Conceptual Design Report

NUCLEAR MATERIALS STORAGE FACILITY RENOVATION

Part III - Supplemental Information

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**Los Alamos
National Laboratory
July 14, 1995**

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CONCEPTUAL DESIGN REPORT

LA-UR96-1

FOR

LINE ITEM PROJECT

NUCLEAR MATERIALS STORAGE FACILITY RENOVATION

AT THE

LOS ALAMOS NATIONAL LABORATORY

Project Identification Number 11818
Technical Area 55
Building PF-41

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DESIGN/BUILD ACQUISITION STRATEGY

A.	TEC AND TPC SUMMARIES	A
B.	CONTINGENCY ANALYSIS	B
C.	ESCALATION ANALYSIS	C
D.	LABORATORY PROCUREMENT BURDEN	D
E.	OTHER PROJECT COSTS	
F.	FIELD OVERHEAD AND EXPENSES	F
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SUPPORTING INFORMATION

PART III A. RENEWABLE ENERGY SYSTEMS ANALYSIS

LIFE CYCLE COST ANALYSIS

LIFE CYCLE COST ANALYSIS FOR NMSF

Three different design alternatives were analyzed to determine the most economically feasible mechanical system to use. The Trace 600 program was used to determine the energy consumption for each alternate. The NIST BLCC program was used to determine the life cycle cost for each alternate. The results from the Trace 600/NIST BLCC programs were used to select alternate #1 as the basis for the design. The initial capital costs and the total life cycle project cost for alternate #3 was higher than either of the two other alternates. Therefore, alternative #3 was eliminated.

The initial capital costs for alternative #1 were slightly higher than alternate #2, however, the total life cycle project cost was lower for alternate #1. Alternate #1 was selected on the basis of a lower total life cycle cost.

Alternate #1

Description:	Air cooled chiller with hot water preheat and terminal heat
Initial capital cost:	\$406,184
Total life cycle project cost:	\$1,326,124

Alternate #2

Description:	Air cooled chiller with hot water preheat and electric terminal heat
Initial capital costs:	\$367,249
Total life cycle project cost:	\$1,362,990

Alternate #3

Description:	Water cooled chiller with hot water preheat and terminal heat
Initial capital costs:	\$434,469
Total life cycle project cost:	\$1,406,520

 * N I S T B L C C - D E T A I L E D L C C A N A L Y S I S (version 4.20-95)*

PART I - INITIAL ASSUMPTIONS AND COST DATA

Project alternative: NMSF-ALT#1
 Run date: 05-02-1995 15:37:19
 Run type: Federal Analysis--Energy Conservation Projects
 Comment: AIR COOLED WITH HOT WATER TERMINAL ZONE HEATING
 Input data file: NMSFALT1.DAT, last modified: 05-02-1995/15:37:05
 LCC output file: NMSFALT1.LCC, created: 05-02-1995/15:37:10
 Base Date of Study: MAY 1995
 Service Date: AUG 1999
 Study period: 20.00 years (MAY 1995 through APR 2015)
 Plan/constr. period: 4.25 years (MAY 1995 through JUL 1999)
 Service Period: 15.75 years (AUG 1999 through APR 2015)
 Discount rate: 4.6% Real (exclusive of general inflation)
 End-of-year discounting convention

INITIAL CAPITAL ASSET COSTS (NOT DISCOUNTED)
 (ADJUSTED FOR PRICE CHANGES DURING PLAN/CONST. PERIOD, IF ANY)

	YEAR (Beginning)	Cost Phasing	Yearly Cost	Total Cost
	MAY 1995	100.0%	\$406,184	
AT SERVICE DATE:	AUG 2000	0.0%	\$0	
TOTAL INITIAL CAPITAL ASSET COSTS				\$406,184

ENERGY-RELATED COSTS

Energy Type	Units	Units/ Year	Price+ (\$/Unit)	Annual Cost Energy	Annual Cost Demand	Total P.V. Cost
Electricity	kWh	1,333,282	\$0.070	\$93,330	\$0	\$865,527
Natural Gas	Therm	10,265	\$0.366	\$3,757	\$0	\$44,568

+Price and annual cost are as of base date (not adjusted for price escalation).

PART II - LIFE-CYCLE COST ANALYSIS
 Discount Rate = 4.6% Real (exclusive of general inflation)

PROJECT ALTERNATIVE: NMSF-ALT#1 RUN DATE: 05-02-1995/15:37:19

	PRESENT VALUE (1995 DOLLARS)	ANNUAL VALUE (1995 DOLLARS)
CASH REQUIREMENTS AS OF SERVICE DATE:		
DURING CONSTRUCTION	\$406,184	\$31,497
AT SERVICE DATE	\$0	\$0
SUBTOTAL	\$406,184	\$31,497
OPERATING, MAINTENANCE & REPAIR COSTS:		
ANNUALLY RECURRING COSTS (NON-ENERGY)	\$9,845	\$763
SUBTOTAL	\$9,845	\$763
ENERGY COSTS	\$910,095	\$70,572
RESALE VALUE OF ORIG CAPITAL COMPONENTS	\$0	\$0
REPLACEMENT VALUE OF CAPITAL REPLACEMENTS	\$0	\$0
TOTAL LIFE-CYCLE PROJECT COST	\$1,326,124	\$102,833

PART III - EMISSIONS SUMMARY \a

PART I - INITIAL ASSUMPTIONS AND COST DATA

Project alternative: NMSF-ALT#2
 Run date: 05-02-1995 15:39:58
 Run type: Federal Analysis--Energy Conservation Projects
 Comment: AIR COOLED WITH ELECTRIC TERMINAL ZONE HEATING
 Input data file: NMSFALT2.DAT, last modified: 05-02-1995/15:39:44
 LCC output file: NMSFALT2.LCC, created: 05-02-1995/15:39:48
 Base Date of Study: MAY 1995
 Service Date: AUG 1999
 Study period: 20.00 years (MAY 1995 through APR 2015)
 Plan/constr. period: 4.25 years (MAY 1995 through JUL 1999)
 Service Period: 15.75 years (AUG 1999 through APR 2015)
 Discount rate: 4.6% Real (exclusive of general inflation)
 End-of-year discounting convention

INITIAL CAPITAL ASSET COSTS (NOT DISCOUNTED)
 (ADJUSTED FOR PRICE CHANGES DURING PLAN/CONST. PERIOD, IF ANY)

	YEAR (Beginning)	Cost Phasing	Yearly Cost	Total Cost
	MAY 1995	100.0%	\$367,249	
AT SERVICE DATE:	AUG 2000	0.0%	\$0	
TOTAL INITIAL CAPITAL ASSET COSTS				\$367,249

ENERGY-RELATED COSTS

Energy Type	Units	Units/ Year	Price+ (\$/Unit)	Annual Cost Energy	Annual Cost Demand	Total P.V. Cost
Electricity	kWh	1,456,796	\$0.070	\$101,976	\$0	\$945,708
Natural Gas	Therm	10,138	\$0.366	\$3,711	\$0	\$44,017

+Price and annual cost are as of base date (not adjusted for price escalation).

PART II - LIFE-CYCLE COST ANALYSIS
 Discount Rate = 4.6% Real (exclusive of general inflation)

PROJECT ALTERNATIVE: NMSF-ALT#2 RUN DATE: 05-02-1995/15:39:58

	PRESENT VALUE (1995 DOLLARS)	ANNUAL VALUE (1995 DOLLARS)
CASH REQUIREMENTS AS OF SERVICE DATE:		
DURING CONSTRUCTION	\$367,249	\$28,478
AT SERVICE DATE	\$0	\$0
SUBTOTAL	\$367,249	\$28,478
OPERATING, MAINTENANCE & REPAIR COSTS:		
ANNUALLY RECURRING COSTS (NON-ENERGY)	\$6,016	\$467
SUBTOTAL	\$6,016	\$467
ENERGY COSTS	\$989,725	\$76,747
RESALE VALUE OF ORIG CAPITAL COMPONENTS	\$0	\$0
REPLACEMENT VALUE OF CAPITAL REPLACEMENTS	\$0	\$0
TOTAL LIFE-CYCLE PROJECT COST	\$1,362,990	\$105,691

PART III - EMISSIONS SUMMARY \a

PART I - INITIAL ASSUMPTIONS AND COST DATA

Project alternative: NMSF-ALT#3
 Run date: 05-02-1995 15:43:24
 Run type: Federal Analysis--Energy Conservation Projects
 Comment: WATER COOLED WITH HOT WATER TERMINAL ZONE HEAT
 Input data file: NMSFALT3.DAT, last modified: 05-02-1995/15:43:11
 LCC output file: NMSFALT3.LCC, created: 05-02-1995/15:43:16
 Base Date of Study: MAY 1995
 Service Date: AUG 1999
 Study period: 20.00 years (MAY 1995 through APR 2015)
 Plan/constr. period: 4.25 years (MAY 1995 through JUL 1999)
 Service Period: 15.75 years (AUG 1999 through APR 2015)
 Discount rate: 4.6% Real (exclusive of general inflation)
 End-of-year discounting convention

INITIAL CAPITAL ASSET COSTS (NOT DISCOUNTED)
 (ADJUSTED FOR PRICE CHANGES DURING PLAN/CONST. PERIOD, IF ANY)

	YEAR (Beginning)	Cost Phasing	Yearly Cost	Total Cost
	MAY 1995	100.0%	\$434,469	
AT SERVICE DATE:	AUG 2000	0.0%	\$0	
TOTAL INITIAL CAPITAL ASSET COSTS				\$434,469

ENERGY-RELATED COSTS

Energy Type	Units	Units/ Year	Price+ (\$/Unit)	Annual Cost Energy	Annual Cost Demand	Total P.V. Cost
Electricity	kWh	1,298,907	\$0.070	\$90,923	\$0	\$843,211
Natural Gas	Therm	10,265	\$0.366	\$3,757	\$0	\$44,568

+Price and annual cost are as of base date (not adjusted for price escalation).

PART II - LIFE-CYCLE COST ANALYSIS
 Discount Rate = 4.6% Real (exclusive of general inflation)

PROJECT ALTERNATIVE: NMSF-ALT#3

RUN DATE: 05-02-1995/15:43:24

	PRESENT VALUE (1995 DOLLARS)	ANNUAL VALUE (1995 DOLLARS)
CASH REQUIREMENTS AS OF SERVICE DATE:		
DURING CONSTRUCTION	\$434,469	\$33,690
AT SERVICE DATE	\$0	\$0
SUBTOTAL	\$434,469	\$33,690
OPERATING, MAINTENANCE & REPAIR COSTS:		
ANNUALLY RECURRING COSTS (NON-ENERGY)	\$15,314	\$1,188
SUBTOTAL	\$15,314	\$1,188
ENERGY COSTS	\$887,780	\$68,842
WATER COSTS	\$68,957	\$5,347
SALE VALUE OF ORIG CAPITAL COMPONENTS	\$0	\$0
RESALE VALUE OF CAPITAL REPLACEMENTS	\$0	\$0
TOTAL LIFE-CYCLE PROJECT COST	\$1,406,520	\$109,067

ENERGY CONSUMPTION

MONTHLY ENERGY CONSUMPTION - ALTERNATIVE 1

----- MONTHLY ENERGY CONSUMPTION -----

Month	ELEC On Peak (kWh)	DEMAND On Peak (kW)	GAS On Peak (Therm)	GAS DMND On Peak (Thrm/hr)
Jan	105,190	150	1,113	2
Feb	96,574	154	963	2
March	112,383	160	968	1
April	109,644	162	903	1
May	117,172	171	682	1
June	115,840	177	542	1
July	119,307	176	580	1
Aug	118,289	172	681	1
Sept	112,767	167	736	1
Oct	113,935	161	966	1
Nov	106,270	157	1,006	1
Dec	105,910	152	1,124	2
Total	1,333,282	177	10,265	2

Building Energy Consumption = 181,958 (Btu/Sq Ft/Year)
Source Energy Consumption = 480,698 (Btu/Sq Ft/Year)

Floor Area = 30,650 (Sq Ft)

EQUIPMENT ENERGY CONSUMPTION - ALTERNATIVE 1

----- EQUIPMENT ENERGY CONSUMPTION -----														
Ref	Equip	Monthly Consumption												Total
Num	Code	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	
0	LIGHTS ELEC PK	56715 76.2	51227 76.2	56715 76.2	54886 76.2	56715 76.2	54886 76.2	56715 76.2	56715 76.2	54886 76.2	56715 76.2	54886 76.2	56715 76.2	667,775 76.2
1	MISC LD ELEC PK	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
2	MISC LD GAS PK	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
3	MISC LD OIL PK	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
4	MISC LD P STEAM PK	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
5	MISC LD P HOTH2O PK	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
6	MISC LD P CHILL PK	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
	EQ1139 ELEC PK	14619 27.9	AIR COOLED SCROLL CHILLER				27096 51.1	27661 49.2	26719 45.6	24428 41.3	22730 36.6	18358 33.6	15312 30.0	260,150 51.1
1	EQ5205 ELEC PK	687 1.5	CONDENSER FANS				2744 6.0	2731 5.9	2334 5.7	1809 5.4	1321 3.3	928 2.3	714 1.6	18,575 6.0
1	EQ5001 ELEC PK	5548 7.5	CHILLED WATER PUMP - CONSTANT VOLUME				5548 7.5	5548 7.5	5548 7.5	5369 7.5	5548 7.5	5369 7.5	5548 7.5	65,324 7.5
1	EQ5309 ELEC PK	744 1.0	CONTROLS				720 1.0	744 1.0	744 1.0	720 1.0	744 1.0	720 1.0	744 1.0	8,760 1.0

EQUIPMENT ENERGY CONSUMPTION - ALTERNATIVE 1

----- EQUIPMENT ENERGY CONSUMPTION -----													
Ref	Equip	Monthly Consumption											
Num	Code	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1	EQ4280	AIR FOIL FAN W/VARIABLE SPEED DRIVE											
	ELEC	482	435	482	466	482	466	482	482	466	482	466	482
	PK	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
1	EQ4280	AIR FOIL FAN W/VARIABLE SPEED DRIVE											
	ELEC	24176	21836	24176	23396	24176	23396	24176	24176	23396	24176	23396	24176
	PK	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5
1	EQ4280	AIR FOIL FAN W/VARIABLE SPEED DRIVE											
	ELEC	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1		USED FOR CEC TESTING ONLY											
	GAS	995	856	850	789	564	428	461	563	622	848	891	1006
	PK	1.4	1.4	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.4
1		USED FOR CEC TESTING ONLY											
	ELEC	2219	2004	2219	2100	1572	1163	1250	1572	1694	2219	2148	2219
	PK	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
1	CECHTGL	USED FOR CEC TESTING ONLY											
	GAS	118	107	118	114	118	114	118	118	114	118	114	118
	PK	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

284,647
32.5

8,874
1.4

22,380
3.0

1,391
0.2

UTILITY PEAK CHECKSUMS - ALTERNATIVE 1

----- UTILITY PEAK CHECKSUMS -----

Utility ELECTRIC DEMAND

Peak Value 177.5 (kW)
Yearly Time of Peak 16 (hr) 6 (mo)

Hour 16 Month 6

Eqp. Ref. Num.	Equipment Code Name	Equipment Description	Utility Demand (kW)	Percent Of Tot (%)
Cooling Equipment				
1	EQ1139	AIR COOLED SCROLL CHILLER	65.1	36.70
Sub Total			65.1	36.70
Heating Equipment				
1		USED FOR CEC TESTING ONLY	3.0	1.68
Sub Total			3.0	1.68
Air Moving Equipment				
1		SUMMATION OF FAN ELECTRICAL DEMAND	33.1	18.67
Sub Total			33.1	18.67
Sub Total			0.0	0.00
, ellaneous				
Lights			76.2	42.95
Base Utilities			0.0	0.00
Misc Equipment			0.0	0.00
Sub Total			76.2	42.95
Grand Total			177.5	100.00

CALIFORNIA TITLE 24 COMPLIANCE - ALTERNATIVE 1

----- CALIFORNIA TITLE 24 COMPLIANCE REPORT -----

Weather Name LAWTR1
Gross Conditioned Floor Area (sqft)..... 30,650
ACM Multiplier 1.025

----- ENERGY USE SUMMARY -----

	ELEC (kWh/yr)	GAS (kBtu/yr)	PERCENT OF TOTAL ENERGY (%)	TOTAL SOURCE ENERGY (kBtu/yr)	ADJUSTED UNIT SOURCE ENERGY (kBtu/yr-sf)
Primary Heating	0.0	1,026,522.2	18.4	1,080,549.6	36.1
Primary Cooling					
Compressor	260,149.8	0.0	15.9	2,663,940.0	89.1
Tower/Cond Fans	18,575.4	0.0	1.1	190,212.4	6.4
Condenser Pump	0.0	0.0	0.0	0.0	0.0
Other Accessories	8,760.0	0.0	0.5	89,702.6	3.0
Auxiliary					
Supply Fans	290,318.8	0.0	17.8	2,972,871.3	99.4
Circulation Pumps	87,703.5	0.0	5.4	898,086.3	30.0
Base Utilities	0.0	0.0	0.0	0.0	0.0
Subtotal	378,022.3	0.0	23.1	3,870,957.5	129.5
Lighting	667,775.2	0.0	40.9	6,838,034.5	223.1
Receptacle	0.0	0.0	0.0	0.0	0.0
Domestic Hot Water	0.0	0.0	0.0	0.0	0.0
Cogeneration	0.0	0.0	0.0	0.0	0.0
Totals	1,333,282.7	1,026,522.2	100.0	14,733,397.0	487.1

MONTHLY ENERGY CONSUMPTION - ALTERNATIVE 2

----- MONTHLY ENERGY CONSUMPTION -----

Month	ELEC On Peak (kWh)	DEMAND On Peak (kW)	GAS On Peak (Therm)	GAS DMND On Peak (Thrm/hr)
Jan	119,999	166	1,089	2
Feb	108,943	169	941	2
March	123,762	176	944	1
April	120,045	178	880	1
May	124,333	185	664	1
June	121,709	192	552	1
July	126,125	190	625	1
Aug	125,421	187	663	1
Sept	121,308	183	754	1
Oct	125,266	177	942	1
Nov	118,905	171	982	1
Dec	120,979	169	1,100	2
Total	1,456,796	192	10,138	2

Building Energy Consumption = 195,298 (Btu/Sq Ft/Year)
Source Energy Consumption = 521,527 (Btu/Sq Ft/Year)

Floor Area = 30,650 (Sq Ft)

EQUIPMENT ENERGY CONSUMPTION

Ref Num	Equip Code	Monthly Consumption												Total
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	
0	LIGHTS ELEC PK	56715 76.2	51227 76.2	56715 76.2	54886 76.2	56715 76.2	54886 76.2	56715 76.2	56715 76.2	54886 76.2	56715 76.2	54886 76.2	56715 76.2	667,775 76.2
1	MISC LD ELEC PK	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
2	MISC LD GAS PK	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
3	MISC LD OIL PK	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
4	MISC LD P STEAM PK	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
5	MISC LD P HOTH2O PK	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
6	MISC LD P CHILL PK	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
	EQ1139 ELEC PK	14619 27.9	AIR COOLED SCROLL CHILLER 14692 31.9	21308 36.2	21438 37.4	25789 44.6	27096 51.1	27661 49.2	26719 45.6	24428 41.3	22730 36.6	18358 33.6	15312 30.0	260,150 51.1
1	EQ5205 ELEC PK	687 1.5	CONDENSER FANS 697 1.8	1191 3.1	1271 3.7	2146 5.6	2744 6.0	2731 5.9	2334 5.7	1809 5.4	1321 3.3	928 2.3	714 1.6	18,575 6.0
1	EQ5001 ELEC PK	5548 7.5	CHILLED WATER PUMP - 5011 7.5	5548 7.5	5369 7.5	5548 7.5	5369 7.5	5548 7.5	5548 7.5	5369 7.5	5548 7.5	5369 7.5	5548 7.5	65,324 7.5
1	EQ5309 ELEC PK	744 1.0	CONTROLS 672 1.0	744 1.0	720 1.0	744 1.0	720 1.0	744 1.0	744 1.0	720 1.0	744 1.0	720 1.0	744 1.0	8,760 1.0

EQUIPMENT ENERGY CONSUMPTION

[illegible]

UTILITY PEAK CHECKSUMS - ALTERNATIVE 2

----- UTILITY PEAK CHECKSUMS -----

Utility ELECTRIC DEMAND

Peak Value 192.3 (kW)
Yearly Time of Peak 14 (hr) 6 (mo)

Hour 14 Month 6

Eqp. Ref. Num.	Equipment Code Name	Equipment Description	Utility Demand (kW)	Percnt Of Tot (%)
----------------------	------------------------	-----------------------	---------------------------	-------------------------

Cooling Equipment

1	EQ1139	AIR COOLED SCROLL CHILLER	64.7	33.63
Sub Total			64.7	33.63

Heating Equipment

1		USED FOR CEC TESTING ONLY	3.0	1.55
2	EQ2262	ELECTRIC RESISTANCE HEAT	15.3	7.93
Sub Total			18.2	9.49

Air Moving Equipment

1		SUMMATION OF FAN ELECTRICAL DEMAND	33.1	17.24
Sub Total			33.1	17.24
Total			0.0	0.00

Miscellaneous

Lights		76.2	39.65
Base Utilities		0.0	0.00
Misc Equipment		0.0	0.00
Sub Total		76.2	39.65
Grand Total		192.3	100.00

CALIFORNIA TITLE 24 COMPLIANCE - ALTERNATIVE 2

CALIFORNIA TITLE 24 COMPLIANCE REPORT

Weather Name LAWTR1
Gross Conditioned Floor Area (sqft)..... 30,650
ACH Multiplier 1.025

ENERGY USE SUMMARY

	ELEC (kWh/yr)	GAS (kBtu/yr)	PERCENT OF TOTAL ENERGY (%)	TOTAL SOURCE ENERGY (kBtu/yr)	ADJUSTED UNIT SOURCE ENERGY (kBtu/yr-sf)
Primary Heating	123,057.4	1,013,835.7	24.0	2,327,306.5	77.8
Primary Cooling					
Compressor	260,149.8	0.0	14.8	2,663,940.0	89.1
Tower/Cond Fans	18,575.4	0.0	1.1	190,212.4	6.4
Condenser Pump	0.0	0.0	0.0	0.0	0.0
Other Accessories	8,760.0	0.0	0.5	89,702.6	3.0
Auxiliary					
Supply Fans	290,318.8	0.0	16.6	2,972,871.3	99.4
Circulation Pumps	88,159.9	0.0	5.0	902,759.4	30.2
Base Utilities	0.0	0.0	0.0	0.0	0.0
Subtotal	378,478.7	0.0	21.6	3,875,630.8	129.6
Lighting	667,775.2	0.0	38.1	6,838,034.5	223.1
Receptacle	0.0	0.0	0.0	0.0	0.0
Domestic Hot Water	0.0	0.0	0.0	0.0	0.0
Cogeneration	0.0	0.0	0.0	0.0	0.0
Totals	1,456,796.5	1,013,835.7	100.0	15,984,826.0	529.0

MONTHLY ENERGY CONSUMPTION - ALTERNATIVE 3

----- MONTHLY ENERGY CONSUMPTION -----

Month	ELEC On Peak (kWh)	DEMAND On Peak (kW)	GAS On Peak (Therm)	WATER (1000 GL)	GAS DMND On Peak (Thrm/hr)
Jan	107,422	147	1,113	80	2
Feb	97,596	149	963	76	2
March	109,989	152	968	97	1
April	106,754	152	903	96	1
May	111,465	156	682	111	1
June	108,930	158	542	115	1
July	112,860	159	580	119	1
Aug	112,373	157	681	115	1
Sept	107,751	155	736	105	1
Oct	110,515	152	966	100	1
Nov	105,556	150	1,006	88	1
Dec	107,695	148	1,124	82	2
Total	1,298,907	159	10,265	1,182	2

Building Energy Consumption = 178,130 (Btu/Sq Ft/Year)
Source Energy Consumption = 469,213 (Btu/Sq Ft/Year)

Floor Area = 30,650 (Sq Ft)

EQUIPMENT ENERGY CONSUMPTION

Ref Num	Equip Code	Monthly Consumption												Total
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	
0	LIGHTS ELEC PK	56715 76.2	51227 76.2	56715 76.2	54886 76.2	56715 76.2	54886 76.2	56715 76.2	56715 76.2	54886 76.2	56715 76.2	54886 76.2	56715 76.2	667,775 76.2
1	MISC LD ELEC PK	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
2	MISC LD GAS PK	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
3	MISC LD OIL PK	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
4	MISC LD P STEAM PK	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
5	MISC LD P HOTH2O PK	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
6	MISC LD P CHILL PK	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
	EQ1130L ELEC PK	16130 24.4	15068 25.7	18402 28.2	18136 29.0	20371 31.7	20983 34.4	21877 34.8	21126 33.4	19430 31.1	18898 28.5	17015 26.7	16368 25.1	223,804 34.8
1	EQ5101 ELEC PK	2078 3.2	1948 3.3	2373 3.5	2330 3.5	2528 4.0	2595 4.0	2739 4.0	2680 4.0	2439 4.0	2403 3.4	2205 3.4	2113 3.2	28,430 4.0
1	EQ5101 WATER PK	80 0.1	76 0.1	97 0.2	96 0.2	111 0.2	115 0.2	119 0.2	115 0.2	105 0.2	100 0.2	88 0.1	82 0.1	1,182 0.2
1	EQ5011 ELEC PK	5548 7.5	5011 7.5	5548 7.5	5369 7.5	5548 7.5	5369 7.5	5548 7.5	5548 7.5	5369 7.5	5548 7.5	5369 7.5	5548 7.5	65,324 7.5

EQUIPMENT ENERGY CONSUMPTION

[illegible]

UTILITY PEAK CHECKSUMS - ALTERNATIVE 3

----- UTILITY PEAK CHECKSUMS -----

Utility ELECTRIC DEMAND

Peak Value 158.6 (kW)
Yearly Time of Peak 15 (hr) 7 (mo)

Hour 15 Month 7

Eqp. Ref. Num.	Equipment Code Name	Equipment Description	Utility Demand (kW)	Perct Of Tot (%)
Cooling Equipment				
1	EQ1130L	WTR-CLD CONDENSER COMPRESSOR > 30 TONS	46.3	29.17
Sub Total			46.3	29.17
Heating Equipment				
1		USED FOR CEC TESTING ONLY	3.0	1.88
Sub Total			3.0	1.88
Air Moving Equipment				
1		SUMMATION OF FAN ELECTRICAL DEMAND	33.1	20.89
Sub Total			33.1	20.89
Sub Total			0.0	0.00
Miscellaneous				
	Lights		76.2	48.06
	Base Utilities		0.0	0.00
	Misc Equipment		0.0	0.00
Sub Total			76.2	48.06
Grand Total			158.6	100.00

CALIFORNIA TITLE 24 COMPLIANCE - ALTERNATIVE 3

CALIFORNIA TITLE 24 COMPLIANCE REPORT

Weather Name LAWTR1
Gross Conditioned Floor Area (sqft)..... 30,650
ACM Multiplier 1.025

ENERGY USE SUMMARY

	ELEC (kWh/yr)	GAS (kBtu/yr)	WATER (1000 gal)	PERCENT OF TOTAL ENERGY (%)	TOTAL SOURCE ENERGY (kBtu/yr)	ADJUSTED UNIT SOURCE ENERGY (kBtu/yr-sf)
Primary Heating	0.0	1,026,522.2	0.0	18.8	1,080,549.6	36.1
Primary Cooling						
Compressor	223,804.1	0.0	0.0	14.0	2,291,759.3	76.6
Tower/Cond Fans	28,430.2	0.0	1,182.1	1.8	291,125.7	9.7
Condenser Pump	65,323.5	0.0	0.0	4.1	668,914.3	22.4
Other Accessories	876.0	0.0	0.0	0.1	8,970.3	0.3
Auxiliary						
Supply Fans	290,318.8	0.0	0.0	18.1	2,972,871.3	99.4
Circulation Pumps	22,380.0	0.0	0.0	1.4	229,171.9	7.7
Base Utilities	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	312,698.8	0.0	0.0	19.5	3,202,043.2	107.1
Lighting	667,775.2	0.0	0.0	41.7	6,838,034.5	223.1
Receptacle	0.0	0.0	0.0	0.0	0.0	0.0
Domestic Hot Water	0.0	0.0	0.0	0.0	0.0	0.0
Cogeneration	0.0	0.0	0.0	0.0	0.0	0.0
Totals	1,298,907.9	1,026,522.2	1,182.1	100.0	14,381,397.0	475.4

ASSUMPTIONS FOR MAINTENANCE COSTS

ENVIRONMENT & ENERGY GROUP

JOB NO. 41552-056

SHEET

OF

ASSUMPTIONS FOR MAINTENANCE COSTS FOR AIT#1
(AIR COOLED W/ HOT WATER ZONE-
TERMINAL HEATING)

DESIGNED BY CLODATE 5/2/95

CHECKED BY TT

DATE 5/24/95

1. INSPECT AND MAINTAIN AIR COOLED CHILLER EVERY SIX MONTHS
(INSPECTION AND MAINTENANCE TAKES 8 HOURS EVERY SIX MONTHS AT \$30⁰⁰/HR)

$$= (8 \text{ Hz})(2/\text{yr})(30^\circ/\text{Hz}) =$$

$$= \$480/\text{yr}$$

2. MATERIAL COSTS FOR CHILLER (CHANGE OIL & PAINT EXTERIOR PIPING).

$$= 120^{\circ}\text{C}/\text{YR}$$

3. INSPECT AND MAINTAIN BOILER EVERY SIX MONTHS.
(INSPECTION AND MAINTENANCE TAKES 2HRS EVERY
SIX MONTHS AT \$ 30⁰⁰/HR)

$$= (2 + 12) (2 / 42) (30^\circ / 12) = 120^\circ / 42$$

4. INSPECTION OF COILS AND CONTROL VALVES.
(12 HRS 1/YR @ \$30/Hr.)

$$(12 \text{ Hz}) (1/4 \text{ Hz}) (3000 \text{ Hz}) = 3600^\circ$$

5. TOTAL MAINTENANCE COSTS/YR

$$\begin{array}{r} \$480.00 \\ + 120.00 \\ + 120.00 \\ + 360.00 \\ \hline \end{array}$$

\$ 1080.00

SHEET 2 OF

CHECKED BY JT DATE 5/24/95

- \$430/YR

- $\$120^{\infty}/YR$

- \$160⁰⁰/YR

- \$660.00

National Brand

EQUIPMENT COSTS FOR ALTERNATES

[Items with '#' have been adjusted by Job Factor and/or Equip Factor]

Item	Work Brkdw Structure 1	J A		Take-Off Item Description	Quantity Unit	L a b o r		Material Rate Ext'd Cost	Const Equip Rate Ext'd Cost	Sub Cntrct Cost	Item Direct Cost
		Trd b ID F	o c t Tag			Factor	Rate Ext'd Cost				
815.	C3A09	61	0 2	EXTERIOR INSULATED FINISH SYSTEM	2000.0 SF	0.163	21.92 7146.	1.53 3060.	0.15 300.	0.	10506.
	C3A09			Category Direct Cost			11943.	6758.	300.	546000.	565002.
799	C3A10			SPECIALITIES							
801	C3A10	73	0 5	SIGNAGE ALLOWANCE	1.0 LOT	1.000	7000.00 7000.	2000.00 2000.	0.00 0.	0.	9000.
802	C3A10	73	0 5	METAL LOCKERS	36.0 EA	0.400	23.70 341.	70.00 2520.	0.00 0.	0.	2861.
803	C3A10	73	0 5	BENCH, LOCKER	20.0 LF	0.090	23.70 43.	20.00 400.	0.00 0.	0.	443.
804	C3A10	73	0 5	RESTROOM ACCESSORY	3.0 EA	1.500	23.70 107.	275.00 825.	0.00 0.	0.	932.
894	C3A10		0 0	TOILET COMPARTMENTS	5.0 EA	4.200	23.70 498.	365.00 1825.	0.00 0.	0.	2323.
	C3A10			Category Direct Cost			7988.	7570.	0.	0.	15558.
14	C3A15			MECHANICAL							
15	C3A15	89	0 0	OUTSIDE AIR FAN (FS-1, FS-2) 3500CFM 7-1/2 HP	2.0 EA	14.000	30.82 863.	5075.00 10150.	0.00 0.	0.	11013.
16	C3A15	89	0 2	RESTROOM EXHAUST FAN (600 CFM)	3.0 EA	4.000	30.82 370.	268.00 804.	0.00 0.	0.	1174.
17	C3A15	89	0 2	OUTSIDE AIR LOUVERS	10.0 SF	0.300	30.82 92.	37.25 373.	0.00 0.	0.	465.

ALT # 1 = \$12,187
 ALT # 2 = \$12,187
 ALT # 3 = \$12,187

[Items with '#' have been adjusted by Job Factor and/or Equip Factor]

Item	Work Brkdw Structure 1	J Trd ID	A o b F	c c t Tag	Take-Off Item Description	Quantity Unit	L a b o r			Material Rate Ext'd Cost	Const Equip Rate Ext'd Cost	Sub Cntrct Cost	Item Direct Cost
							Factor	Rate	Ext'd Cost				
18	C3A15	89	0	2	AIR HANDLING UNIT (2500 CFM)	1.0 EA	30.000	30.82	925.	4500.00 4500.	0.00 0.	0.	5425. —
19	C3A15	89	0	2	18 X 18 SUPPLY DIFFUSER	38.0 EA	1.000	30.82	1171.	105.00 3990.	0.00 0.	0.	5161.
20	C3A15	89	0	2	24 X 24 SUPPLY DIFFUSER	16.0 EA	1.500	30.82	740.	167.00 2672.	0.00 0.	0.	3412.
21	C3A15	89	0	0	12 X 12 SUPPLY DIFFUSER	4.0 EA	1.000	30.82	123.	57.00 228.	0.00 0.	0.	351.
22	C3A15	89	0	2	24 X 24 EXHAUST GRILL	8.0 EA	0.500	30.82	123.	67.00 536.	0.00 0.	0.	659.
23	C3A15	89	0	2	RECIRC FANS (FR-1, FR-2 19,400 CFM, 40 HP)	2.0 EA	24.000	30.82	1479.	18000.00 36000.	0.00 0.	0.	37479. —
24	C3A15	89	0	2	24 X 24 RETURN GRILL	26.0 EA	0.600	30.82	481.	39.00 1014.	0.00 0.	0.	1495.
25	C3A15	89	0	2	FANS (FE-4, FS-3, 3H P, 1994)	2.0 EA	10.000	30.82	616.	3150.00 6300.	0.00 0.	0.	6916. —
26	C3A15	89	0	2	OPPOSED BLADE DAMPER 12 X 12	45.0 EA	0.500	30.82	693.	28.00 1260.	0.00 0.	0.	1953.
27	C3A15	89	0	2	DAMPER ACTUATOR 12 X 12	25.0 EA	0.800	30.82	616.	112.00 2800.	0.00 0.	0.	3416.
28	C3A15	89	0	2	GALVINIZED DUCTWORK + 5% FOR FITTINGS	23000.0 LBS	0.110	30.82	77975.	0.40 9200.	0.00 0.	0.	87175.
29	C3A15	89	0	2	STAINLESS DUCTWORK	2000.0 LBS	0.120	30.82	7397.	1.50 3000.	0.00 0.	0.	10397.
30	C3A15	89	0	2	TEST & BALANCE	245.0 EA	1.600	30.82	12081.	0.00 0.	0.00 0.	0.	12081. —

ALT#1 = \$ 61,901
 ALT#2 = \$ 61,901
 ALT#3 = \$ 61,901

[Items with '#' have been adjusted by Job Factor and/or Equip Factor]

Item	Work Brkdwn Structure 1	J o b ID	A c t Tag	Take-Off Item Description	Quantity Unit	L a b o r			Material		Const Equip		Sub Cntrct Cost	Item Direct Cost
						Factor	Rate	Ext'd Cost	Rate	Ext'd Cost	Rate	Ext'd Cost		
31	C3A15	69	0 2 3"	BLACK STEEL PIPE	770.0 LF	0.450	30.53	10579.	7.80	6006.	0.00	0.	0.	16585. —
32	C3A15	69	0 2 2"	BLACK STEEL PIPE	760.0 LF	0.400	30.53	9281.	3.75	2850.	0.00	0.	0.	12131. —
33	C3A15	69	0 2 1"	BLACK STEEL PIPE	30.0 LF	0.180	30.53	165.	2.00	60.	0.00	0.	0.	225. —
34	C3A15	69	0 0 3	WAY VALVES	1.0 LOT	7.000	30.53	214.	2035.00	2035.	0.00	0.	0.	2249. —
35	C3A15	89	0 2	EXHAUST FAN (FE-3, 3/4 HP, 480 CFM)	1.0 EA	7.000	30.82	216.	1950.00	1950.	0.00	0.	0.	2166. —
36	C3A15	69	0 2	CHILLED WATER COIL	2.0 EA	32.000	30.53	1954.	1845.00	3690.	0.00	0.	0.	5644. —
37	C3A15	69	0 2	PRE-HEAT COIL	1.0 EA	8.000	30.53	244.	530.00	530.	0.00	0.	0.	774. —
38	C3A15	69	0 0	TERMINAL HEATING COILS <i>ELC DUCT HTR</i>	28.0 EA	6.500	30.53	5556.	510.00	14280.	0.00	0.	0.	19836. — <i>32,368</i>
39	C3A15	69	0 2	MISC VALVES & FITTINGS FOR TERMINA L HEATING COILS	28.0 EA		0.00	0.	120.00	3360.	0.00	0.	0.	3360. —
68	C3A15		0 0	HEATING PIPE INSULATION	1.0 LOT	160.000	23.70	3792.	5000.00	5000.	0.00	0.	0.	8792. —
84	C3A15		0 0	BACKFLOW PREVENTER	2.0 EA	0.600	30.53	37.	150.00	300.	0.00	0.	0.	337. —
90	C3A15	69	0 2	EXHAUST FANS (FE-1, FE-2 3,417CFM 7-1/2 HP)	2.0 EA	14.000	30.53	855.	5075.00	10150.	0.00	0.	0.	11005. —

ALT # 1 = \$ 83,104
 ALT # 2 = \$ 83,484
 ALT # 3 = \$ 83,104

[Items with '#' have been adjusted by Job Factor and/or Equip Factor]

Item	Work Brkdwn Structure 1	J Trd ID	A o b F	C c t t	Cntrct Markup Tag	Take-Off Item Description	Quantity Unit	L a b o r			Material		Const Equip		Sub Cntrct Cost	Item Direct Cost
								Factor	Rate	Ext'd Cost	Rate	Ext'd Cost	Rate	Ext'd Cost		
92	C3A15	89	0	2	0	OUTSIDE/EXHAUST AIR 2X2 THREE STAGE PLENUM	4.0 EA	30.000	30.82	3698.	68640.00	274560.	0.00	0.	0.	278258.
93	C3A15	89	0	2	0	RETURN AIR PLUNUM 5X4 THREE STAGE PLEN UM	2.0 EA	86.000	30.82	5301.	189360.00	378720.	0.00	0.	0.	384021.
94	C3A15	89	0	2	0	HEPA FOR PACK/UNPACK AREA W/ ENCLOSURE	2.0 EA	8.000	30.82	493.	8330.00	16660.	0.00	0.	0.	17153.
796	C3A15	69	0	2	0	CHEMICAL FEEDER	2.0 EA	3.000	29.56	177.	300.00	600.	0.00	0.	0.	777. —
797	C3A15	69	0	2	0	3/4" 3-WAY VALVE FOR TERMINAL HEATING COI LS	30.0 EA	0.500	29.56	443.	119.00	3570.	0.00	0.	0.	4013. —
798	C3A15	69	0	2	0	1-1/2" 3-WAY VALVE	1.0 EA	0.740	29.56	22.	220.00	220.	0.00	0.	0.	242. —
809	C3A15	69	0	2	0	1" COPPER PIPES (INCLUDING FITTINGS)	1080.0 LF	0.160	30.53	5276.	2.56	2765.	0.00	0.	0.	8040. —
810	C3A15	69	0	2	0	3/4" COPPER PIPES (INCLUDING FITTINGS)	1540.0 LF	0.140	30.53	6582.	2.02	3111.	0.00	0.	0.	9693. —
811	C3A15	45	0	2	0	1/2" COPPER PIPES (INCLUDING FITTINGS)	570.0 LF	0.130	30.53	2262.	1.28	730.	0.00	0.	0.	2992. —
826	C3A15	69	0	2	0	3" BLACK STEEL	840.0 LF	0.480	30.53	12310.	9.15	7686.	0.00	0.	0.	19996. —
831	C3A15	69	0	2	0	1 1/2" COPPER PIPE (INCLUDING FITTINGS)	240.0 LF	0.200	30.53	1465.	4.03	967.	0.00	0.	0.	2433. —
						4" SANITARY SEWER CAST IRON PIPE	240.0 LF	0.330	30.53	2418.	5.10	1224.	0.00	0.	0.	3642.

