May 10 '95

STAGING AND STORAGE FACILITY FEASIBILITY STUDY

0050672

Final Report

Prepared for

Westinghouse Hanford Company

MAY 1999
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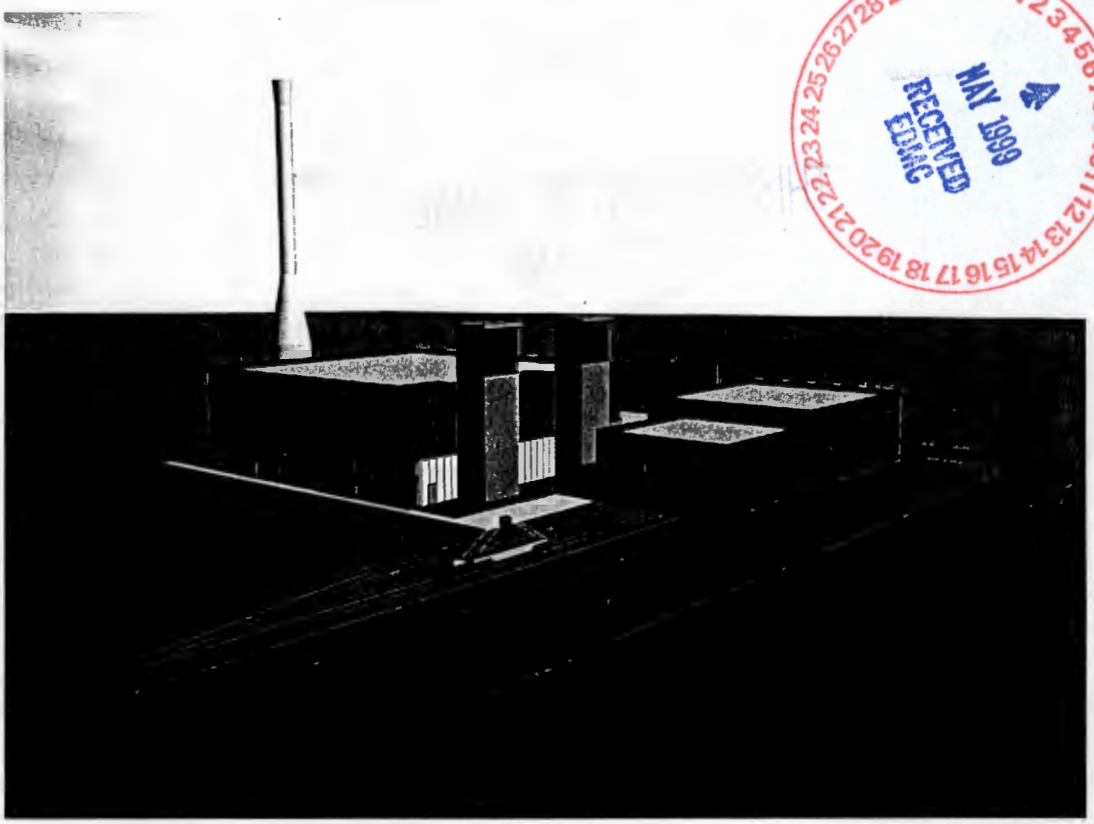

Prepared By

Fluor Daniel, Inc.
Government Services Operating Company
February 1995

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LIST OF ACRONYMS

B&O	Business and Occupation Tax
CEDE	Committed Effective Dose Equivalent
CFD	Computational Fluid Dynamic
CSB	Canister Storage Building
DBA	Design Basis Accident
DBE	Design Basis Earthquake
DBW	Design Basis Wind
ES&H	Environmental, Safety and Health
F&Rs	Functions and Requirements
FHA	Fire Hazards Analysis
HWVP	Hanford Waste Vitrification Plant
ICE	Independent Cost Estimate
ISFSIs	Independent Spent Fuel Storage Installations
K-D	Key Decision
LANL	Los Alamos National Laboratory
MAR	Material At Risk
MCO	Multi-Canister Overpack
MIC	Microbiologically Influenced Corrosion
MOI	Maximum Offsite Individual
NPH	Natural Phenomena Hazards
PHA	Preliminary Hazards Analysis
RCRA	Resource Conservation and Recovery Act
RF	Release Fraction
ROM	Rough Order of Magnitude
RR	Respiration Rate
SAR	Safety Analysis Report
SC	Safety Class
SCT	Shielded Canister Transporter
SNF	Spent Nuclear Fuel
SS	Stainless Steel
SSCs	Structures, Systems and Components
SSF	Staging and Storage Facility
SWP	Special Work Procedure
TSR	Technical Safety Requirements
WAC	Washington Administrative Code
WBS	Work Breakdown Structure
WHC	Westinghouse Hanford Company
TWRS	Tank Waste Remediation System

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1.0 INTRODUCTION

1.1 BACKGROUND

In October 1994, Westinghouse Hanford Company (WHC) published a report (WHC-EP-0830) entitled Hanford Spent Nuclear Fuel Project Recommended Path Forward. That report described a recommended approach for expedited removal of spent nuclear fuel, including sludge, from the K Basins at Hanford and its placement in a stable dry storage configuration until final disposition is possible. An essential part of the recommended approach was the use of a new facility, called the Staging and Storage Facility (SSF), to perform two principal functions. The first is to provide safe storage for the wet fuel and sludge from the K Basins until it can be dried and passivated in another new facility, the Stabilization Facility. The second principal function of the SSF is to provide passive dry storage of the stabilized fuel and sludge until final disposition.

Although the location of these new facilities was not selected, movement of the spent nuclear fuel and sludge away from the Columbia River is an important objective. One of the leading options being considered is the construction of the required facilities within the 200 Area of the Hanford Reservation. This approach is most compatible with current plans to centralize future Hanford Reservation waste operations in the 200 Areas.

Another related project, which had previously been initiated to vitrify Hanford defense liquid high-level wastes into borosilicate glass, is the Hanford Waste Vitrification Plant (HWVP) Project. This project, which was to be located in the 200 East Area, included a Canister Storage Building (CSB) to provide passive dry storage of stainless steel canisters containing the borosilicate glass until they could be sent to a geologic repository. Design of the CSB was complete and construction was underway when the HWVP Project was put on hold in 1993. Figures 1-1 and 1-2 show the status of CSB construction after work was halted in October 1993.

Since the functions of the SSF and CSB are very similar, since the CSB is located in an area that is a prime candidate for the SSF, and since there are no other current plans to resume construction of the HWVP or otherwise utilize the partially completed CSB, it was logical to consider whether the CSB design and construction could be adapted to meet the needs of the SSF. If this were

possible, it could result in significant cost and schedule benefits to the WHC Spent Nuclear Fuel Project. This study was therefore initiated to investigate the technical feasibility of the adaptation and quantify the resultant cost and schedule benefits.

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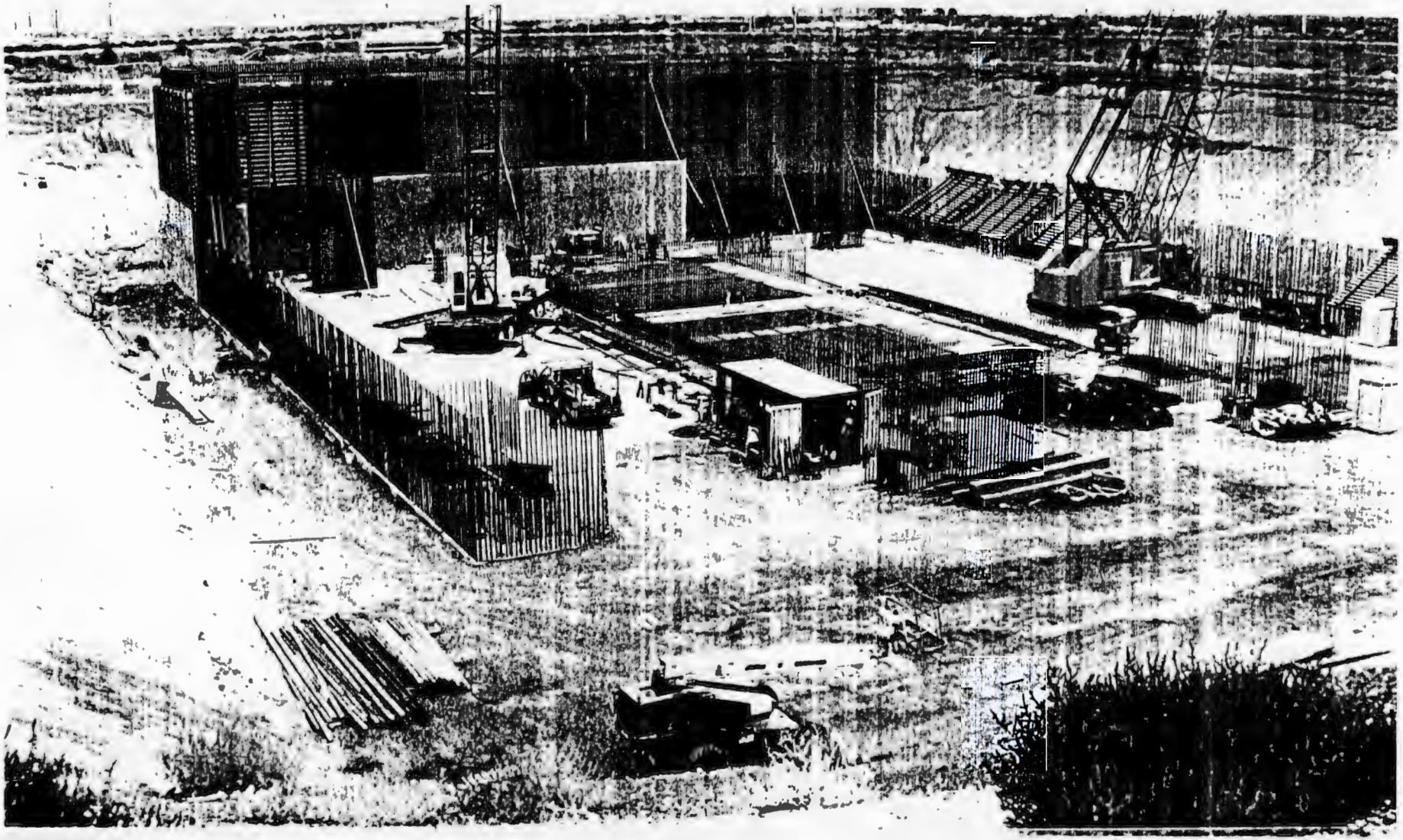


FIGURE 1-1, CANISTER STORAGE BUILDING CONSTRUCTION, 10/27/93

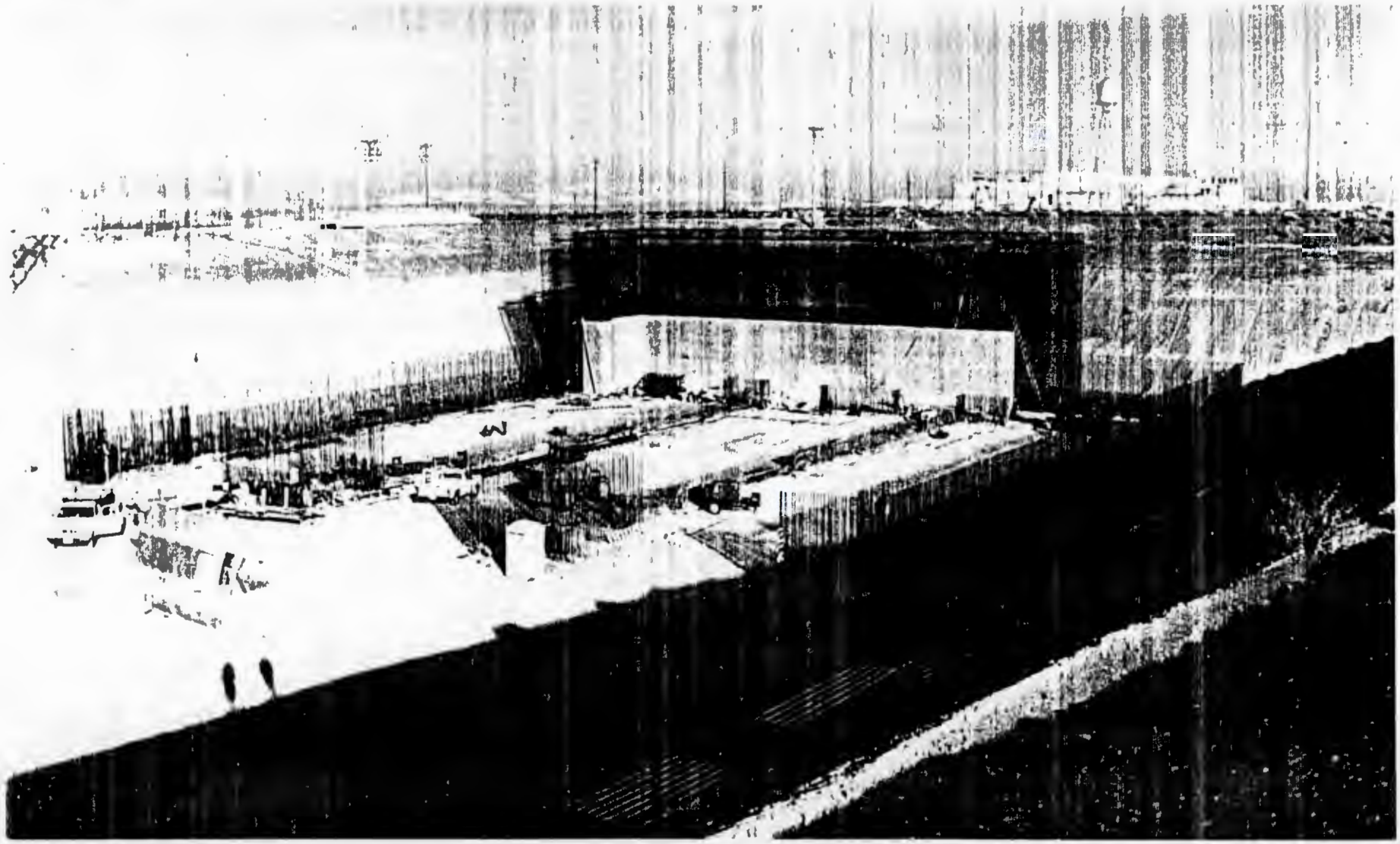


FIGURE 1-2, CANISTER STORAGE BUILDING CONSTRUCTION, 11/12/93

1.2 STUDY OBJECTIVES

The objectives of this study were to determine the technical feasibility of adapting the design of the CSB to meet the functions and requirements (F&Rs) of the SSF and to develop rough order of magnitude (ROM) cost and schedule estimates for feasible alternatives.

