks, lunchroom sinks, health physics lavatory, and electric water coolers, emergency eyewash and shower stations are provided by other disciplines.

Water closets shall be of the wall hung type, with elongated vitreous china bowl, molded composition split seat, with water closet support carrier and automatic flush valves operation (1.6 gallons per flush). Pipe chases shall be sized to provide installation of piping, carriers, and insulation material, if required.

Urinals shall be wall hung type, with vitreous china bowl with support carrier and automatic operated flush valve (1 gallon per flush).

Restroom lavatories shall be wall hung type, vitreous china bowl with splash lips, and front overflow, complete with anti-scald faucet (2.2 gallons per minute maximum) and provisions for soap dispenser.

Showers shall be single occupancy with a 32-inch square stone textured floor receptor with concealed water supply, drainage, and vent piping. Walls and floors may be of ceramic tile in lieu of metal cubicle and textured stone floor pan as indicated in Section 4.2.3.4.8, "Architectural Specialties." Single lever type shower valves (2.5 gallons per minute maximum) with anti-scald mixer and vandal proof showerheads shall be provided.

Service sinks shall be wall hung type, acid resisting enameled cast iron with wall hanger to suit. Faucet shall be service type with integral bucket hook and hose connection.

Corner guards shall be provided at each gypsum wall board constructed corridor corner within the facilities and other areas that operations will use moveable carts or equipment. Guards are not required at corridors within office type areas. Guards shall resist impacts of a minimum 25.4 ft-lb./in^2, Izod test, per standard, which has been identified and is being procured, and be 6 foot in length, minimum.

Identifying devices shall be provided throughout the MGR complex facilities. Signage in accordance with Americans with Disabilities Act includes main entry signs, emergency exit signs, area identification signs, room signs, emergency exit signs, and main directory sign.

Lockers and benches shall be provided in change rooms. Lockers shall be 12-inches wide x 15-inches deep single tier metal with sloping top. Benches shall be 12-inch wide x 1-1/4-inch thick wood (type of wood and species to be indicated in specification) with 18-inch high steel pedestals.

Fire extinguisher cabinets shall be provided throughout the MGR facilities in quantities and locations required by standard to be provided later. Cabinets shall be semi-recessed or surface mount, 20-gage metal, and 12-inches wide x 27-inches high x 7-1/2-inch diameter inside dimension.

Cubicle curtains shall be provided in personnel decontamination rooms for personnel privacy. Curtain assemblies shall be 8 ft-3-inches by 8 ft 3-inches "L" shaped with 12-inch radius corner and include surface mounted aluminum cubicle track, metal bead chain and hook assembly with nylon axle, 5-1/2 ounce per square yard fire retardant cotton cloth curtain. Use flame spread/smoke index rating.

Toilet and bath accessories shall be provided in each restroom, shower room, and janitor closet. Accessories shall have a satin chrome steel finish and include paper towel dispensers, lavatory mirrors, liquid soap dispensers, sanitary napkin dispenser, toilet seat cover dispensers, sanitary napkin disposals, robe hooks, and mop holders.

Technical Rationale–The architectural specialties described represent good architectural practices in architectural design and configuration.

4.2.3.4.9 Fixed Equipment

Criteria–Fixed equipment includes general casework and countertops, laboratory casework and worktops, laboratory storage casework, work clothes storage bins, main entry mats, and exterior window blinds.

General casework shall be installed in lunchrooms, workrooms, health physics rooms, and other similar spaces. Casework shall include lower and upper cabinetry, countertops, and splashes. Casework shall be plastic laminate faces high-density particleboard with 4-inch splash.

Laboratory casework and storage units shall be installed in all laboratories. Fume hoods are provided by other disciplines. Casework shall include lower and upper cabinetry and worktops with integral splash. Casework shall be steel construction with plastic epoxy resin worktop and 6-inch splash. Cabinet doors shall be hinged, with steel-framed glass.

Double bowl lunchroom sinks with appropriate fixtures shall be provided in each lunchroom. Faucets shall be 2.2 gallons per minute maximum.

Each health physics personnel decontamination room shall be provided with a single bowl stainless steel lavatory with ¼ turn wrist blade type fixtures (2.2 gallons per minute maximum).

Electric water coolers shall be wall mounted with adjustable stream regulator. Water coolers shall comply with ICC/ANSI A117.1-1998, and implementing regulations, which have been identified and are being procured.

Technical Rationale–The plumbing fixtures described represent good architectural practices in architectural design and configuration.

Table 4.2.3-1. Stair and Ladder Design Requirements

Stair and Ladder Description	NFPA 101-2000 Life Safety Code	29 CFR 1910
1. *Stairs*: providing fire egress from all areas except equipment platforms	Section 7.2.2, Stairs, including Table 7.2.2.2.1(a), New Stairs	N/A
2. *Stairs*: at industrial equipment access walkways and platforms which serve as a means of egress component from adjacent spaces serving not more than 20 people	Section 40.2.5.6 including Table 40.2.5.6, Equipment Access Dimensional Criteria	N/A
3. *Stairs*: at operating platforms which do not serve as a means of egress component and require routine access to equipment, or daily access where there is exposure to personnel to harmful substances, or where carrying tools/equipment by hand is normally required	N/A	Section 1910.24, Fixed Industrial Stairs, including Table D-1
4. *Ladders*: allowed at operating/equipment platforms at elevated tanks, towers, and similar structures, overhead traveling cranes, etc., where the use of fixed ladders is common practices	N/A	Section 1910.24 (description), and Section 1910.27, Fixed Ladders
5. *Ladders and Alternating Tread Devices*: allowed at elevated platforms around machinery not falling under previous descriptions with an occupancy of less than 3 persons as determined by NFPA 101-000, Section 28-1.7, Occupant Load, Exception	Section 7.2.9, Fire Escape Ladders, and Section 7.2.11, Alternating Tread Devices	N/A

4.2.3.4.12 Lighting

Lighting criteria to be provided later

4.2.4 Subsurface Structural Design Criteria

4.2.4.1 Subsurface Structural Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5].
Civil/Structural/ Architectural	Structural*	ICC 2000 (IBC), AISC 1989, AISC 1995, AISC 1997, AISC S341-999, ANSI/AISC N690-1994, ACI 318-02/318 R02, ACI 349-01, ASCE 4-98, AWS D1.1/D1.1M:2002, ASTM A36/A 36M -01, ASTM A307-00, ASTM A325-02, ASTM A490-00, ASTM A615/A 615M-01b, ASTM A706/A 706M-01
		RG 1.61 Rev 0
		10 CFR 63, 29 CFR 1910, 29 CFR 1926
		NUREG 0800 1987 (NRC 1987)
		DOE STD-1020-2002

Technical Rationale:

1 This codes and standards support compliance with requirements of Project Requirements Document (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21 (c)(2)), PRD-022 and *Emplacement Drift System Description Document* (BSC 2002f). Determination of applicable sections of this document will be determined during the design process and in development of design products.

2 This Regulatory Guide has been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guide will be determined during the design process and in development of design products that are impacted by these Regulatory Guides. Addressing these Regulatory Guides supports compliance with requirements in Emplacement Drift System Description Document (BSC 2002f).

3 Addressing Code of Federal Regulations supports compliance with requirements in Emplacement Drift System Description Document (BSC 2002f) and PRD-015/P-015, PRD-015/P-020, PRD-015/P-021 and PRD-005.

4 This NUREG provide guidance on acceptable methods and approaches that could be utilized in MGR design.

5 Addressing the DOE Standard supports compliance with requirements of PRD-018/P-019. Determination of applicable sections of this DOE Standard will be determined during the design process and in development of design products.

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.2.4.2 Site Information

4.2.4.2.1 General

The Yucca Mountain Project site is located in Nye County, State of Nevada, approximately 100 miles northwest of the city of Las Vegas.

4.2.4.2.2 Rock Properties

Rock properties will be addressed later.

4.2.4.2.3 Seismology

Criteria–Yucca Mountain site-specific acceleration time histories and associated acceleration response spectra, will be developed at the repository elevation and at the rock surface above repository elevation, in the three orthogonal directions (2 horizontal and 1 vertical) for three seismic ground motion hazard levels with annual probability of exceedance of 1×10^{-3} (1,000-year return period), 5×10^{-4} (2,000-year return period) and 1×10^{-4} (10,000-year return period).

Technical Rationale–The Yucca Mountain Project is committed to using site specific ground motion.

4.2.4.2.4 Groundwater

Criteria–Groundwater is not anticipated to be encountered during the tunnel boring and shaft sinking operations. The water table is estimated to be 450 to 1,150 ft below the repository horizon. Although local and perched water may be encountered, conditions in the drifts and shafts are generally expected to be dry.

Technical Rationale–Water table is determined based on site investigations and *Soils Report for North Portal Area, Yucca Mountain Project* 100-00C-WRP0-00100-000-000 (BSC 2002u).

4.2.4.3 Seismic Categorization of Structures, Systems and Components

Criteria–SSCs are classified into two main categories, depending on their function during and after a seismic event. Those SSCs whose failure or malfunction during a seismic event could directly or indirectly result in a condition adversely affecting public safety, or whose failure would result in consequences in excess of dose exposure limits as specified in 10 CFR 63, are classified as SSCs Important to Safety and shall be designed to withstand the effects of earthquake without the loss of capability to perform their safety functions. SSCs Important to Safety are those that are important to nuclear safety and/or waste isolation. SSCs Important to Safety for the seismic design basis, are further categorized as Frequency Category 1 (FC-1), Frequency Category 1A (FC-1A) and Frequency Category 2 (FC-2) and shall be designed for the ground motions corresponding to 1,000-year, 2,000-year and 10,000-year return periods respectively. These categories are summarized in Table 4.2.4-1. Those SSCs not categorized as Important to Safety are categorized as Conventional Quality (CQ). Conventional Quality SSCs that are located at the surface above repository elevation shall be designed for the ground accelerations in accordance with its Seismic Use Groups as classified in ICC 2000 (IBC) and are summarized in Table 4.2.4-2. Conventional Quality SSCs that are located at the repository elevation shall be designed for the site specific ground motions corresponding to 2000-year return period.

Table 4.2.4-1. Seismic Frequency Categories of SSCs Important to Safety

Frequency Category	Earthquake (Annual Probability of Exceedance)	Earthquake (Return Period)	Applicability
FC-2	1×10^{-4}	10,000-year	SSCs Important to Safety as defined by the Preclosure Safety Analysis to meet dose exposure limits. SSCs are designed to governing codes and allowed limited inelastic behavior without the loss of function.
FC-1A	5×10^{-4}	2,000-year	SSCs Important to Safety as defined by the Preclosure Safety Analysis to meet dose exposure limits. SSCs are designed to governing codes to remain within the elastic limit. Provides additional strength to assure functionality during $1x10^{-4}$ seismic event.
FC-1	1×10^{-3}	1,000-year	SSCs Important to Safety as defined by the Preclosure Safety Analysis to meet dose exposure limits. SSCs are designed to governing codes to remain within the elastic limit.

Table 4.2.4-2. Seismic Use Group of SSCs Designed to IBC (ICC 2000)

Seismic Use Group	Importance Factor I	Nature of Occupancy
III	1.5	SSCs Containing Toxic, Explosive and Hazardous Materials.
II	1.25	SSCs that represent substantial Hazard to Human Life. (Example: Heavy Equipment Maintenance Facility)
I	1.0	SSCs except those listed in Use Group II and III. (Example: Normal Occupancy less than 300 People)

Seismic design basis for the various SSCs is as shown in Table 4.2.4-3.

Table 4.2.4-3. Seismic Design Basis for SSCs

SSC	Seismic Design Basis*
Invert Steel Structure in Emplacement Drifts	FC-1A
Ground Support Steel Sets in Emplacement Drifts	FC-1A
Ground Support Steel Sets in Access and Exhaust Mains	CQ (2,000 year)
Isolation Barriers, Steel Bulkheads and Doors in Main Drifts (Access and Ventilation)	CQ (2,000 year)
Invert Structure in Access and Exhaust Mains	CQ (2,000 year)
Muck Handling Facilities, Structures and Supports	CQ (2,000 year)
Steel Platforms and Walkways at repository elevation	CQ (2,000 year)
Supports for Utility Lines	CQ (2,000 year)
Shaft Liners and Collars	CQ (2,000 year)
Ventilation System Supports	CQ (2,000 year)
Transfer Dock, Invert and Air Locks in Turnouts	CQ (2,000 year)
South Portal Structures and Foundations	IBC Use Group II
Misc. Structures and Foundation Pads, Closures, etc. at rock surface above repository elevation	IBC Use Group II

* These seismic design bases will be checked with the results of Preclosure Safety Analysis.

Table 4.2.4-4 provides a summary of the structural design codes and standards that apply to different seismic category SSCs.

Table 4.2.4-4. Applicability of Design Codes and Standards to Seismic Categories

Title	Applicability	Quality Level SSCs	Conventional Quality SSCs
ICC-2000 International Building Code	Seismic Design		X
ASCE 4-98 Seismic Analysis of Safety-Related Structures	Seismic Analysis	X	
ACI 349-01 Code Requirements for Nuclear Safety-Related Concrete Structures	Design of Concrete Structures	X	
ACI 318-02/318R02 Building Code Requirements for Structural Concrete	Design of Concrete Structures		X
ANSI/AISC N690-1994 Steel Safety-Related Structures for Design, Fabrication and Erection	Design of Structural Steel	X	
AISC-1995 Manual of Steel Construction, Load and Resistance Factor Design	Design of Structural Steel	X	X
AISC-1997 Manual of Steel Construction, Allowable Stress Design	Design of Structural Steel	X	X
AISC S341-1997 Seismic Provisions for Structural Steel Buildings	Seismic Detailing of Structural Steel (Part III)	X	X

Technical Rationale–For SSCs that are important to safety, the seismic categorization is in accordance with site specific seismic ground motion. For conventional quality SSCs, seismic categorization is in accordance with industry standards.

4.2.4.4 Materials

Criteria–The use of materials in the emplacement drifts shall be limited to steel, and crushed ballast. Any other materials shall not be allowed for use until appropriate testing and modeling work is done with respect to potential impacts on postclosure performance. Materials other than those specified above may be used in the non-emplacement drifts.

Technical Rationale–The use of materials was recommended in *Emplacement Drift Invert-Low Steel Evaluation*, CRWMS 2000d.

4.2.4.4.1 Structural Steel

Criteria–Structural steel for the invert structure and ground support steel sets shall conform to, standards which have been identified and are being procured, corrosion resistant, high-strength, low-alloy steel.

Platforms, bulkheads and miscellaneous steel shall conform to ASTM A36/A 36M-01 carbon steel, with a minimum yield stress of 36 ksi, unless special conditions exist requiring the use of higher strength and/or corrosion resistant material.

Structural bolts shall conform to ASTM A325-02 or ASTM A490-02. Bolts for the platform and stairs may conform to ASTM A307-00. Structural connections shall be Bearing Type connections, except where slip critical connections are essential. Size of bolts for the structural connections should be limited to 7/8" in diameter and for the miscellaneous platforms and stairs should be limited to 5/8 in. in diameter.

Welding electrode shall conform to Table 3.1 of the AWS D1.1/D1.1M:2002.

Technical Rationale–Structural steel in emplacement drifts is subjected to corrosive environment and, therefore, corrosion resistant material is recommended. Outside emplacement drifts industry standard materials are used.

4.2.4.4.2 Concrete and Reinforcing Steel

Criteria–Reinforced concrete structures are not used in the emplacement drifts. Concrete structures used in non-emplacement areas shall conform to the following material properties:

- Concrete compressive strength (f'c), based on 28 days strength shall be 4,000 psi minimum.
- Reinforcing steel shall be deformed bars conforming to ASTM A615/A615M-01b or ASTM A706/A706M-01, Grade 60 with a minimum yield stress of 60,000 psi.

Technical Rationale–Concrete and reinforcing materials are selected to conform with the industry standards.

4.2.4.4.3 Non-Shrink Grout

Criteria–Non-shrink grout where used shall be based on type K cement using silica fume, super plasticizer and admixtures.

Technical Rationale–Grout mix is selected to minimize its impact on the performance of the waste packages.

4.2.4.4.4 Ballast

Criteria–The ballast material for the emplacement drift invert shall be crushed tuff generated from the tunnel boring machine excavations. The ballast material shall be well graded ranging from 2 inches to No. 200 sieve style size (with 1.0% as maximum material passing). The ballast material shall be compacted to provide a minimum density of 90 percent of the maximum dry density. The ballast material shall be free from impurities, oil leaks and organic materials.

Technical Rationale–Ballast material is selected because of its compatibility with the host rock and provides a cost-effective alternative.

4.2.4.5 Environment and Corrosion Effects

The emplacement drifts are subject to the following environment.

4.2.4.5.1 Temperature

Criteria–High temperature in the emplacement drifts is caused by heat output generated by the waste packages. Peak temperature in the emplacement drifts during the preclosure period is expected to be less than 205°F at the end of emplacement of the last waste package.

Technical Rationale–Peak temperature in emplacement drafts is provided in N.H. Williams 2002a.

4.2.4.5.2 Relative Humidity

Criteria–Relative humidity in the emplacement drifts will range from 3 percent to 35 percent during the preclosure period. Continuous ventilation will be provided during this period. Forced ventilation will be provided during the first 50 years following start of waste emplacement, followed by natural ventilation for the remaining period.

Technical Rationale–Relative humidity in emplacement drifts is based on BSC 2001a (CAL-SVS-HV-000003, Rev 00).

4.2.4.5.3 Radiation

Criteria–Structural steel will be exposed to ionizing radiation from spent nuclear fuel in the form of beta particles, neutrons and high and low energy photons (gamma and x-rays). Neutron radiation is a primary concern since it is able to penetrate through the ground support steel sets and invert steel. However, cumulative neutron dose is too small to cause any appreciable mechanical damage to the structural steel and grouted anchor bolts over the preclosure period. *Longevity of Emplacement Drift Ground Support Materials*, BSC 2001c. Gamma and beta radiation are not known to produce any effects on structural steel. Glasstone, S. and Sesonske, A., *Nuclear Reactor Engineering, 1981.*

Technical Rationale–Radiation exposure to the steel and grout material is evaluated by the Nuclear group.

4.2.4.5.4 Biological

Criteria–In the repository environment, many different microbes could grow and provide a plethora of potential chemical processes that may effect bulk chemistry within the emplacement drift construction materials. However, during the preclosure period, the emplacement drifts are expected to be dry and low in relative humidity of no greater that 40 percent. The potential microbiological impact on steel material will be insignificant below relative humidity of 90 percent.

Technical Rationale–Microbiological impact on the mechanical properties of the materials used in emplacement drifts are evaluated in *Corrosion Evaluation of Steel Ground Support Components*, BSC 2003c.

4.2.4.5.5 Groundwater Chemistry

Criteria–Percolation rate for the water is expected to be small. The pH of seepage water is expected to be near neutral (DTN: LL020805523125.002). However, based on the planned use of grout, the pH of seepage could be as great as 13 (DTN: LB0302DSCPTHCS.002). Accumulation of biofilms due to microbial growth and the active corrosion of emplaced steel and alloys could result with localized chemistry on introduced components to pH as low as 3 CRWMS M&O 2000b (ANL-EBS-MD-000038, Rev 00, ICN 1; BSC 2001b (ANL-EBS-MD-000037, Rev 01). These effects result in the overall pH of the water to range of 3 to 13. Design consideration for construction materials, should be evaluated for these drift conditions.

Technical Rationale–The expected range of pH of the groundwater due to the planned use of grout and due to the dissolution of waste form and potential microbial growth is quantified.

4.2.4.5.5.1 Corrosion Effects

Criteria–Steel corrosion in mines is usually caused by sulfuric acid that results from the oxidation of sulfide phases. This type of aggressive corrosion is not expected to be present in the emplacement drifts since no sulfides have been observed in the repository host formation. Dry oxidation and humid-air conditions in the emplacement drifts will not contribute significantly to the corrosion rate. Aqueous corrosion is not expected to occur during preclosure period because of low relative humidity. However, due to the low relative humidity expected in the preclosure drift environment, any seepage entering into the drift would tend to evaporate. Salt brines are generated from local groundwater due to the evaporative concentration of chlorides and bromides. The presence of these brines can cause rapid corrosion that needs to be evaluated in the selection and design for the invert and ground support steels. Also, materials used in the repository should be resistant to microbial induced corrosion in a subsurface environment. The thickness of steel invert section shall be increased by 1/16 inch beyond what is required structurally to allow for material degradation due to potential corrosion during the preclosure period in emplacement drifts.

Technical Rationale–Factors that might effect corrosion in emplacement drifts are identified in *Corrosion Evaluation of Steel Ground Support Components*, BSC 2003c, and hence a corrosion allowance is provided.

4.2.4.6 Design Loads

SSCs shall be designed for the following loads.

4.2.4.6.1 Dead Loads (D)

Dead loads are those loads that remain permanently in place and include the weight of framing, permanent equipment and all attachments.

4.2.4.6.2 Live Loads (L and L_o)

Criteria–Live loads (L) are those loads that are superimposed by the use and occupancy of the building or structure. Minimum live loads used for the design shall not be less than the following:

Platforms, Walkways and Stairs

Uniform live load	------	100 psf
Concentrated load	------	1,000 lbs.

These loads are concurrent. Concentrated load shall be applied to maximize moment and shear.

Construction loads for the Steel Invert Structure ----- 500 psf.

Live load (L_o) is defined as the live load expected to be present during an earthquake event. L_o equal to 25 percent of the minimum uniform design live loads, as specified above may be used.

Technical Rationale–Recommended live loads and construction loads are based on the industry standard and construction experiences.

4.2.4.6.3 Seismic Loads (E)

Criteria–Seismic loads for the SSCs Important to Safety shall be computed based on the Equivalent Static Load Method in accordance with the requirements of NUREG-0800 (NRC 1987), Section 3.7.2 (Ref. 3.2.3). To obtain an equivalent static load in the horizontal and the vertical direction, a factor of 1.5 shall be applied to the respective peak acceleration of the applicable response spectra, using appropriate damping value for the structure or component. Damping values as expressed in terms of the percent of critical damping are shown on the following table:

Table 4.2.4-5. Damping Values

Structure or Component	Damping Value
Welded Steel Structures	4 percent
Bolted Steel Structures	7 percent
Reinforced Concrete Structures	7 percent

Alternatively, a dynamic analysis, e.g., time history method or response spectrum method should be used when the use of the equivalent static load method can not be justified. Analysis shall account for effects of soil-structure interaction. Torsional effects shall be included.

For the total seismic response, responses from the three orthogonal components of earthquake motion shall be combined by taking either the square root of the sum of the squares of the maximum codirectional responses caused by each of the three components of earthquake motion (SRSS Methods) or the Component Factor Method (1.0+0.4+0.4) (ASCE 4-98). Each component factor represents codirectional responses from the two horizontal and the vertical seismic motion.

In addition, steel invert structure connected to the subsurface emplacement drift walls will undergo structural deformations that are imposed and controlled by the tunnel deformations caused by the seismic ground motion. Such actions are termed deformation-controlled, which shall be evaluated and accounted for in the design of steel inverts in emplacement drifts.

Seismic loads for the structures and components designated as Conventional Quality (CQ), that are located at the surface above the repository elevation, shall be computed in accordance with the requirement of the International Building Code (ICC 2000). For Conventional Quality SSCs that are located at the repository elevation, the seismic loads shall be computed using the site specific ground accelerations corresponding to 2000-year return period.

Technical Rationale–Method for determining seismic loads for the surface SSCs that are important to safety or waste isolation are provided based on the requirements of NUREG-0800 (NRC 1987), Section 3.7.2. Guidelines for the seismic response for the underground structures are based on industry practices. ICC 2000 (IBC) does not provide any guideline for computing seismic loads for the underground structures.

4.2.4.6.4 Gantry Crane Loads (CL)

Criteria–Gantry crane supplier's information shall be used for the crane weight, wheel loads and lifted loads for the design of crane rails and supporting structural steel beams. Impact allowances shall be in accordance with Sections A4.2 and A4.3 of the AISC 1989. The weight of the unloaded crane shall be considered simultaneously with the seismic loads. The horizontal and vertical inertia forces shall be obtained by multiplying the weight of the crane by the appropriate accelerations.

Technical Rationale–Crane load guidelines are provided according to AISC 1989.

4.2.4.6.5 Waste Package Loads

Criteria–Waste package characteristics and the maximum loaded weights of the various commercial spent nuclear fuels (CSNF) from the commercial nuclear power plants and the defense high level waste (DHLW) are provided by the Analysis and Component Design group. For steel invert design, the maximum weight of the largest waste package shall be used. The estimated maximum weight of the pallet, supporting the largest waste package is also provided by the Analysis and Component Design group.

Technical Rationale–Maximum waste package and supporting pallet loads are needed for the design of the steel invert. The loads are provided by the A&CD group.

4.2.4.6.6 Drip Shield Loads

Criteria–Drip shields in the emplacement drifts are planned to protect the waste packages from the rock fall and the water intrusion during the postclosure period of 10,000 years. Drip shields will be installed after the completion of emplacement of all waste packages and prior to closure.

Drip shield loads shall be provided by the Analysis and Component Design group. No back-fill is anticipated for the postclosure period. However, back-fill option shall not be precluded.

Technical Rationale–Drip shield loads are needed for the design of the steel invert. It is provided by the Analysis and Component Design group.

4.2.4.6.7 Ventilation Pressure Loads (P)

Criteria–Isolation barriers, steel bulkheads, and doors shall be designed for the ventilation differential pressure load, in addition to the dead and seismic loads. Maximum ventilation differential pressure shall be equivalent to the potential maximum primary fan pressure transmitted when the barrier and bulkhead doors are closed.

Technical Rationale–Maximum ventilation differential pressure is needed to design the barriers, bulkheads and doors and is provided by the HVAC group.

4.2.4.6.8 Temperature Loads (T)

Criteria–The design of SSCs shall include the effects of variations in temperatures. Peak temperature in the emplacement drifts is not expected to exceed 205 degrees Fahrenheit. The design temperature for the structural steel shall be 205 degrees Fahrenheit. Expansion joints shall be provided in the longitudinal members of the steel invert and the rails, in emplacement drifts.

Technical Rationale–Peak temperature in emplacement drifts is provided in Section 4.2.4.5.1 of this document.

4.2.4.7 Load Combinations and Stress Allowables

Notations:

D = Dead Loads
L = Live Loads
Lo = Live Loads present during an Earthquake
E = Seismic Loads
CL = Gantry Crane Loads
WP = Waste Package Loads
DS = Drip Shield Loads
P = Ventilation Pressure Differential Loads
T = Temperature Loads

4.2.4.7.1 Steel Structures

Criteria–Invert steel structures in the emplacement drifts shall be designed in accordance with the following load combinations, as applicable and shall conform to the requirements of ANSI/AISC N690-1994. These load combinations meet the intent of the requirements of NUREG-0800 (NRC 1987), Section 3.8.4:

$$S = D + CL + L + P$$
$$S = D + CL + L + P + T$$
$$S = D + WP + DS + L + P$$
$$S = D + WP + DS + L + P + T$$
$$1.6S = D + CL + Lo + P + E$$
$$1.6S = D + CL + Lo + P + T + E$$
$$1.6S = D + WP + DS + Lo + P + E$$
$$1.6S = D + WP + DS + Lo + P + T + E$$

The following load combinations shall be used for design of members in shear and for design of bolted connections:

$$1.4S = D + CL + Lo + P + E$$
$$1.4S = D + CL + Lo + P + T + E$$
$$1.4S = D + WP + DS + Lo + P + E$$
$$1.4S = D + WP + DS + Lo + P + T + E$$

S = Allowable stress as permitted by ANSI/AISC N690-1994 specification.

NOTE: Seismic load E is equivalent to safe shutdown earthquake (SSE) as defined in ANSI/AISC N690-1994.

Ground support steel sets if required, shall be designed for the loads as furnished by the Geotechnical group.

Steel structures and components designated as Conventional Quality (CQ) shall be designed in accordance with the following load combinations of ICC 2000 (IBC) Section 1605.3.2 and conform to the requirements of AISC Allowable Stress Design (ASD) method:

$$S = D + L$$
$$S = D + L + P + T$$
$$S = D + L + 0.7E$$
$$S = D + L + P + T + 0.7E$$
$$S = D + 0.7E$$

S = Allowable stress as permitted by AISC (ASD) method.

Alternatively, steel structures designated as Conventional Quality (CQ) may also be designed by the AISC 1989 Load and Resistance Factor Design (LRFD) method with appropriate load factors and stress allowables.

Technical Rationale–The design load combinations listed for the steel structures in emplacement drifts that are important to safety and/or waste isolation are based on

AISC N690-1994 and meet the intent of the requirements of NUREG-0800 (NRC 1987), Section 3.8.4. Steel structures that are not important to safety are based on AISC Allowable Stress Design method which are in conformance with the industry practice.

4.2.4.7.2 Concrete Structures

Criteria–Concrete structures are not expected to be used in the emplacement drifts. Concrete structures where used in the non-emplacement areas are designated as CQ and shall be designed in accordance with the following load combinations, conforming to the requirements of ICC 2000 (IBC):

U = 1.2D + 1.6L
U = 1.2D + 1.2T + 1.6L
U = 1.2D + 1.0L + 1.0E
U = 1.2D + 1.2T + 1.0L + 1.0E
U = 0.9D + 1.0E
U = Required strength per ICC 2000 (IBC).

NOTE: Above load combinations are not applicable to concrete liners and shaft collar designs.

Technical Rationale–The design load combinations listed for the concrete structures that may be used in the non-emplacement area are based on ICC 2000 (IBC). These structures are classified as Conventional Quality and it is an industry practice to design them in accordance with the ICC 2000 (IBC).

4.2.4.7.3 Foundation Design

Criteria–Foundation design for the SSCs designated as Important to Safety, shall be in accordance with the requirements of NUREG-0800 (NRC 1987), Section 3.8.5. Foundation design for the SSCs designated, as CQ, shall be in accordance with the requirements of Chapter 18 of ICC 2000 (IBC).

Technical Rationale–Foundations that are important to safety are required to be designed in accordance with the requirements of NUREG-0800 (NRC 1987), Section 3.8.5. Other foundations are designed to ICC 2000 (IBC).

4.2.4.8 Rock Anchors

Criteria–Materials, design and installation of rock anchors shall be in accordance and consistent with the design criteria and specification as developed by the Geotechnical Group for their use in ground support system.

Technical Rationale–Rock anchors if used are to be consistent with the technical requirements that are adopted for the rock anchors that will be used for the ground supports.

4.2.4.9 Constructability

Criteria–Logistics of handling, transporting and installing materials within the confined space of waste emplacement drift is of prime importance. Modular fabrication of steel invert in panels, consisting of the following assemblies are planned:

- Longitudinal and transverse support beams with attached base plates
- Runway beams with cap plates or structural channels and stiffened brackets.

Suitable lengths of these panels will have to be determined. These panels are to be attached by bolting.

Technical Rationale–Constructibility requirements are provided to ease the installation of the steel invert in emplacement drifts.

4.3 ELECTRICAL DESIGN CRITERIA

4.3.0.1 System Design Criteria

Criteria–The system shall maintain the power factor at the utility interface at a level greater than 0.85.

Technical Rationale–This criteria is required to define the minimum power factor at the utility interface. Normally, the power factor is provided by the utility company because it is important for system performance. It is desirable to have a higher power factor. It is also important for utility to recover their cost in transmission line loss and to minimize the transmission loss. Power factor of 0.85 is reasonable since it indicates that the system is performing well and it is not too difficult for the user to comply. The power factor for all transmission lines are different and all electrical applications in various areas of the MGR are different. The over-all average of 0.85 at interface point is a reasonable number for all concerned parties to accept.

Criteria–The YMP power systems shall be divided into normal, standby, and ITS power systems. The uninterruptible, and DC power sources shall be included for uninterruptible power and control functions.

Technical Rationale–This criteria is required to define the power distribution subsystems.

Criteria–The facility normal power supply voltages shall be 12.47 kV, 4.16 kV, 480/277 V, and 208/120 V, 3 phase, 60 Hz for AC system. The DC battery system voltage shall be 125 V.

Technical Rationale–This criteria is required to define the plant application voltages, in compliance with IEEE Std 141-1993. These voltages are most commonly used in the industry in the United States for medium and low voltage systems. The electrical equipment is most readily available in these voltages. Their performances have long been proven. The medium voltage 12.47 kV is currently used in the existing system at the site, therefore, it is selected over 13.8 kV system for the sake of service continuity.

Criteria–The DC power system shall be used for medium voltage switchgear control, as needed.

Technical Rationale–This criteria is required to define the plant medium voltage switchgear control voltage, for the service continuity capability. The DC power will be available even during plant blackout. Therefore, the critical circuit breaker control capability is secured.

Criteria–All facility electrical loads shall be designated as either group A or group B. Each group receives power from one of two main switchgears A and B. The loads shall be distributed as much as possible to achieve balance between the two main switchgears.

Technical Rationale–This criteria is required to avoid a common mode failure or minimize the effects of failure of one load group. The redundant power system for the "important to safety" loads will achieve the nuclear safety goal. Division of the loads can also facilitate maintenance and increase availability of the plant loads.

Criteria–All electrical equipment, raceways, and cables of the YMP Facility shall be given unique identification numbers, except for lighting, communications, cathodic protection, fire protection and grounding systems.

Technical Rationale–This criteria is required to facilitate the safety, correct installation and operation, and easiness of inventory and maintenance.

Criteria–Transformers shall be liquid-filled for outdoor service and dry-type for indoor service.

Technical Rationale–This criteria is required for increasing the outdoor transformer efficiency and minimize the potential fire hazards which can be caused by indoor transformers.

Criteria–The transformers for outdoor installation shall be 12.47 kV to 4.16 kV and 12.47 kV to 480 V, 3-phase, 60 Hz, with no-load manually operated taps. The primary side shall be delta connected, secondary side shall be wye connected and the neutral resistance grounded for 4.16 kV secondary and solid grounded for 480 V secondary.

Technical Rationale–This criteria is required to standardize design for safe operation. The neutral resistance grounding in the medium voltage system will minimize the fault current for human safety. The solid neutral grounding for low voltage system will facilitate quick clearing of fault. The delta-wye connection will minimize grounding fault effects and minimize harmonics in the system.

Criteria–The medium voltage switchgears shall be rated at 12.47 kV or 4.16 kV, 3-phase, 60 Hz. The switchgears shall be rated to withstand the maximum short-circuit current available in the system.

Technical Rationale–This criteria is required to define the system operation voltages and to standardize design. The maximum short-circuit current withstanding capability is required for protection of personnel safety, equipment and system protection.

Criteria–Lighting and instrumentation transformers shall be dry type. The primary shall be delta connected and secondary shall be wye connected and neutral solidly grounded (480/277 V or 208/120V). Single phase lighting transformer of 480-240/120 V can also be used as required.

Technical Rationale–This criteria is required to standardize design for safe operation. It will minimize fire hazards by not using oil-filled transformer, and minimize harmonics in the system.

Criteria–The 480 V load center (switchgear) shall be used to provide power to the downstream motor control centers and motors larger than 150 hp up to 300 hp, and static loads up to 400 kW.

Technical Rationale–This criteria is required to define the role of 480 V load center and safe operation of medium size 480V motors and other static loads. This is the common accepted industry practice. This practice will minimize the stress in electrical equipment. This will enable equipment long-term operation.

Criteria–The 480 V motor control center (MCC) shall be used to provide AC power to induction motors and other loads rated 150 hp or below but above 1/3 hp, and miscellaneous branch circuits. Static (resistive) loads up to 240 kW can be served from MCCs.

Technical Rationale–This criteria is required to define the role of 480 V MCC and safe operation of low integral or fractional size motors and other static loads. This is the common accepted industry practice. This practice will facilitate easy installation and easy replacement of motors or static loads.

Criteria–In general, AC motors shall be squirrel-cage, induction type, suitable for operation from the following supplies:

Motor Size	Utilization Voltage	System Supply
1/3 hp and smaller	115 V	120 V, 1-phase, 60 Hz
1/2 hp to 300 hp	460 V	480 V, 3-phase, 60 Hz
300 hp to 4,000hp	4 kV	4.16 kV, 3-phase, 60 Hz
4,000 hp and above	11.5 kV	12.47 kV, 3-phase, 60 Hz

Technical Rationale–This criteria is required to define the motor application voltages for safe operation. This is commonly accepted industry practice and listed in IEEE Std. 141-1993 and ANSI Std. C84.1-1995.

Criteria–The motors used for outdoor installation or in the hazard location shall be either totally enclosed fan-cooled (TEFC), totally enclosed non-ventilated (TENV), or weather-protected, type II (WP II).

Technical Rationale–This criteria is required to ensure that the motor is protected from weather or chemical hazards.

Criteria–Adjusted speed drive shall be used where it is required to control speed of the driven mechanical equipment.

Technical Rationale–This criteria is required because some mechanical equipment requires variable speeds for operation, or requires large torque to start rotation.

Criteria–The DC battery system shall be 125 VDC nominal voltage. The battery system shall be designed for a long life and low maintenance requirements. Battery shall be sized for a minimum of 1 hour and 30 minutes discharge time without re-charging per NFPA 70-2002 (Article 700-12). The DC power system shall be backed-up by diesel generators.

Technical Rationale–This criteria is required to define the DC system voltage. The voltage is most commonly used in the industry. The performance and reliability are superior. Since the acid used in battery and the generated hydrogen gas pose as health and fire hazards, battery with long life and low maintenance type shall be required. The minimum battery discharge time is required to assure a continuous power supply during a utility power blackout. This is critical for a safe facility operation and shut down by providing sufficient backup power.

Criteria–Uninterruptible Power Supply (UPS) shall be provided to supply critical power of acceptable quality, without delay or transient during a power interruption, to important monitoring and control loads that can not tolerate a power interruption. Important computer system shall also be supplied by UPS.

Technical Rationale–This criteria is required per IEEE Std 446-1995, Emergency and Standby Power System for Industrial and Commercial Applications. This system is also of critical importance to nuclear safety.

Criteria–The uninterruptible power supply (UPS) system for plant control and instrumentation applications shall be supplied by 480 V AC power and the output shall be 208/120 V, 3-phase, 60 Hz. The UPS battery banks shall be sized to provide full UPS rated load for a minimum of 1 hour and 30 minutes.

Technical Rationale–This criteria is required to define the UPS system voltage. The voltage is most commonly used in the industry. The performance and reliability are superior. The minimum continuous UPS operating time is required to assure a nuclear safety for facility operation or shutdown during a utility power blackout. The requirement of providing uninterruptible power is also indicated in NFPA 70-2002.

Criteria–The standby diesel generators shall be rated 12.47 kV and the important to safety (ITS) diesel generators shall be rated 4.16 kV, 3-phase and 60 Hz, Y connected. Upon loss of off-site power, the diesel generator shall be automatically started and ready to accept loads within 30 seconds.

Technical Rationale–This criteria is required for the optimum system design. The amount of standby power required during loss of offsite power is expected to be in several megawatts. That amount will require a 12.47 kV generator to support. Since the scope of ITS equipment or system will be kept to a minimum, the ITS diesel generator can be rated at a lower voltage.

Criteria–The system design shall provide a 30 percent margin to accommodate future load growth.

Technical Rationale–This criteria is needed to ensure that the electrical system is designed with sufficient margin for the future. The value of 30 percent is based on engineering judgement derived from standard engineering practice regarding system margins. The 30 percent value is applied in addition to the system loads defined during the final design.

Criteria–The system shall regulate the utilization voltage to +10/-10 percent.

Technical Rationale–This criteria is needed to define the utilization voltage limits for the end item equipment. This voltage drop limit is for normal operations because a momentary voltage drop will occur for the starting of large motors. IEEE Std. 141-1993, IEEE Recommended Practice for Electrical Power Distribution for Industrial Plants and ANSI C84.1-1995, Electric Power Systems and Requirements, identify a range of +/-10 percent. The voltage range is +10/-10 percent. By NEMA Standards, the electrical equipment are made to perform well within +10/-10 percent of rated voltage

4.3.0.2 Lighting System

Criteria–Lighting systems shall be in accordance with ANSI/IES-RP-7-1991 and code which has been identified and is being procured. It will consist of the Normal and Emergency Lighting Systems. The normal lighting shall include general lighting, exterior lighting, subsurface lighting, site and area lighting. The emergency lighting shall include egress lighting, emergency operating lighting, essential lighting, exit lighting, and safeguard and security lighting.