ALT # 1 = \$ 48,186
 ALT # 2 = \$ 44,173
 ALT # 3 = \$ 48,186

[Items with '#' have been adjusted by Job Factor and/or Equip Factor]

Item	Work Brkdw Structure 1	J A		Take-Off Item Description	Quantity Unit	Labor			Material		Const Equip		Sub Cntrct Cost	Item Direct Cost
		Trd b	o c			Factor	Rate	Ext'd Cost	Rate	Ext'd Cost	Rate	Ext'd Cost		
832	C3A15	69	0	2 2" SANITARY SEWER CAST IRON PIPE	140.0 LF	0.320	30.53	1368.	4.13	578.	0.00	0.	0.	1946.
833	C3A15			PLUMBING FIXTURES										
834	C3A15	69	0	2 WALL HUNG FLUSH VA. WATER CLOSETS	5.0 EA	3.920	30.53	598.	705.00	3525.	0.00	0.	0.	4123.
836	C3A15	69	0	2 WALL HUNG LAVATORIES W/ FAUCET	4.5 EA	6.000	30.53	824.	220.00	990.	0.00	0.	0.	1814.
837	C3A15	69	0	2 JANITOR SINKS	2.0 EA	4.720	30.53	288.	465.00	930.	0.00	0.	0.	1218.
838	C3A15	69	0	2 SHOWER STALL 1 PIECE	5.0 EA	7.500	30.53	1145.	462.00	2310.	0.00	0.	0.	3455.
839	C3A15	69	0	2 HOSE BIBBS	2.0 EA	0.740	30.53	45.	125.00	250.	0.00	0.	0.	295.
845	C3A15		0	0 MONITORING WIRE	2000.0 LF		0.00	0.	7.00	14000.	0.00	0.	0.	14000.
846	C3A15		0	0 MONITORING PANEL	1.0 EA		0.00	0.	2500.00	2500.	0.00	0.	0.	2500.
848	C3A15		0	2 HVAC CONTROLS	1.0 LOT		0.00	0.	80000.00	80000.	0.00	0.	0.	80000.
920	C3A15			GAS PIPING IN BUILDING										
921	C3A15	69	0	2 2" BLACK STEEL PIPE	60.0 LF	0.250	30.53	458.	4.05	243.	0.00	0.	0.	701. —
922	C3A15	69	0	2 1-1/2" BLACK STEEL PIPE	80.0 LF	0.220	30.53	537.	3.05	244.	0.00	0.	0.	781. —
923	C3A15	69	0	2 1" BLACK STEEL PIPE	40.0 LF	0.200	30.53	244.	2.18	87.	0.00	0.	0.	331. —

ALT #1 = \$1,813

ALT #2 = \$1,813

ALT #3 = \$1,813

[Items with '#' have been adjusted by Job Factor and/or Equip Factor]

Item	Work Brkdwn Structure 1	J A		Take-Off Item Description	Quantity Unit	L a b o r			Material		Const Equip		Sub Cntrct Cost	Item Direct Cost
		Trd b ID F	c Markup t Tag			Factor	Rate	Ext'd Cost	Rate	Ext'd Cost	Rate	Ext'd Cost		
924	C3A15		0	2 MISC VALVES AND FITTINGS	1.0 LOT			0.00	200.00		0.00			
931	C3A15			HEATING HOT WATER PIPING										200. —
932	C3A15	69	0	2 3" COPPER PIPE TYPE	260.0 LF	0.300	30.53	7938.	10.70	2782.	0.00		0.	5163. —
933	C3A15	69	0	2 2" COPPER PIPE TYPE	120.0 LF	0.200	30.53	3664.	5.30	636.	0.00		0.	1369. —
934	C3A15	69	0	2 1" COPPER PIPE TYPE	360.0 LF	0.150	30.53	1099.	3.45	1242.	0.00		0.	2891. —
935	C3A15	69	0	2 3/4" COPPER PIPE TYPE	460.0 LF	0.120	30.53	1405.	1.57	722.	0.00		0.	2407. —
936	C3A15		0	2 MISC VALVES AND FITTINGS (10% OF TOTAL LAB. AND MAT. COST)	1.0 LOT			0.00	1200.00		0.00		0.	1200. —
937	C3A15			HEATING WATER PIPE INSULATION										
938	C3A15	81	0	2 3" FIBERGLASS INSULATION	260.0 LF	0.270	33.06	8596.	6.80	1768.	0.00		0.	4089. —
939	C3A15	81	0	2 2" FIBERGLASS INSULATION	120.0 LF	0.250	33.06	3967.	6.20	744.	0.00		0.	1736. —
940	C3A15	81	0	2 1" FIBERGLASS INSULATION	360.0 LF	0.230	33.06	1190.	5.75	2070.	0.00		0.	4807. —
941	C3A15	81	0	2 3/4" FIBERGLASS INSULATION	440.0 LF	0.210	33.06	1455.	5.25	2310.	0.00		0.	5365. —
942	C3A15			CHILLED WATER PIPING										
943	C3A15	69	0	2 4" COPPER PIPE TYPE	260.0 LF	0.420	30.53	7938.	17.10	4446.	0.00		0.	7780. —

ALT #1 = \$ 37,007
 ALT #2 = \$ 17,232
 ALT #3 = \$ 37,007

[Items with '#' have been adjusted by Job Factor and/or Equip Factor]

Item	Work Brkdw Structure 1	J Trd ID	A o b F	c c t t	Take-Off Item Description	Quantity Unit	L a b o r			Material		Const Equip		Sub Cntrct Cost	Item Direct Cost
							Factor	Rate	Ext'd Cost	Rate	Ext'd Cost	Rate	Ext'd Cost		
944	C3A15	69	0	2	3" COPPER PIPE TYPE	180.0	0.300	30.53	10.70	0.00	0.00	0.00	0.00	0.00	3575. —
					L	LF		1649.	1926.						
945	C3A15		0	2	MISC VALVES & FITTING	1.0		0.00	1150.00	0.00	0.00	0.00	0.00	0.00	1150. —
					GS (10% OF TOT. LAB & MAT)	LOT		0.	1150.						
946	C3A15	81	0	2	4" CHILLED WATER	260.0	0.333	33.06	11.05	0.00	0.00	0.00	0.00	0.00	5735. —
					PIPING INSULATION	LF		2862.	2873.						
947	C3A15	81	0	2	3" CHILLED WATER	180.0	0.286	33.06	8.20	0.00	0.00	0.00	0.00	0.00	3178. —
					PIPING INSULATION	LF		1702.	1476.						
951	C3A15				POTABLE HOT & COLD WATER PIPING										
952	C3A15	69	0	2	1-1/4" COPPER PIPE	380.0	0.140	30.53	2.86	0.00	0.00	0.00	0.00	0.00	2711.
					TYPE L	LF		1624.	1087.						
953	C3A15	69	0	2	1" COPPER PIPE TYPE	240.0	0.120	30.53	2.10	0.00	0.00	0.00	0.00	0.00	1383.
					L	LF		879.	504.						
954	C3A15	69	0	2	3/4" COPPER PIPE	60.0	0.110	30.53	1.57	0.00	0.00	0.00	0.00	0.00	296.
					TYPE L	LF		201.	94.						
955	C3A15	69	0	2	1/2" COPPER PIPE	140.0	0.100	30.53	1.31	0.00	0.00	0.00	0.00	0.00	611.
					TYPE L	LF		427.	183.						
956	C3A15		0	0	MISC VALVES & FITTING	1.0		0.00	500.00	0.00	0.00	0.00	0.00	0.00	500.
					GS (10% OF TOT. LAB. & MAT.)	LOT		0.	500.						
962	C3A15				SOIL WASTE AND VENT PIPING IN BLDG.										
963	C3A15	69	0	2	4" CAST IRON PIPE	240.0	0.280	30.53	7.85	0.00	0.00	0.00	0.00	0.00	3936.
					L	LF		2052.	1884.						
964	C3A15	69	0	2	3" CAST IRON PIPE	120.0	0.260	30.53	6.20	0.00	0.00	0.00	0.00	0.00	1697.
					L	LF		953.	744.						

ALT# 1 = \$ 13,638
 ALT# 2 = \$ 13,638
 ALT# 3 = \$ 13,638

[Items with '#' have been adjusted by Job Factor and/or Equip Factor]

Item	Work Brkdw Structure 1	J A			Quantity	L a b o r			Material		Const Equip		Sub Cntrct Cost	Item Direct Cost
		Trd b	c	Markup		Factor	Rate	Ext'd	Rate	Ext'd	Rate	Ext'd		
		ID F	t	Tag	Description	Unit		Cost		Cost		Cost		
965	C3A15	69	0	2	2" CAST IRON PIPE	100.0	0.240	30.53	4.70	0.00				
					LF			733.	470.	0.	0.			1203.
966	C3A15	69	0	2	1-1/2" CAST IRON PIP	140.0	0.230	30.53	4.69	0.00				
					E	LF		983.	657.	0.	0.			1640.
967	C3A15		0	2	MISC VALVES & FITTING	1.0		0.00	850.00	0.00				
					GS (10% OF TOT LAB. & MAT.)	LOT		0.	850.	0.	0.			850.
968	C3A15				DRAIN PIPING AND INSULATION									
969	C3A15				DRAIN PIPING AND INSULATION									
970	C3A15	69	0	2	3/4" COPPER PIPE	220.0	0.110	30.53	1.57	0.00				
					LF			739.	345.	0.	0.			1084. -
971	C3A15	81	0	2	3/4" INSULATION	220.0	0.089	33.06	2.24	0.00				
					LF			647.	493.	0.	0.			1140. -
976	C3A15				ROOF DRAINS & OVERFLOW PIPING FOR PENTHOUSE									
977	C3A15	69	0	2	4" STEEL PIPING	120.0	0.450	30.53	9.45	0.00				
					LF			1649.	1134.	0.	0.			2783.
978	C3A15		0	2	MISC FITTINGS (10% OF TOTAL LAB. & MAT)	1.0		0.00	280.00	0.00				
					LOT			0.	280.	0.	0.			280.
979	C3A15	69	0	2	ROOF DRAINS	2.0	1.500	30.53	65.00	0.00				
					EA			92.	130.	0.	0.			222.
985	C3A15				BREATHING AIR SYSTEM									
986	C3A15	69	0	2	REGULATOR FROM BOTTLE MANIFOLD TO 150 PSI	1.0	1.000	30.53	165.00	0.00				
					EA			31.	165.	0.	0.			196.
987	C3A15	69	0	2	REGULATOR FROM 150 PSI TO 100 PSI	4.0	1.000	30.53	165.00	0.00				
					EA			122.	660.	0.	0.			782.

ALT# 1 = \$ 2224
 ALT# 2 = \$ 2224
 ALT# 3 = \$ 2224

[Items with '#' have been adjusted by Job Factor and/or Equip Factor]

Items with " " have been adjusted by Job Factor and/or Equip Factor																
Item	Work Brkdwn Structure 1	J Trd ID	A o b F	c c t t	Markup Tag	Take-Off Item Description	Quantity Unit	L a b o r			Material		Const Equip		Sub Cntrct Cost	Item Direct Cost
								Factor	Rate	Ext'd Cost	Rate	Ext'd Cost	Rate	Ext'd Cost		
1026	C3A15	45	0	2	0	DEMO EXISTING CONCRETE	295.0 SF	0.471	16.76	2329.	0.00	0.	1.74	513.	0.	2842.
1027	C3A15	53	0	2	0	TRENCHING	470.0 CF	0.200	19.88	1869.	0.00	0.	1.74	818.	0.	2687.
1028	C3A15	45	0	2	0	SAND BED FOR PIPING	18.0 CY	0.030	16.76	9.	0.03	1.	6.00	108.	0.	118.
1029	C3A15		0	2	0	REPLACE CONCRETE IN TRENCH CUT (INSTALLED)	6.0 CY		0.00	0.00	200.00	6.00	36.	0.	1236.	
1030	C3A15	69	0	2	0	DOUBLE CONTAINED 90 DEG ELBOW	8.0 EA	0.200	30.53	49.	193.00	1544.	0.00	0.	0.	1593.
1031	C3A15	69	0	2	0	DOUBLE CONTAINED 45 DEG ELBOW	4.0 EA	0.200	30.53	24.	189.00	756.	0.00	0.	0.	780.
1032	C3A15	69	0	2	0	DOUBLE CONTAINED P-TRAP	12.0 EA	0.400	30.53	147.	650.00	7800.	0.00	0.	0.	7947.
1033	C3A15	69	0	2	0	DOUBLE CONTAINED SAN TEE	5.0 EA	0.200	30.53	31.	591.00	2955.	0.00	0.	0.	2986.
1034	C3A15	69	0	2	0	DOUBLE CONTAINED CLEANOUT	3.0 EA	0.300	30.53	27.	245.00	735.	0.00	0.	0.	762.
1036	C3A15					SLOTTED FUME HOOD IN PACK/UNPACK AREA										
1037	C3A15	89	0	2	0	FUME HOOD W/ 1X1 HEPA FILTER	1.0 EA	16.000	30.82	493.	10000.00	10000.	0.00	0.	0.	10493.
1038	C3A15	89	0	2	0	SS SHEET METAL HEPA FILTER ENCLOSURE	3200.0 LBS	0.120	30.82	11835.	1.75	5600.	0.00	0.	0.	17435.
1043	C3A15					CRANE FOR SETTING EQUIPMENT										

ALT# 1 = \$ 17,435
 ALT# 2 = \$ 17,435
 ALT# 3 = \$ 17,435

[Items with '#' have been adjusted by Job Factor and/or Equip Factor]

Item	Work Brkdw Structure 1	J Trd ID	A o b F	c c t t	Contract Markup Tag	Take-Off Item Description	Quantity Unit	Factor	Rate	Ext'd Cost	Material Rate Cost	Ext'd Cost	Const Equip Rate Cost	Ext'd Cost	Sub Contract Cost	Item Direct Cost
1044	C3A15	53	0	2		CRANE FOR SETTING EQUIPMENT	5.0 DAYS	8.000	19.88	795.	0.00	0.	600.00	3000.	0.	3795. —
1050	C3A15	45	0	2		CLEANUP 2 LABORERS 1HR/DAY FOR 14 MONTHS	1.0 LOTS	560.000	16.76	9386.	0.00	0.	600.00	600.	0.	9986.
1051	C3A15					UTILITY BUILDING EQUIPMENT.										
1052	C3A15	69	0	2		CHILLER 70 TON WATER COOLED TOWER	2.0 EA	200.000	30.53	11,562	35000.00	33,250	0.00	0.	0.	82212. 78,062
1053	C3A15	69	0	2		CHILLED WATER PUMPS	3.0 EA	7.500	30.53	687.	975.00	2925.	0.00	0.	0.	3612. —
1054	C3A15	69	0	2		AIR SEPARATOR	1.0 EA	2.000	30.53	61.	1234.00	1234.	0.00	0.	0.	1295. —
1055	C3A15	69	0	2		EXPANSION TANK	1.0 EA	2.400	30.53	73.	1286.00	1286.	0.00	0.	0.	1359. —
1062	C3A15	69	0	2		BOILER (900 MBH) BOILER (400 MBH)	2.0 EA	60.000	30.53	1,527	11000.00	14,000	0.00	0.	0.	25664. — 15,527
1063	C3A15	69	0	2		BOILER PUMPS 1-1/2HP (32 GPM)	3.0 EA	6.000	30.53	3604.	895.00	2685.	0.00	0.	0.	3235. —
1064	C3A15	69	0	2		AIR SEPARATOR	1.0 EA	2.000	30.53	61.	1234.00	1234.	0.00	0.	0.	1295. —
1065	C3A15	69	0	2		EXPANSION TANK	1.0 EA	2.400	30.53	73.	1286.00	1286.	0.00	0.	0.	1359. —
1066	C3A15	89	0	2		BOILER FLUE	2.0 EA	10.000	30.82	616.	500.00	1000.	0.00	0.	0.	1616. —
1067	C3A15	82	0	2		WATER HEATER FLUE	1.0 EA	5.000	30.82	154.	250.00	250.	0.00	0.	0.	404. —
						COOLING TOWER	2 EA			980		8340				9320
						PUMPS & PIPE	3 EA			2315		3800				6115
						CHEMICAL TREATMENT	1 Lot			2500		5500				8000
						CONTROLS	1 Lot			2000		4000				6000
						PAD & ELEC	1 Lot			1000		2000				3000

ALT # 1 = \$ 125,846

ALT # 2 = \$ 110,319

ALT # 3 = \$ 154,131

[Items with '#' have been adjusted by Job Factor and/or Equip Factor]

Item	Work Brkdw Structure 1	J A		Take-Off Item Description	Quantity Unit	L a b o r			Material Rate Ext'd Cost	Const Equip Rate Ext'd Cost	Sub Cntrct Cost	Item Direct Cost
		Trd b	c Markup			Factor	Rate	Ext'd Cost				
1071	C3A15			UNIT HEATERS								
1072	C3A15	69	0	2 UTILITY BUILDING	1.0	8.000	30.53	470.00	0.00			
				ELECTRIC UNIT HEATER	EA		244.	470.	0.	0.		714. —
1073	C3A15	69	0	2 MECHANICAL PENTHOUSE	1.0	4.000	30.53	380.00	0.00			
				UNIT HEATER	EA		122.	380.	0.	0.		502. —
1074	C3A15	69	0	2 TRUCK LOADING AREA	1.0	4.000	30.53	380.00	0.00			
				UNIT HEATER	EA		122.	380.	0.	0.		502. —
1075	C3A15	89	0	2 UTILITY BLDG	1.0	5.000	30.82	420.00	0.00			
				VENTILATION FAN	EA		154.	420.	0.	0.		574. —
1076	C3A15	89	0	2 UTILITY BLDG	6.0	0.400	30.82	26.50	0.00			
				INTAKE LOUVER WITH	SF		74.	159.	0.	0.		233. —
				FILTERS W/ DAMPER								
1077	C3A15	89	0	2 MOTOR FOR DAMPER	1.0	0.571	30.82	300.00	0.00			
					EA		18.	300.	0.	0.		318. —
1093	C3A15			FIRE PROTECTION SYSTEM								
1094	C3A15	69	0	2 PREACTION SPRINK.	23140.0		0.00	2.05	0.00			
				SYS. COVER 90% OF	SF		0.	47437.	0.	0.		47437.
				BLDG (INSTALLED)								
1095	C3A15	69	0	2 WET SPRINKLER SYS.	2572.0		0.00	1.75	0.00			
				COVER 10% OF BLDG	SF		0.	4501.	0.	0.		4501.
				(INSTALLED)								
1096	C3A15	69	0	2 DELUGE SYSTEM FOR	6.0		0.00	26000.00	0.00			
				HEPA FILTER UNITS	UNIT		0.	156000.	0.	0.		156000.
				INSTALLED								
1097	C3A15	69	0	2 SPRINKLER SYSTEM	6.0		0.00	6000.00	0.00			
				RISERS (INSTALLED)	EA		0.	36000.	0.	0.		36000.

ALT # 1 = \$ 2843	TOTALS
ALT # 2 = \$ 2,843	\$ 406,184
ALT # 3 = \$ 2,843	\$ 367,249
	\$ 434,469

ICF KAISER ENGINEERS

1900 Diamond Drive
Los Alamos, New Mexico 87544

DESIGN CALCULATION INDEX

CALC. NO.

SHEET NO.

1

JOB NUMBER 41552-056-02

AREA OR BUILDING

CALCULATION DESCRIPTION

DISCIPLINE

JOB TITLE NMSF CDR

TA-35

Civil / Misc. STRUCTURAL

C/S

CALCULATIONS APPLY TO DRAWINGS AND REVISIONS SHOWN

DRAWING	REV	DRAWING	REV	DRAWING	REV	DRAWING	REV

DESIGN ENGINEER

Christopher C. Ehrman 1/25
(SIGNATURE) (DATE)

JOB ENGINEER

(SIGNATURE)

(DATE)

CALCULATIONS CHECKED

Mark D. Dyer 3/95
(SIGNATURE) (DATE)

DESIGN SUPERVISOR

(SIGNATURE)

(DATE)

CALCULATIONS AGREE WITH DESIGN CRITERIA

(SIGNATURE) (DATE)

CALCULATIONS AGREE WITH APPVD. VENDOR DWGS.

(SIGNATURE)

(DATE)

CALCULATION KEYS

90% CDR
Submitted

2/95

DATES

DATES

DATES

DESIGN ENGINEER

DESIGN SUPERVISOR

STATUS:

PRELIMINARY

FINAL

CHECK

VOID

HOLD

OTHER

REASON FOR VOID OR HOLD:

INDEX

SHEET NO

DESCRIPTION

1

Index

2-3

Purpose, Given, Assumptions & References

4-17

Storm Runoff Design

17-20

Earthwork

20-40

Misc. Structural Design

41-87

Civil / STRUCTURAL / ARCHITECTURE

ESTIMATE, NOTES & DATA

Reference Material

o Field Survey

o Soils Report

o Chiller Dimensions

o Mechanical Piping Sizes

NMSP CDR

DESIGNED BY C. Ehsan DATE 1/24/95

CHECKED BY DDP DATE 3/95

PURPOSE:

DESIGN MODIFICATIONS TO EXISTING BUILDING
@ TA-55

GIVEN:

1. SOIL REPORT
2. AS-BUILT DRAWINGS
3. MERRICK'S CDR

ASSUMPTIONS:

DESIGNED BY C. EHRSAM

DATE 1/95

CHECKED BY DRSF

DATE 1/95

REFERENCES & CODES

1. UNIFORM BUILDING CODE - 1994 (UBC)
2. ARCHITECTURAL GRAPHICS STANDARDS - 1988
3. DOE 6430.1A.
4. LOS ALAMOS CLIMATOLOGY - 1990
5. SOIL REPORT - SERGENT, HAUSKINS & BECKWITH -
NUCLEAR MATERIALS STORAGE FACILITY - APRIL - 1984
6. URBAN HYDROLOGY FOR SMALL WATERSHEDS - JUNE 1986
- ~~7. UGRL - 15910 - DESIGN & EVALUATION GUIDELINES FOR
DOE FACILITIES SUBJECTED TO NATURAL PHENOMENA
HAZARDS - JUNE 1990.~~
8. DOE-STD-1020-94
9. NFPA 101 - LIFE SAFETY CODE
10. AASHTO DESIGN GUIDELINES
11. STRUCTURAL ENGINEERING HANDBOOK
3RD EDITION - GAYLORD & GAYLORD
12. STANDARD HANDBOOK FOR CIVIL ENGINEERS
3RD EDITION - MERRITT
13. AS-BUILT CONSTRUCTION DRAWINGS -
BURKS & ROE PACIFIC INC., ENGINEERS & CONSTRUCTORS
OCTOBER 1985 (LT # 6481-55)

STORM RUNOFF/DRAINAGE

NMSE CDR

DESIGNED BY C. Ghram DATE 1/95

CHECKED BY DWP DATE 3/95

DRAINAGE

REFERENCES:

DOE 6430.1 A

LOS ALAMOS CLIMATOLOGY - 1990

FACILITY ENGINEERING - VOL. 3

URBAN HYDROLOGY FOR SMALL WATERSHEDS - JUNE 1986

HCRL-15910 - DESIGN AND EVALUATION GUIDELINES FOR
DOE FACILITIES SUBJECTED TO NATURAL PHENOMENA
HAZARDS - JUNE 1990

GIVEN:

FIELD SURVEY - ICF KAISER 12-94

AREA CONTRIBUTING TO STORM RUNOFF 1.70 AC.

C FACTORS

- .47 NATURAL GROUND < 2% SLOPE
- .51 NATURAL GROUND 2% → 7% SLOPE
- .54 NATURAL GROUND > 7% SLOPE

USE RATIONAL METHOD TO CALCULATE STORM
RUNOFF.

DESIGN CONSIDERATION 100 YR, 5 MIN STORM

DESIGNED BY C. EIRSAM

DATE 1/25

CHECKED BY DDOE

DATE 3/95

CIVIL DRAINAGEEXISTING CONDITIONS:AREA = 1.70 AC
74180 $\pm$ C. FACTORS

- .47 NATURAL GROUND $< 2\%$ SLOPE, COMPACTED SOIL
(DIRT SERVICE ROAD)
- .51 NATURAL GROUND $2\% - 7\%$ SLOPE
- .54 NATURAL GROUND $> 7\%$ SLOPE
- .97 IMPERVIOUS AREAS (CONCRETE, ASPHALT, ROOFS)

Q = C.I.A RATIONAL METHOD

.47	NATURAL GROUND	$< 2\%$ SLOPE	8100 $\pm$	.186 AC	
.51	"	"	2-7% SLOPE	35600 $\pm$	.817 AC
.54	"	"	$> 7\%$ SLOPE	29370 $\pm$	.674 AC.
.97	IMPERVIOUS AREAS.		9640 $\pm$	.221 AC.	
				<hr/>	
				$\Sigma = 82,710 \pm$	$\Sigma = 1.899 AC$

 $L = 4.60$ FOR 100 YR. 15 MIN. STORM

$$Q = C * I * A$$

$$Q = .47 \times 4.60 \times .186 + .51 \times 4.60 \times .817 + .54 \times 4.60 \times .674$$

$$+ .97 \times 4.60 \times 0.221 = 4.98 CFS$$

NMSF CDR

DESIGNED BY C. Ehrsam DATE 1/95

CHECKED BY TDF DATE 3/95

DEVELOPED CONDITIONS

- .47 LATERAL 12% SLOPE
- .51 " 2%-7% SLOPE
- .54 " >7% SLOPE
- .97 CONCRETE
- .97 BUILDING

$$Q = CIA$$

1 OUTBUILD 1344 #, 1 CHILLER PAD 336 #
ENTRANCE NORTH SIDE OF BUILDING TO DRAIN TO SE
STORM DRAIN INLET

.47	<12% slope	6510 #	.149 AC.
.51	2-7% slope	35,600 #	.817 AC.
.54	>7% slope	29370 #	.674 AC.
.97	IMPERVIOUS AREAS	11,290	.258 AC.
$\Sigma = 82,710$			1.899 AC.

$$Q = CIA$$

$$Q = .47 * 4.60 * .149 + .51 * 4.60 * .817 + .54 * 4.60 * .674 + .97 * 4.60 * .258$$

$$Q_F = 5.06 \text{ CFS}$$

$$Q_i = 4.98$$

CHANGE IN Q AFTER DEVELOPED .084 CFS

NMSF CDR

DESIGNED BY C. Ehrsam DATE 1/95

CHECKED BY DAF DATE 3/95

RUNOFF

GIVEN: 100 yr
15 min storm Q_u = undeveloped flowrate Q_D = developed flowrate V_u = Vol. of runoff undeveloped V_D = Vol. of runoff developed

$$Q_u = 4.95 \text{ FT}^3/\text{s}$$

$$Q_D = 5.04 \text{ FT}^3/\text{s}$$

$$V = Q \cdot t$$

$$V_u = 4.95 \frac{\text{FT}^3}{\text{s}} \times 15 \text{ min} \times \frac{60 \text{ s}}{\text{min}} = 4482 \text{ FT}^3$$

$$V_D = 5.04 \frac{\text{FT}^3}{\text{s}} \times 15 \text{ min} \times \frac{60 \text{ s}}{\text{min}} = 4554 \text{ FT}^3$$

$$\Delta V = 72.0 \text{ FT}^3$$

CONCLUSION: INCREASE IN RUNOFF IS INSIGNIFICANT

NO STORM WATER PIPING OR PONDING
WILL BE NECESSARY.ALSO - DISTURBED AREA < 5.0 AC.
NPDES IS NOT APPLICABLE.

NM3F CDR

 DESIGNED BY C. Ehrsam DATE 1/95
 CHECKED BY DPD DATE 3/95

TABLE 11.2.1

Runoff coefficients for use in the rational method (Chow, Maidment, and Mays, 1988)

Character of surface	Return period (years)						
	2	5	10	25	50	100	500
Developed							
Asphaltic	0.73	0.77	0.81	0.86	0.90	0.95	1.00
Concrete/roof	0.75	0.80	0.83	0.88	0.92	0.97	1.00
Grass areas (lawns, parks, etc.)							
<i>Poor condition</i> (grass cover less than 50% of the area)							
Flat, 0-2%	0.32	0.34	0.37	0.40	0.44	0.47	0.58
Average, 2-7%	0.37	0.40	0.43	0.46	0.49	0.53	0.61
Steep, over 7%	0.40	0.43	0.45	0.49	0.52	0.55	0.62
<i>Fair condition</i> (grass cover on 50% to 75% of the area)							
Flat, 0-2%	0.25	0.28	0.30	0.34	0.37	0.41	0.53
Average, 2-7%	0.33	0.36	0.38	0.42	0.45	0.49	0.58
Steep, over 7%	0.37	0.40	0.42	0.46	0.49	0.53	0.60
<i>Good condition</i> (grass cover larger than 75% of the area)							
Flat, 0-2%	0.21	0.23	0.25	0.29	0.32	0.36	0.49
Average, 2-7%	0.29	0.32	0.35	0.39	0.42	0.46	0.56
Steep, over 7%	0.34	0.37	0.40	0.44	0.47	0.51	0.58
Undeveloped							
Cultivated Land							
Flat, 0-2%	0.31	0.34	0.36	0.40	0.43	0.47	0.57
Average, 2-7%	0.35	0.38	0.41	0.44	0.48	0.51	0.60
Steep, over 7%	0.39	0.42	0.44	0.48	0.51	0.54	0.61
Pasture/Range							
Flat, 0-2%	0.25	0.28	0.30	0.34	0.37	0.41	0.53
Average, 2-7%	0.33	0.36	0.38	0.42	0.45	0.49	0.58
Steep, over 7%	0.37	0.40	0.42	0.46	0.49	0.53	0.60
Forest/Woodlands							
Flat, 0-2%	0.22	0.25	0.28	0.31	0.35	0.39	0.48
Average, 2-7%	0.31	0.34	0.36	0.40	0.43	0.47	0.56
Steep, over 7%	0.35	0.39	0.41	0.45	0.48	0.52	0.58

Note: 1. Values in this table are the standards to use for the rational method.

Figure 4

NM5F COR

11/87

LA-11735-MS

UC-902

Issued: May 1990

Los Alamos Climatology

Brent M. Bowen

9 Extremes

9.1 Extreme Value Analysis

Annual extreme weather variables are analyzed in order to estimate return periods for specific values. The 50- and 100-year precipitation magnitudes, for example, are useful for estimating stream run-off and structural design. Snowfall, snow depth, maximum wind gusts, and minimum temperatures, along with precipitation, are all analyzed for annual extreme values.

The extreme value analyses for different meteorological variables are presented in the following probability plots (for example, see Fig. 9.1). A special Gaussian probability scale is used on the graphs to represent the cumulative probability. In Fig. 9.1, the ordinate represents annual precipitation; the abscissa, the cumulative probability. After the annual extreme values are ranked, they are plotted for cumulative probability versus the value. A best-fit line is then drawn through the points. The data will form a straight line if the extreme value distribution is Gaussian (normal). Departures from the best-fit line are a measure of either the lack of data (small data set) or the non-Gaussian behavior of variables. In the figures, the "return period" is the number of years, on average, that will elapse before a given annual precipitation amount will recur, based on the best-fit line. Some values, such as precipitation and snow depth, have more log-normal distributions. Relatively long return periods of specific values, such as 50 and 100 years, can be estimated from the best-fit lines. Reliability of the return-period estimates increases with the size of the data set.

Fig. 9.1. Annual extreme precipitation analyses for Los Alamos (1911-1987) and White Rock (1965-1987).

9.1.1 Precipitation

Annual extreme precipitation values are plotted in Fig. 9.1 for Los Alamos and White Rock. The Los Alamos extreme values are significantly higher than those at White Rock. For example, the maximum annual precipitation representing a 100-year return period ($T_R = 100$ years) is about 10 in. (25 cm) greater at Los Alamos than at White Rock. Both the Los Alamos and White Rock data coincide very well with their respective best-fit lines. An exception is the data point for the lowest annual precipitation at Los Alamos, which is quite far from the best-fit line, representing an extremely low annual precipitation.

Daily extreme precipitation values have also been analyzed for Los Alamos and White Rock and are shown in Fig. 9.2. As with annual precipitation, daily extreme precipitation values exhibit a near-normal distribution. Again, the daily extreme precipitation amounts for Los Alamos are considerably higher than those for White Rock, and the best-fit lines represent both Los Alamos and White Rock data very well. Note that the daily precipitation values represent calendar days and not 24-hour periods overlapping 2 calendar days.

Extreme precipitation values for shorter time periods (12 hours, 1 hour, and 15 minutes) are shown in Figs. 9.3 and 9.4 for TA-59 and Area G (TA-54), respectively. Area G short-term precipitation values are used because comparable data are unavailable for White Rock. The Area G precipitation amounts are expected to closely approximate, or slightly exceed, the White Rock amounts. The extreme values of the shorter time

Fig. 9.2. Daily extreme precipitation values for Los Alamos (1911–1987) and White Rock (1965–1987).

Fig. 9.3. Shorter-period extreme precipitation values for Los Alamos (TA-59) during 1980-1988.

Fig. 9.4. Shorter-period extreme precipitation values for Area G (TA-54) during 1980-1988.

periods are based on tower data available since 1980 at both sites; therefore, only 9 years of extreme values are available at both sites.

Los Alamos extreme precipitation amounts for shorter periods are generally higher than those at White Rock. The shortest periods have the greatest year-to-year variations, as indicated by the increased slope of the best-fit lines for the 15-minute and 1-hour data.

Return periods from 2 to 100 years are listed in Table 9.1 for various precipitation durations at TA-59 and Area G/White Rock. The daily and annual return periods are based on a greater number of years and therefore are the most reliable. However, the shorter periods, based on only 9 years of data, appear to be very consistent. The daily precipitation values represent calendar days and not maximum 24-hour periods. Extreme values for 24-hour periods are probably slightly higher than values for calendar days because heavy-precipitation events sometimes extend over 2 calendar days. Note the heavier precipitation amounts at Los Alamos for all return periods. Also note that the difference in precipitation amounts between return periods decreases slightly with longer durations.

9.1.2 Snowfall

Los Alamos seasonal extreme snowfall values are shown in Fig. 9.5. Only limited snowfall data are available for White Rock; therefore, an analysis could only be made for

Table 9.1. Precipitation for various return periods and time periods at Los Alamos (TA-59) and Area G (TA-54)/White Rock.

T_R (yr)	Precipitation (in.)						Annual
	15 min	30 min	1 h	3 h	12 h	Daily	
TA-59							
2	0.59	0.84	1.03	1.24	1.47	1.45	18.10
5	0.88	1.15	1.38	1.60	1.84	1.90	22.90
10	1.09	1.35	1.59	1.83	2.07	2.18	25.80
25	1.37	1.61	1.86	2.10	2.35	2.54	29.00
50	1.59	1.80	2.06	2.32	2.55	2.80	31.70
100	1.82	2.00	2.25	2.52	2.74	3.06	34.00
Area G^a							
2	0.49	0.62	0.69	0.81	1.06	1.18	13.10
5	0.73	0.88	0.96	1.08	1.36	1.55	16.40
10	0.90	1.05	1.15	1.27	1.55	1.78	18.40
25	1.12	1.27	1.38	1.50	1.78	2.08	21.00
50	1.28	1.45	1.56	1.68	1.95	2.31	22.90
100	1.46	1.62	1.75	1.86	2.11	2.52	24.40

^a Daily and annual Area G values are White Rock values.

Facilities Engineering Standards
Civil Engineering Standards

ivil 3-200
Revision No. 1

Suitable materials and methods of placing and compacting backfill for all buildings, parking areas, roads, loading areas, utility trenches, and the general site shall be specified within the construction documents for all Laboratory projects.

The grading design shall provide existing and new contours at an interval of 2 ft. and spot elevations shown for grade changes and structure elevations. Cross sections shall be provided where practical and earthwork quantities are substantial. After all construction is complete, including clean up, finish grading to the final contours as shown on the drawings shall conform to a tolerance of ± 0.1 ft.

205.6 Earthwork

Natural soil shall not have a finished slope steeper than 3 horizontal to 1 vertical (3:1). Undisturbed volcanic tuff shall not have a finished slope steeper than 1 horizontal to 6 vertical (1:6).

Subgrade preparation shall be defined as the top 6 in. of all site work under slabs and pavement. It shall be scarified, moistened to optimum conditions, and compacted to 95% of maximum density. Elevation tolerance shall be limited to $\pm .05$ ft. per 10 ft. in any direction from specified grade and cross section.

205.7 Utility Trenches

Trench excavation shall be in accordance with OSHA Standards.

All piping shall be bedded with selected granular material to provide protection to the pipe.

Backfill for underground piping systems shall not be completed until the piping systems have been tested and approved.

The width of trenches for pipe and conduit shall be specified to be not greater than necessary to permit satisfactory jointing and thorough tamping of the bedding. Trenches excavated in tuff shall be excavated 6 in. below the pipe invert and backfilled to the pipe bottom with sand.

After the pipe has been installed and all testing has been completed, backfill around the pipe with 6 in. of sand and then with selected fill material, at optimum moisture content to the appropriate density in layers not exceeding 6 in. in depth. Care shall be taken to ensure thorough compaction of the fill under and around the full length of pipe and the full depth of the trench.

EARTHWORK

CHD TROP 3/15 19/8-

NMSF
41552-056-02
EARTHWORK CALCULATIONS

The earthwork calculations were performed using DCA. The grid and average end methods were employed. A net of approximately 2500 yards of earth will need to be removed from the site.

NWST COR

40

PAJARITO ROAD

Site Volume Table: Unadjusted

Stratum	Surf1	Surf2	yards	Cut	yards	Fill	yards	Net	Method
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
;	vol1	exist	pprsd						
				3134		682		2452 (C)	Grid
				3240		738		2502 (C)	End area

20/87

MISCELLANEOUS STRUCTURAL

KWSE CDR

DESIGNED BY C Ehrsam DATE 1/95

CHECKED BY J. Rongillo DATE 3/95

MINIMUM THREAD 11"
MAXIMUM RISER 7"
MINIMUM LANDING 44"

WELL STAIRS

EXISTING STAIRS AT BASEMENT

EXISTING STAIRS AT FIRST FLOOR AND MEZZINE LEVEL

NEW STARS BASEMENT LEVEL

NEW STAIRS @ MEZZANINE LEVEL

NEW STAIRS @ FIRST FLOOR LEVEL

NWSF CDR

28/87

1. ALL STAIRS AND HANDRAILS SHALL CONFORM TO RULES AND REGULATIONS BY THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION. (O. S. H. A.)
2. EXTENT OF HANDRAIL, STAIR LAYOUTS AND TREAD ETC. ARE SHOWN ON DESIGN DRAWINGS.
3. HANDRAIL SHALL BE SHOP FABRICATED IN SECTIONS SUITABLE FOR SHIPPING AND ERECTION BY BOLTING. (EXCEPT BAR HANDRAIL)
4. CONTACT SURFACES OF HANDRAIL SHALL BE SMOOTH AND FREE FROM BURRS AND SHARP PROJECTIONS.
5. STAIR TREAD BEARING BAR SIZE SHALL BE AS RECOMMENDED BY THE NATIONAL ASSOCIATION OF ARCHITECTURAL METAL MANUFACTURERS (NAAMM), BUT NOT LESS THAN THAT USED FOR FLOOR GRATING.
6. ANGLE & PIPE HANDRAIL POST SHALL BE EQUALLY SPACED AT, 8'-0" MAX. CTRS.
7. BAR HANDRAIL POST SHALL BE EQUALLY SPACED AT, 5'-0" MAX. CTRS.
8. VARIATIONS OF TYPICAL DETAILS SHALL REQUIRE APPROVAL BY THE ENGINEER.