1.3 SCOPE OF WORK

WHC defined two concepts for evaluation, one using water cooling prior to stabilization and the other using refrigerated air. Both concepts were to use passive dry storage technology after stabilization. The following is the scope of work for the study:

1.3.1 Evaluate the technical feasibility of converting the CSB to provide temporary water pool storage of unstabilized N-Reactor fuel contained within multi-canister overpacks (MCO's). Determine if the existing CSB footprint provides adequate pool storage space and if it is practical to convert the facility to passive dry storage of stabilized fuel. Develop conceptual process flow diagrams and facility layout drawings, including the addition of a rail tunnel shipping cask unloading station, for feasible alternatives. In consultation with WHC, select one preferred alternative for evaluation under 1.3.4 and 1.3.5.

1.3.2 Evaluate the technical feasibility of converting the CSB to provide temporary refrigerated-air cooled storage of unstabilized N-Reactor fuel contained within MCO's. Determine if the fuel temperatures within the MCO's can be maintained within acceptable limits and if it is practical to convert the facility to passive dry storage of stabilized fuel. Develop conceptual process flow diagrams and facility layout drawings, including the addition of a rail tunnel shipping cask unloading station, for feasible alternatives. In consultation with WHC, select one preferred alternative for evaluation under 1.3.4 and 1.3.5.

1.3.3 Perform a parametric qualitative evaluation of the cost of a transporter cask system (similar to HLW canister transporter) versus an overhead crane system as a function of MCO size and weight.

1.3.4 Perform a comparative evaluation of the safety issues associated with the selected concepts defined in 1.3.1 and 1.3.2.

considerably longer since the entire facility must be constructed when fuel and sludge from the K Basins are initially received. Construction of the three vaults will be a time consuming operation, even if they are all constructed in parallel instead of in series as previously scheduled for the CSB. Comparison of the schedules for these alternatives revealed that even with accelerated construction, alternative 1D will require about 6 months more to be operational than alternatives 1B or 1C.

From a technical feasibility standpoint, Alternative 1D has a potential microbiologically influenced corrosion (MIC) problem. As described in the June 1990 issue of Power article, "Avoid MIC-Related Problems in Nuclear Cooling Systems", stainless steel in contact with stagnant water which contains corrosive microorganisms has been found to be susceptible to this type of corrosion. Prevention of this problem with Alternative 1D will require some as yet unidentified means of treating the stagnant water inside the tubes or other means to prevent MIC from occurring.

The Other factors noted in Table 2-1 identify various other considerations which influence the selection of Alternatives. The cost for Alternative D is based on using an epoxy lined vault. If a stainless steel liner is required, the cost of Alternative 1D would increase by about $10 million. The release of hydrogen inside the confined space within a storage tube also results in the potential for developing explosive hydrogen concentrations. This will require some means of maintaining an inert gas space within the storage tube and periodically relieving the pressure build up.

Review of the above data resulted in the decision to drop Alternative 1D from further consideration. In light of the current uncertainty in the number of MCOs to be stored, it was decided to continue to evaluate both Alternatives 1B and 1C since they are very similar and evaluation of both required very little additional effort.

2.2 CONCEPT 2 - REFRIGERATED AIR/PASSIVE DRY STORAGE

2.2.1 Description of Alternatives Considered

Concept 2 allows the existing CSB configuration to be used virtually unchanged. The refrigeration and forced air recirculation systems and equipment will be located outside of the existing CSB building envelope for this concept. The principal challenge is meeting the requirement for a 50 F temperature inside the MCOs prior to storage with air as the heat transfer fluid. The following two alternatives were considered:

Alternative 2A Storage of 1200 MCOs in water filled tubes in vaults 1, 2 and 3, with forced refrigerated air cooling of the tubes during staging. MCOs are

removed and returned to the tubes after stabilization. After all fuel is stabilized, natural circulation passive cooling is established.

Alternative 2B Storage of 1200 MCOs in perforated tubes in vaults 1, 2 and 3, with forced refrigerated air cooling of the MCOs during staging. Unperforated confinement barrier sleeves are installed in the tubes while the MCOs are removed for stabilization, after which the stabilized MCOs are reinstalled in the tubes. After all fuel is stabilized, natural circulation passive air cooling is established.

Alternative 2A is based on utilization of water filled tubes since it was determined that a 50 F MCO temperature could not be achieved with air inside the tubes and refrigerated air temperatures in excess of 32 F. (Calculations indicated that 19 F air at 200,000 CFM was required to achieve a 50 F MCO temperature.) Refrigerated air temperatures in excess of 32 F are needed to preclude the possibility of freezing water and rupturing MCOs having very low heat generation. The use of water inside the tubes requires that the tube material be changed from corten to stainless steel for the same reasons discussed above under Alternative 1D. Other heat transfer fluids such as oils or other organics were considered, but they would represent a fire hazard and would be subject to degradation due to the ionizing radiation present.

Alternative 2B was conceived as a way to achieve the 50 F MCO temperature with refrigerated air temperatures in excess of 32 F without having to put water or some other heat transfer fluid inside the storage tubes. Other variations of this alternative such as piping refrigerated air connections to each of the storage tubes were rejected as being more costly and difficult to construct.

2.2.2 Evaluation and Selection of Alternatives

Table 2-2 shows the results of the evaluation of the above Concept 2 alternatives with respect to the same four evaluation criteria used for Concept 1. As before, all costs are preliminary rough order of magnitude estimates expressed in millions of dollars.

Alternatives 2A and 2B were found to be similar with respect to the identified cost differentiators, with a $6 million cost advantage being indicated for Alternative 2A.

The schedule for the start of operations under Alternatives 2A and 2B would be the same.

From a technical feasibility standpoint, Alternative 2A is subject to the same MIC concerns discussed above for Alternative 1D.

TABLE 2-2 - EVALUATION OF ALTERNATIVES

CONCEPT 2 - REFRIGERATED AIR/PASSIVE DRY STORAGE

	ALT A		ALT B	
COST	▲ HVAC FOR LOWER AIR TEMPERATURE	NEG	TUBE LINER	+9.9
	SS TUBE ▲	+21.1	TUBE LINER INSTALLATION AND HARDWARE	+3.0
	TUBE H_2O MAINTENANCE OP COST	TBD	INCREASE BUILDING HT 20'	+3.2
			SHIELDING FOR LINER INSTALLATION	+0.1
			VAULT & HVAC SECOND CONFINEMENT	+10.0
			REENGINEERING	+1.0
			ADDITIONAL RADIATION MONITORING EQUIPMENT	+0.5
	TOTAL	+21.1+TBD	TOTAL	+27.7
SCHEDULE	SAME		SAME	
TECHNICAL FEASIBILITY	SS CORROSION IN STAGNANT H_2O		- Vault & HVAC system must provide second confinement during staging. - MCO failure during staging would spread contamination, (decon difficult), and risk of pyrophoric incident with unstabilized fuel exposed to air	
OTHER	Requires provisions to preclude explosive hydrogen concentrations inside tube		Details of sleeve installation, MCO support in sleeve, etc. not defined and difficult.	

Alternative 2B requires that the vault and HVAC system provide a second confinement barrier prior to stabilization since the perforated tubes would not satisfy the requirement for a second barrier. Furthermore, failure of an MCO during this phase would spread contamination throughout the vault and HVAC system, making decontamination very difficult. In addition, failure of an MCO during this phase could result in water draining from the MCO and exposure of the unstabilized fuel to air, possibly initiating a pyrophoric reaction.

The Other factors noted indicate that both alternatives have additional negative features to be considered.

Review of the information contained in Table 2-2 led to the selection of Alternative 2A for further evaluation. The indicated concerns regarding the potential consequences of an MCO failure prior to stabilization under Alternative 2B was the principal reason for this selection.

storage tube/cask cavity and providing shielding during the transfer.

3.3 OVERHEAD CASK/CRANE DESCRIPTION

The overhead cask/crane method is currently being employed as a canister loading method by the British at Sellafield, the French at Marcoule and at the Fort St. Vrain dry fuel storage facility in Colorado.

Unlike the SCT, the overhead cask/crane method will require a means to transport the MCO to the SSF. If the stabilization plant is close coupled to the dry storage facility an unshielded transfer cart operating in a below grade tunnel can be used to make the transfer as described in Figure 3-2. If the stabilization plant is at a distant location, a top-loading shipping cask can be used.

The overhead cask/crane method will require four basic components to load the canisters into the SSF storage tubes.

1) The bottom loading MCO shield cask
2) The floor plug shield valve
3) The floor plug handling flask
4) The overhead bridge crane

The bottom loading MCO shield cask has many of the same features as the SCT except that it is transferred and located by the overhead bridge crane. The cask will contain an integral hoist and grapple system to handle the MCO. It will incorporate a shield valve at the bottom and a ventilation system to control the atmosphere within the storage tube during MCO transfer.

The floor plug shield valve is used to seal and shield the storage tube when the tube's shield plug is removed. The valve is located over the desired storage tube using the overhead bridge crane. The floor plug handling flask is then mated with the top of the shield valve. A grapple within the flask is used to lift the plug thru the open shield valve. The valve is then closed and the flask containing the plug removed. The storage tube is now ready for installation of the MCO.

The MCO contained within the MCO cask is next positioned on top of the shield valve using the overhead bridge crane. The floor valve and the MCO cask bottom valve are next opened and the MCO lowered into the storage tube. Upon reaching bottom, the MCO cask grapple is disengaged and raised back into the MCO cask. The valves are closed and the MCO cask removed from the storage tube. Finally, the storage tube floor plug is re-installed, and the floor valve removed and installed over the next storage tube to be loaded.

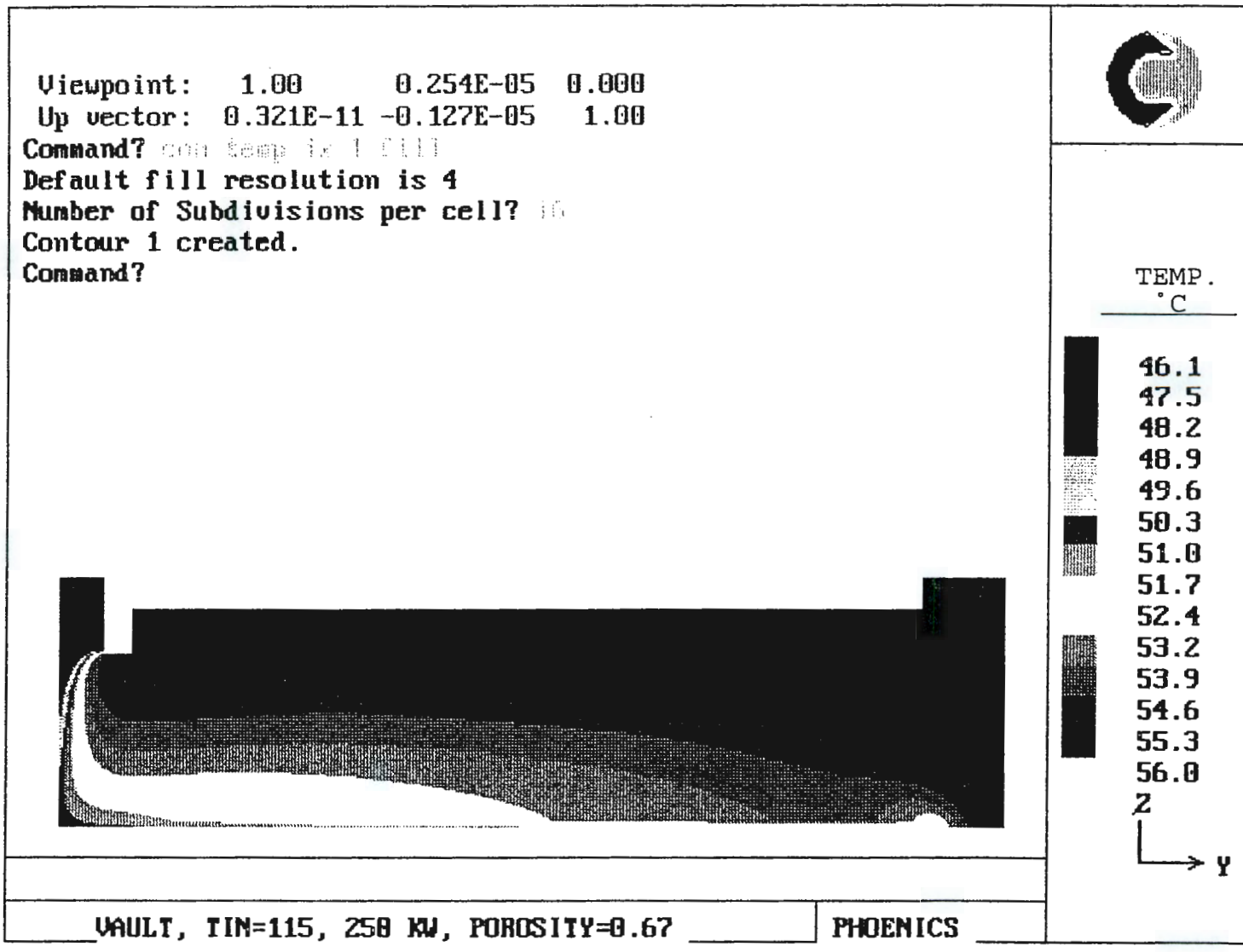


FIGURE 4-16

PASSIVE COOLING VAULT TEMPERATURE
PROFILE CONCEPTS 1C AND 2A

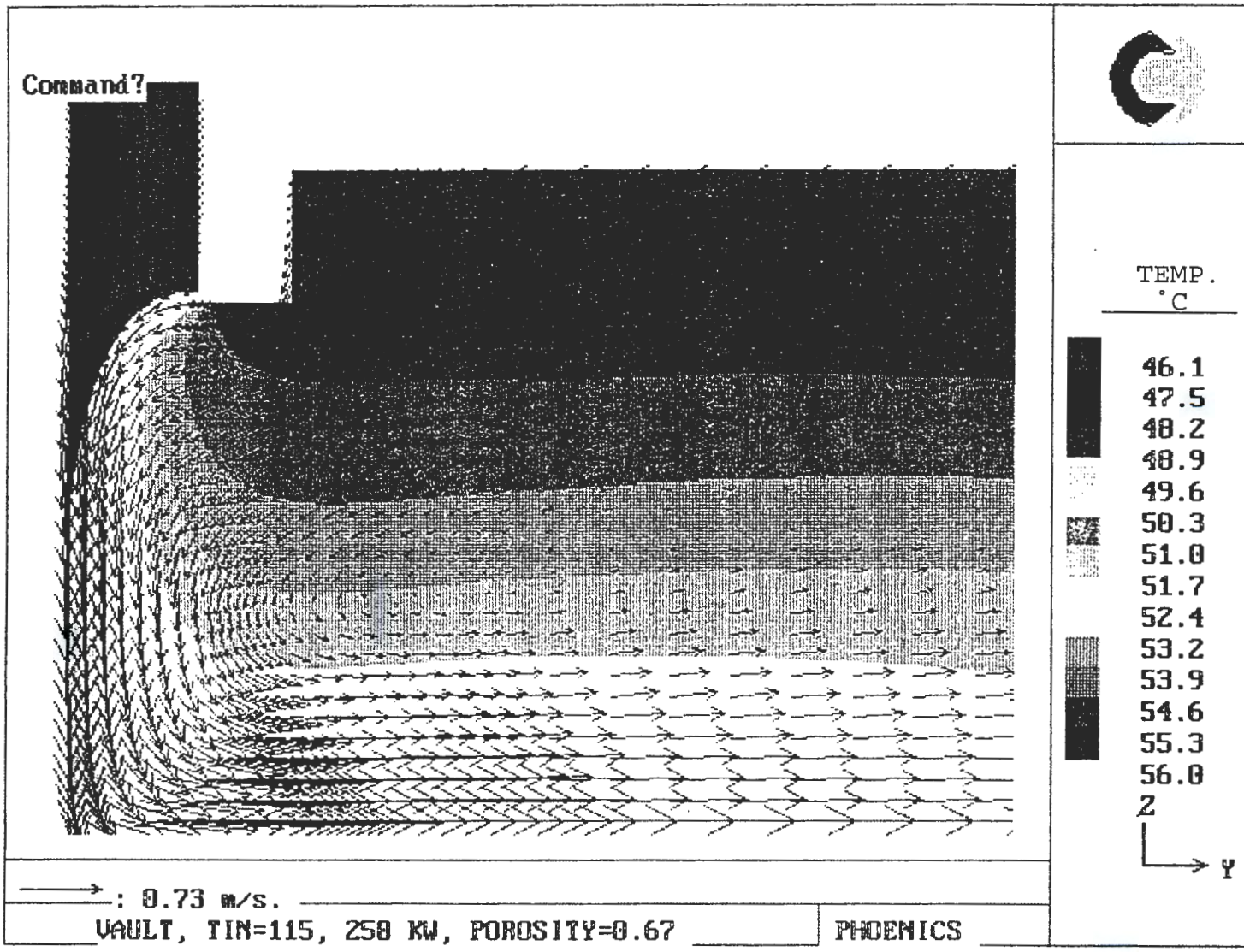


FIGURE 4-17

PASSIVE COOLING VELOCITY PROFILE,
CONCEPTS 1C AND 2A

plug will prevent airborne contamination from spreading out of the tube. The floor plugs have test fittings which allow for periodic gas sampling to detect MCO failure. The contamination is localized, but there is no built-in design feature for clean-up.

