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Complete only applicable items.

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1.PURPOSE

The purpose of this analysis is to establish bounded minimum inherent availability requirements for the Mined Geologic Disposal System (MGDS) System Description Documents (SDDs). The purpose of the bounded minimum inherent availability is to provide a lower bound on availability which will allow design to meet throughput requirements while not affecting the ability of the items to perform their intended safety function.

2.QUALITY ASSURANCE

The MGDS systems and facilities are identified as "Q" in the project Q-List by direct inclusion. Therefore, the items addressed in this analysis will be treated as Q items. An activity evaluation has been performed in accordance with QAP-2-0 (Specialty Engineering (1.2.1.8) dated 8/7/97) and has determined that this analysis is applicable to the QA program. Therefore, technically this activity is subject to QA controls. However, the activities associated with performing this work do not affect the ability of the items to perform their intended safety function. The activities in this analysis can only affect number, configuration, and cost of the Q items and their ability to meet throughput requirements within the constraints of safety.

3.METHOD

The following methodology was employed in developing the analysis:

The overall MGDS bounded minimum inherent availability is established as shown in Section 7.1.

The apportionment of the overall MGDS bounded minimum inherent availability to individual SDDs is accomplished by applying the mathematical models provided in Reference 5.3, as shown in Section 7.2 in conjunction with assumption 4.3.1, as follows.

3.1 Establish Overall MGDS Bounded Minimum Inherent Availability (Section 7.1).

3.2 Select and Rank SDDs that have the Potential to Affect Throughput (Section 7.2).

3.3 Apportion Overall MGDS Bounded Minimum Inherent Availability To Selected SDDs (Section 7.3).

4.DESIGN INPUTS

4.1 Design Parameters

Page 69 of Reference 5.2 and page 9 of Reference 5.5 define inherent availability as the probability that a system or equipment, when used under stated conditions in an ideal support environment (i.e., readily available tools, spares, maintenance personnel, etc.), will operate satisfactorily at any point in time as required. It excludes preventive or scheduled maintenance actions, logistics delay time and administrative delay time.

Based on the above references and rationale, inherent availability is (according to page 9 of Ref. 5.5) "composed entirely of parameters that are controlled by the designer", therefore, inherent availability is the appropriate availability design parameter.

In order to establish an overall bounded minimum inherent availability, the following parameters are needed:

The bounded total number of casks received at MGDS (Section 7.1) = 12470 (Ref. 5.4, key 001).

The bounded number of years of operation of MGDS (Section 7.1) = 24 (Ref. 5.4, key 001).

The bounded peak receipt rate (Section 7.1) = 820 casks/year (Ref. 5.4, key 001).

4.2 Criteria

A requirement for availability in the SDDs as defined in the parent document YMP/CM-0025, Mined Geologic Disposal Systems Requirements Document MGDS - RD, Rev. 3, paragraph 3.3.A. (Ref. 5.1).

Paragraph 3.3.A states "All MGDS Structures Systems and Components (SSCs) shall be designed and fabricated in accordance with applicable industry codes, standards, engineering principles and practices with particular attention to those which incorporate system safety, human factors, reliability, availability, maintainability and habitability standards."

A requirement for a reasonably bounded availability meets the intent of this criteria.

4.3 Assumptions and Limitations

The following assumptions are made regarding availability requirements:

4.3.1 Assumptions were made in Attachment I regarding estimates of relative complexity. The relative complexity compares one type of system to another type based on engineering experience with similar designs subject to review and comments by the checker and reviewers.

4.4 Codes and Standards

None applicable.

5.REFERENCES

5.1 Mined Geologic Disposal Systems Requirements Document, YMP/CM-0025, Rev. 3, February, 1998.

5.2 Blanchard, Benjamin S., Logistics Engineering and Management, Prentice Hall, 1992.

5.3 D. D. Orvis et. al., Guidebook for Reliability, Availability, and Maintainability Analysis of NWTS Repository Equipment, Volumes I and II, ONWI-334, April 1981.