Technical Rationale–This criteria is required for providing sufficient illumination for all areas in the Facility in all operation modes.

Criteria–The system shall provide the minimum facility lighting for the areas defined in the following table.

Table 4.3-1. Facility Illumination Levels

Facility Areas	Illumination Levels
Ramps, Main Tunnels	10 foot-candles
Alcoves, Ventilation Shafts, Drifts Construction	10 foot-candles
Shops, BOP Buildings	30 foot-candles
Office, Laboratories, Waste Processing Area facilities	50 foot-candles

NOTE: These illumination levels will be revised later and based on ANSI/IES-RP-7-1991.

Technical Rationale–This criteria is required to define the lighting requirements for the surface and subsurface facilities to support the conduct of operations. The lighting table values for illumination are based on 29 CFR 1926.56(a), Table D-3, but will be revised based on ANSI/IES-RP-7-1991

4.3.0.3 Cable

Criteria–The 15 kV and 5 kV power cable shall be single conductor or triplexed Class B stranded copper conductor, 133 percent insulation level and rated for continuous operation at 90 degree Celsius, 130 degree Celsius for emergency overload operation and 250 degree Celsius for short circuit conditions in accordance with applicable standards that have been identified and are being procured.

Technical Rationale–This criteria is required to assure the quality of cables to be satisfactory for normal and emergency applications. It is based on standard that has been identified and is being procured.

Criteria–The power, lighting, motor feeder and control cables shall be single conductor or multi-conductors, copper, rated 600 V, 75 degree Celsius. Conductor shall be hard drawn copper. All power and control wiring shall be standard copper flame-retardant moisture and heat-resistant or heat-resistant thermoplastic insulated 75 degree Celsius.

Technical Rationale–This criteria is required to assure the quality of cables for YMP application. These are the most common and reliable cables, which satisfy standards, which have been identified and are being procured.

Criteria–Power cables of size #2/0 and larger shall be single conductor or triplexed. Cables for lighting circuits shall be single conductor, solid copper. Cable insulation and jacket material shall be resistant to heat, moisture, impact, radiation (where required) and ozone.

Technical Rationale–This criteria is required to assure the quality of cables for YMP application. These are the most common and reliable cables, which satisfy standards to be provided later. Cables installed near radiation need to be protected for long-term performance.

Criteria–All lighting and receptacle panel branch circuits shall have a maximum of three circuits sharing a common neutral for single-phase loads. Where non-linear loads have been identified, the neutral shall be sized accordingly.

Technical Rationale–This criteria is required to limit the ground fault current passing a neutral conductor, for protection of integrity of the circuit. This is in accordance with the requirements of NFPA 70-2002 (Article 250).

Criteria–Instrument cables shall be single-pair, triad-twisted, and shielded or multi-pair with shielded pair and overall shield and drain wire, unless supplied by the instrument vendor.

Technical Rationale–This criteria is required to shield off noise to the transmitted signal in the cable in order to prevent instrument malfunction due to the noises in the instrumentation cable.

Criteria–All instrument cable shall be fire-resistant. All instrument wiring shall be stranded. Fiber optic cable and field-bus shall be used for most data network, voice and video communication.

Technical Rationale–This criteria is required to assure the satisfactory performance of cables with the state-of-art technologies. This will ensure integrity of instrumentation system function.

Criteria–Bulk cable insulation and jacket material used shall be of the low flammability type.

Technical Rationale–This criteria is required to protect cables from failure due to fire or heat.

Criteria–The minimum size of conductor shall be as follows (not including cabling integral to components):

Duty	Minimum Conductor Size (AWG)
Power and Lighting	12
Current transformer Wiring	10
Control Circuits (120 VAC/125 VDC) and Instrument Power circuits	14
Instrumentation - Single pair cable	18
Instrumentation - Multi-pair cable	20

Technical Rationale–This criteria is required to ensure that the cables are not over-loaded.

Criteria–Control cables shall be multi-conductor, color coded in accordance with the ICEA standard method.

Technical Rationale–This criteria is required to comply with standards to be provided later.

4.3.0.4 Grounding System

Criteria–The system shall provide ground-fault detection and relaying to automatically de-energize any high voltage system component that has developed a ground fault for circuits that are 1,000 volts or higher.

Technical Rationale–This criteria is needed to address ground-fault relaying and circuit de-energization. This criteria supports 29 CFR 1910.304(f)(7)(ii)(C) and 29 CFR 1926.404(f)(11)(ii)(C).

Criteria–A ground grid shall be furnished in the Facility area to provide for personnel safety and to facilitate for systems, structures, and equipment grounding.

Technical Rationale–This criteria is required to protect the safety of site personnel and general public personnel in the area during a system fault (short circuit), a lightning strike, or a system voltage surge. It will also prevent equipment failure and mitigate damages to system, structure and component. This requirement is in compliance with IEEE Std 142-1991.

Criteria–The ground grid shall be designed to limit touch and step potentials to safe values under the calculated ground fault conditions. The grounding conductors shall be of sufficient size to carry the maximum available ground fault current.

Technical Rationale–This criteria is required for the personnel safety, equipment and structure protection, based on the procedures and recommendations of IEEE Std 142-1991 and requirements in NFPA 70-2002.

Criteria–The main ground grid shall be made of bare copper no smaller than No. 4/0 American Wire Gauge (AWG), buried below the earth surface at no less than two and a half ft deep. Rods used for grounding electrodes shall be made of copper.

Technical Rationale–This criteria is required for the personnel safety and equipment protection, based on the procedures and recommendations of IEEE Std 142-1991 and requirements of NFPA 70-2002.

Criteria–Electrical equipment, building steel, and metal components likely to become energized under abnormal conditions shall be effectively grounded by direct or indirect connection to the building ground grid that connects to the main ground grid. Ground plates shall be located for multiple grounding runs from single location. Columns and beams shall be connected to the facility ground grid.

Technical Rationale–This criteria is required for the personnel safety and equipment protection, based on the procedures and recommendations of IEEE Std 142-1991 and requirements of NFPA 70-2002.

Criteria–Instrument signal and computer systems shall be provided with a low impedance isolated ground system. This system shall be connected at a test point for periodic check. The grid impedance shall be maintained at less than five ohms. The isolated ground shall be a radial system without loops connected to the main grid at a single point. Separate isolated ground terminals (buses) shall be provided for the equipment to be connected.

Technical Rationale–This criteria is required for the operational integrity of instruments and computer system. The voltage surges in the main power ground grid will propagate to instrument circuit if a path is realized. Damaging voltage ripples in instrumentation circuit will disable instrument function.

Criteria–Plant power system grounding shall be based on the following criteria:

- 12.47 kV system. This system shall be grounded through a resistor to limit damaging ground fault current to a value adequate for relay operation (low resistance grounding).
- 4.16 kV system. This system shall be grounded through a resistor to limit damaging ground fault current to a value adequate for relay operation (low resistance grounding).
- 480Y/277 V system. The system neutral point shall be solidly grounded to the ground grid.
- 208Y/120 V (including UPS). The system neutral point shall be solidly grounded to the ground grid.
- 240/120 V, 1 phase. Solidly grounded.
- 125 V DC. Ungrounded.
- Instrumentation and signal. Separate ground grid. Connected at one point of electrical main ground grid.

Technical Rationale–This criteria is required for the personnel safety and equipment protection, based on the procedures and recommendations of IEEE Std.142-1991 and requirements of NFPA 70-2002.

Criteria–All underground connections shall be made by thermo-welding process or a ANSI/UL 467-1998 listed compression type connection approved for this application. Exposed connections and taps shall be made with pressure-type connectors.

Technical Rationale–This criteria is required because the thermo-weld connection in underground is a better selection for prevention of corrosion. For exposed application, pressure type connection costs less and it is easier to install or replace.

Criteria–Cable trays shall be grounded at both ends and individual tray sections shall be connected together for ground continuity.

Technical Rationale–This criteria is required to secure the path continuity for ground fault current.

Criteria–All motors shall be grounded through the grounding conductor enclosed in the power cable, or a ground wire run with the power circuit in conduit, to the ground bus in the MCC and/or switchgear.

Technical Rationale–This criteria is required for the personnel safety and equipment protection, based on the procedures and recommendations of IEEE Std 142-1991 and requirements of NFPA 70-2002.

4.3.0.5 Lightning Protection

Criteria–Electrical equipment and power lines shall be protected where necessary with lightning arresters and surge capacitors.

Technical Rationale–This criteria is required for the personnel safety and equipment protection.

Criteria–Lightning protection shall be installed for all buildings and high structures in accordance with the recommendations of NFPA 780-2001. The protection system shall consist of air terminals bussed together and connected by down conductors to the facility main ground grid.

Technical Rationale–This criteria is required for the personnel safety and equipment protection, based on the procedures and recommendations of NFPA 780-2001.

4.3.0.6 Cathodic Protection

Criteria–Cathodic Protection System shall be provided for underground metal piping systems, and water and fuel oil tanks in contact with soil.

Technical Rationale–Cathodic Protection System is provided for prevention of underground metal corrosion. This is for prevention of metal tank or piping premature failure. Using impressed current cathodic protection equipment and sacrificial anode equipment will maintain negative potential in the underground metal, prevent or slow down the corrosion process.

4.3.0.7 Heat Tracing

Criteria–Electrical heat tracing (freeze protection) shall be provided for liquid filled piping and instrument sensing lines that are subject to freezing. The system shall be operable when subject to an outdoor temperature range of minus 30 degree F to plus 115 degree F. Selection of the heat tracing turn on and turn off temperature shall be based on the fluid properties and of the pipe insulation characteristics.

Technical Rationale–This criteria is required to assure the continuous facility normal operation even in the freezing weather. This can only be achieved by preventing freezing of liquid-filled piping and instrumentation sensing lines.

Criteria–The heat tracing cable supply voltage shall be 120 VAC or 240 VAC, 1-phase, 60 Hz. The incoming power shall be 480 VAC, 3-phase, 60 Hz at the primary side of heat tracing power distribution transformer.

Technical Rationale–This criteria is required to assign the application voltages to the heat tracing system. This is the most commonly accepted system in the industry.

Criteria–The normal power shall be used to supply heat tracing system except where a standby power or emergency power is required.

Technical Rationale–This criteria is required to minimize unnecessary loading of diesel generators.

Criteria–In heat tracing circuit, ground leakage protection shall be employed and be configured to provide both local and remote indication of a ground fault.

Technical Rationale–This criteria is required for the safety operation of the system by detecting ground leak early. The detection will enable prevention of larger fault. This is based on NFPA 70-2002. This is the industry common practice.

4.3.0.8 Raceway Grouping

Criteria–Redundant ITS cables and raceways shall be separated in accordance with the principles defined in IEEE Std 384-1992, which may include routing via separate fire areas.

Technical Rationale–This criteria is required because physical separation requirements for ITS electrical cabling shall be compliant with the general principles defined in IEEE Std 384-1992.

Criteria–Cable raceways shall be physically separated in accordance with the function and voltage class of the cables, as follows:

- 15 kV cables

- 5 kV cables
- Low voltage power AC and DC-600 V cables
- High-level signal and control or discrete on/off control cables (120 V AC, 125 V DC)
- ITS Controls
- Cables for general instrumentation (that is, low-level analog and digital signals, data communication, etc.)
- Fire Detection

Technical Rationale–Physical separation of electrical raceways are required to prevent common mode failure of a cabling system for preventing a complete failure of an ITS SSCs. This is in accordance to requirements listed in IEEE Std 384-1992 and RG 1.75 Rev 2.

4.3.0.9 Raceway System

Criteria–Depending on ways of exposure, raceways are divided into two major classes; exposed systems and embedded systems. Exposed systems shall utilize cable tray or conduit, arranged in a main distribution pattern branching out to serve individual equipment or devices. Embedded systems shall consist of conduit embedded in building floors (including trench), walls, and in underground duct banks.

Technical Rationale–This criteria is required for mechanical protection of cables. This is the common practice in industry. In-floor trenches and cable pits can be used as required as special cases.

Criteria–Cables shall be routed in conduit or in cable trays with conduit dropouts to the individual equipment and devices. Underground duct banks shall be used between facilities and outlying structures.

Technical Rationale–This is the common practice in industry for protection of cables.

Criteria–Cable runs to remote area through uneven surface areas shall be by overhead lines.

Technical Rationale–This criteria is required for cost effective and practical way to route cables to remote areas.

Criteria–A raceway designated for a single class of cables shall contain only cables of the same class. Cable trays containing low voltage instrumentation cables with very low current control signals shall provide protection against spurious signal sources.

Technical Rationale–This criteria is required to prevent interference between different classes of cables. This is the common practice in industry. Protection of instrumentation cables is for prevention of equipment malfunctions due to noises mixed in normal signal.

Criteria-Only metallic type cable trays shall be used. Instrumentation trays shall have solid bottoms and covers. Tray lengths shall be provided as necessary to fit the design situation with the tray widths and heights as listed below.

- 12 in. wide by 4 in. high.
- 18 in. wide by 4 in. high.
- 24 in. wide by 4 in. high.
- 30 in. wide by 4 in. high.
- 36 in. wide by 4 in. high.

Technical Rationale-This criteria is required to standardize cable tray types. The metal type tray will serve as the partial ground fault return path for protection of personnel and equipment. This is the common practice in industry.

Criteria-The distance between cable tray supports shall not exceed 10 ft. Design of seismic supports where required and seismic zone classification shall be reviewed and approved by the Civil, Structural, and Architectural (CS&A) group.

Technical Rationale-This criteria is required to protect the integrity of cable tray system during seismic event. This is normally required in a nuclear facility.

Criteria-In general, for areas using vertically stacked trays, the highest voltage cables shall occupy the highest position in the stack. Low voltage power cables in vertically stacked trays shall be located below medium voltage power cables. Control cables shall be located below low voltage power trays and low voltage analog and digital communication cables or fiber optic cables located below control cable trays.

Technical Rationale-This criteria is required because the higher voltage cables are more prone to start a fire. In case of a fire, generated heat will flow above. This practice will prevent damaging lower voltage cables in case of fire generated in higher voltage cable trays. This is the common practice in industry.

Criteria-Cable rated at 300 V may be routed in the same raceway and share the same enclosures (boxes) as 600 V cable, provided the maximum applied voltage of the 600 V cable does not exceed 300 V.

Technical Rationale-This criteria is required to prevent the mixing of 120 V low power or control circuit cables with 600V class power cables. Very low voltage power cables and control circuit cables are rated 300 V or below. This is the common practice in industry. (Although both 300 V and 600 V cables belong to low voltage class, 600 V cables normally carry higher amount of power).

Criteria-For variable speed drive systems using pulse width modulated voltage, the cable from the drive to the motor shall be routed separately from power supply feeds, as the pulse width modulation (PWM) voltage may cause coupling onto the feeders.

Technical Rationale-This criteria is required to prevent malfunction of affected system.

Criteria–Conduit for power, lighting, instrumentation, and all indoor exposed conduit shall be rigid, galvanized steel. Lighting may use electrical metal tubing (EMT) for concealed work in non-hazardous areas, such as offices and control rooms. Generally, PVC Conduit shall be used for underground duct banks, except PVC-coated RGS shall be used under heavy traffic areas.

Technical Rationale–This is the common practice in industry for a reliable and long lasting raceway installation.

4.3.0.10 Duct Banks and Manholes

Criteria–For underground installation, concrete encased underground duct banks and manhole systems shall be installed throughout the site for the pulling and protection of power, control, and instrumentation cables. Twenty percent conduit spare capacity shall be provided for underground duct banks.

Technical Rationale–This criteria is required to facilitate the cable routing between buildings or facilities. This is a common practice in industry for a reliable power distribution system. Overhead distribution lines are minimized to prevent interference with above ground activities.

Criteria–The cables between the YMP main switchgear building in 230 kV and 138 kV switchyard and each stand alone building shall be installed in the underground duct bank system. The exceptions are power distribution lines from main switchgear building to Balance of Plant area, other portal areas, and other remote areas as required.

Technical Rationale–This criteria is required to optimize between cost and system integrity. This is the common practice in industry for a reliable power distribution system. Overhead distribution lines are minimized to prevent interference with above ground activities. The exceptions are where the land is not flat and duct bank installation is not practical.

Criteria–Manholes and pull points shall be used as required to facilitate cable pulling and inspection. Their sizes and locations shall depend on associated duct banks, type and sizes of the cables to be installed, and shall be shown on the layout drawings. The maximum distance between manholes and pull points shall be as allowed by the NFPA 70-2002. Manholes and pull points shall be provided with appropriate drainage. Copper grounding pad shall be provided in each manhole. The pad shall be connected back to main ground grid by AWG 4/0 copper cable.

Technical Rationale–This criteria is required to facilitate cable-pulling activities. Grounding provision is for the protection of personnel and equipment. This is the common practice in industry for a reliable manhole installation.

4.3.0.11 Cable Segregation

Criteria–Cable trains for load groups A and B shall be routed in separate raceways. Where space will not facilitate this separation, non-ITS load group A and B can be routed in the same tray, using suitable barriers for separation.

Technical Rationale–Physical separation two train cables are required to prevent common mode failure of a cabling system for preventing a complete failure of an ITS SSCs. This is in accordance to requirements listed in IEEE Std 384-1992 and RG 1.75 Rev 2.

Criteria–For ITS circuits, the cable and raceway segregation principles of IEEE Std 384-1992 shall be incorporated. Cabling for redundant ITS power and control circuits shall be routed in separate trays or conduits and may be required to be routed in separate fire zones.

Technical Rationale–Physical separation of two train cables are required to prevent common mode failure of a cabling system for preventing a complete failure of an ITS SSCs. This is in accordance to requirements listed in IEEE Std 384-1992 and RG 1.75 Rev 2.

4.3.1 Emergency Electrical Power Design Criteria

4.3.1.1 Emergency Electrical Power Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5].
Electrical	Emergency Electrical Power*	IEEE Std 308-2001, IEEE Std 384-1992, IEEE Std 741-1997, IEEE Std 446-1995 , IEEE Std 484-1996, IEEE Std 485-1997, IEEE Std 323-1983, IEEE Std 379-1994, IEEE Std 387-1995, IEEE Std 946-1992, NFPA 801-1998
		RG 1.32 Rev 2, RG 1.75 Rev 2
		10 CFR 50.49
		None
		DOE Order O 420.1 Change 3, DOE G 420.1-1 2000

Technical Rationale:

[1] These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21 (c)(2)), PRD-022 and *Emergency Electrical Power System Description Document* (BSC 2002b). Determination of applicable sections of these documents will be determined during the design process and in development of design products.

[2] These Regulatory Guides have been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guides will be determined during the design process and in development of design products that are impacted by these Regulatory Guides. Addressing these Regulatory Guides supports compliance with requirements in *Emergency Electrical Power System Description Document* (BSC 2002b).

[3] Addressing CFRs supports compliance with requirements in *Emergency Electrical Power System Description Document* (BSC 2002b) and PRD-015/P-015, PRD-015/P-020, PRD-015/P-021 and PRD-005.

[4] None

[5] Addressing these DOE Orders supports compliance with requirements of PRD-016/P-019. Determination of applicable sections of this DOE Order will be determined during the design process and in development of design products.

*Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.3.2 Switchyard and Transmission Design Criteria

4.3.2.1 Switchyard and Transmission Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5].
Electrical	Switchyard & Transmission*	ANSI/IEEE Std 80-1986 (reaffirmed 1991), NFPA 70-2002
		None
		None
		None
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21 (c)(2)) and PRD-022. Determination of applicable sections of these documents will be determined during the design process and in development of design products.

[2] None

[3] None

[4] None

[5] None

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.3.2.2 Switchyard and Transmission Design Criteria

Criteria–The switchyard shall be used to receive power via 230 kV and 138 kV overhead transmission lines from the utility power company and NTS power loop.

Technical Rationale–This criteria is required to define the entry point of utility power transmission lines.

Criteria–The switchyard shall be fenced and the access gate shall be locked to limit the access to only qualified workers.

Technical Rationale–This criteria is required to protect the safety of non-job-related personnel, as required in the NFPA 70-2002.

Criteria–The 230 kV and 138 kV power at switchyard shall be stepped down to 12.47 kV by means of step-down transformers located in the switchyard.

Technical Rationale–This criteria is required to define the application voltage of the Facility.

Criteria–The 230 -12.47 kV step down transformer shall be the primary main transformer. It shall supply all plant loads normally. The 138-12.47 kV step down transformer shall be the standby main transformer. It shall supply all plant loads when the primary main transformer is not available.

Technical Rationale–This criteria is required to define the roles of two main step down transformers.

Criteria–The 12.47 kV power shall be connected to the main switchgears in the switchgear building via underground duct banks or overhead non-segregated phase bus.

Technical Rationale–This criteria is required to define the method of power line connection.

4.3.3 Normal Electrical Power Design Criteria

4.3.3.1 Normal Electrical Power Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5].
Electrical	Normal Electrical Power*	IEEE Std C2-2002, IEEE Std C37.0101-1999, ANSI C84.1-1995, ANSI/IES-RP-7-1991, ANSI/IEEE Std 80-1986, IEEE Std 141-1993, IEEE Std 142-1991, IEEE Std 242-2001, IEEE Std 399-1997, IEEE Std 739-1995, IEEE Std 446-1995, IEEE Std 1202-1991, NFPA 1-2000, NFPA 70-2002, NFPA 780-2000, NEMA PB 1-1990, NEMA MG1-1998, NEMA MG10-1994, NEMA WC 8-1988, ANSI/UL 467-1998
		RG 5.44 Rev 3
		29 CFR 1910, 29 CFR 1926
		None
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21(c)(2)), PRD-022 and *Emergency Electrical Power System Description Document* (BSC 2002b). Determination of applicable sections of these documents will be determined during the design process and in development of design products.

[2] These Regulatory Guides have been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guides will be determined during the design process and in development of design products that are impacted by these Regulatory Guides.

[3] Addressing Code of Federal Regulations supports compliance with requirements in PRD-015/P-020 and PRD-015/P-021. Determination of applicable sections of these documents will be determined during the design process and in development of design products.

[4] None

[5] None

*Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.3.4 Safeguards and Security Design Criteria

4.3.4.1 Safeguards and Security Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5].
Electrical	Safeguards and Security*	ANSI/HFS-100-1988, ANSI/IES-RP-7-1991, ICC/ANSI A117.1-1998, UL 437-2000, UL 768-1999
		RG 5.7, Rev 1, RG 5.12 Rev 0, RG 5.44 Rev 3, RG 5.65 Rev 0
		29 CFR 1910, 29 CFR 1926, 10 CFR 73
		None
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21(c)(2)) and PRD-022. *Determination of applicable sections of these documents will be determined during the design process and in* development of design products.

[2] These Regulatory Guides have been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guides will be determined during the design process and in development of design products that are impacted by these Regulatory Guides.

[3] Addressing Code of Federal Regulations supports compliance with requirements in PRD-015/P-020 and PRD-015/P-021. *Determination of applicable sections of these documents will be determined during the* design process and in development of design products.

[4] None

[5] None

*Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.3.4.2 Safeguards and Security Design Criteria

Criteria–Site physical barriers, building and perimeter surveillance systems and cameras, intrusion detection devices, intrusion alarms, access control system, hazardous material tracking system, and radiological safety and control systems shall be provided.

Technical Rationale–This criteria is required to define the scope of safeguard and security system for the plant security, general and facility personnel.

Criteria–Access to the buildings that make up the YMP facility shall be via automatic turnstiles actuated by individual passes under the supervision of a single building access control system. The access control system shall have the capability of granting or denying access at all points on an individual basis. The system shall record locations of personnel for the purposes of roll call following an incident. Access to this information shall be provided at the relevant security points.

Technical Rationale–This criteria is required to define the access control equipment.

Criteria–The facility shall be provided with a Safeguard and Security Room facility, separate from the Central Control Room (CCR), which will house the Central Alarm Station (CAS). The SSR facility shall have substantial penetration resisting walls, doors, ceilings and floor. The interior of the CAS shall not be visible from outside the protected area. The CAS shall monitor and assess system surveillance, detection, access/egress, and all other security alarm functions.

Technical Rationale–This criteria is required to monitor all functions of the safeguard and security requirements of the MGR facility.

Criteria–To provide system redundancy, the facility shall be provided with a Secondary Alarm Station (SAS) which shall be located inside the protected area and close to the facility access point. The SAS shall monitor and alarm the same security alarming functions provided by the CAS, and shall be provided with the same physical construction attributes.

Technical Rationale–This criteria is required to provide redundancy to the Central Alarm Station.

4.3.5 Electrical Support Design Criteria

4.3.5.1 Electrical Support Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Electrical	Electrical Support*	IEEE C2-2002, ANSI C84.1-1995, IEEE Std 141-1993, IEEE Std 142-1991, IEEE Std 242-01, IEEE Std 446-1995, IEEE Std 739-1995, IES-1987 (Kaufman, et al.), IEEE Std 1202-1991, NFPA 1-2000, NFPA 70-2002, NFPA 780-2001, ANSI/IES-RP-7-1991, ANSI/NEMA 250-1997, ANSI/UL 467-1998
		None
		29 CFR 1910, 29 CFR 1926
		None
		DOE Order 420.1

Technical Rationale:

[1] These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21(c)(2)) and PRD-022. Determination of applicable sections of these documents will be determined during the design process and in development of design products.

[2] None

[3] Addressing Code of Federal Regulations supports compliance with requirements in PRD-015/P-020 and PRD-015/P-021. Determination of applicable sections of these documents will be determined during the design process and in development of design products.

[4] None.

[5] Addressing this DOE Order supports compliance with requirements of PRD-018/P-019. Determination of applicable sections of this DOE Order will be determined during the design process and in development of design products.

*Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.3.6 Communication Design Criteria

4.3.6.1 Communication Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Electrical	Communications*	TIA/EIA Telecommunications Building Wiring Standards; (TIA/EIA-568-1, TIA/EIA-568-2, TIA/EIA-568-3), ANSI/ANS-57.9-1992, IEEE Std 802.3ae-2002, NFPA 70-2002, NFPA 75-1999,
		RG 1.29 Rev 3, RG 1.118 Rev 3, RG 1.180 Rev 0
		None
		None
		None

Technical Rationale:

[1] This codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21 (c)(2)) and PRD-022. Determination of applicable sections of this document will be determined during the design process and in development of design products.

[2] These Regulatory Guides have been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guides will be determined during the design process and in development of design products that are impacted by these Regulatory Guides.

[3] None.

[4] None

[5] None

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.3.6.2 Central Communications Room

Criteria–The surface and subsurface areas shall have the capability to communicate via a common Central Communications Room (CCR) located on the surface.

Technical Rationale–A surface located CCR is provided to house various communications Structures, Systems, or Components (SSCs) and serve as a primary interface point with other systems to provide fully integrated operations.

4.3.6.3 Public Address System

Criteria–The Public Address (PA) system shall be designed to broadcast emergency notifications, announcements, and information over a hard-wired system. The PA system shall include amplifiers, microphones/handsets, loudspeaker units, and may provide visual area warning and message lights.

Technical Rationale–A PA system is provided to broadcast emergency notifications, announcements, and information throughout selected buildings and areas to assist with the day-to-day management and operation of the Monitored Geologic Repository (MGR). Visual area warning and message lights may be required in high-noise areas.

4.3.6.4 Surface Telephone System

Criteria–The MGR subsurface telephone system shall be designed to provide voice communications between various subsurface areas. Acoustical booths, loud ringers, and/or visual signaling devices shall be provided in high-noise areas. A communications link between the surface and subsurface telephone systems shall be provided

Technical Rationale–A subsurface telephone system is provided to establish voice communications between the surface and subsurface to assist with the day-to-day management and operation of the MGR.

4.3.6.5 Radio Communications

Criteria–Radio communications with the surface and subsurface areas shall be provided via wireless radio frequency (RF) and other similar technologies.

Technical Rationale–A radio transmission system is provided to allow communications throughout the MGR to assist with day-to-day management and operation.

4.3.6.6 Closed Circuit Television System

Criteria–Closed Circuit Television (CCTV) cameras shall be located to give optimum viewing angles to support MGR operations. Monitors shall be provided at various surface and subsurface locations to provide local or remote monitoring capabilities.

Technical Rationale–A CCTV system is provided for remote viewing of equipment and operations within surface and subsurface areas. Camera control features (e.g. pan, tilt, zoom, etc.) are selectable at any location where an operator requires a variable view to assist in operations.

4.3.6.7 System Architecture

Criteria–The communications system shall have an open, non-proprietary architecture.

Technical Rationale–An open, non-proprietary system architecture will avoid potential technology obsolescence, as well as allow the PA, telephone, radio, and CCTV systems to be integrated together (if required).

4.3.6.8 System Hardware

Criteria–The communications system shall have spare installed capacity and space for future growth and expansion.

Technical Rationale–The MGR will be constructed in phases. Spare installed capacity and space for future growth and expansion is required to support MGR operations as additional phases are added.

Criteria–The communications system shall be comprised of modular components to allow provisions for future upgrades, refurbishment, or replacement.

Technical Rationale–Communications SSCs will be modular in order to permit online replacement and maintenance.

Criteria–Various portions of the communications system shall be designed with radiation hardened and environmentally qualified SSCs.

Technical Rationale–Various communications SSCs will be located in high radiation or demanding environmental locations. Radiation hardened and environmentally qualified SSCs susceptible to radiation and various environmental elements can withstand and operate in the environment in which that SSC is installed.

4.3.6.9 System Power

Criteria–The communications system shall receive normal and UPS power from the Electrical Power System.

Technical Rationale–The communications system shall be capable of performing its intended functions during loss of normal power by relying on the UPS.

4.3.6.10 Interface with Other Systems

Criteria–The communications system shall interface with other waste management systems via an open, non-proprietary network protocol.

Technical Rationale–The communications system will interface with other waste management systems to provide for the necessary data exchange between their elements.

4.4 FABRICATION AND MATERIALS DESIGN CRITERIA

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5].
Materials and Fabrication Technology	Fabrication and Materials*	ANSI N14.6-1993, ANSI/AISC N690-1994, ANSI/ANS-55.1-1992, ANSI/ANS-55.6-1993, ANSI/ANS-57.1-1992, ANSI/ANS-57.7-1998, ANSI/ANS-57.9-1992, AWS D1.1/D1.1M-2002, ASME AG-1-1997, ASME N509-1989, ASME NOG-1-2002, ASTM C 1217-00, CMAA-70-2000, CMAA-74-2000, ICC-2000 (IBC)
		RG 1.71 Rev 0, RG 1.143 Rev 2, RG 3.28 Rev 0, RG 3.29 Rev 0, RG 3.60 Rev 0
		None
		None
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21 (c)(2)) and PRD-022. Determination of applicable sections of these documents will be determined during the design process and in development of design products.

[2] These Regulatory Guides have been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guides will be determined during the design process and in development of design products that are impacted by these Regulatory Guides.

[3] None

[4] None

[5] None

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.5 GEOTECHNICAL DESIGN CRITERIA

4.5.1 Geotechnical Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Geotechnical	Geotechnical *	ICC-2000 (IBC), ACI 209R-92, ACI 223-98, ACI 318/318R-02, ACI 349-01, ACI 506.2-95, ACI 506R-90, AISC 1997, ASTM A 36/A 36M-01, ASTM A 572/A 572M-01, ASTM A185-01, ASTM A820-01, ASTM C 1240-01, ASTM C 150-02, ASTM C 494/C 494M-99a, ASTM C 845-96, ASTM E 136-99, ASTM F 432-95, MIL-STD-1472E-1996, UCRL-15673 (Bongarra et al. 1985)
		RG 1.28 Rev 3
		29 CFR 1910, 29 CFR 1926
		None
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21(c)(2)) and PRD-022. Determination of applicable sections of these documents will be determined during the design process and in development of design products.

[2] These Regulatory Guides have been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guides will be determined during the design process and in development of design products that are impacted by these Regulatory Guides.

[3] Addressing Code of Federal Regulations supports compliance with requirements in PRD-015/P-020 and PRD-015/P-021. Determination of applicable sections of these documents will be determined during the design process and in development of design products.

[4] None

[5] None

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.5.2 Geotechnical Design Criteria

4.5.2.1 Functional and Performance Criteria

Criteria–The ground control system shall be designed to maintain adequate operating envelopes through permanent closure for the following subsurface openings: emplacement drifts, access mains, portals and access ramps, exhaust air mains and raises, ventilation shafts, performance confirmation openings, and miscellaneous support openings. The system shall allow for the expected variations in excavated opening dimensions, lining thickness, alignment, and deformation.

Technical Rationale–10 CFR 63.111(e)(1) requires that the waste retrieval option be maintained. This requires safe access to waste packages, transportation vehicles, and installed components for purposes of testing, inspection, and maintenance. The ground control system maintains safe access to the emplacement drifts, as well as all other subsurface openings. Therefore, this criterion supports this requirement.

Criteria–The system shall include provisions, which support a deferral of closure for up to 300 years after the start of waste emplacement, with appropriate monitoring and maintenance.

Technical Rationale–This criteria in, Curry, P.M. and Loros, E.F. 2002. *Project Requirements Document,* PRD-014/T-007, establishes the maximum length of time that the system will have to operate to provide safe accessibility of stable underground openings for these purposes.

Criteria–The ground control system shall accommodate geologic mapping of emplacement drifts so the maximum distance between mapped emplacement drifts does not exceed 300 m, geologic mapping of 100 percent of non-emplacement drift openings, and the observation/recording of rock mass conditions during construction and operation.

Technical Rationale–10 CFR 63.132(a) requires that a continuing program of surveillance, measurement, testing, and geologic mapping be conducted to ensure that geotechnical and design parameters are confirmed, and to ensure that appropriate action is taken to inform the U.S. Nuclear Regulatory Commission of changes needed in design to accommodate actual field conditions encountered. Thus, a criterion to allow for geologic mapping is needed because the ground control design impacts mapping capabilities. The rationale for the maximum 300 m distance between mapped emplacement drifts is that this frequency of mapped drifts will ensure the detection of features (e.g., faults) anticipated to possibly affect repository performance. The rationale for mapping 100 percent of the non-emplacement drift openings is to provide appropriate coverage for the confirmation of rock mass quality conditions and fracture statistics.

Criteria–The ground control system shall provide for the monitoring of ground control performance parameters including, as a minimum, opening convergence, ground support and rock temperatures, and ground support loads, for design and performance confirmation.

Technical Rationale–To comply with 10 CFR 63.111(d) and 10 CFR 63.132(e), in situ monitoring of the thermomechanical response of the underground facility is required. This criterion is provided to ensure monitoring capabilities of ground control performance parameters. The parameters to be monitored include opening convergence, ground support and rock temperatures, and ground support loads. Opening convergence is monitored to ensure that the required clearances are being maintained. Ground support and rock temperatures are monitored to confirm thermal stress design limits are not being exceeded. Ground support loads are monitored to confirm actual loads are within design limits.

Criteria–The ground control system shall be designed for the appropriate worst case combination of in situ, thermal, seismic, construction, and operation loads.

Technical Rationale–This system prevents the rock falls in the emplacements drifts that could lead to an annual dose beyond statutory limits. The geologic repository has to be designed for a rock fall in the emplacement drifts in excess of the waste packages design limit. Furthermore, system safety requires that all the underground openings be designed to minimize the potential for deleterious rock movement or fracturing, so that operations can be carried out safely. This criterion is provided to ensure that ground control is designed to withstand the worst-case loads and load combinations.

Criteria–The ground control system for emplacement drifts shall consider the following factors of safety margin in design:

Load Type	Concrete	Steel
Static Loads (in situ + thermal)	2.0 - 2.5	1.4 - 1.8
Static plus Dynamic Loads (in situ + thermal + seismic)		1.2 -1.5

Technical Rationale–All MGR systems, structures, and components should be designed and fabricated in accordance with applicable engineering principles and practices, particularly those that incorporate system safety. This criterion provides safety margin factors that are conservative for the design of the emplacement drift ground control system. These safety factors are the recommended factors in *Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain, Topical Report* YMP/TR-003-NP, 1997, for components of the emplacement drift ground control system.

Criteria–The ground control system for non-emplacement openings shall be designed for safety factors compatible with maintenance plans.

Technical Rationale–The safe maintenance of the ground control system in the non-emplacement openings is an important consideration in repository operations. This criterion will ensure that the system design will permit the safe maintenance of the system.

Criteria–The inspection plan and maintenance strategy shall be an integral part of ground control design.

Technical Rationale–The design of the system should facilitate the planned inspection and maintenance of the system. This criterion will assist in ensuring that the design will be compatible with conducting planned inspections and maintenance during repository operations.

Criteria–As part of the performance confirmation program, the geotechnical instrumentation program shall be designed to confirm sensitive design parameters, including thermomechanical responses and strength degradation of the rock mass.

Technical Rationale–10 CFR 63.111(d) requires that a Performance Confirmation Program be implemented within the geologic repository operations area through permanent closure. 10 CFR 63.132(a) states that a specific requirement of this Performance Confirmation Program is to provide a continuing program of surveillance, measurement, testing, and geologic mapping during repository construction and operation to confirm geotechnical and design parameters, including the thermomechanical responses and strength degradation of the rock mass. This criterion will ensure that the geotechnical instrumentation system will provide the necessary monitoring data for the confirmation of these parameters.

4.5.2.2 Important to Safety Criteria

Criteria–The ground control system shall be designed to prevent such a rockfall in the emplacement drifts that either initiates a stress corrosion crack or causes a breach of the waste package during the preclosure period. The rock block size or weight will be determined by the Performance Assessment and will be added later.

Technical Rationale–The system is relied upon to eliminate the credibility of an event sequence resulting from a large block fall on the waste packages in excess of their design limit, causing either stress corrosion cracks or breaches during the preclosure period. This criterion supports 10 CFR 63.112(e)(8) by ensuring that the waste packages will perform their intended safety functions, assuming the occurrence of event sequences

Criteria–The ground control system shall use materials having acceptable (i.e., acceptability based on the results of waste isolation site impact evaluations) long-term effects on waste isolation.

Technical Rationale–10 CFR 63.113(b) requires the engineered barrier system to be designed so that, working in combination with natural barriers, it will limit the expected annual dose after permanent closure. Ground control materials remaining after permanent closure may have chemical or other effects on the ability of the engineered and natural barriers to provide this assurance. This criterion ensures that the ground control materials do not impede the long-term waste isolation performance of the engineered and natural barriers.

Criteria–The ground control system shall be designed to withstand a design basis earthquake, as appropriate to the seismic frequency classification assigned to a specific SSC, shown in Section 4.2.2.2.

Technical Rationale–10 CFR 63.112(e)(8) requires that the performance analysis of SSCs that are important to safety include consideration of the "ability of structures, systems, and components to perform their intended safety functions, assuming the occurrence of event sequences." 10 CFR 63.111(a) and 10 CFR 63.111(b) require that the repository be designed for different frequency categories of event sequences during the preclosure period, in order to ensure that radiation exposures will not exceed acceptable limits in the geologic repository operations area. This criterion establishes the applicable frequency categories for seismic event sequences.

4.5.2.3 Conventional Quality Criteria

Criteria–The ground control system shall be designed to prevent rock falls that could potentially result in personnel injury.

Technical Rationale–System safety requires that the underground openings be designed to minimize the potential for deleterious rock movement or fracturing, and so that operations can be carried out safely. To provide for safe operations, this criterion ensures a system design that minimizes the potential of immediate or progressive failure (due to gradual deterioration) of the surrounding rock mass and deleterious rock movement that could result in unsafe subsurface conditions.

Criteria–The system shall use noncombustible and heat resistance material as defined by ASTM E 136-99, *Standard Test Method for Behavior of Material in a Vertical Tube Furnace at 750°C.*

Technical Rationale–System safety requires, to the extent practicable, the geologic repository operations area be designed to incorporate the use of noncombustible and heat resistant materials. Ground control material is prevalent underground, and it is important to fire safety that the material be noncombustible and heat resistant. Material is considered noncombustible per "Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 [degrees] C" (ASTM E 136-99), which is a standard accepted by the NRC. This criterion contributes to underground fire safety.

4.5.2.4 Environmental Criteria

To be provided later.

4.5.2.5 System Interfacing Criteria

Criteria–The ground control system shall interface with the Subsurface Tunneling System to accommodate opening orientation, configuration, and excavated opening sizes.