NOTES FOR STAIRS AND HANDRAILS

S904AA

**KAISER
ENGINEERS**

KAISER
ENGINEERS

STAIR BOTTOM CONNECTION - BENT STRINGER

S904BC

**KAISER
ENGINEERS**

STAIR TOP CONNECTION AT STEEL FRAME

S904BI

**KAISER
ENGINEERS**

STAIRCO

STEEL STAIRS

Metal Service Company, Inc. has been through the years the leader of the metal stair industry in innovative products designed and produced to quality standards for tremendous savings in time and money.

DT/Document

This Metal Service Company, Inc. catalog has been prepared to give the professional user full and complete information on Stairco Steel Stairs. It contains descriptions, details and specifications on specific products as well as their advantages, features, uses and applications.

The organization and content follow Sweet's GuideLines for the preparation of technical literature. All data on Stairco products therefore has been carefully selected and arranged to make it as easy as possible for you to not only locate the data wanted, but to make selection and specification convenient.

CONTENTS

FIELD-BOLTED PRE-STACKED	3
FULL-FLIGHT/INDUSTRIAL	3
DROP-IN	4
RAILING & TREAD DESIGN	4

MR/Manufacturer

Metal Service Company, Inc. has maintained leadership in metal stair assembly through the years. The company's low product costs, exacting standards, excellent workmanship, and speed of delivery have earned it a position of respect in this demanding field. Metal Service company, Inc. offers steel stairs from all types of construction; from two-story garden apartments to the highest high-rise; from schools to hospitals to commercial towers and industrial plants.

Because of its long experience and knowledge of metals the company has become a qualified producer for Nuclear Power Plants, supplying them with exacting metal items specifically designed for their needs.

The company invites inquiries on any fabrications that require precision and production skill in the metal working field.

UA/Uses, Applications

Metal Service Company, Inc. manufactures a complete product line of steel stairs that can be used or adapted for all situations in the building field.

Your project may be modular construction, high rise buildings, garden apartments, commercial-institutional centers, or industrial plants. It need not be a ground up new idea, Metal Service Company, Inc. is equally adept in the field of renovation and modernizing.

STAIRCO products—Field-bolted, Pre-Stacked, Drop-In, Full-Flight and Industrial—are currently installed and fulfilling their function in a variety of applications across the country.

PP/Product Presentation

All of the metal stair products of Metal Service Company, Inc. meet or exceed model and national building codes. STAIRCO products—Field-Bolted Pre-Stacked, Full-Flight, Industrial or Drop-In—have been tested and are guaranteed to support in excess of 100 lbs. per sq. foot live load.

STAIRCO'S new Field-Bolted design offers architects and builders a revolutionary concept in stacked steel stairs . . . on site stacking of pre-fabricated assembled components, field-bolted on the job with a minimum crew using only hand tools. The resultant savings in time and expense are demonstrable and exact. Metal Service Company, Inc. manufactures all STAIRCO™ stairs to exacting production standards using bent plate or Jr. channel for stringers and assembling treads and risers, adding 3" sq. tube newels with steel caps and drops. Railings are pipe or a combination of picket and pipe meeting model and national codes.

Before shipping, all STAIRCO stairs receive a generous shop coat of rust inhibitive primer.

All of this attention to design and detail combines to give the customer a stair that does an effective job at a reasonable cost.

Metal Service Company, Inc. allows you flexibility of design insofar as floor to floor dimensions and well opening sizes are concerned. Materials to provide required design strength are used in addition to standard alternate profiles for treads and risers.

STAIRCO INVITES CUSTOMER INQUIRIES . . .

Metal Service Company, Inc. maintains a staff of technicians and draftsmen to adapt standard or custom STAIRCO designed stairs to your building requirements. In addition, the company has a nationwide network of dealers, thoroughly familiar with local conditions. Your call to us will bring immediate response.

ADVANTAGES AND FEATURES

PRECISION DESIGN

All STAIRCO Steel Stairs are precision designed to support in excess of 100 lb. live load per sq. ft. and to meet all model and national building codes and AISC specifications.

PRECISION FABRICATION

STAIRCO Steel Stairs are fabricated by our most modern techniques and must meet our rigid quality control.

PRECISION PRODUCTION STANDARDS

Exacting standards are maintained during all phases of production of STAIRCO products to assure they are produced as required by your plans and specifications.

MATERIALS—STAIRCO BASIC

Steel stringers—MC 10 x 6.5.
Treads and risers—14 gauge hot rolled sheet.
Newels—steel tube 3" square by 14 gauge.
Headers—C 6 x 8.2.
Platforms—20 gauge Type B steel deck.
Platform header—M 6 x 4.4.
Railing pipes—1½" nominal O.D.
Railing panels—½" square bar pickets with 1" x ½" flat bar top and bottom Treads and risers.
Headers—plate, heavier channel or tube.
Platforms—sheet steel, diamond plate, or heavier metal deck.
Platform header—channel, tube, or heavier beam.
Railings—any custom design or as shown.

COST SAVINGS USING STAIRCO™ PRODUCTS

All STAIRCO steel chairs are produced in conformance with the advanced engineering design and technology developed through years of experience to assure you the best product; Field-Bolted Pre-Stacked, Full-Flight/Industrial, Drop-In at substantial savings in time and money.

OP/Overall Product

All STAIRCO Stair Systems are available for many construction conditions featuring substantial savings over concrete. The same expertise of volume production and exacting manufacturing standards apply to all types of STAIRCO Steel Stairs, assure you uninterrupted floor to floor stairs for economical use. STAIRCO Stairs are shop assembled with stringers, treads and risers in place. Connections, platforms, railings, newels, etc. are supplied with the system when the design requires their use.

TIME SAVINGS

STAIRCO Full-Flight and Industrial steel stairs arrive at your site completely shop assembled. You'll find STAIRCO Full-Flight and Industrial steel stairs can be installed quickly and efficiently with connections at the head and foot ready to use.

PRODUCT FLEXIBILITY

Alternate railing and tread design expand uses of STAIRCO Full-flight and Industrial steel stairs.

STAIRCO PRECISION DETAIL

In product, design, fabrication, and standards you have Metal Service Company's years of know-how to bring you a superior product that answers your needs and specifications.

SHOP DRAWINGS

Submit shop drawings of stairs and railings as specified. No work is to be done until drawings are approved.

PRE-CISION STACKED FIELD BOLTED STEEL STAIRS

ADVANTAGES AND FEATURES

ERECTION TIME*

*STAIRCO Field-Bolted stairs can save 85% erection costs at the site—minimum field work with job crane can handle the whole erection.

PERALL SAVINGS*

*STAIRCO Field-Bolted stairs can save 50% over conventional stair designs—consider reducing stand-by costs, time costs, and erection costs.

COLOR CODED

*STAIRCO Field-Bolted stairs and components are color coded for fast, simple, and fool proof erection.

SIMPLE EQUIPMENT

*No complicated tools needed—two workers need only a 3/4" electric impact wrench, a jacking crane, and two level beams.

TECHNICAL SPECIFICATIONS

*Erect and install, where indicated on drawings, STAIRCO "Pre-Cision Stacked" Field-Bolted Steel Stairs as manufactured by Metal Service Company, Inc., Enterprise, Alabama, or approved licensee. Stair components, consisting of stair runs, platforms, stair rails, and temporary bracing shall be completely fabricated in a licensed shop and shall be color coded and packaged for shipment to job site for easy assembly.

Assembly, Installation DETAILS

FULL-FLIGHT AND INDUSTRIAL STEEL STAIRS

Assembly, Installation DETAILS.

Industrial Stairs, STAIRCO Factory Produced Stairs, Platforms, Catwalks, Railings. Designed and Produced to Customer Specifications.

Full-Flight, STAIRCO Factory Produced Stairs, Platforms, Catwalks, Railings. Designed and Produced to Customer Specifications.

DROP-IN STEEL STAIRS

OP/Overall Product

AI/Assembly, Installation

TS/Specifications

PLATFORM SUPPORTS:

In concrete walls; carrier angles, field welded to embedded plates.

In concrete block walls; carrier angles field bolted to walls.

In structural framing; steel hanger rods from overhead beams.

Newels shall be steel tube with caps and drops, shipped loose for field installation.

OM/Maintenance

Only normal building maintenance with periodic painting, as required.

AC/Availability Cost

For further information on Metal Service Company's stairs, or any custom work, please call Metal Service Company, Inc. Our national network of representatives assures you of fast, prompt and efficient response to your inquiry. Our years in metal stair applications and production assures you quality construction, competitive pricing prompt service and shipment. Access to major carriers on land and sea insures prompt delivery.

CC/Code Acceptability

STAIRCO products will meet national and local codes when specified, to include OSHA and NFPA Life Safety Code 101 as required. Independent Engineering and Certified Design Calculations are available, also certified test reports from Independent Laboratories. Product design and production are in accordance with latest NAAMM Standards.

Metal Service Company, Inc. reserves the right to make engineering changes or other modifications at our discretion without notice.

STAIRCO™

Field-Bolted Pre-Stacked Drop-In/
Full-Flight/Industrial by

METAL SERVICE COMPANY, INC.
A wholly owned subsidiary of Alfab, Inc.
84 By Pass East
P.O. Box 1334
Enterprise, Alabama 36331
Telephone (205) 347-9451

CALL SWEET'S BUYLINE FOR YOUR
NEAREST REPRESENTATIVE

Design Patents:
U.S. 3,175,654; 3,788,018; 3,859,771 & 3,927,518
U.K. 1,014,144; Canada 697,299 & 954,268

Available Tread And Riser Designs For All Stairs

Railings Available For All Stairs

streets or sidewalks to the accessible building entrance they serve.

2. At least one accessible route shall connect accessible buildings, facilities, elements and spaces that are on the same site.
3. At least one accessible route shall connect accessible building or facility entrances with all accessible spaces and elements within the building or facility.

Width, 4.3.3:

The minimum clear width of an accessible route shall be 36 in. (915 mm) except at doors.

Head Room, 4.3.5:

Accessible routes shall comply with 4.4.2.

- **Protruding Objects, Section 4.4:**

Head Room, 4.4.2:

Walks, halls, corridors, passageways, aisles, or other circulation spaces shall have 80 in. (2030 mm) minimum clear head room. If vertical clearance of an area adjoining an accessible route is reduced to less than 80 in. (nominal dimension), a barrier to warn blind or visually-impaired persons shall be provided.

- **Ground and Floor Surfaces, Section 4.5:**

General, 4.5.1:

Ground and floor surfaces along accessible routes and in accessible rooms and spaces, including floors, walks, ramps, stairs, and curb ramps, shall be stable, firm, slip-resistant, and shall comply with 4.5.

• Stairs, Section 4.9:

Handrails, 4.9.4:

Stairways shall have handrails at both sides of all stairs. Handrails shall comply with 4.26 and shall have the following features:

1. Handrails shall be continuous along both sides of stairs. The inside handrail on switchback or dogleg stairs shall always be continuous.
2. If handrails are not continuous, they shall extend at least 12 in. (305 mm) beyond the top riser and at least 12 in. (305 mm) plus the width of one tread beyond the bottom riser. At the top, the extension shall be parallel with the floor or ground surface. At the bottom, the handrail shall continue to slope for a distance of the width of one tread from the bottom riser, the remainder of the extension shall be horizontal. Handrail extensions shall comply with 4.4.
3. Top of handrail gripping surface shall be mounted between 30 in. and 34 in. (760 mm and 865 mm) above stair nosings.

Outdoor Conditions, 4.9.6:

Outdoor stairs and their approaches shall be designed so that water will not accumulate on walking surfaces.

• Doorways, Section 4.13:**General, 4.13.1:**

Doors required to be accessible by 4.1 shall comply with the requirements of 4.13.

Clear Width, 4.13.5:

Doorways shall have a minimum clear opening of 32 in. (815 mm) with the door open 90 degrees, measured between the face of the door and the stop. Openings more than 24 in. (610 mm) in depth shall comply with

CHECKED BY CAE DATE 3/95

- ASSUME COLUMN HT = 12'-0" MAX.
- METAL DECK & SIDING
- SIMPLE CONNECTIONS
- EXIST ROOF IS ADEQUATE.

SHEET 37 OF 87

CHECKED BY CAT DATE 3/95

$$M = \frac{1}{2} \omega L^2 = 121,5 \text{ kg}$$

13 787 500 S/S I/S, FRITH 5 SQUARE
42 201 500 P/L I/S EYE EASY 5 SQUARE
42 202 500 P/L I/S EYE EASY 5 SQUARE
42 208 700 S/S I/S EYE EASY 5 SQUARE
42 247 100 P/CYCLED WHITE 5 SQUARE
42 299 200 P/CYCLED WHITE 5 SQUARE

SHEET 40 OF 87

DESIGNED BY

DATE _____

CHECKED BY

DATE _____

W14x74 Wm work

M = 173 kg.

$$h_u = 30'$$

CHECK COLUMNS:

$$P_{MAX} = \frac{(60)(23)(15)}{1000} = 20.7^{\text{K}}$$

FROM AISC QTH ED, P. 3-32

W 8x24 w/12 w012K

$$(P_{MAX} = 101^K \text{ w/IKL} = 12')$$

[illegible]

CIVIL/STRUCTURAL/ARCHITECTURAL
ESTIMATE DATA AND NOTES

ESTIMATE TAKE OFF

Civil - C1

WILSON
THURSTON

10⁴ FIRE PROTECTION LINE = 775 LF.

CW/HW/ETC. RPPING = 340 LF.
(4 LINES)

$$1^u \text{ GAS} = 130 \text{ CF}$$

$PW = 150 \text{ LF (TO UTILITY BUDG)}$

$$1^u \text{ DW} = 25 \text{ LF (TO NUBSF)} \quad \text{BUDG}$$

2 STAGE PRESSURE REDUCING STATION

CHILDER PAD

$$28' \times 12' = 336 \text{ SF.}$$

PLW LINE 4" (NORTH SIDE) = 60 LF.

SHEET 43 OF

DESIGNED BY DKP DATE 3/95
CHECKED BY CAE DATE 3/95

SHEET C2

EXCAVATION = 3300 CF
FROM DTM.

SHEET C3 & C4

FROM MEIRICK ESTIMATE_

VERIFIED BY DENNIS BASILE (JCFKS)
MET W/ FRANK PEARCE (FSS-10)

TO CONFIRM ARRANGEMENTS &
CONFIGURATION (3/10/95)

[illegible]

ENVIRONMENT & ENERGY GROUP

NHSP

JOB NO. 41552-050

SHEET 44 OF 87

DESIGNED BY DDP DATE 3/95

CHECKED BY CAE DATE 3/95

SHEET A1 (DEMOLITION)

FROM MERRICK ESTIMATE W/ MODS AS FOLLOWS?

- ✓ DEMOLISH
✓ CONC. WALL IN BASEMENT -

$$(20)(120) = 2400$$

$$(2400)(1.100) = 2400 \text{ CF} = 89 \text{ CY}$$

- ✓ NO NEED FOR SHORING AS IN
ORIGINAL MERRICK ESTIMATE - WILL
REMOVE EQUIPMENT THROUGH NEW
VENT IN SOUTH WALL.

- ✓ SHELVING SYSTEM REMOVAL - OK

- ✓ STORAGE BOX DEMO - OK

- ✓ STAIRS & SLAB @ ENTRANCE =
 $96 \text{ FT}^2 + 40 \text{ FT}^2 = 136 \text{ FT}^2 \rightarrow$
USE 140 FT^2

- ✓ WALLS @ ENTRANCE = 200 FT^2

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National Brand

SHEET 45 OF 87

CHECKED BY CAE DATE 3/95

✓ SAWCUT BASEMENT WALLS (FOR NEAT EDGES.)

SOUTH END WING WALLS = 40 LF

② TABC STORAGE = 20 LF

② COLUMN LINE (C) (1) = 20 LF

$$\text{Q OPS AREA} = \frac{40\text{LF}}{120\text{LF}}$$

✓ SAWCUT MEZZANINE DOOR @ WALL = $(10')(2) = \underline{20\text{ LF}}$

✓ [2] FLOOR SLAB = (150)(30.33) = 4550
(10)(25) = 250

4800 SF

✓ SAW CUT: 1ST RR SLAB = 400
 $+ 50 LF + 25' + 10'$
 $= \underline{\underline{185 LF.}}$

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JOB NO. 41552-086

SHEET 46 OF 87

DESIGNED BY DDE DATE 3/95

CHECKED BY CAE DATE 3/95

SHEET A1 (CONT'D)

✓ DEMOLISH CONCRETE MIDDLE WALL
IN BASEMENT =

(ALREADY
ON SHEET 3)

$$(120' \times 20') = 2400 \text{ SF.}$$

$$(1' 0" \text{ TK})$$

✓ DEMOLISH WALL @ OPS AREA

$$(60' \times 20') = 1200 \text{ SF}$$

$$(1' 0" \text{ TK})$$

✓ CONCRETE CURB

$$(6' \times 8') = 48 \text{ SF (AVG 8" DEEP)}$$

✓ CONCRETE WING

$$\text{WALLS} = (4)(6')(20') = 480 \text{ SF}$$

(SOUTH END)

✓ WALL @ STAIRWELL = 860 SF (PER MEASURE)

$$\text{MEZZANINE DECK} = (22)(53) = 1200 \text{ SF}$$

$$(1' 0" \text{ TK})$$

SHEET 47 OF 87

DESIGNED BY DWF DATE 3/95

CHECKED BY CAE DATE 3/95

✓ SHEAR WALL (1st Floor) =
 $(55)(15) = 825 \text{ ft}^2$
 $- \text{DOORWAYS} = 112 \text{ ft}^2$
713 ft²
USE 725 ft²

SAWCUT EXISTING 1ST FLOOR
FOR NEW CONC. WALLS

LF OF NEW WALLS NEEDING
FOOTINGS (2'-0" WIDE.) = 450 LF. (+)

$$\checkmark \text{ CONCRETE REMOVAL} = (450)(2)(6) = 5400 \text{ FT}^2$$

(6" TK)

43 782	5034115	FLIR	5534115
43 781	5034115	FLIR	5534115
42 780	5034115	FLIR	5534115
42 779	5034115	FLIR	5534115
42 792	5034115	FLIR	5534115
42 790	5034115	FLIR	5534115

ENVIRONMENT & ENERGY GROUP

NIMSR

JOB NO. 4155Z-03-00

SHEET 48 OF 87

DESIGNED BY DW DATE 3/95

CHECKED BY CAE DATE 3/25

13 702 500 SHIRTS WITH 5 SQUARE
42 261 500 SHIRTS EYE-EAST 5 SQUARE
42 262 100 SHIRTS EYE EAST 5 SQUARE
42 269 200 SHIRTS EYE-EAST 5 SQUARE
42 302 100 HI CYCLED WHITE 5 SQUARE
42 309 200 HI CYCLED WHITE 5 SQUARE

Made in U S A

DEMO WALK @ GARAGE (@ DISPATCHER.)

$$(8'-0'')(8'-0'') = \underline{64 \text{ SF}}$$

(1'-0'' TK.)

✓ REMOVE FOOTING @ ENTRANCE RAMP = 24UF.

✓ SAWCUT SOFTWALL
FOR INTAKE LOUVER = 84 LF.

✓ ROOF DEMO (FOR VENT) = (4)(30) = 120 SF

13 761 500 SHEETS, FULL SIZE
 13 762 100 SHEETS, FULL SIZE
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 13 765 100 SHEETS, FULL SIZE
 13 766 100 SHEETS, FULL SIZE
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ICF KAISER

ENVIRONMENT & ENERGY GROUP

NAK

JOB NO. 41552-056

SHEET 50 OF 87

DESIGNED BY DJF DATE 3/95

CHECKED BY CAE DATE 3/95

ITEM	WBS	QTY	UNIT	LABOR FACT.	RATE TAG	UNIT# MAT'L	UNIT \$ EQUIP
BASEMENT DEMO (CONT)							
SHOULDER BASEMENT WALLS	C1C03	120	LF	2.20	16.76 45	5.76	9.12
SHOULDER MEZZANINE DOOR CURB	C1C03	20	LF	2.20	16.76 45	5.76	9.12
DEMO WALL C-OPS AREA	C1C03	1200	SF	0.500	16.76 45	-	1.80
CONC. CURB	C1C03	40	SF	0.20	16.76 45	-	1.00
CONC WING WALLS	C1C03	430	SF	0.500	16.76 (45)	-	1.80
STAIRWELL WALLS (PER MEZZANINE)	C1C03	360	SF				
MEZZANINE DECK (10" TH)	C1C03	1200	SF	2.00	16.76 45	-	1.80

JOB NO. 41552-050

SHEET 51 OF 87

DESIGNED BY DVDF DATE 3/95

CHECKED BY CAT DATE 3/25

[illegible]

ITEM	WBS	QTY	UNIT	FACTOR LABOR	RATE TAG	\$ MAT'L	\$ EQUIP
<u>FIRST FLOOR</u>	CR003						
1 ST FLOOR SLAB		4800	SF	0.15	16.76 45	0	0.52
SHORING / SCAFFOLD		48	CST	0.640	23.70 73	\$120	-
SAW CUT 1 ST FLOOR DEMO SLAB		185	LF	1.70	16.76 45	3.84	
SAW CUT 1 ST FLOOR FOR NEW WALLS		450	LF	0.20	16.76 45	2.16	3.00
DEMO FLOOR STRIPS		5400	SF	0.133	16.76 45	-	0.51
DEMO EXISTING WALL 1 ST FLOOR		725	SF	3.50	16.76 (45)	-	1.52
DEMO WALL @ GARAGE		64	SF	3.0	16.76 45	-	1.52
REMOVE FTG @ ENTRANCES GARAGE		24	LF	0.286	16.76 45	-	3.85
SAW CUT FOR INTAKE		84	LF	1.20	16.76 45	5.76	9.12

⇒ ICF KAISER

ENVIRONMENT & ENERGY GROUP

JOB NO. 41952-086

SHEET 52 OF 87.

DESIGNED BY DJOE DATE 3/95

CHECKED BY CAE DATE 3/25

13 782	500 SHRTS, FILTER	5 SQUARE
42 281	50 SHRTS EYE-EASE	5 SQUARE
42 282	100 SHRTS EYE-EASE	5 SQUARE
42 389	200 SHRTS EYE-EASE	5 SQUARE
42 392	100 RECYCLED WHITE	5 SQUARE
42 393	200 IN CYCLED WHITE	5 SQUARE

Made in U.S.A.

ITEM	WBS	QTY	UNITS	LABOR TAXES	LABOR RATE	UNIT MATERIAL	UNIT EQUIP
ROOF DETACH FOR EXHAUST	C1003	120	SF	0.20	16.76 45	0	1.00
SHORING		1	C/SF	0.640	23.70	20	—
SAWCUT ROOF		68	LF	1.70	73 16.76 45	384	16.00
HAULING - RUBBLE		11	YD	1.20	19.88 53	500	29.75
SWEEP UP LOAD DEBRIS		650	CY	0.50	16.76 45		1.00
LOAD TRUCKS & PILE RUBBLE		650	CY	0.50	19.88 53	500	10.00
DUMP FEES		80	TONS	—	—	16.00	—

SHEET 53 OF 87

CHECKED BY CAE DATE 3/95

SHEET A2

REMOVES LOUVERS / IRON WORK / ETC.

104 LF

SAT 2 IRON WORKERS 2 DAYS (24 HRS)
W/ BRUSHES \$30 EQUIP & MAT'L

LABORER/OPERATOR - 1 DAY TO

(TAKE DOWN CRANE \$550 / DAY) NO-USE WINCH & HAND LOAD TRUCK

Haul - 4 hrs @ 19.88/hr + dump fees
(10 tons)

REMOVE ROOFING = 1380 SF.
INSULATION & GRAVEL.

[illegible]

SHEET A3

LOWER DEMO $\rightarrow$ SEE METRIC ESTIMATE

✓ INTAKE VENT → SEE P. 7

SHARP ACT → SELF ESTIMATE

SHEET A5

✓ VESTIBULAR WAVE = $\frac{(1.0)(25-8)(10.)}{27} = 6.3 \text{ ug}$

WAYS FOR
NEW STARLWAY = $\frac{(25)(36)(1.0)}{27} = 33 \text{ yrs}$
(SOUTH END)

✓ STAIRS - 2ea @ 2,400 (QUOTE)
(N $\frac{1}{2}$ S)

1 VAULT DOOR. $\frac{1}{2}$ JAMB

1 BALISTIC DOOR 4 JAMB

STEEL BARRIERS - $12 \frac{1}{4} \times 4 \times 45 \times 200 = 3700 \text{ lb}$

13 787	500 SHELTERS	5 SQUARE
47 361	50 SHELTERS	5 SQUARE
47 362	100 SHELTERS	5 SQUARE
47 363	200 SHELTERS	5 SQUARE
47 364	100 IN CYCLO WHITE	5 SQUARE
47 365	200 IN CYCLO WHITE	5 SQUARE

MADE IN U.S.A.

NIMSE

JOB NO.

SHEET 55 OF 87

DESIGNED BY DAF DATE 5/75

CHECKED BY CAE DATE 3/95

TUBE x PER CHASE :

$$(12)(10)(1) = 120 \text{ cr}$$

$$(2)(14)(10)(1) = \frac{280 CF}{300 CF}$$

12cy.

SHEET A6

CONCRETE WALLS (1'0")

TUBE LOADING $\approx 11 \text{ k}\Omega$

IN PROCESS #1 = 11 d

IN PROCESS #2 = 7d

WASANT HAN

$$8 \times 72\text{ ft} = 576 \text{ SF}$$

FAULT MONITOR = $(15)(8) = 1200 \text{ SF}$

4. BAWSTIK DOORS 73 x 7

-2- 3'-0" x 7'-0" VENT DOORS

2- 8x7 BAMBIZ DOORS

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SHEET 56 OF 87

CHECKED BY CAE DATE 3/25

SHEET A7

$$\text{NEW CONC WAUS (12")} = \frac{(450 \text{ LF})(13.87)(1.0)}{27} = 232 \text{ d}$$

FOOTINGS

$$(3)(450)(2.0)/27 = 100 \text{ cf.}$$

(JUST FILL HOLE UP W/ CONCRETE &
FIN BUT)

CMU PARTITIONS = 2300 SF

SEE ESTIMATE FOR FINISHES &
SINKS, ETC.

SHEET 48

SEE ESTIMATE

500 SH#125, FATH 5 SQUAR
50 SH#125 EYE FAST 5 SQUAR
100 SH#125 EYE FAST 5 SQUAR
200 SH#125 EYE FAST 5 SQUAR
100 1R CYCLED WHITE 5 SQUAR
200 1R CYCLED WHITE 5 SQUAR

Sheet 57 of 87 left intentionally blank.

NIMSE

JOB NO. 4132-086

SHEET 58 OF 87

DESIGNED BY DWSE DATE 3/95

CHECKED BY CAE DATE 3/95

13 7K2 500 SHEETS, FULL 5 SQUARE
42 3K1 50 SHEETS EYE EASY 5 SQUARE
42 3K2 100 SHEETS EYE EASY 5 SQUARE
42 3K3 200 SHEETS EYE EASY 5 SQUARE
42 3K4 100 RECYCLED WHITE 5 SQUARE
42 3K5 200 RECYCLED WHITE 5 SQUARE
Made in U.S.A.

WT OF 4'x4' SPAN BE'S = (12)(12) = 144 #^{ea}.

$$\left(\frac{28.33}{33} + 1 \right) (144) = 12507 \text{ LB}$$

WALK SPAN BE'S

$$(144) (28.33/4) = 1020 \text{ #}^{\text{ea}}$$

$$\left(\frac{43}{4} + 1 \right) (1020) = 13260 \text{ LB}$$

$$12507 + 13260 = 25767 \text{ LB / ea section}$$

$$\underline{26,000 \text{ #}}^{\text{#}} \text{ BSN @ EXHAUST + 65,000 @ INTAKE}$$

FIBEROPTIC DETECTION CABLES

?

Sheet 59 of 87 left intentionally blank.

SHEET 61 OF 87

DESIGNED BY

DATE _____

CHECKED BY

DATE _____

ARMED/BIAUTIC DOORS $3 \times 7 = 4$

✓ VAULT DOORS - $3 \times 7 = 2$

✓ ARMED/BLASTIC 8x7 doors = 2

$$C_{CTV} = 3 \text{ ea}$$

SNM DETECTOR = 1 ea.

SHEET A 17

- INDUSTRIAL DOORS (3x7) = 1'6" ea

✓ INDUSTRIAL DOORS (8x7) = 2 ea.

✓ ALARMED / BALLISTIC DOORS (3x7) = 6 ea.

$$(8\sqrt{7}) = 3 \text{ cm}$$

✓ VAULT DOORS (3x7) = 4 ea.

✓ " " $(8 \times 7) = 1 \text{ ea}$

Sparks
pools
do sinker

NHSE

JOB NO.

SHEET

OF 87

DESIGNED BY

DATE 2/15

CHECKED BY

DATE 3/9/

UTILITY BUILDING - SHEET A18.

ASSUME 60 PSF ROOF LOAD

JOBS SPACED @ 2' 0" O.C.

FROM VULCAFT CATALOG -

$$\omega / \omega = (2)(60) = 120 \text{ pwr}$$

$$Q = 32 \mu$$

USE 18K5 JOIST, 7.745/FT

ROOFING :

$$40 \times 50 = 2000 \text{ SF @ } 0.80$$

20012/FRAMS: 1 ea @ 3'x7'

DOOR HARDWARE: 1 SET @ \$500 ±

OVERHEAD POOL = \$360 8' x 8'

MASONRY = 8" CMU REINFORCED.

2.49 / SF

[illegible]

National Brand

STANDARD LOAD TABLE / OPEN WEB STEEL JOISTS, K-SERIES

63 OF 87

Based on a Maximum Allowable Tensile Stress of 30,000 psi

JOIST DESIGNATION	18K3	18K4	18K5	18K6	18K7	18K9	18K10	20K3	20K4	20K5	20K6	20K7	20K9	20K10	22K4	22K5	22K6	22K7	22K9	22K10	22K11
DEPTH (IN.)	18	18	18	18	18	18	18	20	20	20	20	20	20	20	22	22	22	22	22	22	22
APPROX. WT. (lbs./ft.)	6.6	7.2	7.7	8.5	9.0	10.2	11.7	6.7	7.6	8.2	8.9	9.3	10.8	12.2	8.0	8.8	9.2	9.7	11.3	12.6	13.8
SPAN (ft.)																					
18	550	550	550	550	550	550	550														
19	514	550	550	550	550	550	550														
20	463	550	550	550	550	550	550	517	550	550	550	550	550	550							
21	420	506	550	550	550	550	550	468	550	550	550	550	550	550							
22	382	460	518	550	550	550	550	426	514	550	550	550	550	550	550	550	550	550	550	550	550
23	349	420	473	516	550	550	550	389	469	529	550	550	550	550	518	550	550	550	550	550	550
24	320	385	434	473	526	550	550	357	430	485	528	550	550	550	475	536	550	550	550	550	550
25	294	355	400	435	485	550	550	329	396	446	486	541	550	550	438	493	537	550	550	550	550
26	272	328	369	402	448	538	550	304	366	412	449	500	550	550	404	455	496	550	550	550	550
27	252	303	342	372	415	498	550	281	339	382	416	463	550	550	374	422	459	512	550	550	550
28	234	282	318	346	385	463	548	261	315	355	386	430	517	550	348	392	427	475	550	550	550
29	218	263	296	322	359	431	511	243	293	330	360	401	482	550	324	365	398	443	532	550	550
30	203	245	276	301	335	402	477	227	274	308	336	374	450	533	302	341	371	413	497	550	550
31	190	229	258	281	313	376	446	212	256	289	314	350	421	499	283	319	347	387	465	550	550
32	178	215	242	264	294	353	418	199	240	271	295	328	395	468	265	299	326	363	436	517	549
33	168	202	228	248	276	332	393	187	226	254	277	309	371	440	249	281	306	341	410	486	532
34	158	190	214	233	260	312	370	176	212	239	261	290	349	414	235	265	288	321	386	458	516
35	149	179	202	220	245	294	349	166	200	226	246	274	329	390	221	249	272	303	364	432	494
36	141	169	191	208	232	278	330	157	189	213	232	259	311	369	209	236	257	286	344	408	467
37	128	156	178	194	218	262	312	148	179	202	220	245	294	349	198	223	243	271	325	386	442
38	118	146	168	184	208	250	300	138	169	192	210	235	284	339	188	213	233	261	315	376	432
39	108	136	158	174	198	240	290	128	159	182	200	225	274	329	178	203	223	251	305	366	422
40	98	126	148	164	188	230	280	118	149	172	190	215	264	319	168	193	213	241	295	356	412
41	88	116	138	154	178	220	270	108	139	162	180	205	254	309	158	183	203	231	285	346	402
42	78	106	128	144	168	210	260	98	129	152	170	195	244	299	148	173	193	221	275	336	392
43	68	96	118	134	158	200	250	88	119	142	160	185	234	289	138	163	183	211	265	326	382
44	58	86	108	124	148	190	240	78	109	132	150	175	224	279	128	153	173	201	255	316	372

ENVIRONMENT & ENERGY GROUP

JOB NO. 41552-056

SHEET, 64 OF 87

DESIGNED BY DWF DATE 3/95

CHECKED BY CAE DATE 3/25

Footnotes -

WT OF WALK SECTION: / (PER LF)
 $(0.67)(125)(16) = 1340 \text{ LB}$

LOAD ON ROOF

$$(60 \text{ PRF})(32/2) = \underline{960 \text{ LB}}$$

2300 VB/4F

ASSUME ALLOWABLE SOIL PRESSURE = 2000 ~~psf~~

$$\frac{2300^{\#}}{2\text{ FT}} = 1150 \text{ psf} \leq 2000 \text{ psf}$$

OK.

USE 1'-0" TH X 2'-0" WIDE CONC. FTG.

DISTRIBUTING, INC.

4700 National Western Drive Denver, Colorado 80216 (303) 292-2111

05/87

TELECOMMUNICATIONS COVER PAGE

COMPANY: ICF KAISER ENGINEERS, INC.

ATTENTION: CHRIS EHRSAM

RE: PUEBLO COMPLEX - 2 STAIR TOWERS

FROM: BOB DANGEL

TOTAL NUMBER OF PAGES (INCLUDING COVER PAGE): 1

DATE: 3-3-95 TIME: 10:00

IF YOU DID NOT RECEIVE ALL PAGES PLEASE CALL 303-292-2111.

ADDITIONAL NOTES:

TWO 40 RISER STAIR TOWERS
WITH STAIR UNIT WIDTHS 3'-8" AND A
4'-0" GAP IN EXISTING STAIR WELL AND A
2'-6" GAP IN NEW STAIR WELL. EACH
TOWER TO INCLUDE 2 INTERMEDIATE
AND 2 FLOOR LEVEL LANDINGS. BECAUSE
OF THE GAP BETWEEN THE STAIR UNITS
A 42" RAIL WITH GRAB BAR IS REQUIRED
TO MEET CODE AT THE STAIR WELL
INTERIOR. SINGLE LINE WALL RAIL IS
INCLUDED AT THE EXTERIOR WALL
LOCATIONS. COLUMNS ARE ALSO INCLUDED
TO CARRY THE LANDINGS AT THE EXISTING
STAIR (TO BE HIDDEN IN THE 6" WOOD
STUD WALL) LOT ERRECTED \$42,800⁰⁰

FAX NO: 303-292-1670

VENDOR QUOTE

6/6/87

JOB TITLE: NMSP RENOVATION

DISCIPLINE: GEOTECHNICAL/STRUCT

NAME: PEREVALLENAS DATE: 3/4/95

VENDOR: SHANNON/WILCO

NAME: PAUL GRANT

PHONE: 206-632-8020

DESCRIPTION:

GEOTECHNICAL INVESTIGATION TO
EVALUATE SOIL STRAINS SUITABLE FOR
DETAILED SEISMIC INVESTIGATION

ITEM:

COST: (\$)

HIGH STRAIN DATA, 2 BORE-
HOLE 150 FT DEEP &
ANALYSIS

75,000 ±

(WILL SEND QUOTE LATER)

COMMENTS:

ROUGH QUOTE ONLY.

ICF KAISER ENGINEERS

1900 Diamond Drive
Los Alamos, New Mexico 87544

ENVIRONMENT & ENERGY GROUP

NYK

JOB NO. 41552-056

SHEET 67 OF 87

DESIGNED BY DJP DATE 3/95

CHECKED BY CAE DATE 3/55

13 782	500 SHELFS, FULL	5 SQUARE
42 781	500 SHELS, FAS	5 SQUARE
42 780	100 SHELS, FAS	5 SQUARE
42 779	200 SHELS, FAS	5 SQUARE
42 782	100 IN CYCLED WHITE	5 SQUARE
42 780	200 RECYCLED WHITE	5 SQUARE

MADE IN U.S.A.

SUPPLEMENTAL

ESTIMATE TAKEOFF

DATA

COST ESTIMATING TAKEOFF FORM

JOB TITLE: NMSE

ESTIMATE DESCRIPTION: DEMOLITION @ NMSE, PF-41

NAME: C. EHRMAN
S. MURPHY

DATE: 2-10-95

JOB #:

ICF KAISER ENGINEERS

1900 Diamond Drive
Los Alamos, New Mexico 875

ITEM #	CSI WBS	DESCRIPTION	QTY.	UNITS	MATERIALS (COST/UNIT)	MAN HRS PER UNIT	LABOR ID	EQUIP. RENTAL
		DEMOLITION @ BASEMENT LEVEL						
		→ REMOVE 3-HANGING PLATFORMS ✓	117	SF		.022	45	
		STAIR #1 INTERIOR DEMOLITION (18,500)	37	RISERS		.400	45	2.96
		SCAFFOLDING	8	CCF	31.50	1.057	45	
		STAIR #2 INTERIOR DEMOLITION (18,500)	37	RISERS		.400	45	2.96
		✓ REMOVE CORE WALL @ STAIR #2 14 LF x 1.6w x 10 FT H	560	SF		.400	45	1.52
		REMOVE STUD WALLS @ STAIR #2 11'	26	LF		.010	45	
		REMOVE STUD PARTITION WALLS 11'	232	LF		.010	45	
		✓ REMOVE 1" THICK CORE WALLS	1700	SF		.400	45	1.52
		✓ REMOVE CORR. FORMS & BRACES	47	SF		.400	45	1.52
9		REMOVE DOORS (16" EA)	27	EA		.400	45	
10		REMOVE GUIDE RAIL (PER MORRIS) (720)	520	LF		.400		1.57
11		REMOVE CROSS MEMBER (PER MORRIS)						

COMMENTS:

2/10

2

DATE:

ICF KAISER ENGINEERS 1902 Diamond Drive
Los Alamos, New Mexico 8754

ICF KAISER ENGINEERS

1902 Diamond Drive
Los Alamos, New Mexico 8754

1287

COMMENTS:

3

DATE:

ICF KAISER ENGINEERS 1902 Hammond Drive
Los Alamos, New Mexico 875

ICF KAISER ENGINEERS

181	
-----	--

COMMENTS:

COST ESTIMATING TAKEOFF FORM

4

JOB TITLE: NMSF

NAME:

DATE:

ESTIMATE DESCRIPTION: DEMOLITION @ 1ST FLR LEVEL

ICF KAISER ENGINEERS

1903 Diamond Drive
Los Alamos, New Mexico 875

JOB #:

ITEM #	CSI WBS	DESCRIPTION	QTY.	UNITS	MATERIALS (COST/UNIT)	MAN HRS PER UNIT	LABOR ID	EQUIP. RENTAL
1		Remove Concrete Tramp	135	SF		.100	45	1.52
2		" STUD WALLS	584	LF		.010	45	
3		" 1" THK CONG WALLS	8175	SF		.100	45	1.52
4		" 1" THK CONG WALLS	210	SF		.100	45	1.52
5		REMOVE 6" SLAB	3120	sq ft		.017	45	.22
6		REMOVE 6" SLAB (57'x60')	3910	SF		.220		.37
7		Hand Grind & Compact	10	SY		.034		.07
8		Pour 6" SLAB	72	CY	60.00	2.0	61	10.00
9		REMOVE CONG. SLAB (6")	80	SF		.220		.37
10		Remove Acoustic Ceiling	1420	SF		.022	45	
11		Remove Crp. Bd Ceiling	2350	SF		.021		
12		Remove Paint Sand blasting	1	SF	26	.057		.22

COMMENTS:

COST ESTIMATING TAKEOFF FORM

5

JOB TITLE:

NAME:

DATE:

ESTIMATE DESCRIPTION: Demolition of 1st flr.