4.2.4 Criticality

4.2.4.1 Introduction

One of the principal feasibility issues identified at the start of this study was the minimum allowable spacing between MCO's, from a criticality standpoint, and the identification of a feasible storage configuration based on criticality considerations. Since criticality safety was identified as a potential design driver, an analysis effort was undertaken to identify and quantify restrictions on N-Reactor fuel storage configurations based on criticality. Although the Design Basis contained in Appendix 1, received after the start of this study, indicates that there are no restrictions on MCO spacing and stacking based on criticality, it was decided to continue the analysis to verify the Design Basis. This section, and Section 5.2.4 for Concept 2, presents the results of this analysis.

4.2.4.2 Summary of Results

Preliminary criticality calculations were performed with simplified geometries, taking no credit for structural material, such as canister and MCO walls, and all simplifying assumptions made were conservative. These calculations confirmed that the MCO's could be stacked, even when loaded with five layers of canisters, and can be placed side-by-side without additional space between MCO's. The worst-case k_{eff} calculated was less than 0.90, well within the 0.95 limit imposed by the Nuclear Criticality Safety Manual, Section 2.0, Paragraph 5.1.3, Allowed Maximum Calculated K-effective.

4.2.4.3 Criteria and Assumptions

The criteria and standards on which these criticality calculations are based, as well as the assumption used in formulating the computations, are given the following paragraphs.

Applicable Orders and Standards. The criticality calculations performed in support of this feasibility study conform with the following criteria and standards:

> DOE Order 5480.24, "Nuclear Criticality Safety"
>
> DOE-STD-3007-93, "Guidelines for Preparing Criticality Safety Evaluations at Department of Energy Non-reactor Nuclear Facilities"

WHC-CM-4-29, "Nuclear Criticality Safety Manual," issued September 15, 1988.

Choice of Computer Models. The principal tool selected for criticality calculations is the PC version of MCNP, Version 4A, developed and supported by the Los Alamos National Laboratory (LANL), Reference 2. This code was selected because of its great flexibility, high fidelity modeling (e.g., ENDF/B-V continuous cross sections), and the ability to perform both shielding and criticality calculations.

Another code available for criticality calculations is KENO, Version V.A (contained in the SCALE-PC, Version 4.1; Reference 3). This code was not used to perform criticality calculations directly for this study, but was used to compare results during the validation and verification process.

Code Verification & Validation. All codes used in shielding and criticality calculations at Fluor Daniel have been verified by running the test problems supplied with the code packages. The test problem results are shown to be in agreement either with the published documentation supplied as part of the code package, or with the sample problem output, if supplied. This information is documented, dated, and retained on file at Fluor Daniel. Any changes, such as upgrades, corrections, modifications, etc., are incorporated into the documentation following rerunning of the verification problems.

MCNP, Version 4A is the latest version, Reference 2, of a widely used and well accepted radiation transport code employed for a wide variety of radiation analyses including neutron, photon and electron transport, and criticality. LANL has performed extensive calculations with MCNP, duplicating a wide range of experimental results, to validate the models contained in this code. The results of these benchmark cases are documented in References 4 and 5. The version of MCNP4A used at Fluor Daniel was tested by exercising the twenty-five sample problems supplied by LANL, and the results were found to be in agreement within reasonable statistical limits. These sample problems are designed to exercise a broad range of the code's computational capabilities, including criticality calculations, which is addressed by five of the twenty-five sample problems.

Material Properties. The densities and composition of materials used in the criticality calculations are given in Tables 4-3 and 4-4.

Preliminary Calculations. Preliminary criticality calculations were performed to define the worst case spacing of fuel elements inside a canister, and/or each layer of a CSB storage tube. To this end, a computational model of seven storage tubes was formulated; with

TABLE 4-3
DENSITIES OF SOME MATERIALS

Material	Density (g/cc)	Material	Density (g/cc)
Air	0.00122	Uranium	18.7
Aluminum	2.70	Water	1.0
Iron (Steel)	7.83	Zirconium	6.4

The fractional densities for compound materials used in this study are listed in Table 4-4.

TABLE 4-4
COMPOSITION OF MATERIALS USED IN RADIATION SHIELDING CALCULATIONS
(Given as Fractional Densities in g/cm^3)

Atomic Number	Element	Air	Water	Stainless Steel 304L ASTM A240
1	H		0.11111	
5	B^{10}			
5	B^{11}			
6	C	0.00000017		0.0023
7	N	0.00092132		
8	O	0.00028276	0.88889	
11	Na			
12	Mg			
13	Al			
14	Si			0.0587
15	P			0.0035
16	S			0.0023
18	Ar	0.00001575		
19	K			
20	Ca			
22	Ti			
24	Cr			1.5660
25	Mn			0.1566
26	Fe			5.1009
28	Ni			0.9396
Total		0.00122	1.00	7.8299

12 vertical layers, each layer consisting of 31 fuel elements in a triangular pitch array. The material composition of this array consisted of fuel elements only: concentric cylinders of 1.25% enriched uranium, with zirconium cladding. All voids and spaces within the fuel elements and storage tubes were filled with water, and water was medium surrounding these storage tubes on all sides. The k_{eff} of this configuration was calculated, varying the pitch of the triangular array. The results are shown in Figure 4-18. The important result of these calculations is that the worst case spacing between fuel elements is 3.2 inches.

The spacing between storage tubes, was 55 inches. These tubes were again arranged in a hexagonal pattern, in cross section, which approximated the storage tube configuration within the CSB vaults. Because of this spacing between tubes, and because the tubes were immersed in water, there was no appreciable interaction between the tubes, and the results show no sensitivity to variations in this spacing (except when the tubes were placed very close together, as discussed below).

Results For Concept 1. In the interest of addressing the key factors, with respect to criticality safety, in each storage configuration, a computational model was formulated which could address these factors for both storage concepts. All uncertainties were compensated for with conservative assumptions. In the event these assumptions led to an unacceptable risk of a criticality event, it was planned to perform sensitivity studies to identify safe limits.

In this computational model, fuel elements were arranged in columns, each containing 280 fuel elements. Each column contained fuel arranged in patterns representative of two MCO's, stacked one on top of the other. Each MCO was modeled with five vertical layers of canisters, two canisters of 28 fuel elements, per layer. The 28 fuel elements in each layer were arranged in a pattern similar to that found in the canisters, Figure 4-19, but the center-to-center separation between fuel elements was taken to be 3.2 inches, the worst-case spacing from Figure 4-18.

In a nominal CSB vault, 220 such columns would have been arranged in a hexagonal pattern. This pattern was modeled as a triangular pitch array, with a 55 inch center-to-center separation between columns, Figure 4-20. (Since interaction between columns is negligible, this will be shown in what follows, changing the size of this array was not required.) The closest spacing between columns, which could be achieved in a flooded pool, was assumed to be 26 inches, center-to-center. This assumes a bare MCO, no tube, and a minimal amount of structural material for keeping the 24 inch OD MCO in place. For this calculation, no credit was taken for either the MCO or the canister walls. In fact, the only materials included in this

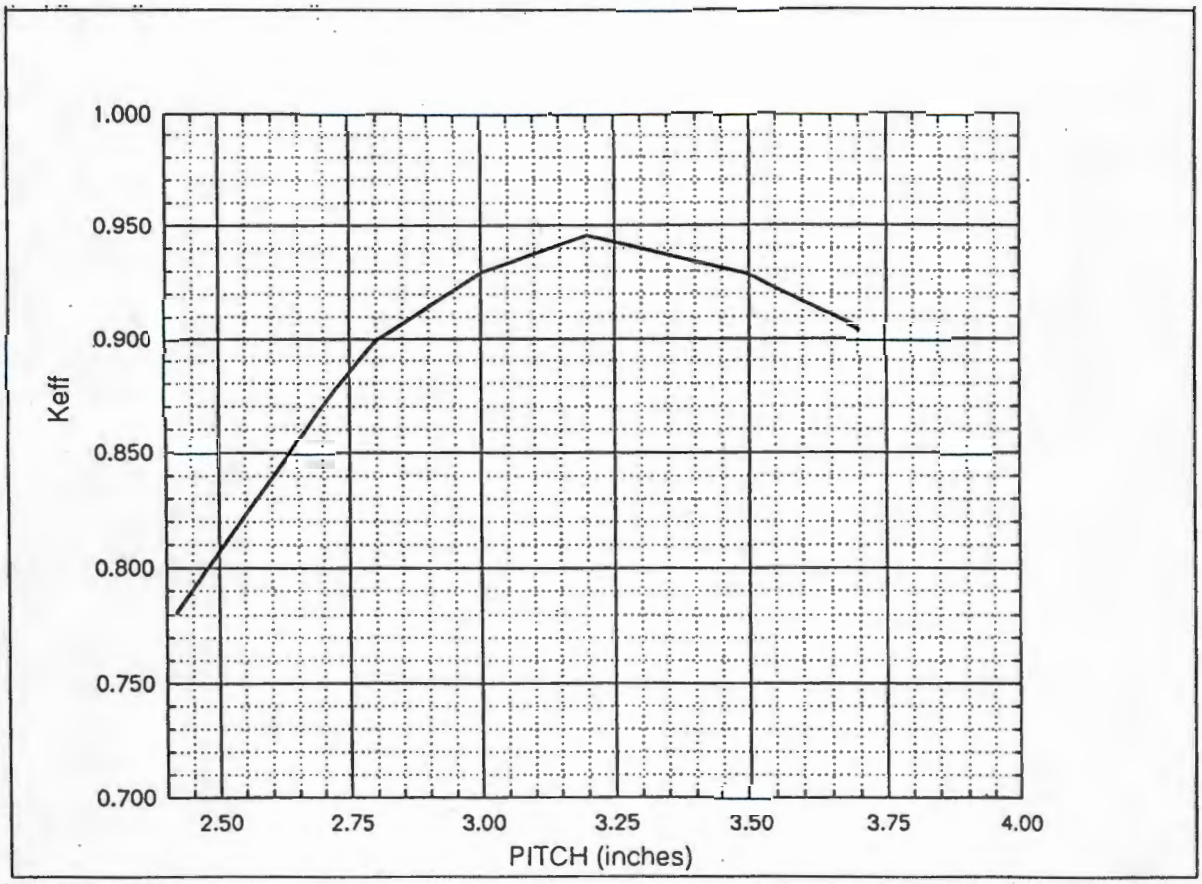


FIGURE 4-18

SENSITIVITY TO SPACING, 31 FUEL ELEMENTS
(IN A TRIANGULAR ARRAY) PER LAYER, 12 LAYERS, 7 COLUMNS

```
I 01/19/95 15:36:49
NF0307, N  fuel, 28
 elements/layer, 220 columns 47
 inch spacing
prehid = I 01/19/95 15:11:34
basis:
( 1.000000, 0.000000, 0.000000)
( 0.000000, 1.000000, 0.000000)
origin:
(      0.00,      0.00,    142.80)
extent = (     50.00,     50.00)

.pz=-142.80
```

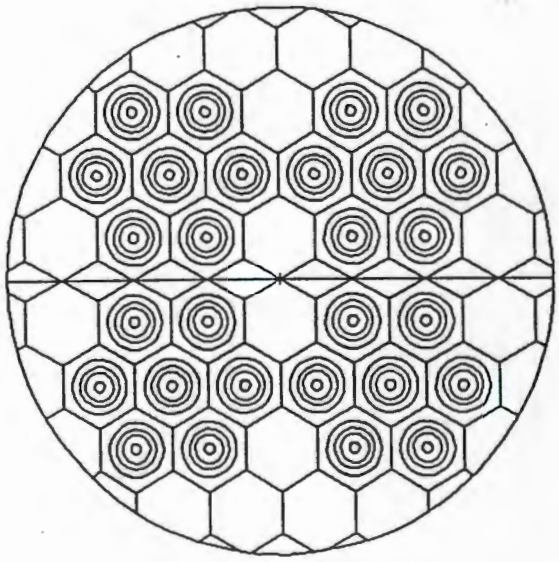


FIGURE 4-19
FUEL ELEMENTS IN A SINGLE LAYER OF AN MCO MODEL

```
I 08/15/94 13:50:37
MF023, N  fuel, hex lattice,3.2
 in pitch, 31  elements per
 layer, full inventory
prohid = I 08/15/94 13:49:16
basis:
( 1.000000, 0.000000, 0.000000)
( 0.000000, 1.000000, 0.000000)
origin:
(      0.00,       0.00,       0.00)
extent = (  1700.00,  1700.00)
possible causes of dotted lines:
 errors in the geometry.
 cookie-cutter cell in the source.
 a problem plane coincident with
  the plot plane.

.end
```

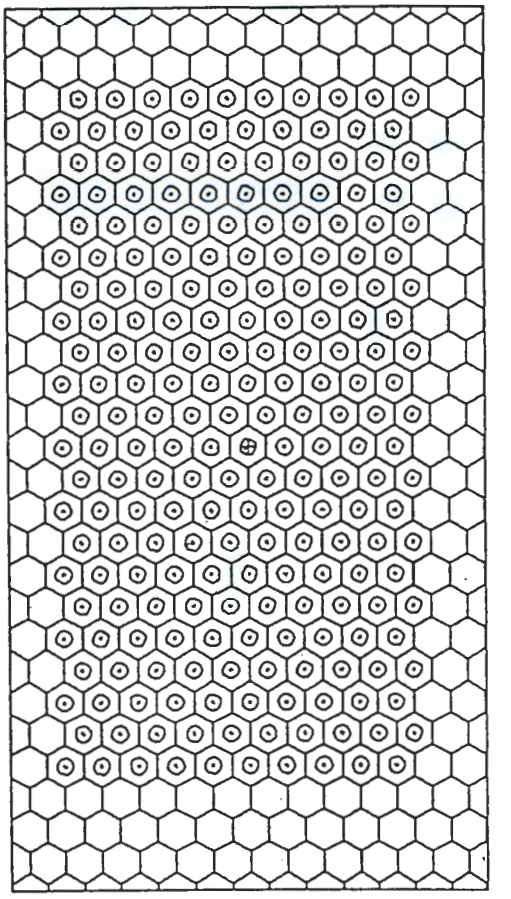


FIGURE 4-20
CSB VAULT MODEL SHOWING STORAGE TUBES IN A TRIANGULAR ARRAY

model are the fuel, cladding, and the surrounding water. The results for this configuration gave a k_{eff} of 0.81289 with a standard deviation of 0.00091 (calculation ID: NF032). Replacing the water outside the MCO boundaries with air, gave a k_{eff} of 0.87063, +/- 0.00073 (NF033). This increase is probably due to the increased interaction between columns for this close a spacing.