Technical Rationale–The subsurface excavated drift opening size, drift configuration, and drift orientation have a significant impact on ground control design. This criterion ensures this system interfaces with the Subsurface Tunneling System with respect to these parameters.

Criteria–The system shall interface with the Emplacement Drift System to ensure compatible ground control material.

Technical Rationale–To comply with the postclosure performance requirements of 10 CFR 63.113(b), the interface between this system and the Emplacement Drift System has to ensure that ground control materials are compatible with long-term waste isolation objectives. The ground control material used in the emplacement drifts will remain there during the postclosure period. Therefore, this criterion ensures a system design that does not impede the long-term performance of the Emplacement Drift System.

Criteria–The system shall interface with the MGR Operations Monitoring and Control System, using appropriate signal protocols, to ensure proper transmission of ground control instrument readings.

Technical Rationale–This criterion requires the system to interface effectively with the MGR Operations Monitoring and Control System, in order to ensure the proper transmission of ground control instrument readings.

Criteria–The system shall interface with the Waste Emplacement/Retrieval System to support waste emplacement operation.

Technical Rationale–System safety requires the underground openings be designed to minimize the potential for deleterious rock movement or fracturing, so that operations can be carried out safely. The system interfaces with the Waste Emplacement/Retrieval System to support safe waste emplacement operations. This interface includes consideration for preventing adverse rocking and shifting of the inverts for waste package emplacement operations.

Criteria–The system shall interface with the Subsurface Excavation System to ensure safe ground support installation.

Technical Rationale–System safety requires that the underground openings be designed to minimize the potential for deleterious rock movement or fracturing, so that ground support installation can be carried out safely. The system interfaces with the Subsurface Excavation System to ensure safe ground support installation during drift excavation operations.

4.5.2.6 Operational Criteria

Criteria–The ground control system for emplacement drifts shall be designed to function without planned maintenance during the operational life, while providing for the ability to perform unplanned maintenance in the emplacement drifts on an as-needed basis.

Technical Rationale–After waste emplacement, the environmental conditions in the emplacement drifts will be too harsh for human entry. Therefore, planned ground control repairs, which would require retrieving waste packages, should be avoided, or at least minimized. This criterion ensures the system is designed to function during the preclosure period without planned maintenance. Due to the length of time of this design and the number of unknown factors that can impact ground control (e.g., amount of convergence, ground relaxation, seismic conditions), system design has to account for the inherent uncertainties. Therefore, ground control design will not prevent the ability to perform unplanned maintenance, if required.

Criteria–The ground control system shall accommodate the maintenance of non-emplacement openings.

Technical Rationale–Due to the possibly long operational life of this system, this criterion is provided to allow or accommodate either planned or unplanned maintenance of this system in the non-emplacement openings. This will ensure the safe accessibility of the subsurface tunneling system over the operational life of the repository.

4.6 INSTRUMENT AND CONTROL DESIGN CRITERIA

4.6.1 Digital Control and Management Information System (MIS) Design Criteria

4.6.1.1 Digital Control and MIS Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5].
Instrumentation and Control	Digital Control & MIS *	ANSI/ANS-57.9-1992, ANSI/ISA S84.01-1996, IEEE Std 802.3ae 2002, NFPA 70-2002, NFPA 75-1999
		RG 1.12 Rev 2, RG 1.21 Rev 1, RG 1.23 Rev 0, RG 1.29 Rev 3, RG 1.62 Rev 0, RG 1.118 Rev 3, RG 1.189 Rev 0, RG 4.1 Rev 1, RG 5.44 Rev 3, RG 8.8, Rev 3, RG 8.25 Rev 1, RG 8.5 Rev 1
		None
		None
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21 (c)(2)), PRD-022 and *Digital Control and Management Information System Description Document* (BSC 2002j). Determination of applicable sections of these documents will be determined during the design process and in development of design products.

[2] These Regulatory Guides have been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guides will be determined during the design process and in development of design products that are impacted by these Regulatory Guides.

[3] None

[4] None

[5] None

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.6.1.2 Central Control Center

Criteria–Central Control Center (CCC) shall be provided for the facility and shall be located on the surface. Surface and subsurface Important to Safety (ITS) and Conventional Quality (CQ) systems shall be monitored from the CCC.

Technical Rationale–This criteria is required to provide a central control center for facility operations.

Criteria–The CCC shall house multiple operator consoles. Each console shall have the ability to access and control functions available in the system. A multilevel user password system shall be provided to control access to specific functions. A minimum of one system printer shall be in the CCC. The CCC shall be environmentally controlled.

Technical Rationale–This criteria is required to define ITS and CQ operator console stations.

Criteria–An Engineering Configuration Room (ECR) shall be provided separate from the CCC. The Engineering Configuration Room shall be environmentally controlled.

Technical Rationale–This criteria is required to separate the facility operations from the group performing engineering configuration work.

Criteria–There shall be a raised floor in the CCC area.

Technical Rational–This criteria is required to facilitate the routing of cables. This practice is commonly used in the industry to provide easy access to cables and ease of installing future cable requirements.

4.6.1.3 Important to Safety/Conventional Quality Systems

Criteria–Control of ITS systems shall be maintained during and after the occurrence of Category 1 and Category 2 event sequences. All ITS systems shall be combined as a group separate from CQ systems. This includes equipment/components and power requirements. ITS systems shall be monitored and may be controlled partially, only to bring about a safety shutdown mode. Note: Robotic control of each ITS system shall be done at the local control panel.

Technical Rationale–This criteria is required to define the control components of all ITS systems.

4.6.1.4 System Design Criteria

Criteria–The system shall provide alarms, operator messages, and status indications.

Technical Rationale–This criteria is required to provide the CCC a plant wide capability to inform a specific area or the general area of any abnormalities or off-normal events.

Criteria–The system shall provide data logging and trending.

Technical Rationale–This criteria is required to collect and provide backup storage for operational data and data related to ITS, CQ, and performance confirmation.

Criteria–System components that could be a single point of failure shall be redundant. The requirement for redundancy includes processors, power supplies, network cables, and network interface devices. This practice is commonly used in the industry. Use of redundant input/output (I/O) modules and redundant transmitters shall be evaluated on a case-by-case basis.

Technical Rationale–This criteria is required to assure system reliability.

Criteria–The system shall have spare installed capacity. This includes spare capacity for I/O modules, terminations, and controllers.

Technical Rationale–This criteria is required to accommodate immediate future growth. This practice is commonly used in the industry.

Criteria–The system shall have space for future growth. This shall include I/O space and allowance for additional nodes.

Technical Rationale–This criteria is required to accommodate long term future growth capacity.

Criteria–The system shall be comprised of fully modular components.

Technical Rationale–This criteria is required to allow provisions for future upgrades or refurbishment.

Criteria–The system components shall be removable and installable under power.

Technical Rationale–This criteria is required to enable online replacement and maintenance of components. This will reduce or eliminate down time.

Criteria–The system components subject to radiation shall be hardened material.

Technical Rationale–This criteria is required such that components susceptible to radiation can withstand and operate in the radiation environment in which the component is installed.

Criteria–The system shall provide built-in-test capabilities and perform self-diagnostics.

Technical Rationale–This criteria is required to perform system maintenance and trouble shooting without affecting the performance of the system.

Criteria–The system shall provide the ability to make configuration changes.

Technical Rationale–This criteria is required to facilitate periodic adjustment and/or reconfiguration of the system or part of the system either at the CCC or ECR.

4.6.1.5 System Power

Criteria–The system shall receive normal and UPS power from the Site Electrical Power System.

Technical Rationale–This criteria is required for surface and subsurface repository operations involving ITS systems. The DCMIS intended for ITS systems shall be capable of performing its intended functions during loss of normal power or after the occurrence of Category 1 and Category 2 event sequences.

4.6.1.6 Interfaces

Criteria–The system shall interface with other waste management systems. The interface to these systems shall be via an opened, non-proprietary network protocol. System shall be able to interface with various off-site locations

Technical Rationale–This criteria is required to monitor and provide the necessary data exchange between systems within the facility.

4.6.2 Radiation/Radiological Monitoring Design Criteria

4.6.2.1 Radiation/Radiological Monitoring Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5].
Instrumentation and Control	Radiation/ Radiological Monitoring*	ANSI/ANS 57.9-1992, ANSI/ANS-HPSCC-6.8.1-1981, ANSI N320-1979, ANSI N42.18-1980 (Reaffirmed 1991), ANSI/ANS 8.3-1997, IEEE Std 802.3ae 2002, NFPA 70-2002
		RG 1.21 Rev 1, RG 1.29 Rev 3, RG 1.62 Rev 0, RG 1.118 Rev 3, RG 1.180 Rev 0, RG 4.1 Rev 1, RG 8.25 Rev 1, RG 8.5 Rev 1
		10 CFR 20
		None
		None

Technical Rationale:

1 These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21 (c)(2)), PRD-022 and *Radiation/Radiological Monitoring System Description Document* (BSC 2002p). Determination of applicable sections of these documents will be determined during the design process and in development of design products.

2 These Regulatory Guides have been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guides will be determined during the design process and in development of design products that are impacted by these Regulatory Guides.

3 Addressing Code of Federal Regulations supports compliance with requirements in PRD-015/P-020 and PRD-015/P-021. Determination of applicable sections of these documents will be determined during the design process and in development of design products.

4 None

5 None

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.6.2.2 Area Radiation Monitors

Criteria–Area radiation monitors (ARMs) shall be provided where required throughout the surface and subsurface facilities.

Technical Rationale–This criteria is required to ensure adequate coverage of areas where radiation exposure to personnel is expected.

Criteria–Each monitor shall have local audible and visual alarms.

Technical Rationale–This criteria is required to alert individuals in the vicinity of the monitor that immediate action is necessary to minimize exposure to gamma radiation.

Criteria–The ARMs shall be located where there is the potential for a sudden change in radiation fields, in normally occupied area.

Technical Rationale–This criteria is required to minimize excess instrumentation in non-occupied areas.

Criteria–The monitors shall provide output signals representing radiation levels along with high level and instrument fault alarms.

Technical Rationale–This criteria is required to provide the Digital Control and Information System (DCMIS) Central Control Center (CCC) an indication that an abnormality or off-normal event has occurred in a specific or general area of the Radiation/Radiological Monitoring (RRM) ARM system.

Criteria–Signals from each monitor shall interface to the DCMIS.

Technical Rationale–This criteria is required to collect and provide data to the DCMIS for backup storage, trending and performance confirmation.

4.6.2.3 Continuous Air Monitors

Criteria–Continuous air monitors (CAMs) shall be provided where required throughout the surface and subsurface facilities.

Technical Rationale–This criteria is required to ensure adequate coverage of areas where exposure to airborne radioactive particulate matter is expected.

Criteria–Each monitor shall have local audible and visual alarms.

Technical Rationale–This criteria is required to alert individuals in the vicinity of the monitor that immediate action is necessary to minimize exposure to airborne radioactive particulate matter.

Criteria–The CAMs shall be located where there is a potential for uptake of airborne radioactive particulate matter by personnel.

Technical Rationale–This criteria is required to minimize excess instrumentation in areas where radioactive particulate matter is not expected to exist.

Criteria–The monitors shall provide output signals representing airborne contamination concentration levels along with high level and instrument fault alarms.

Technical Rationale–This criteria is required to provide the DCMIS CCC an indication that an abnormality or off-normal event has occurred in a specific or general area of the RRM CAM system.

Criteria–Signals from each monitor shall interface to the DCMIS.

Technical Rationale–This criteria is required to collect and provide data to the DCMIS for backup storage, trending and performance confirmation.

4.6.2.4 Stack Monitoring

Criteria–The radiological stack monitoring systems will normally be provided on emplacement exhaust shafts and ventilation extracts from the facility.

Technical Rationale–This criteria is required to ensure adequate coverage of areas where airborne radioactive particulate matter, radioactive iodine and noble gas releases are expected.

Criteria–The system shall continuously or intermittently sample the exhaust air for airborne particulate radioactive particulate matter, radioactive iodine and noble gas releases.

Technical Rationale–This criteria is required to ensure proper monitoring of radioactive material in the exhaust air.

Criteria–The system shall have the capability to alarm at a preset level and on instrument fault.

Technical Rationale–This criteria is required to provide the DCMIS CCC an indication that an abnormality or off-normal event has occurred in a specific or general area of the stack monitoring system.

Criteria–Signals representing the activity level and status shall be input to the DCMIS to allow the system status to be remotely monitored.

Technical Rationale–This criteria is required to collect and provide data to the DCMIS for backup storage, trending and performance confirmation.

4.6.2.5 Criticality Monitors

Criteria–Criticality monitors will normally be provided in areas where a substantial quantity of fissile material is stored or handled in order to monitor the critical state of the material.

Technical Rationale–This criteria is required to ensure adequate coverage of areas where a criticality incident is credible.

Criteria–The detectors shall have local and remote audible and visual alarm.

Technical Rationale–This criteria is required to alert individuals in the vicinity of the monitor and other locations that immediate action is necessary to minimize radiation exposure.

Criteria–The instrument shall alarm at a preset measure of change in subcriticality or very rapid increase in radiation level.

Technical Rationale–This criteria is required to minimize the occurrence of spurious alarms.

Criteria–Signals representing the status of criticality shall be input to the DCMIS to allow the system status to be remotely monitored.

Technical Rationale–This criteria is required to collect and provide data to the DCMIS for backup storage, trending and performance confirmation.

4.6.2.6 Alarm Annunciation System

Criteria–The alarm annunciation system shall normally indicate the status and locate problems with instruments within the facility's Radiation and Radiological Monitoring (RRM) system.

Technical Rationale–This criteria is required to ensure proper system operation.

Criteria–An alarm annunciation system shall be provided locally (if required) and in the central control center with the capability to monitor instrument parameters and provide alarm information for the following items:

- area radiation monitors
- continuous air monitors
- stack effluent monitors
- criticality detectors

Technical Rationale–This criteria is required to alert the CCC operator that immediate action is necessary to minimize personnel exposure.

4.6.2.7 System Hardware

Criteria–The RRM system hardware shall include provisions for upgrades.

Technical Rationale–This criteria is required to increase the system's operational life and support closure deferral.

Criteria–The RRM system components shall provide self test capabilities and performance diagnostics to verify the integrity and accuracy of the RRM data.

Technical Rationale–This criteria is required to perform system maintenance and trouble shooting without affecting the performance of the system.

Criteria–The system components shall function normally if installed in radiation environments.

Technical Rationale–This criteria is required such that components susceptible to radiation can withstand and operate in the radiation environment in which the component is installed.

4.6.2.8 System Power

Criteria–The system shall receive normal and Uninterruptible Power Source (UPS) power from the Site Electrical Power System.

Technical Rationale–This criteria is required for surface and subsurface repository operations involving systems that are important to safety (ITS). The ITS systems shall be capable of performing their intended functions during loss of normal power or after the occurrence of Category 1 and Category 2 event sequences.

Criteria–The radiation/radiological monitoring system for surface and subsurface repository operations shall be capable of performing its intended functions during loss of normal power or after the occurrence of Category 1 and Category 2 event sequences. All ITS systems shall be combined as a group separate from the conventional quality systems. This includes equipment/components and power requirements. ITS systems shall be monitored and may be controlled partially, only to bring about a safety shutdown mode.

Technical Rationale–This criteria is required to define the control components of all ITS systems

4.6.3 Environmental/Meteorological Design Criteria

4.6.3.1 Environmental/Meteorological Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Instrumentation and Control	Environmental/ Meteorological*	ANSI/ANS 57.9-1992, ANSI/ANS-3.11-2000, IEEE Std 802.3ae 2002, NFPA 70-2002, NFPA 75-1999
		RG 1.12 Rev 2, RG 1.21 Rev 1, RG 1.23 Rev 0, RG 1.29 Rev 3, RG 1.62 Rev 0, RG 1.118 Rev 3, RG 1.180 Rev 0, RG 4.1 Rev 1, RG 8.25 Rev 1
		10 CFR 20
		None
		None

Technical Rationale:

1 These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21 (c)(2)), PRD-022 and *Environmental/Meteorological Monitoring System Description Document* (BSC 2002m). Determination of applicable sections of these documents will be determined during the design process and in development of design products.

2 These Regulatory Guides have been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guides will be determined during the design process and in development of design products that are impacted by these Regulatory Guides.

3 Addressing Code of Federal Regulations supports compliance with requirements in PRD-015/P-020 and PRD-015/P-021. Determination of applicable sections of this document will be determined during the design process and in development of design products.

4 None

5 None

*Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.6.3.2 System Design Criteria

Criteria–Alarms and status information shall be provided through an operator display interface console at the Central Control Center (CCC). The system shall record, as a minimum, the occurrence of alarms, operator actions, alarms setting changes, faults, calibration, and maintenance activities.

Technical Rationale–This criteria is required to provide the CCC information in protecting other personnel against undue risk from exposure to radiation releases. The environmental and meteorological system (EMM) may provide a hierarchy of displays ranging from an overall mimic diagram of the facility to building and area displays, and displays showing the states of individual monitors. The EMM will normally allow analysis of current and historical activity measurements, alarm settings, and report generation.

Criteria–An active internal audit circuit shall be provided to test both the detector and electronics and provide an appropriate remote readout at the CCC.

Technical Rationale–This criteria is required to maintain the radiological instruments operations within the established performance parameters.

Criteria–Meteorological and radiological instruments for outdoor installation shall have weatherproof enclosures.

Technical Rationale–This criteria is required to ensure that instruments will normally operate and will be protected from outdoor weather conditions.

Criteria–All units of similar function, including detectors, electronic modules, readout and display devices and power supplies shall be interchangeable.

Technical Rationale–This criteria is required to minimize spare parts requirements.

Criteria–Provisions shall be made to service the equipment/devices. Construction of access way to each equipment/devices shall be provided.

Technical Rationale–This criteria is required to provide easy access to equipment/devices during checkout and maintenance service.

4.6.3.3 Measurement Devices

Criteria–An automatic weather station shall be used to measure wind (speed/direction), pressure, relative humidity/temperature, atmospheric stability, and precipitation within site boundaries.

Technical Rationale–This criteria is required to monitor the weather conditions within the site boundaries. The weather conditions and pattern will be used for dispersion analysis during radiation releases.

Criteria–Continuous air monitors for radiation detection shall be provided within the site boundaries.

Technical Rationale–This criteria is required to monitor radiation releases within the site boundaries.

Criteria–Hand held or fixed surface water radiation instrument should be provided.

Technical Rationale–This criteria is required to monitor radionuclide levels in naturally occurring surface water bodies within the site boundaries.

Criteria–Seismic instruments shall be provided within site boundary.

Technical Rationale–This criteria is required to measure and record ground vibrations.

4.6.4 General Instrumentation Design Criteria

4.6.4.1 General Instrumentation Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Instrumentation & Control	General Instrumentation*	ANSI/ANS 57.9-1992, ANSI/ISA S84.01-1996, NFPA 70-2002, NFPA 75-1999, ASME 2001 Section I and VIII
		RG 1.29 Rev 3, RG 1.62 Rev 0, RG 1.118 Rev 3, RG 1.180 Rev 0, RG 8.5 Rev 1
		None
		None
		None

Technical Rationale:

1 These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21 (c)(2)), PRD-022, and PRD-013/T-027. Determination of applicable sections of these codes and standards will be determined during the design process and in development of design products.

2 These Regulatory Guides have been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guides will be determined during the design process and in development of design products that are impacted by these Regulatory Guides.

3 None

4 None

5 None

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.6.4.2 Transmitters

Criteria–Whenever possible, transmitters used for any measurement application shall have a 2 wire, 4-20 mA, or digital output signal.

Technical Rationale–The output signal of 2 wire 4-20 mA for instrumentation transmitters is a well known industry standard. 4-20 mA is a commonly accepted industry practice and is listed in standard that has been identified and is being procured.

4.6.4.2.1 Temperature Transmitters

Criteria–Temperature transmitters shall meet the following minimum criteria:

Repeatability:	+/- 0.25 percent
Accuracy:	+/- 0.5 percent full scale
Stability:	+/- 0.5 percent for 50° F ambient change

Technical Rationale–These parameters for Temperature Transmitters are commonly adhered to through out industry. Transmitters with greater criteria are available and the intent is to provide the minimum requirements.

4.6.4.2.2 Flow Transmitters

Criteria–Differential type flow transmitters shall normally be used for cases where remote flow control is desired. The range specified shall normally be 100-inches of water column (WC).

Technical Rationale–Flow transmitters with 100-inches of water column (WC) are routinely used for good rangeability.

4.6.4.3 Temperature Measurement

Criteria–Temperature measurement shall be primarily made by the use of either:

- Resistance temperature detectors (RTDs)
- Thermocouples (TCs).

Runs of RTD or TC wire shall be minimized. Temperature transmitters may be provided with both RTDs and TCs. Wherever possible, these devices shall be located in sensor heads, on racks, or within instrument enclosures.

A thermowell shall be provided, made of stainless steel or other material suitable for the process conditions. On radioactive duties, extended thermowell guide tube(s) shall be used to allow insertion and removal of the radioactive service thermal elements from a non-active area.

Technical Rationale–Use of RTDs and TCs is good engineering practice.

4.6.4.3.1 Resistance Temperature Detectors

Criteria–Resistance temperature detectors shall normally use dual 100-Ω platinum 3 wire elements.

Technical Rationale–100 -Ω platinum 3 wire elements have become an increasingly popular standard for use in industrial applications because of their increased accuracy. They are widely used in HVAC, electric motors, process control and electronic circuits.

4.6.4.3.2 Thermocouples

Criteria–In general, thermocouples shall only be used on high temperature applications that have a wide range of temperature measurement. Thermocouples shall be selected to meet the requirements of the application.

Technical Rationale–TCs are the most commonly used method of industrial temperature measurement in the United States. TCs are listed in standard, which has been identified and is being procured. They are characterized by their low cost and wide rangeablilty.

4.6.4.3.3 Temperature Controllers

Criteria–Control modes shall normally be adjustable proportional control and automatic reset. Control room mounted instruments shall be provided with adjustable derivative response.

Technical Rationale–This criterion is required for safe operation of slow response systems such as temperature control. Derivative response is not normally specified for remote (local) mounted controllers where operators may not be readily available to adjust the response during upset conditions.

4.6.4.3.4 Temperature Gauges

Criteria–Dial thermometers shall be bimetal, gas or vapor actuated. Dial thermometers shall normally have 5-inch diameter dials, white face with black markings, and be of the any-angle type.

Technical Rationale–The use of bimetal, gas or vapor actuated thermometers with large 5" dials is commonly used in industrial systems. Any angle facilitates the positioning of the thermometer for ease in viewing.

4.6.4.4 Flow Measurement

4.6.4.4.1 Orifice Plate

Criteria–Orifice plates shall normally be installed between line-sized orifice flanges, equipped with flange taps. The d/D, or beta ratio, should normally be between 0.2 and 0.7.

Technical Rationale–The Beta ratio of .2 to .7 is a commonly used standard for differential orifice plate measurement. Ratios below .2 are not recommended because of pressure loss. Ratios above 0.7 are not recommended because of the reduction in differential pressure.

4.6.4.4.2 Flow Measurement in Radiation Environments

Criteria–Radiation tolerant electromagnetic flow meters or differential pressure (DP) flow instruments with DP cells located outside the radioactive area shall be used, or other radiation tolerant instruments housed in suitably shielded enclosures.

Technical Rationale–Isolation of electronic components from radiation is a commonly used practice in industry to protect the instruments from degradation due to the radiation environment.

4.6.4.5 Level Measurement

Criteria–Level measurement applications vary from slurries, liquids with high salt concentrations, highly radioactive liquids and solids, to clean liquids. The appropriate level measurement shall generally be made by one of the following techniques:

- Bubblers–measurement of hydrostatic head
- Radar (submerged waveguide and non-contact)
- Differential pressure transducers–tank gauges
- Capacitance / admittance (RF)
- Conductance
- Ultrasonic
- Laser

Technical Rationale–Non-contact radar level measurement is an accepted industry measurement technique. Radar transmitters should be located close to the process cell to minimize error. Advantages are the ease of maintenance because the process does not contact the instrument. Hydrostatic level measurements using bubblers shall be used where physical constraints such as distance, tank location, or tank internals preclude the use of radar. Other level measurement techniques indicated above shall be considered where radar or bubblers are impractical.

4.6.4.5.1 Gauge Glasses

Criteria–The visibility of the level glass shall be specified such that the glass covers the operating range of the level instrument. In alarm and shutdown service, the visibility shall normally cover the range of all instruments including the shutdown set points. Minimum pressure rating shall be based on published manufacturer's pressure / temperature charts.

Technical Rationale–The gauge glass criteria stated above is a typical industry standard for checking the accuracy and operational condition of level instruments.

4.6.4.6 Pressure and Differential Pressure Measurement

Criteria–Pressure measurement shall normally be made by the use of electronic pressure and DP transmitters. Where necessary, drain valves shall be installed at the lowest point in each gas-containing line to facilitate moisture removal. Two- or 5-valve manifolds shall be installed on the transmitters for calibration purposes. Process wetted transmitters, such as pressure transmitters, shall be located in shielded locations. For low activity waste (LAW), the requirement for pressure transmitters to be housed within shielded enclosures shall be evaluated based on as low as is reasonably achievable (ALARA) principles. Pressure transmitters used as part of bubbler level/density measurements shall be located above the point of measurement (as a design principle, a minimum of 1 barometric head above liquid surfaces) to prevent possible moisture collection and contamination.

Technical Rationale–Transmitters used in radioactive service are designed for radiation tolerance.

4.6.4.6.1 Pressure Gauges

Criteria–Accuracy of direct connected gauges in process service shall be at least 0.5% percent of maximum scale reading over the entire scale. Maximum operating temperature and pressure must be less than the rating of the gauge. The range shall be specified so that the gauge operates in the middle third of the scale. Normally, the maximum operating pressure should not exceed 75 percent of the full scale range. Over pressure protection shall be 1.3 times the maximum rating to prevent set or loss of calibration from continuous over pressures. Dials shall normally be 4-1/2 inch diameter, white face with black markings.

Technical Rationale–The criteria listed above are an accepted industry standard for good practice in specifying pressure gauges. The criteria are commonly used in industry in the United States.

4.6.4.7 Density Measurement

Criteria–Gas density shall normally be specified to determine purity of hydrogen streams, carbon dioxide in stack gas, and other purposes. Liquid density instruments shall normally be specified when the concentration of a solution is to be determined or when density is a variable of a process stream. Density measurement shall generally be made by one of the following techniques:

- Bubblers–hydrostatic head
- Coriolis
- Refractometer
- Gamma ray densitometer

Technical Rationale–Bubblers are an inexpensive and versatile method of measuring density, and the technique is commonly used in industry. Coriolis measurement of density is the mass per unit of volume and can be measured in the flow in piping systems. Refractometers use the turning or bending of any wave, such as a light or sound wave, when it passes from one medium into another of different optical density (index of refraction). Gamma Ray densitometers may have some application for measurement of density. A radioactive source is placed in a designed location and counts from the source can be calibrated to yield density of rock for example.

4.6.4.8 Control Valves

4.6.4.8.1 Body Styles

Criteria–Cage guided globe valves shall be generally preferred.

Technical Rationale–Because of their higher capacity, low noise trim, and availability in single port design for tight shutoff or low leakage.

Criteria–Conventional globe valves are generally preferred for large line sizes.

Technical Rationale–Conventional globe valves are readily available when larger sizes and higher ratings are required.

Criteria–Butterfly valves shall generally be used when larger sizes, and low cost are required (generally 4" and above). Rotation of conventional discs should be limited to 60 degrees from the closed position. Flow characteristic of the butterfly valve should approach equal percentage.

Technical Rationale–The following features are utilized when selecting butterfly valves:

- High capacity, but lower rangeability
- High pressure drop recovery
- Should not be considered when tight shutoff is required, unless pressure and temperature limitations allow the use of elastomer linings.

Criteria–Ball Valves shall be considered.

Technical Rationale

- High rangeability
- High pressure drop recovery, good control characteristics, and tight shutoff
- Ball valves have pressure drop and temperature limitations which can restrict their use

4.6.4.8.2 Valve Characteristics

Criteria–The following shall be considered in the selection of valve characteristics:

- Quick opening
- Linear characteristic
- Equal percentage

Quick opening shall be considered for On-Off service and for direct connected regulators utilizing low lifts. Linear characteristic shall be considered for most level control, slow pressure control loops, and loops where the measurement is linear and the variation in the pressure drop across the control valve is small. Equal percentage may also be desirable on flow control, or when the valve is in bypass service (valve closes to increase flow). Equal percentage is also desirable on loops that have large variations in valve pressure drops, fast pressure control loops, and most flow control loops. Where no guidelines are available, equal percentage is usually the best choice.

Technical Rationale–The selection of valves is based on good engineering practice.

4.6.4.8.3 Control Valve Noise

Criteria–Valves shall not produce noise in excess of 85 dBA at 3 feet unless otherwise specified on the control valve data sheets.

Technical Rationale–This is an acceptable Industry standard for the control of noise for the protection of plant operating and maintenance personnel.

4.6.4.9 Relief Valves

Criteria–The following general guidelines shall be used for the selection and specification of relief valves:

- Valve vendor shall check sizing of all valves for service conditions given, including back pressure. Valve vendor shall also check that the type of valve selected conforms to code serving as the basis of selection

- The orifice area of safety valves on fired boilers shall be determined in accordance with ASME 2001 Boiler and Pressure Vessel Code (BPVC)

- The orifice area of safety relief valves in pressure vessels shall be determined in accordance with the American Petroleum Institute. Plain lifting levels shall normally be furnished on all safety valves for steam or air service

- All safety relief valves shall be furnished with a threaded cap over the spring adjusting screw, unless otherwise stated.

Technical Rationale–Relief valve vendors are commonly asked to check the sizing of their relief valves. See Section I PT PG; Para PG-67 through PG-73.5-1998 (safety valves and safety relief valves, and Section VIII D1 A PT UG PT PG; Para PG-67 through PG-73.5-1998 (pressure relief devices) for sizing of relief valve orifice area for fired boilers.

Standards have been identified and are being procured for sizing of orifice areas on pressure vessels.

4.6.4.10 Analyzers

Analyzers and specialty instruments shall be used to measure the concentration of one or more components in a process stream, or to measure some property that is of interest in meeting specifications of the stream.

Criteria–Gas chromatographs shall generally be used when it is necessary to determine several components simultaneously or when it is necessary to determine a component from a mixture. Applications for gas chromatography include gas or vapor streams and liquid streams that can be vaporized at the operating temperature of the column.

Technical Rationale–Gas chromatographs is a generally accepted industry standard to be used when it is necessary to determine several process components simultaneously.

Criteria–Infrared analyzers shall be used for the analysis of a single component in a gas or vapor stream. Compounds which can be analyzed successfully by infrared include most hydrocarbons and their derivatives, other compounds containing hydrogen and some other gases such as carbon monoxide and carbon dioxide.

Technical Rationale–Infrared analyzers are commonly used in industrial applications for the analysis of a single component in a gas or vapor stream. Infrared analyzers work on the principle that the process gas absorbs infrared light. The output of the infrared analyzer is proportional to the amount of infrared light absorbed which, in turn, is correlated with the amount of the process gas present.

Criteria–Thermal conductivity analyzers shall be used for the determination of hydrogen purity. They may also be applied to other two component determinations.

Technical Rationale–Thermal conductivity analyzers measure the specific composition of gases using a heat conductivity method that utilizes the differences in heat conductivity among electrically charged bodies. This principle makes the determination of Hydrogen purity especially applicable to this type of instrument. A bridge network provides the means for measuring the relative ability of the sample gas and reference gases to conduct heat away from their respective temperature sensors.

Criteria–Paramagnetic analyzers shall be used only for the determination of oxygen in gas streams.

Technical Rationale–Thermal sensing paramagnetic analyzers is preferred because of their more rugged construction.

Criteria–Electrochemical analyzers shall normally be used to measure the properties of water solutions. They are also widely used for the determination of pollution. Electrolytic conductivity shall be used to measure the total ion content of water. They shall generally be used to measure boiler feed water, desalination plants, and waste streams.

Technical Rationale–Electrochemical analyzers are commonly used for the analysis of water solutions in the United States. Deionized water hardly conducts electricity, but when salts are dissolved in the water, they dissociate into ions, making the deionized water electrolytically conductive. As the amount of salts becomes larger, the electrolytic conductivity increases. This principal makes electrolytic conductivity the analyzer of choice to measure the total ion content of water.

Criteria–pH analyzers shall be used generally to determine acidity or alkalinity of water solutions. Plastic reference electrodes are preferred since they require less attention than glass electrodes.

Technical Rationale–pH is the method used for determining the acidity or alkalinity of an aqueous solution. The practical pH scale is 0 to 14 pH, a pH of 7.0 being neutral, neither acid nor alkaline. Acid solutions are below 7.0 pH and alkaline solutions are above 7.0 pH.

Criteria–Oxidation-Reduction potential analyzers (ORP) shall generally be used when the presence of oxidizing or reducing agents in a solution is to be determined. These instruments shall be used for wastewater and also for determining the condition of reacting solutions.

Technical Rationale–When metal is immersed in a solution, electric potential is detected according to that solution. This electric potential represents the oxidation or reduction force of the solution. This force (potential difference) is called the oxidation-reduction potential (ORP) of the solution, from which the oxidation or reduction ability of the solution can be obtained. This principal makes the ORP analyzer the analyzer of choice in the analysis of wastewater streams.

Criteria–Electrolytic analyzers shall generally be used for the determination of water vapor in a gas stream. Calibration of these instruments is generally not required since the electrical signal is proportional to the water being electrolyzed.

Technical Rationale–Electrolytic analyzers are used for the determination of water vapor because the measurement principle is simple and direct. Calibration of these instruments is generally not required since the electrical signal is proportional to the water being electrolyzed.

Criteria–Turbidity instruments or nephelometers shall generally be used when particulate material in gases or solutions must be determined. Both absorbance and dispersion instruments are available.

Technical Rationale–Photometers subdivide down into two basic types: absorption and scattering. In an absorption system, a beam of light is interrupted by a sample of gas or liquid. Light enters the sample and the amount of light leaving the sample is reduced due to scattering and absorption when the light enters the container. The principle of scattering or absorption when light strikes the particles makes this type of instrument ideal for turbidity measurements.

4.6.4.11 Tagging

Criteria–All instruments shall be provided with a permanently attached stainless steel tag. Either stainless steel wires or stainless steel screws shall attach tags. Tags shall be stamped with a minimum of instrument tag number, purchase order number, and purchase order item number.

Technical Rationale–This tagging method is commonly used in industry.

4.7 MECHANICAL HANDLING

4.7.1 Mechanical & Remote Handling Design Criteria

4.7.1.1 Mechanical & Remote Handling Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5].
Mechanical Handling	Mechanical & Remote Handling*	AISC 1989, ANSI N14.6-1993, ANSI/ANS 57.1-1992, ASME B30.2-1996 , ASME B30.9-1996, ASME B30.16-1993, ASME B30.20-1993, ASME NOG-1-2002, ANSI/AWS D14.1-97, AREA 1997, CMAA-70-2000, CMAA-74-2000, MIL-STD-1472E-1996, UCRL-15673 (Bongarra et al. 1985)
		RG 1.111 Rev 1, RG 1.25 Rev 0, RG 1.8 Rev 3, RG 3.48 Rev 1, RG 3.49 Rev 0, RG 3.71 Rev 0, RG 8.8, Rev 3
		29 CFR 1910, 29 CFR 1926, 10 CFR 20, 10 CFR 71, 49 CFR 172, 49 CFR 173
		NUREG-0700 1996 (NRC 1996) , NUREG-0554 1979 (NRC 1979), NUREG-0612 1980 (NRC 1980), NUREG/CR-6407 (McConnell et al 1996)
		DOE-STD-1090-99

Technical Rationale:

[1] These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21 (c)(2)), PRD-022, PRD-013/T-027 and *Mechanical and Remote Handling System Description Document* (BSC 2002c). Determination of applicable sections of these codes and standards will be determined during the design process and in development of design products.

[2] These Regulatory Guides have been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guides will be determined during the design process and in development of design products that are impacted by these Regulatory Guides. Addressing these Regulatory Guides supports compliance with requirements in *Mechanical and Remote Handling System Description Document* (BSC 2002c).

[3] Addressing Code of Federal Regulations supports compliance with requirements in PRD-015/P-020 and PRD-015/P-021. Determination of applicable sections of these documents will be determined during the design process and in development of design products.

[4] These NUREGs provides guidance on acceptable methods and approaches that could be utilized in MGR design

[5] Addressing this DOE Standard supports compliance with requirements of PRD-018/P-019. Determination of applicable sections of this DOE Standard will be determined during the design process and in development of design products.

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.7.1.2 Cask Transporter Processing

Criteria

- Transportation package handling equipment shall be capable to accept all of the transportation packages.
- Lifting yokes and hoist system shall be able to orient a cask from horizontal to vertical position.

- Grapples and lifting fixtures shall provide positive engagement during lift.
- Maximum lift capability of 200 tons shall be provided.
- Adequate storage space shall be provided for special tools, unique to each transportation package.
- Cranes and other equipment shall be designed to be tested, maintained, and inspected in accordance with industry standards and OSHA requirements such as guarding floor and wall openings and holes.
- Means shall be provided to decontaminate external surfaces of the transportation package, ancillary equipment, as required to meet the contamination limits of 49 CFR 172 and 49 CFR 173.

Technical Rationale–Codes and standards such as ASME B30.20-1993, ASME B30.16-1993, CMAA-70-2000, CMAA-74-2000 and ANSI N14.6-1993 are used.

4.7.1.3 Disposal Container Processing

Criteria

- Inspection stands shall be capable of holding waste packages in horizontal position.
- Personnel lift platforms and inspection tools shall be provided.
- Lifting yokes and hoist systems shall accommodate various size waste packages (Weight, length, & OD).
- Stands for holding/staging inspected waste packages in vertical position shall be provided.
- Waste package lifting collar loading machine shall be capable of handling lift collars, weighing up to 4000 pounds.

Technical Rationale–ASME B30.9-1996, ASME B30.16-1993, and DOE-STD-1090-99 provide details for extremely complex, critical, and hazardous hoisting and rigging operations as applicable to various handling operations including handling of waste packages.

4.7.1.4 Dry Waste Transfer

Criteria

- The material shall withstand the cumulative effect of radiation exposure anticipated over their design life.
- Capability for emergency shutdown of the lifting and handling equipment power supply (i.e., manual disconnect) shall be incorporated into the equipment design.

- If provision for remote maintenance is not provided, handling equipment for fuel units and transportation package closure lid(s) shall have sufficient redundancy so that no single failure in the handling system will preclude returning unshielded fuel units to shielded storage location.
- Grapples and lifting attachments, and handling equipment for fuel units and transportation package closure lid(s) shall be designed for remote operation, and active lifting components shall be designed to retain their load in the event of loss of actuating power.
- Grapples and tools shall be designed to facilitate decontamination, nondestructive testing, maintenance, handling, and storage. Cracks and crevices shall be avoided, likely to collect contamination.
- Process fixtures, temporary storage locations, fuel unit container, and similar devices shall be designed with lead-ins and chamfers to facilitate insertion and removal.
- Facilities for putting on and taking off anti-contamination clothing and personnel monitoring devices shall be provided adjacent to access doors to the shielded cell.
- Fuel crud released during handling shall be considered for determining potential activity release levels during normal or off-normal situations.
- Interior surfaces of the shielded cell shall be coated or lined to facilitate decontamination.
- Dual Purpose Cask cutting tool and hoisting system shall be provided for lifting loaded Dual-Purpose Casks weighing up to 50 tons
- Design features shall be provided to ensure that the fuel unit handling and storage areas remain subcritical.
- Equipment shall be of modular design and easy to maintain.

Technical Rationale–Code and standards such as ASME NOG-1-2002, ANSI/AWS D14.1-1997, ANSI/ANS-57.1-1992, CMAA-70-2000, CMMA-74-2000, NUREG-0554-1979, NUREG-6407 1996 and NUREG-0612 1980 provide guidance on the actions that should be taken to assure safe handling of heavy loads.

4.7.1.5 Remediation/Repair

Criteria–The remediation area shall provide shield windows and remote viewing system (CCTV) to assist operators in performing required normal process operations and recovery from off-normal events.

The procedures for handling damaged fuel or damaged fuel units shall be anticipated and provisions made in the design.