JOB #:

ICF KAISER ENGINEERS

1902 Randolph Drive
Los Altos, New Mexico 875

ITEM #	CSI	WBS	DESCRIPTION	QTY.	UNITS	MATERIALS (COST/UNIT)	MAN HRS PER UNIT	LABOR ID	EQUIP. RENTA
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13			Remove Flr. coverings	18,500	SF		.040	45	.30
----	--	--	-----------------------	--------	----	--	------	----	-----

14			Remove Doors	53	EA				
----	--	--	--------------	----	----	--	--	--	--

15			Remove counter top	12	LF				
----	--	--	--------------------	----	----	--	--	--	--

16			Remove locker	12	LF				
----	--	--	---------------	----	----	--	--	--	--

17			Remove lavatory	4	EA				
----	--	--	-----------------	---	----	--	--	--	--

18			Remove urinal	1	EA				
----	--	--	---------------	---	----	--	--	--	--

19			Remove water closet	3	EA				
----	--	--	---------------------	---	----	--	--	--	--

20			Remove Access panels	12	EA				
----	--	--	----------------------	----	----	--	--	--	--

21			Remove FIRE EX. CABINET	5	EA				
----	--	--	-------------------------	---	----	--	--	--	--

22			Remove steel ladder	1	EA				
----	--	--	---------------------	---	----	--	--	--	--

23			Remove 2-11'x10' platforms	400	SF				
----	--	--	----------------------------	-----	----	--	--	--	--

24									
----	--	--	--	--	--	--	--	--	--

COMMENTS:

28/01

COST ESTIMATING TAKEOFF FORM

JOB TITLE:

10 X

NAME:

DATE:

ESTIMATE DESCRIPTION:

220 sq ft

JOB #:

ICF KAISER ENGINEERS

10111 (Harwood Drive)
10111 (Harwood Drive)
10111 (Harwood Drive)

ITEM #
CSI WBS

DESCRIPTION

QTY. UNITS

MATERIALS
(COST/UNIT)

MAN HRS
PER UNIT

LABOR
ID

EQUIP.
RENTAL

Boiler flue

2

EA

500

10

DOUBLE CONCRETE PILING
(NOTE)

380

LF

35.00

0.6

EXISTING CONCRETE

295

YF

0.471

TRUCKING

470

CF

0.2

GRASS REMOVAL FOR PILE

18

CY

7.50

0.03

REPLACE CONCRETE IN

TRUCK CUT (INSTRUMENT)

6

CY

200

DOUBLE CONCRETE 90° ELBOW

8

EA

173

0.2

DOUBLE CONCRETE 45° ELBOW

4

EA

189

0.2

DOUBLE CONCRETE P-PILE

12

EA

650

0.4

DOUBLE CONCRETE - SPLIT

5

EA

591.5

0.2

COMMENTS:

[illegible]

DATE:

John Hammond (Vice)
105 Alameda New Mexico 8/54

[illegible]

COMMENTS:

11/87

on resistance encountered in drilling this material, as well as previous experience in this area, the tuff can be excavated by first ripping utilizing a large tractor with a single shank ripper. The material generally breaks down readily for placement as structural fill.

Temporary open cut slopes in the overburden soils should be made with side slopes of 1 to 1 (horizontal to vertical). Cuts within the tuff can be made at 1/4 to 1 slopes (horizontal to vertical).

Permanent cut slopes within the overburden soils and the tuff can be made at 2 to 1 and 1 to 1 (horizontal to vertical) slopes, respectively. Slopes in fill sections comprised of overburden soils or reworked tuff rock should be made at 2 to 1 grades or flatter.

5.7 Factors for Earthwork Computations

In performing the earthwork cut and fill balances, it is recommended that the following earthwork factors be utilized to compensate for the change in material volume from cut sections to fill sections. These factors are a percentage of the initial volume of material in the cut section.

<u>Material</u>	<u>Earthwork Factor</u>
Overburden Soil, 0-5 foot cut	25% Shrink
Volcanic Tuff	5% Shrink

SERGENT, HAUSKINS & BECKWITH

CONSULTING GEOTECHNICAL ENGINEERS
P.O. BOX 1000, ALAMOS, N.M. 87511

10/87

The alignment is moderately rolling, topographically. Based on visual inspection, it appears that maximum cuts and fills on the order of 15.0 feet will be required to achieve the required road grade.

4.2 Geotechnical Profile

As indicated by the exploratory borings, the subsoils underlying the site can be characterized into a two-strata system as follows:

- A. Alluvial deposits consisting of clayey and silty sands and sandy clays with lesser deposits of sandy silts extend to depths of about 2 to 7 feet below existing grade at boring locations within the building area, and to a maximum of 2 feet along the road alignment. These soils vary from moderately firm to firm and are of low plasticity to nonplastic.
- B. Volcanic tuff underlies Stratum A and extended to the full depth of the borings. The ~~tuff is~~ generally soft, geologically; however, it is a firm to hard material from an engineering standpoint, and is an excellent foundation material.

4.3 Soil Moisture & Groundwater Conditions

No free groundwater was encountered in the borings. Soil moisture contents were relatively low, being below the plastic limit for the clayey soils.

SERGENT, HAUSKINS & BECKWITH

CONSULTING GEOTECHNICAL ENGINEERS
INCORPORATED - 1000 PASEO DE LA MAR - SAN DIEGO, CALIF. 92101

NM5F CPR

DESIGNED BY C. Ehrig DATE 1/95

CHECKED BY DATE

10' x 10' ROOM NEAR GARAGE

REMOVE ASPHALT

REMOVE CONCRETE PAD

EXCAVATE FOR FOOTINGS

$$2'W \times 3'D \times 20'L = 120 CF$$

$$4.5 CY$$

COMPACTION @ FOOTINGS

SET PATTERN BOARDS

PLACE REBAR

POUR CONCRETE 1.5 CY

PLACE A.B. FOR WALL CONNECTIONS

REMOVE FORMS

REMOVE DEBRIS

NIMSF CDR

DESIGNED BY C. Ehrsum DATE 1/25

CHECKED BY DATE

REMODELING OF ENTRANCE

REMOVE EXISTG STAIRS & PORTION OF PLANTER 10' x 35'
350 SF.

COMPACT SOIL

PLACE FORMS & REBARS

POUR CONCRETE 10' x 35' x 6" = 65 CY

REMOVE FORMS

REMOVE DEBRIS

COST ESTIMATING TAKEOFF FORM

JOB TITLE: NMSF

NAME: C. Ennsam

DATE: 1/31/95

ESTIMATE DESCRIPTION:

JOB #:

ICF KAISER ENGINEERS

1900 Diamond Drive
Los Alamos, New Mexico 87544

ITEM #	CSI WBS	DESCRIPTION	QTY.	UNITS	MATERIALS (COST/UNIT)	MAN HRS PER UNIT	LABOR ID	EQUIP. RENTAL
1.		EARTHWORK						
		Strip top soil	1500	CY	-	0.50	Equip	6.60
		Strip volcanic tuff	1000	CY	-	0.50	Equip	6.00
		Load trucks	2500	CY		0.25	Equip	10 -
		Drive time 4000/16 =	140	RT	-	1	truck	225
		Pump fees - store	140	RT	100 -	-	-	-
		Erosion Control - Jute mat	400	SY	.65	0.010		
2.		SITE GRADING						
3.		SURVEY - SET GRADE STAKES						
		3 days, 2 people						

COMMENTS:

10/10

COST ESTIMATING TAKEOFF FORM

JOB TITLE: NMSF

NAME: C. E. Hysum DATE: 1/31/95

ESTIMATE DESCRIPTION:

JOB #:

ICF KAISER ENGINEERS

1900 Diamond Drive
Los Alamos, New Mexico 87544

ITEM #	CSI WBS	DESCRIPTION	QTY. UNITS	MATERIALS (COST/UNIT)	MAN HRS PER UNIT	LABOR ID	EQUIP. RENTAL
4	020	Construction of 10' x 10' Room @ Garage					
020	020	Demolish existing pavement	100 SF	0.010	45/15.73		0.10
020	020	Backhole / Ram	100 SF	0.005	53/19.88		1.00
022		Excavate for Footings	4.5 CY	0.5	45/15.73		45.00
033		Form and Pour Footings 24" x 1' T x 20	1.5 CY	107	73/23.70		10.95
033		Form & Pour Stem Walls 1.5 x 1 x 20	1.5 CY	125	73/23.70		15.00
022		Install gravel fill for slab 6" Thick x 100	50 SF	0.35	45/15.73		0.125
1033		Pour Slab 6" Thick	2 CY	60	60/21.72		10-
033		Pour 1' Thick Cast in Place Wall 10' H	7.5 CY	125	73/23.70		16.00
033		Form & Pour Conc. Roof 100 SF x 1' Thick	2 CY	125	73/23.70		16.00
021		Haul Debris	2 CY	-	0.010	47/17.94	
		Load on Tractor	2 CY	-	0.160	53/19.88	
		Sweep / Clean up	2 CY	-	0.160	45/15.73	

COMMENTS:

10/1/95

COST ESTIMATING TAKEOFF FORM

JOB TITLE: NMSF

NAME: C Ehrmann DATE: 1/31/25

ESTIMATE DESCRIPTION:

JOB #:

ICF KAISER ENGINEERS 1902 Diamond Drive
Los Alamos, New Mexico 87544

ITEM #	CSI WBS	DESCRIPTION	QTY.	UNITS	MATERIALS (COST/UNIT)	MAN HRS PER UNIT	LABOR ID	EQUIP. RENTAL
#		Remodeling @ MAIN Entrance stairs & ramp -						
	020	Remove 12' x 34' of exist. conc. walk, planter, asphalt.	103	SF	-	0.60	45/15.73	1.00
	022	Excavate for footings 30" deep	7	CT		0.5	45/15.73	45.00
	033	FORM and pour WALLS -	2.5	CT	125	.5.1	73/23.70	16.00
	022	Backfill understairs, ramp & Landing	9	CT	10	0.30	45/15.73	4.00
	033	pour STAIRS & ramp	35	LF NOS	6.00	.75	73/23.70	1.00
	033	FORM & pour sidewalk to stairs	2	CT	107	3.0	73/23.70	8.00
	055	install handrails	63	LF	15.00	0.30	85/29.16	2.0
	021	HAUL Debris	8	CT	-	.010	49/17.94	4.00
		Load on truck	8	CT	-	0.16	53/19.88	10.00
		Load/sweep/clean-up	8	CT	-	0.16	45/15.73	-

COMMENTS:

10/10

COST ESTIMATING TAKEOFF FORM

JOB TITLE: NYSE

ESTIMATE DESCRIPTION: MECHANICAL REPAIRING / ROOF

JOB #: 41852-056-00

ICF KAISER ENGINEERS

1001 Diamond Drive
Los Angeles, New Mexico 875

NAME: CE

DATE: 2/95

ITEM #	CSI WBS	DESCRIPTION	QTY.	UNITS	MATERIALS (COST/UNIT)	MAN HRS PER UNIT	LABOR EQUIP. ID RENTAL
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30' x 46' x 10' CL4 HT
MAH RENTHOUSE

1. 05 BEST STRUCTURAL STEEL

BEAMS - W10 x 22

7176 LBS 0.50 0.02 85/27.93 0.10

COLUMNS - W8 x 24 x 12' 8"

8880 LBS 0.50 0.02 85/27.93 0.10

RAFTERS - 2x8

1 LOT 100 8.0 85/27.93 0.10

CRATE

2. 05 ROOFING - 20 ga - 3" DECK

1330 SF 1.00 0.01 85/27.93 0

3. 05 GIRTS - C8 x 11.5

5714 LBS 0.50 0.02 85/27.93 0.10

4. 05 SIDING (1/2" STEEL)

150 SF 1.00 0.01 85/27.93 0

5. 05 DOOR

1 ea. 1450 2.0 13/23.32 0

6. 08 DOOR FRAME - DOUBLES

1 ea. 100 1.50 13/23.32 0

7. 08 WHEELWAX

1 ea. 225 1.0 13/23.32 0

8. 08 COMMENTS:

3/4/95

COST ESTIMATING TAKEOFF FORM

20 -

JOB TITLE: NMSP RENOVATION

NAME: DVOZ

DATE: 3/95

ESTIMATE DESCRIPTION: EXTERIOR BUTTRESSES

JOB #: 41552-056

ICF KAISER ENGINEERS

1900 Diamond Drive
Los Alamos, New Mexico 87544

ITEM #	CSI WBS	DESCRIPTION	QTY.	UNITS	MATERIALS (COST/UNIT)	MAN HRS PER UNIT	LABOR ID	EQUIP. RENTAL
		INSTALL EXTERIOR BUTTRESSES - 2FT X 4FT						
		DRILL 5'-0" X 36'-0" DEEP HOLES						
		W/ CAISSON RIG INSTEAD OF EXCAVATOR, USE NOTCHED CABLING / PILE						
		AS SHORING -						
1.0023		MAKE CONNECTIONS / INSTALL INSIDE TO OPS @ COLUMN LINES.	5	ea	300	24	16176 45	18 ⁰⁰
2.0023		EXCAVATION, CONCRETE REINFORCING 5'-0" CAISSON X 36 DEEP.	180	VLF	95 ⁰⁰	01533	85/29.62	19 ⁰⁰
3.0023		INSPECTION	5	ea	-0-	7.00	99/24.88	-
4.0023		MOBILIZATION (BACKHOE 5/214)	1	ea	2100-			
5.0021		LOAD SPOILS	150	cy	-0-	0.02	53/19.88	2.00
6.0021		HAUL SPOILS & DUMP FEES	12	RT	16.00	4.00	49/18.60	70
7.003		MISC. FORMWORK @ TOP 5'-0"	350	ft ²	2.00.	0.25	73	0

COMMENTS:

TOP 5'-0"

1.0/60

COST ESTIMATE, TAKEOFF FORM

1 of 1

JOB TITLE: NAF RENOVATION

ESTIMATE DESCRIPTION: ROOF REINFORCEMENT

JOB #: 41552-056-00

ICF KAISER ENGINEERS

1900 Diamond Drive
Los Alamitos, New Mexico 87544

NAME: DR. F

DATE: 3/95

ITEM #	CSI	DESCRIPTION	QTY. UNITS	MATERIALS (COST/UNIT)	MAN HRS PER UNIT	LABOR ID	EQUIP. RENTAL
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1.	CR03	REMOVE TOPPING (3") PRECAST DOUBLES TEES ROOF DEMOLITION/OVER	5500 SF	0	0.20	45/16/76	0.32
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2	CR05	ROOFING REMOVAL (INCL. GRAVEL)	5500 SF	0	0.06	45/16/76	0
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3.	CR05	REMOVE INSULATION BOARD	5500 SF	0	0.013	45/16/76	0
----	------	----------------------------	---------	---	-------	----------	---

4.	CR03	REINFORCEMENT OF EXISTING ROOF - 24" x 12" CON. BMS @ 4'-0" O.C.	100 LF	\$ 175	24	73/23/70	75
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5.	CR03	NEW CONC BEAMS (24" x 12") - INCREASE DUE TO DIFFICULTY OF WORKING INSIDE EXISTING STEEL STUBS & CUT HOLES IN ROOF	25 BEAMS	\$500	16	45/16/75	25
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COMMENTS:

18/92

129

22

81

28

64

21

20年

NAME: DJCF

DATE: 3/95

ICF KAISER ENGINEERS 1900 Diamond Drive
Los Alamos, New Mexico 87544

JOB #:

2	2
	12
	5
	5
	2
	<u>4</u>

COMMENTS:

$$\frac{87}{87}$$

REFERENCES

NMSF TOPO

object: ta55

Thu Dec 8 12:06:21 1994

point statistics:

Starting point number: 1
 Max point number used: 5501
 Min point number used: 1
 Current point number: 5002

Current Coordinate Listing (All)

Point	Northing	Easting	Elevation	Description
1	1769415.50	1624270.26	7311.28	55 1
2	1769236.36	1624431.95	7302.10	55 2
101	1769491.80	1624483.36	7319.92	AUX101
102	1769637.45	1624393.70	7302.75	AUX102
103	1769448.25	1624625.08	7296.93	AUX 103 GV
1000	1769389.59	1624379.15	7320.99	WALL COR TOP
1001	1769388.89	1624378.62	7320.98	WALL COR TOP
1002	1769361.02	1624415.14	7320.97	WALL COR TOP
1003	1769361.77	1624415.67	7320.97	WALL COR TOP
1004	1769361.76	1624416.31	7319.84	BLDG COR
1005	1769356.83	1624412.52	7316.94	BLDG COR
1006	1769356.83	1624412.51	7317.46	CONC PAD TOP
1007	1769359.21	1624409.59	7317.35	CONC PAD TOP
1008	1769362.91	1624412.31	7317.37	CONC PAD TOP
1009	1769360.67	1624415.26	7317.46	CONC PAD TOP
1010	1769359.00	1624414.15	7317.95	FF CEN 3FT DOOR
1011	1769368.52	1624404.95	7318.64	GRND AT WALL
1012	1769378.56	1624391.86	7319.20	GRND AT WALL
1013	1769388.85	1624378.42	7319.07	GRND AT WALL
1014	1769389.80	1624379.13	7318.63	GRND AT WALL
1015	1769443.91	1624419.54	7319.64	TOB
1016	1769431.53	1624409.51	7319.61	TOB
1017	1769418.23	1624398.27	7319.47	TOB
1018	1769406.10	1624388.78	7319.53	TOB
1019	1769388.24	1624374.22	7318.64	TOB
1020	1769378.36	1624385.20	7318.84	TOB
1021	1769368.02	1624397.93	7318.70	TOB
1022	1769353.33	1624416.89	7316.38	TOB
1023	1769345.59	1624414.35	7314.94	TOB
1024	1769333.62	1624409.63	7310.96	TOB
1025	1769322.93	1624403.85	7308.67	TOB
1026	1769309.64	1624394.68	7306.58	TOB
1027	1769293.45	1624386.29	7304.69	TOB
1028	1769293.43	1624386.31	7304.69	EDGE OF RD
1029	1769309.57	1624369.66	7306.05	EDGE OF RD
1030	1769327.70	1624356.93	7307.37	EDGE OF RD
1031	1769347.19	1624348.60	7308.70	EDGE OF RD
1032	1769367.54	1624344.69	7310.19	EDGE OF RD
1033	1769388.56	1624346.54	7311.94	EDGE OF RD
1034	1769410.93	1624355.45	7312.96	EDGE OF RD
1035	1769431.66	1624366.07	7313.33	EDGE OF RD
1036	1769451.67	1624375.94	7313.53	EDGE OF RD
1037	1769465.49	1624381.82	7313.60	EDGE OF RD
1038	1769453.90	1624410.95	7315.40	TS

NMSF TOPO

Object: ta55

Thu Dec 8 12:06:24 1994

1039	1769442.11	1624401.34	7315.15	TS
1040	1769430.06	1624391.04	7315.04	TS
1041	1769417.60	1624379.46	7314.28	TS
1042	1769401.49	1624366.81	7314.05	TS
1043	1769385.79	1624355.63	7313.02	TS
1044	1769369.91	1624363.72	7312.63	TS
1045	1769356.77	1624377.35	7312.16	TS
1046	1769344.36	1624389.91	7311.67	TS
1047	1769329.70	1624406.98	7310.12	TS
1048	1769244.99	1624439.51	7302.08	EOR
1049	1769261.41	1624408.43	7301.81	EOR
1050	1769279.38	1624379.55	7303.18	TS
1051	1769302.32	1624355.25	7305.01	EOR
1052	1769323.01	1624340.56	7306.46	EOR
1053	1769354.03	1624325.43	7307.33	EOR
1054	1769366.31	1624319.17	7307.54	EOR
1055	1769393.10	1624299.57	7309.61	EOR
1056	1769412.04	1624279.15	7311.19	EOR
1057	1769421.93	1624291.46	7312.40	EOR
1058	1769403.35	1624311.16	7311.07	EOR
1059	1769386.60	1624329.54	7310.25	EOR
1060	1769414.63	1624336.18	7311.93	EOR
1061	1769439.28	1624337.95	7312.98	EOR
1062	1769444.35	1624334.30	7313.40	EOR
1063	1769434.72	1624318.21	7313.09	GRND
1064	1769419.56	1624311.55	7312.03	GRND
1065	1769426.44	1624294.15	7312.75	BC 55-215
1066	1769430.98	1624287.40	7312.94	BC 55-215
1067	1769463.98	1624309.69	7314.47	BC 55-215
1068	1769373.82	1624234.15	7304.99	GRND
1069	1769384.81	1624246.62	7305.60	GRND
1070	1769364.87	1624277.38	7305.82	GRND
1071	1769351.49	1624268.86	7305.26	GRND
1072	1769330.97	1624302.90	7305.41	GRND
1073	1769350.28	1624307.90	7305.95	GRND
1074	1769324.05	1624322.40	7305.65	GRND
1075	1769347.11	1624424.72	7311.81	BC
1076	1769343.81	1624429.33	7309.27	BC
1077	1769347.64	1624432.25	7309.64	BC
1078	1769329.36	1624455.84	7302.99	BOT STAIR
1079	1769313.05	1624476.99	7302.30	BC
1080	1769296.58	1624471.57	7302.45	FC
1081	1769274.85	1624454.58	7302.82	FC
1082	1769307.52	1624413.22	7303.06	FC
1083	1769328.49	1624430.16	7304.41	FC
1084	1769334.32	1624425.51	7306.42	TS
1085	1769322.98	1624415.83	7304.49	TS
1086	1769302.15	1624400.95	7304.00	TS
1087	1769287.69	1624392.94	7303.37	TS
1088	1769274.41	1624419.66	7302.12	EOR
1089	1769259.16	1624454.65	7302.55	EOR
1090	1769209.11	1624406.38	7301.52	TOB
1091	1769223.41	1624373.10	7301.77	TOB NAIL
1092	1769240.77	1624341.15	7301.77	TOB

NMSF TOPO

object: ta55		Thu Dec 8 12:06:26 1994		
1093	1769258.49	1624311.64	7302.01	TOB
1094	1769276.46	1624283.07	7302.29	TOB
1095	1769296.66	1624251.54	7302.59	TOB
1096	1769315.72	1624223.94	7302.79	TOB
1097	1769336.86	1624195.23	7302.74	TOB
1098	1769349.18	1624204.29	7301.00	FL
1099	1769328.80	1624229.87	7301.24	FL
1100	1769298.93	1624266.87	7301.13	FL
1101	1769287.67	1624299.54	7300.99	FL
1102	1769264.42	1624336.10	7300.88	FL
1103	1769242.05	1624383.12	7300.86	FL
1104	1769229.82	1624411.67	7300.95	FL
1105	1769293.33	1624332.72	7303.40	TOB
1106	1769334.23	1624256.03	7303.67	TOB
1107	1769355.96	1624217.20	7303.65	TOB
1108	1769316.01	1624152.97	7291.59	TS
1109	1769300.01	1624174.16	7291.83	TS
1110	1769254.90	1624233.62	7291.13	TS
1111	1769194.77	1624312.91	7287.60	TS
1112	1769152.60	1624364.94	7283.96	LT POLE
1113	1769220.52	1624276.23	7289.89	LT POLE
1114	1769284.14	1624195.17	7292.39	LT POLE
1115	1769278.39	1624207.51	7293.18	MH COR
1116	1769281.84	1624210.05	7293.36	MH COR
1117	1769279.27	1624213.65	7293.10	MH COR
1118	1769275.85	1624210.88	7292.86	MH COR
1119	1769309.55	1624152.77	7289.55	FL ASPH SWL
1120	1769278.39	1624189.58	7288.10	FL ASPH SWL
1121	1769214.04	1624271.57	7284.61	FL ASPH SWL
1122	1769177.90	1624318.77	7282.23	FL ASPH SWL
1123	1769148.70	1624358.75	7279.93	FL ASPH SWL
1124	1769140.64	1624356.11	7279.84	SEC FEN
1125	1769171.69	1624316.35	7282.53	SEC FEN
1126	1769208.59	1624268.40	7284.76	SEC FEN
1127	1769233.52	1624236.66	7286.25	SEC FEN
1128	1769254.14	1624209.91	7287.20	SEC FEN GP
1129	1769257.65	1624205.68	7287.20	SEC FEN
1130	1769289.53	1624165.22	7288.83	SEC FEN
1131	1769236.63	1624433.14	7301.93	PAD COR
1132	1769248.78	1624442.52	7302.16	PAD COR
1133	1769238.84	1624455.04	7302.38	PAD COR
1134	1769226.97	1624446.05	7302.11	PAD COR
1135	1769225.51	1624448.54	7302.25	PULL BOX
1136	1769226.60	1624444.84	7301.72	GRD RL
1137	1769215.68	1624455.52	7301.69	GRD RL
1138	1769229.67	1624470.22	7301.98	GRD RL
1139	1769238.63	1624481.27	7301.84	GRD RL
1140	1769250.21	1624497.25	7301.54	GRD RL
1141	1769259.96	1624509.78	7301.91	GRD RL
1142	1769275.03	1624523.68	7301.57	GRD RL
1143	1769260.18	1624482.69	7302.32	GRD RL
1144	1769253.87	1624473.58	7302.32	GRD RL
1145	1769253.86	1624467.60	7302.47	GRD RL
1146	1769259.97	1624455.87	7302.59	GRD RL

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Object: ta55

Thu Dec 8 12:06:28 1994

1147	1769263.66	1624459.23	7302.69	FH
1148	1769259.19	1624466.08	7302.95	WM
1149	1769255.78	1624467.69	7302.57	PIV
1150	1769262.58	1624468.56	7302.74	PIV
1151	1769267.62	1624471.97	7302.59	PIV
1152	1769206.25	1624460.07	7296.08	LT POLE
1153	1769272.31	1624522.29	7301.57	LT POLE
1154	1769237.98	1624449.19	7302.36	TWR COR
1155	1769242.26	1624443.68	7302.35	TWR COR
1156	1769236.75	1624439.57	7302.33	TWR COR
1157	1769440.60	1624367.31	7313.15	FOR
1158	1769456.13	1624376.41	7313.47	FOR
1159	1769482.12	1624386.81	7314.34	FOR
1160	1769510.92	1624388.37	7314.86	FOR
1161	1769536.92	1624377.60	7315.02	FOR
1162	1769561.66	1624360.58	7315.30	FOR
1163	1769551.05	1624349.76	7315.07	FOR
1164	1769535.06	1624364.39	7315.16	FOR
1165	1769503.32	1624374.42	7314.34	FOR
1166	1769470.14	1624366.10	7313.37	FOR
1167	1769393.62	1624380.55	7319.50	TOB
1168	1769421.56	1624402.62	7319.68	TOB
1169	1769453.01	1624428.97	7319.76	TOB
1170	1769483.73	1624454.43	7319.95	TOB
1171	1769504.92	1624471.53	7319.64	TOB
1172	1769475.60	1624509.74	7320.11	TOB
1173	1769453.17	1624495.30	7320.40	TOB
1174	1769413.55	1624465.03	7320.13	TOB
1175	1769358.50	1624422.74	7319.92	TOB
1176	1769389.09	1624380.16	7319.12	TOB
1177	1769398.31	1624365.46	7313.90	TS
1178	1769447.00	1624401.71	7314.51	TS
1179	1769502.26	1624454.22	7315.91	TS
1180	1769505.43	1624454.66	7315.68	TOB
1181	1769526.06	1624427.79	7315.53	TOB
1182	1769539.61	1624416.94	7315.59	TOB
1183	1769515.25	1624398.02	7315.36	TOB
1184	1769521.55	1624401.20	7314.75	TOB
1185	1769547.27	1624379.64	7315.12	TOB
1186	1769574.06	1624367.89	7315.36	TOB
1187	1769516.13	1624392.42	7315.21	GRND LEAD
1188	1769500.96	1624453.88	7316.04	GRND LEAD
1189	1769493.30	1624410.23	7315.12	PAD COR
1190	1769484.75	1624421.24	7315.09	PAD COR
1191	1769489.71	1624424.83	7315.03	PAD COR
1192	1769498.10	1624413.67	7315.16	PAD COR
1193	1769497.44	1624413.75	7315.44	TOC
1194	1769481.89	1624436.09	7315.93	MH COR
1195	1769484.96	1624432.89	7315.20	MH COR
1196	1769481.92	1624429.85	7315.22	MH COR
1197	1769478.63	1624433.05	7315.50	MH COR
1198	1769479.62	1624433.14	7316.01	MH TOP
1199	1769621.18	1624391.62	7301.82	TEL MH-COMM
1200	1769594.47	1624395.62	7302.00	MH COR

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object: ta55

Thu Dec 8 12:06:31 1994

1201	1769590.12	1624391.97	7302.00	MH COR
1202	1769593.93	1624387.50	7302.03	MH COR
1203	1769598.25	1624391.38	7302.09	MH COR
1204	1769594.20	1624391.56	7302.33	MH TOP
1205	1769573.92	1624437.45	7300.48	WV
1206	1769543.63	1624447.71	7299.95	MH
1207	1769499.40	1624539.47	7298.30	PB
1208	1769522.87	1624554.84	7298.19	WV
1209	1769485.04	1624593.39	7297.48	PIV
1210	1769475.95	1624605.01	7297.31	PIV
1211	1769441.39	1624640.28	7296.52	PIV
1212	1769448.22	1624625.11	7296.95	GV
1213	1769425.77	1624673.46	7296.17	COR STORM DRN
1214	1769429.99	1624676.45	7296.03	COR STORM DRN
1215	1769426.89	1624680.78	7295.93	COR STORM DRN
1216	1769422.56	1624677.91	7296.13	COR STORM DRN
1217	1769412.66	1624642.93	7297.07	CO
1218	1769446.00	1624605.56	7298.27	BLDG COR
1219	1769468.59	1624581.49	7298.21	CO
1220	1769495.78	1624540.65	7298.35	BLDG COR
1221	1769469.40	1624520.58	7298.55	BLDG COR
1222	1769532.69	1624438.44	7300.20	RET WALL
1223	1769537.85	1624414.08	7303.24	BLDG COR PF-142
1224	1769515.75	1624397.29	7315.13	BLDG COR PF-142
1225	1769505.71	1624455.81	7315.19	BLDG COR PF-142
1226	1769383.41	1624622.40	7298.07	CO
1227	1769379.51	1624619.57	7298.10	GRND LEAD
1228	1769432.18	1624619.95	7297.40	WV
1229	1769413.53	1624588.46	7298.57	MH
1230	1769372.31	1624600.61	7298.73	GRND LEAD
1231	1769358.25	1624589.02	7299.31	LT POLE
1232	1769360.79	1624513.78	7301.97	BLDG FACE
1233	1769418.30	1624584.39	7298.68	BLDG COR
1235	1769567.74	1624409.23	7300.00	.
1236	1769549.43	1624407.16	7300.00	.
1237	1769563.95	1624394.05	7301.00	.
1238	1769575.36	1624379.16	7301.00	.
2000	1769415.56	1624270.20	7311.27	55 1
2001	1769122.13	1624330.45	7279.95	FNC
2002	1769081.56	1624382.31	7276.58	GATE
2003	1769074.56	1624391.98	7276.02	GATE
2004	1769060.74	1624409.27	7274.53	GATE
2005	1769028.24	1624451.37	7270.41	GATE
2006	1769028.23	1624451.37	7270.41	FNC
2007	1768985.92	1624505.81	7266.93	FNC
2008	1768960.64	1624538.23	7266.24	FNC
2009	1768944.71	1624558.73	7266.51	FNC
2010	1768905.91	1624608.27	7267.49	FNC
2011	1768937.25	1624543.26	7265.28	CONC
2012	1768931.89	1624538.90	7265.01	CONC
2013	1768932.60	1624533.94	7265.18	CONC
2014	1768937.01	1624532.46	7264.96	CONC
2015	1768943.32	1624535.17	7265.23	CONC
2016	1768936.29	1624536.12	7264.90	CONC

0.30" ± cm

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Thu Dec 8 12:06:34 1994

1768952.33	1624548.63	7265.90	FL
1768943.11	1624535.11	7265.12	FL
1768951.14	1624515.53	7265.49	FL
1768977.13	1624469.02	7266.24	FL
1769001.33	1624437.83	7267.09	FL
1769023.31	1624408.94	7267.43	FL
1769093.31	1624310.65	7268.43	FL
1769043.33	1624366.62	7268.16	EP
1769002.33	1624429.63	7267.54	EP
1768957.14	1624486.09	7267.14	EP
1768924.31	1624527.21	7266.81	EP
1768886.34	1624575.86	7266.40	EP
1768833.31	1624635.40	7265.87	EP
1768843.33	1624649.59	7264.86	FL
1768882.33	1624601.75	7265.09	FL
1768913.13	1624559.10	7265.29	FL
1768936.13	1624536.08	7264.88	DI
1768936.13	1624535.89	7259.50	FL
1769111.11	1624313.22	7275.30	TB
1769081.13	1624348.12	7273.43	TB
1769053.11	1624374.12	7271.20	TB
1769033.13	1624404.58	7268.65	TB
1769413.13	1624270.19	7311.26	55 1
1769211.14	1624398.99	7301.38	BERM
1769206.11	1624421.74	7301.13	BERM
1769203.13	1624444.30	7301.14	BERM
1769224.11	1624464.35	7301.93	BERM
1769213.13	1624455.52	7301.61	GRDRL
1769223.13	1624444.91	7301.64	GRDRL
1769253.13	1624431.50	7302.01	NG
1769224.11	1624405.58	7300.87	NG
1769181.15	1624374.36	7289.80	NG
1769153.13	1624358.63	7283.94	NG
1769151.13	1624351.95	7279.54	FL
1769147.11	1624349.98	7279.63	CABLE TRAY
1769143.13	1624348.84	7279.71	FNC
1769113.13	1624383.98	7277.88	GATE
1769113.13	1624388.34	7277.60	GATE
1769103.12	1624404.33	7277.82	FNC
1769103.13	1624403.90	7278.40	CABLE TRAY
1769111.13	1624398.93	7277.76	CONC
1769107.13	1624403.26	7278.30	CONC
1769112.13	1624406.70	7278.69	CONC
1769113.13	1624402.26	7277.36	CONC
1769143.13	1624440.74	7282.84	FNC
1769151.14	1624439.46	7282.88	CABLE TRAY
1769183.13	1624469.83	7288.68	FNC
1769211.13	1624487.42	7292.59	FNC
1769213.13	1624486.34	7292.59	CABLE TRAY
1769213.14	1624486.52	7292.80	FL
1769213.15	1624481.74	7293.06	EP
1769211.13	1624475.46	7296.97	NG
1769131.14	1624451.86	7293.73	NG
1769131.12	1624458.31	7288.03	EP

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2073	1769184.41	1624461.80	7287.51	EP
2074	1769171.45	1624451.73	7285.43	FL
2075	1769181.37	1624436.81	7291.01	FL
2076	1769182.59	1624438.00	7293.94	NG
2077	1769179.85	1624435.18	7293.37	NG
2078	1769188.96	1624427.22	7297.25	NG
2079	1769187.41	1624428.75	7294.06	FL
2080	1769188.53	1624431.50	7297.51	NG
2081	1769204.06	1624433.01	7299.97	FL
2082	1769166.91	1624419.56	7290.88	NG
2083	1769128.83	1624412.77	7280.29	NG
2084	1769147.18	1624432.99	7282.01	FL
2085	1769120.48	1624411.16	7278.80	FL
2086	1769113.87	1624400.27	7276.42	FL
2087	1769122.83	1624400.92	7278.92	EP
2088	1769128.47	1624386.28	7278.78	EP
2089	1769125.42	1624383.30	7278.14	FL
2090	1769150.10	1624352.00	7279.51	FL
2091	1769152.71	1624353.91	7280.02	EP
2092	1769152.25	1624379.29	7284.76	MH
2093	1769182.65	1624374.60	7290.25	NG
2094	1769174.99	1624403.73	7291.18	NG
2095	1769236.30	1624431.89	7302.17	SS 2
2096	1769314.31	1624853.36	7293.98	TRENCH
2097	1769318.44	1624856.50	7294.06	TRENCH
2098	1769358.06	1624805.91	7294.48	TRENCH
2099	1769353.95	1624802.75	7294.51	TRENCH
2100	1769394.18	1624750.62	7294.57	TRENCH
2101	1769398.33	1624753.52	7294.20	TRENCH
2102	1769434.00	1624707.83	7295.22	TRENCH
2103	1769442.02	1624703.99	7295.42	TRENCH
2104	1769442.16	1624696.61	7295.48	TRENCH
2105	1769431.96	1624700.13	7295.32	TRENCH
2106	1769452.36	1624706.61	7297.79	LID
2107	1769380.14	1624705.20	7295.02	TRANS
2108	1769375.37	1624701.64	7295.12	TRANS
2109	1769371.28	1624706.79	7295.04	TRANS
2110	1769375.87	1624710.45	7294.96	TRANS
2111	1769373.13	1624714.33	7294.87	TRANS
2112	1769368.44	1624710.76	7294.95	TRANS
2113	1769364.15	1624715.96	7294.84	TRANS
2114	1769368.87	1624719.62	7294.77	TRANS
2115	1769366.07	1624726.14	7295.19	TELEMH
2116	1769372.16	1624710.44	7295.33	TELEMH
2117	1769426.99	1624680.62	7295.95	TELEMH
2118	1769429.96	1624676.43	7295.99	GRATE
2119	1769425.83	1624673.45	7296.16	GRATE
2120	1769422.88	1624677.72	7296.15	GRATE
2121	1769647.19	1624379.69	7302.51	FH
2122	1769236.30	1624431.90	7302.16	CP SS 2
4801	1770252.44	1623423.61	7326.60	A4801
5001	1768420.43	1625421.60	7274.60	A5001
5501	1769815.64	1624111.94	7314.10	A5501

SHEET 1 OF 1

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SARGENT, HAAS, MINS & BECKWITH

GEOTECHNICAL INVESTIGATION REPORT
Nuclear Materials Storage Facility
Los Alamos, New Mexico

SHA Job No. CH-1041

Consulting Geotechnical Engineers

PHOENIX • ALBUQUERQUE • SANTA FE • SALT LAKE CITY

SERGEANT, HAUSKINS & BECKWITH

CONSULTING GEOTECHNICAL ENGINEERS

APPLIED SOIL MECHANICS • ENGINEERING GEOLOGY • MATERIALS ENGINEERING

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April 11, 1984

Burns and Roe Pacific, Inc.
11221 North 28th Drive
Suite E-108
Phoenix, Arizona 85029

SHB Job No. E84-1044

Attention: Mr. Peter Ellesmere-Jones

Re: Nuclear Materials Storage Facility
Los Alamos, New Mexico

Gentlemen:

Our Geotechnical Investigation Report on the referenced project is herewith submitted. The report includes the results of test drilling, laboratory analyses and recommended criteria for foundation and basement wall design, slab support, and paving.