To evaluate the impact of some of the structural material, assumed to be stainless steel (SS 304), the case with air outside the MCO was repeated, but this time the canister walls were included in the model. This calculation gave a k_{eff} of 0.77375, with a standard deviation of 0.00065 (NF034). Including the MCO wall material, further reduced the k_{eff} to 0.74524 +/-0.00069 (NF035). (To accommodate the 3.2 inch spacing between fuel elements, the canister outside diameter was taken to be 9.2 inches and its thickness 0.25 inches, Figure 4-21. This should be compared to a standard schedule 20, 8 inch pipe which has an outside diameter of 8.625 inches and the same thickness.)

Increasing the spacing between columns to 55 inches and including the tube material, reduced the k_{eff} to 0.7234 +/-0.00061 (NF036). The relatively small decrease between this case and case NF035, indicates that the interaction between columns has already been significantly reduced by the addition of the MCO wall material.

Case NF036 is representative of both the Concept 1 dry vault storage and Concept 2 storage of MCO's in water filled tubes with forced refrigerated air cooling of the tubes. Eliminating water from the calculation will result in an under-moderated situation with an effective decrease in k_{eff}. Filling the vault with water would have only a minor effect on the vault k_{eff}, since there is only negligible interaction between tubes at this spacing and when taking credit for tube and MCO wall thicknesses. (The case of a water filled vault is a credible accident scenario and would have to be considered in a criticality safety evaluation. Partial filling of the vault with water may actually be a worst case situation, as was illustrated by comparing results for cases NF032 and NF033.)

4.2.5 Shielding

The shielding evaluations were performed with MicroShield 4 which is adequate for the bulk shielding studies performed. Penetrations, ducts, and cracks were not evaluated but are noted where additional work will be needed in the future. Some allowances were taken with the bulk shielding thicknesses in anticipation of the more complicated geometries.

4.2.5.1 Introduction

The shielding issues for Concept 1 involve health protection of the occupants of the SSF throughout its life. The selection of an appropriate source term is examined by looking at the defined

```
I 02/08/95 15:17:05
MF036, M  fuel, MCO,can.&tube
 walls, 220 columns 55 inch
 spacing, air in vault
probid = I 02/08/95 15:09:47
basis:
( 1.000000, 0.000000, 0.000000)
( 0.000000, 1.000000, 0.000000)
origin:
(      0.00,      0.00,    142.00)
extent = (    50.00,    50.00)

.end
```

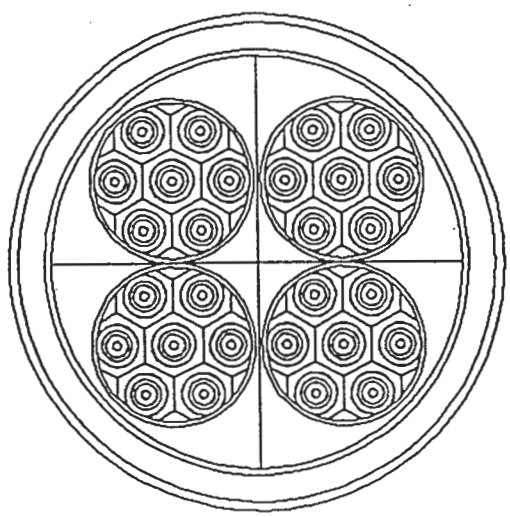


FIGURE 4-21
CROSS SECTION OF STORAGE TUBE SHOWING MCO AND CANISTER WALLS

"limit" source and another "shield" source, as well as a combination of the two sources. There are several water conditions that must be met at all times to provide a maximum dose rate of 0.5 mrem/hr. These include the minimum pool water depth over the filled MCO racks and the minimum water level over an individual MCO. The interior and exterior wall thicknesses are important to provide health protection during possible construction activities. The operating floor thickness must protect workers during maintenance activities. The thickness of the transporter or shielded cask must provide adequate shielding during transport, insertion and removal of the shield plugs and MCO's. The shielding parameters are identical for Alternatives 1B and 1C.

4.2.5.2 Source Selection

Three possible sources were examined to determine the most appropriate for the shielding studies. The "limit" source is that found in Appendix 1, "MCO Proposed Description" Draft Rev. A, R. G. Cowan, January 12, 1995. The "shield" source is that found in Table 3.6 - Safety Basis Radionuclides - referenced as the shield source in paragraph 3.6 - Shielding Design Basis of the "Draft Design Basis Feed Development", A. L. Pajunen, December 22, 1994. Direction from Westinghouse indicated that the "limit" source should be used. Previous experience and the increased number of radionuclides in the "shield" source prompted examination of the two sources. The "shield" source is based on the most radioactive fuel elements currently in the K-Basins. Apparently, there is only 0.6 metric tons of this material, which is considerably less than one filled MCO. However, three cases were examined: 1) filled MCO with the "limit" source; 2) filled MCO with the "shield" source; and 3) combined MCO with 0.6 metric tons of the "shield" source and the balance of the fuel elements of the "limit" source. A simple geometry of an MCO immersed in water with a 2 foot concrete wall was used to evaluate the three sources. All other things being equal, except for the radionuclide composition, the resulting dose rates were: "limit" - 0.0112 mrem/hr; "shield" - 0.0122 mrem/hr; and "combined" - 0.0114 mrem/hr. The limit source was selected since all sources were very close to being equal.

4.2.5.3 Minimum Water Depth Over a Single MCO

The MCO is brought into the SSF in a shielded cask. The cask is immersed in water before withdrawing the MCO. Radiation shielding of the MCO is provided by the water surrounding the cask and the MCO. Whenever the MCO is not in the cask, it must be surrounded and covered by water. Personnel do not generally have access to the sides or bottom of the pool (Section 4.2.5.5) so only the top of the MCO must be shielded. This shielding is provided by establishing a minimum water depth above the MCO which must be maintained. This minimum water depth is 6 feet.

4.2.5.4 Minimum Water Depth Over MCO Rack

Radiation shielding of the MCO rack is provided by the water surrounding and covering the MCO's in the racks. The MCO's in the racks must always be covered with water to provide cooling as well as shielding. Personnel do not generally have access to the sides or bottom of the pool (Section 4.2.5.5) so that only the top of the MCO's in the pool must be shielded. The normal pool depth above the racks must be at least 21 feet which accounts for a 15 foot long MCO and 6 feet of water above the single MCO. However, under emergency conditions, the minimum water depth above the rack is of interest. This is assuming that all MCO's are in the rack and that none are being inserted into the rack. This minimum water depth is 8 feet.

4.2.5.5 Minimum Concrete Thickness of Interior and Exterior Walls

There are several construction sequence possibilities for the SSF. The thickness of the interior walls is not important from a health protection standpoint if all construction is performed initially. However, if the pool is constructed first and filled and the dry storage vaults are built at a later time, the construction workers will need to be shielded against radiation penetrating the interior wall between the pool and the adjacent vault. The minimum wall thickness required is 36 inches. Since a 42 inch wall thickness has been specified to structurally contain the pool, the wall thickness is more than adequate from a shielding perspective.

The second construction sequence involves the construction of the Stabilization Facility adjacent to the exhaust plenum. Excavation could remove all of the soil surrounding the exterior wall. Again, the minimum wall thickness is 36 inches, so that the 54 inch exterior wall is more than adequate.

4.2.5.6 Minimum Thickness of Operating Floor

Radiation protection of personnel from stabilized MCO's in dry storage is provided by the concrete operating floor. This floor, along with the individual shield plugs which provide access into each storage tube, must provide shielding sufficient to maintain a target dose rate of 0.5 mrem/hr. The minimum floor thickness must be 48 inches. This floor thickness allows for a solid floor. When the floor is cast with plug holes and the holes are fitted with plugs which do not completely fill the space, radiation streaming is possible. Plugs and holes with steps solve this problem. It is estimated that the current design thickness of the floor is 60 inches which will provide adequate shielding. The geometry with the holes and plugs will need to be examined thoroughly at a later date.

4.2.5.7 Minimum Transporter/Cask Thickness of Steel and Tungsten

There are two options for transporting the MCO's filled with stabilized fuel tubes. The first would involve a stand alone transporter which would be driven around on the operating floor. The second would involve a special remote controlled cask which would be moved with an overhead crane. In either case, personnel health protection and shielding weight are important. The target contact dose rate is 0.5 mrem/hr. The thickness of iron to achieve this dose rate is 13 inches. The thickness of tungsten to achieve this dose rate is 4.5 inches. The tungsten shield is more expensive, but considerably lighter which reduces the cost of the transporter or overhead crane. These thicknesses provide gamma shielding only. The shielding will need to be checked for neutron shielding adequacy (Section 4.2.5.8)

4.2.5.8 Special Shielding Issues (Neutrons, Betas)

A neutron source was not provided and neutrons have been ignored during this study. However, in future design efforts, neutron dose rates will need to be evaluated. The areas of particular concern are the incoming and outgoing casks and the transporter/cask. These shielding structures are designed to provide adequate gamma shielding. Neutron shielding may be needed. The neutron source will result from some n,α reactions and spontaneous fission of the transuranics.

The beta source does not appear to be significant in the MCO. The shielding concern is not to provide beta shielding which is provided by the shell of the MCO, but to provide adequate shielding of the Bremsstrahlung radiation resulting from the beta absorption in the gamma shield.

4.2.6 Conversion

Conversion of Alternative 1B from water cooled staging of unstabilized fuel to passive dry storage of stabilized fuel is accomplished by installing the storage tubes in the already constructed vaults, constructing the metal builting over the vaults and installing the enclosed mechanical, piping, HVAC and electrical equipment. Conversion of Alternative 1C requires construction of the third vault, which is a substantial distance away from the pool, followed by the same steps as for Alternative 1B.

As discussed in the preceding section, the radiation levels in Vault 2 when the pool is filled with MCOs will not preclude personnel entry into Vault 2 to install the storage tubes. Precautions to preclude accidents during construction of the metal building above Vault 2 from causing foreign objects to fall into the adjacent pool will be necessary, but are expected to be practical. However, if necessary, any structures which might present an unacceptable hazard if constructed during conversion could be built during the first phase to a point sufficiently removed from the pool to eliminate the need for such precautions.

5.0 CONCEPT 2 TECHNICAL DESCRIPTION

5.1 FACILITY DESCRIPTION

5.1.1 Plot Plans

Figure 5-1 shows the outline of the Concept 2 SSF and an assumed adjacent Stabilization Facility superimposed on a modified Master Site Plan for what was previously the HWVP site within the 200 East Area. The SSF is shown on the location of the existing CSB foundation. Other existing buildings, roads, rail lines and underground utilities in the area are shown in their current locations. New facilities which have been proposed for construction in the area as shown in the Master Site Plan currently being prepared by Fluor Daniel for the Tank Waste Remediation System (TWRS) Site Integration Task Force have been rearranged to be compatible with the Concept 2 layout and location. The Figure shows that location of the SSF on the existing CSB foundation is feasible and provides good access to all required utilities, roads and rail lines. It also shows that location of the SSF in this area is compatible with plans for other facilities which have been proposed for construction in the area.

A more detailed plot plan for Alternative 2A is shown in Figure 5-2. The Stabilization Facility outline shown in Figure 5-2 shows one possible location for the Stabilization Facility relative to the SSF and is not intended to portray an accurate representation of its size or geometry.