Technical Rationale–Code and standards such as ASME NOG-1-2002, ANSI/AWS D14.1-1997, ANSI/ANS-57.1-1992, CMAA-70-2000, CMMA-74-2000, NUREG-0554 1979, NUREG-6407 1996 and NUREG-0612 1980 provide guidance on the actions that should be taken to assure safe handling of heavy loads.

4.7.1.6 Waste Aging

Criteria

- A concrete pad shall be provided for staging up to 100 casks (1000 MTU) in vertical or horizontal position.
- The aging pad shall be capable of placing cask weighing up to 200 tons
- The radiation dose rate shall not exceed 10 mrem/hr at 2 meters and 2 mrem/hr at 50 meters, without additional shielding.

Technical Rationale–ASME B30.5 applies to crawler cranes for construction, installation, operation, inspection, and also provides enforcement of safety directives.

4.7.2 Waste Package Handling Design Criteria

4.7.2.1 Waste Package Handling Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Mechanical Handling	Waste Package Handling*	ANSI/ANS 57.1-1992, ANSI/ANS 57.2-1983, ANSI/ANS-57.9-1992, AWS D1.1/D1.1M-2002, ASME NOG-1-2002, ASTM C 1217-00, ASTM C992-89, ANSI N305-1975, CMAA-70-2000, CMAA-74-2000, UCRL-15673 (Bongarra et al. 1985)
		RG 8.8 Rev 3
		10 CFR 20, 29 CFR 1910, 29 CFR 1926, 10 CFR 71, 10 CFR 72
		NUREG-0700 1996 (NRC 1996)
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21(c)(2)), PRD-022 and *Mechanical and Remote Handling System Description Document* (BSC 2002c). Determination of applicable sections of these codes and standards will be determined during the design process and in development of design products.

[2] This Regulatory Guide has been assessed to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guide will be determined during the design process and in development of design products that are impacted by this Regulatory Guide. Addressing this Regulatory Guide supports compliance with requirements in *Mechanical and Remote Handling System Description Document* (BSC 2002c).

[3] Addressing Code of Federal Regulations supports compliance with requirements in PRD-015/P-015, PRD-015/P-020 and PRD-015/P-021. Determination of applicable sections of these documents will be determined during the design process and in development of design products

[4] This NUREGs provides guidance on acceptable methods and approaches that could be utilized in MGR design

[5] None

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.7.2.2 Waste package Handling

Criteria

- Tools/yokes/grapples for handling shall be provided to handle different sizes and weights of Waste Packages.
- Capability to determine WP identification numbers shall be provided.
- Capability for downending WP weighing up to 40 tons shall be provided.
- Adequate storage space shall be provided for each size of WP including lifting yokes/grapples.
- Lifting tools will be designed so that they shall not damage or mar WP surface.

- Subsurface transporter shall be provided which transfer a WP from surface to subsurface.
- Equipment for off loading WP to final position in the drift shall be provided.
- Capability to record WP location in the drift shall be maintained.
- WP staging area in the WP load out area shall be provided.
- Cranes and other equipment shall be designed so that they are tested, maintained, and inspected in accordance with industry standards and OSHA requirements.
- Remote handling equipment shall be incorporated into the design of the area to permit performance of normal process operations. Particular attention shall be given in the design to methods and equipment required to recover from equipment failure, off normal events, and accidents.

Technical Rationale–CMAA-70-2000, CMMA-74-2000, ANSI/AWS D14.1-1997, NUREG-0554 1979 and ASME NOG-1-2002 provide guidance addressing waste handling equipment.

4.8 MECHANICAL DESIGN CRITERIA

4.8.1 Fire Protection Design Criteria

4.8.1.1 Fire Protection Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Mechanical	Fire Protection*	ANSI/NFPA 80 1999, ASTM D5144-00, ICC-2000 (IBC), ICC 2002 (IFC) NFPA 1-2000, NFPA 10-2002, NFPA 11-2002, NFPA 13-1999, NFPA 14-2000, NFPA 15-2001, NFPA 16-1999, NFPA 17-2002, NFPA 20-1999, NFPA 22-1998, NFPA 24-1995, NFPA 25-2002, NFPA 30-2000,NFPA 68-2002,NFPA 69-2002, NFPA 70-2002, NFPA 72-2002, NFPA 75-1999, NFPA 80A-2001, NFPA 90A-2002, NFPA 101-2000, NFPA 221-2000, NFPA 502-2001, NFPA 750-2000, NFPA 780-2001, NFPA 801-1998, NFPA 1144-2002, NFPA 1963-1998, NFPA 2001-2000
		RG 1.189 Rev 0, RG 1.29 Rev 3
		10 CFR 20, 10 CFR 73, 29 CFR 1910, 29 CFR 1926
		NUREG –0800 1987 (NRC 1987)
		DOE Order 420.1 Change 3 –2000, DOE G 440.1-5-1995, DOE Std 1066-99

Technical Rationale:

[1] These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21(c)(2)), PRD-022 and *Fire Protection System Description Document* (BSC 2002n). Determination of applicable sections of these codes and standards will be determined during the design process and in development of design products.

[2] These Regulatory Guides have been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guides will be determined during the design process and in development of design products that are impacted by these Regulatory Guides.

[3] Addressing Code of Federal Regulations supports compliance with requirements in PRD-015/P-015, PRD-005, PRD-015/P-020 and PRD-015/P-021. Determination of applicable sections of these documents will be determined during the design process and in development of design products

[4] This NUREG provides guidance on acceptable methods and approaches that could be utilized in MGR design.

[5] Addressing these DOE Orders supports compliance with requirements of PRD-018/P-019. Determination of applicable sections of these DOE Orders will be determined during the design process and in development of design products.

*Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.8.1.2 Facilities Hazard Classification

Facilities at the MGR will handle large quantities of radioactive and hazardous materials. Consequently, it is necessary to ensure that facilities are designed to control, suppress, and contain the effects of fire events that are postulated to occur during the life of the facility.

To ensure that adequate levels of fire protection are provided, a graded approach is used in the design of facilities and areas. The fire hazard for these facilities has been classified as shown in the following tables.

Surface Facility Fire Protection Design Basis Summary**

No.	Facility	IBC Classification (*)	NFPA 101 Occupancy / Hazard Classification (*)
1	Dry Transfer Facility # 1		
2	Dry Transfer Facility # 2		
3	Remediation Building		
4	Low Level Waste Building		
5	Transporter Receipt Building		
6	Disposal Container Preparation Building		
7	Surface Aging Pads		
8	Heavy Equipment Maintenance Building		
9	Balance of Plant		

*- based on the predominant use of the facility

** - to be added later

Subsurface Fire Protection Design Basis Summary

Area	Hazard Classification (Method to be Determined)	Area Fire Protection Criteria (To be determined)
Development Area		
Emplacement Area		

4.8.1.3 Applicable Design Codes and Standards to Fire Protection Design

Title	Applicability	Surface Facilities		Subsurface Areas	
		Nuclear Buildings	Non-Nuclear Buildings	Development Area	Emplacement Area
NFPA 10, Standard for Portable Extinguishers	Sizing and spacing of portable fire extinguishers for all accessible areas	X	X	X	X
NFPA 11, Standard for Low-, Medium-, and High-Expansion Foam	Design of foam based fire suppression systems	X	X	X	
NFPA 13, Standard for the Installation of Sprinkler Systems	Selection and design of automatic sprinkler systems	X	X		
NFPA 14, Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems	Layout and design of all standpipe and hose station outlets for backup suppression and fire brigade use	X		X	
NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection	Layout and design of fixed water spray systems in buildings and external areas	X	X		

Title	Applicability	Surface Facilities		Subsurface Areas	
		Nuclear Buildings	Non-Nuclear Buildings	Development Area	Emplacement Area
NFPA 16, Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems	Layout and design of foam water suppression systems	X	X		
NFPA 17, Standard for Dry Chemical Extinguishing Systems	Design of fire suppression systems for mobile equipment	X	X	X	X
NFPA 20, Standard for the Installation of Stationary Pumps for Fire Protection	Design and specification of firewater pumping system	X	X	X	
NFPA 22, Standard for Water Tanks for Private Fire Protection	Design and layout of firewater storage	X	X	X	
NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances	Design, arrangement, and piping material selection for Firewater distribution	X	X	X	
NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems	Design considerations for the inspection, testing and maintenance of water based extinguishing systems	X	X	X	
NFPA 72, National Fire Alarm Code	Design of fire alarm, detection systems in buildings and mobile equipment	X	X	X	X
NFPA 750, Standard on Water Mist Fire Protection Systems	Design of limited water usage fire suppression systems	X	X	X	
NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems	Design of non-aqueous suppression systems	X	X	X	

4.8.1.4 General Criteria

Criteria–The system shall provide automatic fire suppression in facilities that have a ground floor area in excess of 5,000 sq. ft., or where the maximum fire loss exceeds $1 million.

Technical Rationale–The DOE imposes DOE Order 420.1, Change 3, *Facility Safety*, on the MGR. DOE G 440.1-5 1995, *Implementation Guide for use with DOE Orders 420.1 and 440.1 Fire Safety Program*, Section IV, paragraph 9.7, requires automatic fire suppression in facilities where the maximum possible fire loss exceeds $1 million or the ground floor area is in excess of 5,000 sq. ft.

Criteria–The system shall provide redundant fire protection in areas where the maximum possible fire loss exceeds $50 million.

Technical Rationale–DOE G 440.1-5 1995, Section IV, paragraph 9.7, requires redundant fire protection in areas where the maximum possible fire loss exceeds $50 million. Redundant fire protection can include items such as a fire barrier system, smoke detection in conjunction with a fully capable fire department, and other options. "Fire protection" in this criterion means fire detection, suppression, and alarm features as needed to protect against the fire and explosion hazards.

4.8.1.5 Site Criteria

Criteria–The minimum access width, building to building spacing, for fire fighting apparatus shall be not less than 26 ft where fire hydrants are provided and shall not be less than 20 ft in width where there are no hydrants. Access pathways shall not exceed 150 ft in length unless a suitable turnaround is provided.

Technical Rationale–This criteria provides for acceptable width for the access and operation of fire fighting apparatus per the International Fire Code Sections (ICC 2002) 503.2.5, D103.1 and D103.4.

Criteria–Roads that are used by fire fighting apparatus shall not exceed 10 percent in grade.

Technical Rationale–This criteria provides for acceptable slope for the response of fire fighting apparatus per the International Fire Code (ICC 2002) Section D.103.2.

Criteria–Exposures to buildings and significant equipment from the natural terrain should be assessed and mitigated per NFPA 1144-2002, *Standard for Protection of Life and Property from Wildfire.*

Technical Rationale–This criteria assists in the identification, assessment of risk, and specification of mitigating features in order to protect buildings and equipment from external fire threats due to the isolated location in an area that could be threatened by wild land fires.

Criteria–Exterior exposures to buildings or equipment created by other buildings or equipment shall be evaluated and mitigated in accordance with NFPA 80A-2001, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures.*

Technical Rationale–This criteria assists in the identification, assessment of risk, and specification of mitigating features in order to protect buildings and equipment from fires in adjacent buildings or equipment.

Criteria–The location, spacing, and protection criteria for flammable and combustible liquid tanks shall be identified, evaluated, and mitigated per NFPA 30-2000, *Flammable and Combustible Liquids Code.*

Technical Rationale–This criteria assists in the identification, assessment of risk, and specification of mitigating features in order to protect flammable and combustible tanks from adversely impacting other buildings and equipment from fire.

4.8.1.6 Nuclear Surface Facilities

Criteria–Noncombustible and heat resistant building materials should be used wherever practical.

Technical Rationale–This criteria is necessary to limit the quantities of materials available to support combustion in a hazard area. Fire propagation is limited by restricting building materials to the use of noncombustible and heat resistant materials that will not support combustion. This criteria is based on Regulatory Guide 1.189, Rev 0, (Section B. GDC 3), which specifies the use of noncombustible and heat resistant materials.

Criteria–Required fire detection and suppression systems of appropriate capacity and capability shall be designed to minimize the adverse effects of fires on SSCs Important to Safety (ITS).

Technical Rationale–This criteria is necessary to specify that system design will be sufficiently comprehensive and adequate to limit damage from a fire, and protect against an inadvertent release, to affected SSCs in the hazard area. Fire protection systems of sufficient capacity and capability will enable fires to be controlled and extinguished in sufficient time so that damage to SSCs is minimized. This criteria is based on Regulatory Guide 1.189, Rev 0, (Section B. GDC 3), which specifies the use of fire protection systems of appropriate capacity and capability for the protected hazard.

Criteria–Fire fighting systems shall be designed to ensure that their failure, rupture, or inadvertent operation does not significantly impair the capability of ITS SSCs to perform their intended function.

Technical Rationale–This criteria is necessary to specify that system design will be sufficiently comprehensive and adequate to limit damage from a fire and protect against inadvertent release, to affected SSCs in the hazard area. This criteria is based on Regulatory Guide 1.189, Rev 0, (Section B. GDC 3), which specifies the use of fire protection systems of appropriate capacity and capability for the protected hazard.

Criteria–Backup fire suppression in the form of a NFPA 14-2000, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems,* Class III Standpipe and Hose installation shall be provided in all Nuclear Facilities. The system shall be able to reach any location that contains or could present an exposure fire hazard to SSCs ITS, with at least one effective hose stream. Additional standpipe and hose installations shall be provided in an area if the fire hazard could block access to a single hose station serving that area. All hose nozzles shall have shutoff capability.

Technical Rationale–This criteria is necessary to specify a minimum threshold level for backup fire system protection that is acceptable in order to limit damage from a fire. Specification of backup suppression protection limits potential fire damage to SSCs ITS and increases the likelihood that fires are promptly controlled and extinguished. This criteria is based on

Regulatory Guide 1.189, Rev 0, Section 3.4, which specifies the criterion for manual suppression systems.

Criteria–The design interface, control, and usage of the building ventilation and exhaust systems shall be accomplished in a manner consistent with NFPA 801-1998, *Standard for Fire Protection for Facilities Handling Radioactive Materials*. Fire and smoke damper specifications shall include parameters to ensure satisfactory closure performance that addresses the total worst-case differential pressures at the damper under airflow conditions.

Technical Rationale–This criteria is necessary to specify a level of fire area performance that is acceptable to the NRC in order to limit damage between adjacent fire areas and their associated hazards. Specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and will not extend to involve SSCs in another fire area. This criteria is based on Regulatory Guide 1.189, Rev 0, Section 4.2.1.3, which specifies the criteria for ventilation system fire dampers.

4.8.1.7 Non-Nuclear Surface Facilities

Criteria–Automatic suppression shall be installed as determined by the fire hazards analysis as necessary to protect against fires and to limit the Maximum Possible Fire Loss (MPFL). The basis for the choice of particular system style for protection shall be described in the fire hazards analysis. Light hazard occupancy sprinkler system design densities shall not be used.

Technical Rationale–This criteria is necessary to specify a minimum level of protection that is acceptable to the DOE before an automatic fire protection system is required to limit damage from a fire. Specification of an appropriate and comprehensive fire protection system of sufficient capacity and capability will increase the likelihood that fires are satisfactorily controlled and extinguished. This criteria implements DOE Order 420.1, Change 3, and DOE Standard 1066-99, Sections 5.3.1, 5.3.2, and 7.1, which specify the criterion for fire protection when the MPFL exceeds $1 million.

4.8.1.8 Subsurface Development Area/ Construction Phase

Criteria–A Fire Command Center shall be provided on the surface for the use of fire fighting forces during an emergency in the subsurface. This may be co-located with other surface or subsurface control equipment, but shall meet the space and survivability criteria of NFPA 72-2002, *National Fire Alarm Code*, Section 6.9.6. The Fire Command Center shall have displays for the status of all detection, alarm, and communication systems in the subsurface. This shall be the principal location for handling a subsurface emergency and from where subsurface systems credited for fire and worker protection can be manually controlled. Status, display, and command override functions shall be provided for all credited subsurface ventilation system dampers and fan controls; all required status, display, communications and functional controls shall be monitored for integrity.

Technical Rationale–This criteria is necessary to specify that system design will be sufficiently comprehensive and adequate to provide an adequate level of life safety. Fire hazards with adequate fire protection system performance of sufficient capacity and capability, together with personnel specific egress features, will provide acceptable life safety for facility occupants to meet DOE criteria for occupant protection. This criteria is based on DOE Order 420.1, Change 3, Section 4.2, which specifies the criteria for minimum level of life safety performance to demonstrate that a facility occupants are adequately and appropriately protected from fire hazards.

4.8.1.9 Subsurface Emplacement Area/ Repository Phase

The design criteria and the manner of implementation for the subsurface will be determined at a later date.

4.8.1.10 Protection of Mobile Equipment

Criteria–Automatic fire detection and suppression of appropriate capacity and capability shall be installed as determined by the fire hazards analysis and as necessary to protect SSCs. The fire hazards analysis shall consider the worst case location and exposure impact to SSCs in determining the protection required. The agent used for automatic suppression shall be based on the fire hazards analysis and any potential nuclear safety concerns.

Technical Rationale–This criteria is necessary to specify a minimum threshold level for automatic fire system protection that is acceptable in order to limit damage from a fire. Specification of mobile equipment automatic suppression limits potential fire damage to SSCs and increases the likelihood that fires are promptly controlled and extinguished. This criteria is based on Regulatory Guide 1.189, Rev 0, Section 3.3, which specifies the criterion for the protection of ITS SSCs.

Criteria–The required mobile equipment fire detection and suppression system shall be designed to transmit signal(s) to the site fire alarm system to annunciate the equipment location and status whether within or exterior to any building, structure, or exterior area where the equipment is expected to operate. The manner in which this signal(s) is transmitted and received shall minimize against adverse effects to SSCs ITS.

Technical Rationale–This criteria is necessary to specify that system design will be sufficiently comprehensive and adequate to promptly control and extinguish a fire, and also protect against inadvertent release to affected SSCs caused by undesirable plant systems interaction. Fire protection systems of sufficient capacity and capability, with normal and abnormal system status indications, will enable fires to be controlled and extinguished. This criteria is based on Regulatory Guide 1.189, Rev 0, (Section B. GDC 3), which specifies the use of fire protection systems of appropriate capacity and capability be provided for the protected hazard.

4.8.1.11 Fire Protection System Redundancy

Criteria–Redundant fire protection systems shall be provided in areas containing ITS SSCs where the resulting protection would not otherwise ensure that the fire would be successfully controlled until such time that the emergency fire fighting forces are expected to arrive to complete fire extinguishment. Redundant fire protection could consist of duplicate localized hazard protection; or the installation of a local hazard fire suppression system together with an appropriately designed area fire suppression system that would protect the entire fire area or hazard space.

Technical Rationale–This criteria is necessary to specify that system design will be sufficiently comprehensive and adequate to limit damage, from a fire and from inadvertent release, to affected SSCs in a hazard area. Fire protection systems of sufficient capacity and capability, with normal and abnormal system status indications, will enable fires to be controlled and extinguished. This criteria is based on Regulatory Guide 1.189, Rev 0, (Section B. GDC 3), which specifies the use of fire protection systems of appropriate capacity and capability, and DOE G-440.1-5-1995, Section IV, 9.6, which specifies additional protection when the manual fire fighting force are delayed in effecting extinguishment.

4.8.1.12 Life Safety Provisions/Surface Facilities

Criteria–Acceptable life safety provisions shall be provided for all facilities. Compliance with NFPA 101-2000, the Life Safety Code is considered to satisfy DOE Order 420.1, Change 3.

Technical Rationale–This criteria is necessary to specify that system design will be sufficiently comprehensive and adequate to provide an adequate level of life safety. Fire hazards with adequate fire protection system performance of sufficient capacity and capability, together with personnel specific egress features, will provide acceptable life safety for facility occupants to meet DOE criteria for occupant protection. This criteria is based on DOE Order 420.1, Change 3, Section 4.2 and DOE Standard 1066-99, Section 10.1, which specify the criteria for minimum level of life safety performance to demonstrate that facility occupants are adequately and appropriately protected from fire hazards.

4.8.1.13 Life Safety Provisions/Subsurface Areas

The design criteria and the manner of implementation for the subsurface will be determined at a later date.

4.8.1.14 Firewater Subsystem

Firewater Storage

Criteria–The fire water supply for nuclear facilities shall be calculated on the basis of the largest expected flow rate for a period of two hours, but not less than 300,000 gallons. This flow rate shall be conservatively based on 500 gpm for manual hose streams plus the largest design demand of any sprinkler or deluge system as determined by hydraulic calculation. Firewater service to non-nuclear buildings, except the subsurface zone, may be serviced by the firewater system as permitted in the firewater subsystem criteria.

Technical Rationale–This criteria is necessary in order to specify a system design that will be sufficiently comprehensive and adequate to limit damage from a fire to affected SSCs in the hazard area. Fire protection systems of sufficient capacity and capability, with allowance for maintenance and other outages, will enable fires to be controlled and extinguished in sufficient time so that damage is minimized. This criteria is based on Regulatory Guide 1.189, Rev 0, Section 3.2.1.b, which specifies the use of fire protection systems of appropriate capacity and capability, be provided for the protected hazard.

Criteria–Two 100 percent system capacity dedicated firewater water supply tanks shall be installed. They shall be so interconnected that pumps can take suctions from either or both tanks; however, a failure in one tank or its piping shall not cause both tanks to drain. The site water supply system shall be capable of totally refilling either tank in eight continuous hours or less.

Technical Rationale–This criteria is necessary to specify that system design will be sufficiently comprehensive and adequate to limit damage from a fire to affected SSCs in the hazard area. Fire protection systems of sufficient capacity and capability, allowing for maintenance and other outages, will enable fires to be controlled and extinguished in sufficient time so that damage to SSCs is minimized. This criterion is based on Regulatory Guide 1.189, Rev 0, Sections 3.2.1.a and c, which specify the use of fire protection systems of appropriate capacity and capability for the protected hazard.

Firewater Pumping

Criteria–If fire pumps are provided, a sufficient number of pumps shall be provided to ensure that 100 percent capacity will be available assuming failure of the largest pump or loss of offsite power (e.g., three 50 percent pumps or two 100 percent pumps). This may be accomplished by providing a combination of electric motor-driven fire pumps and diesel-driven fire pumps.

Technical Rationale–This criteria is necessary to specify that system design will be sufficiently comprehensive and adequate to limit damage from a fire to affected SSCs in the hazard area. Fire protection systems of sufficient capacity and capability, allowing for maintenance and other outages, will enable fires to be controlled and extinguished in sufficient time so that damage to SSCs is minimized. This criteria is based on Regulatory Guide 1.189, Rev 0, Section 3.2.2, which specifies the use of fire protection systems of appropriate capacity and capability for the protected hazard.

Criteria–Individual fire pump connections to the yard fire main loop shall be separated with appropriate sectionalizing valves between connections. Diesel-driven fire pumps together with the pump driver and controls shall be located in a room separated from the remaining fire pumps by a firewall with a minimum fire rating of three hours. Fire pump status signals shall be provided to annunciate pump running, driver availability, failure to start, and low fire-main pressure to the main control room.

Technical Rationale–This criteria is necessary to specify that system design will be sufficiently comprehensive and adequate to limit damage from a fire to affected SSCs in the hazard area. Fire protection systems of sufficient capacity and capability, allowing for maintenance and other outages, will enable fires to be controlled and extinguished in sufficient time so that damage to SSCs is minimized. This criteria is based on Regulatory Guide 1.189, Rev 0, Sections 3.2.2.b and c, which specify the use of fire protection systems of appropriate capacity and capability for the protected hazard.

Firewater Distribution Piping

Criteria–The firewater distribution piping shall be of a looped type grid that provides two-way water flow; firewater piping, except the subsurface zone, shall be separate from all other water piping systems. Sectional valves shall be arranged to provide alternate water flow paths to any point in the system. The firewater loop shall be sized as required to furnish anticipated water criteria; the type of pipe and any required water treatment should consider the possible effects of tuberculation. Sectional control valves shall be provided to limit the number of hydrants and individual sprinkler systems made inoperative during a single line break or impairment to a maximum of five.

Technical Rationale–This criteria is necessary to specify a maximum level of fire system inoperability that is acceptable in order to limit damage from a fire. Specification of an upper limit in the number of suppression systems and hydrants out of service for an impairment increase the likelihood that fires are promptly controlled and extinguished. This criteria is based on Regulatory Guide 1.189, Rev 0, Sections 3.2.3.a and GDC 3, DOE Order 420.1 Change 3, and DOE Standard 1066-99, Section 6.2.2, which specify the criterion for the arrangement of the firewater distribution system.

Criteria–Control valves shall also be provided to isolate portions of the firewater subsystem serving SSCs, which are or contain SSCs ITS from portions of the firewater subsystem serving SSCs that are not or do not contain SSCs ITS, without simultaneously shutting off the firewater supply to areas containing SSCs ITS. The firewater distribution piping shall be capable of delivering this design demand over the longest piping route to the protected hazard. The distribution piping shall be capable of meeting the calculated design demand at a residual pressure not less than 20 psig at ground elevation.

Technical Rationale–This criteria is necessary to specify a maximum level of fire system inoperability that is acceptable in order to limit damage to SSCs important to safety in the event a fire. Specification of isolation valves to prevent the simultaneous unavailability of primary and backup suppression systems from any impairment increases the likelihood that fires are promptly controlled and extinguished. This criteria is based on Regulatory Guide 1.189, Rev 0, Sections 3.2.3.g and h and GDC 5, and DOE Standard 1066-99, Section 6.1.1, which specifies the criterion for the arrangement of the firewater distribution system in regard to impairment of the primary and backup fire suppression subsystem.

Criteria–Control and sectionalizing valves in fire mains and water-based fire suppression systems shall be electrically supervised. Electrical supervision signals shall transmit to the location of the fire alarm monitoring console. Control and sectional valves shall be a visually indicating type valves.

Technical Rationale–This criteria is necessary to specify a level of fire system status indication that is acceptable in order to limit damage from a fire. Specification of a valve type and its position supervision when out of service for impairment increases the likelihood that fires are promptly controlled and extinguished. This criteria is based on Regulatory Guide 1.189, Rev 0, Section 3.2.3.d, which specifies the criteria for the valve supervision of the firewater distribution system.

Criteria–Sprinkler systems and backup standpipe and hose stations shall be provided with connections to the firewater distribution system so that a single active failure or a line break will not simultaneously impair both the primary and backup fire suppression systems. Alternatively, firewater headers fed from two ends are permitted inside buildings to supply both sprinkler and standpipe subsystems. Such headers shall be considered an extension of the firewater distribution subsystem. Each sprinkler and standpipe system shall be separately equipped with a means to detect water flow and transmit a water flow condition to a remote location.

Technical Rationale–This criteria is necessary to specify a maximum level of fire system inoperability that is acceptable in order to limit damage from a fire. Specification of configuration limits the simultaneous impairment of primary and backup suppression systems out of service for impairment increases the likelihood that fires are promptly controlled and extinguished. This criteria is based on Regulatory Guide 1.189, Rev 0, Section 3.2.3.i, which specifies the criterion for the arrangement of the firewater distribution system.

- Fire Hydrants

Criteria–Fire hydrants shall be capable of providing the water flow rates established in the International Fire Code (ICC 2002) based on the most severe facility fire risk on site. This rate shall be reduced by a maximum of 50 percent, in accordance with DOE Std 1066-99, for automatic sprinkler protected facilities. Fire hydrants shall each be capable of flowing a minimum of 1500 gpm at 20-psig residual pressure.

Technical Rationale–This criteria is necessary to specify a defense-in-depth design that will be sufficiently comprehensive and adequate to limit damage from a fire should one of the systems not be able to perform as intended to control a fire in the hazard area. Establishment of fire hydrant minimum waterflow rates will ensure that sufficient capacity is available for manual fire fighting which will increases the likelihood that fires are promptly controlled and extinguished. This fire hydrant criteria is based on ICC 2002 Sections B102.1 and B105.2 and Table B105.1 and DOE Std 1066-99, Section 6.1.2.

Criteria–Fire hydrants shall be located so that a sufficient and effective hose stream can be provided to any onsite location where fixed or transient combustibles could jeopardize facility SSCs, both those ITS or those Conventional Quality. Hydrants shall be installed approximately every 250-ft. on the firewater distribution subsystem. Valves shall be installed to permit isolation of fire hydrants from other portions of the firewater distribution subsystem for maintenance or repair without interrupting the water supply to other portions of the distribution subsystem. Hose threads compatible with those used by local fire departments shall be provided on all hydrants, hose couplings, and standpipe risers consistent with NFPA 1963-1998, *Standard for Fire Hose Connections.*

Technical Rationale–This criteria is necessary to specify a maximum level of fire system inoperability that is acceptable to the NRC in order to limit damage from a fire. Specification of a subsystem configuration, which limits the simultaneous impairment of primary and backup suppression systems out of service for impairment, increases the likelihood that fires are promptly controlled and extinguished. This criteria is based on Regulatory Guide 1.189, Rev 0, Sections 3.2.3.h and 3.4.2, which specifies the criteria for the arrangement of the firewater distribution system.

Firewater Subsystem-Subsurface Zone

The design criteria for the separately piped and zoned subsurface firewater subsystem will be determined at a later date.

4.8.1.15 Fire Detection Subsystem

Criteria–Fire detection subsystems shall be provided in all areas that contain or present a fire exposure to SSCs important to safety (ITS). Fire detection subsystems comply with the criteria for Class A systems (NFPA 72-2002) and Class I circuits (NFPA 70-2002).

Technical Rationale–This criteria is necessary to specify a minimum threshold level for automatic fire detection system performance that is acceptable to limit damage from a fire. Specification of automatic detection performance limits potential fire damage to SSCs ITS and increases the likelihood that fires are promptly controlled and extinguished. This criteria is based on Regulatory Guide 1.189, Rev 0, Sections 3.1, 3.1.1.b, d, e, and i, which specify the criteria for the protection of ITS SSCs.

Criteria–Fire detection subsystems shall be capable of operating with or without offsite power.

Technical Rationale–This criteria is necessary to specify a level of fire detection subsystem performance that is acceptable in order to limit damage from a fire. Specification of the capability for the fire detection subsystem to detect fires when offsite power is both available and unavailable increases the likelihood that fires are promptly controlled and extinguished. This criteria is based on Regulatory Guide 1.189, Rev 0, Section 3.1, which specifies the criteria for the fire detection performance during normal and off normal conditions.

Criteria–Fire detection shall be provided for all other buildings and area where fire damage is postulated to occur per a fire hazards analysis and no other fire protection system is provided.

Technical Rationale–This criteria is necessary to specify performance for fire detection subsystems in buildings and areas, which would otherwise not be provided with fire suppression. Specification of a fire detection system will increase the likelihood that fires are promptly controlled and extinguished. This criteria implements DOE Order 420.1 Change 3, Section 4.2.2.6; and DOE G 440.1-5-1995, Section III, 2.0 and 6.6, and Section IV, 9.6, which specifies the criteria for fire protection when other fire suppression are not otherwise installed.

4.8.1.16 Fire Suppression Subsystem

Criteria–Automatic suppression shall be installed as determined by the fire hazards analysis and as necessary to protect ITS SSCs. The type of automatic suppression chosen for protection shall be based on the fire hazards analysis and any potential nuclear safety concerns.

Technical Rationale–This criteria is necessary to specify a minimum threshold level for automatic fire system protection that is acceptable in order to limit damage from a fire. Specification of automatic suppression protection limits potential fire damage to SSCs ITS and increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189, Rev 0, Section 3.3, which specifies the criteria for the protection of ITS SSCs.

Criteria–SSCs ITS that do not otherwise require protection by water-based suppression subsystems but are subject to unacceptable damage if wetted by water suppression discharge shall be appropriately protected by water shields or baffles.

Technical Rationale–This criteria is necessary to specify protection feature levels for automatic fire system protection to limit damage from unintended system discharge effects to SSCs. Specification of water shields or baffles where automatic suppression systems are located limits potential unintended damage to SSCs ITS. This criteria is based on Regulatory Guide 1.189, Rev 0, Section 3.3.1, which specifies the criterion for the protection of ITS SSCs.

Criteria–Water mist suppression subsystems shall be considered for use in specialized situations where the application of water needs to be restricted. The basis for selection of a water mist subsystem as for hazard protection shall be documented in the fire hazards analysis.

Technical Rationale–This criteria is necessary to specify a minimum threshold level for automatic fire system protection that is acceptable to limit damage from a fire. Specification of automatic suppression protection limits potential fire damage to SSCs ITS and increases the likelihood that fires are promptly controlled and extinguished. This criterion is based on Regulatory Guide 1.189, Rev 0, Sections 3.3.1 and 3.3.1.2, which specify the criteria for the protection of ITS SSCs.

Criteria–Hydraulically designed automatic and manual suppression subsystems shall be designed for a supply pressure of at least 10 percent but not less than 10 psig below the supply curve.

Technical Rationale–This criteria is necessary to specify a margin of safety in subsystem design that will be sufficiently comprehensive and adequate to limit damage from a fire should one of the systems not be able to perform as intended to control a fire in the hazard area. The specification of a safety margin in the design of fire suppression systems ensures that systems of sufficient capacity and capability will be available which will increase the likelihood that fires are promptly controlled and extinguished. This criteria implements DOE Order 420.1 Change 3, and DOE Standard 1066-99, Section 7.2, which specifies the criterion for hydraulic design of suppression systems in DOE facilities.

Criteria–Floor drains, curbs, ramps or sills shall be sized to accommodate anticipated fire fighting water without the flooding SSCs ITS in all areas where automatic or manual water fire suppression systems are installed. Facility design shall also ensure that firewater discharge in one area does not impact SSCs ITS in adjacent areas.. The size and method of collection for fire suppression water shall be determined in a manner consistent with NFPA 801-1998, *Standard for Fire Protection for Facilities Handling Radioactive Materials*.

Technical Rationale–This criteria is necessary to specify protection from accumulation of firewater system discharge at an acceptable level to limit damage from firewater flooding. Specification of protection from firewater flooding limits potential fire damage to SSCs ITS and increases the likelihood that necessary or inadvertent fire system discharges do not result in degraded SSC performance. This criteria is based on DOE Order 420.1, Section 4.2.3, Regulatory Guide 1.189, Rev 0, Section 4.1.5, and NFPA 801-1998, Section 3-10, which specify the criterion for the protection of ITS SSCs for inadvertent effects of firewater system discharge.

Criteria–Fire protection for high-efficiency particulate air (HEPA) filter combustion shall protect against the potential of spread fire to other facility areas. A fire hazards analysis shall determine the need for and the type of fire detection and suppression for the HEPA filters and their exposure to SSCs ITS.

Technical Rationale–This criteria is necessary to specify a minimum threshold level for automatic fire system protection that is acceptable to limit damage from a fire. Specification of automatic suppression protection limits potential fire damage to SSCs ITS and increases the likelihood that fires are promptly controlled and extinguished. This criteria is based on Regulatory Guide 1.189, Rev 0, Section 4.1.4, and DOE Standard 1066-99, Section 14, which specify the criteria for the protection of ITS SSCs.

Criteria–Foam water subsystems fire suppression protection shall be considered where significant flammable and combustible liquid fire hazards are present. This shall be documented in the fire hazards analysis.

Technical Rationale–Specification of an appropriate and comprehensive fire protection system of sufficient capacity and capability will increase the likelihood that fires are promptly controlled and extinguished before unacceptable fire losses incur. This criteria implements DOE Order 420.1 Change 3, and DOE Standard 1066-99, Sections 5.3.1 and 5.3.2, which specifies the criteria for fire protection when the MPFL exceeds $ 1 million.

Criteria–When the use of water sprinklers is precluded because of nuclear criticality or other incompatibility, non-aqueous extinguishing subsystems shall be used.

Technical Rationale–This criteria is necessary to specify fire protection means when firewater system discharge could produce an undesired criticality event. Specification of alternative fire protection agents will limit potential fire damage to SSCs ITS, increasing the likelihood that fire may still be controlled and extinguished as well the prevention a fire system agent discharge criticality event. This criteria is based on Regulatory Guide 1.189, Rev 0, Sections 3.3.1 and 3.3.2, which specify the criteria for protection using automatic suppression systems.

Criteria–Alternative halon or clean agent fire-extinguishing subsystems shall only use listed or approved agents. Provisions for locally disarming automatic systems shall be key-locked. The basis for selection of given clean agent subsystems for hazard protection shall be documented in the fire hazards analysis.

Technical Rationale–This criteria is necessary to specify a minimum threshold level for automatic fire system protection that is acceptable in order to limit damage from a fire. Specification of automatic suppression protection limits potential fire damage to SSCs ITS and increases the likelihood that fires are promptly controlled and extinguished. This criteria is based on Regulatory Guide 1.189, Rev 0, Sections 1.2, 3.3.2 and 3.3.2.3, which specify the criterion for the protection of ITS SSCs.

Criteria–The introduction of the fire-extinguishing agent into a compartment shall not result in over-pressurization and failure of the ventilation confinement system barrier.

Technical Rationale–This criteria is necessary to specify limits to fire protection agent discharge that could otherwise produce a loss of confinement. Specification of a limit on the pressure effects from alternative fire protection agent discharge will limit will allow a fire to be controlled and extinguished, as well as prevent potential loss of ventilation system confinement. This criteria is based on Regulatory Guide 1.189, Rev 0, Section 3.3.2, which specifies the criterion for protection using gaseous fire suppression systems.

4.8.1.17 Fire Alarm Subsystem

Criteria–The site fire alarm subsystem shall be designed to minimize the adverse effects of fires on SSCs ITS. The site fire alarm subsystem shall be a proprietary type system and shall be installed in all site buildings and areas to connect all active fire protection subsystems with the main fire alarm monitoring console and other required system interfaces. The fire alarm subsystem shall be capable of operating with or without offsite power.

Technical Rationale–This criteria is necessary to specify a level of fire alarm subsystem performance that is acceptable in order to limit damage from a fire. Specification of the capability for the fire alarm subsystem to transmit fire related signals when offsite power is available and unavailable increases the likelihood that fires are promptly controlled and extinguished before unacceptable fire losses incur. This criteria is based on Regulatory Guide 1.189, Rev 0, Sections 3.1, 3.1.1.a and f, which specify the criteria for fire alarm performance during normal and off normal conditions.

Criteria–Local fire alarm occupant notification shall be provided for the protected zone originating the alarm. A fire zone alarm panel or graphic zone alarm panel shall be provided at the main entrance to major facilities. A manual fire notification method, such as manual fire alarm station shall be provided at all normally occupied facilities.

Technical Rationale–This criteria is necessary to specify a level of fire alarm subsystem performance that is acceptable to the NRC and the DOE in order to limit damage from a fire. Specification of the capability for the fire alarm subsystem features at the local protected hazard area increases the likelihood that fires are promptly controlled and extinguished before unacceptable fire losses incur and to provide for acceptable levels of life safety. This criteria is based on Regulatory Guide 1.189, Rev 0, Section 3.1.1.d, DOE Order 420.1 Change 3, and DOE Standard 1066-99, Sections 8.1, and 8.2, which specify the criteria for fire alarm performance at the local protected hazard area.

Criteria–Signaling Line Circuits (SLC) serving the subsurface shall be separate from those serving surface facilities, except ventilation shaft fan houses.

Technical Rationale–This criteria is necessary to specify a level of fire alarm subsystem performance that is acceptable in order to limit damage from a fire. Specification of the separate signaling line circuits for the surface and subsurface reduces the probability that faults on the surface will not impact subsurface fire alarm capability and vice versa. This increases the likelihood that fires are promptly controlled and extinguished. This criteria is based on

Regulatory Guide 1.189, Rev 0, Section 3, which specifies the criteria for fire alarm performance.

4.8.1.18 Explosion Protection Subsystem

Criteria–In situ explosion hazards shall be identified and suitable protection provided. Transient explosion hazards that cannot be eliminated shall be controlled and suitable protection provided. Explosion hazards and their specific means of protection shall be discussed in the fire hazards analysis. NFPA 68-2002, *Guide for the Venting of Deflagrations*, and NFPA 69-2002, *Standard for Explosion Prevention Systems*, shall be used for the identification, evaluation and mitigation of explosive hazards.

Technical Rationale–This criteria is necessary to specify a level of explosion protection subsystem performance that is acceptable in order to limit damage from an explosion. Specification of the capability for the explosion protection subsystem increases the likelihood that an explosion is controlled and mitigated. This criteria is based on Regulatory Guide 1.189, Rev 0, Section 4.1.8, which specifies the criteria for explosion protection subsystem performance.