5.4 Controlled Design Assumptions Document, B00000000-01717-4600-00032, Rev. 04, ICN 3, November 6, 1997.

5.5 Reliability, Maintainability, Availability (RMA) Planning, DOE Good Practice Guide GPG-FM-004, March 1996.

5.6 Mined Geologic Disposal Systems Description Document (SDD) Identification List, B00000000-01717-1705-00001, Rev. 00, February 23, 1998.

5.7 Yucca Mountain Site Characterization Project Reliability, Availability, and Maintainability Plan, YMP/93-15, Rev. 0., November 1993.

6.COMPUTER PROGRAMS

The calculations contained in this analysis were performed by hand held calculator. No computer programs were used.

7.DESIGN ANALYSIS

7.1 Establishment of an Overall MGDS Bounded Minimum Inherent Availability

The overall MGDS bounded minimum inherent availability is established by applying the logic of paragraph two from page 6-6, Vol. I of Reference 5.3. For peak throughput, the overall availability is:

Overall Availability = Average Receipt Rate/Peak Receipt Rate.

Note that the overall availability is analogous to capacity factor in power plant and process plant terminology.

Where,

The bounded total number of casks received at MGDS (Section 7.1) = 12470 (Ref. 5.4).

The 12470 value for total casks received is bounded because this value can only increase with additional power plants or extended plant life. If the total number of casks increases then the overall availability requirement (see below) would stay above minimum.

The bounded number of years of operation of MGDS (Section 7.1) = 24 (Ref. 5.4).

This is a bounded value since any increase in years of operation would be caused by an increase in the number of casks received offsetting the effect of an increase in the number of years of operation.

The bounded peak receipt rate (Section 7.1) = 820 casks/year (Ref. 5.4).

The Peak Receipt Rate is 820 casks/year is stated in Ref. 5.4 as a bounding value (page 3-3 of Reference 5.4, Exception 1: The total number of transportation casks received in any single year could reach 820).

Thus

Average Receipt Rate = (Total number of casks received)/(years of operation).

= 12470 casks/24 years = 520 casks/year based on Table 3-4 of Reference 5.4.

Therefore,

Overall Availability = Average Receipt Rate/Peak Receipt Rate = (520 casks/year)/(820 casks/year) = 0.6. Therefore, the bounded minimum MGDS Overall Availability is 0.6 and is apportioned to the relevant SDDs.

7.2 Select and Rank SDDs that have the Potential to Affect Throughput

The selected SDDs are based on the list in Ref. 5.6. Since this analysis does not affect the safety function (as stated in Section 2.) or items on the Q List then Ref. 5.6 does not have to be qualified. The selected SDDs that have the potential to affect throughput are bounded by this analysis. Any future changes adding to any system will be governed by the requirements resulting from this analysis. The verification that any new subsystem meets requirements will be determined by independent analysis (RAM predictions, Section 4.1.2 of Ref. 5.7). Note that scope of Ref. 5.7 extends to all phases of the YMP project. As an example, if a new safety system is added as the result of Design Basis Event (DBE) analyses the impact of that new system on throughput would be assessed as a part of the independent analysis verification effort. The independent analysis verification effort would utilize existing SDD requirements, and, therefore would not require revision of this document (Bounded Minimum Inherent Availability Requirements For The System Description Documents).

Table 7.2-1 contains the selected SDDs that have the potential to affect throughput using the following codes in the Applicability column:

Y = Yes this system will affect throughput.

N = The system will have negligible or no affect on throughput.

The complexity column ranks SDDs according to relative complexity. Each SDD is ranked from 1 to 10 (1 being least complex and 10 being most complex). Details of the complexity ranking are shown in Attachment I.

Guidelines or factors that affect complexity are:

1. Active equipment is generally more complex than passive equipment.

2. Remote equipment is generally more complex than manual equipment.

3. Safety related equipment is generally more complex than non-safety.

It should be noted that there is potential for overlap in the guidelines, therefore, they cannot be used as an absolute numerical determination of complexity. The relative complexity compares one type of system to another type based on engineering experience with similar designs solely for the purpose of apportioning an overall availability to lower levels. Systems that are redundant (thus higher availability) are more complex, but they are also subject to common mode failures (one failure defeats redundancy). Furthermore, safety systems have a higher reliability in performing safety functions often at the expense of production. For example, safety systems can experience spurious shutdowns which does not sacrifice safety but does interfere with production.