Should any questions arise concerning this report we would be pleased to discuss them with you.

Respectfully Submitted,
Sergeant, Hauskins & Beckwith Engineers

By

Reviewed by

Robert D. Booth, P.E.

Copies: Addressee (6)
Scanlon & Associates (1)

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SHB Job No. E84-1044

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SAN FRANCISCO - SAN DIEGO - SAN JOSE - LOS ANGELES - OAKLAND

1. INTRODUCTION

This report is submitted pursuant to a geotechnical investigation made by this firm of the site of the proposed Nuclear Materials Storage Facility, and the relocation alignment of Pajarito Road, located in Los Alamos, New Mexico. The object of this investigation was to evaluate the physical properties of subsoils and rock underlying the site to provide recommendations for foundation and basement wall design, slab support and paving.

2. PROPOSED CONSTRUCTION

It is understood that the proposed Nuclear Materials Storage Facility will consist of a one story structure, approximately 150 feet by 127 feet in plan area, with finished floor elevation near existing grade. One below grade level extending to a depth of approximately 16 feet below existing grade will underlie the western portion of the structure. Earth berms will be constructed against the above grade walls of the structure, and at least 2 feet of soil will cover the roof of the western portion of the structure. The structure will be of concrete construction with ~~maximum column loads on the order of 150 kips.~~ The proposed facility will be connected to the existing Building TA55 by an 8 foot wide by 8 foot high tunnel. Maximum cover above the tunnel is assumed to be on the order of 20 feet.

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Approximately one mile of the existing Pajarito Road will be relocated 300 to 400 feet south of the existing alignment and will roughly parallel the existing alignment. The roadway is estimated to carry approximately 1,000 vehicles per day, with 95 percent of the traffic being cars and light trucks.

Should final design details vary significantly from those outlined above, this firm should be notified for review and possible revision of recommendations.

3. INVESTIGATION

3.1 Subsurface Exploration

Five exploratory borings were drilled to depths of 39 feet below existing grade within the building area. An additional 19 borings were drilled along the approximate centerline of the realignment for Pajarito Road. Scanlon & Associates personnel established approximate centerline locations in the field and provided approximate stationing and surface elevations for the borings. These borings extended to depths of approximately 5 to 11 feet below existing grade. Standard penetration testing and 2.42 inch diameter open-end drive sampling were performed at selected intervals in the borings. During the field investigation, the soils encountered were continuously examined, visually classified, and logged. Results of the field investigation are presented in Appendix A, which includes a brief description of

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drilling and sampling equipment and procedures, a site plan showing the boring locations and logs of the test borings.

3.2 Laboratory Analysis

Moisture content determinations were made on all tube samples recovered, while dry densities were determined for the relatively undisturbed, 2.42 inch diameter, open-end drive samples. Results of these tests are shown on the boring logs.

Grain-size analysis, Atterberg limits, consolidation and soil resistivity tests were performed on selected samples. Results of these tests are presented in Appendix B, along with a brief description of soil mechanics testing procedures.

4. SITE CONDITIONS & GEOTECHNICAL PROFILE

4.1 Site Conditions

The site of the proposed Nuclear Materials Storage Facility lies immediately west of Building TA55 and is located on the existing Pajarito Road. The site slopes slightly to the east, with topographic relief across the site on the order of 7 feet. On-site vegetation consists of small pinion and juniper trees.

The proposed alignment of Pajarito Road lies to the west of, and roughly parallels, the existing road alignment.

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The alignment is moderately rolling, topographically. Based on visual inspection, it appears that maximum cuts and fills on the order of 15.0 feet will be required to achieve the required road grade.

4.2 Geotechnical Profile

As indicated by the exploratory borings, the subsoils underlying the site can be characterized into a two-strata system as follows:

- A. Alluvial deposits consisting of clayey and silty sands and sandy clays with lesser deposits of sandy silts extend to depths of about 2 to 7 feet below existing grade at boring locations within the building area, and to a maximum of 2 feet along the road alignment. These soils vary from moderately firm to firm and are of low plasticity to nonplastic.
- B. Volcanic tuff underlies Stratum A and extended to the full depth of the borings. The ~~tuff is~~ generally soft, geologically; however, it is a firm to hard material from an engineering standpoint, and is an excellent foundation material.

4.3 Soil Moisture & Groundwater Conditions

No free groundwater was encountered in the borings. Soil moisture contents were relatively low, being below the plastic limit for the clayey soils.

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5. DISCUSSION & RECOMMENDATIONS

5.1 Analysis of Results

With the subgrade level of the proposed structure, it appears portions of the foundations for the Nuclear Materials Storage Facility will be bearing on the volcanic tuff. Accordingly, in order to have uniform foundation support, all foundations for the structure should bear on the tuff. Design criteria for spread-type footings bearing on tuff, subgrade walls, and for pavements are given in the following sections of this report.

5.2 Spread-Type Foundations

5.2.1 Design Criteria for Downward Loads

A safe bearing pressure of 5,000 psf is recommended for the design of spread-type footings bearing on the volcanic tuff. This value applies to full dead plus live loads and can be safely increased by one-third when considering wind or seismic forces. Foundations should extend at least 2.0 feet below lowest finished grade, or 6 inches below the surface contact of the tuff, whichever is the lower elevation. Two feet and 1.33 feet are minimum recommended widths of square and continuous footings, respectively.

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5.2.2 Lateral Loads

Passive soil resistance against the edges of footings, stem walls, etc., with properly compacted backfill, should be considered as being equal to forces exerted by a fluid of 300 pounds per cubic foot unit weight. A coefficient of friction of 0.40 is recommended for computing the lateral resistance between the bases of footings and slabs and the soil or bedrock in analyzing lateral loads.

5.2.3 Estimated Settlements

It is estimated that settlements of foundations designed in accordance with the above criteria which bear on the volcanic tuff are estimated to be less than 1/2 inch.

5.3 Subgrade Walls

Earth pressures against subgrade walls will depend upon the degree of restraint. Rigid, absolutely restrained, walls with horizontal backfill would be subjected to earth pressures represented by a hydrostatic load diagram of about 55 pounds per square foot per foot of depth. Rotation or lateral translation of the walls equal to about 0.001 times their height would reduce earth pressures to the active state of about 35 pounds per square foot per foot of depth. Slight lateral translation equal to about 0.0005 times the height would result in an intermediate pressure diagram on the order of 45 pounds per square foot per foot of depth.

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A clean, free draining backfill, in conjunction with a weep hole or drainage tile system, should be used behind retaining walls or basement walls where the possibility of saturation of the backfill exists. Compaction of the backfill should be accomplished in accordance with guidelines presented in Section 5.4 of this report.

5.4 Site Grading & Slab Support

Guide specifications for site grading and construction of fills for Pajarito Road are presented in Appendix C.

Building area subgrades prepared in accordance with these recommendations will provide adequate structural support for lightly loaded slabs cast-on-grade so that no granular base will be necessary for this purpose. However, if desired as a working surface, a 4-inch course of granular base can be placed beneath concrete floor slabs cast-on-grade. Six inches of granular base is recommended beneath any heavily loaded floor slabs on the project. With these support conditions, a modulus of subgrade reaction (k) of 350 pci is recommended for the structural design of concrete floors slabs.

If granular base is used, it should meet the following gradation requirements as determined in accordance with ASTM C136.

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<u>Sieve Size</u> <u>(Square Openings)</u>	<u>Percent Passing</u> <u>by Weight</u>
1 inch	100
3/4 inch	85-100
no. 4	45-95
no. 200	0-8

Granular base should have a plasticity index of no greater than 3 when tested in accordance with ASTM D423 and D424. The coarse aggregate should have percent of wear, when subjected to the Los Angeles abrasion test (ASTM C131), of no greater than 50. The granular base should be compacted to at least 95 percent of maximum dry density in accordance with ASTM D1557.

Granular base will tend to act as a capillary barrier to moisture, but will not provide a positive barrier against the rise of moisture through the slabs. If the moisture sensitivity of floor coverings is considered critical, an impervious membrane vapor barrier should be placed beneath floor slabs. A 2-inch layer of clean, nonplastic, sand should be placed over the membrane to minimize differential shrinkage of the slabs.

5.5 Pavement for Pajarito Road

Based on results of exploratory borings and conditions observed along the proposed Pajarito Road alignment, pavements in cut sections will be constructed on soils with low expansion potential or on undisturbed volcanic

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tuff. Fill will be constructed of the reworked volcanic tuff, placed and compacted in accordance with the guide specifications in Appendix C.

The following traffic distribution was assumed for pavement design:

<u>Class</u>	<u>Coverages Daily</u>
5 Axle Trucks	11
4 Axle Trucks	1
3 Axle Trucks	3
2 Axle Trucks	35
Light Trucks & Cars	950

From this traffic distribution, an equivalent number of daily 18 kip axle loads (ADL) of 75 was calculated. No increase in traffic over the design life of the pavement was assumed.

A pavement section consisting of 4 inches of asphaltic concrete overlying 11 inches of granular base is recommended for the relocated Pajarito Road. This section should have a design life of 20 years and a serviceability Index of 2.0 at the end of the design life.

Asphaltic concrete materials quality and construction requirements should conform to Section 401 of the current New Mexico State Highway Department Standard Specifications for Road and Bridge Construction.

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Mineral aggregate should comply with either Grading A or B, Type II. A job mix formula should be established using the Marshall method of mix design which has a stability of at least 1,600 pounds, as determined in accordance with ASTM D1559. The bituminous material and aggregate proposed for use in construction by the contractor should be used in the mix design.

Aggregate base course material should meet the following gradation requirements when tested in accordance with the ASTM C136 test method.

<u>Sieve Size</u> <u>(Square Openings)</u>	<u>Percent Passing</u> <u>by Weight</u>
1 inch	100
3/4 inch	85-100
no. 4	40-70
no. 10	30-55
no. 200	4-12

The base course material should have a plasticity index of no greater than 3 when tested in accordance with ASTM D423 and D424. The aggregate should have a percent of wear of no greater than 50 when tested in accordance with the ASTM C131 test method. All base course material should be compacted to at least 95 percent of the ASTM D1557 maximum dry density.

5.6 Construction Excavations

Excavations required for the Nuclear Materials Storage Facility will encounter volcanic tuff bedrock. Based

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on resistance encountered in drilling this material, as well as previous experience in this area, the tuff can be excavated by first ripping utilizing a large tractor with a single shank ripper. The material generally breaks down readily for placement as structural fill.

Temporary open cut slopes in the overburden soils should be made with side slopes of 1 to 1 (horizontal to vertical). Cuts within the tuff can be made at 1/4 to 1 slopes (horizontal to vertical).

Permanent cut slopes within the overburden soils and the tuff can be made at 2 to 1 and 1 to 1 (horizontal to vertical) slopes, respectively. Slopes in fill sections comprised of overburden soils or reworked tuff rock should be made at 2 to 1 grades or flatter.

5.7 Factors for Earthwork Computations

In performing the earthwork cut and fill balances, it is recommended that the following earthwork factors be utilized to compensate for the change in material volume from cut sections to fill sections. These factors are a percentage of the initial volume of material in the cut section.

<u>Material</u>	<u>Earthwork Factor</u>
Overburden Soil, 0-5 foot cut	25% Shrink
Volcanic Tuff	5% Shrink

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TEST DRILLING EQUIPMENT & PROCEDURES

Drilling Equipment Truck-mounted CME-55 and CME-75 drill rigs powered with 6 cylinder Ford industrial engines are used in advancing test borings. The 6 cylinder engines are capable of delivering about 6,500 foot/pounds torque to the drill spindle. The spindle is advanced with twin hydraulic rams capable of exerting 12,000 pounds downward force. Drilling through soil or softer rock is performed with 6-1/2 inch O.D., 3-1/4 I.D. hollow stem auger or 4-1/2 inch continuous flight auger. Carbide insert teeth are normally used on the auger bits so they can often penetrate rock or very strongly cemented soils which require blasting or very heavy equipment for excavation. Where refusal is experienced in auger drilling, the holes are sometimes advanced with tricone gear bits and NX rods using water or air as a drilling fluid.

Sampling Procedures Dynamically driven tube samples are usually obtained at selected intervals in the borings by the ASTM D1586 procedures. In most cases, 2" O.D., 1-3/8" I.D. samplers are used to obtain the standard penetration resistance. "Undisturbed" samples of firmer soils are often obtained with 3" O.D. samplers lined with 2.42" I.D. brass rings. The driving energy is generally recorded as the number of blows of a 140 pound 30 inch free fall drop hammer required to advance the samplers in 6 inch increments. However, in stratified soils, driving resistance is sometimes recorded in 2 or 3 inch increments so that soil changes and the presence of scattered gravel or cemented layers can be readily detected and the realistic penetration values obtained for consideration in design. These values are expressed in blows per foot on the logs. "Undisturbed" sampling of softer soils is sometimes performed with thin walled Shelby tubes (ASTM D1587). Where samples of rock are required, they are obtained by NX diamond core drilling (ASTM D2113). Tube samples are labeled and placed in watertight containers to maintain field moisture contents for testing. When necessary for testing, larger bulk samples are taken from auger cuttings.

Continuous Penetration Tests Continuous penetration tests are performed by driving a 2" O.D. blunt nosed penetrometer adjacent to or in the bottom of borings. The penetrometer is attached to 1-5/8" O.D. drill rods to provide clearance to minimize side friction so that penetration values are as nearly as possible a measure of end resistance. Penetration values are recorded as the number of blows of a 140 pound 30 inch free fall drop hammer required to advance the penetrometer in one foot increments or less.

Boring Records Drilling operations are directed by our field engineer or geologist who examines soil recovery and prepares boring logs. Soils are visually classified in accordance with the Unified Soil Classification System (ASTM D2487), with appropriate group symbols being shown on the logs.

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UNIFIED SOIL CLASSIFICATION SYSTEM

Soils are visually classified by the Unified Soil Classification system on the boring logs presented in this report. Grain-size analysis and Atterberg Limits Tests are often performed on selected samples to aid in classification. The classification system is briefly outlined on this chart. For a more detailed description of the system, see "The Unified Soil Classification System" Corp of Engineers, US Army Technical Memorandum No. 3-357 (Revised April 1960) or ASTM Designation: D2487-66T.

MAJOR DIVISIONS				GRAPHIC SYMBOL	GROUP SYMBOL	TYPICAL NAMES
COARSE-GRAINED SOILS (Less than 50% passes No. 200 sieve)	GRAVELS (50% or less of coarse fraction passes No. 4 sieve)	CLEAN GRAVELS (Less than 5% passes No. 200 sieve)			GW	Well graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
					GP	Poorly graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart		GM	Silty gravels, gravel-sand-silt mixtures.
			Limits plot above "A" line & hatched zone on plasticity chart		GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (More than 50% of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Less than 5% passes No. 200 sieve)			SW	Well graded sands, gravelly sands.
					SP	Poorly graded sands, gravelly sands.
FINE-GRAINED SOILS (50% or more passes No. 200 sieve)	SILTS (Limits plot below "A" line & hatched zone on plasticity chart)	SILTS OF LOW PLASTICITY (Liquid Limit Less Than 50)			ML	Inorganic silts, clayey silts with slight plasticity.
		SILTS OF HIGH PLASTICITY (Liquid Limit More Than 50)			MH	Inorganic silts, micaceous or diatomaceous silty soils, elastic silts.
	CLAYS (Limits plot above "A" line & hatched zone on plasticity chart)	CLAYS OF LOW PLASTICITY (Liquid Limit Less Than 50)			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		CLAYS OF HIGH PLASTICITY (Liquid Limit More Than 50)			CH	Inorganic clays of high plasticity, fat clays, sandy clays of high plasticity.

NOTE: Coarse grained soils with between 5% & 12% passing the No. 200 sieve and fine grained soils with limits plotting in the hatched zone on the plasticity chart to have double symbol.

PLASTICITY CHART

DEFINITIONS OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Cobbles	Above 3 in.
Gravel	3 in. to No. 4 sieve
Coarse gravel	3 in. to 1/2 in.
Fine gravel	1/2 in. to No. 4 sieve
Sand	No. 4 to No. 200
Coarse	No. 4 to No. 10
Medium	No. 10 to No. 40
Fine	No. 40 to No. 200
Fines (silt or clay)	Below No. 200 sieve

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TERMINOLOGY USED TO DESCRIBE THE RELATIVE DENSITY,
CONSISTENCY, OR FIRMNESS, OF SOILS

The terminology used on the boring logs to describe the relative density, consistency, or firmness of soils relative to the standard penetration resistance is presented below. The standard penetration resistance (N) in blows per foot is obtained by ASTM D1586 procedure using 2" O.D., 1-3/8" I.D. samplers.

1. Relative Density. Terms for description of relative density of cohesionless, uncemented sands and sand-gravel mixtures.

<u>N</u>	<u>Relative Density</u>
0-4	Very loose
5-10	Loose
11-30	Medium dense
31-50	Dense
50+	Very dense

2. Relative Consistency. Terms for the description of clays which are saturated or near saturation.

<u>N</u>	<u>Relative Consistency</u>	<u>Remarks</u>
0-2	Very soft	Easily penetrated several inches with fist
3-4	Soft	Easily penetrated several inches with thumb
5-8	Medium stiff	Can be penetrated several inches with thumb with moderate effort
9-15	Stiff	Readily indented with thumb, but penetrated only with great effort
16-30	Very stiff	Readily indented with thumbnail
30+	Hard	Indented only with difficulty by thumbnail

3. Relative Firmness. Terms for the description of partially saturated and/or cemented soils which commonly occur in the Southwest including clays, cemented granular materials, silts and silty and clayey granular soils:

<u>N</u>	<u>Relative Firmness</u>
0-4	Very soft
5-8	Soft
9-15	Moderately firm
16-30	Firm
31-50	Very firm
50+	Hard

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TERMINOLOGY FOR THE DESCRIPTION OF ROCK

<u>General Property</u>	<u>Descriptive Term</u>	<u>Visual or Physical Properties</u>
WEATHERING	VERY WEATHERED	Abundant fractures coated with oxides, carbonates, sulfates, mud, etc., thorough discoloration, rock disintegration, mineral decomposition
	MODERATELY WEATHERED	Some fracture coating, moderate or localized discoloration, little to no effect on cementation, slight mineral decomposition
	SLIGHTLY WEATHERED	A few stained fractures, slight discoloration, little to no effect on cementation, no mineral decomposition
	FRESH	Unaffected by weathering agents, no appreciable change with depth
FRACTURING	INTENSELY FRACTURED	Less than 1" spacing
	VERY FRACTURED	1" to 6" spacing
	MODERATELY FRACTURED	6" to 12" spacing
	SLIGHTLY FRACTURED	12" to 36" spacing
	SOLID	36" spacing or greater
STRATIFICATION	THINLY LAMINATED	less than 1/10"
	LAMINATED	1/10" to 1/2"
	VERY THINLY BEDDED	1/2" to 2"
	THINLY BEDDED	2" to 2 feet
	THICKLY BEDDED	more than 2 feet
HARDNESS	SOFT	Can be dug by hand and crushed by fingers
	MODERATELY HARD	Friable, can be gouged deeply with knife and will crumble readily under light hammer blows
	HARD	Knife scratch leaves dust trace, will withstand a few hammer blows before breaking
	VERY HARD	Scratched with knife with difficulty, difficult to break with hammer blows

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SITE PLAN SHOWING LOCATIONS OF TEST BORINGS

Reference Drawing: "Site and Utility Plans"
by Los Alamos National Laboratory, Los Alamos,
New Mexico, dated February, 1984

Nuclear Materials Storage Facility
Los Alamos, New Mexico
SHB Job No. E84-1044

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RIG TYPE CME-55
BORING TYPE 6 1/2" Hollow Stem Auger
SURFACE ELEV. 94.0'
DATUM Assumed See Site Plan

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 JOB NO. EB4-1042 DATE 3/16/84

LOG OF TEST BORING NO.

Depth in feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification
0			⊗ S	S	7		15	SM
			⊗ U	U	58		23	
5			⊗ S	S	47		19	
10			⊗ S	S	72		16	
15			⊗ S	S	67		32	
20			⊗ S	S	63		7	
25			⊗ S	S	50/6"		7	
30			⊗ S	S	45-50/4"		7	
35			⊗ S	S	50/5 1/4"		7	
40			⊗ S	S	50/2 1/2"		8	
45								

RIG TYPE CME-55
 BORING TYPE 6 1/2" Hollow Stem Auger
 SURFACE ELEV. 96.0'
 DATUM Assumed See Site Plan

REMARKS	VISUAL CLASSIFICATION
soft to firm	SILTY SAND, fine, nonplastic, brown
	VOLCANIC TUFF, fine, nonplastic, gray
	Stopped auger at 39'6" Sampler refused at 39'8 1/2"

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Auger cuttings. B - Block sample
 S - 2" O.D. 1.38" I.D. tube sample.
 U - 3" O.D. 2.42" I.D. tube sample.

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 JOB NO. E84-1044 DATE 3/16/84

LOG OF TEST BORING NO. 3

Depth in feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	RIG TYPE <u>CME-55</u>	
									BORING TYPE <u>6 1/2" Hollow Stem Auger</u>	
									SURFACE ELEV. <u>95.8'</u>	
									DATUM <u>Assumed See Site Plan</u>	
									REMARKS	VISUAL CLASSIFICATION
0			☒	S	21		32	CL	firm	SANDY CLAY, low plasticity, brown
			☒	S	67		18			VOLCANIC TUFF, fine, non-plastic, gray
5			☒	U	84		16			
10			☒	S	87		17			
15			☒	S	43		24			
20			☒	S	77		7			
25			☒	S	13		6			
30			☒	S	21		7			
35			☒	S	34-50/6"		5			
40			☒	S	50/4 1/2"		6			
45										Stopped auger at 39'6" Sampler refused at 39'10 1/2"

GROUND WATER		
DEPTH	HOUR	DATE
	none	

SAMPLE TYPE
 A - Auger cuttings. B - Block sample
 S - 2" O.D. 1.32" I.D. tube sample.

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PROJECT nuclear Materials Storage Facility
 JOB NO. E84-1044 DATE 3/16/84

LOG OF TEST BORING NO. 4

Depth in feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			X	S	19		14		firm to hard	CLAYEY SAND, fine, low plasticity, tan
	X		S	51		11	SC			
5	X		U	100/8"		7				
10			X	S	70		2			VOLCANIC TUFF, fine, non-plastic, gray
15	X		U	80		2				
20	X		S	55		1				
25	X		S	47		1				
30			S	50/4"		1				
35			S	50/2"		1				
40			S	50/2"		2		Stopped auger at 39'6" Sampler refused at 39'8"		
45										

GROUND WATER		
DEPTH	HOUR	DATE
	none	

SAMPLE TYPE
 A - Auger cuttings. B - Block sample
 S - 2" O.D. 1.38" I.D. tube sample.

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Depth, Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification
0			☒	S	16		15	SC
			☒	S	41		11	
5			☒	S	70		2	
10			☒	S	84		13	
15			☒	S	74		2	
20			☒	S	20		8	
25			☒	S	22		1	
30			☒	S	43		1	
35			☒	S	50/5"		1	
40			☒	S	50/2"		1	
45								

RIG TYPE CME-55
 BORING TYPE 6 1/2" Hollow Stem Auger
 SURFACE ELEV. 97.0'
 DATUM Assumed See Site Plan

REMARKS	VISUAL CLASSIFICATION
firm to very firm	CLAYEY SAND, fine low plasticity, light brown
	VOLCANIC TUFF, fine, non-plasticity, gray
	Stopped auger at 39'6" Sampler refused at 39'8"

GROUND WATER		
DEPTH	HOUR	DATE
	none	

SAMPLE TYPE
 A - Auger cuttings. B - Block sample.
 S - 2" O.D. 1.38" I.D. tube sample.
 U - 3" O.D. 2.42" I.D. tube sample.

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Depth, Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒	S	19		12	CL	firm	SANDY CLAY, low plasticity, brown
5			☒	S	123		5			VOLCANIC TUFF, nonplastic, gray
			☒	S	89		3			
10			☒	S	32		6			
15										Stopped auger at 9'6"
										Stopped sampler at 11'

GROUND WATER		
DEPTH	HOUR	DATE
	none	

SAMPLE TYPE
 A - Auger cuttings. B - Block sample
 S - 2" O.D. 1.38" I.D. tube sample.
 U - 3" O.D. 2.42" I.D. tube sample.

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Feet	Continuous Penetration Resistance	Graphical Log	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒ S	74		8	SC		CLAYEY SAND, fine, low plasticity, brown
			☒ S	42-50/4 1/2"		5			VOLCANIC TUFF, fine grained, nonplastic, gray
5			☒ S	50/4 1/2"		4			
10			☒ S	31-50/5"		3			
15									Stopped auger at 9'6" Sampler refused at 10'5"

GROUND WATER		
DEPTH	HOUR	DATE
	none	

SAMPLE TYPE
 A - Auger cuttings. B - Block sample
 S - 2" O.D. 1.38" I.D. tube sample.
 U - 3" O.D. 2.42" I.D. tube sample.

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Depth, Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			☒ S	50/5 1/2"			9			VOLCANIC TUFF, fine grained, nonplastic, gray
	☒ S		46-50/5 1/2"				5			
5			☒ S	36-50/4"				4		
10										Stopped auger at 4'6" Sampler refused at 5'4"

GROUND WATER		
DEPTH	HOUR	DATE
	none	

SAMPLE TYPE
 A - Auger cuttings. B - Block sample.
 S - 2" O.D. 1.38" I.D. tube sample.
 U - 3" O.D. 2.42" I.D. tube sample.
 T - 3" O.D. 2.42" I.D. Shelby tube

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JOB NO. E84-1044 DATE 3/15/84

Station: 25+95

[illegible]

BORING TYPE 6 1/2" Hollow Stem Auger

SURFACE ELEV. 7275.0'

DATUM Scanlon & Associates

REMARKS

VISUAL CLASSIFICATION

VOLCANIC TUFF, fine grained
nonplastic, gray

Stopped auger at 4'6"
Sampler refused at 4'8"

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Auger cuttings. B - Block sample
S - 2" O.D. 1.38" I.D. tube sample. -
U - 3" C.D. 2.42" I.D. tube sample.

5 - 2" O.D. 1.38" I.D. tube sample.

U - 3" C.C. & 42" I.C. tube sample.

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PUNJ LLOYD LTD. - NEW DELHI - INDIA

2010-11-09 10:00:00

Station: 22+95

SAMPLE TYPE
A - Auger cuttings. B - Block sample
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.

CONSULTING GEOTECHNICAL ENGINEERS
PO BOX 430000 - SAN ANTONIO, TEXAS 78243-0000

Station: 19+95

CONSULTING ENGINEER SA. PHOENIX

CONSULTING GEOTECHNICAL ENGINEERS

Station: 5495

RIG TYPE	CHE-55
BORING TYPE	6" Hollow Stem Auger
SURFACE ELEV.	7351.0'
DATUM	Scanlon & Associates

CME-55

BORING TYPE 6 1/2" Hollow Stem Auger

7351.0

DATUM _____ Scanlon & Associates

DATE	TIME	DEPTH	TEST	REMARKS	TESTER	DATE	TIME	DEPTH	TEST	REMARKS	TESTER
0						0					
5						5					
10						10					
15						15					
20						20					
25						25					
30						30					
35						35					
40						40					
45						45					
50						50					
55						55					
60						60					
65						65					
70						70					
75						75					
80						80					
85						85					
90						90					
95						95					
100						100					

REMARKS

VISUAL CLASSIFICATION

CLAYEY SAND, fine, low plas-
ticity, brown

VOLCANIC TUFF, fine, non-plastic, gray

Stopped auger at 4'6"
Sampler refused at 4'11 1/2"

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE .

A - Auger cuttings. B - Block sample
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" C.D. thin-walled Shelby tube.

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A-26

Depth, Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification
0			X	S	18		9	SC
			X	S	44		9	
5			X	S	50/6"		2	
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
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41								
42								
43								
44								
45								
46								
47								
48								
49								
50								

RIG TYPE CME-55
 BORING TYPE 6 1/2" Hollow Stem Auger
 SURFACE ELEV. 7270.0'
 DATUM Scanlon & Associates

REMARKS

VISUAL CLASSIFICATION

CLAYEY SAND, fine, low plasticity, tan

VOLCANIC TUFF, fine, non-plasticity, gray

Stopped auger at 4'6"
 Sampler refused at 5'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A - Auger cuttings. B - Block sample
 S - 2" O.D. 1.38" I.D. tube sample.
 U - 3" O.D. 2.42" I.D. tube sample.
 T - 3" O.D. 1.62" I.D. tube.

1
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DEPTH	HOUR	DATE
	none	

A - Auger cuttings. B - Block sample
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" C.D. thin-walled Shelby tube.

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LABORATORY TESTING PROCEDURES

Consolidation Tests Soiltest or Clockhouse apparatus of the "floating-ring" type are employed for the one-dimensional consolidation tests. They are designed to receive one inch high, 2.5 inch O.D. brass liner rings with soil specimens as secured in the field. Procedures for the tests generally are those outlined in ASTM D2435. Loads are applied in several increments to the upper surface of the test specimen and the resulting deformations are recorded at selected time intervals for each increment. For soils which are essentially saturated, each increment of load is maintained until the deformation versus log of time curve indicates completion of primary consolidation. For partially saturated soils, each increment of load is maintained until the rate of deformation is equal or less than 1/10,000 inch per hour. Applied loads are such that each new increment is equal to the total previously applied loading. Porous stones are placed in contact with the top and bottom of the specimens to permit free addition or expulsion of water. For partially saturated soils, the tests are normally performed at in situ moisture conditions until consolidation is complete under stresses approximately equal to those which will be imposed by the combined overburden and foundation loads. The samples are then submerged to show the effect of moisture increase and the tests continued under higher loadings. Generally, the tests are continued to about twice the anticipated curve due to overburden and structural loads, with a rebound curve then being established by releasing loads.

Expansion Tests The same type of consolidometer apparatus described above is used in expansion testing. Undisturbed samples contained in brass liner rings are placed in the consolidometers, subjected to appropriate surcharge loads and submerged. The loads are maintained until the expansion versus log of time curve indicates the completion of "primary swell".

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Job No. E84-1044

Date _____

Client:

Project Nuclear Materials Storage Facility

Los Alamos, New Mexico

Material

Source

[illegible]

SUMMARY OF CONSOLIDATION TESTS

PROJECT Nuclear Materials Storage Facility

JOB NO. E84-1046

CURVE	SAMPLE	INITIAL DRY DENSITY LBS./CU. FT.	MOISTURE CONTENT % DRY WEIGHT		UNIFIED SOIL CLASSIFICATION
			INITIAL	FINAL	
	Boring #2 @ 2½'	80.0	14.5	37.1	SM

SOIL MOISTURE CONDITION

—	INSITU
- - -	SUBMERGED

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ENGINEERS AND SURVEYORS

SUMMARY OF CONSOLIDATION TESTS

PROJECT Nuclear Materials Storage Facility JOB NO. E84-1044

CURVE	SAMPLE	INITIAL DRY DENSITY LBS./CU. FT.	MOISTURE CONTENT % DRY WEIGHT		UNIFIED SOIL CLASSIFICATION
			INITIAL	FINAL	
	Boring #3 @ 4 1/2'	72.4	15.9	41.4	SM

SOIL MOISTURE CONDITION

—	INSITU
- - -	SUBMERGED

SERGENT, HAUSKINS & BECKWITH

CONSULTING ENGINEERS AND SURVEYORS

B-4

DATE: April 10, 1984

LAB. NO. 40684-3

FOR: Sergent, Hauskins & Beckwith
Attention: ~~Tom Romero~~
4700 Lincoln Road, NE
Albuquerque, NM 87109

SAMPLE: 2 soils - Nuclear Mat. Storage Facility

DATE DELIVERED: _____

RESULTS:	Soil Resistivity
B-1 @ 4 1/2'	580. micromhos/cm
B-4 @ 2 1/2'	920. micromhos/cm

BY: *Alan Auger*
Chemist

Figure No. 1 - Design Earth Pressures for
Tunnel on Incompressible Foundation

Where:

$\sigma_c = 0.12NH$, in ksf

H = Height of fill above crown, in feet

N = Crown pressure factor (Figure No. 2)

Note: Surcharge pressures above ground surface can be accounted for by increasing effective height of fill above crown

$$H^1 = H + \frac{\text{Surcharge Pressure (ksf)}}{0.12}$$

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Project Nuclear Materials Storage Fac.

Job No: E84-1044

Computed by: DLB Ckd. by: _____

Date: _____ Page _____ of _____ C-1

Figure No. 2 - Crown Pressure Factors for
Tunnels on Incompressible Foundation

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Project Nuclear Materials Storage Fac.
Job No: E84-1044

Computed by: DLB Ckd. by: _____

GUIDE SPECIFICATIONS FOR EARTHWORK

1. SCOPE

Includes all clearing and grubbing, removal of obstructions, general excavating, grading and filling, and any related items necessary to complete the grading for the entire project in accordance with these specifications.

2. SUBSURFACE SOIL DATA

Subsurface soil investigations have been made, and the results are available for examination by the contractor. The contractor is expected to examine the site and determine for himself the character of materials to be encountered.

No additional allowance will be made for rock removal, site clearing and grading, filling, compaction, disposal, or removal of any unclassified materials.

3. CLEARING & GRUBBING

- A. General: Clearing and grubbing will be required for all areas shown on the plans to be excavated or upon which fill is to be constructed.
- B. Clearing: Clearing shall consist of the removal and disposal of other vegetation as well as brush, trees and rubbish within the areas to be cleared.
- C. Grubbing: Stumps, matted roots, and roots larger than 2 inches in diameter shall be removed from within 6 inches of the surface of areas on which fills are to be constructed except in roadways. Materials as described above within 18 inches of finished subgrade of roadways in either cut or fill sections shall be removed. Areas disturbed by grubbing will be filled as specified hereinafter for EMBANKMENT.
- D. Grass & Topsoil: Grass, grass roots, and the incidental topsoil shall not be left beneath a fill

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area, nor shall this material be used as fill material. Grass, grass roots, and topsoil may be stockpiled and later used in the top 6 inches of fills outside roadways and building pads.

4. EARTH EXCAVATION

- A. Earth excavation shall consist of the excavation and removal of suitable soils for use as embankment as well as the satisfactory disposal of all vegetation, debris, and deleterious materials encountered within the area to be graded and/or in a borrow area.
- B. Excavated areas shall be continuously maintained such that the surface shall be smooth and have sufficient slope to allow water to drain from the surface.

5. STRUCTURAL FILL

- A. General: The structural fill shall consist of controlled fill placed as backfill against subgrade walls, pier caps and footings, as well as embankment placed for site grading within the building areas.
- B. Fill Materials: Fill materials shall consist of soils that conform to the following physical characteristics:

<u>Sieve Size</u> <u>(Square Openings)</u>	<u>Percent Passing</u> <u>by Weight</u>
6 inch	100
no. 4	40-100
no. 200	15-40

The plasticity index of the material, as determined in accordance with ASTM D423 and D424, shall not be more than 15.

The fill material shall be free from roots, grass, other vegetable matter, clay lumps, rocks larger than 6 inches, or other deleterious materials.

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Site soils from cuts may be used for fill, provided they meet the requirements in paragraph 5.B. Most of the native soils will be satisfactory, although some selective blending may be necessary.

C. Construction

(1) Treatment of Natural Ground Surface in Building Areas: After excavating the area of the structure to near final grade, the excavation shall be observed by the geotechnical engineer to verify that any existing man-made fill is removed from within building areas upon which slab-on-grade floors are to be constructed. Native soils exposed in the excavation shall be scarified to a minimum depth of 12 inches and watered to bring the moisture content as close as practicable to optimum moisture content. The upper 8 inches of the native soils shall be compacted to the minimum dry density required in paragraph 5.C(3). Scarification can be deleted in areas in which tuff rock is exposed at the finished subgrade.

(2) Treatment of Natural Ground Surfaces in Non-Building Areas: The upper 8 inches of native soils outside building areas and in areas to be paved, upon which fills are to be constructed, and in cuts near final grade, shall be scarified, brought to a moisture content of 2 percent below optimum, or higher, and compacted to requirements in Section 5.C(3). Scarification can be deleted in areas in which tuff rock is exposed at the finished subgrade.

(3) Compaction: The fill shall be spread in layers not exceeding 8 inches, watered as necessary, and compacted. Thicker layers of fill may be accepted, provided the contractor can demonstrate the ability to achieve adequate densification. Moisture content at the time of compaction shall be $\pm$ 2 percent of optimum.

Compaction shall be by whatever method the contractor chooses to use to obtain a density of not less than 95 percent of maximum dry density for the

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Nuclear Materials Storage Facility
Los Alamos, New Mexico
SHB Job No. E84-1044

building pads and areas to be paved. Embankments outside the building pads shall be compacted to 90 percent of maximum dry density. All backfill in the various areas of the project shall be compacted as specified above.

Optimum moisture and maximum dry density for each soil type used shall be determined in accordance with ASTM D1557.

6. FIELD OBSERVATION & TESTS

A. Field Observation & Testing: The owner shall retain the geotechnical engineer to observe all controlled earthwork. The geotechnical engineer shall provide continuous on-site observation by experienced personnel during construction of controlled earthwork. The contractor shall notify the engineer at least two working days in advance of any field operations of the controlled earthwork, or of any resumption of operations after stoppages. Tests of fill materials and embankments shall be made at the following minimum rates:

(1) One field density test per each 750 square yards of original ground surface prior to placing fill or in cut areas.

(2) One field density test per each 175 cubic yards of fill placed or each layer of fill for each work area, whichever is greater.

(3) One moisture-density curve for each type of material used, as indicated by sieve analysis and plasticity index.

B. Report of Field Density Tests: The geotechnical engineer shall submit, daily, the results of field density tests required by these specifications.

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CONSULTING GEOTECHNICAL
ENGINEER - ALBUQUERQUE, NEW MEXICO

DESIGNED BY _____ DATE _____

CHECKED BY _____ DATE _____

1. this

50

~~11/10/1977~~

DESIGNED BY CLQ DATE 2/77

CHECKED BY _____ DATE _____

QTY	DESCRIPTION	FIXTURE UNITS	TOTAL FIXTURE UNITS
5	SHOWERS	4	20
1	SINK	4	4
5	WATER CLOSETS	3	15
1	ELECTRIC WATER COOLER	1	1
1	MOP SINK.	4	4
1	URINAL	5	5
9	LAVATORIES.	2	18

TOTAL FIXTURE UNITS = 67

~~11/10/1977~~ 2nd FLOOR BUILDING

SANITARY ~~SEWER MAINS~~

~~10" DIA WASTE LINE~~ ~~5" FIRE PROTECTION~~
MAIN

DESIGNED BY CLK

DATE 2/7

CHECKED BY

DATE

QTY	DESCRIPTION	FIXTURE UNITS	TOTAL FIXTURE UNITS
5	WATER CLOSETS	6	30
1	URINAL	2	2
5	SHOWERS	2	10
1	SINK	2	2
1	MOP SINK	3	3
2	FLOOR DRAINS	3	6
1	ELECTRIC WATER COOLERS	1	1
9	LAVATOIRES	1	9
			<u>63 UNITS</u>

12" DIA SANITARY SEWER MAIN

12" DIA ACID WASTE LINE

12" DIA FIRE PROTECTION LINE

(SEE PRELIMINARY
FIRE PROTECTION
ANALYSIS).