Criteria–Miscellaneous storage and piping for flammable or combustible liquids or gases shall not create a potential exposure hazard to SSCs ITS or to the fire protection subsystems that serve those areas of concern. Processes that may evolve hydrogen or explosive gases shall be designed to prevent development of explosive mixtures by limiting the concentration of explosive gases and vapors within enclosures to less than 50 percent of their lower explosive limit.

Technical Rationale–This criteria is necessary to specify a level of explosion protection subsystem performance that is acceptable in order to limit damage from an explosion. Specification of the capability for the explosion protection subsystem increases the likelihood that an explosion is controlled and mitigated before unacceptable damage occurs to SSCs. This criteria is based on Regulatory Guide 1.189, Rev 0, Section 4.1.8, which specifies the criteria for explosion protection subsystem performance.

Criteria–If the potential for an explosive mixture of hydrogen and oxygen exists in off gas systems, the systems shall either be designed to withstand the effects of a hydrogen explosion or be provided with dual automatic control functions to preclude the formation or buildup of explosive mixtures.

Technical Rationale–This criteria is necessary to specify a level of explosion protection subsystem performance that is acceptable to the NRC in order to limit damage from an explosion. Specification of the capability for the explosion protection subsystem increases the likelihood that an explosion is controlled and mitigated before unacceptable losses incur. This criteria is based on Regulatory Guide 1.189, Rev 0, Section 4.1.8, which specifies the criteria for explosion protection subsystem performance.

4.8.1.19 Fire Barrier Subsystem

Criteria–New permanent structures in excess of 5,000 square ft floor area shall be of noncombustible or fire resistive construction.

Technical Rationale–This criteria is necessary to specify performance for building construction type, which would otherwise not meet the improved risk criteria, which is acceptable to the DOE and will limit damage from fires. Specification of a building construction type will increase the likelihood that fire hazards are limited and controlled. This criteria implements DOE Order 420.1 Change 3, and DOE Standard 1066-99, Section 5.2.1, which specifies the criteria for building construction type when other criteria are not otherwise specified.

Criteria–Fire areas shall be separated from other portions of a building or facility (other fire areas) by suitable fire barriers, including suitably rated components of construction such as beams, joists, columns, penetration seals or closures, fire doors, and fire dampers. Fire barriers in buildings containing SSCs ITS shall define a fire area boundary and have a minimum fire resistance rating of three hours; exterior walls forming a portion of a fire area boundary may be unrated if there is no fire exposure or other over-riding requirement to the wall which would otherwise require the wall to be rated. The construction and performance of fire barrier walls and firewalls shall comply with NFPA 221-2000, *Standard for Fire Walls and Fire Barrier Walls*.

NOTE: Fire zones (fire area subdivisions) may be used to establish zones within fire areas where subdivision into other fire areas is not practical; fire zones shall be based on fire hazard analyses. Fire zone boundaries are usually not sufficient to protect from exposure fires within the same fire area.

Technical Rationale–This criteria is necessary to specify a level of fire area performance that is acceptable to the NRC in order to limit damage between adjacent fire areas and their associated hazards. Specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and not will extend to involve SSCs in another fire area. This criteria is based on Regulatory Guide 1.189, Rev 0, Section 4.1.2, which specifies the criteria for fire area construction and compartmentation.

Criteria–Fire areas shall be established in the fire hazards analysis. Fire areas shall be defined to separate SSCs ITS from potential fires in other areas containing conventional quality SSCs that could affect the ability of SSCs ITS to perform their safety function

Technical Rationale–This criteria is necessary to specify a level of fire area performance that is acceptable to the NRC in order to limit damage between adjacent fire areas and their associated hazards. Specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and will not extend to involve SSCs in another fire area. This criteria is based on Regulatory Guide 1.189, Rev 0, Section 4.1.2, which specifies the criteria for fire area construction and compartmentation.

Criteria–Fire areas shall be defined to the extent feasible to isolate fire hazards from SSCs ITS in order to limit damage from a single fire. Separate fire areas shall be employed to limit the spread of fires between similar SSC components, including those configurations where high concentrations of cables serve other components of the same respective SSC.

Technical Rationale–This criteria is necessary to specify a level of fire area performance that is acceptable in order to limit damage between different components of the same SSC from a given fire hazard. Specification of fire area parameters increases the likelihood that a fire is contained within the same fire area, will limit the scope of damage to a given SSC, and will not extend to involve additional components of the same SSC. This criteria is based on Regulatory Guide 1.189, Rev 0, Section 4.1.2, which specifies the criteria for fire area construction and compartmentation.

Criteria–Where fire area boundaries are not three hour rated; or not continuous from boundary to boundary, with all penetrations sealed equal to the required fire rating of the boundary; an evaluation shall be performed to assess the adequacy of the fire area boundary. This evaluation shall determine whether the fire area boundaries are adequate to withstand the hazards associated with the area and, as necessary, protect SSCs ITS in the area from a fire originating outside the area. Said evaluation shall be referenced or made part of the fire hazards analysis for the area of concern. Unsealed openings shall be identified and considered when evaluating the overall effectiveness of the barrier. If a fire area boundary contains major unprotected openings, such as hatchways or stairways, locations on either side of such a boundary shall be considered as part of a single fire area.

Technical Rationale–This criteria is necessary to specify a level of fire area performance that is acceptable to the NRC in order to limit damage between adjacent fire areas and their associated hazards. Specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and will not extend to involve SSCs in another fire area. This criteria is based on Regulatory Guide 1.189, Rev 0, Sections 1.8.7 and 4.1.2.1, which specifies the criteria for fire area construction and compartmentation.

Criteria–Exterior walls, including any penetrations, shall be qualified as rated fire barriers if they are required to protect SSCs ITS on the interior of the facility from in situ hazards located in the vicinity of the exterior wall. The exterior yard area (without fire barriers) shall be considered as one fire area, though it may consist of several fire zones. The surrounding native terrain and vegetation, considering the degree of spatial separation, shall also be evaluated for fire hazards to site SSCs.

Technical Rationale–This criteria is necessary to specify a level of fire area performance that is acceptable in order to limit damage between onsite fire areas and any offsite fire hazard exposure. Specification of this fire area parameter increases the likelihood that an exterior exposure fire is prevented from breaching the exterior fire area boundaries and will not extend to involve SSCs within the building. This criteria is based on Regulatory Guide 1.189, Rev 0, Section 4.1.2.1, which specifies the criteria for fire area construction and exposure to fire area boundaries.

Criteria–Building design shall ensure that openings through fire barriers are properly protected. Openings and penetrations through fire barriers that serve as fire area boundaries shall be appropriately sealed or protected to provide a minimum fire resistance rating equal to that required of the barrier. The construction and installation techniques for rated penetrations and openings through fire barriers shall be qualified by fire endurance tests conducted by nationally recognized laboratories. Structural steel whose sole purpose is to carry dynamic loads from a seismic event need not be protected solely to meet fire barrier criteria, unless the failure of any structural steel member owing to a fire could result in significant degradation of the fire barrier.

Technical Rationale–This criteria is necessary to specify a level of fire area performance that is acceptable in order to limit damage between adjacent fire areas and their associated hazards. Specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and will not extend to involve SSCs in another fire area. This criteria is based on Regulatory Guide 1.189, Rev 0, Sections 2.1.4, 4.1.2.1, 4.1.2.2, 4.2.1, 4.2.1.4, 4.2.2 and Appendix A, A-2, which specify the criteria for fire area construction and compartmentation.

Criteria–Fire barrier walls that also act as part of a radioactive material confinement structure shall be able to withstand the worst case fire condition assuming a loss of any active fire suppression systems within the fire area. The fire resistance of these fire area and confinement barrier enclosures shall be attained by the use of monolithic concrete construction.

Technical Rationale–This criteria is necessary to specify a level of fire area performance that is acceptable in order to limit fire damage and maintain confinement during a worst case fire exposure condition. Specification of this fire barrier performance increases the likelihood that a fire is prevented from breaching the fire area boundary and will not result in the loss of confinement for the structure. This criteria is based on Regulatory Guide 1.189, Rev 0, Section 4.1.2.1, which specifies the criteria for fire area construction, and DOE Standard 1066-99, Section 9.2.2 which specifies criteria for walls serving as fire barriers and confinement boundaries.

Criteria–Ventilation fire dampers shall be installed in ducts at fire barrier penetrations with a minimum fire rating of two hours or greater. Fire damper specifications shall include parameters to ensure satisfactory closure performance that addresses the total worst-case differential pressures at the damper under airflow conditions

Technical Rationale–This criteria is necessary to specify a level of fire area performance that is acceptable to the NRC in order to limit damage between adjacent fire areas and their associated hazards. Specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and will not extend to involve SSCs in another fire area. This criterion is based on Regulatory Guide 1.189, Rev 0, Section 4.2.1.3, which specifies the criteria for fire dampers used to maintain compartmentation.

Criteria–Fire barrier penetrations that also function as environmental isolation, pressure differential, or airborne radiation barriers shall be qualified by test to maintain barrier integrity under such conditions.

Technical Rationale–This criteria is necessary to specify a level of fire area performance that is acceptable to the NRC in order to limit damage between adjacent fire areas and their associated hazards. Specification of fire area parameters increases the likelihood that a fire is contained within the same fire area and will not extend to involve SSCs in another fire area. This criterion is based on Regulatory Guide 1.189, Rev 0, Section 4.2.1.4, which specifies the criteria for fire area construction and compartmentation.

Criteria–Fire barriers in non-nuclear buildings and areas shall comply with the criteria as stated for nuclear buildings, except that fire area boundaries shall have a minimum fire rating of two hours. In addition, separate evaluations are not required to justify exceptions to stated criteria; exceptions may be directly cited and justified in the fire hazards analysis for the area of concern.

Technical Rationale–This criteria is necessary to specify that the system design will be sufficiently comprehensive and adequate to provide an adequate level of life safety and property protection. Passive fire protection features with adequate fire protection system performance will provide acceptable life safety for facility occupants and property protection to meet DOE criteria. This criteria is based on DOE Order 420.1 Change 3, Section 4.2, DOE G 440.1-5-1995, Section IV, Paragraph 4.0, and DOE Standard 1066-99, Section 9, which specify the criteria for the minimum level of passive fire protection subsystem performance to demonstrate that a facility occupants and property are adequately and appropriately protected from fire hazards.

4.8.2 Surface Ventilation Design Criteria

4.8.2.1 Surface Ventilation Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Mechanical	Surface Ventilation*	ANSI/ANS-57.7-1988, ANSI/ANS-57.9-1992, ANSI/HFS 100-1988, ANSI/HPS N13.1. 1999, ANSI/ASHRAE 55(55a)-1995, ANSI/ASHRAE 62-1989, ASHRAE 2001, ASHRAE DG-1-93, ASME AG-1-1997, ASME N509-1989, ASME N510-1989, ERDA 76-21 (Burchsted et al. 1979), ESD-TR-86-278 (Smith and Mosier 1986), NFPA 90A 1999, ISO 9241-8-1997, SMACNA 1995, NFPA 801-1998
		RG 1.140 Rev 2, RG 1.52 Rev 2, RG 1.62 Rev 0, RG 3.18 Rev 0, RG 3.32 Rev 0, RG 3.49 Rev 0, RG 5.65, RG 8.8 Rev 3
		10 CFR 20, 29 CFR 1910, 40 CFR 50, 40 CFR 61, 10 CFR 63, 10 CFR 73
		NUREG-0700 1996 (NRC 1996), NUREG-0800 1987 (NRC 1987)
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21 (c)(2)), PRD-022, *Surface HVAC System Description Document* (BSC 2002g) and *Surface Industrial HVAC System Description Document* (BSCw). Determination of applicable sections of these codes and standards will be determined during the design process and in development of design products.

[2] These Regulatory Guides have been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guides will be determined during the design process and in development of design products that are impacted by these Regulatory Guides. Addressing these Regulatory Guides supports compliance with requirements in *Surface HVAC System Description Document* (BSC 2002g) and *Surface Industrial HVAC System Description Document* (BSC 2002w).

[3] Addressing Code of Federal Regulations supports compliance with requirements in PRD-015/P-015, PRD-015/P-020 and PRD-021. Determination of applicable sections of these documents will be determined during the design process and in development of design products.

[4] These NUREGs provides guidance on acceptable methods and approaches that could be utilized in MGR design

[5] None.

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

Criteria–The surface facilities of the MGR shall be provided with ventilation systems to ensure the indoor design environmental conditions for the health and safety of the facility workers, and shall limit the release of radioactive airborne contaminants for the protection of the public and the quality of the environment. The surface facilities shall be provided with the following types of ventilation systems:

1. Nuclear HVAC System for the confinement areas of the following waste handling and waste treatment facilities:

    - Dry Transfer Facility #1 (DF1)
    - Dry Transfer Facility #2 (DF2)
    - Low Level Waste Treatment Building
    - Remediation Building

2. Industrial HVAC System for the following uncontaminated (clean) areas or facilities

    - Non-Confinement areas of the waste handling and waste treatment facilities not served by the Nuclear HVAC System
    - Transporter Receipt Building
    - Disposal Canister Preparation Building
    - Heavy Equipment Maintenance Building
    - Support Areas and Offices
    - Computer/Control Rooms
    - Balance of Plant Facilities

Technical Rationale–The HVAC systems have been segregated based on their application to facilities that are important to safety or conventional quality

4.8.2.2 Nuclear HVAC System

4.8.2.2.1

Criteria–The nuclear HVAC system shall maintain the nominal indoor design temperatures defined in the following Table 4.8.2-1.

Table 4.8.2-1. Nominal Indoor Design Temperatures

Area	Summer/Winter (°F DB)
Normally Occupied Areas (e.g., Offices, Maintenance Areas, Access Control)	76°F / 72°F
Normally Unoccupied Areas (e.g., Mechanical & Electrical Equipment Rooms, Cask Receiving, Preparation & Handling Areas, Fuel Handling Areas, Disposal Canister Weld Areas, Waste Treatment Areas)	90°F / 65°F
Unoccupied Areas (e.g., Assembly and Transfer Cells, DC Handling Cells, Assembly Staging Areas, Waste Package Remediation, Lag Storage Areas)	104°F (max) /40°F (min)
Sensitive Electronics Equipment Areas (e.g., Control Rooms, Computer Room, Monitoring Rooms, etc.)	72°F / 72°F

NOTES: [a] Temperature control is not required during event sequence conditions such as loss of power or equipment failure. Further study is required to evaluate the impact of extreme low and high temperatures in all the listed areas.

[b] The values for the unoccupied areas are intended to protect equipment (e.g., electrical equipment without capacity deration) and to prevent freezing conditions during winter.

Technical Rationale–This criteria is based on the applicable comfort criteria in ANSI/ASHRAE 55(55a)-1992, including addenda 55a-1995 - *Thermal Environmental Conditions for Human Occupancy*. This is also in conformance with Appendix E of ANSI/ANS-57.7-1988, - *American National Standard Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type)*, Chapter 8 of 2001 ASHRAE *Fundamentals Handbook*, and Code identified and being procured.

4.8.2.2.2

Criteria–The nuclear HVAC system shall maintain nominal indoor relative humidity within the ranges defined in the following Table 4.8.2-2.

Table 4.8.2-2. Design Relative Humidity

Area	Summer/Winter
Normally Occupied Areas (e.g., Offices, Maintenance Areas, Access Control)	30%-60% / 30%-60%[b]
Normally Unoccupied Areas (e.g., Mechanical & Electrical Equipment Rooms, Cask Receiving & Handling Areas, Fuel Handling Areas, Lag Storage Area)	Humidity Control Not Required[a]
Unoccupied Areas (e.g., Assembly Cells, Canister Transfer Cells, Disposal Container Handling Cells)	Humidity Control Not Required[a]
Sensitive Electronics Equipment Areas	45%-55% / 45%-55%[a-b-c]

NOTES: [a] Special provisions may be provided for components with special humidity requirements.

[b] Humidity is not controlled during loss of power or equipment failure.

[c] Further study is required to evaluate the impact of humidity on sensitive electronic equipment.

Technical Rationale–This criteria is in accordance with the applicable comfort criteria in ANSI/ASHRAE 55(55a)-1992, including addenda 55a-1995 - *Thermal Environmental*

Conditions for Human Occupancy. This is also in conformance with Chapter 8 of 2001 ASHRAE *Fundamentals Handbook*, and Code which has been identified and is being procured.

4.8.2.2.3

Criteria–The nuclear HVAC system shall be designed based on the ambient (outdoor) design condition indicated in the following Table 4.8.2-3.

Table 4.8.2-3. Ambient (Outdoor) Design Condition

Parameters	Design Data	
Site: Mercury, Nevada	Latitude: 36.62° Longitude: 116.02° Elevation: 3310 feet	
	Frequency of Occurrence	Temperature
Heating Dry-Bulb	99.6%	24°F
Cooling Dry-Bulb	0.4%	102°F
Cooling Mean Coincident Wet Bulb	0.4%	65°F
Wet Bulb	0.4%	69°F
Dew Point	0.4%	64°F
Mean Coincident Dry-Bulb	0.4%	72°F
Range of Dry-Bulb		25.9°F

Technical Rationale–The outdoor design conditions are obtained from Tables 1A and 1B in Chapter 27 of the 2001 ASHRAE *Fundamentals Handbook*. This criteria establishes the outdoor design requirements for the heating and cooling load calculations. The selection of Mercury, Nevada as the representative site is appropriate due to its close proximity to the North Portal area. The data provided in the above Table 4.8.2-3 is not intended to be all-inclusive and additional data may be obtained from qualified sources to implement the requirement of the Energy Conservation Program. Deviation from the specific parameters must be documented.

4.8.2.2.4

Criteria–The nuclear HVAC system shall maintain the differential pressures between the prescribed contamination confinement areas of the facilities during normal operating mode and during an event sequence in accordance with the following Table 4.8.2-4

Table 4.8.2-4. Differential Pressures in Confinement and Non-Confinement Areas

Confinement Zone Classification	Definition	Pressure Requirement
Primary	Areas where radioactive materials or contamination is present during normal operations	-0.7 to -1.0 in. wg relative to Secondary -0.8 to -1.15 in. wg relative to Tertiary
Secondary	Areas where potential for contamination is greater than the tertiary, or could become contaminated from an abnormal event	-0.1 to -0.15 in. wg relative to Tertiary, and at least -0.25 in. wg relative to the atmosphere
Tertiary	Areas where potential for contamination is lesser than the secondary	-0.1 to -0.15 in. wg relative to atmosphere
Non-Confinement Area	Areas with no potential for contamination	Atmospheric to +0.15 in. wg

Technical Rationale–The confinement zone classification definitions and pressure requirements in Table 4.8.2-4 above were obtained from Sections 1 and 2 of ASHRAE DG-1-93, *Heating, Ventilating, and Air-Conditioning Design Guide for Department of Energy Nuclear Facilities.* Also conforms to the regulatory position described in Section C of Regulatory Guide 3.18, Rev 0, *Confinement Barriers and Systems for Fuel Reprocessing Plants,* and with Section C of Regulatory Guide 3.32, Rev 0, *General Design Guide for Ventilation Systems for Fuel Reprocessing Plants.*

4.8.2.2.5

Criteria–The nuclear HVAC system shall, in conjunction with physical barriers, divide and arrange the waste handling and treatment facilities into prescribed contamination confinement compartments based on their level of, or potential for, airborne radioactive or hazardous contamination. The confinement zone classification and boundaries shall be based on consideration of the type, quantity, physical and chemical form, and packaging of the nuclear materials handled by the facility. Engineering judgement based on past experience for similar application shall be used to determine the preliminary confinement zone boundaries. The final boundaries will be determined during the design process based on quantitative calculations of radioactive contaminants in the facility.

Technical Rationale–This criteria is in accordance with Section C of Regulatory Guide 3.18, Rev 0, *Confinement Barriers and Systems for Fuel Reprocessing Plants*, and Section C of Regulatory Guide 3.32, Rev 0, *General Design Guidelines for Ventilation Systems for Fuel Reprocessing Plants.*

4.8.2.2.6

Criteria–The nuclear HVAC system shall be designed such that the primary, secondary, tertiary, and the non-confinement areas ventilation system are separate and independent from each other.

Technical Rationale–This criteria is based on the general requirement of designing the ventilation system based on the level of potential for airborne radioactive contamination in accordance with Section 6.6 of ANSI/ANS-57.7-1988, *Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type)*, to reduce the potential for cross contamination within the facility. This criteria also supports the general requirement in 10 CFR 63.112(e)(1) which requires performance analysis of the SSCs that are important to safety to include consideration of a means to limit concentrations of radioactive materials in air. This criterion also supports the performance objective of 10 CFR 63.111(a)(1), which requires geologic repository operation area to meet the requirements of 10 CFR 20, *Standards for Protection Against Radiation.*

4.8.2.2.7

Criteria–The nuclear HVAC system shall provide once-through ventilation system in the primary and secondary confinement areas of the facilities as defined in Table 4.8.2-4.

Technical Rationale–This criterion supports the requirement in Section 6.6.2.2.3.1 of ANSI/ANS-57.7-1988, *Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type)*, which requires that subsystem with high potential for contamination be designed for once-through flow. This criterion is also based on the general requirement of 10 CFR 63.112(e)(1) which requires performance analysis of the SSCs that are important to safety to include consideration of a means to limit concentrations of radioactive materials in air. This criterion also supports the performance objective of 10CFR63.111(a)(1), which requires geologic repository operation area to meet the requirements of 10CFR20, *Standards for Protection Against Radiation.*

4.8.2.2.8

Criteria–The nuclear HVAC system utilizing the recirculation system for the tertiary and non-confinement areas shall be provided with outdoor air of no less than 10% of the total system supply airflow rate, or as required to maintain proper indoor air quality, for the safety, comfort, and health of the occupational workers in the normally occupied areas.

Technical Rationale–The required outdoor air is to meet the requirements in Table 2 of ANSI/ASHRAE 62-1989, *Ventilation for Acceptable Indoor Air Quality*. The 2001 ASHRAE *Fundamentals Handbook*, Chapter 26, Ventilation and Infiltration, state that the conventional air handling systems utilizing the recirculation systems provides approximately 10% to 40% outside air fraction for ventilation purposes.

4.8.2.2.9

Criteria–The nuclear HVAC supply subsystem shall be comprised of the necessary controls and interlocks, air handling units with filters and coils, supply fans and distribution ductwork, and balancing devices. The nuclear HVAC exhaust subsystem in the confinement areas shall be comprised of the necessary controls and interlocks, exhaust air cleanup units, exhaust fans and ductwork, and balancing devices.

Technical Rationale–This criteria is in accordance with ASME/AG-1-1997 - *Code on Nuclear Air and Gas Treatment*. This criterion is also in accordance with ASME N509-1989 - *Nuclear*

Power Plant Air-Cleaning Units and Components, and with ASME N510-1989 - *Testing of Nuclear Air Treatment Systems*.

4.8.2.2.10

Criteria–The nuclear HVAC system design utilizing a recirculation system for any contamination confinement area shall include at least one stage of HEPA filters.

Technical Rationale–This criteria is based on Sections 6.6.2.2.2.2 of ANSI/ANS-57.7-1988, *Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type)* which requires filtration of the recirculated air through a HEPA filter unit to prevent buildup of radioactive particulate in the air.

4.8.2.2.11

Criteria–The exhaust from the confinement areas through air cleaning units shall be provided with the required stages of 99.97 % High Efficiency Particulate Air (HEPA) filters, and prefilters and carbon adsorbers (if required), to assists in the removal of airborne radioactive contaminants. The required stages of HEPA filters will be determined during the design process by analyzing the derived air concentration (DAC) of radioactive particulate matter in the confinement areas.

Technical Rationale–This criteria is based on the general performance requirement of ANSI/ANS-57.7-1988, *Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type)*, which requires the ventilation system to be designed and installed with the capability to collect radioactive airborne particulates during normal operation of the facility. Sections 6.6.2.2.2.1 and 6.6.2.2.3.1 of ANSI/ANS-57.7-1988 requires the use of 90% prefilters and 99.97% HEPA filter banks for the confinement areas. Section 2.2.1 of ERDA 76-21, *Nuclear Air Cleaning Handbook, Design, Construction, and Testing of High-Efficiency Air Cleaning Systems for Nuclear Application*, requires two stages of HEPA filters in the air cleaning units for the primary confinement areas.

4.8.2.2.12

Criteria–The airflow capacity of a 24" x 24" x 11-1/2" HEPA filter module shall be 1000 cfm at clean filter resistance of 1 inch wg and the maximum size of an air cleaning unit shall be limited to 30,000 cfm.

Technical Rationale–This HEPA filter size is based on the requirement of Section 3.2.1 and Table 3.1 of ERDA 76-21, *Nuclear Air Cleaning Handbook, Design, Construction, and Testing of High-Efficiency Air Cleaning Systems for Nuclear Application*. The maximum size of the air cleaning unit is based on of Section 4.1 of ERDA 76-21, *Nuclear Air Cleaning Handbook, Design, Construction, and Testing of High-Efficiency Air Cleaning Systems for Nuclear Application* and paragraph 3.2 of NRC Regulatory Guide 1.140, Rev 2.

4.8.2.2.13

Criteria–The nuclear HVAC system shall be designed such that the confinement areas are provided with an air change frequency of 4 to 8 air changes per hour. Determination of the actual number of air changes will be determined during the design process by analyzing the derived air concentration (DAC) of radioactive particulate matter in the confinement areas, and will be compared with the cooling requirements for adequacy.

Technical Rationale–This criteria is based on the general requirement of Section 6 of ASHRAE DG-1-1993, *Heating, Ventilating, and Air-Conditioning Design Guide for Department of Energy Nuclear Facilities,* for contamination control and to preclude buildup of combustible or toxic gases from reaching dangerous level.

4.8.2.2.14

Criteria–The nuclear HVAC confinement exhaust air discharge for each waste handling and waste treatment building shall be provided with a dedicated elevated vent stack.

Technical Rationale–This criteria is based on qualitative economic and technical evaluation of individual building stack versus a centrally located stack for all the buildings. These options were presented and reviewed by the management and the individual building stack option was selected because of its flexibility to the modular phase of building construction and its ability to meet the allowable dispersion requirement.

4.8.2.2.15

Criteria–The nuclear HVAC confinement exhaust air discharge vent stack shall be sized for a minimum velocity of 2500 feet per minute and minimum height of 12 feet above the adjacent building roof line.

Technical Rationale–This criteria is based on the recommendation from Code, which has been identified and is being procured. The minimum velocity of 2500 feet per minute is to provide adequate plume rise and jet dilution, and to keep moisture and rain draining down the stack. The minimum stack height of 12 feet above the adjacent building roof line is based on Section 5.5.2 of ERDA 76-21, *Nuclear Air Cleaning Handbook, Design, Construction, and Testing of High-Efficiency Air Cleaning Systems for Nuclear Application*. This minimum stack height is to prevent recirculation of stack effluents into the air intake and to prevent accidental inhalation of potentially contaminated air by the maintenance personnel.

4.8.2.2.16

Criteria–The plant vent stack shall be provided with continuous air emission monitoring of the effluent air from the confinement areas. This design objective ensures that the maintenance personnel are forewarned of unsafe system conditions.

Technical Rationale–This criteria is in conformance with Section 6.6.2.2.3.4 of ANSI/ANS-57.9-1992, *Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type)*.

4.8.2.2.17

Criteria–The nuclear HVAC system configuration, operation, and maintenance activities shall incorporate as low as is reasonably achievable (ALARA) principles to maintain radiation doses to all occupational workers to below regulatory limits.

Technical Rationale–This criteria is in accordance with 10 CFR 20 - *Standard for Protection Against Radiation.*

4.8.2.2.18

Criteria–The nuclear HVAC system shall be designed to ensure that occupational doses are as low as is reasonably achievable in accordance with the project ALARA program goals. This design objectives ensures the system's continuous operation and readiness to perform its safety function while achieving the occupational ALARA goals during the planning, design, and operations phases.

Technical Rationale–This criteria is in accordance with the applicable guidelines of Regulatory Guide 8.8, Rev 3, *Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations will be as Low as is Reasonably Achievable.*

4.8.2.2.19

Criteria–The nuclear HVAC system shall be designed to provide an exhaust airflow pattern from areas of low potential for contamination to areas of higher potential for contamination.

Technical Rationale–This criteria is based on the general requirement of Figure 1-1 of ASHRAE DG-1-1993, *Heating, Ventilating, and Air-Conditioning Design Guide for Department of Energy Nuclear Facilities*. This criterion also supports the requirement in Section 6.6.2.1.2 of ANSI/ANS-57.7-1988, *Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type)*, to reduce the potential for cross contamination within the facility.

4.8.2.2.20

Criteria–The nuclear HVAC system shall maintain a controlled airflow path directed from the outside environment to areas of lesser potential for contamination, then to areas of greater potential for exposure to airborne radioactive materials. This limits the spread or releases of those airborne radioactive materials and helps to reduce the potential for cross-contamination between areas within the confines of the nuclear facilities.

Technical Rationale–This criteria is in accordance with Section 6.6.2.1.2 of ANSI/ANS-57.7-1988, *Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type).*

4.8.2.2.21

Criteria–The nuclear HVAC system shall be capable of isolating areas or zones subject to contamination by airborne radioactive materials from those that have no potential for contamination by those materials.

Technical Rationale–This criteria is in accordance with Section 5.6 of ANSI/ANS-57.7-1988, *Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type).*

4.8.2.2.22

Criteria–The nuclear HVAC system shall be provided with filters at the inlet air to prevent accumulation of nuisance dust or other toxic particulate matter in the facility. Adequate filtration of the inlet air is required to reduce the accumulation of nuisance dust on the potentially contaminated exhaust filters in the air cleanup units.

Technical Rationale–This criteria is in accordance with Section 6.6.2.1 of ANSI/ANS-57.7-1988, *Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type).*

4.8.2.2.23

Criteria–The nuclear HVAC system shall be provided with all the necessary instrumentation and control hardware that directly operates, controls, monitors, alarms, and provide equipment status required to identify the meaning and significance of the conditions for the functions identified in Table 4.8.2-5.

Table 4.8.2-5. System Monitoring, Status, and Alarm Functions

Requirements	Location / Characteristics
Space Temperature	Indication and control of air temperature at strategic locations of the systems and in the waste handling and waste treatment facilities
Air Flow Rate	All filter trains, stack exhaust
Differential Pressure	Filters, moisture eliminators, and at strategic locations of the waste handling and waste treatment facilities, which require specific pressure differential control with respect to other areas or the outside atmosphere
Radiation Level Indication and Monitoring	Indication of radiation level at the HEPA filtration units and at the stack discharge to ALARA.
Smoke/High Heat Detection	Detection interface with the fire protection system for protection ventilation ductwork and final exhaust units
On-Off Status	Status for all electrically powered or controlled equipment
Open-Closed Status	Status for all motor and air operated valves and dampers
Failure Alarms	Alarm the failure of all equipment and components

NOTES: The following issues will be identified in a future revision:

a The system manual and automatic start, operation, and stop controls.

b The system operator control panels, indicators, and alarms.

c The system instrumentation and control hardware ranges, setpoints, and nominal operating value.

d The system instrumentation and control hardware subject to technical specification requirements.

Technical Rationale–The nuclear HVAC system provides the means to monitor and limit the spread or release of radioactive contaminants. It facilitates prompt termination of operations and permit evacuation of personnel during an emergency. Instrumentation (with appropriate alarm setpoints) for the air cleaning units are specified in Section 4.9.2 and Tables 4-1 and 4-2 of ASME N509-1989, *Nuclear Power Plant Air-Cleaning Units and Components*, in Section 5.6 of ERDA 76-21, *Nuclear Air Cleaning Handbook, Design, Construction, and Testing of High-Efficiency Air Cleaning Systems for Nuclear Application*, and in Section IA of ASME AG-1-1997, *Code on Nuclear Air and Gas Treatment*.

4.8.2.2.24

Criteria–Ductwork conveying air that is normally contaminated with airborne radioactive contaminants, or those ductwork with great potential for being contaminated by airborne radioactive contaminants shall be designed to prevent accumulation or trapping of such contaminants, and shall be provided with access doors or hatches at strategic and accessible locations.

Technical Rationale–This criteria is in conformance with the requirements of Section 2.3.8 of ERDA 76-21, *Nuclear Air Cleaning Handbook, Design, Construction, and Testing of High-Efficiency Air Cleaning Systems for Nuclear Application*.

4.8.2.2.25

Criteria–The nuclear HVAC system shall permit periodic inspection, in-place testing, and maintenance of the system's equipment and components.

Technical Rationale–This criteria is in conformance with the requirements in 10 CFR 63.112(e)(13), and with Section 2.3.8 of ERDA 76-21, *Nuclear Air Cleaning Handbook, Design, Construction, and Testing of High-Efficiency Air Cleaning Systems for Nuclear Application.*

4.8.2.2.26

Criteria–The nuclear HVAC system shall facilitate safe decontamination, dismantlement, and removal of structures, systems, or components. This criteria specifies general performance requirements to limit radiation exposures and spread or releases of airborne radioactive material.

Technical Rationale–This criteria is in accordance with 10 CFR 63.52.

4.8.2.2.27

Criteria–The nuclear HVAC system shall be provided with sufficient redundancy and/or standby units to ensure its continued operation in the event of a failure of any of its components during normal operation and during an event sequence, or during maintenance.

Technical Rationale–This criteria meets the requirement of Section 9 of ASHRAE DG-1-1993, *Heating, Ventilating, and Air-Conditioning Design Guide for Department of Energy Nuclear Facilities.*

4.8.2.2.28

Criterion–The nuclear HVAC system shall interface with the fire protection features, such as fire rated barriers, fire suppression, fire detection, and with the alarm system. The system shall be constructed from non-combustible and heat resistant materials and located so it can continue to perform its safety function effectively under a credible fire event sequence.

Technical Rationale–This criteria is in accordance with the criteria specified in Section 4.8.1, and with the applicable requirements specified in Chapter 3, Section 3-9 of NFPA 801-1998, *Standard for Fire Protection for Facilities Handling Radioactive Materials.*

4.8.2.2.29

Criteria–The nuclear HVAC system shall interface with the Site Radiological Monitoring System to provide continuous monitoring for radioactive contaminants in the system's exhaust air during normal operation and during an event sequence.

Technical Rationale–This criteria is in accordance with the criteria specified in Section 4.6.2, and with the applicable requirements in Section 6.5.3 of ANSI/ANS--57.9-1992, *Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type).* The referenced documents establish the minimum instrumentation and controls required to assess system performance and continuous monitoring (and alarm) of radioactive level in the ventilation exhaust system. This is also in conformance with ANSI/HPS N13.1. 1999. *American National Standard Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities.*

4.8.2.2.30

Criteria–The nuclear HVAC system shall interface with the Digital Control and Management Information System and the Normal Electrical Power System, and if required with the Emergency or Standby Electrical Power System.

Technical Rationale–This criteria is required for providing reliable power and control management to ensure continuous operation and continuous monitoring of the Nuclear HVAC System.

4.8.2.2.31

Criteria–The nuclear HVAC system design shall include environmental, safety, and health requirements related to personnel safety and Occupational Safety and Health Administration considerations. Included are considerations to minimize noise and confined spaces that may compromise work during component installation, maintenance, and/or replacement. This also ensures that all rotating equipment or moving parts are adequately provided with safety enclosures, guardrails or safety screens, safety disconnect switches, and lighting to protect personnel from accidentally getting caught in the rotating machine during all system operating or maintenance modes.

Technical Rationale–This criteria is in accordance with Section 6.6.2.1.4 of ANSI/ANS-57.7-1988, *Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type)*, and 29 CFR 1910, *OSHA Safety and Health Standards*.

4.8.2.2.32

Criteria–The nuclear HVAC system components located within the confines of the facility shall be designed to operate in the environmental conditions (temperature and humidity) as defined in Tables 4.8.2-1 and 4.8.2-2, and as required for expected radiation levels.

Technical Rationale–This criteria establishes the equipment environmental compatibility in accordance with Section 6.9.2 of ANSI/ANS-57.7-1988, *American National Standard Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type)*. This standard states: "System components shall be designed and qualified to operate within environmental limits established for their location within the installation including but not limited to, temperature, humidity, and radiation levels for the applicable performance requirements."

4.8.2.2.33

Criteria–The nuclear HVAC system components located outdoors shall be designed for the maximum wind speed that is specified in Section 6.1, Natural Phenomena, of this document. Wind is an environmental parameter that can affect buildings and structures located outside.

Technical Rationale–This criteria ensures that outdoor components are adequately protected from the wind and can perform their design operation and readiness function in accordance with the requirements of 10 CFR 63.112(e).

4.8.2.2.34

Criteria–The nuclear HVAC system components located outdoors shall be designed to operate in the extreme outside (ambient) temperature specified in Section 6.1, Natural Phenomena, of this document.

Technical Rationale–The outside temperature is an environmental condition that affects component performance or result in their accelerated degradation. This criteria establishes the outdoor temperature range in which the system's components are expected to operate in accordance with the equipment manufacturer recommendations to ensure system's continued operation and readiness.

4.8.2.2.35

Criteria–The nuclear HVAC system components located outside shall be designed for an external environment with maximum daily snowfall and precipitation as specified in Section 6.1, Natural Phenomena, of this document.

Technical Rationale–This criteria is in accordance with Section 2.3.3 of ERDA 76-21, *Nuclear Air Cleaning Handbook, Design, Construction, and Testing of High-Efficiency Air Cleaning Systems for Nuclear Application*, which emphasizes the importance of protecting the supply air intakes from the environmental elements. Similar requirements are invoked in Sections 6.4.4.1.3 and 6.4.4.1.4 of ANSI/ANS-57.9-1992, *Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type)*. This requirement establishes the snowfall and precipitation conditions in which the system's components are expected to operate to ensure the system's continued operation and readiness in accordance with the equipment manufacturer recommendations.

4.8.2.2.36

Criteria–The nuclear HVAC system components located outside shall be designed for the ambient relative humidity environment specified in Section 6.1, Natural Phenomena, of this document.

Technical Rationale–This criteria is in accordance with Section 2.3.3 of ERDA 76-21, *Nuclear Air Cleaning Handbook, Design, Construction, and Testing of High-Efficiency Air Cleaning Systems for Nuclear Application,* which emphasizes the importance of protecting the supply air intakes from the environmental elements. Similar requirements are invoked in Sections 6.4.4.1.3 and 6.4.4.1.4 of ANSI/ANS-57.9-1992, *Design Criteria for an Independent Spent Fuel Storage*

Installation (Dry Type). This requirement establishes the external environment humidity in which the system's components are expected to operate to ensure the system's continued operation and readiness in accordance with the equipment manufacturer recommendations.

4.8.2.2.37

Criteria–The nuclear HVAC system components susceptible to blockage or damage by sand (e.g., air intake system and outdoor units) shall be protected from and designed to operate in sandstorms.

Technical Rationale–This criteria is in accordance with Section 2.3.3 of ERDA 76-21, *Nuclear Air Cleaning Handbook, Design, Construction, and Testing of High-Efficiency Air Cleaning Systems for Nuclear Application,* which emphasizes the importance of protecting the supply air intakes from the environmental elements. Similar requirements are invoked in Sections 6.4.4.1.3 and 6.4.4.1.4 of ANSI/ANS-57.9-1992 - *Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type)*. This requirement establishes effect of sandstorms on the air intake systems and on the outdoor equipment coatings and seals.

4.8.2.2.38

Criteria–The nuclear HVAC system components that provides confinement and filtration of airborne radioactivity, if required, shall be designed to function during and after a design basis earthquake.

Technical Rationale–This criteria supports the general requirement in 10 CFR 63.112(e)(8) which requires performance analysis of the SSCs that are important to safety to include consideration of the ability to perform their intended safety functions assuming the occurrence of an event sequence.

4.8.2.2.39

Criteria–The nuclear HVAC system components that provides confinement and filtration of airborne radioactivity shall be designed, if required, to function following a design basis tornado.

Technical Rationale–This criteria supports the general requirement in 10 CFR 63.112(e)(8) which requires performance analysis of the SSCs that are important to safety to include consideration of the ability to perform their intended safety functions assuming the occurrence of an event sequence. The parameters for the tornado loads are in accordance with paragraph 4.2.2.3.7 of this document.

4.8.2.2.40

Criteria–The nuclear HVAC system design shall ensure that the coating and materials of construction of the system components shall be compatible with other mechanical components, as well as with the waste forms being handled, and any deleterious chemicals resulting from process functions.