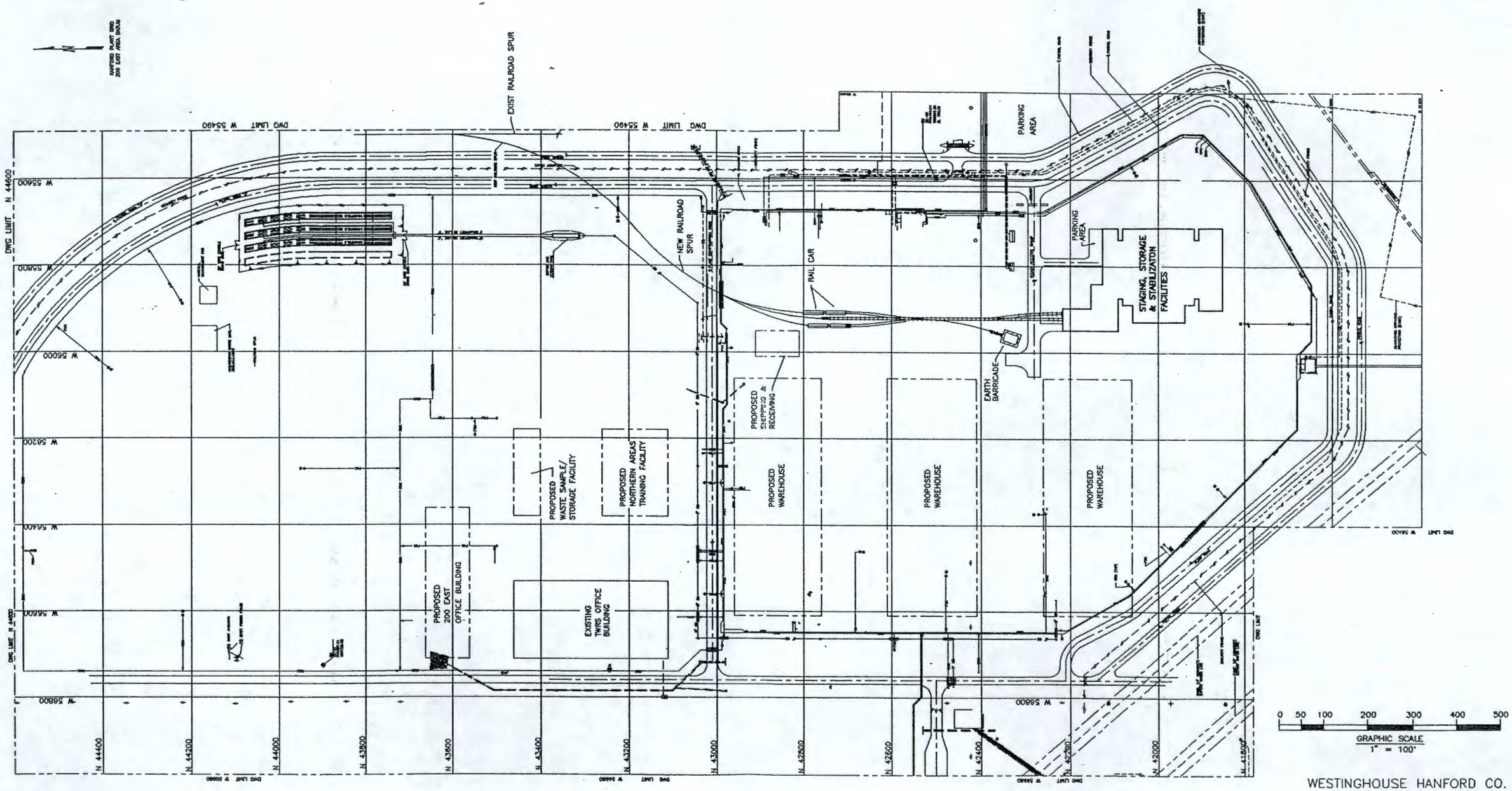
5.1.2 Rail Tunnel/Cask Unloading Area

5.1.2.1 General Description

The Rail Tunnel/Cask Unloading area is a new addition of approximately 10,000 square feet to the original SSF design. It is located in the north west corner of the SSF and interfaces with the MCO Storage Tube Area via a covered water canal as shown in Figure 5-3.

The main functions of this area are to safely receive, handle and prepare the incoming packaged MCO for placement in the storage tubes prior to stabilization. The packaged MCOs are delivered inside a shipping cask, via rail car, one at a time. Before being returned to the K-Basins, the shipping casks are prepared for handling and loaded with a empty MCO.

Except for the use of an underwater transfer canal to transfer MCOs to a receiving station within the operating area of the storage facility where they can be retrieved by the bottom loading MCO shield cask for transfer to their storage tubes, the Rail



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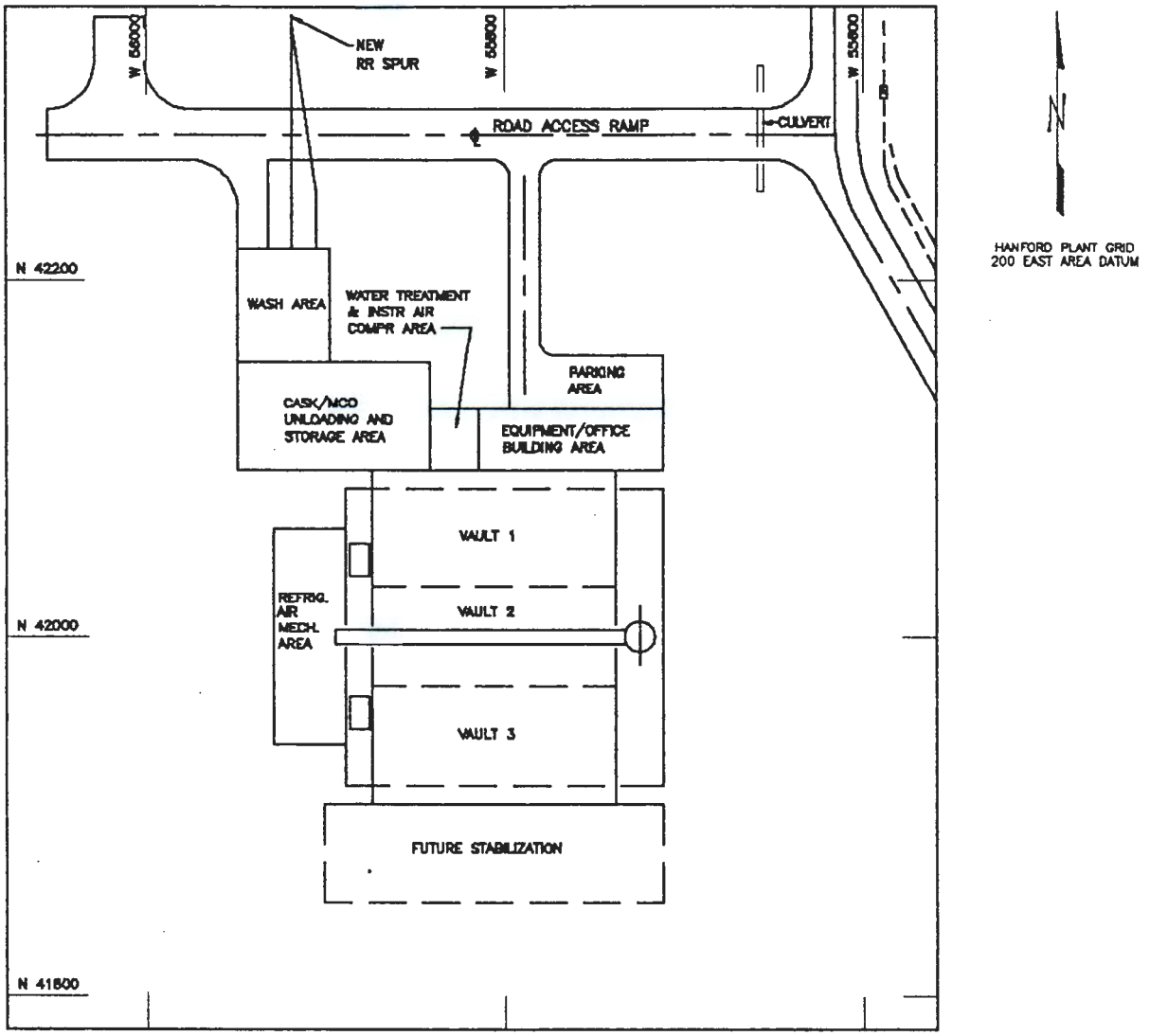
STAGING & STORAGE FACILITY
MASTER SITE PLAN
CONCEPT 2 ALT A

FIGURE 5-1

CADFILE FB4 RAC 2/10/95



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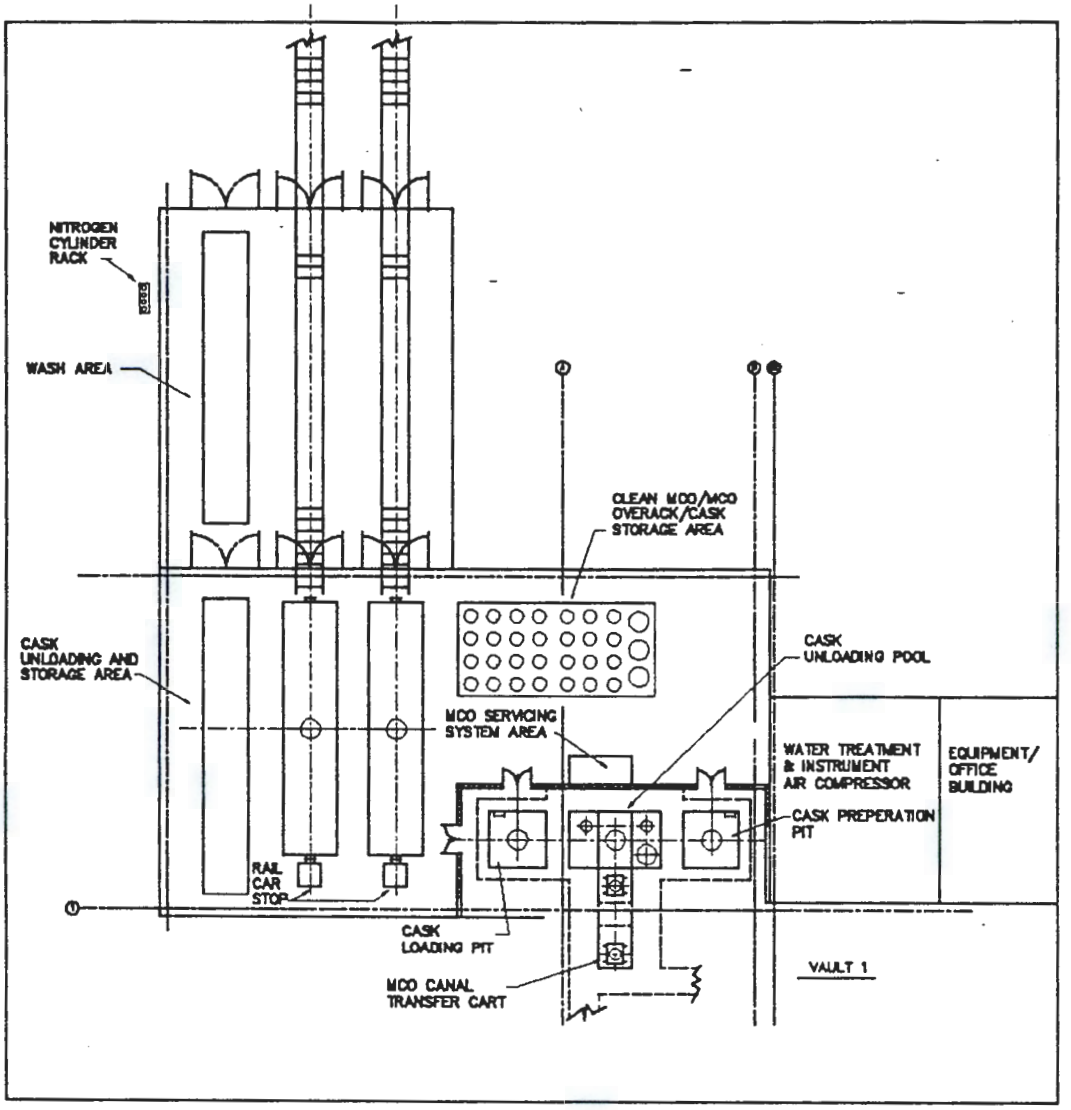
STAGING & STORAGE FACILITY
PLOT PLAN
CONCEPT 2 ALT A

FIGURE 5-2

CADFILE C2A RAC 2/27/95



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STAGING & STORAGE FACILITY
RAIL TUNNEL/ CASK UNLOADING AREA
CONCEPT 2 ALT A

FIGURE 5-3

CADFILE FB2 RAC 2/13/95

Tunnel/Cask Unloading Area for Concept 2 is the same as previously described for Concept 1. A remotely operated hot cell type facility was considered as an alternative to the Cask Preparation Pit/Cask Unloading Pool/MCO Transfer Canal/Cask Loading Pit, but was expected to be more costly than the facilities described for Concept 1 and was therefore not considered further.

5.1.3 MCO Servicing

MCO Servicing is performed in the same manner and using the same equipment previously described for Concept 1.

5.1.4 Cask Unloading Pool Water Treatment System

The Cask Unloading Pool Water Treatment System performs the same functions for the Cask Unloading Pool and Transfer Canal as the Staging Pool Water Treatment System performs for the Staging Pool in Concept 1. Its design is similar to the Staging Pool Water Treatment System for Concept 1, except that it is much smaller, is designed for a 36 hour turnover of pool volume and the deionization units will not be regenerated. Because of the small size of the units, the resin beds are replaced when they become saturated.

Table 5-1 lists the major equipment for the Cask Unloading Pool Water Treatment System.

5.1.5 MCO Cooling and HVAC

5.1.5.1 HVAC Systems for Normal Operation

Vault Refrigerated Air System. The block flow diagram for the HVAC system serving the SSF Vaults during staging is shown on Figure 5-4. The HVAC system is a recirculating refrigerated air system consisting of five 50,000 CFM Air Handling Units (4-operating and 1-standby) which supply chilled air at 35°F to the vault. This supply air temperature to the vault will maintain the MCOs at 50 °F. Since the MCO's are stored in water filled tubes which serve as a secondary confinement barrier, the air inside the vault will not be contaminated.

Vault Passive Ventilation System. The passive ventilation system for the Vault during dry storage will be identical to the CSB design. This concept has three vaults, each with 220 tubes. There are provisions for 17 overpacks and the tube spacing for this concept will be identical to the CSB design.

Operating Area HVAC System. The Operating Area HVAC System for the CSB design will be modified to accommodate the ventilation system for the MCO service area and the MCO/Cask unloading and storage

TABLE 5-1

EQUIPMENT LIST
STAGING AND STORAGE FACILITY
SSF
(CONCEPT 2)

EQUIPMENT DESCRIPTION	EQUIPMENT ID	CAPACITY/FLOW RATE	PHYSICAL SIZE (DIA X H)	MATERIAL	POWER	HEAT LOAD	COMMENT
POOL WATER TREATMENT SYSTEM							
RECIRCULATION PUMPS	P-3A/B/C	30 GPM, 300 PSIG	2" SUCTION	SS	10.00 HP		ONE SPARE
PRIMARY POOL FILTERS	F-2A/B	30 GPM, 50 PSIG		SS			
DEIONIZATION UNIT	R-1A/B	30 GPM, NET	FOUR TANKS 18' OD X 6' H	SS			
WASTE SLURRY HOLD TANK	V-4	25 PSIG	3' OD X 6' H	SS			
WASTE WATER HOLD TANK	V-5	15 PSIG	3' OD X 6' H	SS			
POOL WATER CHILLERS	CH-1A/B	2,200 BTUH/HR (0.18 TONS) NET		STEEL	60.00 HP		ONE SPARE
POOL WATER EXCHANGERS	E-1A/B	1,100 BTU/HR		STEEL & SS			
POOL WATER STERILIZERS	UV-1A/B	30 GPM		GLASS & SS			
INSTRUMENT AIR SYSTEM							
AIR COMPRESSOR	C-1A/B	100 SCFM, 100 PSIG		STEEL			ONE SPARE
INSTRUMENT AIR DRYER	DY-1	100 SCFM, NET					DUPLEX
INSTRUMENT AIR RECEIVER	V-1	150 PSIG	8' OD X 8' H	STEEL			

area. The system is capable of diluting the hydrogen and krypton-85 to acceptable levels by introducing sufficient amounts of outside air. The block flow diagram for this system is the same as for Concept 1 (see Figure 4-8).

Pool Water Treatment Building. This building consists of clean areas and potentially contaminated areas. This is a much smaller system than required for Concept 1. A single HVAC system will be used to serve these areas.