TABLE 7.2-1 BOUNDED MINIMUM INHERENT AVAILABILITY APPORTIONMENT

MGDS ELEMENT	APPLICABILITY	COMPLEXITY FACTOR	SDD/GROUP BOUNDED MINIMUM INHERENT AVAILABILITIES
MGDS Site Layout	N	N/A	N/A
Carrier Preparation Building System	Y	1	0.9941
Carrier Preparation Building Materials Handling System	Y	5	0.9711
Carrier/Cask Transport System	Y	2	0.9883
Waste Handling Building System	Y	1	0.9941
Waste Handling Building Electrical System	Y	2	0.9883
Waste Handling Building Fire Protection System	N	N/A	N/A
Waste Handling Building Radiological Monitoring System	Y	1	0.9941
Waste Handling Building Ventilation System	Y	3	0.9825

TABLE 7.2-1 BOUNDED MINIMUM INHERENT AVAILABILITY APPORTIONMENT			
MGDS ELEMENT	**APPLICABILITY**	**COMPLEXITY FACTOR**	**SDD/GROUP BOUNDED MINIMUM INHERENT AVAILABILITIES**
Carrier/Cask Handling System	Y	5	0.9711
Assembly Transfer System	Y	8	0.9541
Canister Transfer System	Y	5	0.9711
Disposal Container Handling System	Y	10	0.9430
Waste Package Remediation System	N	N/A	N/A
Subsurface Facility System	N	N/A	N/A
Subsurface Safety and Monitoring System	Y	1	0.9941
Ground Control System	Y	1	0.9941
Waste Emplacement System	Y	9	0.9485
Subsurface Ventilation System	Y	3	0.9825
Backfill Emplacement System	N	N/A	N/A
Waste Retrieval System	N	N/A	N/A
Subsurface Emplacement Transportation System	Y	3	0.9825
Subsurface Closure & Seal System	N	N/A	N/A
Subsurface Electrical Distribution System	Y	2	0.9883
Subsurface Water Collection/Removal System	Y	1	0.9941
Subsurface Fire Suppression System	N	N/A	N/A

TABLE 7.2-1 BOUNDED MINIMUM INHERENT AVAILABILITY APPORTIONMENT

MGDS ELEMENT	APPLICABILITY	COMPLEXITY FACTOR	SDD/GROUP BOUNDED MINIMUM INHERENT AVAILABILITIES
Subsurface Water Distribution System	Y	1	0.9941
Subsurface Compressed Air System	Y	1	0.9941
Waste Treatment Building Facility	N	N/A	N/A
Site-Generated Radiological Waste Handling System	N	N/A	N/A
Waste Treatment Building Ventilation System	N	N/A	N/A
Ex-Container Systems	N	N/A	N/A
Uncanistered SNF Disposal Container	N	N/A	N/A
Canistered SNF Disposal Container	N	N/A	N/A
DHLW Disposal Container	N	N/A	N/A
DOE Waste Forms Disposal Container	N	N/A	N/A
Performance Confirmation Emplacement Drift System	N	N/A	N/A
Pu Disposal Container	N	N/A	N/A
Non-Fuel Disposal Container	N	N/A	N/A
Navy Fuel Disposal Container	N	N/A	N/A
Subsurface Excavation System	Y	2	0.9883
Muck Handling System	Y	2	0.9883