Technical Rationale–This criteria complies with Section 6.6 of ANSI/ANS-57.7-1988, *Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type)* and also with Section 6.5 of ANSI/ANS-57.9-1992, *Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type).*

4.8.2.2.41

Criteria–The Nuclear HVAC system ductwork, air cleaning units and components shall be designed, constructed and supported to remain in-place during normal operation and including an event sequence, and the pressure boundary leakage shall be limited to that allowed by the system functional and environmental design requirements.

Technical Rationale–This criteria is in accordance with SMACNA-1995, *HVAC Duct Construction Standards,* and with Section SA and TA of ASME AG-1-1997, *Code on Nuclear Air and Gas Treatment.*

4.8.2.2.42

Criteria–The design of the nuclear HVAC system shall be in accordance with the physical security criteria applicable to the MGR facilities. Physical barriers, if required, shall be provided in the outside air intake and exhaust openings to provide delay to forced entry into the protected or restricted areas of the facility.

Technical Rationale–This complies with the requirements of 10 CFR 73, *Physical Protection of Plants and Materials*, and also with Regulatory Guide 5.65, *Vital Area Access Controls, Protection of Physical Security Equipment, and Key and Lock Controls.*

4.8.2.2.43

Criteria–The nuclear HVAC system total air and water subsystems shall be tested, balanced, and adjusted.

Technical Rationale–The criteria is in accordance with the requirement specified in a Code, which has been identified and is being procured.

4.8.2.3 Industrial HVAC System

4.8.2.3.1

Criteria–The industrial HVAC system shall maintain the nominal indoor design temperatures defined in Table 4.8.2-7.

Table 4.8.2-7. Nominal Indoor Design Temperatures

Area	Summer/Winter (°F DB)
Normally Occupied Areas (e.g., Offices, Access Control, etc.)	76°F / 72°F
Normally Unoccupied Areas (e.g., Mechanical & Electrical Equipment Rooms, Warehouses, Shops, etc.)	104°F / 65°F
Sensitive Electronics Equipment Areas (e.g., Control Rooms, Computer Rooms, Monitoring Rooms, etc.)	72°F / 72°F

NOTE: Temperature control is not required during event sequence conditions such as loss of power or equipment failure.

Technical Rationale–This criteria is in accordance with the applicable comfort criteria in ANSI/ASHRAE 55(55a)-1992, including addenda 55a-1995 - *Thermal Environmental Conditions for Human Occupancy*. This is also in conformance with ANSI/ANS-57.7-1988, Appendix E - *American National Standard Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type)*, Chapter 8 of 2001 ASHRAE *Fundamentals Handbook*, and Code, which has been identified and is being procured.

4.8.2.3.2

Criteria–The industrial HVAC system shall maintain nominal indoor relative humidity within the ranges defined in Table 4.8.2-8.

Table 4.8.2-8. Design Relative Humidity

Area	Summer/Winter
Normally Occupied Areas (e.g., Offices, Access Control, etc.)	30%-60% / 30%-60%[b]
Normally Unoccupied Areas (e.g., Mechanical & Electrical Equipment Rooms, Warehouses, Shops, etc.)	Humidity Control Not Required[a]
Sensitive Electronics Equipment Areas (e.g., Control Rooms, Computer Rooms, Monitoring Rooms, etc.)	45%-55% / 45%-55%[a-b-c]

NOTES: [a] Special provisions may be provided for components with special humidity requirements.

[b] Humidity is not controlled during loss of power or equipment failure.

[c] Further study is required to evaluate the impact of humidity on sensitive electronic equipment.

Technical Rationale–This criteria is in accordance with the applicable comfort criteria in ANSI/ASHRAE 55(55a)-1992, including addenda 55a-1995 - *Thermal Environmental Conditions for Human Occupancy*. This is also in conformance with Chapter 8 of 2001 ASHRAE *Fundamentals Handbook*, and Code, which has been identified and is being procured.

4.8.2.3.3

Criteria–The industrial HVAC system shall be designed based on the ambient (outdoor) design condition indicated in Table 4.8.2-9.

Table 4.8.2-9. Ambient (Outdoor) Design Condition

Parameters	Design Data			
Site: Mercury, Nevada	Latitude: 36.62° Longitude: 116.02° Elevation: 3310 feet			
	Use for Personnel Comfort System		Use where Close Temperature or Humidity is Required	
	Frequency of Occurrence	Temperature	Frequency of Occurrence	Temperature
Heating Dry-Bulb	99%	28°F	99.6%	24°F
Cooling Dry-Bulb	1%	100°F	0.4%	102°F
Cooling Mean Coincident Wet Bulb	1%	64°F	0.4%	65°F
Wet Bulb	1%	67°F	0.4%	69°F
Dew Point	1%	60°F	0.4%	64°F
Mean Coincident Dry-Bulb	1%	77°F	0.4%	72°F
Range of Dry-Bulb		25.9°F		25.9°F

Technical Rationale–The outdoor design conditions are obtained from Tables 1A and 1B in Chapter 27 of the 2001 ASHRAE *Fundamentals Handbook*. This criterion establishes the outdoor design requirements for the heating and cooling load calculations. The selection Mercury, Nevada as the representative site is appropriate due to its close proximity to the North Portal area. The data provided in Table 4.8.2-9 is not intended to be all-inclusive and additional data may be obtained from qualified sources to implement the requirement of the Energy Conservation Program. Deviation from the specific parameters must be documented.

4.8.2.3.4

Criteria–The industrial HVAC system utilizing the recirculation system shall be provided with outdoor air of no less than 10 percent of the total system supply airflow, or as required to maintain proper indoor air quality and slight pressurization relative to atmosphere, or to adjacent confinement areas.

Technical Rationale–The required outdoor air is to meet the requirements of ANSI/ASHRAE 62-1989, Table 2, *Ventilation for Acceptable Indoor Air Quality* for the safety, health and comfort of the occupational workers, and to minimize infiltration of unconditioned air and/or nuisance dust during normal operation. The 2001 ASHRAE *Fundamentals Handbook*, Chapter 26, Ventilation and Infiltration, state that the conventional air handling systems utilizing the recirculation systems provides approximately 10 percent to 40 percent outside air fraction for ventilation purposes.

4.8.2.3.5

Criteria–The industrial HVAC system design shall be designed such that the normally occupied areas are provided with a circulation air change frequency of 4 to 10 air changes per hour. If the area has high internal heat gain, an air change of frequency of 10 air changes per hour shall be provided. The actual number of air changes will be determined during the design process and will be compared with the actual cooling or makeup air requirements for adequacy.

Technical Rationale–This criterion is to provide sufficient air movement in the occupied areas and to maintain proper air quality standards. The range of the air change frequency is based on Code, which has been identified and is being procured.

4.8.2.3.6

Criteria–The industrial HVAC system design shall include environmental, safety, and health requirements related to personnel safety and Occupational Safety and Health Administration considerations. Included are considerations to minimize noise and confined spaces that may compromise work during component installation, maintenance, and/or replacement. This also ensures that all rotating equipment or moving parts are adequately provided with safety enclosures, guardrails or safety screens, safety disconnect switches, and lighting to protect personnel from accidentally getting caught in the rotating machine during all system operating or maintenance modes.

Technical Rationale–This criteria is in accordance with 29 CFR 1910, *Occupational Safety and Health Standards*.

4.8.2.3.7

Criteria–The industrial HVAC system components located within the confines of the facilities shall be designed to operate in the environmental conditions (temperature and humidity) as defined in Tables 4.8.2-7 and 4.8.2-8.

Technical Rationale–This criteria establishes the conditions in which the system components are expected to operate in accordance with the equipment manufacturer recommendation to ensure the system's continued operation and readiness.

4.8.2.3.8

Criteria–The industrial HVAC system components located outdoors shall be designed for the maximum wind speed that is specified in Section 6.1, Natural Phenomena, of this document. Wind is an environmental parameter that can affect buildings and structures located outside.

Technical Rationale–The criteria ensures that outdoor components are adequately protected from the wind and can perform their operation function in accordance with the requirements of 10 CFR 63.112(e).

4.8.2.3.9

Criteria–The industrial HVAC system components located outdoors shall be designed to operate in the extreme outside (ambient) temperature specified in Section 6.1, Natural Phenomena, of this document.

Technical Rationale–The outside temperature is an environmental condition that affects component performance or result in their accelerated degradation. This criteria establishes the outdoor temperature range in which the system's components are expected to operate in accordance with the equipment manufacturer recommendations to ensure system's continued operation and readiness.

4.8.2.3.10

Criteria–The industrial HVAC system components located outdoors shall be designed for an external environment with maximum daily snowfall and precipitation as specified in Section 6.1, Natural Phenomena, of this document. This emphasizes the importance of protecting the supply air intakes from the environmental elements.

Technical Rationale–This criteria establishes the snowfall and precipitation conditions in which the system's components are expected to operate to ensure the system's continued operation and readiness in accordance with the equipment manufacturer recommendations.

4.8.2.3.11

Criteria–The industrial HVAC system components located outdoors shall be designed for the ambient relative humidity environment specified in Section 6.1, Natural Phenomena, of this document.

Technical Rationale–This criteria establishes the external environment humidity in which the system's components are expected to operate to ensure the system's continued operation and readiness in accordance with the equipment manufacturer recommendations.

4.8.2.3.12

Criteria–The industrial HVAC system components susceptible to blockage or damage by sand (e.g., air intake system and outdoor units) shall be protected from and designed to operate in sandstorms. This emphasizes the importance of protecting the supply air intakes from the environmental elements.

Technical Rationale–This criteria establishes the effect of sandstorms in which the system's components are expected to operate to ensure the system's continued operation and readiness in accordance with the equipment manufacturer recommendations.

4.8.2.3.13

Criteria–The industrial HVAC system ductwork and components shall be designed, constructed and supported to remain in-place during normal operation and including an event sequence if required. The pressure boundary leakage shall be limited to that allowed by the system functional and environmental design requirements.

Technical Rationale–This criteria is in accordance with SMACNA-1995, *HVAC Duct Construction Standards* and with Section SA and TA of ASME AG-1-1997, *Code on Nuclear Air and Gas Treatment*.

4.8.2.3.14

Criteria–The industrial HVAC system shall be provided with fire protection features to operate in conjunction with the fire rated barriers, fire suppression, fire detection, and with the fire alarm system. The system shall be constructed from non-combustible and heat resistant materials and located so it can continue to perform its function effectively under a credible fire event sequence.

Technical Rationale–This criteria is in accordance with the criteria specified in Section 4.8.1 of this document.

4.8.2.3.15

Criteria–The industrial HVAC system total air and water subsystems shall be tested, balanced, and adjusted.

Technical Rationale–This criteria is in accordance with the criteria specified in the Code, which has been identified and is being procured.

4.8.3 Subsurface Ventilation Design Criteria

4.8.3.1 Subsurface Ventilation Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Mechanical	Subsurface Ventilation*	ANSI N13.8-1973, ASHRAE 2001, ICC-2000 (IBC), MIL-STD-1472E 1996, NFPA 90A 1999, ACGIH 2001
		RG 3.18 Rev 0, RG 3.32 Rev 0
		10 CFR 20, 29 CFR 1910, 29 CFR 1926, 10 CFR 63
		None
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21 (c)(2)), PRD-022 and *Subsurface Ventilation System Description Document* (BSC 2003a). Determination of applicable sections of these codes and standards will be determined during the design process and in development of design products.

[2] These Regulatory Guides have been assessed to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guides will be determined during the design process and in development of design products that are impacted by these Regulatory Guides. Addressing these Regulatory Guides supports compliance with requirements in *Subsurface Ventilation System Description Document* (BSC 2003a).

[3] Addressing Code of Federal Regulations supports compliance with requirements in PRD-015/P-015, PRD-015/P-020 and PRD-015/P-021. Determination of applicable sections of these documents will be determined during the design process and in development of design products.

[4] None.

[5] None

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

Subsurface Ventilation Design Criteria

IMPORTANT NOTE REGARDING MSHA (30 CFR 57)

DOE is not subject to the Federal Mine Safety and Health Act (MSHA) of 1977, as to the construction and operation of any facilities in the GROA. However, some worker protection provisions of MSHA may be used as guidance in the subsurface design of SSCs in the GROA.

By using such guidance, there is no explicit or implicit expectation other than its use in the Project Design Criteria document. DOE is not obligated to comply with any aspect of MSHA and that the Mine Safety and Health Administration has no jurisdiction or enforcement authority over construction or operation of any facility of the MGR.

4.8.3.2 Control of access to high radiation areas

Criteria

(a) The licensee shall ensure that each entrance or access point to a high radiation area has one or more of the following features

(1) A control device that, upon entry into the area, causes the level of radiation to be reduced below that level at which an individual might receive a deep-dose equivalent of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates;

(2) A control device that energizes a conspicuous visible or audible alarm signal so that the individual entering the high radiation area and the supervisor of the activity are made aware of the entry; or

(3) Entryways that are locked, except during periods when access to the areas is required, with positive control over each individual entry.

(b) In place of the controls required by paragraph (a) of this section for a high radiation area, the licensee may substitute continuous direct or electronic surveillance that is capable of preventing unauthorized entry. [10 CFR 20.1601]

(c) The licensee shall institute additional measures to ensure that an individual is not able to gain unauthorized or inadvertent access to areas in which radiation levels could be encountered at 500 rads (5 grays) or more in 1 hour at 1 meter from a radiation source through which the radiation penetrates. [10 CFR 20.1602]

***Technical Rationale*–**This is to ensure that the regulatory mandated access controls to high radiation area are incorporated into the subsurface ventilation system.

4.8.3.3 Monitoring Program General Requirements

Criteria

(d) The program must be implemented so that:

(2) It provides baseline information and analysis of that information on those parameters and natural processes pertaining to the geologic setting that may be changed by site characterization, construction, and operational activities.

(3) It monitors and analyzes changes from the baseline condition of parameters that could affect the performance of a geologic repository. [10 CFR 63.131d, 2 and 3].

***Technical Rationale*–**This is to ensure that the subsurface ventilation system includes interface with general requirements of the monitoring program.

4.8.3.4 Contaminant Control General Requirement

Criteria

General–Whenever hazardous substances such as dusts, fumes, mists, vapors, or gases exist or are produced in the course of construction work, their concentrations shall not exceed the limits specified in ACGIH 2001. When ventilation is used as an engineering control method, the system shall be installed and operated according to the requirements of this section.

Technical Rationale–This is to limit the concentration of hazardous substances and to provide acceptable working environmental conditions.

4.8.3.5 General Reference for TLV Limits

Criteria

Exposure of employees to inhalation, ingestion, skin absorption, or contact with any material or substance at a concentration above those specified in ACGIH 2001 shall be avoided.

Technical Rationale–This is to limit the concentration of material or substances at working places to meet the standards of ACGIH 2001.

4.8.3.6 Underground Ventilation Design Parameters

Criteria

(k) Ventilation. (1)(i) Fresh air shall be supplied to all underground work areas in sufficient quantities to prevent dangerous or harmful accumulation of dusts, fumes, mists, vapors or gases. [29 CFR 1926.800(k)]

(ii) Mechanical ventilation shall be provided in all underground work areas except when the employer can demonstrate that natural ventilation provides the necessary air quality through sufficient air volume and airflow. [29 CFR 1926.800(k)]

(4) The direction of mechanical air flow shall be reversible. [29 CFR 1926.800(k)]

Volume Per Employee

(2) A minimum of 200 cubic ft (5.7 m3) of fresh air per minute shall be supplied for each employee underground. [29 CFR 1926.800(k)]

Drift Velocity

(3) The linear velocity of air flow in the tunnel bore, in shafts, and in all other underground work areas shall be at least 30 ft (9.15 m) per minute where blasting or rock drilling is conducted, or where other conditions likely to produce dust, fumes,

mists, vapors, or gases in harmful or explosive quantities are present. [29 CFR 1926.800(k)]

Blast Fume Clearing

(5) Following blasting, ventilation systems shall exhaust smoke and fumes to the outside atmosphere before work is resumed in affected areas. [29 CFR 1926.800(k)]

Ventilation Door Design

(6) Ventilation doors shall be designed and installed so that they remain closed when in use, regardless of the direction of the airflow. [29 CFR 1926.800(k)]

Dust Control

(9) When drilling rock or concrete, appropriate dust control measures shall be taken to maintain dust levels within limits set in ACGIH 2001. Such measures may include, but are not limited to, wet drilling, the use of vacuum collectors, and water mix spray systems.

Dust shall be controlled at muck piles, material transfer points, crushers, and on haulage roads where hazards to persons would be created as a result of impaired visibility. [30 CFR 57.9315]

Diesel Use

(10)(i) Internal combustion engines, except diesel-powered engines on mobile equipment, are prohibited underground. [29 CFR 1926.800(k)]

(ii) Mobile diesel-powered equipment used underground in atmospheres other than gassy operations shall be either approved by MSHA in accordance with the provisions of a CFR that has been identified and is being procured, or shall be demonstrated by the employer to be fully equivalent to such MSHA-approved equipment, and shall be operated in accordance with that part. (Each brake horsepower of a diesel engine requires at least 100 cubic ft (28.32 m3) of air per minute for suitable operation in addition to the air requirements for personnel. Some engines may require a greater amount of air to ensure that the allowable levels of carbon monoxide, nitric oxide, and nitrogen dioxide are not exceeded.) [29 CFR 1926.800(k)]

Technical Rationale–This is to provide part of the air quality standards and general ventilation requirements for working places. The OSHA criteria in Section 4.8.3.6 (4) above related to reversible mechanical airflow cannot be implemented in the planned subsurface ventilation system design for the repository. It is recommended that BSC submit an analysis to the DOE for their consideration in the grant of waiver or exemption for BSC from the OSHA criteria. The OSHA criteria in Section 4.8.3.6 (6) above related to design of ventilation doors applies only when the doors are closed not when the system is designed to keep the doors open or partially open.

4.8.3.7 Fire Alarm Systems

Criteria

(a) Fire alarm systems capable of promptly warning every person underground, except as provided in paragraph (b), shall be provided and maintained in operating condition. [29 CFR 1910]

(b) If persons are assigned to work areas beyond the warning capabilities of the system, provisions shall be made to alert them in a manner to provide for their safe evacuation in the event of a fire. [29 CFR 1910]

Technical Rationale–This is to ensure that subsurface ventilation design interfaces with fire alarm system design.

4.8.3.8 Underground Fan Installations

Criteria

(a) Fan houses, fan bulkheads for main and booster fans, and air ducts connecting main fans to underground openings shall be constructed of noncombustible materials.

(b) Areas within 25 ft of main fans or booster fans shall be free of combustible materials, except installed wiring, ground and track support, headframes, and direct-fired heaters. Other timber shall be coated with 1-inch of shotcrete, one-half inch of gunite, or other noncombustible materials. [30 CFR 57.4504]

When auxiliary fan systems are used, such systems shall minimize recirculation and be maintained to provide ventilation air that effectively sweeps the working places. [30 CFR 57.8529]

Shutdown or failure of auxiliary fans. [30 CFR 57.8534]

Technical Rationale–This is to provide general guidance for ventilation fan installations.

4.8.3.9 Underground Shops

Criteria–To confine or prevent the spread of toxic gases from a fire originating in an underground shop where maintenance work is routinely done on mobile equipment, one of the following measures shall be taken: use of control doors or bulkheads, routing of the mine shop air directly to an exhaust system, reversal of mechanical ventilation, or use of an automatic fire suppression system in conjunction with an alternate escape route. The alternative used shall at all times provide at least the same degree of safety as control doors or bulkheads [30 CFR 57.4761].

Technical Rationale–This is to provide general guidance for ventilation fan installations.

4.8.3.10 Exposure Limits for Airborne Contaminants and Exposure Monitoring.

Criteria–Limits in 30 CFR 57.5001 and 30 CFR 57.5002 shall be used for airborne contaminants and exposure monitoring

Technical Rationale–This is to limit workers' exposure to airborne contaminants and to provide general guidance for exposure monitoring.

4.8.3.11 Control of Exposure to Airborne Contaminants

Criteria–Control of employee exposure to harmful airborne contaminants shall be, insofar as feasible, by prevention of contamination, removal by exhaust ventilation, or by dilution with uncontaminated air. However, where accepted engineering control measures have not been developed or when necessary by the nature of work involved (for example, while establishing controls or occasional entry into hazardous atmospheres to perform maintenance or investigation), employees may work for reasonable periods of time in concentrations of airborne contaminants exceeding permissible levels if they are protected by appropriate respiratory protective equipment. Whenever respiratory protective equipment is used a program for selection, maintenance, training, fitting, supervision, cleaning, and use shall meet the following minimum requirements (ANSI N13.8 –1973, Section 14.5)

Technical Rationale–This is to control workers' exposure to airborne contaminants by proper ventilation, or by use of protective equipment.

4.8.3.12 Radon Daughter Exposure Monitoring

Criteria

(a) In all mines at least one sample shall be taken in exhaust mine air by a competent person to determine if concentrations of radon daughters are present. Sampling shall be done using suggested equipment and procedures described in Section 14.3 of ANSI N13.8-1973, American National Standard Radiation Protection in Uranium Mines, approved July 18, 1973, pages 13-15, by the American National Standards Institute, Inc., which is incorporated by reference. If concentrations of radon daughters in excess of 0.1 WL are found in an exhaust air sample, thereafter

(b) If concentrations of radon daughters less than 0.1 WL are found in an exhaust mine air sample, thereafter:

(2) Where uranium is not mined - no further exhaust mine air sampling is required.

(c) The sample date, locations, and results obtained under (a) and (b) above shall be recorded and retained at the mine site or nearest mine office for at least two years and shall be made available for inspection. [30 CFR 57.5037]

Radon Sampling Procedure is defined in ANSI N13.8-1973 Section 14.3.3 and includes "other procedures if they are capable of developing information of essentially the same quality. [ANSI N13.8-1973 Section 14.3.3]

Technical Rationale–This is to provide general guidance for radon sampling.

4.8.3.13 Radon Annual Exposure Limits

Criteria–No person shall be permitted to receive an exposure in excess of 4 WLM in any calendar year. [29 CFR 1910.1096]

Technical Rationale–This is to limit the annual radon exposure.

4.8.3.14 Maximum Permissible Radon Concentration

Criteria–Persons shall not be exposed to air containing average concentrations of radon exceeding 30 picocuries per liter [29 CFR 1910.1096].

Technical Rationale–This is to limit the maximum radon concentration.

4.8.3.15 Diesel Particulate Regulations

Criteria

(b) After January 19, 2006, any mine operator covered by this part must limit the concentration of diesel particulate matter to which miners are exposed in underground areas of a mine by restricting the average eight-hour equivalent full shift airborne concentration of total carbon, where miners normally work or travel, to 160 micrograms per cubic meter of air (160TC μg/m 3). [30 CFR 57.5060 and 30 CFR 57.5062]

Criteria for monitoring of diesel particulate and posting of the information are provided in 30 CFR 57.5071.

Technical Rationale–This is to provide a basis for limiting worker exposure to emission of diesel equipment, if used in the subsurface facility.

4.8.3.16 Construction, Maintenance and Use of Ventilation Doors

Criteria

Ventilation doors shall be:

(a) Substantially constructed;

(b) Covered with fire-retardant material, if constructed of wood;

(c) Maintained in good condition;

(d) Self-closing, if manually operated; and

(e) Equipped with audible or visual warning devices, if mechanically operated [30 CFR 57.8531].

When ventilation control doors are opened as a part of the normal mining cycle, they shall be closed as soon as possible to re-establish normal ventilation to working places [30 CFR 57.8532].

Ventilation control measures shall be used for:

(a) Control doors
(b) Mechanical Ventilation Reversal
(c) Evacuation [30 CFR 57.4760]

Technical Rationale–This is to provide general guidance for design, maintenance, and operation of ventilation door.

4.8.3.17 Ventilation Barriers

Criteria–Subsurface Ventilation Barriers should be designed prevent air leakage from subsurface zones of low potential for contamination to zones of higher potential for contamination (NRC Regulatory Guide 3.18, Rev 0).

Technical Rationale–This is to provide a basis for development of ventilation network modeling and planning for various operating stages.

4.8.3.18 Fail-safe Features

Criteria–Subsurface ventilation systems and components should have fail-safe features to prevent leakage of ventilation air from emplacement area to the development area normally occupied by personnel. (NRC Regulatory Guide 3.32, Rev 0, paragraph C.1a & c).

Technical Rationale–This is to protect workers in the development area from potential contamination of emplacement area during simultaneous repository development and waste emplacement operations.

4.8.3.19 Emergency Power

Criteria–Onsite emergency power should be provided to operate the subsurface ventilation systems and components, including instruments and controls, ITS. (NRC Regulatory Guide 3.32, Rev 0, paragraph C.1c & C.5d).

Technical Rationale–This is to ensure continuous operation of the subsurface ventilation systems.

4.8.3.20 NFPA Regulation

Criteria–The subsurface ventilation system shall interface with the Fire Protection System to ensure all applicable NFPA standards are addressed.

Technical Rationale–This is to ensure that applicable NFPA standards identified in Section 4.8.1 of this document are addressed.

4.8.3.21 Human Engineering

Criteria–Subsurface ventilation design shall utilize, where necessary and applicable MIL-STD-1472E- 1996.

Technical Rationale–This standard establishes general human engineering criteria for design of systems, equipment, and facilities to (1) achieve required performance by operator, control and maintenance personnel, (2) minimize skill and personnel requirements and training time, (3) achieve required reliability of personnel-equipment/ software combinations, and (4) foster design standardization within and among systems.

4.8.3.22 Structures

Criteria–Subsurface ventilation related structures shall interface with Subsurface Structural design and use ICC 2000 (IBC) wherever applicable.

Technical Rationale–This is to ensure integration of appropriate structural codes and standards in structural designs that impact subsurface ventilation.

4.8.4 Waste Processing Design Criteria

4.8.4.1 Waste Processing Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Mechanical	Waste Processing*	ANSI/ANS-40.35-1991, ANSI/ANS-55.1-1992, ANSI/ANS-55.6-1993, ANSI/ANS-57.7-1988, ANSI/ANS-57.9-1992, ANSI/HFS 100-1988, ANSI/ISA-S84.01-1996, ESD-TR-86-278 (Smith and Mosier 1986), ASME B31.1-2001, ASME B31.3-2002, ASME 2001, ICC-2000 (IBC), IEEE Std. 1100-1999, IEEE Std 1224-1993, ISO 9241-10 1996, ISO 9241-14 1997, ISO 9241-15 1997, ISO 9241-3 1992, ISO 9241-8 1997, MIL-STD-1472E 1996, NFPA 70 2002, NFPA 75 1999, UCRL-15673 (Bongarra et al. 1985)
		RG 1.143 Rev 2, RG 1.21 Rev 1, RG 1.25 Rev 0, RG 1.29 Rev 3, RG 3.32 Rev 0, RG 5.12 Rev 0, RG 8.8, Rev 3
		10 CFR 20, 10 CFR 71, 29 CFR 1910, 29 CFR 1926, 40 CFR 265 Chapter I Subpart I, 49 CFR 173, 40 CFR 61, 10 CFR 61
		NUREG-0700 1996 (NRC 1996)
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21 (c)(2)), PRD-022 and *Site-Generated Radiological Waste System Description Document* (BSC 2002q). Determination of applicable sections of these codes and standards will be determined during the design process and in development of design products.

[2] These Regulatory Guides have been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guides will be determined during the design process and in development of design products that are impacted by these Regulatory Guides.

[3] Addressing Code of Federal Regulations supports compliance with requirements in PRD-015/P-015, PRD-003, PRD-015/P-020, PRD-015/P-021, PRD-021 and PRD-011a/T-001. Determination of applicable sections of these documents will be determined during the design process and in development of design products.

[4] This NUREGs provides guidance on acceptable methods and approaches that could be utilized in MGR design

[5] None

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.8.4.2 Gaseous Radioactive Waste System

4.8.4.2.1

Criteria–Materials for pressure related components, excluding the HVAC duct and fire protection piping, shall conform to the requirements of the specifications for materials listed in Section II of the ASME BPVC (ASME 2001), except that malleable, wrought or cast iron materials and plastic pipe should not be used. (Regulatory Guide 1.143, Rev 2, Par. 2.2)

Technical Rationale–This criteria is required to define acceptable materials of construction, including material properties, for pressure containing components of this system.

4.8.4.2.2

Criteria–Radioactive waste management SSCs shall be designed to control leakage and facilitate access, operation, inspection, testing and maintenance in order to maintain radiation exposures to operating and maintenance personnel as low as is reasonable achievable (ALARA). (Regulatory Guide 1.143, Rev 2, Par. 4.1)

Technical Rationale–This criteria is required to facilitate compliance with ALARA

4.8.4.2.3

Criteria–Pressure-retaining components of process systems shall use welded construction to the maximum practical extent. Flanged joints or suitable rapid-disconnect fittings should be used only where maintenance or operational requirements clearly indicate such construction is preferable. (Regulatory Guide 1.143, Rev 2, Par.4.3)

Technical Rationale–This criteria is required in order to establish a preferred piping connection method for these systems

4.8.4.2.4

Criteria–Classification of Radioactive Waste Management Systems for design purposes shall follow the guidelines outlined in RG 1.143, Rev 2, Par.5, for High Hazard (RW-IIa), Hazardous (RW-IIb), and Non-Safety (RW-IIc) classifications. (Regulatory Guide 1.143, Rev 2, Par. 5)

Technical Rationale–This criteria is required in order to be consistent with the NRC endorsed approach in Regulatory Guide 1.143, Rev 2.

4.8.4.2.5

Criteria–Process equipment in the Gaseous Radioactive Waste piping system shall be designed per the following codes and standards identified in Table 4.8.4-1 (ANSI/ANS-55.1-1992, Table 1).

Table 4.8.4-1. Codes and Standards for the Design of SSCs in Radioactive Waste Service

Component	Design and Construction	Material [a,b]	Welder and Procedure Qualifications	Inspection and Testing
Piping and Valves	ASME B31.1 [j]	Code identified, being procured[g] or ASME-Sec II[c,k]	ASME Sec IX [c]	ANSI/ASME B31.1 [j]
Vessels (atmospheric) or 0-15 psig	Code identified, being procured [d e f]	Code identified, being procured [g,h]	ASME Code Sec IX [c]	Code identified, being procured [d e f]
Pressure Vessels	ASME Code Sec. VIII [c]	ASME Code Sec. II [c]	ASME Code Sec I [c].	ASME Code Sec. VIII [c]
Pumps	Manufacturer's Stds. [l]	ASME Code Sec. II [c] or Manufacturer's Standards [l]	ASME Code Sec. IX [c] or Manufacturer's Standards [l]	Code identified, being procured [m,n]
Heat Exchangers	ASME Code Sec. VIII [c] and Code identified, being procured [i]	ASME Code Sec. II [c]	ASME Code Sec IX [c]	ASME Code Sec. VIII [c]

NOTES:

[a] Manufacturer's material certificates of compliance with the material specification may be provided in lieu of certified materials test reports. The later should be obtained whenever possible.

[b] Malleable wrought or cast iron materials shall not be used.

[c] ASME Boiler and Pressure Vessel Code - 2001

Section II, Material Specifications;
Section VIII, Pressure Vessels;
Section IX, Welding and Brazing Qualifications;

[d] Code identified, being procured.

[e] Code identified, being procured.

[f] Code identified, being procured.

[g] Code identified, being procured.

[h] Fiberglass reinforced plastic tanks may be used in accordance with Part M, Section X, American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code.

[i] Code identified, being procured.

[j] ASME B31.1-2001, Power Piping.

[k] Plastic (including fiberglass-reinforced plastic) pipes shall not be used for radioactive service.

[l] Manufacturer's Standards: Documents from individual manufacturers of pumps.

[m] Code identified, being procured.

[n] Hydrotesting should be at 1.5 times the design pressure.

Technical Rationale–Regulatory Guide, 1.143, Rev 2, has identified ANSI/ANS-55.1-1992 as the consensus standard applicable for the overall design of radioactive waste facilities.

4.8.4.3 Solid Radioactive Waste System

4.8.4.3.1

Criteria–Materials for pressure related components, excluding HVAC ducts and fire protection piping, shall conform to the requirements of the specifications for materials listed in Section II of the ASME 2001, except that malleable, wrought or cast iron materials and plastic pipe should not be used. (Regulatory Guide1.143, Rev 2, Par. 3.2)

Technical Rationale–This criteria is required to define acceptable materials of construction, including material properties, for pressure containing components of this system.

4.8.4.3.2

Criteria–The SSCs of the solid radioactive waste treatment system shall be designed and tested to the requirements set forth in the codes and standards listed in Section 4.8.4.1. (Regulatory Guide 1.143, Rev 2, Par. 3.1)

Technical Rationale–This criteria is required in order to establish a set of accepted codes and standards for design, construction, materials, welder and welding procedure qualification and inspection and testing for various categories of mechanical equipment utilized in the radiological waste system.

4.8.4.3.3

Criteria–The system for processing dry active waste (DAW) shall include a volume reduction process for treatment of the compressible fraction of the as-collected waste. Means shall be provided in any volume reduction process for collecting and filtering the expelled gas through a high-efficiency particulate air filter so that particulate matter will be prevented from entering the building atmosphere. The release shall be monitored. (ANSI/ANS-55.1-1992, Par. 4.1.2.5)

Technical Rationale–This criteria is necessary to establish a rationale for volume reduction of dry active waste, as well as for handling of expelled gases.

4.8.4.3.4

Criteria–System design shall incorporate gaseous waste treatment that can remove particulates and iodine (if present) prior to release to the building and ventilation exhaust system. (ANSI/ANS-55.1-1992, Par.5.6.5.4)

Technical Rationale–This criteria is required in order to define a gaseous waste treatment strategy.

4.8.4.3.5

Criteria–The solid radioactive waste processing system shall accommodate waste volumes generated during normal operation as well as those from anticipated maintenance activities. In addition, the system shall accommodate solid waste input for a reasonable period of time when normal shipment of packaged solid waste from the plant is not possible, i.e., up to 30 days of anticipated normal waste generation. (ANSI/ANS-55.1-1992, Par. 8.1)

Technical Rationale–This criteria defines a basis for sizing of the waste treatment system.

4.8.4.3.6

Criteria–All containers for waste that will ultimately be disposed of by near-surface disposal shall comply with the requirements of 10 CFR 61, *Licensing Requirements for Land Disposal of Radioactive Waste*, Subpart D, Sections 61.55, 61.56, and 61.58. In addition, wastes that are not stabilized, are classified B or C, and rely on the waste container for stability shall be packaged in NRC or state approved HICs. (ANSI/ANS-55.1-1992, Par. 5.9)

Technical Rationale–This criteria identifies the requirements for low-level waste (LLW) containers to be used for disposal of llW in shallow land burial sites.

4.8.4.3.7

Criteria–The compactor station design shall include area radiation monitoring instrumentation. A gamma-sensitive radiation detector shall be positioned to monitor the container's radiation level. Local display of radiation levels shall be provided. Both audible and visual alarms shall be provided. Compactor station design shall evaluate the need to include airborne radiation monitoring instrumentation. Channels shall be provided to measure and locally display both iodine and particulates. Both channels shall have independent audible and visual alarms. Each channel shall use fixed filter sample assemblies. (ANSI/ANS-55.1-1992, Par. 5.11.3)

Technical Rationale–This criteria defines safety instrumentation to be used with waste compaction systems.

4.8.4.3.8

Criteria–Liquid waste for shipment shall be satisfactorily solidified or absorbed using approved absorbent material in sufficient volume to absorb twice the volume of liquid. (ANSI/ANS-55.1-1992, Par. 4.1.2.1)

Technical Rationale–This criteria identifies a requirement for solidification or absorption of generated liquid LLW.

4.8.4.3.9

Criteria–The solid radioactive waste processing system equipment is not required to be designed to withstand the effects of a seismic event. (ANSI/ANS-55.1-1992, Par. 4.2.2.1)

Technical Rationale–This criteria presents a position on seismic design of LLW treatment facilities for light water cooled reactor plants, which should be an acceptable approach for this system.

4.8.5 Mechanical Support System Design Criteria

4.8.5.1 Mechanical Support System Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Mechanical	Mechanical Support System*	NAC 445A, NAC 445B, ANSI/AWS A5.32/A5.32M-97, ANSI/AWWA D100-96, AWWA D102-97, ASME B31.1-2001, ASME B31.3-2002, ASME B31.4a-2001, ICC 2000 (IPC)
		None
		10 CFR 36, 10 CFR 60, 29 CFR 1910, 29 CFR 1926, 29 CFR 1960, 40 CFR 141, 40 CFR 143, 33 USC 1251, 42 USC 300f
		None
		DOE Order 5400.1, Change 1, DOE O 440.1A 1998

Technical Rationale:

1 These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (Information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21 (c)(2)), and PRD-022. Determination of applicable sections of these codes and standards will be determined during the design process and in development of design products.

DOE is not subject to the Federal Mine Safety and Health Act (MSHA) of 1977, as to the construction and operation of any facilities in the Geologic Repository Operations Area (GROA). However, some worker protection provisions of MSHA (30 CFR 57) may be used as guidance in the subsurface design of Structures, Systems and Components in the GROA.

By using such guidance, there is no explicit or implicit expectation other than its use in the Project Design Criteria document. DOE is not obligated to comply with any aspect of MSHA and that the Mine Safety and Health Administration has no jurisdiction or enforcement authority over construction or operation of any facility of the Monitored Geologic Repository.

2 None.

3 Addressing Code of Federal Regulations supports compliance with requirements in PRD-015/P-015, PRD-015/P-020, PRD-015/P-021 and PRD-005.

4 None.

5 Addressing DOE Standards supports compliance with requirements of PRD-018/P-019. Determination of applicable sections of DOE Standards will be determined during the design process and in development of design products

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

The Mechanical Support System consists of the following subsystems:

- Water
- Fuel Oils
- Air (compressed)
- Service Gases.

4.8.5.2 Water Supply

4.8.5.2.1

Criteria–Raw well water coming from Nevada Test Site (NTS) Well J13 and Well J12 shall be used for the following purposes: 1) initial supply and make-up to the firewater system; 2) feed to the softened water system; and 3) feed to the de-ionized water system.

Technical Rationale–This criteria is required to define the primary sources of raw water supply to the north, south and proposed construction portals. To accommodate estimated future consumption requirement, modifications to the existing well water pumping, tankage, and water line systems may be required.

4.8.5.2.2

Criteria–The water supply subsystem shall be designed so that essential safety functions can be performed under both normal and accident conditions.

Technical Rationale–This criteria is in accordance with 10 CFR 60.131 (f)(1)(2)(3), *General Design Criteria for the Geologic Repository Operations Area.* Redundant pumps are to be provided to ensure that water supply pressure is maintained and are to be connected to back up electrical power in the event of an electrical outage. Where the possibility exists for the eyes or body of any person to be exposed to corrosive materials, suitable facilities for quick drenching or flushing of the eyes and body shall be provided within the immediate work area for emergency use.

4.8.5.2.3

Criteria–The potable water subsystem shall be designed and installed to comply with all Federal, State, and local requirements, administrative authorities, and process and sanctions regarding the provisions of safe drinking water. Potable water shall also be used as utility water in the non-radiological facility wash down and housekeeping.

Technical Rationale–This criteria is in accordance with 40 CFR 141 - National Primary Drinking Water Regulations and 40 CFR 143 - National Secondary Drinking Water Regulations. Plumbing providing water for human consumption shall be lead-free in compliance with Safe Drinking Water Act (42 USC 300 f).

4.8.5.2.4

Criteria–The water quality monitoring system shall have the capability to sample, measure, and analyze physical, chemical, and biological conditions consistent with the requirements of the Clean Water Act (33 USC 1251) and the Safe Drinking Water Act (42 USC 300 f) as identified in their implementing regulations, 40 CFR 141 and 40 CFR 143.

Technical Rationale–This criteria is in accordance with DOE Order 5400.1, Change 1, *General Environmental Protection Program.* Such capability must also be compatible with the type and range of concentrations/occurrences of conditions specified in the governing regulations such as 40 CFR 141, 40 CFR 143 and State and local regulations, which will be identified later.

4.8.5.2.5

Criteria–The softened water shall be used primarily for cooling tower supply/makeup and for initial fill and make-up for the chilled water and hot water system.