~~NATURAL GAS PIPING MAIN~~ LINE
SIZE

DESIGNED BY LLO

DATE 3/7/8

CHECKED BY

DATE

1- BOILERS INPUT = 675,000 BTU/H EACH

1- WATER HEATER = 300,000 BTU/H

USE MEDIUM PRESSURE GAS FROM METER TO BUILDING.
200 FT OF PIPE 5.0 PSIG W/ A 10% PRESSURE DROP AND
A SPECIFIC GRAVITY OF 0.6 SG (FROM TABLE 10-9 OF
NFPA 54 1992 EDITION.)

1000 BTU = 1 CUFT OF GAS

975,000 BTU = 296 CUFT/HK OF GAS

USE 1" PIPE

LOW PRESSURE GAS INTO BUILDING USE 50 FT
PIPE OF 0.5 PSIG W/ PRESSURE DROP OF 0.3 INCH OF
WATER. GAS OF 0.6 SG.

~~USE 1/2" PIPE INTO~~ BUILDING

~~USE 1/2" PIPE TO~~ BOILER

~~USE 1/2" PIPE TO~~ WATER HEATER

ICF KAISER ENGINEERS

1900 Diamond Drive
Los Alamos, New Mexico 87544

DESIGN CALCULATION INDEX

CALC. NO.

SHEET NO.

1

JOB NUMBER 41552-056-00

AREA OR BUILDING

CALCULATION DESCRIPTION

DISCIPLINE

JOB TITLE NMISF CDR

TA-55

ARCHITECTURAL REFER. Material

CALCULATIONS APPLY TO DRAWINGS AND REVISIONS SHOWN

DRAWING	REV	DRAWING	REV	DRAWING	REV	DRAWING	REV

DESIGN ENGINEER

Susie Murphy 3/95
(SIGNATURE) (DATE)

JOB ENGINEER

(SIGNATURE) (DATE)

CALCULATIONS CHECKED

(SIGNATURE) (DATE)

DESIGN SUPERVISOR

John R. Riquelme 5-95
(SIGNATURE) (DATE)

CALCULATIONS AGREE WITH DESIGN CRITERIA

(SIGNATURE) (DATE)

CALCULATIONS AGREE WITH APPLIC. VENDOR DWGS.

(SIGNATURE) (DATE)

CALCULATION KEYS

DATES

DATES

DATES

DATES

REVISION DESCRIPTION

100% LDR

5/95

DESIGN ENGINEER

DESIGN SUPERVISOR

STATUS

PRELIMINARY

FINAL

CHECK

VOID

HOLD

OTHER

REASON FOR VOID OR HOLD:

INDEX

SHEET NO.

DESCRIPTION

1

Index

2-8

UBC Reference Material.

9-12

CODE ANALYSIS, LIFE SAFETY CODE

CODE ANALYSIS - UBC 1994

A. PROPOSED BUILDING

1. AREA (OUTSIDE MAA) 3,752 S.F.
2. NUMBER OF STORIES 2
3. DISTANCE TO PROPERTY LINE N/A
4. TYPES OF SPACES
 - a. SECURITY VESTIBULE
 - b. TRUCK LOADING AREA
 - c. RESTROOM
 - d. COLD JANITOR
5. CONSTRUCTION TYPE: II

B. OCCUPANCY

1. OC TYPE B-2 (CHAPTER 3)
2. REQUIRED SEPARATIONS (1) HR (TABLE 3-B)

C. SPECIAL USE N/A

D. BUILDING LIMITATIONS (CHAPTER 5)

1. FIRE RESISTANCE OF EXTERIOR WALLS AND OPENINGS - NOT PERMITTED LESS THAN 5 FEET, PROTECTED LESS THAN 20 FEET (TABLE 5-A)
2. ALLOWABLE FLOOR AREA: 36,000 (TABLE 5-B AND SECTION 504.2)
3. ALLOWABLE AREA INCREASES - N/A
4. MAXIMUM HEIGHT - 4 STORIES, 65 FEET IN HEIGHT (TABLE 5-B)

E. TYPE OF CONSTRUCTION - II

1. STRUCTURAL ELEMENTS - N/A
2. FLOOR ELEMENTS - NONCOMBUSTIBLE
3. WALLS AND PERMANENT PARTITIONS - NONCOMBUSTIBLE
4. SHAFT WALLS ARE TO BE 2 HOUR, ALL OTHER ELEMENTS HAVE NO GENERAL REQUIREMENTS FOR FIRE RESISTANCE EXCEPT THAT THEY ARE NONCOMBUSTIBLE (SECTION 603.1)

H. FIRE PROTECTION SYSTEM - SPRINKLER SYSTEM PROVIDED THROUGHOUT BUILDING EXCEPT IN THE CHARGE HALL

I. MEANS OF EGRESS

1. OCCUPANT LOAD - 50 MINIMUM OF TWO EXISTS OTHER THAN ELEVATORS ARE REQUIRED WHERE NUMBER OF OCCUPANTS IS AT LEAST 50 (TABLE 10-A).
OCCUPANT LOAD FACTOR IS 15 (TABLE 10-A)
2. EXITS REQUIRED - SEE ABOVE
3. MIN. TOTAL EXIT WIDTH -
4. TRAVEL DISTANCE TO EXTERIOR -
5. DOORS OPEN IN DIRECTION OF TRAVEL
6. DEAD END CORRIDORS: N/A

openings in another story or if less than 10 feet (3048 mm) from other doors or windows of the same building shall be protected by a fire assembly having a three-fourths-hour fire-protection rating. Such fire assemblies shall be fixed, automatic or self-closing. For heating equipment occupancy separation see Section 302.5.

303.9 Fire Alarm Systems. An approved fire alarm system shall be installed as set forth in the Fire Code in Group A, Divisions 1, 2 and 2.1 Occupancies.

For amusement building alarm systems see Section 408.5.1.

SECTION 304 — REQUIREMENTS FOR GROUP B OCCUPANCIES

304.1 Group B Occupancies Defined.

Group B Occupancies shall include buildings, structures, or portions thereof, for office, professional or service-type transactions, which are not classified as Group H Occupancies. Such occupancies include occupancies for the storage of records and accounts, and eating and drinking establishments with an occupant load of less than 50. Business occupancies shall include, but not be limited to, the following:

1. Animal hospitals, kennels, pounds.
2. Automobile and other motor vehicle showrooms.
3. Banks.
4. Barber shops.
5. Beauty shops.
6. Car washes.
7. Civic administration.
8. Outpatient clinic and medical offices (where five or less patients in a tenant space are incapable of unassisted self-preservation).
9. Dry cleaning pick-up and delivery stations and self-service.
10. Educational occupancies above the 12th grade.
11. Electronic data processing.
12. Fire stations.
13. Florists and nurseries.
14. Laboratories—testing and research.
15. Laundry pick-up and delivery stations and self-service.
16. Police stations.
17. Post offices.
18. Print shops.
19. Professional services such as attorney, dentist, physician, engineer.
20. Radio and television stations.
21. Telephone exchanges.

For occupancy separations, see Table 3-B.

304.2 Construction, Height and Allowable Area.

304.2.1 General. Buildings or parts of buildings classed as Group B Occupancies because of the use or character of the occupancy shall be limited to the types of construction set forth in Table S-B.

TABLE 5-A—EXTERIOR WALL AND OPENING PROTECTION BASED ON LOCATION ON PROPERTY FOR ALL CONSTRUCTION TYPES^{1,2,3}—(Continued)

OCCUPANCY GROUP ⁴	CONSTRUCTION TYPE	EXTERIOR WALLS		OPENINGS ⁵
		Bearing	Nonbearing	
		Distances are measured to property lines (see Section 503).		
		v 304.8 for mm		
A-3 cont.	V One-hour	Two-hour less than 5 feet One-hour elsewhere	Same as bearing	Not permitted less than 5 feet Protected less than 10 feet
	V-N	Two-hour less than 5 feet One-hour less than 20 feet NR elsewhere	Same as bearing	Not permitted less than 5 feet Protected less than 10 feet
A-4	II One-hour	One-hour N/C	Same as bearing except NR, N/C 40 feet or greater	Protected less than 10 feet
	II-N	One-hour N/C less than 10 feet NR, N/C elsewhere	Same as bearing	Protected less than 10 feet
	III-N	Four-hour N/C	Four-hour N/C less than 5 feet Two-hour N/C less than 20 feet One-hour N/C less than 40 feet NR, N/C elsewhere	Not permitted less than 5 feet Protected less than 10 feet
	V One-hour	One-hour	Same as bearing	Protected less than 10 feet
	V-N	One-hour less than 10 feet NR elsewhere	Same as bearing	Protected less than 10 feet
B, F-1, M, S-1, S-3	I-F.R. II-F.R. III One-hour III-N IV-H.T.	Four-hour N/C less than 5 feet Two-hour N/C elsewhere	Four-hour N/C less than 5 feet Two-hour N/C less than 20 feet One-hour N/C less than 40 feet NR, N/C elsewhere	Not permitted less than 5 feet Protected less than 20 feet
B F-1 M S-3	II One-hour	One-hour N/C	Same as bearing except NR, N/C 40 feet or greater	Not permitted less than 5 feet Protected less than 10 feet
	II-N ³	One-hour N/C less than 20 feet NR, N/C elsewhere	Same as bearing except NR, N/C 40 feet or greater	Not permitted less than 5 feet Protected less than 10 feet
	V One-hour	One-hour	Same as bearing	Not permitted less than 5 feet Protected less than 10 feet
	V-N	One-hour less than 20 feet NR elsewhere	Same as bearing	Not permitted less than 5 feet Protected less than 10 feet

E-1 E-2 E-3	I-F.R. II-F.R. III One-hour III-N IV-H.T.	Four-hour N/C	Four-hour N/C less than 5 feet Two-hour N/C less than 20 feet One-hour N/C less than 40 feet NR, N/C elsewhere	Not permitted less than 5 feet Protected less than 20 feet
	II One-hour	Two-hour N/C less than 5 feet One-hour N/C elsewhere	Same as bearing except NR, N/C 40 feet or greater	Not permitted less than 5 feet Protected less than 10 feet
	II-N	Two-hour N/C less than 5 feet One-hour N/C less than 10 feet NR, N/C elsewhere	Same as bearing except NR, N/C 40 feet or greater	Not permitted less than 5 feet Protected less than 10 feet
	V One-hour	Two-hour less than 5 feet One-hour elsewhere	Same as bearing	Not permitted less than 5 feet Protected less than 10 feet
	V-N	Two-hour less than 5 feet One-hour less than 10 feet NR elsewhere	Same as bearing	Not permitted less than 5 feet Protected less than 10 feet
S-2 S-2	I-F.R. II-F.R. III One-hour III-N IV-H.T.	Four-hour N/C less than 5 feet Two-hour N/C elsewhere	Four-hour N/C less than 5 feet Two-hour N/C less than 20 feet One-hour N/C less than 40 feet NR, N/C elsewhere	Not permitted less than 3 feet Protected less than 20 feet
	II One-hour	One-hour N/C	Same as bearing NR, N/C 40 feet or greater	Not permitted less than 5 feet Protected less than 10 feet
	II-N ³	One-hour N/C less than 5 feet NR, N/C elsewhere	Same as bearing	Not permitted less than 5 feet Protected less than 10 feet
	V One-hour	One-hour	Same as bearing	Not permitted less than 5 feet Protected less than 10 feet

B—BASIC ALLOWABLE BUILDING HEIGHTS AND BASIC ALLOWABLE FLOOR AREA FOR BUILDINGS ONE STORY IN HEIGHT¹

TYPE OF CONSTRUCTION		TYPES OF CONSTRUCTION								
		I	II		III		IV	V		
		F.R.	F.R.	One-hour	N	One-hour	N	H.T.	One-hour	N
		Maximum Height (feet)								
		UL	160 (48 768 mm)	65 (19 812 mm)	55 (16 764 mm)	65 (19 812 mm)	55 (16 764 mm)	65 (19 812 mm)	50 (15 240 mm)	40 (12 192 mm)
Use Group	Height/Area	Maximum Height (stories) and Maximum Area (sq. ft.) (× 0.0929 for m ²)								
A-1	H A	UL UL	4 29,900	Not Permitted						
A-2, 2, 1 ²	H A	UL UL	4 29,900	2 13,500	NP NP	2 13,500	NP NP	2 13,500	2 10,500	NP NP
A-3, 4 ²	H A	UL UL	12 29,900	2 13,500	1 9,100	2 13,500	1 9,100	2 13,500	2 10,500	1 6,000
B, F-1, M, S-1, S-3, S-5	H A	UL UL	12 39,900	4 18,000	2 12,000	4 18,000	2 12,000	4 18,000	3 14,000	2 8,000
E-1, 2, 3 ⁴	H A	UL UL	4 45,200	2 20,200	1 13,500	2 20,200	1 13,500	2 20,200	2 15,700	1 9,100
F-2, S-2 ³	H A	UL UL	12 59,900	4 27,000	2 18,000	4 27,000	2 18,000	4 27,000	3 21,000	2 12,000
H-1 ⁵	H A	1 15,000	1 12,400	1 5,600	1 3,700	Not Permitted				
H-2 ⁵	H A	UL 15,000	2 12,400	1 5,600	1 3,700	1 5,600	1 3,700	1 5,600	1 4,400	1 2,500
H-3, 4, 5 ⁵	H A	UL UL	5 24,800	2 11,200	1 7,500	2 11,200	1 7,500	2 11,200	2 8,800	1 5,100
H-6, 7	H A	3 UL	3 39,900	3 18,000	2 12,000	3 18,000	2 12,000	3 18,000	3 14,000	1 8,000
I-1, 1, 1 ⁶	H A	UL UL	3 15,100	1 6,800	NP NP	1 6,800	NP NP	1 6,800	1 5,200	NP NP
I	H A	UL UL	3 15,100	2 6,800	NP NP	2 6,800	NP NP	2 6,800	2 5,200	NP NP
I-3	H A	UL UL	2 15,100	Not Permitted ⁷						
R-1	H A	UL UL	12 29,900	4 13,500	2 ⁹ 9,100 ⁹	4 13,500	2 ⁹ 9,100 ⁹	5 13,500	3 10,500	2 ⁹ 6,000 ⁹

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R-3	H	UL	3	3	3	3	3	3	3	3
	A	Unlimited								
S-4	H A	See Table 3-H								
U ⁸	H A	See Chapter 3								

—Building area in square feet.
 —Building height in number of stories.
 T.—Heavy timber.
 P.—Not permitted.

N—No requirements for fire resistance.
 F.R.—Fire resistive.
 UL—Unlimited.

²For multistory buildings, see Section 504.2.

³For limitations and exceptions, see Section 303.2.

⁴For open parking garages, see Section 311.9.

see Section 305.2.3.

see Section 307.

see Section 308.2.1 for exception to the allowable area and number of stories in hospitals, nursing homes and health-care centers.

see Section 308.2.2.2.

for agricultural buildings, see also Appendix Chapter 3.

for limitations and exceptions, see Section 310.2.

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protected only on the exterior side with materials approved for one-hour fire-resistive construction. See Section 503.

503.4.9 Exterior wall assemblies. Exterior wall assemblies complying with Section 2602.5.2 may be used in all types of construction.

SECTION 504 — ALLOWABLE FLOOR AREAS

504.1 One-story Areas. The area of a one-story building shall not exceed the limits set forth in Table 5-B except as provided in Section 505.

504.2 Areas of Buildings over One Story. The total combined floor area for multistory buildings may be twice that permitted by Table 5-B for one-story buildings, and the floor area of any single story shall not exceed that permitted for a one-story building.

504.3 Allowable Floor Area of Mixed Occupancies. When a building houses more than one occupancy, the area of the building shall be such that the sum of the ratios of the actual area for each separate occupancy divided by the total allowable area for each separate occupancy shall not exceed one.

EXCEPTIONS: 1. The major occupancy classification of a building may be used to determine the allowable area of such building when the major use occupies not less than 90 percent of the area of any floor of the building and provided that other minor accessory uses shall not exceed the basic area permitted by Table 5-B for such minor uses and that various uses are separated as specified in Section 302.4.

2. Groups B, F, M and S and Group H, Division 5 Occupancies complying with the provisions of Section 505.2 may contain other occupancies provided that such occupancies do not occupy more than 10 percent of the area of any floor of a building, nor more than the basic area permitted in the occupancy by Table 5-B for such occupancy, and further provided that such occupancies are separated as specified in Section 302.4.

504.4 Mezzanines. Unless considered as a separate story, the floor area of all mezzanines shall be included in calculating the allowable floor area of the stories in which the mezzanines are located.

504.5 Basements. A basement need not be included in the total allowable area, provided such basement does not exceed the area permitted for a one-story building.

504.6 Area Separation Walls.

504.6.1 General. Each portion of a building separated by one or more area separation walls which comply with the provisions of this subsection may be considered a separate building. The extent and location of such area separation walls shall provide a complete separation.

When an area separation wall also separates occupancies that are required to be separated by an occupancy separation, the most restrictive requirements of each separation shall apply.

504.6.2 Fire resistance and openings. Area separation walls shall not be less than four-hour fire-resistive construction in Types I, II-F.R., III and IV buildings and two-hour fire-resistive construction in Types II One-hour, II-N or V buildings. The total width of all openings in such walls shall not exceed 25 percent of the length of the wall in each story. All openings shall be protected by a fire assembly having a three-hour fire-protection rating in four-hour fire-resistive walls and one- and one-half-hour fire-protection rating in two-hour fire-resistive walls.

504.6.3 Extensions beyond exterior walls. Area separation walls shall extend horizontally to the outer edges of horizontal projecting elements such as balconies, roof overhangs, canopies, marquees or architectural projections extending beyond the floor area as defined in Section 207.

EXCEPTIONS: 1. When horizontal projecting elements do not contain concealed spaces, the area separation wall may terminate at the exterior wall.

2. When the horizontal projecting elements contain concealed spaces, the area separation wall need only extend through the concealed space to the outer edges of the projecting elements.

In either Exception 1 or 2, the exterior walls and the projecting elements above shall not be of less than one-hour fire-resistive construction for a distance not less than the depth of the projecting elements on both

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504.6.4 Ter
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3. 1
or slab

504.6.5 Par
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504.6.6 Bu
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fourths-hou

EN
or slab

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2
framing

See Cha

SECTION

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505.1.3
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TABLE 6-A—TYPES OF CONSTRUCTION—FIRE-RESISTIVE REQUIREMENTS (In Hours)
For details, see occupancy section in Chapter 3, type of construction sections in this chapter and sections referenced in this table.

BUILDING ELEMENT	TYPE II				TYPE III		TYPE IV	TYPE V	
	Noncombustible				Combustible				
	Fire-resistive	Fire-resistive	1-Hr.	N	1-Hr.	N	H.T.	1-Hr.	N
walls—exterior	4 Sec. 602.3.1	4 Sec. 603.3.1	1	N	4 Sec. 604.3.1	4 Sec. 604.3.1	4 Sec. 605.3.1	1	N
walls—interior	3	2	1	N	1	N	1	1	N
partitioning walls—	4 Sec. 602.3.1	4 Sec. 603.3.1	1 Sec. 603.3.1	N	4 Sec. 604.3.1	4 Sec. 604.3.1	4 Sec. 605.3.1	1	N
structural frame ¹	3	2	1	N	1	N	1 or H.T.	1	N
columns—permanent	1 ²	1 ²	1 ²	N	1	N	1 or H.T.	1	N
enclosures ³	2	2	1	1	1	1	1	1	1
stair and floor-ceilings	2	2	1	N	1	N	H.T.	1	N
stair and roof-ceilings	2 Sec. 602.5	1 Sec. 603.5	1 Sec. 603.5	N	1	N	H.T.	1	N
exit doors and windows	Sec. 602.3.2	Sec. 603.3.2	Sec. 603.3.2	Sec. 603.3.2	Sec. 604.3.2	Sec. 604.3.2	Sec. 605.3.2	Sec. 606.3	Sec. 606.3
day construction	Sec. 602.4	Sec. 603.4	Sec. 603.4	Sec. 603.4	Sec. 604.4	Sec. 604.4	Sec. 605.4	Sec. 606.4	Sec. 606.4

H.T.—Heavy timber.
General requirements for fire resistance.
¹Frame elements in an exterior wall that is located where openings are not permitted or where protection of openings is required, shall be protected against external fire as required for exterior bearing walls or the structural frame, whichever is greater.
²Wood (see Section 207) may be used in the assembly, provided fire-resistance requirements are maintained. See Sections 602 and 603.
³see Sections 304.6, 306.6 and 711.

6-A

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Chapter 7 FIRE-RESISTANT MATERIALS

SECTION 701 — SCOPE

This chapter applies to materials and systems used in buildings safeguarded against the spread of fire and smoke within buildings.

SECTION 702 — DEFINITIONS

For the purposes of this chapter, the terms, phrases and definitions shall have the indicated meanings.

CONCRETE, CARBONATE AGGREGATE, is mainly of calcium or magnesium carbonate, e.g., lime or less quartz, chert or flint.

CONCRETE, LIGHTWEIGHT AGGREGATE, is made of clay, shale, slag or slate or sintered fly ash and water (1360 to 1840 kg/m³).

CONCRETE, SAND-LIGHTWEIGHT, is concrete of clay, shale, slag or slate or sintered fly ash and natural sand and 120 pcf (1680 and 1920 kg/m³).

CONCRETE, SILICEOUS AGGREGATE, is concrete consisting mainly of silica or compounds other than containing more than 40 percent quartz, chert or flint.

FIRING is the time period that a through-penetration and hot gases through the fire-stop assembly, including distance with the time-temperature curve defined in U.B.C.

TEMPERATURE CURVE is the time period that a through-penetration fire-stop assembly, including penetrating element temperature curve defined in U.B.C. Standard 7-1.

SECTION 703 — FIRE-RESISTIVE MATERIAL

703.1 General. Materials and systems used for fire-resistance shall be specified in this chapter unless accepted under the provisions of the International Building Code. The materials and details of construction for the fire-resistance shall be in accordance with all other provisions of the International Building Code. For the purpose of determining the degree of fire-resistance listed in this chapter shall be assumed to have the fire-resistance of 7-B or 7-C.

As an alternate to Table 7-A, 7-B or 7-C, fire-resistance building official on the basis of evidence submitted required fire-resistance classification.

703.2 Qualification by Test. Material or assembly shall be tested in accordance with the requirements set forth in U.B.C. Standard 7-1 and 7-2.

1021.7.10 Minimum exit width. No exit shall be less than 42 inches (1067 mm) in width.

SECTION 1022 — BUILDING SECURITY

See Appendix Chapter 10 for requirements governing building security.

TABLE 10-A—MINIMUM EGRESS REQUIREMENTS¹

USE ²	MINIMUM OF TWO EXITS OTHER THAN ELEVATORS ARE REQUIRED WHERE NUMBER OF OCCUPANTS IS AT LEAST	OCCUPANT LOAD FACTOR ³ (square feet) × 0.0929 for m ²
1. Aircraft hangars (no repair)	10	500
2. Auction rooms	30	7
3. Assembly areas, concentrated use (without fixed seats) Auditoriums Churches and chapels Dance floors Lobby accessory to assembly occupancy Lodge rooms Reviewing stands Stadiums Waiting area	50	7
4. Assembly areas, less-concentrated use Conference rooms Dining rooms Drinking establishments Exhibit rooms Gymnasiums Lounges Stages	50	15
5. Bowling alley (assume no occupant load for bowling lanes)	50	4
6. Children's homes and homes for the aged	6	80
7. Classrooms	50	20
8. Congregate residences	10	200
9. Courtrooms	50	40
10. Dormitories	10	50
11. Dwellings	10	300
12. Exercising rooms	50	50
13. Garage, parking	30	200
14. Hospitals and sanitariums— Health-care center Nursing homes Sleeping rooms Treatment rooms	10 6 10	80 80 80
15. Hotels and apartments	10	200
16. Kitchen—commercial	30	200
17. Library reading room	50	50
18. Locker rooms	30	50

(Continued)

19. Malls (see
20. Manufactu
21. Mechanical
22. Nurseries to
23. Offices
24. School shop
25. Skating rink
26. Storage and st
27. Stores—retail
Basements and
Upper floors
28. Swimming pool
29. Warehouses
30. All others

¹Access to, and egress to, for additional provision, equipment or cellulose.
²This table shall not be used.
³Occupant load based on

TABLE W

NUMBER OF SEATS
Unlimited
See Section 1014.3 for determination

TABLE 10-C—C
S

NUMBER OF SEATS
2,000
5,000
10,000
15,000
20,000
25,000 or more
See Section 1014.3 for determination

Code Analysis

- Materials Access Area

DOE Order 5632.1C - Protection and Control of Safeguards and Security Interests

Section 7E.1.A. Security Areas shall be established when the nature, size, revealing characteristics, sensitivity, monetary value, or importance of safeguards and security interests is such that access to them cannot otherwise be effectively controlled. Materials Access Areas shall be defined by barriers, and access to them shall be controlled.

Section 7E.4. Barriers. Permanent physical barriers shall be installed to control, deny, impede, or delay unauthorized access into Materials Access Areas.

Section 7E.5. Lock. Security locks shall be used to secure safeguards and security interests.

Section 7E.6. Secure Storage. Secure storage for the interest under protection shall be provided in a graded manner.

DOE Order 6430.1A - General Design Criteria

- Material Access Area

Section 0110-13.2.1. A security area denotes a physically defined space containing (DOE) security interest and subject to physical protection and access controls. Security areas shall be established when the nature, size, revealing characteristics, sensitivity, or importance of the classified matter or associated security interests are such that access to them cannot be effectively controlled by other internal measures. The type of security area established depends on the nature of the security interests to be protected, with the following types required for the protection of the listed security interests: (one of which is the materials access area).

Section 1300-10.2.4. Material access areas shall be contained within protected areas. Material access areas shall have clearly defined barriers sufficient to direct the flow of personnel and vehicles through designated portals and allow effective searches by providing reasonable assurance that prohibited articles are not introduced and Special Nuclear Materials cannot be transported outside of the material access area without detection.

Adequate space shall be designed for exit inspections/searches of all personnel, vehicles, and hand-carried items, including packages, briefcases, and lunch pails, to prevent unauthorized removal of Special Nuclear Materials. Personnel inspections/searches may be accomplished through the use of SNM portal monitors and metal detectors.

Specific SNM/metal detection levels shall be established, justified, and documented in Site Safeguards and Security Plan and/or Master Safeguards and Security Agreement.

Section 1300-10.25. Rooms, buildings, or portions of a building within a material access area or controlled and alarmed process containing unattended Category I quantities of in-process Special Nuclear Materials shall be equipped with Departmental-approved intrusion alarm systems or other equally effective means of detection approved by the responsible field element.

Section 1300.10.32. The objective of the MAA boundary is to prevent or detect the unauthorized movement of material through it, while allowing for authorized personnel access, authorized material movement, and emergency evacuation as necessary. This means that designed-in penetrations of the MAA boundary shall either be monitored or shall not present a credible path for material removal and that malevolent penetration of the MAA boundary is either not credible or detectable.

The wall defining the MAA boundary shall be designed/constructed so that penetration within the specified delay times is not credible. Some type of monitoring shall be provided in areas where penetration is credible; designs in which the walls are easily penetrated or are hidden from view are not advisable. MAA walls shall not provide hiding places or redoubt-like structures for adversaries.

Penetrations in the floor and ceiling for piping, HVAC, and other support systems shall not be large enough or accessible enough to create credible paths for the removal of material. As with walls, ceilings should not provide places to hide material.

Portal systems shall allow for the passage of personnel while detecting the presence of nuclear material and metal. Sometimes, in addition, equipment/package portals are used so that tools and packages can be monitored separately. The following should apply to the design of portals: Physical relationships should be considered in determining locations of vaults, processing areas, shipping/receiving areas and NDA stations, as materials will flow from one of these to the other.

Section 1300-10.3.4. Personnel access to various parts of a facility (and materials within the facility) is often controlled at a finer level than the MAA. To accomplish this, it is necessary to subdivide the MAA into rooms or sets of rooms to which access is granted by electronic card systems, keypads, guard stations, or other devices. This reduces the number of people having access to a wide range of materials.

Section 1304-5. Space shall be provided within each MAA that is adequate for receiving, handling, storing, and measuring receipts.

- Change Rooms

Section 1300-6.8. Men's and women's change rooms shall be provided for changing into and from protective clothing. These areas shall be adjacent to shower facilities and shall be designed to ensure that clean clothing (e.g., personal clothing) and protective clothing are segregated. The design shall ensure that storage of contained protective clothing will control contamination so that it does not spread beyond the storage container area. The change-room exhaust air shall be HEPA filtered if dispersible radionuclides are handled in the process area it serves.

- Airlocks

Section 0011-6.4. The design of hazardous areas shall facilitate access by emergency personnel from the exterior and, at the same time, shall maintain any required confinement or containment using airlocks.

Section 1300-7.3. Special features shall be considered for access through confinement barriers to minimize the impact of facility access requirements on the ventilation system and to prevent the release of radioactive airborne materials. Provision for normal and emergency equipment shall be provided in or adjacent to the access ways.

Section 1304-6.3. Penetration of the secondary barrier shall have positive seals on permanent penetration or double closure with controlled secondary to prevent leakage on pass-through penetration (e.g., personnel airlocks)

Section 1305-5.3. Penetrations of the secondary confinement barrier shall have positive seals to prevent the migration of contamination. The use of positive seals shall be considered for penetration of enclosures within the facility building to ensure the availability of proper ventilation flow paths and to prevent the migration of contamination within the facility.

Section 1305.5.4. Air locks or enclosed vestibules shall be provided for access through confinement barriers.

Section 1550-99.02. The design of a confinement ventilation system shall ensure the ability to maintain designed airflow characteristics when personnel access doors or hatches are open. When necessary, airlocks or enclosed vestibules shall be used to minimize the impact of this on the ventilation system and to prevent the spread of airborne contaminants within the facility.

NFPA 101 - Life Safety Code

Section 1-4.6. Any alteration or any installations of new equipment shall be accomplished as nearly as practical in conformance with the requirements for new construction. Alterations shall not diminish the level of life safety below that which exists prior to the alteration. In no case shall the resulting life safety be less than that required for existing buildings. Life safety features that do not meet the requirements for new buildings but exceed the requirements for existing buildings shall not be further diminished. Life safety features in excess of those required for new construction are not required to be maintained.

Section 4-1. Industrial. Industrial occupancies include factories making products of all kinds and properties devoted to operations such as processing, assembling, mixing, packaging, finishing or decorating, and repairing.

Section 4-2.2.3. Ordinary Hazard. Ordinary hazard contents shall be classified as those that are likely to burn with moderate rapidity or to give off a considerable volume of smoke.

Section 5-5.1.2. Where exits are not immediately accessible from an open-floor area, safe and continuous passageways, aisles, or corridors leading directly to every exit shall be maintained and shall be arranged to provide access for each occupant to at least two exits by separate ways of travel.

Section 5.5.1.3. Where more than one exit is required from a building or portion thereof, such exits shall be remotely located from each other and shall be arranged and constructed to minimize the possibility that more than one can be blocked by any one fire or other emergency condition.

Section 5-5.1.4. In buildings protected throughout by an approved, supervised automatic sprinkler system in accordance with Section 7-7, the minimum separation distance between two exits or exit access doors measured in accordance with 5-5.1.4 shall be not less than one-third the length of the maximum overall diagonal dimension of the building or area to be served.

Section 5-8.1.1. Illumination of means of egress shall be required.

Section 5-9.1.1. Emergency lighting facilities for means of egress shall be provided.

Section 5-10.1.2. Exits shall be marked by an approved sign readily visible from any direction of exit access.

Section 5-11.3. At least two means of egress shall be provided from each building or hazardous area.

Section 5-11.4. Means of egress shall be arranged so that there are no dead ends in corridors.

Section 28-1.7. Occupant Load. The occupant load for which means of egress shall be provided from any floor of an industrial occupancy shall be the maximum number of persons intended to occupy that floor, but not less than one person for each 100 sq. ft of gross floor area.

Section 28-2.4.1. There shall be not less than two means of egress from every story or section, and at least one exit must be reached without traversing another story.

Section 28-2.5.2. Dead-end corridors in general industrial and special-purpose industrial occupancies shall not exceed 50 ft. Exception: In buildings protected throughout by an approved, supervised automatic sprinkler system installed in accordance with Section 7-7, common paths of travel shall not exceed 100 ft.

Section 28-2.6.1. Travel distance to exits shall not exceed 200 ft.

Section 28-3.1. Protection of Vertical Openings. Every stairway, elevator shaft, escalator opening, and other vertical opening shall be enclosed or protected.

900 Deming Drive
Los Alamos New Mexico 87544

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ALL INFORMATION CONTAINED HEREIN IS UNCLASSIFIED

DRAWING	REV	DRAWING	REV	DRAWING	REV	DRAWING	REV
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500

DESIGN ENGINEER Chris Hunter 3/13/95 JOB ENGINEER _____

CALCULATIONS CHECKED Thomas P. Blum 3/14/95
 SIGNATURE DATE
 DESIGN SUPERVISOR _____
 SIGNATURE DATE

CALCULATIONS AGREE WITH DESIGN CRITERIA				SIGNATURE		DATE		CALCULATIONS AGREE WITH APP'D. VENDOR DWG.				SIGNATURE		DATE	
CALCULATION KEYS						DATES				DATES				DATES	

REVISION DESCRIPTION							

DESIGN ENGINEER							
DESIGN SUPERVISOR							

STATUS	REASON	DATE	TIME	VOO	HOLD	OTHER
REASON FOR VOO OR HOLD						

SHEET NO.

DESCRIPTION

1 THR 13 OF 117	11-VALUE CALCULATIONS
4 OF 117	ZONE LAYOUT DIAGRAM
5 THR 16 OF 117	HEAT GAIN HEAT LOSS CALCULATIONS
17 THR 104 OF 117	EQUIPMENT CALCULATIONS, EQUIPMENT SELECTION, AND EQUIPMENT CUT SHEETS.
105 THR 107 OF 117	UTILITY MAIN PIPE SIZE CALCULATIONS (WATER, SANITARY SEWER, RAD/ACID WASTE, FIRE PROTECTION, NATURAL GAS)
106 THR 114 OF 117	VAULT STORAGE ARRAY HVAC ALTERNATIVES (EQUIPMENT SELECTION AND LIFE CYCLE COST ANALYSIS ASSUMPTIONS)
115 OF 117	BREATHING AIR SYSTEM CALCULATIONS
116, 117 OF 117	POSITION PAPER ON WALK-IN PLENUMS FOR NMSE

"U" VALUE CALCULATIONS

JOB NAME: NMSF

BUILDING: TA-55-41

JOB# 41552-056

SHEET 1 OF 117

DESIGNED: CLC

CHECKED: *[Signature]*

DATE: 27-Feb-95

DATE: 2/27/95

ROOF

OUTSIDE AIR FILM
ROOF MEMBRANE
4" RIGID INSULATION
2-1/2" LIGHTWEIGHT CONCRETE
4" PRECAST CONCRETE TEES
INSIDE AIR FILM

R VALUE

0.17
0.5
26.30
1.72
0.34
0.61

R TOTAL

$\frac{2}{29.64 \text{ hr-ft-deg F/btu}}$

U=1/R TOTAL

U= 0.0337 btuh/deg f/sf

WALLS

OUTSIDE AIR FILM
3-1/2" EXTERIOR FINISH INSULATION FINISH SYSTEM (EIFS)
12" CONCRETE WALL
INSIDE AIR FILM

0.17
14.6
1.00
0.68

R TOTAL

$\frac{2}{16.45 \text{ hr-ft-deg F/btu}}$

U=1/R TOTAL

U= 0.0608 btuh/deg f/sf

PERIMETER INSULATION 2" THICK R=5 HR-FT^2-DEG F/BTU/IN

U= 0.100 btuh/deg f/sf

GLASS 1/4" THICK DOUBLE GLAZE 1/2" AIR SPACE (ASHRAE 1985 FUNDAMENTALS)

PG. 27.33 TABLE 33

U= 0.540 btuh/deg f/sf

PEOPLE

SENSIBLE = 245 BTUH/PERSON
LATENT = 205 BTUH/PERSON

DESIGNED BY CLP

DATE 12/16/94

CHECKED BY TJ

DATE 2/20/95

EXTERIOR WALL CONSTRUCTION

ICF KAISER ENGINEERS		JOB NO. 4552-056 SHEET 3 OF 17	
DESIGNED BY <i>CLB</i> DATE 12/16/95		CHECKED BY <i>JJ</i> DATE 2/26/96	
ROOF CONSTRUCTION		4\" RIGID INSULATION 2-1/2\" LIGHTWEIGHT CONCRETE ROOF MEMBRANE OUTSIDE AIR FILM	

Sheet 4 of 117 left intentionally blank.