TABLE 7.2-1 BOUNDED MINIMUM INHERENT AVAILABILITY APPORTIONMENT

MGDS ELEMENT	APPLICABILITY	COMPLEXITY FACTOR	SDD/GROUP BOUNDED MINIMUM INHERENT AVAILABILITIES
Site Electrical Power System	Y	2	0.9883
Site Water System	Y	1	0.9941
Site Communications System	Y	2	0.9883
Off-site Utilities System	Y	1	0.9941
Site Compressed Air System	Y	2	0.9883
Security and Safeguards System	N	N/A	N/A
Emergency Response System	N	N/A	N/A
Health Safety System	N	N/A	N/A
Surface Environmental Monitoring System	N	N/A	N/A
Central Command & Control Operations System	Y	5	0.9711
Maintenance & Supply System	N	N/A	N/A
Administration System	N	N/A	N/A
Subsurface Central Control System	Y	5	0.9711
General Site Transportation System	N	N/A	N/A
Off-site Rail and Road system	N	N/A	N/A
Subsurface Development Transportation System	N	N/A	N/A

TABLE 7.2-1 BOUNDED MINIMUM INHERENT AVAILABILITY APPORTIONMENT			
MGDS ELEMENT	**APPLICABILITY**	**COMPLEXITY FACTOR**	**SDD/GROUP BOUNDED MINIMUM INHERENT AVAILABILITIES**
Site-Generated Hazardous & Nonhazardous Waste Disposal System	N	N/A	N/A
Performance Confirmation Data Acquisition/Monitoring System	N	N/A	N/A
Performance Confirmation Waste Isolation Verification/Validation System	N	N/A	N/A
Sum of the complexity factors k = 87			
Overall Bounded Minimum Inherent Availability $A_{overall}$ = 0.6			

7.3 Apportion Overall MGDS Bounded Minimum Inherent Availability To Selected SDDs

The bounded minimum inherent availability requirements are obtained (as shown in Table 7.2-1) by applying Equation 1 (based on equation 6-8 of Reference 5.3, Volume I, page 6-10) to each SDD then the product of each SDD availability forms the overall availability.

Equation 1: $A_i = (A_{overall})^{1/W_i}$

where,

$A_{overall}$ = Overall MGDS bounded minimum inherent availability Requirement.

A_i = Allocated subsystem availabilities based on relative complexity.

W_i = Weighting factor based on the complexity of each SDD relative to the overall waste handling and emplacement operation complexity. The weighting factor (ranging from 1 to 10) concept is from Vol. II, Appendix A of Reference 5.3. For the purposes of the apportionment, the element used for weighting is relative complexity.

For example, if there were two systems (ss and su) and the ss was weighted at 4 and the su was weighted at 9 then,

$A_{overall} = [A_{ss}][A_{su}]$

$A_{overall} = [(A_i)(A_i)(A_i)(A_i)][(A_i)(A_i)(A_i)(A_i)(A_i)(A_i)(A_i)(A_i)(A_i)]$.

$A_{ss} = (A_i)^4$

$A_{su} = (A_i)^9$

$A_{overall} = (A_i)^{13}$, the product of 13 equal availabilities.

And the total of both weighting factors (based on subsystem complexities) = 13.

Using an example overall availability of 0.8, then

$A_i = (A_{overall})^{1/13} = (0.8)^{1/13} = 0.983$ (the required bounded minimum inherent availability of the unit subsystem) and

$A_{ss} = (0.983)^4 = 0.934$ (the allocated bounded minimum inherent availability for system ss).

and

$A_{su} = (0.983)^9 = 0.857$ (the allocated bounded minimum inherent availability for system su).

Stated in another way,

W_i (of equation 1) $= k/w_j$

where,

k = Sum of all the complexity factors.

$w_j =$ The complexity factor for each system (i.e., $w_1 = w_{ss} = 4$ and $w_2 = w_{su} = 9$, $k = w_1 + w_2 = 13$).

therefore,

$A_{ss} = (0.8)^{4/13} = 0.934$

and

$A_{su} = (0.8)^{9/13} = 0.857$

For Table 7.2-1, the bounded minimum inherent availability for each SDD (A_{SDDj}) is determined by:

$A_{SDDj} = (A_{overall})^{1/W_i} = (0.6)^{1/k/w_j} = (0.6)^{w_j/k}$

SDD Example:

Carrier/Cask Transport System $A_{SDD} = (0.6)^{2/87} = 0.9883$.