Technical Rationale–To minimize the potential of hard water deposit formation on components within the cooling tower system, the water is to be softened, replacing calcium and magnesium ions with sodium ions. The net result of this water softening will be water conservation. If the water going to the cooling tower were not to be softened, the amount of recycled water within the cooling tower system would have to be decreased sufficiently to minimize hard water scale deposit formation.

4.8.5.2.6

Criteria–The de-ionized water will be required for several operations in the surface facilities. The primary use of de-ionized water will be for initial fill and makeup water for the fuel storage pool in the Remediation Building (RB). Other de-ionized water users will include the Chilled Water System, the Hot Water System and miscellaneous laboratory applications.

Technical Rationale–A de-ionized water quality with a conductivity of 0.1 micro-mhos (micro-siemens) shall be adequate for fuel storage pools with normal ion exchange systems using separate cation and anion beds. Although there is an existing requirement to maintain fuel storage pool per 10 CFR 36.63, *Pool Water Purity*, this is not a requirement for the pools within the RB. Conductivity below 20 micro-mhos sets the limit on water quality level for the purposes of the design. Because the de-ionized water is used primarily to provide cooling for fuel in the RB storage pools, it is important to maintain water flow in the event of a long term power outage, for this reason, two redundant pumps will be provided with standby power.

4.8.5.2.7

Criteria–The cooling tower water will provide condenser water to the chillers. Cooling tower water makeup is provided by the softened water subsystem. Cooling tower water system shall be designed for economical pipe size based on ASHRAE 2001 recommended pressure drop and pipe velocity design limitations. Make-up water shall be supplied to the cooling tower to replenish the sum of water losses due to drift, evaporation and blow down.

Technical Rationale–The function of the cooling tower water subsystem will be to provide evaporative cooling capacity for the Chilled Water System.

4.8.5.2.8

Criteria–Raw process water shall be provided to the subsurface for dust control and rock cuttings removal during excavation and development of the subsurface repository. While drifts are being excavated , water shall be supplied to the subsurface in pipelines hung on the ribs of the tunnels.

The small and infrequent amounts of water needed for activities such as cleanup shall be provided using mobile car-mount tank.

Technical Rationale–This process water shall be used primarily for dust suppression.

4.8.5.3 Fuel Oil

4.8.5.3.1

Criteria–Fuel storage tanks shall be designed and located in accordance with applicable regulations and shall be accessible by tank truck and rail. Fuel oil shall be pumped from the main storage tank to a day tank located at the Utility Building to be used as fuel for the Hot Water (HW) boilers.

Technical Rationale–This criteria is in accordance with the provisions of 29 CFR 1910, *Occupational Safety and Health Standards.*

Criteria–Fuel oil shall be pumpable at the design temperature of 22.5° F. Hot water system shall be the major consumer of fuel oil with smaller users such as emergency generator sets, back-up diesel driven pump for the fire water system, and tank heaters associated with the fire water system.

Technical Rationale–The appropriate selection of the grade of fuel oil is important to ensure the ability of fuel oil flow to emergency diesel engines (emergency generators, standby generators, and diesel-driven firewater pumps) in the event of tank heater or pipe tracing failure. №. 2 (API) fuel oil can be both stored and pumped and mechanically atomized down to about 0° F (Figure 9-4, Handbook identified, being procured), which allows the use of №. 2 fuel oil without having to heat trace lines or heat fuel oil storage tanks.

4.8.5.4 Compressed Air

4.8.5.4.1

Criteria–The function of the breathing air will be to provide breathing air through hose connections for the purposes of allowing personnel access into the cell areas for the performance of non-routine maintenance and to correct off-normal occurrences.

Technical Rationale–This breathing air system is designed per the requirements of standard that has been identified and is being procured, and 29 CFR 1910, OSHA *Selected General Industry Safety and Health standards*. The air quality will comply with the requirements of code, which has been identified and is being procured.

4.8.5.4.2

Criteria–The air compressors supplying breathing air to respirators shall be constructed to prevent entry of contaminated air into the air supply system and have suitable in-line air purifiers, filters, and a carbon monoxide detector to ensure breathing air quality. To maintain operator comfort, the breathing air temperature at the respirator shall be maintained between

45° - 80° F. The breathing air supply equipment and distribution piping shall be designed to provide 15 SCFM/outlet. The design capacity for the breathing air supply equipment and piping distribution systems shall be equal to the maximum number of outlets anticipated to be in use at one time multiplied by 15 SCFM/outlet. To provide sufficient reserve capacity for emergency egress in the event of a main air system outage, a 1000 gal (150- psig) air reserve tank shall be installed.

Technical Rationale–This criterion is in accordance with 29 CFR 1910.134, *Respirator Protection.*

4.8.5.4.3

Criteria–The breathing air subsystem shall be designed with air receivers of sufficient capacity to enable the respirator wearer to escape from a contaminated atmosphere in the event of compressor failure. The electric motors for the compressors shall be connected to standby power to provide breathing air in the event of a lengthy power outage.

Technical Rationale–This criteria is in accordance with 29 CFR 1910.

4.8.5.4.4

Criteria–In addition to the engineering controls which are the primary method for providing healthful air, respiratory equipment approved by the Occupational Safety and Health Standards shall be provided to persons exposed for short periods to inhalation hazards from gas, dust, fumes or mist.

Technical Rationale–This criteria is in accordance with 29 CFR 1910.

4.8.5.4.5

Criteria–Since breathing air will have extremely low actual usage, the same compressor system shall be used to provide both breathing and instrument/shop air. Air receivers and distribution systems shall be totally independent and breathing air system shall be isolated through double check-valves from the instrument air system. Receiver for instrument/shop air shall be sized to allow for a reasonable shutdown of equipment in the event of compressor failure(s).

Technical Rationale–Compressed air is provided during construction and emplacement operation phase in the surface and subsurface facilities for powering rock drills, rock bolters, rail switches, ventilation doors, and maintenance services.

4.8.5.5 Service Gases

4.8.5.5.1

Criteria–The rate of consumption of service gases such as Nitrogen, Argon, Argon/Helium blend and Helium shall be based primarily on the waste handling schedule. The total waste shipments received in a given year shall be determined by the number of truck and rail shipments.

Technical Rationale–Service Gases will be consumed in the process of receiving and repackaging wastes for the repository. Other possible consumers of service gases, other than those associated with receiving and repackaging activities on the surface facilities, will be the activities associated with subsurface construction and development.

4.8.5.5.2

Criteria–Nitrogen, Argon, Argon/Helium blend, and Helium gas shall be supplied to the surface facilities either from a dewar or from the tanks to be located near the buildings being served.

Technical Rationale–Facilities for storing and handling hazardous and combustible gases shall be designed in accordance with 29 CFR 1910 and Compressed Gas Association. 1990. *Handbook of Compressed Gases*. 3rd Edition. Compressed gas cylinders are used in well-ventilated areas.

4.8.5.5.3

Criteria–Hoses, piping, and compressed gas cylinders shall be labeled with the identity of the gas contained therein and/or color-coded as appropriate.

Technical Rationale–This criteria is in accordance with 29 CFR 1910.

4.8.5.5.4

Criteria–Nitrogen shall be used for purging of casks and for drying of fuel assemblies contained in the handling baskets after their removal from the fuel storage pool.

Technical Rationale–This criteria is required to ensure that the cladding on the enclosed fuel assemblies is intact. The first step in the processing of the waste casks will be to sample the gas within the cask after purging with Nitrogen and have the purge gas sample fed through the radiological monitoring equipment for composition and radionuclide contamination. The second step will involve placing the basket containing fuel assemblies inside a drying chamber after being removed from the pool and washed down with de-ionized water. The chamber will be closed, evacuated and pressurized with Nitrogen gas to atmospheric pressure.

4.8.5.5.5

Criteria–Service gases delivery systems shall be designed with proper ventilation in accordance with the applicable provisions of 29 CFR 1910.

Technical Rationale–Argon or Argon/Hydrogen blend may be used as shielding gas during the welding of the inner stainless shell lid of the waste package. Argon or Argon/Helium blend may be used as shielding gas during the welding of the Alloy 22 middle lid and outer lid of the waste package after the inner lid is welded. Helium gas will be used to provide an inert heat transfer gas placed in the waste package after the inner lid is welded. Breathing Argon or Helium in an oxygen poor atmosphere can cause sudden and acute asphyxia resulting in immediate unconsciousness or possible death.

4.8.5.6 Control and Monitoring System

4.8.5.6.1

Criteria–Instrumentation and control systems shall include provisions to monitor and control the behavior of Mechanical Support Systems important to safety over anticipated ranges for normal operation and off-normal conditions. The systems shall be either controlled or managed through local computer control or through the use of a process controller located in the Utility Building.

Technical Rationale–This criteria is required to define the integral functional requirements that ensure the system's proper operation and the alarming of unsafe conditions for the protection of the health and safety of the occupational workers per 29 CFR 1926.

4.8.5.7 System Boundaries Requirements

4.8.5.7.1

Criteria–The boundaries of Mechanical Support System shall include:

- Identification of various utility services to be provided throughout the surface and subsurface facilities
- Expected utility consumption through review of current project documentation
- Developed design flow rates for the utility services identified
- Sizing of components, subsystems, and distribution mains using standard engineering calculation techniques.

Technical Rationale–This criteria is required to define the design parameters for each subsystems that need to be in compliance with the requirements of the applicable codes and standards.

4.8.5.8 System Interfaces Requirements

4.8.5.8.1

Criteria–The Mechanical Support System shall interface with the Heating, Ventilation, and Air Chilled (HVAC) Water, and Heating Water Systems, Fire Protection System, Site Communication System, Site Electrical Power System, Non-Radiological Waste Management System, Subsurface Facilities System, and Balance of the Plant (BOP) Facilities. The following is a list of interfaces with their associated functions:

- Interface with HVAC Water and Heating Water Systems to ensure availability of sufficient softened and de-ionized water for the cooling tower and closed loop water system.

- Interface with Fire Protection System to ensure availability of raw water for adequate firewater supply.

- Interface with Site Communication System to provide secured communications capability to monitor the site alarm system and controls to the operating personnel at other Utility Systems Monitoring Stations.

- Interface with Site Electrical Power System through emergency power provided by a backup diesel generator to ensure continuous operation by the critical devices whose failure to operate satisfactorily would jeopardize the health and safety of personnel.

- Interface with Non-Radiological Waste Management System to provide an environmentally acceptable method for disposal of cooling tower blow down water, ion exchange bed regeneration neutralized effluent, and storm water to support operations of the surface and subsurface facilities.

- Interface with Subsurface Facilities System for space and access to all underground service lines and installations.

- Interface with BOP Facilities located in the BOP area adjacent to the Radiological Control Area (RCA) to provide non-radiological support to surface and subsurface operations, including management and administration, warehousing, maintenance, medical, utility (water treatment and compressed air generation), and security.

Technical Rationale–This criteria is required to identify the different interfaces associated with Mechanical Support System. These interfaces are all subjected to the requirements and provision of 29 CFR 1910 for the protection of the health and safety of the occupational workers.

4.8.5.9 Piping Requirement

4.8.5.9.1

Criteria–The North Portal repository site plan and the utility building location shall be used to establish the utility piping distribution layout. Water flow (well water, potable water, softened and de-ionized water) through pipes shall be designed near or below the maximum velocity of 4 feet per second (fps). Piping shall be designed for economical pipe sizes and for future system expansion based on allowable pressure drop, flow rate, and pump selection criteria as prescribed by the applicable codes.

Technical Rationale–This criteria is in accordance with ICC 2000 (IPC), to lessen the erosion and corrosion of piping and to minimize water hammer.

4.8.5.10 Personal Protection Requirement

4.8.5.10.1

Criteria–The system design shall include provisions for the protection of the occupational workers during the installation, maintenance and/or replacement of structures, systems or components (SSCs) with consideration to rotating equipment, confined spaces, noise barriers, chemical leaks, and respiratory hazards.

Technical Rationale–This criteria is required to ensure that personnel are protected from all rotating equipment by the use of safety guards or safety screens and equipment rooms that provide sensors, alarms, escape provisions, and respiratory protection equipment.

4.8.5.11 Equipment Protection Requirement

4.8.5.11.1

Criteria–The system components located underground and outdoors shall be designed to withstand and operate in the extreme underground and outside temperature environment. Interlocks, alarms, access, hazard access, and edge rounding shall be provided and designed in accordance with the applicable requirements of 29 CFR 1910 for surface equipment and 30 CFR 57 for underground equipment.

Technical Rationale–This criteria is required for the operational integrity of the system components. Underground and outdoor temperature can affect component performance, equipment degradation (coatings, seals, fluids), and system's operation and capability.

4.8.5.12 Testing and Maintenance Requirements

4.8.5.12.1

Criteria–The system shall include provisions and features to perform testing and maintenance of the system and its components essential to safety. The system shall be designed based on planned maintenance program and the appropriate quantity and type of maintenance spares and supplies required for planned and unplanned maintenance operations.

Technical Rationale–This criteria is required to ensure that the system includes facilities to test intrusion and emergency alarms, physical barriers, and other security-related devices.

4.8.5.13 Workmanship Requirements

4.8.5.13.1

Criteria–Special processes applicable to SSCs important to safety, including welding, heat treating and non-destructive testing, shall be controlled and accomplished by qualified personnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria and other special requirements, which will be identified later.

Technical Rationale–This criteria is required to identify the currently applicable codes, standards, regulations, engineering principles and practices specified in DOE directives.

4.9 NUCLEAR DESIGN CRITERIA

4.9.1 Nuclear Engineering Design Criteria

4.9.1.1 Nuclear Engineering Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5].
Nuclear Engineering	Nuclear Engineering*	ANSI N13.8-1973, ANSI N305-1975, ANSI/ANS-59.3-1992, ANSI/ANS-57.1-1992, ANSI/ANS-57.2-1983, ANSI/ANS-57.9-1992, ANSI/ANS-6.1.1-1977, ANSI/ANS-6.1.2-1999, ANSI/ANS-6.4-1997, ANSI/ANS-6.4.2-1985, ASTM C 1217-00, ASTM C992-89, ERDA 76-21 (Burchsted et al. 1979)
		RG 1.13 Rev 1, RG 1.143 Rev 2, RG 1.28 Rev 3, RG 1.69 Rev 0, RG 1.109, Rev 1, RG 1.145, Rev 1, RG 3.60 Rev 0, RG 3.71 Rev 0, RG 4.1 Rev 1, RG 8.10 Rev 1-R, RG 8.25 Rev 1, RG 8.34 Rev 0, RG 8.38 Rev 0, RG 8.5 Rev 01, RG 8.8 Rev 3
		10 CFR 20, 10 CFR 63.111(a), 10 CFR 63.111(b), 10 CFR 63.204, 10 CFR 71
		NUREG-0800 1987 (NRC 1987), NUREG-1567 2000 (NRC 2000a), NUREG-1520 2002 (NRC 2002c), NUREG-1617 2000 (NRC 2000b), NRC 2001
		None

Technical Rationale:

1 These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21 (c)(2)), and PRD-022. Determination of applicable sections of these codes and standards will be determined during the design process and in development of design products.

2 These Regulatory Guides have been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guides will be determined during the design process and in development of design products that are impacted by these Regulatory Guides.

3 Addressing Code of Federal Regulations supports compliance with requirements in PRD-015/P-015, PRD-002/T-012, and PRD-002/T-022. Determination of applicable sections of these documents will be determined during the design process and in development of design products.

4 These NUREGs provide guidance on acceptable methods and approaches that could be utilized in MGR design.

5 None

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.9.1.2 General Radiation Dose Criteria for Occupational Personnel

Criteria–The repository surface and subsurface facility design shall meet the general dose criteria provided in Table 4.9.1-1 for occupational personnel. The dose criteria for the general public are addressed separately as part of the preclosure safety analysis.

Technical Rationale–The general radiation dose criteria are required to meet the occupational dose requirements in 10 CFR 20.1201, and the Yucca Mountain Project ALARA design goal specified in Section 4.9.3.

Table 4.9.1-1. General Occupational Dose Criteria

Description	Criterion	Basis
Maximum individual annual total effective dose equivalent (TEDE)	5000 mrem	Compliance with 10 CFR 20.1201 (a)(1)(i)
Annual individual ALARA dose goal	500 mrem	This goal is consistent with the ALARA design criteria specified in Section 4.9.3.
Design dose rate for normal continuous access	0.25 mrem/h	Based on 2000 work hours per year and the ALARA goal of 500 mrem/yr.
Maximum steady-state or transient dose rate in accessible areas for normal operations	100 mrem/h	100 mrem/h represents the upper limit of a radiation area as defined in 10 CFR 20.1003. For normal operations, only radiation areas are accessible by workers. Special controls as specified in 10 CFR 20.1601and 20.1602 are required for access to high radiation areas (>100 mrem/h) and very high radiation areas (>500 rad/h), respectively.

4.9.1.3 Specific Dose Rate Criteria for Shielding Design

Criteria–Table 4.9.1-2 provides the specific dose rate criteria for use in shielding design for the surface and subsurface facilities, consistent with the general dose criteria established in Table 4.9.1-1.

Table 4.9.1-2. Specific Dose Rate Criteria for Shielding Design

Description Surface Facilities	Criterion	Basis
Restricted areas outside buildings on personnel level (8 ft height minimum)	0.25 mrem/h	To allow continuous occupational access and meet the ALARA goal of 500 mrem/yr.
Restricted areas outside buildings above personnel level	2.5 mrem/h	Higher dose rate is allowed above personnel level, provided that the contribution from the high level will not cause the dose rate on personnel level to exceed the limit.
Operating galleries, support rooms, offices on personnel level	0.25 mrem/h	To allow continuous occupational access and meet the ALARA goal of 500 mrem/yr.
Operating galleries, support rooms, offices above personnel level	2.5 mrem/h	Higher dose rate is allowed above personnel level, provided that the contribution from the high level will not cause the dose rate on personnel level to exceed the limit.
Intermittent access areas	2.5 to 100 mrem/h	Dose rate limit will vary with the access requirement for each area, provided that the general dose criteria are met and are consistent with the Area Dose rate Classification (Table 4.9.3-1).
Transportation cask Transporter surface	10 mrem/h	Supplemental shielding on Transporter to reduce the dose rate for ALARA purposes, and for transport between TRB and DF-1, DF-2 or Remediation Building.
Waste Package Transporter surface	100 mrem/h	No access is required around the WP Transporter during normal operations. Shielding is provided only for Category 1 event sequences and recovery operations.

Table 4.9.1-2. Specific Dose Rate Criteria for Shielding Design (Continued)

Description Subsurface Facilities	Criterion	Basis
Waste Package Transporter surface	100 mrem/h	Same limit as for the WP Transporter. No access is required around the WP Transporter during normal operations. Shielding is provided only for Category 1 event sequences and recovery operations.
Access main	1 mrem/h	For the area facing each emplacement drift. The dose rate for the area between the two adjacent drifts is considerably lower, because of substantial shielding by the host rock for conditions without the WP transporter present or the access main.
Turnout ventilation door location	10 mrem/h	For the door near the access main. Access is required only for door maintenance.
Exhaust main	10 mrem/h	Access is required only for inspection and maintenance activities.

Technical Rationale–The specific dose rate criteria are required for surface and subsurface facility shielding design to determine shielding thickness. These criteria are consistent with the general dose criteria provided in Section 4.9.1.2, and based on the personnel access requirements and radiological classifications for the various facility areas.

4.9.1.4 Shielding Source Term Criteria

Criteria–Shielding source terms for the surface and subsurface facility design shall be based on the limiting waste form as well as the limiting waste package type.

Design basis and maximum source terms shall be established to provide sufficient and bounding coverage, respectively, of the historical and projected fuel inventory for normal operations and Category 1 event sequences. The design basis source term shall cover a minimum of 95 percent of the total inventory, with provisions made available to accommodate the remaining 5 percent. The maximum source term shall represent the bounding fuel assembly in the entire inventory to be received at the repository. Use of the design basis or maximum source term shall be justified on a case-by-case basis.

Minimum initial enrichment shall be established in accordance with NRC Interim Storage Guidance –6, NRC 2001, for the selected fuel assembly used in determining the source term, since lower enriched fuel irradiated to the same burnup as higher enriched fuel produces a higher source term.

Technical Rationale–The source term criteria are required to provide the radiation source terms as a basis for surface and subsurface facility shielding design. These criteria are consistent with those used in the previous YMP shielding calculations and NRC regulatory guidance.

4.9.1.5 Flux-to-Dose Conversion Factors

Criteria–Shielding calculations shall use the flux-to-dose conversion factors as provided in ANSI/ANS-6.1.1-1977 for converting the calculated neutron and gamma fluxes to the respective dose rates. The selection of this standard complies with Table 1004 (b).2 of 10 CFR 20.1004, and is consistent with the specification in NUREG-1567 (NRC 2000a) (p. 7-12) and NUREG-1617 (NRC 2000b) (p. 5-5).

Technical Rationale–The flux-to-dose conversion factors are required to convert the calculated neutron and gamma fluxes to dose rates for demonstration of regulatory compliance. NRC has accepted the use of the ANSI/ANS-6.1.1-1977 standard for this conversion.

4.9.1.6 Shielding Computational Methods

Criteria–Shielding calculations shall be performed using the NRC-accepted computer codes that have been benchmarked, validated, qualified and baselined in accordance with the project software management procedure. The analytical tools may include codes that use Monte Carlo, deterministic transport, and point-kernel integration techniques for the various shielding problems encountered in the repository design.

Currently, these codes include MCNP, SCALE, QAD-CGGP, PATH, and MicroSkyshine. Except for PATH, NRC recognizes the acceptance of these codes for analysis for spent fuel storage facilities in NUREG-1567 (pp. 7-12 and 7-13). PATH is similar to the QAD-CGGP code, and accepted by the NRC in the GA-4 transportation cask certification.

Technical Rationale–The qualified shielding codes are required to perform shielding calculations. NRC has accepted these computer codes for shielding analyses for spent fuel storage facilities and transportation packaging.

4.9.1.7 Worker Dose Assessment

Criteria–Worker dose assessment shall include individual and collective doses for both normal operations and Category 1 event sequences in compliance with 10 CFR 63.111(b)(1). Total dose including internal and external exposures shall be calculated on an annual basis by summing the contributions from normal operations and frequency-weighted doses from Category 1 event sequences for demonstration of regulatory compliance.

Technical Rationale–The worker dose assessment criterion is required to calculate annual individual and collective doses to workers, including normal operations and Category 1 event sequences. The summation approach is consistent with that used for off-site dose consequence calculations as part of the preclosure safety analysis, and has been accepted by NRC for demonstration of compliance with 10 CFR 63.111(b)(1).

4.9.2 Criticality Design Criteria

4.9.2.1 Criticality Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Nuclear Engineering	Criticality*	ANSI/ANS-8.1-1998, ANSI/ANS-8.3-1997, ANSI/ANS-8.5-1996, ANSI/ANS-8.6-1983, ANSI/ANS-8.7-1998, ANSI/ANS-8.9-1987, ANSI/ANS-8.10-1983, ANSI/ANS-8.12-1987, ANSI/ANS-8.15-1981, ANSI/ANS-8.17-1984, ANSI/ANS-8.19-1996, ANSI/ANS-8.20-1991, ANSI/ANS-8.21-1995, ANSI/ANS-8.22-1997, ANSI/ANS-8.23-1997, ASTM C992-89 (Re-approved 1997)
		RG 1.13, Rev 1, RG 3.71 Rev 0
		10 CFR 20, 10 CFR 63.111(a), 10 CFR 63.111(b), 10 CFR 63.112 (e)(6), 10 CFR 63.204, 10 CFR 70, 10 CFR 72
		NUREG-0800 1987 (NRC 1987), NUREG-1520 2002 (NRC 2002c), NUREG-1536 1997 (NRC 1997), NUREG-1567 2000 (NRC 2000a), NUREG/CR-2300 1983 (NRC 1983), NUREG/CR-6483 (Emmett and Jordan 1996), NUREG/CR-6361 (Lichtenwalter et al.1997), NRC 2002a NUREG/CR-6328 (Parks et al. 1995)
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21 (c)(2)), and PRD-022. Determination of applicable sections of these codes and standards will be determined during the design process and in development of design products.

[2] These Regulatory Guides have been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guides will be determined during the design process and in development of design products that are impacted by these Regulatory Guides.

[3] Addressing Code of Federal Regulations supports compliance with requirements in PRD-015/P-015, PRD-002/T-012, and PRD-002/T-022. Determination of applicable sections of these documents will be determined during the design process and in development of design products.

[4] NUREGs provide guidance on acceptable methods and approaches that could be utilized in MGR design

[5] None

*Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.9.2.2 Criticality Safety Design Criteria

4.9.2.2.1

Criteria–SNF processing and handling facilities shall be designed for criticality safety, incorporate means to prevent and control criticality [10 CFR 63.112(e)(6)], and include criticality monitoring systems where SNF is handled and stored. The criteria for criticality safety for all SNF (except for naval SNF for which a preclosure methodology is being developed) prior to being loaded into waste packages shall be met by the following:

1. Ensuring that at least two unlikely, independent and concurrent or sequential changes must occur under normal condition, and Category 1 and 2 event sequence, before a nuclear criticality accident is possible.

Technical Rationale–This criteria is a consequence of 10CFR 63.112(e)(6) which requires that the geologic repository provide the means to prevent and control criticality. It also reflects the criteria for the storage of SNF and high-level radioactive waste in 10 CFR 72.124 (a), which includes very nearly identical wording. It meets the requirement for double-contingency protection as stated in 10 CFR 70.64 (a)(9). Note that in NRC letter, L. Kopp to Timothy Collins, "*Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light Water Reactor Power Plants*", Kopp, L. 1998, it states in item 3 that, "The criticality analysis should consider all credible incidents and postulated accidents. However, by virtue of the double-contingency principle, two unlikely independent and concurrent incidents or postulated accidents are beyond the scope of the required analysis." Consequently, double-contingency need only be demonstrated without the extra accidents assumed.

2. Including margins of safety for nuclear criticality parameters that are commensurate with the uncertainties in the data and methods of analysis. Specifically, the multiplication factor, keff, including all biases and two-sigma uncertainty will not exceed 0.95 under all normal, conditions and Category 1 and 2 event sequences.;

Technical Rationale–The specification [revised] for bias and uncertainty for the multiplication factor is stated in NUREG-1536 (NRC 1997), *Standard Review Plan for Dry Casks Storage Systems*.

3. Basing facility designs on the use of favorable geometry, permanently fixed neutron absorbing materials, or both, and without the use of burnup credit;

Technical Rationale–This comes from the criteria for the storage of SNF and High-Level radioactive waste in 10 CFR 72. Specifically, 10 CFR 72.124 (b) requires the use of favorable geometry and/or fixed neutron absorbing materials (poisons) or both. Excluding the use of burnup credit is a reflection of NRC Interim Staff Guidance-8, Revision 2, NRC 2002a, which requires measurement of burnup credit for use and is limited to PWR application only. This is also stated in RG 3.71, Section C which endorses standard, ANSI/ANS-8.17-1984 with the exception that, "-credit for fuel burnup may be taken only when the amount of burnup is confirmed by physical measurements that are appropriate for each type of fuel assembly in the environment in which it is to be stored." Since the facility will be handling and storing a variety of SNF besides PWR and since a decision has not been made to measure burnup at this time, the prudent measure is to not use burnup credit in non-waste package nuclear criticality safety.

4. Include criticality monitoring and alarm systems in areas where spent nuclear fuel is handled or stored, unless it can be demonstrated that a criticality event is not credible (that is, beyond category 2 event sequence).

Technical Rationale–This reflects the criteria for the handling and storage of SNF and High-Level radioactive waste in 10 CFR 72. Specifically, 10 CFR 72.124 (c) defines the requirements for criticality monitoring and alarms and excludes the need for such monitoring for SNF handling or storage beneath sufficient water shielding. These are also consistent with the criticality monitoring and alarm requirements for the possession of SNF as noted in 10 CFR 70.24.

4.9.2.2.2

Criteria–The waste package shall be redesigned if the total probability of criticality has a chance of 1 over the 10,000 year regulatory period.

Technical Rationale–This is required by the *Disposal Criticality Analysis Methodology Topical Report*, Rev 01, YMP/TR-004Q, Section 3.2.2, p. 3-5 (YMP 2000).

4.9.2.2.3

Criteria–To minimize the potential for a criticality in the surface facility, no moderator (water or other hydrogenous materials) shall be present in any area where radioactive waste is being handled (cask unloading, storage areas, disposal container loading area, waste package closure area, etc.) unless the facility design (such as a SNF storage pool) or proposed quantity of moderator material can be shown to impose no criticality concerns. Moderator sources include the potential for flooding from areas in which waste forms is not directly present.

Technical Rationale–This criteria is based on NUREG-1520, *Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility*, Section 5.4.3.4.2 (NRC 2002c).

4.9.2.2.4

Criteria–Systems, structures and components shall be designed such that adequate controls and procedures are put in place to ensure that neutron moderator basket materials and neutron absorber rods are inserted into the CSNF waste package as required.

Technical Rationale–This criteria is based on NUREG-1520, *Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility*, Section 5.4.3.4.2. (NRC 2002c)

4.9.2.2.5

Criteria–Systems, structures and components shall be designed such that adequate controls and procedures are put in place to ensure correct loading of the CSNF assemblies into a waste package as prescribed by the derived waste package loading curves.

Technical Rationale–This criteria is based on NUREG-1520, *Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility*, Section 5.4.3.4.2. (NRC 2002c)

4.9.2.2.6

Criteria–Systems, structures and components shall be designed such that adequate controls and procedures are put in place to ensure closure of the waste package is performed in a manner to preclude moderator introduction during the preclosure period and to ensure waste package performance objectives are met during the postclosure period.

Technical Rationale–This criteria is based on NUREG-1520, *Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility*, Section 5.4.3.4.2. (NRC 2002c)

4.9.2.2.7

Criteria–Systems, structures and components shall be designed such that adequate controls and procedures are put in place to ensure that the handling of the disposal container and waste package does not result in waste package damage or reconfiguration of the waste package internals that may pose criticality concerns during the preclosure period or that may impact waste package performance objectives during the postclosure period.

Technical Rationale–This criteria is supported by the requirements in 10 CFR 63.112 (e) (6).

4.9.2.2.8

Criteria–Systems, structures and components shall be designed such that adequate controls and procedures can be effectively implemented to ensure that acceptable verification of the burnup assignment of received commercial spent nuclear fuel has been made. If burnup assignment cannot be acceptably verified, a measurement of the commercial spent nuclear fuel assembly's burnup shall be made prior to insertion into a disposal container.

Technical Rationale–This criteria meets the requirements of Regulatory Guide 3.71, Rev 0, and the NRC Interim Staff Guidance - 8, *Burnup Credit in the Criticality Safety Analyses of PWR Spent Fuel in Transport and Storage Casks*, Rev 2, Recommendation 5 (NRC 2002a).

4.9.3 ALARA Design Criteria

4.9.3.1 ALARA Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Nuclear Engineering	ALARA*	ERDA 76-21 (Burchsted et al. 1979)
		RG 8.8 Rev 3, RG 8.10 Rev 1-R, RG 8.34, Rev 0
		10 CFR 20.1101(b),(d), 10 CFR 20.1003, 10CFR 63.111(a), 10 CFR 63.204
		NUREG-0800 1987 (NRC 1987), NUREG-1567 2000 (NRC 2000a)
		None

Technical Rationale:

[1] This code and standard support compliance with requirements of Project Requirements Document (Curry and Loros 2002) such as PRD-002/T-004 (Information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21 (c)(2)), and PRD-022. Determination of applicable sections of this code and standard will be determined during the design process and in development of design products.

[2] These Regulatory Guides have been determined to be critical to the development of design products for preliminary design. The level of conformance with regulatory positions in the Regulatory Guides will be determined during the design process and in development of design products that are impacted by these Regulatory Guides.

[3] Addressing Code of Federal Regulations supports compliance with requirements in PRD-015/P-015, PRD-002/T-012, and PRD-002/T-022. Determination of applicable sections of these documents will be determined during the design process and in development of design products.

[4] These NUREGs provide guidance on acceptable methods and approaches that could be utilized in MGR design.

[5] None

*Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.9.3.2 ALARA Design Criteria

Criteria–ALARA is a regulatory requirement for the Yucca Mountain Repository that must be addressed.

Technical Rationale–10 CFR 63.111(a) states that "the geologic repository operations area must meet the requirements of part 20 of this Chapter [10CFR20]." A portion of part 20, 10 CFR 20.1101(b), states "The licensee shall use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA)." In addition, 10CFR63 and 10 CFR 20 provide limits and constraints on radiation doses to the public.

4.9.3.3 ALARA Design Goals

The repository will receive, prepare, and package spent nuclear fuel and high-level radioactive waste for emplacement underground. This SNF and HLW contains large amounts of radioactive material, and this potential hazard must be handled in a manner that achieves radiation safety for the general public and repository workers. A combination of management commitments, radiation safety considerations for design development, and regulatory requirements and guidance are employed to achieve designs that support radiatioin safety at the Yucca Mountain Repository. This discussion addresses incorporating the radiation safety practice of "As Low As Is Reasonably Achievable" (ALARA) in the design of repository facilities.

Criteria–The ALARA Design Goals for occupational workers are to ensure that both individual and collective annual doses are maintained at ALARA levels during normal operations and as a result of Category 1 event sequences. Category 1 event sequences will be included in ALARA dose assessments. The following ALARA design goals are established for the design process:

- Individual Dose:

  The ALARA design goal for individual radiation worker doses is to minimize the number of individuals that have the potential of receiving more than 500 mrem/yr total effective dose equivalent (TEDE). That goal is 10% of the annual TEDE limit in 10 CFR 20.1201, and includes both internal and external exposures.

  The ALARA goal for on-site members of the general public is to maintain individual doses less than 10-20 percent of the annual TEDE limit of 100 mrem in 10 CFR 20.1301.

  The general public dose shall comply with the pre-closure performance objectives as specified in 10 CFR 63.111, as well as the annual effluent dose limit of 10 mrem in 10 CFR 20.1101(d).

- Collective Dose:

  The ALARA design goal for collective doses is to maintain the average annual individual dose for each worker group at less than 500 mrem/yr total effective dose equivalent (TEDE). That goal is 10% of the annual TEDE limit for individuals in 10 CFR 20.1201, and includes internal and external exposures. Worker groups are defined as groups of individuals with the same or similar work duties, such as operators, maintenance, and radiation safety personnel. Minimize the number of personnel in each worker group in testing conformance with the collective dose ALARA goal. (In combination with the Individual Dose Goal, it is expected that no individual worker in a work group could have a dose substantially above 500 mrem/yr and the group will still satisfy the Collective Dose Goal.)

Technical Rationale–The individual and collective dose goals criterion is required to meet the regulatory guidance contained Regulatory Guide 8.8, Rev 3, which is a method acceptable to the NRC staff for implementing the regulatory requirements in 10 CFR 20.1101(b). This criterion supports compliance with 10 CFR 63.111 (b)(1), which requires, in part, meeting the 10 CFR Part 20 requirement to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable.

4.9.3.4 Cost Benefit Analysis–Value of Person-Rem Averted

Criteria–In developing the design, qualitative cost benefit considerations will be used for comparing design alternatives and justifying design decisions, where appropriate. In determining whether a dose-reducing design alternative is reasonable, $10,000 per person-rem averted will guide decisions based on current industry practices. Other values may be used as appropriate, with adequate justification, and documentation.

Technical Rationale–This criteria is in accordance with the guidance provided in Regulatory Guide 8.8, Rev 3, approaches and related NUREGs. This guidance is a method acceptable to the NRC staff for implementing the regulatory requirements in 10 CFR 20.1101(b). 10 CFR 20 is applicable as required by 10 CFR 63.111(b)(1). The dollar person-rem value is required in order to perform cost benefit considerations.

4.9.3.5 Radiological Condition Area Classifications

Criteria–Radiological conditions in facility areas during normal operations and as a result of Category 1 event sequences are fundamental inputs for the ALARA design process. The classification of facility areas provides Designers/Engineers useful information for minimizing occupational radiation doses by incorporating in design appropriate features, such as access control, equipment layout and shielding design. Each area of the facility will be classified by radiological conditions, both dose rate range and contamination information as described in the following Tables 4.9.3-1 and 4.9.3-2. This classification information is available to Designers/Engineers in developing and evaluating Designs and alternatives. Areas should be re-classified as the radiological conditions change during the design evolution.

On-site facility areas are classified by radiation level to support the ALARA Design process. Dose rates are for exposure due to licensed material, and do not include exposure due to background radiation. The following classification system is used.

Table 4.9.3-1. Area Dose Rate Classification

Radiation Dose Rate Classification	Dose Rate Range For Preliminary Design (MREM/HR)	Basis
R1 Controlled Area	0 to 0.05	Inside Controlled Area and outside Restricted Areas; continuous occupancy possible. Upper end of range set at 100% of public limit - 10CFR20.1301(a)(1), assuming occupancy for full work year. [100 mrem/yr / 2000 hr/yr x 1.0]
R2 Restricted Area	>0.05 to 5.0	Continuous occupancy possible. (up to 2.5 mrem/hr for 2,000 hr/yr). Upper end of range is lower limit for Radiation Area - 10CFR20.1003 [5 mrem/hr]
R3 Radiation Area	>5.0 to100	Occasional occupancy possible. Upper end of range is the lower limit for High Radiation Area - 10CFR20.1003 [100 mrem/hr]
R4 High Radiation Area (design lower range)	>100 to 1,000	Infrequent and limited occupancy possible. Upper end of range set at 10 times the lower limit for High Radiation Area - 10CFR20.1003 [100 mrem/hr x 10]
R5 High/Very High Radiation Area (design upper range of High Radiation Area and Very High Radiation Area)	>1,000	No occupancy at these dose rates. High Radiation Area effective upper limit is 500 rad/hr - 10CFR20.1003. No upper limit for Very High Radiation Area - 10CFR20.1003

NOTES:

1 Occupancy is not allowed in areas classified as R5. The design intent is that in order to permit occupancy in these areas, the source of radiation must be removed or shielded and dose rates reduced to allow temporary reclassification to R2, R3 or R4.

2 Areas R2 through R5 are Restricted Areas, per 10 CFR 20.1003.

On-site facility areas are classified by radioactive material contamination levels (surface/airborne) to support the ALARA design process. The classification of an area in terms of contamination will be more dependent on the type of control regime necessary than the mean or maximum contamination level present. This reflects the fact that the potential contamination is as important as the actual contamination. The contamination considered is due to licensed material, and does not include exposure due to naturally occurring radioactive material. The following classification system is used.

Table 4.9.3-2. Area Contamination Classification

Radioactive Material Contamination Classification	Preliminary Design Contamination Characteristics	Typical Controls
C1	No potential for contamination; clean	None required.
C2	Low potential for contamination; normally clean	No specific protective clothing requirements. Contamination monitoring at exit.
C3	High potential for contamination	Protective clothing and monitoring with respiratory equipment available.
C4	Normally contaminated	Full protective clothing and monitoring with respirators or full-face masks.
C5	High levels of contamination	Full body protective clothing and monitoring with respirators or full-face masks. Entry typically forbidden until cleaned to C4 or lower level. Additional confinement design features may be warranted.

NOTE: Classifications C1 to C4 reflect Zones IV to I of ERDA 76-21.

Technical Rationale–This criteria is required to mitigate potential risk associated with radiation dose to occupational workers and the public, and as an element of engineering controls applied to the geological repository operations areas to support the as low as is reasonably achievable philosophy. This criterion is based on the requirements of 10 CFR Part 20, and the guidance of Regulatory Guide 8.8, rev 3, NUREG-0800 (12.3) (NRC 1987) and ERDA 76-21 (Burchsted et al. 1979).

4.10 OFFSITE UTILITY INTERFACE DESIGN CRITERIA

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], RGs[2], CFRs[3], NUREGs[4], DOE Directives[5]
Electrical	Offsite Utility Interface*	To be added later
		To be added later
		To be added later
		To be added later
		To be added later

Technical Rationale:

1.
2.
3.
4.
5.

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.11 PLANT DESIGN CRITERIA

4.11.1 Surface Design Criteria

4.11.1.1 Surface Code and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1],RGs[2],CFRs[3], NUREGs[4], DOE Directives[5].
Plant Design	Surface*	ICC-2000 (IBC), NFPA 101-2000, NFPA 70-2002
		None
		29 CFR 1926
		None
		None

Technical Rationale:

[1] These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21 (c)(2)), and PRD-022. Determination of applicable sections of these codes and standards will be determined during the design process and in development of design products.