The block flow diagram for the HVAC system serving these areas is shown on Figure 5-5. Redundant 2,000 CFM Air Handling Units (AHU-1 and AHU-2) with evaporative cooler and heating coil supply air to these areas and the air is exhausted through redundant HEPA filter plenums (PF-1 and PF-2) and exhaust fans (EF-1 and EF-2).

5.1.5.2 HVAC Systems for Abnormal Operation

Vault Refrigerated Air System. It has been estimated that on failure of the vault refrigerated air system used during staging, the water temperature inside the MCO will increase by 10 °F in approximately 50 hours. This would allow sufficient time to provide other emergency means of cooling, such as flooding the vault with water, in the event refrigerated air cooling could not be reestablished before MCO temperatures became excessive. The vault refrigerated air system therefore does not include any special features for abnormal operation.

Vault Passive Ventilation System. The Vault passive ventilation system used during dry storage is designed to operate following all DBA's. No other HVAC systems are required for operation of the vaults during abnormal operation.

Operating Area. The block flow diagram for the HVAC system for emergency ventilation of the Operating Area is the same as for Concept 1 (see Figure 4-11). This system is designed to be activated following an accident (potential drop of an MCO and release of contamination to the operating area) and is interlocked to stop the normally operating HVAC system. The HVAC system consists of two trains with HEPA filter plenums (PF-1 and PF-2) and exhaust fans (EF-1 and EF-2).

5.1.6 Structural

There are very few structural modifications to the current CSB design required for the SSF under this concept. The operating floor shelter over Vaults 1, 2 and 3 will be a steel frame building very similar to the original CSB design except it will have crane rails and a girder for the overhead cask/crane system described in Section 3. This building will be approximately 46 ft high.

On the west side of the Storage Vault will be the Refrigerated Air Mechanical Building, a 120 ft long, 40 ft wide, and 20 ft high steel frame building. West of that will be five air cooled condensers, each supported on a 8 ft X 15 ft concrete pad. North of the Storage Vault will be four other support buildings: the Cask/MCO Unloading and Storage Building (170 ft long, 61 ft wide, 33 ft high); the Wash Area Building (64 ft long, 50 ft wide, 27 ft high); the Water Treatment & Instrument Air Compressor Building (35 ft long, 30 ft wide, 17 ft high); and the Equipment/Office Building (100 ft long, 33 ft wide, 17 ft high). All support buildings will be steel frame buildings with metal siding and metal roof deck.

An HVAC duct, ~10ft x ~5 ft in size will be added connecting the exhaust stack and the Refrigerated Air Mechanical Area. This duct will be supported by the operating shelter. Refrigerated air will be returned to the air inlet ducts via ducts from the Refrigerated Air Mechanical Area. Removable blinds in the air inlet ducts and exhaust stack will isolate the refrigerated air system from the environment. The inlet air temperature to the vault will be ~ 35 F during staging. Due to the reduced heat load, insulating concrete will probably not be required in the vaults during refrigerated air or natural circulation ambient air cooling.

The storage tubes will be very similar to those designed for the CSB except they will be made out of stainless steel since they will be filled with water during staging. A 1/8 inch increase in the wall thickness of the storage tubes will be required for stainless steel.

5.1.7 Material Flow

5.1.7.1 General Description

The Material Flow includes two distinct phases: the Staging Material Flow and the Storage Material Flow which takes place only after completion of the Stabilization Facility.

5.1.7.2 Staging Material Flow

The Staging Material Flow involves tasks and sequences necessary to place packaged MCOs, received from the K-Basins, into forced air cooled storage tubes, filled with deionized water, in the Storage Tube Area, prior to stabilization.

The Staging Material Flow begins with a packaged MCO in a cask, on top of a rail road car parked outside the Rail Tunnel/Cask Unloading Area. It terminates at the removal, from the facility, of a decontaminated cask loaded with an empty, ready to use, MCO. Figures 5-6 through 5-9 depict the tasks, sequences, equipment and estimated time required to perform the tasks.

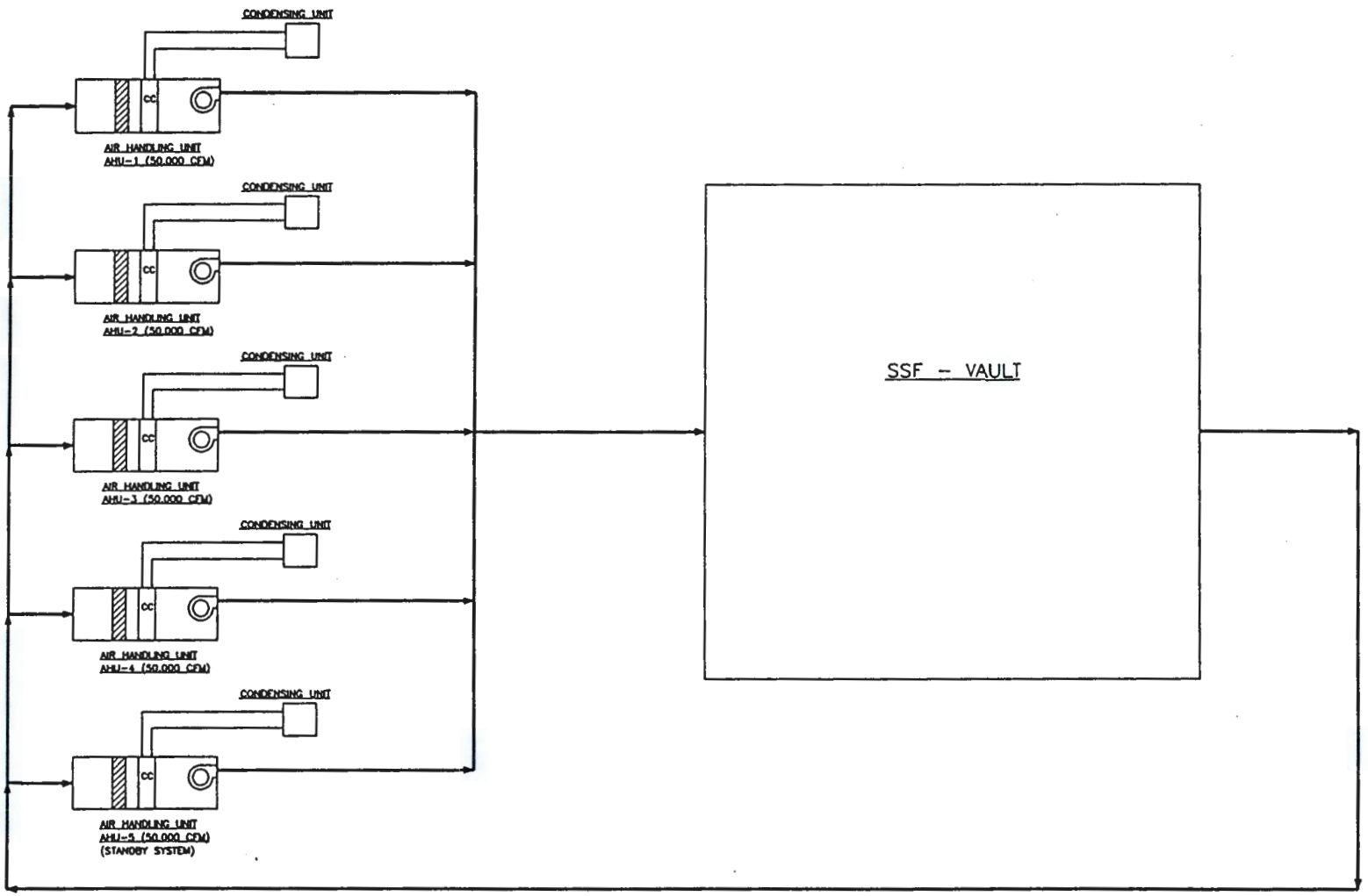


FIGURE: 5 - 4

SSF FEASIBILITY STUDY
CONCEPT NUMBER: 2
VAULT - HVAC SYSTEM

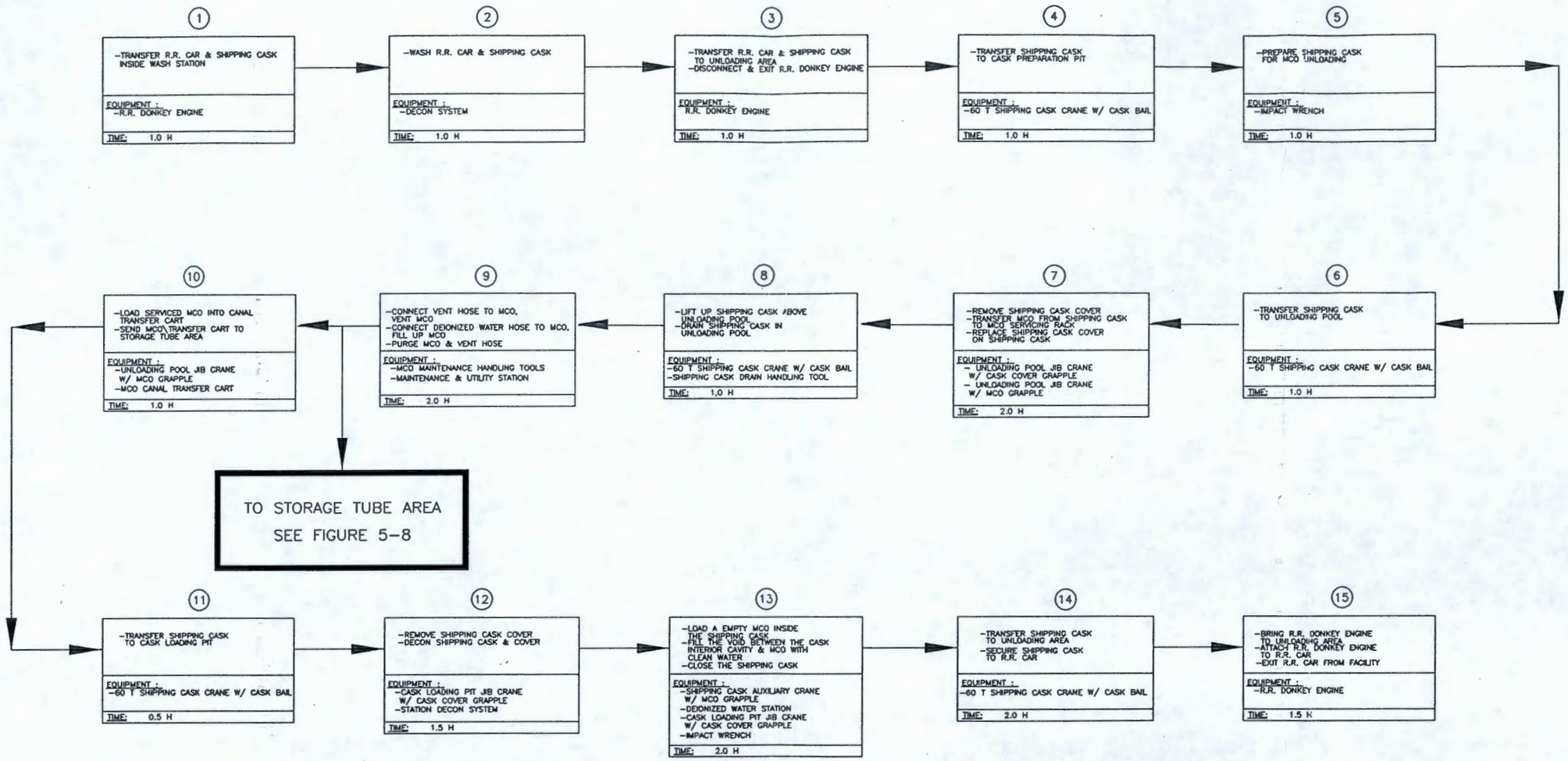


FIGURE 5-6

CONCEPT "2", ALTERNATIVE "A"