7.4 Combine the Selected SDD Bounded Minimum Inherent Availabilities to Determine System Group Bounded Minimum Inherent Availabilities

As an example, each group bounded minimum inherent availability is the result of taking the product of the selected SDDs within each group as follows (from Ref. 5.3, vol. I, equation 6-6, page 6-7);

$Ag_n = (A_1)(A_2)(A_3)\ldots(A_n)$

Example (from Table 7.2-1):

Ag_1 = Carrier/Cask Shipping and Receiving System Group

$= (0.9941)(0.9711)(0.9883) = 0.9541$

8.CONCLUSIONS

Based on the assumptions of Section 4 and the calculations of Section 7, the bounded minimum overall inherent availability for the MGDS is 60% and is recommended for incorporation into the MGDS-RD document. The apportioned bounded minimum inherent availabilities for each relevant SDD are contained in Table 7.2-1.

The apportioned, bounded minimum overall inherent availability is verified by analysis during design by comparing the calculated value from the verification analysis to the apportioned value for each SDD. The calculated value (equivalent availability) must be greater than or equal to the apportioned value (inherent availability). The calculated value gives credit, wherever appropriate, for the effect of lag storage. Lag storage effectively reduces downtime because throughput can be increased, after a failure has been corrected, resulting in a reduced impact on throughput.

9. ATTACHMENTS

ATTACHMENT	DESCRIPTION
I	Ranking Based on Relative Complexity

ATTACHMENT I. Ranking Based on Relative Complexity

The ranking of the selected SDDs contained in Table 7.2-1 is based on engineering judgement and estimated complexity with input from the checker and reviewers.

TABLE 9.1-1 COMPLEXITY RELATIVE RANKING

SDD DESCRIPTION	EQUIPMENT DESCRIPTION	ESTIMATED NUMBER OF PIECES OF EQUIPMENT	COMPLEXITY FACTOR
Waste Emplacement System	1. Transporter 2. Gantry 3. Emplacement drift shield door	numerous	9
Subsurface Ventilation System	1. Motors 2. Fans 3. Controls	numerous	3
Subsurface Emplacement Transportation System	1. Rails/other passive components 2. Locomotive 3. Electrification	1 2 1 1	3
Carrier Preparation Building Materials Handling System	1. Cranes/Lifting Devices	1	5
Carrier/Cask Transport System	1. Prime Movers	1	4
Electrical System	1. Breakers 2. Transformers 3. Cables 4. Diesel genrators 5. Switch gear 6. Controls	numerous	2

TABLE 9.1-1 COMPLEXITY RELATIVE RANKING			
SDD DESCRIPTION	**EQUIPMENT DESCRIPTION**	**ESTIMATED NUMBER OF PIECES OF EQUIPMENT**	**COMPLEXITY FACTOR**
Ventilation System	1. Motors 2. Fans 3. Controls 4. HEPA filters	numerous	3
Carrier/Cask Handling System	1. Bridge crane/yoke 2. Gantry mounted manipulator	1 1	5
Assembly Transfer System	1. Cranes/lifting devices 2. Cart 3. Manipulator 4. Wet/dry transfer machine 5. Decon Device 6. Shield plug	4 8 4 2 1 3	8
Canister Transfer System	1. Cranes/lifting devices 2. Cart 3. Manipulator	1 2 2	5
Disposal Container Handling System	1. Welding Machine 2. Cranes/lifting devices 3. Cart 4. Manipulator 5. Inspection equipment	8 9 3 2	10

TABLE 9.1-1 COMPLEXITY RELATIVE RANKING

SDD DESCRIPTION	EQUIPMENT DESCRIPTION	ESTIMATED NUMBER OF PIECES OF EQUIPMENT	COMPLEXITY FACTOR
Site Electrical Power System	1. Breakers 2. Transformers 3. Cables	numerous	2
Building Systems	Doors etc.	numerous	1
Control Systems	1. Electronics/ mechanical 2. Computers 3. Com. Lines 4. Programed logic controllers	numerous	5
Compressed Air	1. Compressors 2. Motors 3. Valves	numerous	1
Water Collection/ removal	1. Compressors 2. Motors 3. Valves	numerous	1