[2] None.

[3] Addressing Code of Federal Regulations supports compliance with requirements in PRD-015/P-020 and PRD-015/P-021. Determination of applicable sections of these documents will be determined during the design process and in development of design products.

[4] None.

[5] None.

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.11.2 Subsurface Design Criteria

4.11.2.1 Subsurface Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5].
Plant Design	Subsurface*	None
		None
		10 CFR 63.111(b) and 112(e), 10 CFR 63.111(d) and 10 CFR 63.132(a)
		None
		None

Technical Rationale:

[1] None

[2] None

[3] Addressing Code of Federal Regulations supports compliance with requirements in PRD-015/P-020 and PRD-015/P-021. Determination of applicable sections of these documents will be determined during the design process and in development of design products. Addressing these regulations will demonstrate compliance with requirements in *the Subsurface Tunneling System Description Document* (BSC 2002r) and *Emplacement Drift System Description Document* (BSC 2002f).

DOE is not subject to the Federal Mine Safety and Health Act (MSHA) of 1977, as to the construction and operation of any facilities in the Geologic Repository Operations Area (GROA). However, some worker protection provisions of MSHA (30 CFR 57) may be used as guidance in the subsurface design of Structures, Systems and Components in the GROA.

By using such guidance, there is no explicit or implicit expectation other than its use in the Project Design Criteria document. DOE is not obligated to comply with any aspect of MSHA and that the Mine Safety and Health Administration has no jurisdiction or enforcement authority over construction or operation of any facility of the Monitored Geologic Repository.

[4] None

[5] None

*Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.11.2.2 Standoffs affecting the location of the repository within the Repository Host Horizon

Criteria–Maintain a minimum PTn thickness of 10 m (33 ft) with a minimum 100-m (328-ft) standoff between the top of this 10 meter section of PTn and the invert of the emplacement drift. *Underground Layout Configuration* (BSC 2003b) Section 7.1.4

Technical Rationale–This is to limit alteration of the permeability (due to heating) of the Paintbrush nonwelded (PTn) hydrologic unit.

Criteria–Establish a minimum 60-m (200-ft) standoff between the CHn and the inverts of the emplacement drifts. *Underground Layout Configuration* (BSC 2003b) Section 7.1.6.

Technical Rationale–This is to limit chemical alteration (due to heating) of the Calico Hills nonwelded (CHn) hydrogeologic unit.

Criteria–Establish a minimum 120-m (328-ft) standoff between the water table and the repository. *Underground Layout Configuration* (BSC 2003b) Section 7.1.1.

Technical Rationale–This is to maintain separation between the repository and the water table under potential future (wetter) climates that could cause the water table to rise.

Criteria–Establish a minimum 30-m (100-ft) standoff between the inverts of the emplacement drifts and the perched water at the North end of the repository area. *Underground Layout Configuration* (BSC 2003b) Section 7.1.2.

Technical Rationale–This is to avoid vaporization of the perched water.

Criteria–Emplacement drifts shall be located within the characterized area. *Underground Layout Configuration* (BSC 2003b) Section 7.1.7.

Technical Rationale–Performance assessment models can only analyze area within the characterized region at the present time.

Criteria–Establish a minimum 60-m (200-ft) standoff between Type 1 faults and repository emplacement openings. *Underground Layout Configuration* (BSC 2003b) Section 7.1.3.

Technical Rationale–This is to reduce impact of potential fault movement.

4.11.2.3 Opening Stability

Criteria–The emplacement drifts shall be oriented 90 degrees to the prevailing joint direction. *Underground Layout Configuration* (BSC 2003b) Section 5.1.4.

Technical Rationale–This is to provide for stable emplacement drift openings.

Criteria–The vertical separation between crossing drifts shall be a minimum of 10 meters (33 ft) from the crown of the lower opening to the invert of the upper opening. *Underground Layout Configuration* (BSC 2003b) Section 6.3.

Technical Rationale–This is to ensure stable openings when drifts cross at different elevations.

Criteria–The minimum spacing (centerline-to-centerline) for non-emplacement drifts, running parallel, is three drift diameters, based upon the diameter of the largest drift. *Underground Layout Configuration* (BSC 2003b) Section 6.3.

Technical Rationale–This is to provide for stable openings.

4.11.2.4 Emplacement Drift Configuration

Criteria–The portion of an emplacement drift loaded with waste packages shall be 600 m or less. *Underground Layout Configuration* (BSC 2003b) Section 6.1.

Technical Rationale–This is so that the heated length within the emplacement drift is within the range analyzed for cooling.

Criteria–The excavated diameter of openings that are used to dispose of waste packages shall be a minimum of 5.5-m (18-ft). *Underground Layout Configuration* (BSC 2003b) Table 3.

Technical Rationale–This establishes a minimum opening for use in designing emplacement drift fittings and the mobile equipment that is intended to use the emplacement drifts.

Criteria–The emplacement drift spacing (center-to-center) shall be a minimum of 81-m (266-ft). *Underground Layout Configuration* (BSC 2003b) Section 6.2.

Technical Rationale–This supports that the engineered barrier system be designed to work in conjunction with the natural barriers to limit radioactive materials released from the geologic repository. This assumed drift spacing promotes drainage of thermally mobilized water and the increase the independence of individual drifts.

Criteria–The grade of the emplacement drifts shall be horizontal. *Underground Layout Configuration* (BSC 2003b) Section 7.2.6.

Technical Rationale–This is to ensure that any water entering the emplacement drift will not collect in pools. It is desired that water drain uniformly along the length of the drift.

4.11.2.5 Operations

Criteria–The excavated diameter of openings (excluding the emplacement drift) used to transport waste packages shall be a minimum of 7.62-m (25-ft). *Underground Layout Configuration* (BSC 2003b) Table 4.

Technical Rationale–This establishes a minimum opening size for use in designing drift fittings and the mobile equipment that is intended to be used in these drifts.

Criteria–The portions of the underground layout (excluding the emplacement drifts) that are to be used to transport waste packages shall have a maximum grade of 2.5 percent to preserve the option of using a rail system for the Waste Package transporter. *Underground Layout Configuration* (BSC 2003b) Section 6.6.

Technical Rationale–This is to provide a basis for mobile equipment design and safety analysis.

Criteria–A minimum 305-meter (1,001 ft) radius curve along the centerline of the drifts used in the ramps and mains for conveyor muck handling. *Underground Layout Configuration* (BSC 2003b) Section 6.6.

Technical Rationale–This is to preserve the option of using conveyor belts to remove muck during construction without using conveyor transfer stations.

Criteria–A minimum 100-meter (328 ft) radius curve along the centerline of the drifts not used for conveyor muck handling. *Underground Layout Configuration* (BSC 2003b) Section 6.6.

Technical Rationale–This is to provide a basis for selecting mobile equipment to be used in these openings.

Criteria–The curved sections of the emplacement drift turnouts shall have a minimum radius of 20-meters (66-foot). *Underground Layout Configuration* (BSC 2003b) Section 6.6.

Technical Rationale–This preserves the option to use a rail system during construction.

Criteria–The nominal mobile equipment (other than waste package transporters) operating speed range is 0-8 mph. *Underground Layout Configuration* (BSC 2003b) Section 6.6.

Technical Rationale–There are not specific rules governing the underground operations regarding speed, right-of-way direction for movement of the vehicles. 30 CFR 57 indicates that the rules should be established and followed at each mine and the operating speed shall be consistent with conditions of roadways, tracks, grades, clearance, visibility, and traffic, and the type of equipment used. For the purpose of the repository design, an operating speed ranging from 0 to 8 mph shall be assumed. This is based on operational experience from activities under similar conditions. (Cummins, A.B. et al 1973, *SME Mining Engineering Handbook*, Section 14.9.3, pp 14 - 46,47).

4.11.2.6 Miscellaneous

Criteria–Locate portal and shaft collar openings outside of the maximum probable flood areas

Technical Rationale–This will prohibit surface waters from entering the emplacement drifts and shaft openings during times of flooding.

Criteria–The surface gradient at the portal openings and shaft collars should be down gradient, away from the openings.

Technical Rationale–This will prohibit surface runoff from rain or spills from entering the openings.

4.11.3 Piping Design Criteria

4.11.3.1 Piping Design Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5].
Plant Design	Piping*	ASME B31.1-2001, ASME B31.3-2002, ASME B31.4a-2001, ASME B31.5-2001, ASME B31.9-1996
		None
		None
		None
		None

Technical Rationale:

1 These codes and standards support compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21(c)(2)), and PRD-022. Determination of applicable sections of these codes and standards will be determined during the design process and in development of design products.

2 None

3 None

4 None

5 None

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.12 SOLAR POWER STATION DESIGN CRITERIA

4.12.1 Solar Power Station Design Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5].
Electrical	Solar Power Station*	To be added later
		To be added later
		To be added later
		To be added later
		To be added later

Technical Rationale:

1.

2.

3.

4.

5.

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

4.12.2 Solar Power Station Design Criteria

Criteria–Solar power system shall be provided in conjunction with normal utility power system.

Technical Rationale–This criteria is required to facilitate renewable energy sources to supplement commercial power. The solar electrical power panels will be built in a phased fashion at the site with a capacity up to 3 MW (PRD014/T-025, Curry, P.M. and Loros, E.F. 2002. *Project Requirements Document*).

Criteria–Applicable industry solar power standards shall apply to the site solar power system.

Technical Rationale–This criteria is required because the solar power development is still in infancy stage. The quality of system and equipment shall be as close to the state-of-art as possible.

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5. WASTE PACKAGE DESIGN CRITERIA

5.1 MECHANICAL DESIGN CRITERIA

5.1.1 Structural Design Criteria

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Specialty Analyses and Waste Package Design	Structural*	2001 ASME Boiler and Pressure Vessel Code-Section III, Division 1, ANSI N14.6-1993
		None
		None
		None
		None

NOTES:

Technical Rationale:

[1] This code supports compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21(c)(2)), PRD-022, *DOE & Commercial Disposal Container/Waste Package System Description Document* (BSC 2002a) and the *Naval Spent Nuclear Fuel System Description Document* (BSC 2002o). Section III, Division 1, of *2001 ASME Boiler and Pressure Vessel Code*, provides rules for design and fabrication of nuclear components. Procurement of waste packages may be done to the code in effect at the time of procurement.

[2] None

[3] None

[4] None

[5] None

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

5.1.1.1 Design Load Combinations

Criteria–The structural evaluation of the waste package shall include the load conditions identified in Tables 5.1.1-1 and 5.1.1-2.

Table 5.1.1-1. Summary of Load Combinations for Normal and Hypothetical Accident Conditions for the Waste Package at the MGR on the Surface and to the Emplaced Condition

Applicable Initial Conditions

	Ambient Temperature[1]		Decay Heat[2]		Internal Pressure[3]		Dead Weight[4]
	116°F	2°F	Max.	Zero	Max.	Min.	
Vertical Lift[5]	X		X		X		X
		X		X		X	X
Horizontal Lift[5]	X		X		X		X
		X		X		X	X
Accident Conditions[6] (Event Sequences)							
Seismic - Frequency Category 2 Event[7]	X		X		X		X
		X		X		X	X
Spherical object fall while vertical from 6.1 ft (2m) of 5,100 lbs (2.3 MT)	X		X		X		X
		X		X		X	X
Free drop Horizontal 7.3 ft (2.4 m)[8]	X		X		X		X
		X		X		X	X
Free drop Vertical 6.1 ft (2.0m)[8]	X		X		X		X
		X		X		X	X
Tip Over Slap Down	X		X		X		X
		X		X		X	X
Free drop w/emplacement pallet 6 ft (2m)	X		X		X		X
		X		X		X	X
Missile Impact from internal source 1.1 lb (0.5 Kg) at 15.7 ft/s (5.7 m/s)	X		X		X		X
		X		X		X	X
Rock Fall while Horizontal 13,230 lbs. (6 MT)	X		X		X		X
		X		X		X	X
Thermal fire accident	X		X		X		X

NOTES:

[1] Values for Ambient Temperature are provided in Section 6.1.1.5.

[2] Max Decay Heat may take credit for the time prior to arrival at the site or before closure for the waste form involved.

[3] Maximum internal pressure would be maximum pressure at package closure plus any additional pressure from failure of fuel and temperature increase.

[4] Dead Weight will include the maximum weight for the specific type of waste package and will consider any significant loading deviations of weight distribution and center of gravity.

[5] The waste package is lifted from one end in the vertical position and from both ends in the horizontal position as it is processed.

[6] Event sequences include those events identified below. These will be taken one event at a time since after an event sequence occurs, work will be stopped until a recovery plan is developed.

[7] If the waste package survives the Frequency Category II Event provided in Section 6.1.3, it can be assumed to survive the Frequency Category I Event.

[8] Drop accidents should evaluate the waste package for any drop from the indicated position or condition onto a flat unyielding horizontal surface. The waste package should strike the surface in a position that is expected to inflict maximum damage. Impacts with the maximum and minimum weight of contents should be considered.

Table 5.1.1-2. Summary of Load Combinations for Normal and Hypothetical Accident Conditions for the Waste Package at the Monitored Geologic Repository in the Emplaced Postclosure Condition on Pallet

Applicable Initial Conditions

	Ambient Temperature[1]		Decay Heat[2]		Internal Pressure[3]		Dead Weight[4]
	205°F	77°F	Max.	Zero	Max.	Min.	
Static on pallet	X		X		X		X
		X		X		X	X
Accident Conditions							
Postclosure Seismic Event	X		X		X		X
		X		X		X	X

NOTES:

[1] Values for Ambient Temperature are maximum in drift temperature from Section 4.2.4.6.8 and estimated ground ambient temperature.

[2] Max Decay Heat may take credit for the time prior to arrival at the site or before closure for the waste form involved.

[3] Maximum internal pressure would be maximum pressure at package closure plus any additional pressure from failure of fuel and temperature increase.

[4] Dead Weight will include the maximum weight for the specific type of waste package and will consider any significant loading deviations of weight distribution and center of gravity.

Technical Rationale–The design load combinations are established to ensure that all appropriate load combinations are considered in the structural evaluation. These combined with the ASME *Boiler and Pressure Vessel Code,* Section III, Division I, 2001 ensure the structural integrity of each waste package. The Frequency Category 2 Seismic event is described in Section 6.1.3. Accident conditions were identified in *Nuclear Safety Criteria for Disposal Container System Description Documents* (CRWMS M&O 2000c). Other parameters including fire are situation or location specific. The Postclosure Seismic Event has not yet been defined.

5.1.2 Metallurgical Design Criteria

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Specialty Analyses and Waste Package Design	Metallurgical*	2001 ASME Boiler and Pressure Vessel Code-Section III, Division I, Subsection NC 2000 and Section II
		None
		None
		None
		None

Technical Rationale:

[1] This code supports compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21(c)(2)), PRD-022, *DOE & Commercial Disposal Container/Waste Package System Description Document* (BSC 2002a) and *Naval Spent Nuclear Fuel System Description Document* (BSC 2002o). Section III of *2001 ASME Boiler and Pressure Vessel Code*, provides rules for design and fabrication of nuclear components. Procurement of waste packages may be done to the code in effect at the time of procurement.

[2] None

[3] None

[4] None

[5] None

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

5.1.3 Thermal Design Criteria

5.1.3.1 Thermal Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Specialty Analyses and Waste Package Design	Thermal*	To be added later
		To be added later
		To be added later
		To be added later
		To be added later

Technical Rationale:

[1] None

[2] None

[3] None

[4] None

[5] None

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

5.1.3.2 Temperature Limits

Criteria–The maximum cladding temperature limit is 350 degrees celsius (also provided in Section 6.3).

Technical Rationale–The maximum cladding temperature limit has been specified by DOE. Arthur, W.J., III. 2003. "*Level 2 Directed Baseline Change.*" Letter from W.J. Arthur, III (DOE/ORD) to J.T. Mitchell (BSC), March 6, 2003.

Note: The temperature limits for storage and accident conditions due to fire obtained from Interim Staff Guidance-11, Rev 2, Appendix Page 3, NRC 2002b, are different than that provided above. Interim Staff Guidance-11, Rev 2, Appendix Page 3, NRC 2002b requires the waste package to maintain SNF zircaloy peak cladding temperature below 400 degrees celsius (688 degrees fahrenheit) for normal conditions during storage and short-term operations, and below 570 degrees celsius (1,058 degrees fahrenheit) during an accident involving fire.

5.2 WELDING DESIGN CRITERIA

5.2.1 Lid Welding Design Criteria

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Materials and Fabrication Technology	Lid Welding*	2001 ASME Boiler and Pressure Vessel Code-Section III, Division I, Subsection NC and Section IX
		None
		None
		None
		None

Technical Rationale:

[1] This code supports compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21(c)(2)), PRD-022 and *Disposal Container Closure System Description Document* (BSC 2002k). Section III, Division I, of *2001 ASME Boiler and Pressure Vessel Code*, provides rules for design and fabrication of nuclear components. Procurement of waste packages may be done to the code in effect at the time of procurement.

[2] None

[3] None

[4] None

[5] None

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

5.2.2 Lid Welding Inspection Design Criteria

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Materials and Fabrication Technology	Lid Welding Inspection*	2001 ASME Boiler and Pressure Vessel Code-Section III, Division I, Subsection NC and Section V
		None
		None
		None
		None

Technical Rationale:

1 This code supports compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21(c)(2)), PRD-022 and *Disposal Container Closure System Description Document* (BSC 2002k). Section III, Division I, of *2001 ASME Boiler and Pressure Vessel Code*, provides rules for design and fabrication of nuclear components. Procurement of waste packages may be done to the code in effect at the time of procurement.

2 None

3 None

4 None

5 None

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

5.2.3 Inerting System Design Criteria

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Materials and Fabrication Technology	Inerting System*	To be added later
		To be added later
		To be added later
		To be added later
		To be added later

Technical Rationale:

1

2

3

4

5

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

5.2.4 Stress Mitigation Design Criteria

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Materials and Fabrication Technology	Stress Mitigation*	To be added later
		To be added later
		To be added later
		To be added later
		To be added later

Technical Rationale:

1

2

3

4

5

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

5.2.5 Fabrication Design Criteria

5.2.5.1 Fabrication Codes and Standards

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Materials and Fabrication Technology	Fabrication *	2001 ASME Boiler and Pressure Vessel Code-Section II, Section III, Division I, Subsection NC/NB/NCA, Section V, Section IX, ASME Y14.5M-1994, ANSI/AWS A2.4-98, ASME Y14.38-1999, ASME Y14.36M-1996, ASME B46.1-1996, ASME NQA-1 2000, ANSI/AWS A5.32/A5.32M-97
		None
		None
		None
		None

Technical Rationale:

1 These codes and standards supports compliance with requirements of *Project Requirements Document* (Curry and Loros 2002) such as PRD-002/T-004 (information relative to codes and standards that DOE proposes to apply to the design and construction of GROA as required by 10 CFR 63.21(c)(2)), PRD-022 and *Disposal Container Closure System Description Document* (BSC 2002k). Section III, Division I, of *2001 ASME Boiler and Pressure Vessel Code*, provides rules for design and fabrication of nuclear components. Procurement of waste packages may be done to the code in effect at the time of procurement.

2 None

3 None

4 None

5 None

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

5.3 INTERFACING CRITERIA

Applicable Discipline	Project SSCs	Applicable Codes/Standards[1], Regulatory Guides (RGs)[2], Code of Federal Regulations (CFRs)[3], NUREGs[4], DOE Directives[5]
Waste Package Mechanical	Interfacing*	To be added later
		To be added later
		To be added later
		To be added later
		To be added later

Technical Rationale:

1

2

3

4

5

* Revised QA classification presently not available. The applicable QA classification will be provided when the revised Q-List is available.

6. DESIGN BASIS FEATURES, EVENTS, AND PROCESSES

6.1 NATURAL PHENOMENA

6.1.1 Meteorological

6.1.1.1 Precipitation

Criteria–The system shall be designed to withstand a frost line depth of 10 inches.

Technical Rationale–Frost line is one of the external environmental parameters that can affect the foundation and footing design for the structures that must be embedded in the ground. The frost line depth will be based on the conditions at the Nevada Test Site. This information is referenced in the *Soils Report for North Portal Area, Yucca Mountain Project* (BSC 2002u).

Criteria–The system shall be designed to withstand and operate in the snowfall environments described in the following:

Parameter	Value
Maximum Daily Snowfall	6 inches (15 cm)
Maximum Daily Snow Depth	4 inches (10 cm)
Maximum Monthly Snowfall	6.6 inches (17 cm)

Technical Rationale–Snowfall is one of the primary design parameters needed for exposed structures to ensure external loadings are accounted for. Snowfall and snow depth was not part of the meteorological monitoring program at Yucca Mountain. Therefore, reasonable estimates of the Yucca Mountain snowfall environment are based upon climatological records from Desert Rock WSMO, Nevada, which is located approximately 45 km east of the repository site at an elevation of 3,300 feet. The Desert Rock period of record is 1984-2001. These values are the actual observations recorded by National Weather Service observers. These data are documented in DTN: MO0212DSRKSNOW.000.

Criteria–The system shall be designed to withstand and operate in the precipitation environment described in the following:

Parameter	Value
Maximum Annual Precipitation	15 inches/yr (38 cm)
Maximum Daily Precipitation	5 inches/day (13 cm)
Precipitation Intensity (50-year return period)	2.30 inches/hour (5.8 cm)
Precipitation Intensity (100-year return period)	2.61 inches/hr (6.6 cm

Technical Rationale–Daily precipitation is an environmental parameter that can affect site drainage and erosion, buried utilities, outdoor equipment seals, and roof drain system sizing. This criterion establishes the rainfall rates through which the affected systems must be able to endure and function. The maximum annual precipitation is derived from the actual annual precipitation amount of 14.43 inches recorded during 1998 (DTN: MO0106SEPSGPCM.001).

This amount is the greatest recorded over the period 1986-2001 at the 60-meter meteorological tower, about 1-km south-southwest of the North Portal. The maximum daily precipitation is derived from the CRWMS M&O 1997, p. 4-21, fourth paragraph (DTN: MO9811DEDCRMCR.000). Precipitation intensity is developed in DTN: MO0004RIB00045.001 and documented in DTN: MO0007SEPPRECP.000. A survey of hourly precipitation records at Yucca Mountain from 1986 through 2000 indicated that the maximum observed hourly precipitation event amounted to 1.24 inch (Site 7, 1999) (DTN: MO9903CLIMATOL.001 and MO0212MXHRPRCP.000).

6.1.1.2 Winds

Criteria–The affected system components and outside structures (the system components that are exposed to outside wind conditions) shall be designed for a maximum wind speed of 121 miles per hour.

Technical Rationale–Wind is one of the primary external environmental parameters that can affect buildings and structures located outside. Proper consideration of wind is required to ensure that buildings and structures can withstand the wind forces, and that system components are adequately protected from the wind. Based on the requirements in Section 3.3.1 of NRC 1987, safety related buildings or structures must also be evaluated for the maximum wind speed. Section 3.3.1.II.1 of NUREG-0800 states: "The wind used in the design shall be the most severe wind that has been historically reported for the site and surrounding area with sufficient margin for the limited accuracy, quantity, and period of time in which historical data has been accumulated." The maximum wind speed is obtained from *MGR Design Basis Extreme Wind/Tornado Analysis* (CRWMS M&O 1999).

Criteria–The system shall operate during and after exposure to a surface (outside) wind speed of 54 meters per second. This value shall be used to design QL-1, 2, and 3 SSCs ITS. For conventional structures not critical to safety, the wind speed of 45 meters per second shall be used.

Technical Rationale–This criterion is needed to ensure the system equipment remains operational during and after exposure to expected environmental extremes. This criterion support Regulatory Guide 5.44, Rev 3, *Perimeter Intrusion Alarm Systems*.

Table 4-6 of CRWMS M&O 1997 (DTN: MO9811DEDCRMCR.000) provides the projections of maximum one-second gust wind speeds at 10 m-agl for the nine meteorological site for 50-year, 100-year, and 200-year return periods. The projection at Site 1 is based on one year of data and the projections for the other sites are based on four years' data. The value of 50-year return value of 54.11 m/s, the upper bounding value for all locations, is based on data recorded at Site 4 the crest of Alice Hill, an exposed location at an elevation of 4,050 feet. The highest recorded wind speed at this site was 39.1 m/s in August 1998 (DTN: MO0212MX1SWSPD.000).

The 50-year return value of 45 m/s was derived for Site 1, which is in a more sheltered location on the floor of Midway Valley. The highest recorded one-second gust at Site 1 is 27.1 m/s (DTN: MO9903CLIMATOL.001). Site 1 is representative of meteorological conditions in the vicinity of both the North and South Portals. The record of extreme wind occurrences in the period 1986-2000 indicates that the return period values continue to be viable estimates.

6.1.1.3 Tornadoes

See Section 4.2.2.3.7.

6.1.1.4 Lightning

Criteria–The system shall be designed to provide lightning protection in accordance with NFPA 780-2001.

Technical Rationale–This criterion establishes the practical safeguarding of persons and property from hazard arising from exposure to lightning.

6.1.1.5 Ambient Temperature

Criteria–The system shall be designed to withstand and operate in the extreme outside (surface) temperature environment of 2 degrees fahrenheit to 116 degrees fahrenheit (-16 degrees celsius to 47 degrees celsius).

Technical Rationale–This criterion establishes the outdoor temperature environment in which structures, systems, and components are expected to operate. Temperature is considered to be one of the primary environmental parameters that can effect component performance or result in advanced degradation. The extreme outside temperature range (2 degrees fahrenheit to 116 degrees fahrenheit) is derived from historical records for the nine meteorological monitoring sites located at Yucca Mountain (DTN: MO0212YMTEMPEX.000) and three regional NOAA stations (Beatty, Amargosa Farms, and Desert Rock WSO) located in the area surrounding Yucca Mountain (DTN: MO0211HISTMPEX.000).

6.1.1.6 Humidity

Criteria–The system shall be designed to withstand and operate in the surface external relative humidity environment described in the following.

Parameter	Value
Annual Mean Value	28%
Minimum summer monthly mean value (June)	13%
Maximum winter month mean value (December)	48%

Technical Rationale–Humidity is considered to be a primary environmental parameter that can affect SSCs' performance and anticipated life expectancy. This criterion establishes the external humidity environment at the site. The site-specific values are based on an updated analysis of Site 1 records for the period 1986-2000 (DTN: MO212RHS18600.000).

6.1.2 Hydrological

6.1.2.1 Flood Events

Criteria–The predicted water surface elevation for the probable maximum flood near the North Portal Pad is 3,684.2 ft. Facilities that could be damaged by flooding shall be located above this elevation or appropriately protected from flood (DTN: MO0209EBSPMFSD.029).

Technical Rationale–Conclusion or recommendations from *Preliminary Hydrologic Engineering Studies for the North Portal Pad and Vicinity* (BSC 2002d) supports this criterion.

6.1.2.2 Floodplains and Floodways

Criteria–The proposed new highway/railroad bridge shall be designed to accommodate a peak discharge of 26,300 cfs and a scour depth of a maximum of 11 ft. (DTN: MO0209EBSPMFSD.029).

Technical Rationale–Conclusions or recommendations from *Preliminary Hydrologic Engineering Studies for the North Portal Pad and Vicinity* (BSC 2002d) support this criterion.

6.1.3 Seismic

Seismic design input for the design of SSCs Important to Safety (ITS) at the MGR are provided in terms of Acceleration Response Spectra, and Acceleration Time Histories at locations B, C, D, and E defined in Figure 6.1.3-1. The locations B and C correspond to the design of subsurface facilities, whereas locations D and E correspond to the design of surface facilities.

The seismic input are generated for SSCs ITS are defined by Frequency Categories (FC) for different annual probability of occurrence of the seismic hazard. Three frequency categories of seismic hazard occurrence, FC-1, FC-1A, and FC-2 are identified with annual exceedance probability of occurrence as shown below:

- FC-1 Mean Annual Probability of Exceedance = 1E-03 (1,000 year Return Period)
- FC-1A Mean Annual Probability of Exceedance = 5E-04 (2,000 year Return Period)
- FC-2 Mean Annual Probability of Exceedance = 1E-04 (10,000 year Return Period)

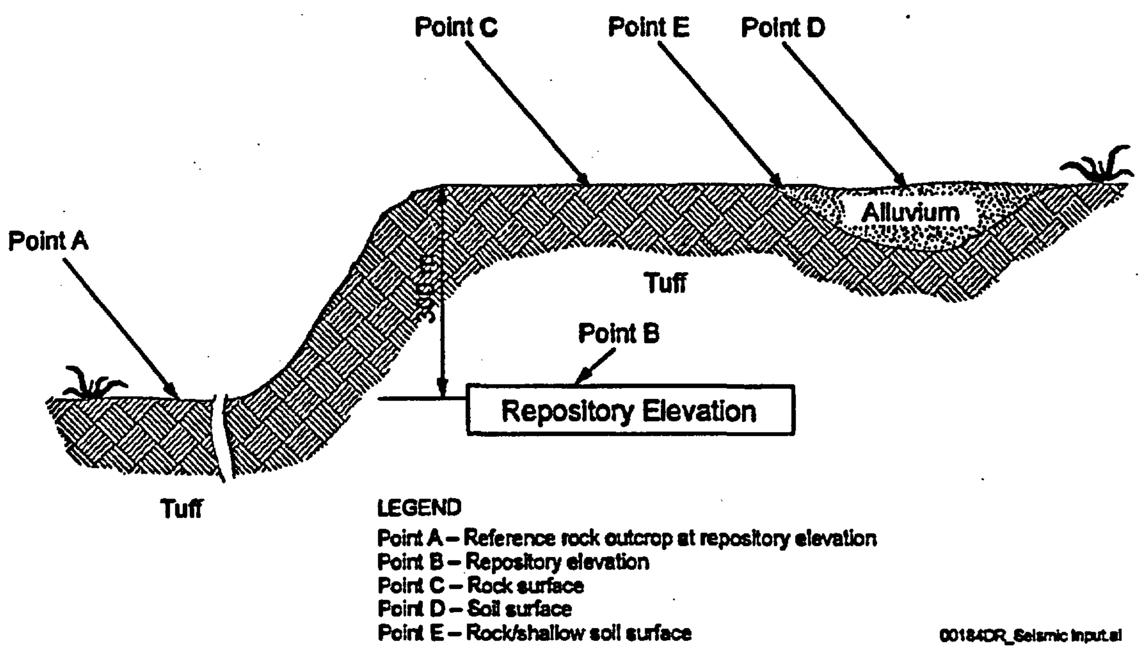

Figure 6.1.3-1. Seismic Design Input Locations

6.1.3.1 Seismic Input for the Design of SSCs that are Important to Safety

Criteria–The Acceleration Response Spectra, and Acceleration Time Histories for SSCs Important to Safety shall be used from Table 6.1.3-1.

Table 6.1.3-1. Seismic Design Input Identifiers

Location	Seismic Frequency Categories		
	FC-1 (1E-03)	FC-1A (5E-04)	FC-2 (1E-04)
B	Response Spectrum: DTN (to be provided later) Time History: DTN(to be provided later)	Response Spectrum: DTN:MO0209SDARS104.000 Time History: DTN:MO0211TMSHIS104.002	Response Spectrum: DTN(to be provided later) Time History: DTN (to be provided later)
C	Response Spectrum: DTN (to be provided later) Time History: DTN (to be provided later)	Response Spectrum: Figures (to be provided later) Time History: DTN (to be provided later)	Response Spectrum: DTN (to be provided later) Time History: DTN (to be provided later)
D	Response Spectrum: DTN (to be provided later) Time History: DTN (to be provided later)	Response Spectrum: DTN:MO0210SDSTMHIS.001 Time History: DTN:MO0210SDSTMHIS.001	Response Spectrum: DTN (to be provided later) Time History: DTN (to be provided later)
E	Response Spectrum: DTN (to be provided later) Time History: DTN (to be provided later)	Response Spectrum: DTN (to be provided later) Time History: DTN (to be provided later)	Response Spectrum: DTN (to be provided later) Time History: DTN (to be provided later)

Technical Rationale–The acceleration response spectra and time histories provided in the table are based on site-specific information.

6.1.3.2 Seismic Input for the Design of Conventional Quality Structure, System, or Components

Criteria–The conventional quality SSCs shall be designed for the acceleration levels of USGS maps defined in Section 1615 of ICC 2000 (IBC). The coordinates that correspond to the North Portal for the determination of acceleration levels from the USGS maps are 36.85° Latitude and –116.43° Longitude.

Technical Rationale–This is required in ICC 2000 (IBC).

6.1.4 Volcanoes

To be provided in a future revision.

6.1.5 Radon

Criteria–Airborne concentrations of radon and radon progeny in *potentially* occupied areas will be controlled so that worker exposures will not exceed the regulatory limit of 4 WLM per year in 29 CFR 1910.1096.

Technical Rationale–The design criteria provides for sufficient ventilation and radon emission controls so that the average radon progeny concentration in the work area will not result in any worker, fully occupying the area for 2,000 hours per year, to exceed the annual limit of 4 WLM.

6.1.6 Silica Dust

Criteria–The silica dust criteria requires that airborne exposures to crystalline silica not exceed the American Conference of Governmental Industrial Hygienists (ACGIH) eight-hour TLV (Threshold Limit Value) of 0.05 mg/M^3 (ACGIH 2001). TWA (8 hour Time Weighted Average), and an IDLH of 25 mg m^3 for Cristobolite Silica. (ACGIH 2001)

Technical Rationale–It is BSC policy to reduce the risk of exposure to crystalline silica during work performed at the MGR to within the ACGIH TLV, as opposed to the United States Occupational Safety and Health Administration's permissible exposure limit for silica, as the TLV is more restrictive and represents a more protective work environment.

6.1.7 Rock Fall

To be provided in a future revision.

6.1.8 Structural Geology

To be provided in a future revision.

6.2 PRECLOSURE SAFETY ANALYSIS

Design criteria, based on Categories 1 and 2 event sequences, for SSCs that have been identified having important to safety functions in the preclosure safety analysis and are related to the design basis for which credit has been taken in the preclosure safety analysis.

6.2.1 Facilities

To be provided later by preclosure safety analysis.

6.2.2 Waste Package

To be provided later by preclosure safety analysis.

6.3 THERMAL

Criteria–Design of pillars shall promote the drainage of water (Williams, N.H. 2002a).

Technical Rationale–The criterion on pillar design is intended to ensure that pore water liberated from the host rock matrix and percolation flux drains through sub-boiling region of the fracture network to the water table rather than accumulate above the repository horizon.

Criteria–Cladding temperature shall not exceed 350 degrees celsius (Williams, N.H. 2002a).

Technical Rationale–Cladding temperature is limited to 350 degrees celsius or less to provide margin to failure by creep rupture.

Criteria–Preclosure drift wall temperature shall be less than 96 degrees celsius (Williams, N.H. 2002a).

Technical Rationale–The goal to limit preclosure drift wall temperature to 96 degrees celsius or less is to not preclude cool operating modes.

Criteria–Postclosure drift wall temperature shall be 200 degrees celsius or less (Williams, N.H. 2002a).

Technical Rationale–The goal to limit postclosure drift wall temperature to 200 degrees celsius or less is to avoid adverse mineralogical transitions.

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APPENDIX A

LIST OF REGULATORY GUIDES AND DOE ORDERS

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APPENDIX A

LIST OF REGULATORY GUIDES

Regulatory Guide No.	Title	Conformance (To be added later)	Conformance with Exceptions (To be added later)
Regulatory Guide 1.8, Rev. 3. 2000	*Qualification and Training of Personnel for Nuclear Power Plants*		
Regulatory Guide 1.12, Rev. 2. 1997	*Nuclear Power Plant Instrumentation for Earthquakes*		
Regulatory Guide 1.13, Rev. 1. 1975	*Spent Fuel Storage Facility Design Basis*		
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Regulatory Guide 1.59, Rev. 2. 1977	*Design Basis Floods for Nuclear Power Plants*		
Regulatory Guide 1.61. 1973	*Damping Values for Seismic Design of Nuclear Power Plants*		
Regulatory Guide 1.62, Rev. 0. 1973	*Manual Initiation of Protective Actions*		
Regulatory Guide 1.69, Rev. 0. 1973	*Concrete Radiation Shields for Nuclear Power Plants*		
Regulatory Guide 1.71, 1973	*Welder Qualification for Areas of Limited Accessibility*		
Regulatory Guide 1.75, Rev. 2. 1978	*Physical Independence of Electric Systems*		
Regulatory Guide 1.76, Rev. 0. 1974	*Design Basis Tornado for Nuclear Power Plants*		

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LIST OF REGULATORY GUIDES (Continued)

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Regulatory Guide 1.140, Rev. 2. 2001	*Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Normal Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants*		
Regulatory Guide 1.143, Rev. 2. 2001	*Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants*		
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Regulatory Guide 1.165. 1997	*Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion*		
Regulatory Guide 1.180, 2000.	*Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems.*		
Regulatory Guide 1.189, 2001	*Fire Protection for Operating Nuclear Power Plants*		
Regulatory Guide 3.18, 1974	*Confinement Barriers and Systems for Fuel Reprocessing Plants*		
Regulatory Guide 3.28, 1975	*Welder Qualification for Welding in Areas of Limited Accessibility in Fuel Reprocessing Plants and in Plutonium Processing and Fuel Fabrication Plants*		

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LIST OF REGULATORY GUIDES (Continued)

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Regulatory Guide 3.71, 1998	*Nuclear Criticality Safety Standards for Fuels and Material Facilities*		
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Regulatory Guide 5.7, Rev. 1. 1980	*Entry/Exit Control for Protected Areas, Vital Areas, and Material Access Areas*		
Regulatory Guide 5.12, 1973	*General Use of Locks in the Protection and Control of Facilities and Special Nuclear Materials*		
Regulatory Guide 5.44, Rev. 03. 1997	*Perimeter Intrusion Alarm Systems*		
Regulatory Guide 5.65, 1986	*Vital Area Access Controls, Protection of Physical Security Equipment, and Key and Lock Controls*		
Regulatory Guide 8.5, Rev. 1. 1981	*Criticality and Other Interior Evacuation Signals*		
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Regulatory Guide 8.34, Rev. 0. 1992	*Monitoring Criteria and Methods to Calculate Occupational Radiation Doses*		
Regulatory Guide 8.38, Rev. 0. 1993	*Control of Access to High and Very High Radiation Areas in Nuclear Power Plants*		

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DOE ORDERS

DOE Order No	Title	Conformance	Conformance with Exceptions*
DOE G 440.1-5, 1995	*Implementation Guide for Use with DOE Orders 420.1 and 440.1 Fire Safety Program*		
DOE HQ O 250.1, 1998	*Civilian Radioactive Waste Management Facilities – Exemption from Departmental Directives*		
DOE O 252.1,1999	*Technical Standards Program*		
DOE Order 420.1, Change 3. 2000	*Facility Safety*		
DOE O 430.2A, 2002	*Departmental Energy and Utilities Management*		
DOE N 450.4, 2001	*Assignment of Responsibilities for Executive Order 13148, Greening the Government Through Leadership in Environmental Management*		
DOE Std 1020, 2002	*Natural Phenomena Hazards Design and Evaluation Criteria for DOE Facilities*		
DOE G 420.1-1, 2000	*Nonreactor Nuclear Safety Design Criteria and explosives Safety Criteria Guide for Use with DOE O 420.1 Facility Safety*		
DOE Order 5400.1 Change 1. 1990	*General Environmental Protection Program*		
DOE O 440.1A. 1998.	*Worker Protection Management for DOE Federal and Contractor Employees.*		
DOE-STD-1090-99	*Hoisting and Rigging*		
DOE-STD-1066-99	*Fire Protection Design Criteria*		

APPENDIX B

TECHNICAL POSITIONS FOR NON-USE OF YMRP CODES AND STANDARDS

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APPENDIX B

TECHNICAL POSITIONS FOR NON-USE OF YMRP CODES AND STANDARDS

1. **ACI 359 1992, Code for Concrete Reactor Vessels and Containment**

   To be developed in a future revision

2. **ANSI-6.1.1-1991, American National Standard for Neutron and Gamma-Ray Fluence – to-Dose Factors**

   To be developed in a future revision

3. **ANSI-15.17, 1981, Fire Protection Program Criteria for Research Reactors**

   To be developed in a future revision

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