STAGING MATERIAL FLOW DIAGRAM, IN RAIL TUNNEL/CASK UNLOADING AREA

CADFILE: FLOW2A

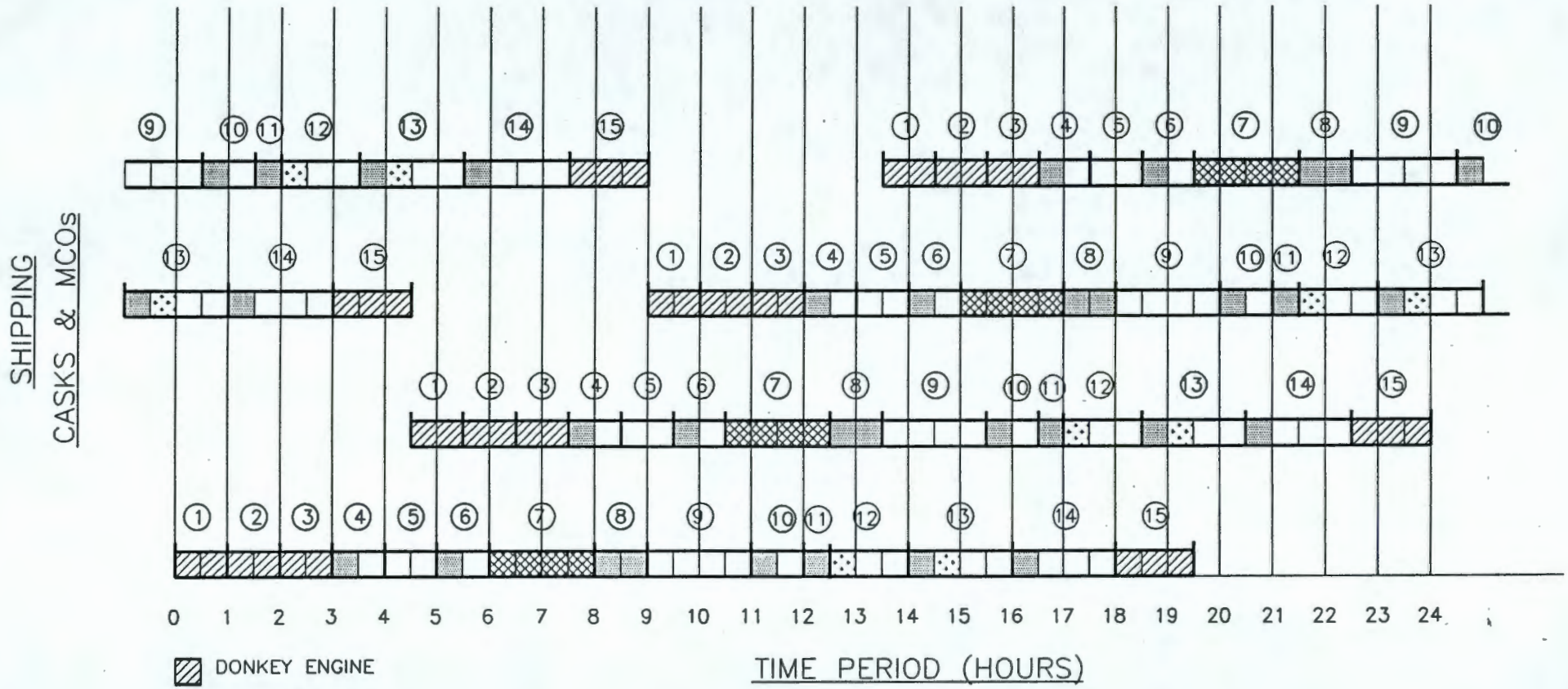


FIGURE 5-7

CONCEPT "2", ALTERNATIVE "A"
STAGING MATERIAL TIME STUDY
IN CASK UNLOADING & STORAGE AREA

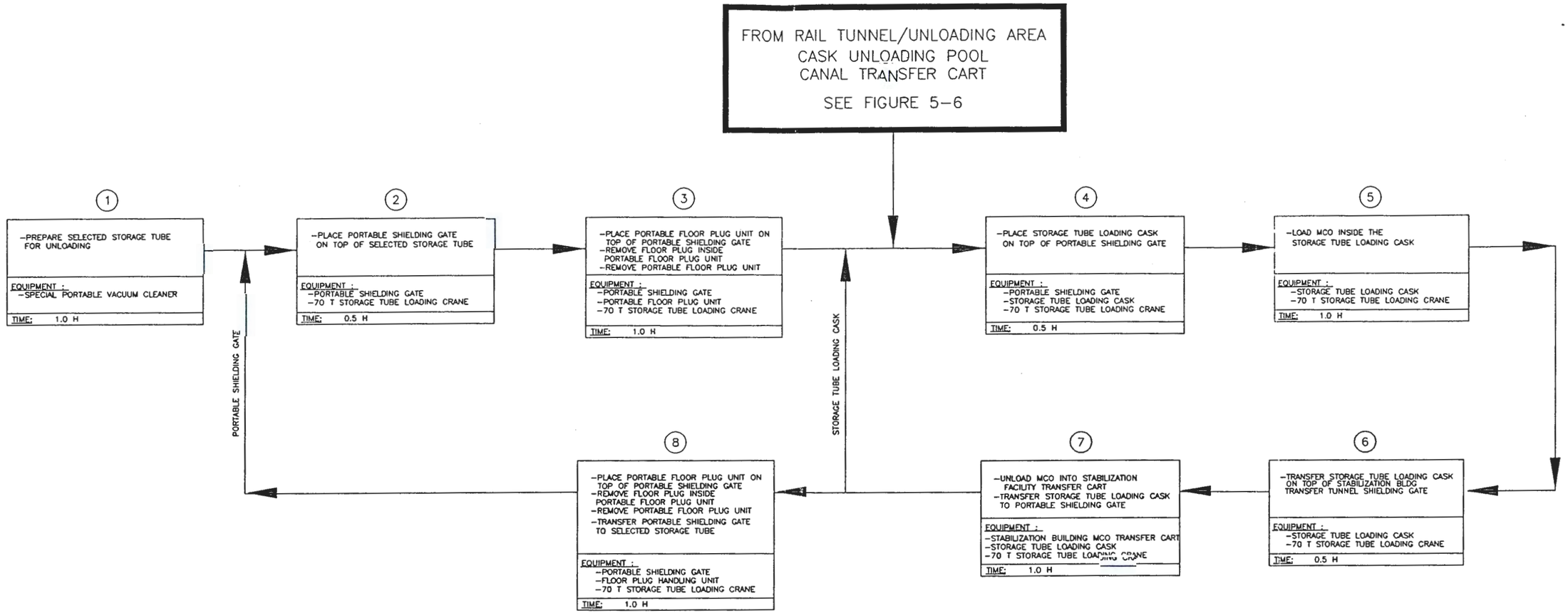
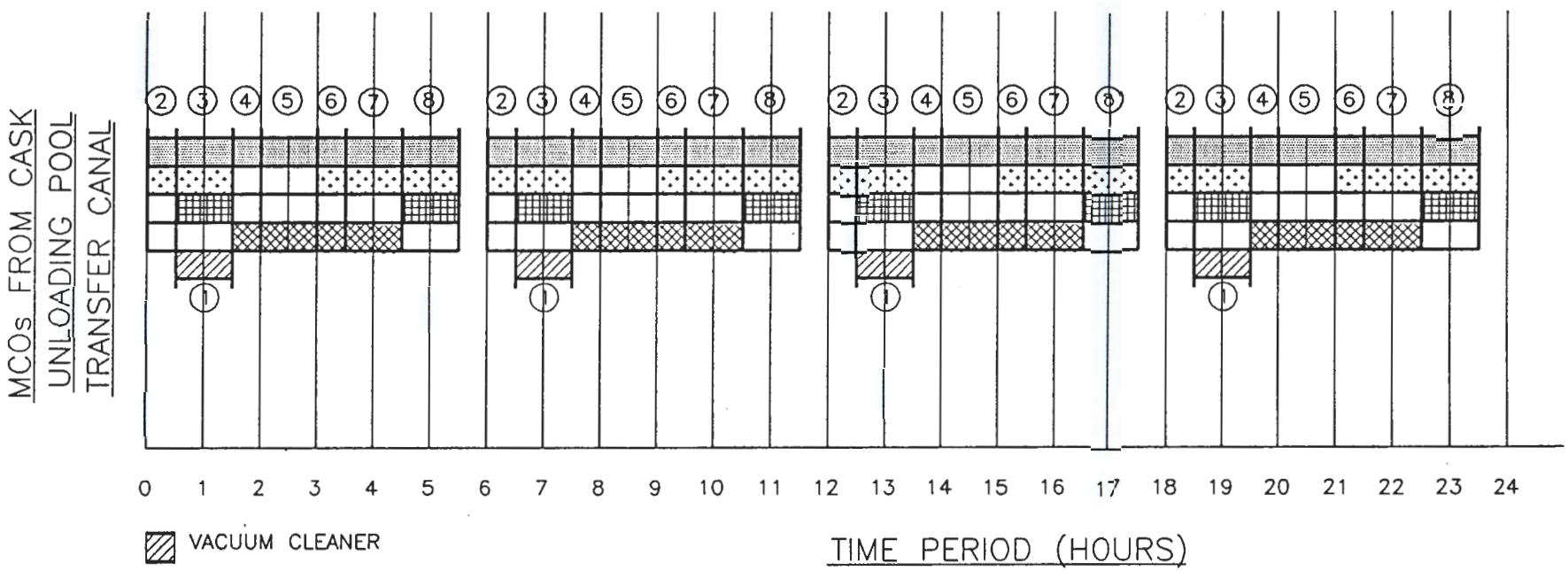


FIGURE 5-8

CONCEPT "2", ALTERNATIVE "A"

STAGING MATERIAL FLOW DIAGRAM, IN STORAGE TUBES AREA

CADFILE: FLOW2A



- VACUUM CLEANER
- 70T/10T CRANE
- STORAGE TUBE LOADING CASK
- PORTABLE SHIELDING GATE
- PORTABLE FLOOR PLUG UNIT
- SEQUENCE #s FROM STORAGE MATERIAL FLOW DIAGRAM, FIG. 5-8

FIGURE 5-9

CONCEPT "2", ALTERNATIVE "A"
STAGING MATERIAL TIME STUDY
IN STORAGE TUBES AREA

CADFILE:

It is assumed that placement of the bottom impact absorbers inside the storage tubes is performed during the completion of construction. The upper impact absorbers are assumed to be installed in a campaign style manner during a down time period. Storage tubes are filled with the required amount of deionized water before the loading of MCOs starts.

5.1.7.3 Storage Material Flow

The storage material flow involves tasks and sequences for storing stabilized MCOs inside dry, passively cooled storage tubes. These tubes being the same used for the prior staging phase. This phase will occur only after the Stabilization Facility has been made operative.

The Storage Material Flow begins with the removal of a submerged MCO from a storage tube and its transfer to the Stabilization Facility. It terminates with closure of a dry storage tube after loading a stabilized MCO in it. If required, MCOs can be retrieved and sent to the Stabilization Facility for overpacking by reversing the sequences order. Figures 5-10 and 5-11 depict the tasks, sequences, equipment and estimated time required to perform the tasks.

It is assumed that removal and replacement of the upper impact absorbers inside the storage tubes is performed outside the MCO handling time frame. The bottom impact absorbers remain in place and do not require handling. The upper impact absorbers are assumed to be removed and reinstalled in a campaign style manner, during a down time period. Removal of deionized water from the storage tubes is accomplished thorough the floor plug access tubes. This action takes place during the stabilization process.

5.2 FEASIBILITY ISSUES

5.2.1 Structural

The same two structural feasibility questions discussed for Concept 1 apply to Concept 2. They are:

1) Changes in the seismic design criteria from the CSB design basis, and

2) Issues associated with design adaptation

5.2.1.1 Changes in the Seismic Design Criteria

As identified in section 4.2.1.1, the new seismic design load has increased 1.32 times from the "old" seismic design criteria that the CSB was designed for. Therefore, even if no changes are made to the original configuration of the facility, the design still has

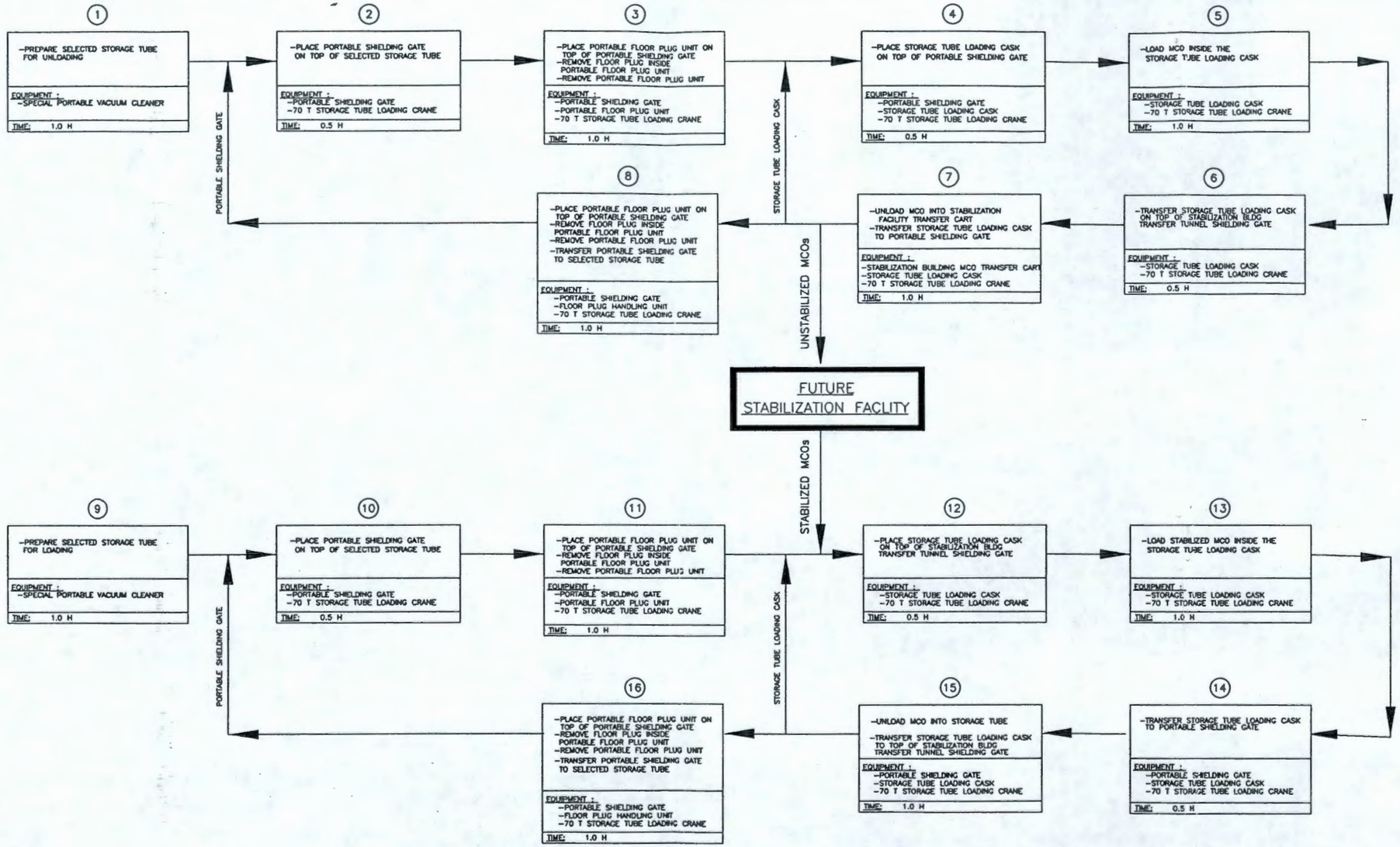


FIGURE 5-10

CONCEPT "2", ALTERNATIVE "A"

STORAGE MATERIAL FLOW DIAGRAM; TO AND FROM FUTURE STABILIZATION FACILITY

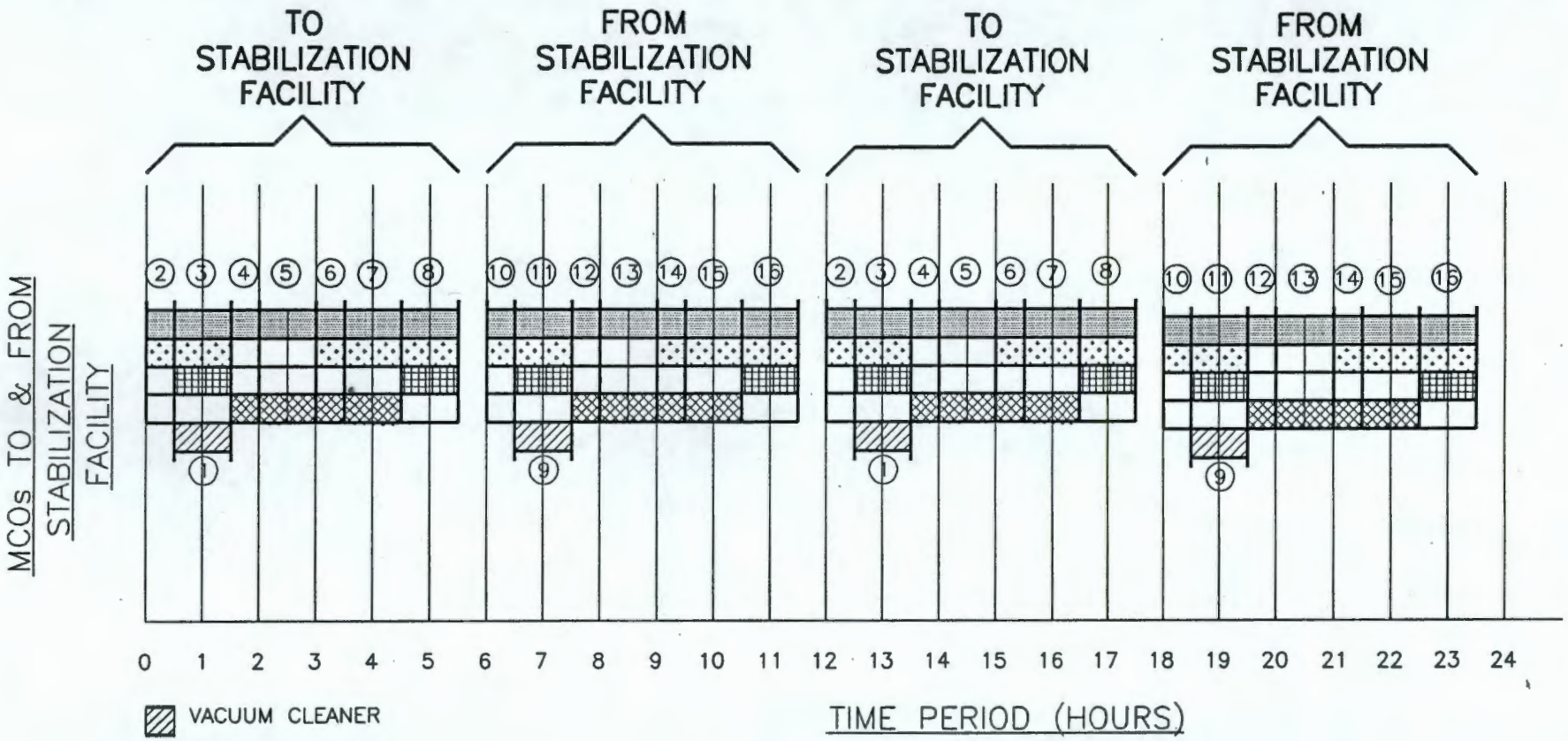


FIGURE 5-11

CONCEPT "2", ALTERNATIVE "A"
STORAGE MATERIAL TIME STUDY
OUT & INTO STORAGE TUBES

CADFILE:

to be re-evaluated for the increased accelerations of the new criteria and there is a high probability that some of the original design may need upgrading in terms of added reinforcement in the concrete and increase in the steel member sizes for the operating shelter. However, there is no reason to believe that this cannot be accomplished during the adaptation of the design of the CSB for the SSF.