**
** TRACE 600 ANALYSIS **
**
** by C.D.S. MARKETING **
**

ck 2/27/95

NUCLEAR MATERIALS STORAGE FACILITY
LOS ALAMOS, NEW MEXICO
LANL
C. QUARTIERI
15% OUTSIDE AIR

Weather File Code: LAWTR1
Location:
Latitude: 36.0 (deg)
Longitude: 106.0 (deg)
Time Zone: 7
Elevation: 7,500 (ft)
Barometric Pressure: 22.1 (in. Hg)

Summer Clearness Number: 1.10
Winter Clearness Number: 1.05
Summer Design Dry Bulb: 89 (F)
Summer Design Wet Bulb: 60 (F)
Winter Design Dry Bulb: 5 (F)
Summer Ground Relectance: 0.20
Winter Ground Relectance: 0.20

Air Density: 0.0560 (Lbm/cuft)
Air Specific Heat: 0.2444 (Btu/lbm/F)
Density-Specific Heat Prod: 0.8211 (Btu-min./hr/cuft/F)
Latent Heat Factor: 3,614.5 (Btu-min./hr/cuft)
Enthalpy Factor: 3.3592 (Lb-min./hr/cuft)

Desigr. Simulation Period: June To November
System Simulation Period: January To December
Cooling Load Methodology: TETD/Time Averaging

Time/Date Program was Run: 14:23:59 2/27/95
Dataset Name: 05615% .TM

FLOW - ALTERNATIVE 1

SYSTEM SUMMARY
(Design Airflow Quantities)

System Number	System Type	Outside Airflow (Cfm)	Cooling Airflow (Cfm)	Main Heating Airflow (Cfm)	Return Airflow (Cfm)	Exhaust Airflow (Cfm)	Auxil. Supply Airflow (Cfm)	Room Exhaust Airflow (Cfm)
1	TRH	3,417	22,780	22,780	22,780	3,417	0	3,417
2	UH	0	0	213	0	0	0	0
3	TRH	375	2,502	2,502	2,502	375	0	375
4	UH	0	0	211	0	0	0	0
Totals		3,792	25,282	25,706	25,282	3,792	0	3,792

CAPACITY - ALTERNATIVE 1

SYSTEM SUMMARY
(Design Capacity Quantities)

System Number	System Type	Cooling					Heating						
		Main Sys. Capacity (Tons)	Aux. Sys. Capacity (Tons)	Sys. Opt. Capacity (Tons)	Vent Capacity (Tons)	Cooling Totals (Tons)	Main Sys. Capacity (Btuh)	Aux. Sys. Capacity (Btuh)	Preheat Capacity (Btuh)	Reheat Capacity (Btuh)	Humidif. Capacity (Btuh)	Opt. Vent Capacity (Btuh)	Heating Totals (Btuh)
1	TRH	44.6	0.0	0.0	0.0	44.6	-365,794	0	0	-321,801	0	0	-365,794
2	UH	0.0	0.0	0.0	0.0	0.0	-13,131	0	0	0	0	0	-13,131
3	TRH	3.6	0.0	0.0	0.0	3.6	-45,412	0	0	-34,766	0	0	-45,412
4	UH	0.0	0.0	0.0	0.0	0.0	-12,972	0	0	0	0	0	-12,972
Totals		48.3	0.0	0.0	0.0	48.3	-437,309	0	0	-356,567	0	0	-437,309

The building peaked at hour 15 month 7 with a capacity of 47.2 tons

ENGINEERING CHECKS - ALTERNATIVE 1

ENGINEERING CHECKS

System Number	Main/Auxiliary	System Type	Percent Outside Air	Cooling				Heating		Floor Area
				Cfm/Sq Ft	Cfm/Ton	Sq Ft/Ton	Btuh/Sq Ft	Cfm/Sq Ft	Btuh/Sq Ft	Sq Ft
1	Main	TRH	15.00	0.97	510.6	527.3	22.76	0.97	-15.55	23,525
2	Main	UH	0.00	0.00	0.0	0.0	0.00	0.07	-4.53	2,900
3	Main	TRH	15.00	1.57	687.5	438.3	27.38	1.57	-28.47	1,595
4	Main	UH	0.00	0.00	0.0	0.0	0.00	0.08	-4.93	2,630

SYSTEM CHECKSUMS System 1 Peak TRH - TERMINAL REHEAT

***** COOLING COIL PEAK ***** CLG SPACE PEAK ***** HEATING COIL PEAK *****
 Peaked at Time ==> Mo/Hr: 7/15 * Mo/Hr: 6/17 * Mo/Hr: 13/ 1
 Outside Air ==> OADB/WB/HR: 87/ 60/ 63.0 * OADB: 87 * OADB: 5

	Space Sens.+Lat. (Btuh)	Ret. Air Sensible (Btuh)	Ret. Air Latent (Btuh)	Net Total (Btuh)	Perct Of Tot (%)		Space Sensible (Btuh)	Perct Of Tot (%)		Space Peak Space Sens (Btuh)	Coil Peak Tot Sens (Btuh)	Perct Of Tot (%)
Envelope Loads												
Skylite Solr	0	0		0	0.00	*	0	0.00	*	0	0	0.00
Skylite Cond	0	0		0	0.00	*	0	0.00	*	0	0	0.00
Roof Cond	17,834	6,896		24,730	4.62	*	20,687	5.53	*	-17,070	-23,716	10.08
Glass Solar	0	0		0	0.00	*	0	0.00	*	0	0	0.00
Glass Cond	0	0		0	0.00	*	0	0.00	*	0	0	0.00
Wall Cond	3,622	0		3,622	0.68	*	4,860	1.30	*	-21,720	-21,720	9.24
Partition	0	0		0	0.00	*	0	0.00	*	0	0	0.00
Exposed Floor	0	0		0	0.00	*	0	0.00	*	-2,064	-2,064	0.88
Infiltration	0	0		0	0.00	*	0	0.00	*	-1	-1	0.00
Sub Total==>	21,456	6,896		28,352	5.30	*	25,548	6.83	*	-40,855	-47,501	20.20
Internal Loads												
Lights	207,835	0		207,835	38.82	*	207,835	55.56	*	0	0	0.00
People	21,600			21,600	4.03	*	11,760	3.14	*	0	0	0.00
Misc	127,373	0	0	127,373	23.79	*	127,373	34.05	*	0	0	0.00
Sub Total==>	356,808	0	0	356,808	66.64	*	346,968	92.75	*	0	0	0.00
Ceiling Load	1,368	-1,368		0	0.00	*	1,587	0.42	*	-2,259	0	0.00
Outside Air	0	0	0	27,407	5.12	*	0	0.00	*	0	-188,559	80.18
Sup. Fan Heat				0	0.00	*		0.00	*		0	0.00
Ret. Fan Heat		122,823		122,823	22.94	*		0.00	*		0	0.00
Duct Heat Pkup		0		0	0.00	*		0.00	*		0	0.00
OV/UNDR Sizing	0			0	0.00	*	0	0.00	*	0	0	0.00
Exhaust Heat		0	0	0	-0.00	*		0.00	*		886	-0.38
Terminal Bypass		0	0	0	0.00	*		0.00	*		0	0.00
Grand Total==>	379,632	128,352	0	535,390	100.00	*	374,103	100.00	*	-43,114	-235,174	100.00

-----COOLING COIL SELECTION-----										-----AREAS-----		
	Total Capacity (Tons)	Sens Cap. (Mbh)	Coil Airfl (cfm)	Entering DB/WB/HR			Leaving DB/WB/HR			Gross Total	Glass (sf)	(%)
				Deg F	Deg F	Grains	Deg F	Deg F	Grains	Floor	23,525	
Main Clg	44.6	535.4	22,780	83.6	59.8	66.0	55.0	50.3	65.9	Part	0	
Aux Clg	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	ExFlr	308	
Opt Vent	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	Roof	10,545	0 0
Totals	44.6	535.4								Wall	5,332	0 0

-----HEATING COIL SELECTION-----					-----AIRFLOWS (cfm)-----			--ENGINEERING CHECKS--			---TEMPERATURES (F)---		
	Capacity (Mbh)	Coil Airfl (cfm)	Ent Deg F	Lvg Deg F	Type	Cooling	Heating	Clg % OA			Type	Clg	Htg
					Vent	3,417	3,417	Clg Cfm/Sqft	15.0		SADB	55.0	74.6
Main Htg	-365.8	22,780	55.0	74.6	Infil	0	0	Clg Cfm/Ton	0.97	510.59	Plenum	76.4	71.1
Aux Htg	0.0	0	0.0	0.0	Supply	22,780	22,780	Clg Sqft/Ton	527.28		Return	83.0	71.9
Preheat	-0.0	22,780	61.9	55.0	Minclm	22,780	22,780	Clg Btuh/Sqft	22.76		Ret/OA	83.6	61.9
Reheat	-321.8	22,780	55.0	72.2	Return	19,363	22,780	No. People	48		Runarnd	75.0	72.0
Humidif	0.0	0	0.0	0.0	Exhaust	0	3,417	Htg % OA	15.0		Fn MtrTD	0.0	0.0
Opt Vent	0.0	0	0.0	0.0	Rm Exh	3,417	0	Htg Cfm/Sqft	0.97		Fn BldTD	0.0	0.0
Total	-365.8				Auxil	0	0	Htg Btuh/Sqft	-15.55		Fn Frict	0.0	0.0

ITEM CHECKSUMS System 2 Block UH - UNIT HEATERS

***** COOLING COIL PEAK *****					***** CLG SPACE PEAK *****					***** HEATING COIL PEAK *****				
Peaked at Time ==> Mo/Hr: 0/ 0					Mo/Hr: 0/ 0					Mo/Hr: 13/ 1				
Outside Air ==> OADB/WB/HR: 0/ 0/ 0.0					OADB: 0					OADB: 5				
Envelope Loads	Space Sens.+Lat. (Btuh)	Ret. Air Sensible (Btuh)	Ret. Air Latent (Btuh)	Net Total (Btuh)	Perct Of Tot (%)	Space Sensible (Btuh)	Perct Of Tot (%)	Space Peak (Btuh)	Coil Peak (Btuh)	Perct Of Tot (%)	Space Sens (Btuh)	Coil Peak (Btuh)	Perct Of Tot (%)	
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00	0	0	0.00	
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00	0	0	0.00	
Roof Cond	0	0		0	0.00	0	0.00	-4,398	-4,398	33.49				
Glass Solar	0	0		0	0.00	0	0.00	0	0	0.00				
Glass Cond	0	0		0	0.00	0	0.00	0	0	0.00				
Wall Cond	0	0		0	0.00	0	0.00	-8,733	-8,733	66.51				
Partition	0			0	0.00	0	0.00	0	0	0.00				
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00				
Infiltration	0			0	0.00	0	0.00	0	0	0.00				
Sub Total==>	0	0		0	0.00	0	0.00	-13,131	-13,131	100.00				
Internal Loads														
Lights	0	0		0	0.00	0	0.00	0	0	0.00				
People	0			0	0.00	0	0.00	0	0	0.00				
Misc	0	0	0	0	0.00	0	0.00	0	0	0.00				
Sub Total==>	0	0	0	0	0.00	0	0.00	0	0	0.00				
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00				
Outside Air	0	0	0	0	0.00	0	0.00	0	0	0.00				
Sup. Fan Heat				0	0.00		0.00			0.00				
Ret. Fan Heat		0		0	0.00		0.00			0.00				
Duct Heat Pkup		0		0	0.00		0.00			0.00				
OV/UNDR Sizing	0			0	0.00	0	0.00	0	0	0.00				
Exhaust Heat		0	0	0	0.00		0.00			0.00				
Terminal Bypass		0	0	0	0.00		0.00			0.00				
Grand Total==>	0	0	0	0	0.00	0	0.00	-13,131	-13,131	100.00				

-----COOLING COIL SELECTION-----										-----AREAS-----		
	Total Capacity (Tons)	Sens Cap. (Mbh)	Coil Airfl (cfm)	Entering DB/WB/HR			Leaving DB/WB/HR			Gross Total	Glass (sf)	(%)
Main Clg	0.0	0.0	0	Deg F	Deg F	Grains	Deg F	Deg F	Grains	Floor	2,900	
Aux Clg	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	Part	0	
Opt Vent	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	ExFlr	0	
Totals	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	Roof	2,900	0 0
										Wall	3,192	0 0

-----HEATING COIL SELECTION-----					-----AIRFLOWS (cfm)-----			-----ENGINEERING CHECKS-----			-----TEMPERATURES (F)-----		
Capacity (Mbh)	Coil Airfl (cfm)	Ent Deg F	Lvg Deg F	Type	Cooling	Heating	Clg % OA	Clg Cfm/Sqft	Clg Cfm/Ton	Clg Sqft/Ton	No. People	Type	Clg Htg
Main Htg	-13.1	213	50.0	125.0	Vent	0	0	0.00	0.00	0.00	0	SADB	0.0 125.0
Aux Htg	0.0	0	0.0	0.0	Infil	0	0	0.00	0.00	0.00	0	Plenum	0.0 50.0
Preheat	0.0	0	0.0	0.0	Supply	0	213	0.00	0.00	0.00	0	Return	0.0 50.0
Reheat	0.0	0	0.0	0.0	Mincfm	0	0	0.00	0.00	0.00	0	Ret/OA	0.0 50.0
Humidif	0.0	0	0.0	0.0	Return	0	213	0	0	0	0	Runarnd	0.0 50.0
Opt Vent	0.0	0	0.0	0.0	Exhaust	0	0	Htg % OA	0.0	0.0	0	Fn MtrTD	0.0 0.0
Total	-13.1				Rm Exh	0	0	Htg Cfm/SqFt	0.07	0.0	0	Fn BldTD	0.0 0.0
					Auxil	0	0	Htg Btuh/SqFt	-4.53	0.0	0	Fn Frict	0.0 0.0

ITEM CHECKSUMS System 3 Peak TRH - TERMINAL REHEAT

***** COOLING COIL PEAK *****					***** CLG SPACE PEAK *****					***** HEATING COIL PEAK *****				
Peaked at Time ==> Mo/Hr: 7/ 9					Mo/Hr: 6/ 8					Mo/Hr: 13/ 1				
Outside Air ==> OADB/WB/HR: 71/ 51/ 42.0					OADB: 68					OADB: 5				
Envelope Loads	Space Sens.+Lat. (Btuh)	Ret. Air Sensible (Btuh)	Ret. Air Latent (Btuh)	Net Total (Btuh)	Percnt Of Tot (%)	Space Sensible (Btuh)	Percnt Of Tot (%)	Space Peak (Btuh)	Coil Peak (Btuh)	Percnt Of Tot (%)	Space Sens (Btuh)	Coil Peak (Btuh)	Percnt Of Tot (%)	
Skylite Solr	0	0	0	0	0.00	0	0.00	0	0	0.00	0	0	0.00	
Skylite Cond	0	0	0	0	0.00	0	0.00	0	0	0.00	0	0	0.00	
Roof Cond	0	2,703	0	2,703	6.19	0	0.00	0	-3,462	9.71	0	-3,462	9.71	
Glass Solar	19,008	0	0	19,008	43.53	19,296	46.97	0	0	0.00	0	0	0.00	
Glass Cond	-197	0	0	-197	-0.45	-316	-0.77	-3,364	-3,364	9.44	-3,364	-3,364	9.44	
Wall Cond	1,000	535	0	1,535	3.52	1,247	3.03	-5,046	-7,964	22.34	-5,046	-7,964	22.34	
Partition	0	0	0	0	0.00	0	0.00	0	0	0.00	0	0	0.00	
Exposed Floor	0	0	0	0	0.00	0	0.00	-1,007	-1,007	2.83	-1,007	-1,007	2.83	
Infiltration	0	0	0	0	0.00	0	0.00	0	0	0.00	0	0	0.00	
Sub Total==>	19,811	3,239	0	23,050	52.79	20,226	49.23	-9,418	-15,799	44.32	-9,418	-15,799	44.32	
Internal Loads														
Lights	14,591	0	0	14,591	33.41	14,591	35.51	0	0	0.00	0	0	0.00	
People	0	0	0	0	0.00	0	0.00	0	0	0.00	0	0	0.00	
Misc	5,461	0	0	5,461	12.51	5,461	13.29	0	0	0.00	0	0	0.00	
Sub Total==>	20,051	0	0	20,051	45.92	20,051	48.81	0	0	0.00	0	0	0.00	
Ceiling Load	727	-727	0	0	0.00	806	1.96	-1,227	0	0.00	-1,227	0	0.00	
Outside Air	0	0	0	-6,352	-14.55	0	0.00	0	-20,621	57.85	0	-20,621	57.85	
Sup. Fan Heat	0	0	0	5,782	13.24	0	0.00	0	0	0.00	0	0	0.00	
Ret. Fan Heat	0	1,134	0	1,134	2.60	0	0.00	0	0	0.00	0	0	0.00	
Duct Heat Pkup	0	0	0	0	0.00	0	0.00	0	0	0.00	0	0	0.00	
OV/UNDR Sizing	0	0	0	0	0.00	0	0.00	0	0	0.00	0	0	0.00	
Exhaust Heat	0	0	0	0	-0.00	0	0.00	0	773	-2.17	0	773	-2.17	
Terminal Bypass	0	0	0	0	0.00	0	0.00	0	0	0.00	0	0	0.00	
Grand Total==>	40,589	3,646	0	43,665	100.00	41,084	100.00	-10,645	-35,647	100.00	-10,645	-35,647	100.00	

-----COOLING COIL SELECTION-----										-----AREAS-----		
	Total Capacity (Tons)	Sens Cap. (Mbh)	Coil Airfl (cfm)	Entering DB/WB/HR	Leaving DB/WB/HR	Gross Total	Glass (sf)	(%)				
Main Clg	3.6	43.7	50.8	2,502	77.2 60.8 82.1	52.2 51.1 73.8	Floor	1,595				
Aux Clg	0.0	0.0	0.0	0	0.0 0.0 0.0	0.0 0.0 0.0	Part	0				
Opt Vent	0.0	0.0	0.0	0	0.0 0.0 0.0	0.0 0.0 0.0	ExFlr	151				
Totals	3.6	43.7	50.8	2,502			Roof	1,595	0	0		
							Wall	2,086	96	5		

-----HEATING COIL SELECTION-----					-----AIRFLOWS (cfm)-----					-----ENGINEERING CHECKS-----					-----TEMPERATURES (F)-----				
	Capacity (Mbh)	Coil Airfl (cfm)	Ent Deg F	Lvg Deg F	Type	Cooling	Heating	Clg % OA	15.0	Type	Clg	Htg							
Main Htg	-45.4	2,502	55.0	77.1	Vent	375	375	Clg Cfm/Sqft	1.57	SADB	55.0	77.1							
Aux Htg	0.0	0	0.0	0.0	Infil	0	0	Clg Cfm/Ton	687.52	Plenum	76.4	69.4							
Preheat	-0.0	2,502	59.8	52.2	Supply	2,502	2,502	Clg Sqft/Ton	438.34	Return	77.1	69.4							
Reheat	-34.8	2,502	55.0	71.9	Mincfm	2,502	2,502	Clg Btuh/Sqft	27.38	Ret/OA	77.2	59.8							
Humidif	0.0	0	0.0	0.0	Return	2,126	2,502	No. People	0	Runarnd	75.0	72.0							
Opt Vent	0.0	0	0.0	0.0	Exhaust	0	375	Htg % OA	15.0	Fn MtrTD	0.6	0.6							
Total	-45.4				Rm Exh	375	0	Htg Cfm/Sqft	1.57	Fn BldTD	0.5	0.5							
					Auxil	0	0	Htg Btuh/SqFt	-28.47	Fn Frict	1.5	1.5							

SYSTEM CHECKSUMS System 4 Block UH - UNIT HEATERS

***** COOLING COIL PEAK ***** CLG SPACE PEAK ***** HEATING COIL PEAK *****
Loaded at Time ==> Mo/Hr: 0/ 0 Mo/Hr: 0/ 0 Mo/Hr: 13/ 1
Outside Air ==> OADB/WB/HR: 0/ 0/ 0.0 OADB: 0 OADB: 5

	Space Sens.+Lat. (Btuh)	Ret. Air Sensible (Btuh)	Ret. Air Latent (Btuh)	Net Total (Btuh)	Perct Of Tot (%)		Space Sensible (Btuh)	Perct Of Tot (%)		Space Peak Space Sens (Btuh)	Coil Peak Tot Sens (Btuh)	Perct Of Tot (%)
Envelope Loads												
Skylite Solr	0	0		0	0.00	*	0	0.00	*	0	0	0.00
Skylite Cond	0	0		0	0.00	*	0	0.00	*	0	0	0.00
Roof Cond	0	0		0	0.00	*	0	0.00	*	-3,988	-3,988	30.75
Glass Solar	0	0		0	0.00	*	0	0.00	*	0	0	0.00
Glass Cond	0	0		0	0.00	*	0	0.00	*	0	0	0.00
Wall Cond	0	0		0	0.00	*	0	0.00	*	-8,331	-8,331	64.22
Partition	0			0	0.00	*	0	0.00	*	0	0	0.00
Exposed Floor	0			0	0.00	*	0	0.00	*	-653	-653	5.03
Infiltration	0			0	0.00	*	0	0.00	*	0	0	0.00
Sub Total==>	0	0		0	0.00	*	0	0.00	*	-12,972	-12,972	100.00
Internal Loads												
Lights	0	0		0	0.00	*	0	0.00	*	0	0	0.00
People	0			0	0.00	*	0	0.00	*	0	0	0.00
Misc	0	0	0	0	0.00	*	0	0.00	*	0	0	0.00
Sub Total==>	0	0	0	0	0.00	*	0	0.00	*	0	0	0.00
Ceiling Load	0			0	0.00	*	0	0.00	*	0	0	0.00
Outside Air	0		0	0	0.00	*	0	0.00	*	0	0	0.00
Sup. Fan Heat				0	0.00	*		0.00	*		0	0.00
Ret. Fan Heat		0		0	0.00	*		0.00	*		0	0.00
Duct Heat Pkup		0		0	0.00	*		0.00	*		0	0.00
OV/UNDR Sizing	0			0	0.00	*	0	0.00	*	0	0	0.00
Exhaust Heat		0	0	0	0.00	*		0.00	*		0	0.00
Terminal Bypass		0	0	0	0.00	*		0.00	*		0	0.00
Grand Total==>	0	0	0	0	0.00	*	0	0.00	*	-12,972	-12,972	100.00

-----COOLING COIL SELECTION-----										-----AREAS-----		
	Total Capacity (Tons)	Sens Cap. (Mbh)	Coil Airfl (cfm)	Entering DB/WB/HR			Leaving DB/WB/HR			Gross Total	Glass (sf)	(%)
				Deg F	Deg F	Grains	Deg F	Deg F	Grains	Floor	2,630	
Main Clg	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	Part	0	
Aux Clg	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	ExFlr	145	
Opt Vent	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	Roof	2,630	0 0
Totals	0.0	0.0								Wall	3,045	0 0

-----HEATING COIL SELECTION-----					-----AIRFLOWS (cfm)-----			-----ENGINEERING CHECKS-----		-----TEMPERATURES (F)-----		
Capacity (Mbh)	Coil Airfl (cfm)	Ent Deg F	Lvg Deg F		Type	Cooling	Heating	Clg % OA		Type	Clg	Htg
Main Htg	-13.0	211	50.0	125.0	Vent	0	0	Clg Cfm/Sqft	0.00	SADB	0.0	125.0
Aux Htg	0.0	0	0.0	0.0	Infil	0	0	Clg Cfm/Ton	0.00	Plenum	0.0	50.0
Preheat	0.0	0	0.0	0.0	Supply	0	211	Clg Sqft/Ton	0.00	Return	0.0	50.0
Reheat	0.0	0	0.0	0.0	Mincfm	0	0	Clg Btuh/Sqft	0.00	Ret/OA	0.0	50.0
Humidif	0.0	0	0.0	0.0	Return	0	211	No. People	0	Runarnd	0.0	50.0
Opt Vent	0.0	0	0.0	0.0	Exhaust	0	0	Htg % OA	0.0	Fn MtrTD	0.0	0.0
Total	-13.0				Rm Exh	0	0	Htg Cfm/Sqft	0.08	Fn BldTD	0.0	0.0
					Auxil	0	0	Htg Btuh/Sqft	-4.93	Fn Frict	0.0	0.0

SYSTEM COOLING - ALTERNATIVE 1

PEAK COOLING LOADS
(Main System)

Room Number	Description	Peak Time Mo/Hr	Space				Space Air Flow (Cfm)	Space Sens. Load (Btuh)	Space Lat. Load (Btuh)	Peak Time Mo/Hr	Coil				Coil Air Flow (Cfm)	Coil Sens. Load (Btuh)	Coil Lat. Load (Btuh)
			OA Cond. DB/WB (F)	Rm Dry (F)	Supp. Dry Bulb (F)	OA Cond. DB/WB (F)					Rm Dry (F)	Supp. Dry Bulb (F)					
1	VAULT AREA	6/17	87	53	75	55.0	4,267	70,074	0	7/15	87	60	75	55.5	4,267	97,296	-1,173
Zone	1 Total/Ave.		87	53	75	55.0	4,267	70,074	0		87	60	75	55.5	4,267	97,296	-1,173
Zone	1 Block	6/17	87	53	75	55.0	4,267	70,074	0	7/15	87	60	75	55.5	4,267	97,296	-1,173
2	PACK-UNPACK AREA	6/17	87	53	75	55.0	1,994	32,754	410	7/15	87	60	75	55.4	1,994	45,695	-138
Zone	2 Total/Ave.		87	53	75	55.0	1,994	32,754	410		87	60	75	55.4	1,994	45,695	-138
Zone	2 Block	6/17	87	53	75	55.0	1,994	32,754	410	7/15	87	60	75	55.4	1,994	45,695	-138
3	TEMP STAGING ARE	6/17	87	53	75	55.0	1,224	20,093	410	7/15	87	60	75	55.4	1,224	28,060	74
Zone	3 Total/Ave.		87	53	75	55.0	1,224	20,093	410		87	60	75	55.4	1,224	28,060	74
Zone	3 Block	6/17	87	53	75	55.0	1,224	20,093	410	7/15	87	60	75	55.4	1,224	28,060	74
4	STORAGE VAULT	6/17	87	53	75	55.0	246	4,039	0	7/15	87	60	75	55.8	246	5,520	-68
Zone	4 Total/Ave.		87	53	75	55.0	246	4,039	0		87	60	75	55.8	246	5,520	-68
Zone	4 Block	6/17	87	53	75	55.0	246	4,039	0	7/15	87	60	75	55.8	246	5,520	-68
5	RCT-HS EQUIP.	6/17	87	53	75	55.0	471	7,743	0	7/15	87	60	75	55.1	471	11,811	-130
Zone	5 Total/Ave.		87	53	75	55.0	471	7,743	0		87	60	75	55.1	471	11,811	-130
Zone	5 Block	6/17	87	53	75	55.0	471	7,743	0	7/15	87	60	75	55.1	471	11,811	-130
6	HOT JANITORS RM	6/17	87	53	75	55.0	295	4,847	0	7/15	87	60	75	55.1	295	7,752	-81
Zone	6 Total/Ave.		87	53	75	55.0	295	4,847	0		87	60	75	55.1	295	7,752	-81
Zone	6 Block	6/17	87	53	75	55.0	295	4,847	0	7/15	87	60	75	55.1	295	7,752	-81
7	AIRLOCK 1	6/17	87	53	75	55.0	49	808	0	7/15	87	60	75	55.1	49	1,292	-14
Zone	7 Total/Ave.		87	53	75	55.0	49	808	0		87	60	75	55.1	49	1,292	-14
Zone	7 Block	6/17	87	53	75	55.0	49	808	0	7/15	87	60	75	55.1	49	1,292	-14
8	MONITORING STATI	6/17	87	53	75	55.0	355	5,836	410	7/15	87	60	75	55.3	355	8,159	312
	8 Total/Ave.		87	53	75	55.0	355	5,836	410		87	60	75	55.3	355	8,159	312
	8 Block	6/17	87	53	75	55.0	355	5,836	410	7/15	87	60	75	55.3	355	8,159	312
9	DECON-RCT STATIO	6/17	87	53	75	55.0	470	7,723	0	7/15	87	60	75	55.4	470	10,780	-129
Zone	9 Total/Ave.		87	53	75	55.0	470	7,723	0		87	60	75	55.4	470	10,780	-129
Zone	9 Block	6/17	87	53	75	55.0	470	7,723	0	7/15	87	60	75	55.4	470	10,780	-129
10	MENS CHNG CONTRL	6/17	87	53	75	55.0	359	5,897	2,050	7/15	87	60	75	55.1	359	8,965	1,951
Zone	10 Total/Ave.		87	53	75	55.0	359	5,897	2,050		87	60	75	55.1	359	8,965	1,951
Zone	10 Block	6/17	87	53	75	55.0	359	5,897	2,050	7/15	87	60	75	55.1	359	8,965	1,951
11	AIRLOCK 2	6/17	87	53	75	55.0	49	808	0	7/15	87	60	75	55.1	49	1,292	-14
Zone	11 Total/Ave.		87	53	75	55.0	49	808	0		87	60	75	55.1	49	1,292	-14
Zone	11 Block	6/17	87	53	75	55.0	49	808	0	7/15	87	60	75	55.1	49	1,292	-14
12	WOMANS CHNG CONT	6/17	87	53	75	55.0	313	5,143	2,050	7/15	87	60	75	55.1	313	7,761	1,964
Zone	12 Total/Ave.		87	53	75	55.0	313	5,143	2,050		87	60	75	55.1	313	7,761	1,964
Zone	12 Block	6/17	87	53	75	55.0	313	5,143	2,050	7/15	87	60	75	55.1	313	7,761	1,964
13	AIRLOCK 3	6/17	87	53	75	55.0	466	7,656	0	7/15	87	60	75	55.6	466	10,584	-128
Zone	13 Total/Ave.		87	53	75	55.0	466	7,656	0		87	60	75	55.6	466	10,584	-128
Zone	13 Block	6/17	87	53	75	55.0	466	7,656	0	7/15	87	60	75	55.6	466	10,584	-128
14	MENS REST CONTRO	6/17	87	53	75	55.0	26	431	0	7/15	87	60	75	55.1	26	689	-7
Zone	14 Total/Ave.		87	53	75	55.0	26	431	0		87	60	75	55.1	26	689	-7
Zone	14 Block	6/17	87	53	75	55.0	26	431	0	7/15	87	60	75	55.1	26	689	-7
15	MENS REST UNCONT	6/17	87	53	75	55.0	43	700	0	7/15	87	60	75	55.1	43	1,120	-12
Zone	15 Total/Ave.		87	53	75	55.0	43	700	0		87	60	75	55.1	43	1,120	-12
Zone	15 Block	6/17	87	53	75	55.0	43	700	0	7/15	87	60	75	55.1	43	1,120	-12

4 SYSTEM COOLING - ALTERNATIVE 1

PEAK COOLING LOADS
(Main System)

Room Number	Description	Peak Time Mo/Hr	Space				Peak Time Mo/Hr	Coil				Coil Air Flow (Cfm)	Coil Sens. Load (Btuh)	Coil Lat. Load (Btuh)
			OA Cond. (F)	Rm Dry (F)	Supp. Dry (F)	Space Air Flow (Cfm)		OA Cond. (F)	Rm Dry (F)	Supp. Dry (F)	Space Lat. Load (Btuh)			
16	MENS LOCKER ROOM	6/17	87	53	75	490	7/15	87	60	75	2,050	490	12,406	1,915
Zone	16 Total/Ave.		87	53	75	490		87	60	75	2,050	490	12,406	1,915
Zone	16 Block	6/17	87	53	75	490	7/15	87	60	75	2,050	490	12,406	1,915
17	HALLWAY	6/17	87	53	75	95	7/15	87	60	75	0	95	2,498	-26
Zone	17 Total/Ave.		87	53	75	95		87	60	75	0	95	2,498	-26
Zone	17 Block	6/17	87	53	75	95	7/15	87	60	75	0	95	2,498	-26
18	WOMANS LOCKER RM	6/17	87	53	75	477	7/15	87	60	75	2,050	477	12,062	1,919
Zone	18 Total/Ave.		87	53	75	477		87	60	75	2,050	477	12,062	1,919
Zone	18 Block	6/17	87	53	75	477	7/15	87	60	75	2,050	477	12,062	1,919
19	WOMANS REST UNCO	6/17	87	53	75	43	7/15	87	60	75	0	43	1,120	-12
Zone	19 Total/Ave.		87	53	75	43		87	60	75	0	43	1,120	-12
Zone	19 Block	6/17	87	53	75	43	7/15	87	60	75	0	43	1,120	-12
20	WOMANS REST CONT	6/17	87	53	75	26	7/15	87	60	75	0	26	689	-7
Zone	20 Total/Ave.		87	53	75	26		87	60	75	0	26	689	-7
Zone	20 Block	6/17	87	53	75	26	7/15	87	60	75	0	26	689	-7
21	HOT MECH. ROOM	6/24	69	47	75	1,314	7/15	87	60	75	0	1,314	29,716	-361
Zone	21 Total/Ave.		69	47	75	1,314		87	60	75	0	1,314	29,716	-361
Zone	21 Block	6/24	69	47	75	1,314	7/15	87	60	75	0	1,314	29,716	-361
22	NDA LABORATORY	6/15	90	57	75	6,888	7/15	87	60	75	410	6,888	160,771	-1,484
Zone	22 Total/Ave.		90	57	75	6,888		87	60	75	410	6,888	160,771	-1,484
Zone	22 Block	6/15	90	57	75	6,888	7/15	87	60	75	410	6,888	160,771	-1,484
23	BASEMENT-TUNNEL	6/13	87	56	75	2,818	7/15	87	60	75	0	2,818	65,776	-775
Zone	23 Total/Ave.		87	56	75	2,818		87	60	75	0	2,818	65,776	-775
Zone	23 Block	6/13	87	56	75	2,818	7/15	87	60	75	0	2,818	65,776	-775
System	1 Total/Ave.		87	53	75	22,780		87	60	75	9,840	22,780	531,813	3,577
System	1 Block	6/17	87	53	75	22,780	7/15	87	60	75	9,840	22,780	531,812	3,577
25	ELEC EQUIP. ROOM	6/17	87	53	75	371	7/15	87	60	75	0	371	8,437	-707
Zone	25 Total/Ave.		87	53	75	371		87	60	75	0	371	8,437	-707
Zone	25 Block	6/17	87	53	75	371	7/15	87	60	75	0	371	8,437	-707
26	HALLWAY	6/ 8	68	48	75	1,462	7/ 9	71	51	75	0	1,462	27,154	-5,167
Zone	26 Total/Ave.		68	48	75	1,462		71	51	75	0	1,462	27,154	-5,167
Zone	26 Block	6/ 8	68	48	75	1,462	7/ 9	71	51	75	0	1,462	27,154	-5,167
27	EXIT	6/17	87	53	75	86	7/15	87	60	75	0	86	1,913	-163
Zone	27 Total/Ave.		87	53	75	86		87	60	75	0	86	1,913	-163
Zone	27 Block	6/17	87	53	75	86	7/15	87	60	75	0	86	1,913	-163
28	SECURITY	6/17	87	53	75	118	7/15	87	60	75	0	118	2,631	-224
Zone	28 Total/Ave.		87	53	75	118		87	60	75	0	118	2,631	-224
Zone	28 Block	6/17	87	53	75	118	7/15	87	60	75	0	118	2,631	-224
29	ENTRANCE	6/17	87	53	75	107	7/15	87	60	75	0	107	2,391	-204
Zone	29 Total/Ave.		87	53	75	107		87	60	75	0	107	2,391	-204
Zone	29 Block	6/17	87	53	75	107	7/15	87	60	75	0	107	2,391	-204
30	LOBBY	6/17	87	53	75	131	7/15	87	60	75	0	131	3,065	-250
Zone	30 Total/Ave.		87	53	75	131		87	60	75	0	131	3,065	-250
Zone	30 Block	6/17	87	53	75	131	7/15	87	60	75	0	131	3,065	-250
31	SECURITY VEST	6/17	87	53	75	36	7/15	87	60	75	0	36	882	-68

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WATER SYSTEM COOLING - ALTERNATIVE 1

----- P E A K C O O L I N G L O A D S -----
(Main System)

Room Number	Description	Peak Time Mo/Hr	Space				Peak Time Mo/Hr	Coil				Coil Air Flow (Cfm)	Coil Sens. Load (Btuh)	Coil Lat. Load (Btuh)
			OA Cond. (F)	Rm Dry (F)	Supp. Dry Bulb (F)	Space Air Flow (Cfm)		OA Cond. (F)	Rm Dry (F)	Supp. Dry Bulb (F)	Space Lat. Load (Btuh)			
Zone	31 Total/Ave.		87	53	75	55.0		87	60	75	55.1	36	882	-68
Zone	31 Block	6/17	87	53	75	55.0		87	60	75	55.1	36	882	-68
Zone	32 UNISEX RESTROOM	6/18	85	52	75	55.0		87	60	75	55.6	95	2,222	-180
Zone	32 Total/Ave.		85	52	75	55.0		87	60	75	55.6	95	2,222	-180
Zone	32 Block	6/18	85	52	75	55.0		87	60	75	55.6	95	2,222	-180
Zone	33 SECURITY VESTIBU	6/23	70	47	75	55.0		87	60	75	56.1	97	2,119	-186
Zone	33 Total/Ave.		70	47	75	55.0		87	60	75	56.1	97	2,119	-186
Zone	33 Block	6/23	70	47	75	55.0		87	60	75	56.1	97	2,119	-186
System	3 Total/Ave.		68	48	75	55.0		71	51	75	55.2	2,502	50,815	-7,150
System	3 Block	6/ 8	68	48	75	55.0		71	51	75	55.2	2,502	45,704	-8,840

4 SYSTEM HEATING - ALTERNATIVE 1

PEAK HEATING LOADS
(Main System)

Room Number	Description	Floor Area (Sq Ft)	Space					Space Air Flow (Cfm)	Space Sens. Load (Btuh)	Coil					Coil Air Flow (Cfm)	Coil Sens. Load (Btuh)
			Peak Time Mo/Hr	OA Cond. DB/WB (F)	Rm Dry Blb (F)	Supp. Dry Bulb (F)	Peak Time Mo/Hr			OA Cond. DB/WB (F)	Rm Dry Blb (F)	Supp. Dry Bulb (F)				
1	VAULT AREA	3,400	13/ 1	5	2	72	78.2	4,267	-21,804	13/ 1	5	2	72	78.2	4,267	-81,367
Zone	1 Total/Ave.	3,400		5	2	72	78.2	4,267	-21,804		5	2	72	78.2	4,267	-81,367
Zone	1 Block	3,400	13/ 1	5	2	72	78.2	4,267	-21,804	13/ 1	5	2	72	78.2	4,267	-81,367
2	PACK-UNPACK AREA	1,620	13/ 1	5	2	72	75.1	1,994	-5,060	13/ 1	5	2	72	75.1	1,994	-32,901
Zone	2 Total/Ave.	1,620		5	2	72	75.1	1,994	-5,060		5	2	72	75.1	1,994	-32,901
Zone	2 Block	1,620	13/ 1	5	2	72	75.1	1,994	-5,060	13/ 1	5	2	72	75.1	1,994	-32,901
3	TEMP STAGING ARE	990	13/ 1	5	2	72	74.2	1,224	-2,235	13/ 1	5	2	72	74.2	1,224	-19,315
Zone	3 Total/Ave.	990		5	2	72	74.2	1,224	-2,235		5	2	72	74.2	1,224	-19,315
Zone	3 Block	990	13/ 1	5	2	72	74.2	1,224	-2,235	13/ 1	5	2	72	74.2	1,224	-19,315
4	STORAGE VAULT	300	13/ 1	5	2	72	81.7	246	-1,952	13/ 1	5	2	72	81.7	246	-5,385
Zone	4 Total/Ave.	300		5	2	72	81.7	246	-1,952		5	2	72	81.7	246	-5,385
Zone	4 Block	300	13/ 1	5	2	72	81.7	246	-1,952	13/ 1	5	2	72	81.7	246	-5,385
5	RCT-HS EQUIP.	440	13/ 1	5	2	72	72.3	471	-130	13/ 1	5	2	72	72.3	471	-6,711
Zone	5 Total/Ave.	440		5	2	72	72.3	471	-130		5	2	72	72.3	471	-6,711
Zone	5 Block	440	13/ 1	5	2	72	72.3	471	-130	13/ 1	5	2	72	72.3	471	-6,711
6	HOT JANITORS RM	450	13/ 1	5	2	72	72.5	295	-133	13/ 1	5	2	72	72.5	295	-4,253
Zone	6 Total/Ave.	450		5	2	72	72.5	295	-133		5	2	72	72.5	295	-4,253
Zone	6 Block	450	13/ 1	5	2	72	72.5	295	-133	13/ 1	5	2	72	72.5	295	-4,253
7	AIRLOCK 1	75	13/ 1	5	2	72	72.6	49	-22	13/ 1	5	2	72	72.6	49	-709
Zone	7 Total/Ave.	75		5	2	72	72.6	49	-22		5	2	72	72.6	49	-709
Zone	7 Block	75	13/ 1	5	2	72	72.6	49	-22	13/ 1	5	2	72	72.6	49	-709
8	MONITORING STATI	270	13/ 1	5	2	72	74.1	355	-610	13/ 1	5	2	72	74.1	355	-5,571
Zone	8 Total/Ave.	270		5	2	72	74.1	355	-610		5	2	72	74.1	355	-5,571
Zone	8 Block	270	13/ 1	5	2	72	74.1	355	-610	13/ 1	5	2	72	74.1	355	-5,571
9	DECON-RCT STATIO	390	13/ 1	5	2	72	74.3	470	-881	13/ 1	5	2	72	74.3	470	-7,445
Zone	9 Total/Ave.	390		5	2	72	74.3	470	-881		5	2	72	74.3	470	-7,445
Zone	9 Block	390	13/ 1	5	2	72	74.3	470	-881	13/ 1	5	2	72	74.3	470	-7,445
10	MENS CHNG CONTRL	320	13/ 1	5	2	75	76.4	359	-399	13/ 1	5	2	75	76.4	359	-6,295
Zone	10 Total/Ave.	320		5	2	75	76.4	359	-399		5	2	75	76.4	359	-6,295
Zone	10 Block	320	13/ 1	5	2	75	76.4	359	-399	13/ 1	5	2	75	76.4	359	-6,295
11	AIRLOCK 2	75	13/ 1	5	2	72	72.6	49	-22	13/ 1	5	2	72	72.6	49	-709
Zone	11 Total/Ave.	75		5	2	72	72.6	49	-22		5	2	72	72.6	49	-709
Zone	11 Block	75	13/ 1	5	2	72	72.6	49	-22	13/ 1	5	2	72	72.6	49	-709
12	WOMANS CHNG CONT	250	13/ 1	5	2	75	76.2	313	-311	13/ 1	5	2	75	76.2	313	-5,454
Zone	12 Total/Ave.	250		5	2	75	76.2	313	-311		5	2	75	76.2	313	-5,454
Zone	12 Block	250	13/ 1	5	2	75	76.2	313	-311	13/ 1	5	2	75	76.2	313	-5,454
13	AIRLOCK 3	590	13/ 1	5	2	72	75.5	466	-1,332	13/ 1	5	2	72	75.5	466	-7,839
Zone	13 Total/Ave.	590		5	2	72	75.5	466	-1,332		5	2	72	75.5	466	-7,839
Zone	13 Block	590	13/ 1	5	2	72	75.5	466	-1,332	13/ 1	5	2	72	75.5	466	-7,839
14	MENS REST CONTRO	40	13/ 1	5	2	70	70.1	26	13	13/ 1	5	2	70	70.1	26	-325
Zone	14 Total/Ave.	40		5	2	70	70.1	26	13		5	2	70	70.1	26	-325
Zone	14 Block	40	13/ 1	5	2	70	70.1	26	13	13/ 1	5	2	70	70.1	26	-325
15	MENS REST UNCONT	65	13/ 1	5	2	70	70.1	43	22	13/ 1	5	2	70	70.1	43	-529
Zone	15 Total/Ave.	65		5	2	70	70.1	43	22		5	2	70	70.1	43	-529
Zone	15 Block	65	13/ 1	5	2	70	70.1	43	22	13/ 1	5	2	70	70.1	43	-529