5.2.1.2 Issues Associated With Design Adaptation

Evaluation of the issues involved in adaptation of the CSB design to refrigerated air cooling initially followed by conversion to natural circulation cooling with ambient air resulted in the conclusion that it is structurally feasible to do so. The following findings describe the results of the evaluation in greater detail:

1. The concrete vault design is essentially unchanged. The air temperature inside the vault during operation with refrigerated air will be ~ 35°F. This is within the operating temperature range that the concrete vault was designed for. Insulating concrete will probably not be required.

2. The operating floor shelter over Vaults 1, 2 and 3 will be a steel frame building very similar to the originally designed building except it will have crane rails and girder for the overhead crane to service MCO and cask. This building will be approximately 46 ft high. An HVAC duct, ~10 ft x ~5 ft in size will be added connecting the exhaust stack to the Refrigerated Air Mechanical Area. This duct will be supported by the operating shelter. There are no feasibility issues related to this addition.

3. The storage tubes will be very similar to what was originally designed except they will be made out of stainless steel to protect them from corrosion. It is estimated that the thickness of the tubes will increase by 1/8 inch, from the original design. This is because stainless steel has a lower yield stress than carbon steel.

5.2.2 Thermal/HVAC

This section documents the results of a series of thermal analyses that were performed to assess the feasibility of meeting the Multi-Canister Overpack (MCO) temperature requirements during wet and dry storage with the Concept 2 Staging and Storage Facility (SSF). These analyses were performed for forced refrigerated air and passive ventilation systems.

The thermal feasibility analyses is based on storage of MCO's in water filled tubes in vaults 1,2 and 3 with a forced refrigeration air cooling of the tubes during staging. MCO's are removed and returned to the tubes after stabilization and water removal from the tubes. After all fuel is stabilized, the passive air ventilation system is made operational.

5.2.2.1 Design Basis Assumptions

The following design basis assumptions were used for the thermal analyses:

- The heat generation rate was based on a total 1200 MCO's. Five percent are assumed to be at the upper limit (1120 BTUH) and the remaining 95% are assumed to be at the nominal value (600 BTUH). Due to the preliminary nature of the heat transfer calculations a ten percent safety factor was used for the heat generation rate. Additional heat loads were added for building heat gains and fan heat.

- The heat generation for the limiting case (1120 BTUH) per MCO was used for the calculating the MCO's water temperature assuming that it is located at the end of the vault.

- The design basis required storage conditions are as follows:

  Staging: Water inside the MCO at 50 °F.
  Storage: Maximum fuel centerline temperature at 400 °F.

- During the staging operation the MCO provides primary confinement and the water filled storage tubes provide the secondary confinement. It is assumed that the interior of the storage tubes are isolated from the vault, which would prevent the vault from getting contaminated.

- The total flow is assumed to be evenly and uniformly distributed around each of the containment tubes. This is a critical assumption that must be assured by design and verified by additional analyses using Computational Fluid Dynamic (CFD) techniques.

- The heat transfer coefficients for air were calculated at the point of maximum vault air temperature.

- One dimensional (radial) heat transfer only. Two-dimensional (radial and axial) heat transfer was not modeled.

- Heat transfer by radiation between the tubes was not considered.

5.2.2.2 Summary of Results:

The results of the thermal analyses during staging are shown in Table 5-2 and involve various combinations of MCO's surrounded by water in tubes for different ventilation flow rates.

The results indicate that it is feasible to maintain the MCO water temperature at 50 °F with a refrigerated forced air ventilation system. This system would require 200,000 CFM at a supply air temperature of 35 °F based on the above heat generation rate. The temperature of 35 °F was selected to prevent freezing of MCO's having very low heat generation. The MCO water temperature is calculated on the basis that the MCO is located at the end of the vault with the limiting heat load.

The results of this thermal analysis during storage with natural circulation cooling were previously presented in Section 4.2.2. The data shown there indicates an MCO fuel centerline temperature of 230°F can be achieved by a passive ventilation system.

The above results demonstrate the feasibility of using the refrigerated air and passive ventilation systems to meet the design basis MCO temperature requirements during both staging and storage.

It must be emphasized that these are rough conservative feasibility analyses using limited design information and do not cover all limiting or upset conditions. More detailed analyses are required using CFD techniques to cover all limiting and upset conditions and to verify some basic assumptions. Also no analysis was performed for MCO's stored in an overpack.

5.2.3 Contamination Control

5.2.3.1 Introduction

The potential hazards are from gas normally generated by the MCOs before stabilization and from the unlikely failure of an MCO to contain the spent fuel. The feasibility concern is whether the MCOs can be cooled and vented while maintaining acceptable confinement/containment.

The characteristics of unstabilized MCOs are described in Section 4.2.3. The remainder of this section addresses confinement and containment during normal venting and accident conditions. The design of the air cooling system was described in the previous section.

TABLE - 5-2

ALTERNATIVE 2A

THERMAL ANALYSIS - SUMMARY

MCO WATER TEMP. (^{o}F)	SUPPLY AIR QUANTITY (CFM)	SUPPLY AIR TEMPERATURE TO VAULT (^{o}F)	REMARKS
59	75,000	35	
56	100,000	35	
52	150,000	35	
50	200,000	35	Design basis

5.2.3.2 Normal Operation

MCO Servicing. The MCOs require servicing after receipt from the K-Basins prior to staging: After each MCO is received into the SSF, the MCO is purged with nitrogen and deionized water is added if needed to reach the desired level in the MCO. The services can be done with the MCO submerged in the Cask Unloading Pool. The pool temperature, clarity, and radioactive contamination must be maintained at acceptable levels; also, the level of contamination above the pool must be acceptable for controlled occupancy. The issues concerning gas and liquid releases from the MCO while submerged are the same as for Concept 1, discussed in Section 4.2.3. The design includes the normal building ventilation system for dilution of hydrogen and krypton-85, and an MCO servicing system that vents MCO gas to a stack and prevents overfilling of MCOs.

Closed Tube Staging. Gas vented from the MCOs rises through 5 ft or more of water in the storage tube to reach the operating area, which is normally ventilated with enough fresh air (over 10,000 cfm) to dilute the hydrogen and krypton-85 to acceptable levels. The operating area ventilation requirements are the same as for open pool staging under Concept 1, described in Section 4.2.3. However, since the storage tube is an enclosed space in which hydrogen could accumulate, provisions must be made to ensure that explosive concentrations do not develop. The following paragraph describes one concept for achieving this objective.

Each storage tube has a sealed floor plug with an embedded vent line and two test lines. The test lines have normally-closed valves and the vent line contains a HEPA filter. The tubes as originally designed can contain a pressure of almost 5 psig before the plug lifts from its sealed seat; the tube wall and bellows were designed for higher pressures. It would be simple to add a relief device to each vent line so that the vent would only be used if the pressure in the tube were to rise to about 4 psig. With a local pressure indicator added to each tube plug, pressures could be monitored and a portable cart used to sample and purge each tube with nitrogen. The cart would consist of a nitrogen cylinder on wheels, a regulator, a vent HEPA filter (similar to the one in the tube plug), and half-inch hoses to connect to the test lines on the plug. As long as each tube is vented and purged with nitrogen before the pressure rises above 0.8 psig, the hydrogen concentration will not exceed 6% by volume. A 6% mixture of hydrogen in nitrogen is non-flammable when mixed with any proportion of air. At the nominal design hydrogen generation rate, a tube with one MCO takes 110 days to reach 0.8 psig after venting and purging. With 1200 MCOs staged in 600 tubes, an average of 14 tubes per day would have to be vented and purged to maintain non-hazardous mixtures of hydrogen in the tubes.

Passive Air-Cooled Storage. After stabilization, the MCOs do not normally vent gas. There are no contamination issues during normal operation.

5.2.3.3 Abnormal Operation

MCO Servicing. The Cask Unloading Pool could become contaminated in the event of the failure of an MCO during unloading or servicing. Until the accident is quantified, it is assumed that the unmitigated consequences are severe enough to require safety class 1 or 2 systems, as defined in WHC document MRP 5.46 and DOE Order 6430.1A. To prevent this potential contamination from reaching the soil, the pit must be lined with stainless steel and monitored for leakage. Any place where pit water is contained, there must be a way to inspect or test for leaks; this includes any piping that penetrates through walls or the ground. The glycol coolant in the chillers must have monitors or test connections to detect any leaks across the glycol/pit water heat exchangers.

The operating area above the pit could become contaminated in the event of a crane accident during cask or MCO handling. Should any abnormal contamination be detected above the pool, alarms warn the operators to leave the area and the Emergency Ventilation System is activated. This system ensures that there is no unfiltered release from the building and that the hydrogen concentration remains orders of magnitude below the flammable limit.

The dropping of an MCO in the pool is not the worst MCO accident (compared, for example, to an accident during MCO handling above the storage tube operating floor), but this accident is a basis for designing the pool water treatment system. The pool water filters and deionizers are sized to contain the upper limit corrosion products from an MCO. The soluble corrosion products (cesium hydroxide) do not pose a criticality threat in the deionizer. The critically-safe geometry for the filters has not been determined in this study, due to time limitations.

Closed Tube Staging. If there is a failure of an MCO during staging, the HEPA filter in the sealed tube plug will prevent airborne contamination from spreading out of the tube. The tube plugs have test fittings which allow for periodic water sampling to detect MCO failure. The contamination is localized, but there is no built-in design feature for clean-up.

Passive Air-Cooled Storage. If there is a failure of a stabilized MCO during storage in a tube, only one tube becomes contaminated. The floor plugs have HEPA filters and test fittings which allow for periodic gas sampling to detect MCO failure. The contamination is localized, but there is no built-in design feature for clean-up.

5.2.4 Criticality

All the criticality calculations performed in support of this study have been reported in Section 4.1.2.4. All assumptions, approximations and computational procedures are discussed in that Section. The calculation identified as NF036 applies to both concepts. This case addressed water filled MCO's, stored in water filled tubes in the SSF vaults, as currently configured for the CSB (i.e., with center-to-center tube spacing of 55 inches). The k_{eff} for this case was found to be 0.7234, with a standard deviation of 0.00061. Other calculations discussed in Section 4.1.2.4 indicate that any variations on this configuration (such as filling the vault with water) would not increase the reactivity of this configuration appreciably. Limiting the MCO configuration to 28 fuel elements per layer is the key to maintaining a critically safe configuration. (This can be verified by observing the considerably higher k_{eff}'s calculated for MCO's with 31 fuel elements per layer.)

When evaluating criticality safety of dry vault storage, credible accident scenarios would have to be considered. These would include various degrees of flooding of the storage vaults. The results discussed in Section 4.1.2.4 can be extrapolated to cover this situation.

5.2.5 Shielding

5.2.5.1 Introduction

The shielding issues for Concept 2 involve health protection of the occupants of the SSF throughout its life. The selection of an appropriate source term is discussed in Section 4.2.5.2. The interior and exterior wall thicknesses are important to worker health protection during possible construction activities. The operating floor thickness is examined in Section 4.2.5.6. The thickness of the transporter or shielded cask is examined in Section 4.2.5.7.

5.2.5.2 Minimum Concrete Thickness of Interior and Exterior Walls

There are several construction sequence possibilities for the SSF. The thickness of the interior walls is not important from a health protection standpoint if all construction is performed initially. However, if one vault is constructed first and filled and the other storage vaults are built at a later time, the construction workers will need to be shielded against radiation penetrating the interior wall between the filled vault and the adjacent vault. An additional need for personnel access to a vault could be for cleanup before conversion to natural convection cooling. If this cleanup is required, all MCO's in the vault to be cleaned will need to be removed. Radiation levels from adjacent filled vaults will need to be less than 0.5 mrem/hr to avoid partial emptying of the

adjacent vaults. The minimum wall thickness required is 42 inches of full density standard concrete. Since the interior walls are currently 36 inches of full density concrete, the wall thickness is less than adequate for maintenance activities near the wall. At one time, there was an additional layer of thermal concrete (low density) applied to the interior surfaces of the vaults. If this additional thermal layer is included in the SSF design, the shielding may be adequate. Also, since entry into the vault will only occur if cleanup is required, localized shielding might be a better solution than increasing the wall thickness.

The second construction sequence involves the construction of the Stabilization Facility adjacent to the exhaust plenum. Excavation could remove all of the soil surrounding the exterior wall. Again, the minimum wall thickness is 42 inches, so that the 54 inch exterior wall is more than adequate.

5.2.6 Conversion

Conversion of Alternative 2A from refrigerated air cooling of unstabilized fuel to passive dry storage will be accomplished after stabilization of all the MCOs is complete. Water will be removed from the interior of the storage tubes as the MCOs are removed for stabilization and the MCOs containing dry stabilized fuel will be installed in the dry tubes upon return from the Stabilization Facility. When all of the fuel has been stabilized and higher fuel and vault temperatures can be tolerated, blinds in the air intake plenums and stack would be removed, air refrigeration equipment would be shut down and isolated if necessary, allowing natural circulation cooling to be established.

There do not appear to be any feasibility issues associated with the conversion from refrigerated air cooling to passive dry storage for this concept.