SYSTEM HEATING - ALTERNATIVE 1

PEAK HEATING LOADS
(Main System)

Room Number	Description	Floor Area (Sq Ft)	Peak Time Mo/Hr	Space			Space Air Flow (Cfm)	Space Sens. Load (Btuh)	Peak Time Mo/Hr	Coil			Coil Air Flow (Cfm)	Coil Sens. Load (Btuh)		
				OA Cond. DB/WB (F)	Rm Dry Bulb (F)	Supp. Dry Bulb (F)				OA Cond. DB/WB (F)	Rm Dry Bulb (F)	Supp. Dry Bulb (F)				
16	MENS LOCKER ROOM	520	13/ 1	5	2	75	76.6	490	-648	13/ 1	5	2	75	76.6	490	-8,699
Zone	16 Total/Ave.	520		5	2	75	76.6	490	-648		5	2	75	76.6	490	-8,699
Zone	16 Block	520	13/ 1	5	2	75	76.6	490	-648	13/ 1	5	2	75	76.6	490	-8,699
17	HALLWAY	145	13/ 1	5	2	72	72.5	95	-43	13/ 1	5	2	72	72.5	95	-1,370
Zone	17 Total/Ave.	145		5	2	72	72.5	95	-43		5	2	72	72.5	95	-1,370
Zone	17 Block	145	13/ 1	5	2	72	72.5	95	-43	13/ 1	5	2	72	72.5	95	-1,370
18	WOMANS LOCKER RM	500	13/ 1	5	2	75	76.6	477	-623	13/ 1	5	2	75	76.6	477	-8,458
Zone	18 Total/Ave.	500		5	2	75	76.6	477	-623		5	2	75	76.6	477	-8,458
Zone	18 Block	500	13/ 1	5	2	75	76.6	477	-623	13/ 1	5	2	75	76.6	477	-8,458
19	WOMANS REST UNCO	65	13/ 1	5	2	70	70.1	43	22	13/ 1	5	2	70	70.1	43	-529
Zone	19 Total/Ave.	65		5	2	70	70.1	43	22		5	2	70	70.1	43	-529
Zone	19 Block	65	13/ 1	5	2	70	70.1	43	22	13/ 1	5	2	70	70.1	43	-529
20	WOMANS REST CONT	40	13/ 1	5	2	70	70.1	26	13	13/ 1	5	2	70	70.1	26	-325
Zone	20 Total/Ave.	40		5	2	70	70.1	26	13		5	2	70	70.1	26	-325
Zone	20 Block	40	13/ 1	5	2	70	70.1	26	13	13/ 1	5	2	70	70.1	26	-325
21	HOT MECH. ROOM	2,900	13/ 1	5	2	72	78.5	1,314	-6,980	13/ 1	5	2	72	78.5	1,314	-25,319
Zone	21 Total/Ave.	2,900		5	2	72	78.5	1,314	-6,980		5	2	72	78.5	1,314	-25,319
Zone	21 Block	2,900	13/ 1	5	2	72	78.5	1,314	-6,980	13/ 1	5	2	72	78.5	1,314	-25,319
22	NDA LABORATORY	3,300	13/ 1	5	2	72	72.1	6,888	0	13/ 1	5	2	72	72.1	6,888	-96,717
Zone	22 Total/Ave.	3,300		5	2	72	72.1	6,888	0		5	2	72	72.1	6,888	-96,717
Zone	22 Block	3,300	13/ 1	5	2	72	72.1	6,888	0	13/ 1	5	2	72	72.1	6,888	-96,717
23	BASEMENT-TUNNEL	6,780	13/ 1	5	2	72	72.1	2,818	0	13/ 1	5	2	72	72.1	2,818	-39,570
	23 Total/Ave.	6,780		5	2	72	72.1	2,818	0		5	2	72	72.1	2,818	-39,570
	23 Block	6,780	13/ 1	5	2	72	72.1	2,818	0	13/ 1	5	2	72	72.1	2,818	-39,570
stem	1 Total/Ave.	23,525		5	2	72	74.6	22,780	-43,114		5	2	72	74.6	22,780	-365,794
system	1 Block	23,525	13/ 1	5	2	72	74.5	22,780	-43,112	13/ 1	5	2	72	74.5	22,780	-364,913
24	COLD MECH. PENT.	2,900	13/ 1	5	2	50	125.0	213	-13,131	13/ 1	5	2	50	125.0	213	-13,131
Zone	24 Total/Ave.	2,900		5	2	50	125.0	213	-13,131		5	2	50	125.0	213	-13,131
Zone	24 Block	2,900	13/ 1	5	2	50	125.0	213	-13,131	13/ 1	5	2	50	125.0	213	-13,131
System	2 Total/Ave.	2,900		5	2	50	125.0	213	-13,131		5	2	50	125.0	213	-13,131
System	2 Block	2,900	13/ 1	5	2	50	125.0	213	-13,131	13/ 1	5	2	50	125.0	213	-13,131
25	ELEC EQUIP. ROOM	430	13/ 1	5	2	72	73.2	371	-352	13/ 1	5	2	72	73.2	371	-5,527
Zone	25 Total/Ave.	430		5	2	72	73.2	371	-352		5	2	72	73.2	371	-5,527
Zone	25 Block	430	13/ 1	5	2	72	73.2	371	-352	13/ 1	5	2	72	73.2	371	-5,527
26	HALLWAY	390	13/ 1	5	2	72	78.6	1,462	-7,889	13/ 1	5	2	72	78.6	1,462	-28,302
Zone	26 Total/Ave.	390		5	2	72	78.6	1,462	-7,889		5	2	72	78.6	1,462	-28,302
Zone	26 Block	390	13/ 1	5	2	72	78.6	1,462	-7,889	13/ 1	5	2	72	78.6	1,462	-28,302
27	EXIT	80	13/ 1	5	2	72	72.9	86	-66	13/ 1	5	2	72	72.9	86	-1,260
Zone	27 Total/Ave.	80		5	2	72	72.9	86	-66		5	2	72	72.9	86	-1,260
Zone	27 Block	80	13/ 1	5	2	72	72.9	86	-66	13/ 1	5	2	72	72.9	86	-1,260
28	SECURITY	110	13/ 1	5	2	72	72.9	118	-90	13/ 1	5	2	72	72.9	118	-1,733
Zone	28 Total/Ave.	110		5	2	72	72.9	118	-90		5	2	72	72.9	118	-1,733
Zone	28 Block	110	13/ 1	5	2	72	72.9	118	-90	13/ 1	5	2	72	72.9	118	-1,733
29	ENTRANCE	100	13/ 1	5	2	72	72.9	107	-82	13/ 1	5	2	72	72.9	107	-1,575
Zone	29 Total/Ave.	100		5	2	72	72.9	107	-82		5	2	72	72.9	107	-1,575

W N SYSTEM HEATING - ALTERNATIVE 1

----- P E A K H E A T I N G L O A D S -----
(Main System)

Room Number	Description	Floor Area (Sq Ft)	Space					Space Air Flow (Cfm)	Space Sens. Load (Btuh)	Coil					Coil Air Flow (Cfm)	Coil Sens. Load (Btuh)
			Peak Time Mo/Hr	OA Cond. DB/WB (F)	Rm Dry Blb (F)	Supp. Dry Bulb (F)				Peak Time Mo/Hr	OA Cond. DB/WB (F)	Rm Dry Blb (F)	Supp. Dry Bulb (F)			
Zone 29	Block	100	13/ 1	5	2	72	72.9	107	-82	13/ 1	5	2	72	72.9	107	-1,575
30	LOBBY	200	13/ 1	5	2	72	73.5	131	-164	13/ 1	5	2	72	73.5	131	-1,990
Zone 30	Total/Ave.	200		5	2	72	73.5	131	-164		5	2	72	73.5	131	-1,990
Zone 30	Block	200	13/ 1	5	2	72	73.5	131	-164	13/ 1	5	2	72	73.5	131	-1,990
31	SECURITY VEST	80	13/ 1	5	2	72	74.2	36	-66	13/ 1	5	2	72	74.2	36	-564
Zone 31	Total/Ave.	80		5	2	72	74.2	36	-66		5	2	72	74.2	36	-564
Zone 31	Block	80	13/ 1	5	2	72	74.2	36	-66	13/ 1	5	2	72	74.2	36	-564
32	UNISEX RESTROOM	125	13/ 1	5	2	70	82.8	95	-991	13/ 1	5	2	70	82.8	95	-2,155
Zone 32	Total/Ave.	125		5	2	70	82.8	95	-991		5	2	70	82.8	95	-2,155
Zone 32	Block	125	13/ 1	5	2	70	82.8	95	-991	13/ 1	5	2	70	82.8	95	-2,155
33	SECURITY VESTIBU	80	13/ 1	5	2	72	83.8	97	-946	13/ 1	5	2	72	83.8	97	-2,305
Zone 33	Total/Ave.	80		5	2	72	83.8	97	-946		5	2	72	83.8	97	-2,305
Zone 33	Block	80	13/ 1	5	2	72	83.8	97	-946	13/ 1	5	2	72	83.8	97	-2,305
System 3	Total/Ave.	1,595		5	2	72	77.1	2,502	-10,646		5	2	72	77.1	2,502	-45,412
System 3	Block	1,595	13/ 1	5	2	72	77.1	2,502	-10,645	13/ 1	5	2	72	77.1	2,502	-45,411
34	TRUCK LOADING AR	2,630	13/ 1	5	2	50	125.0	211	-12,972	13/ 1	5	2	50	125.0	211	-12,972
Zone 34	Total/Ave.	2,630		5	2	50	125.0	211	-12,972		5	2	50	125.0	211	-12,972
Zone 34	Block	2,630	13/ 1	5	2	50	125.0	211	-12,972	13/ 1	5	2	50	125.0	211	-12,972
System 4	Total/Ave.	2,630		5	2	50	125.0	211	-12,972		5	2	50	125.0	211	-12,972
System 4	Block	2,630	13/ 1	5	2	50	125.0	211	-12,972	13/ 1	5	2	50	125.0	211	-12,972

FLR AREA (LG HEIGHT) ft^3

HOT MECHANICAL RM

$$= (2700 \text{ SQFT}) / (14.5 \text{ ft}) = 39,150 \text{ ft}^3$$

Pack/Unpack Area

$$= (1620 \text{ SFT}) (14.5 \text{ ft}) = 23,490 \text{ ft}^3$$

TEMP STAGING & SHORT TERM STORAGE AREA

$$= (1290 \text{ sft}) / (14.5 \text{ ft}) = 10,705 \text{ ft}^2$$

RCT ANALYSIS Room =

$$= (390 \text{ sq ft})(9) = 3510 \text{ ft}^3$$

CHARGE HALL

$$= (3400)(1^3) = 61,200 \text{ ft}^3$$

NDA LA13

$$= (3300)/(9.5) = 31,350 \text{ ft}^3$$

BASEMENT/TUNNEL

$$= (2818)(9) = 25,362 \text{ ft}^3$$

REST OF MAA

$$= (8007)(9) = 72,063 \text{ ft}^3$$

TOTAL = 274,830 ft³

$$\textcircled{a} (6 \text{ AC/HR})(1 \text{ HR/60 MIN})(274,830 \text{ CUF}) = 27,483 \text{ CFM}$$

$$\textcircled{c} (4 \text{ Hz} / 1 \text{ Hz}) / (1 \text{ Hz} / 60 \text{ min}) (274,830 \text{ CUFT}) = 18,322 \text{ CFM}$$

DESIGN $AC/HR = (22,780 \text{ L/min}) / (374,830 \text{ L/RT}) (60 \text{ min})$
 $= 4.97 \text{ AC/HR}.$

OUTSIDE AIR FAN STATIC PRESSURE
CALCULATIONS FS-1 & FS-2

DESIGNED BY CLQ DATE 1/10/95

CHECKED BY TJT DATE 2/26/95

1. OUTSIDE AIR LOUVER	0.15
2. OUTSIDE AIR DAMPER	0.02
3. PRE-FILTER (DIRTY)	0.3
4. PRE-HEAT COIL	0.2
5. ISOLATION DAMPER	0.02
6. PRE-FILTER	0.3
7. TEST SECTION	0.01
8. HEPA FILTER (FIRST STAGE)(DIRTY)	3.0
9. TEST SECTION	0.1
10. HEPA FILTER (SECOND STAGE)(DIRTY)	3.0
11. TEST SECTION	0.1
12. HEPA FILTER (THIRD STAGE)(DIRTY)	3.0
13. TEST SECTION	0.1
14. ISOLATION DAMPER	0.02
15. COOLING COIL	0.6
16. 150' OF DUCT (0.1/100 FT OF DUCT)	0.15
17. ISOLATION DAMPER	0.02

11.1

1.2

12.3"

18. SAFETY FACTOR 107.

19. CORRECTION FOR 7500FT ELEV $(12.3)(.76) -$

$= 9.35''$

USE 9.5" WG

OUTSIDE AIR FAN EQUIPMENT SELECTION
CALCULATIONS FS-1 & FS-2

DESIGNED BY CLK

DATE 1/12/95

CHECKED BY TJJ

DATE 2/25/95

STATIC PRESSURE = 9.5" WG

CFM = 3417 CFM

	BHP	RPM
9" SP =	7.03	3379
9.5" SP X 0.81		X 144
10" SP	7.84	3523

$$BHP(x) = (0.5 / 1) (0.81) + 7.03 = 7.435 \text{ BHP @ SL}$$

$$\text{CORRECTION FOR 7500 FT ELEV.} = (7.435) (.76) =$$

$$5.70 \text{ FOR LOSSES} = (5.65 / 0.95) = 5.95$$

USE 7 1/2 HP MOTOR

$$RPM(x) = (0.5 / 1) (144) + 3379 = 3451 \text{ RPM}$$

SELECTION:

MANUFACTURER: BUFFALO

MODEL: BL 300 SINGLE INLET

WHEEL DIA = 15.00"

CLASS III

HP: 7 1/2

RPM: 3451

CFM: 3456

TYPE "BL" Limit Load
FANS

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Dimensions SINGLE INLET

ARRANGEMENT 4 CLASS I, II & III

SIZES 245-730

CLOCKWISE SHOWN
ALSO AVAILABLE
COUNTER CLOCKWISE ROTATION

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
15	12 1/4	15 3/4	9 1/2	13 3/4	12 1/8	13 3/8	14	14	16 1/2	27 1/8	10 3/8	13	6 1/8	184T
16	13 1/2	17	10 1/2	14 3/4	13 1/8	14 3/8	16 1/2	16 1/2	16 1/2	28 3/8	11 1/4	13	6 1/8	215T
17	15	19	11 3/4	16 3/4	15 1/8	16 3/8	16 1/2	16 1/2	19	29 1/8	12 1/4	13	7 3/8	215T
18	16 1/2	20 3/4	13	17 3/4	16 1/8	18	18	18	20 1/2	32 3/8	13 3/4	13 3/4	8	215T
19	18 3/4	23 3/4	14 3/4	19 3/4	18 3/8	19 3/8	21 3/4	21 3/4	21 3/4	33 3/8	14 3/4	14 3/4	9 3/8	254T
20	20	24 3/4	15 3/4	21 3/4	20 1/8	21 3/8	21 3/4	21 3/4	24 3/4	35 3/8	15 3/4	15 3/4	9 3/4	254T
21	22 1/4	27 3/4	17 3/4	24	22 1/8	24 3/8	24	24	26 1/2	38 3/8	17 3/4	17 3/4	10 3/4	256T
22	24 1/2	29 3/4	19 3/4	26 1/2	24 1/8	26 3/8	26 3/4	30 3/4	30 3/4	40 3/8	18 3/4	18 3/4	11 3/4	256T
23	27	32 1/2	21 3/4	29 3/4	26 1/8	29 3/8	30 1/2	30 1/2	34 1/2	46 3/8	20 3/4	20 3/4	12 3/4	286T
24	30	36	23 3/4	32 3/4	30 3/8	32 3/8	30 1/2	36 1/2	36 1/2	48 3/8	23 3/4	31	14 3/4	326T
25	33	38 3/4	25 3/4	35 3/4	33 3/8	35 3/8	33 1/2	39 1/2	39 1/2	51 3/8	25 3/4	33 1/2	15 3/8	326T
26	36 1/2	42 3/4	28 3/4	39 3/4	36 3/8	39 3/8	36 1/2	42 1/2	42 1/2	53 3/8	27 3/4	35 1/2	16 3/4	326T

TYPE "BL" Limit Load FANS

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Dimensions SINGLE AND DOUBLE INLET

OVERALL DIMENSIONS FOR ALL ARRANGEMENTS & CLASSES

SIZES 245-2175

NOTES

1) WHEN FLANGED OUTLET IS FURNISHED ON 245-1200 ADD APPROX. 2" AS REQ'D.
FLANGED OUTLETS ARE STD ON CLASS I AND II SIZE 1320 AND UP AND ON ALL CLASS III SIZES.
NOT AVAILABLE ON DOWN BLAST DISCHARGE.

2) *DIM'S. GIVEN TO FLOOR - LINE HSG EXTENDS BELOW FLOOR - LINE.

Fan Size	AA				AB				UB				CA			
	TH	TAU	TAU	BAU	TH	TAU	TAU	BAU	TH	TAU	TAU	BAU	TH	TAU	TAU	BAU
215	16 1/2	16 1/2	16 1/2	16 1/2	22 1/8	24 1/8	24 1/8	23	30 1/2	31 1/2	9 1/2	11 1/2	27 1/2	27 1/2	24 1/2	26 1/2
270	16 1/2	16 1/2	16 1/2	16 1/2	25 1/8	26 1/8	26 1/8	25 1/2	32 1/2	33 1/2	10 1/2	12 1/2	31 1/2	28 1/2	27 1/2	30 1/2
330	16 1/2	16 1/2	16 1/2	16 1/2	27 1/8	29 1/8	29 1/8	30 1/2	34 1/2	35 1/2	11 1/2	14 1/2	33 1/2	31 1/2	28 1/2	31 1/2
390	18 1/2	18 1/2	18 1/2	18 1/2	29 1/8	31 1/8	32 1/8	30 1/2	37 1/2	38 1/2	12 1/2	15 1/2	36 1/2	34 1/2	31 1/2	34 1/2
450	18 1/2	18 1/2	18 1/2	18 1/2	32 1/8	35 1/8	35 1/8	33 1/2	41	42 1/2	14 1/2	16 1/2	42 1/2	37 1/2	36 1/2	40 1/2
510	18 1/2	18 1/2	18 1/2	18 1/2	35 1/8	39 1/8	39 1/8	36 1/2	44 1/2	46	15 1/2	18 1/2	44	41 1/2	37 1/2	41 1/2
570	22 1/2	22 1/2	22 1/2	22 1/2	39 1/8	43 1/8	43 1/8	40 1/2	49 1/2	50 1/2	17 1/2	20 1/2	48 1/2	45 1/2	41 1/2	46 1/2
630	22 1/2	22 1/2	22 1/2	22 1/2	43 1/8	47 1/8	47 1/8	44 1/2	54 1/2	55 1/2	18 1/2	22 1/2	53 1/2	50 1/2	44 1/2	50 1/2
690	22 1/2	22 1/2	22 1/2	22 1/2	47 1/8	52 1/8	52 1/8	49 1/2	59 1/2	60 1/2	20 1/2	24 1/2	60 1/2	56 1/2	50 1/2	57 1/2
750	40	40	40	40	53 1/8	58 1/8	58 1/8	55	72 1/2	74	23 1/2	27 1/2	63 1/2	61 1/2	53 1/2	60 1/2
810	42 1/2	42 1/2	42 1/2	42 1/2	58 1/8	64 1/8	64 1/8	60 1/2	79 1/2	80 1/2	25 1/2	30 1/2	70 1/2	67 1/2	58 1/2	66 1/2
870	46 1/2	46 1/2	46 1/2	46 1/2	64 1/8	70 1/8	70 1/8	66 1/2	86 1/2	87 1/2	27 1/2	33 1/2	76 1/2	72 1/2	64 1/2	72 1/2
930	48 1/2	48 1/2	48 1/2	48 1/2	70 1/8	78 1/8	78 1/8	73 1/2	95 1/2	96 1/2	30 1/2	36 1/2	80 1/2	78 1/2	71 1/2	78 1/2
990	54 1/2	54 1/2	54 1/2	54 1/2	77 1/8	85 1/8	85 1/8	80 1/2	104 1/2	106 1/2	33 1/2	40 1/2	86 1/2	87 1/2	78 1/2	85 1/2
1050	58 1/2	58 1/2	58 1/2	58 1/2	84 1/8	94 1/8	94 1/8	88 1/2	114 1/2	115 1/2	37 1/2	44 1/2	94 1/2	96 1/2	85 1/2	92 1/2
1110	63 1/2	63 1/2	63 1/2	63 1/2	93 1/8	104 1/8	104 1/8	97 1/2	125 1/2	127 1/2	41 1/2	49 1/2	105 1/2	106 1/2	94 1/2	101 1/2
1170	70 1/2	70 1/2	70 1/2	70 1/2	107 1/8	115 1/8	115 1/8	108 1/2	138 1/2	140 1/2	45 1/2	54 1/2	115 1/2	117 1/2	107 1/2	114 1/2
1230	76 1/2	76 1/2	76 1/2	76 1/2	113 1/8	126 1/8	126 1/8	118 1/2	149 1/2	149 1/2	49 1/2	59 1/2	127 1/2	129 1/2	118 1/2	125 1/2
1290	83 1/2	83 1/2	83 1/2	83 1/2	125 1/8	139 1/8	139 1/8	130 1/2	164 1/2	164 1/2	54 1/2	65 1/2	140 1/2	142 1/2	130 1/2	137 1/2
1350	93 1/2	107 1/8	117 1/8	139 1/8	142 1/8	154 1/8	154 1/8	144 1/2	181 1/2	-	60 1/2	72 1/2	155 1/2	157 1/2	143 1/2	151 1/2
1410	102 1/2	118 1/8	126 1/8	152 1/8	157 1/8	170 1/8	170 1/8	159 1/2	199 1/2	-	66 1/2	80 1/2	170 1/2	172 1/2	157 1/2	166 1/2
1470	111 1/2	129 1/8	138 1/8	167 1/8	173 1/8	187 1/8	187 1/8	175 1/2	219 1/2	-	73 1/2	88 1/2	188 1/2	190 1/2	173 1/2	183 1/2
1530	121 1/2	142 1/8	152 1/8	178 1/8	191 1/8	207 1/8	207 1/8	194 1/2	242 1/2	-	81 1/2	97 1/2	208 1/2	210 1/2	192 1/2	202 1/2

RECIRCULATING FAN STATIC
PRESSURE CALCULATIONS
FR-1, FR-2

DESIGNED BY CLQ DATE 2/10/9

CHECKED BY JJ DATE 2/26/9

1. RETURN AIR REGISTER	0.1
2. ISOLATION DAMPER	0.02
3. 250' OF DUCT (0.1 / 100 FT. OF DUCT)	0.25
4. ISOLATION DAMPER	0.02
5. PRE-FILTER	0.3
6. TEST SECTION	0.01
7. HEPA FILTERS (FIRST STAGE) (DIRTY)	3.0
8. TEST SECTION	0.01
9. HEPA FILTERS (SECOND STAGE) (DIRTY)	3.0
10. TEST SECTION	0.01
11. HEPA FILTERS (THIRD STAGE) (DIRTY)	3.0
12. TEST SECTION	0.01
13. ISOLATION DAMPERS	0.02
14. 50' OF DUCT (0.1 / 100 FT OF DUCT)	0.05
15. COOLING COIL	0.6
16. 150' OF DUCT (0.1 / 100 FT OF DUCT)	0.15
17. ISOLATION DAMPER	0.02
	10.57
	1.1
	11.67

18. 10% SAFETY FACTOR

19. CORRECTION FOR 7500 FT ELEV $(11.67)(0.76)$
= 8.9" WLG

USE 9.0" WLG

TYPE "BL" Limit Load
FANS

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Dimensions SINGLE INLET

ARRANGEMENT I - CLASS II & III

SIZES 245-730

CLOCKWISE SHOWN
ALSO AVAILABLE
COUNTER CLOCKWISE ROTATION

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
10	12 1/4	15 1/4	9 1/2	13 1/4	12 1/8	13 1/8	14	14	16 1/2	27 1/8	10 1/8	13	6 1/8	184T
12	13 1/2	17	10 1/2	14 1/4	13 1/8	14 1/8	16 1/2	16 1/2	16 1/2	28 1/8	11 1/8	13	6 3/8	215T
14	15	19	11 1/4	16 1/4	15 1/8	16 1/8	16 1/2	16 1/2	19	29 1/8	12 1/8	13	7 1/8	215T
16	16 1/2	20 1/4	13	17 1/4	16 1/8	18	18	18	20 1/2	32 1/8	13 1/8	13 1/4	8	215T
18	18 1/4	23 1/4	14 1/4	19 1/4	18 1/8	19 1/8	21 1/4	21 1/4	21 1/4	33 1/8	14 1/8	14 1/4	9 1/8	254T
20	20 1/4	24 1/4	15 1/4	21 1/4	20 1/8	21 1/8	21 1/4	21 1/4	24 1/4	35 1/8	15 1/8	15 1/4	9 1/4	254T
22	22 1/4	27 1/4	17 1/2	24	22 1/8	24 1/8	24	24	26 1/2	38 1/8	17 1/8	17 1/4	10 1/4	256T
24	24 1/2	29 1/4	19 1/4	26 1/2	24 1/8	26 1/8	26 1/4	30 1/4	30 1/4	40 1/8	18 1/8	18 1/4	11 1/4	256T
26	27	32 1/2	21 1/4	29 1/4	26 1/8	29 1/8	30 1/2	30 1/2	34 1/2	46 1/8	20 1/4	20 1/4	12 1/4	286T
28	30	36	23 1/2	32 1/4	30 1/8	32 1/8	30 1/2	36 1/2	36 1/2	48 1/8	23 1/4	31	14 1/4	326T
30	33	38 1/4	25 1/4	35 1/4	33 1/8	35 1/8	33 1/2	39 1/2	39 1/2	51 1/8	25 1/4	33 1/2	15 1/8	326T
32	36 1/2	42 1/4	28 1/2	39 1/4	36 1/8	39 1/8	36 1/2	42 1/2	42 1/2	53 1/8	27 1/4	35 1/2	16 1/4	326T

TYPE "BL" Limit Load FANS

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Dimensions SINGLE AND DOUBLE INLET

OVERALL DIMENSIONS FOR ALL ARRANGEMENTS & CLASSES

Sizes 245-2175

Fan Size	AA				AB				BB				CA				LL			
	TH	TAL	BH	UB	TH	BH	UB	DB	TAU	C 1 & 2	C 3	TAL	TH	BH	UB	DB	TAU	C 1 & 2	C 3	TAL
245	16 1/2	16 1/2	16 1/2	16 1/2	22 1/8	24 1/8	24 1/8	23	30 1/4	31 1/4	9 1/4	11 1/4	27 1/4	27 1/4	24 1/4	26 1/4	32 1/4	33 1/4	27 1/4	23 1/4
270	16 1/2	16 1/2	16 1/2	16 1/2	25 1/8	26 1/8	26 1/8	25 1/4	32 1/4	33 1/4	10 1/4	12 1/4	31 1/4	28 1/4	27 1/4	30 1/4	36 1/4	37 1/4	31 1/4	27 1/4
299	16 1/2	16 1/2	16 1/2	16 1/2	27 1/8	29 1/8	29 1/8	30 1/2	34 1/4	35 1/4	11 1/4	14 1/4	33 1/4	31 1/4	28 1/4	31 1/4	37 1/4	38 1/4	32 1/4	28 1/4
330	18 1/4	18 1/4	18 1/4	18 1/4	29 1/8	37 1/8	32 1/8	30 1/2	37 1/4	38 1/4	12 1/4	15 1/4	36 1/4	34 1/4	31 1/4	34 1/4	40 1/4	41 1/4	35 1/4	30 1/4
365	18 1/4	18 1/4	18 1/4	18 1/4	32 1/4	35 1/4	35 1/4	33 1/4	41 1/4	42 1/4	14 1/4	16 1/4	42 1/4	37 1/4	36 1/4	40 1/4	45 1/4	47 1/4	41 1/4	35 1/4
400	18 1/4	18 1/4	18 1/4	18 1/4	35 1/8	39 1/8	39 1/8	36 1/4	44 1/4	46 1/4	15 1/4	18 1/4	44 1/4	41 1/4	37 1/4	41 1/4	48 1/4	49 1/4	43 1/4	37 1/4
445	22 1/2	22 1/2	22 1/2	22 1/2	39 1/8	43 1/8	43 1/8	40 1/4	49 1/4	50 1/4	17 1/4	20 1/4	48 1/4	45 1/4	41 1/4	46 1/4	53 1/4	54 1/4	47 1/4	41 1/4
490	22 1/2	22 1/2	22 1/2	22 1/2	43 1/8	47 1/8	47 1/8	44 1/4	54 1/4	55 1/4	18 1/4	22 1/4	53 1/4	50 1/4	44 1/4	50 1/4	58 1/4	59 1/4	52 1/4	49 1/4
540	22 1/2	22 1/2	22 1/2	22 1/2	47 1/8	52 1/8	52 1/8	49 1/4	59 1/4	60 1/4	20 1/4	24 1/4	60 1/4	56 1/4	50 1/4	57 1/4	65 1/4	66 1/4	59 1/4	51 1/4
600	40	40	40	40	53 1/4	58 1/4	58 1/4	55 1/4	72 1/4	74 1/4	23 1/4	27 1/4	63 1/4	61 1/4	53 1/4	60 1/4	75 1/4	76 1/4	62 1/4	59 1/4
660	42 1/4	42 1/4	42 1/4	42 1/4	58 1/4	64 1/4	64 1/4	60 1/4	79 1/4	80 1/4	25 1/4	30 1/4	70 1/4	67 1/4	58 1/4	66 1/4	82 1/4	84 1/4	68 1/4	64 1/4
730	46 1/4	46 1/4	46 1/4	46 1/4	64 1/4	70 1/4	70 1/4	66 1/4	86 1/4	87 1/4	27 1/4	33 1/4	76 1/4	72 1/4	64 1/4	72 1/4	89 1/4	91 1/4	75 1/4	70 1/4
805	48 1/4	48 1/4	48 1/4	48 1/4	70 1/4	78 1/4	78 1/4	73 1/4	95 1/4	96 1/4	30 1/4	36 1/4	78 1/4	80 1/4	71 1/4	68 1/4	96 1/4	97 1/4	76 1/4	77 1/4
890	54 1/4	54 1/4	54 1/4	54 1/4	77 1/4	85 1/4	85 1/4	80 1/4	104 1/4	106 1/4	33 1/4	40 1/4	86 1/4	87 1/4	78 1/4	75 1/4	105 1/4	106 1/4	84 1/4	84 1/4
980	58 1/4	58 1/4	58 1/4	58 1/4	84 1/4	94 1/4	94 1/4	88 1/4	114 1/4	115 1/4	37 1/4	44 1/4	94 1/4	96 1/4	85 1/4	82 1/4	115 1/4	116 1/4	92 1/4	93 1/4
1065	63 1/4	63 1/4	63 1/4	63 1/4	93 1/4	104 1/4	104 1/4	97 1/4	125 1/4	127 1/4	41 1/4	49 1/4	105 1/4	106 1/4	94 1/4	91 1/4	126 1/4	128 1/4	102 1/4	103 1/4
1230	70 1/4	70 1/4	70 1/4	70 1/4	107 1/4	115 1/4	115 1/4	108 1/4	138 1/4	140 1/4	45 1/4	54 1/4	115 1/4	117 1/4	107 1/4	104 1/4	139 1/4	141 1/4	112 1/4	113 1/4
1320	76 1/4	76 1/4	76 1/4	76 1/4	113 1/4	126 1/4	126 1/4	118 1/4	149 1/4	149 1/4	49 1/4	59 1/4	127 1/4	129 1/4	118 1/4	117 1/4	153 1/4	153 1/4	123 1/4	124 1/4
1460	83 1/4	83 1/4	83 1/4	83 1/4	125 1/4	139 1/4	139 1/4	130 1/4	164 1/4	164 1/4	54 1/4	65 1/4	140 1/4	142 1/4	130 1/4	129 1/4	168 1/4	168 1/4	136 1/4	137 1/4
1615	93 1/4	107 1/4	117 1/4	139 1/4	142 1/4	154 1/4	154 1/4	144 1/4	181 1/4	-	60 1/4	72 1/4	155 1/4	157 1/4	143 1/4	142 1/4	181 1/4	-	151 1/4	151 1/4
1790	102 1/4	118 1/4	126 1/4	152 1/4	157 1/4	170 1/4	170 1/4	159 1/4	199 1/4	-	66 1/4	80 1/4	170 1/4	172 1/4	157 1/4	157 1/4	199 1/4	-	166 1/4	166 1/4
1965	111 1/4	129 1/4	138 1/4	167 1/4	173 1/4	187 1/4	187 1/4	175 1/4	219 1/4	-	73 1/4	88 1/4	188 1/4	190 1/4	173 1/4	173 1/4	220 1/4	-	183 1/4	183 1/4
2175	121 1/4	142 1/4	152 1/4	178 1/4	191 1/4	207 1/4	207 1/4	194 1/4	242 1/4	-	81 1/4	97 1/4	208 1/4	210 1/4	192 1/4	191 1/4	243 1/4	-	202 1/4	203 1/4

EXHAUST FAN STATIC PRESSURE
CALCULATIONS FOR FE-1 & FE-2
FE-1 & FE-2

DESIGNED BY CLQ

DATE 2/10/95

CHECKED BY TJ

DATE 2/26/95

1. RETURN AIR REGISTER	0.1
2. ISOLATION DAMPER	0.02
3. 250 FT OF DUCT (0.1/100 FT OF DUCT)	0.25
4. ISOLATION DAMPER	0.02
5. PRE-FILTER	0.3
6. TEST SECTION	0.01
7. HEPA FILTER	3.0
8. TEST SECTION	0.01
9. HEPA FILTER	3.0
10. TEST SECTION	0.01
11. HEPA FILTER	3.0
12. TEST SECTION	0.01
13. ISOLATION DAMPER	0.02
14. 50' OF DUCT (0.1/100 FT OF DUCT)	0.05

9.8"

0.98

10.78"

16. CORRECTION FOR 7500 FT ELEV $(10.78)(0.76) =$
 $= 8.2" \text{ WG}$

USE 8.25" WG

EXHAUST FAN EQUIPMENT

SELECTION

FE-1 & FE-2

DESIGNED BY CLD

DATE 7/12/94

CHECKED BY TJ

DATE 2/26/95

STATIC PRESSURE = 8.25" WG

CFM = (3417) / (10% FOR NEGATIVITY) = 3760 CFM

		BHP	RPM
1.0 { 8.0 SP	} 0.25	5.38	3126
8.25 SP		X	X
9.0 SP		6.10	3284
			158

$$BHP(x) = \left(\frac{0.25}{1.0} \right) (0.12) + 5.38 = 5.56 \text{ BHP}$$

$$5\% \text{ FOR BELT LOSSES} = (5.56) / (0.95) = 5.9 \text{ BHP}$$

$$\text{CORRECTION FOR 7500 FT ELEV} = (5.9) / (1.26) = 4.5 \text{ HP}$$

USE 5 HP MOTOR

$$RPM(x) = \left(\frac{0.25}{1.0} \right) (158) + 3126 = 3,165 \text{ RPM}$$

SELECTION:

MANUFACTURER: BUFFALO

MODEL: BL 300 SINGLE INLET

WHEEL DIA 15.00"

CLASS III:

HP: 5 HP

CFM: 2944

RPM: 3,165 RPM

TYPE "BL" Limit Load

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Dimensions SINGLE INLET

FRAMING NEW - SEE PAGE III

SEE PAGE VII

CLOCKWISE SHOWN
ALSO AVAILABLE
COUNTER CLOCKWISE ROTATION

12 1/4	15 1/4	9 1/2	13 1/4	12 1/8	13 3/4	14	14	16 1/2	27 1/8	10 3/4	13	6 1/8	184T
13 1/2	17	10 1/2	14 1/4	13 1/8	14 1/4	16 1/2	16 1/2	16 1/2	28 3/8	11 1/4	13	6 3/8	215T
15	19	11 1/4	16 1/4	15 1/8	16 3/4	16 1/2	16 1/2	19	29 1/8	12 1/4	13	7 1/8	215T
16 1/2	20 1/4	13	17 1/4	16 1/8	18	18	18	20 1/2	32 1/8	13 1/4	13 1/4	8	215T
18 1/4	23 1/4	14 1/4	19 1/4	18 1/8	19 1/4	21 1/4	21 1/4	21 1/4	33 1/8	14 1/4	14 1/4	9 1/8	254T
20	24 1/4	15 1/4	21 1/4	20 1/8	21 1/4	21 1/4	21 1/4	24 1/4	35 1/8	15 1/4	15 1/4	9 1/4	254T
22 1/4	27 1/4	17 1/2	24	22 1/4	24 3/8	24	24	26 1/2	38 1/8	17 1/4	17 1/4	10 1/4	256T
24 1/2	29 1/4	19 1/4	26 1/2	24 1/8	26 1/4	26 1/4	30 1/4	30 1/4	40 1/8	18 1/4	18 1/4	11 1/4	256T
27	32 1/2	21 1/4	29 1/4	26 1/8	29 3/4	30 1/2	30 1/2	34 1/2	46 1/8	20 1/4	20 1/4	12 1/4	286T
30	36	23 1/2	32 1/4	30 1/8	32 3/4	30 1/2	36 1/2	36 1/2	48 1/8	23 1/4	31	14 1/4	326T
33	38 1/4	25 1/4	35 1/4	33	35 1/4	33 1/2	39 1/2	39 1/2	51 1/8	25 1/4	33 1/2	15 1/8	326T
36 1/2	42 1/4	28 1/2	39 1/4	36 1/8	39 1/4	36 1/2	42 1/2	42 1/2	53 1/8	27 1/4	35 1/2	16 1/4	326T

TYPE "BL" Limit Load
FANS

Dimensions SINGLE AND DOUBLE INLET

OVERALL DIMENSIONS FOR ALL ARRANGEMENTS & CLASSES

Sizes 115-2175

NOTES

1.) WHEN FLANGED
OUTLET IS FURNISHED
ON 245-1200 ADD
APPROX. 2" AS REQ'D.
FLANGED OUTLETS ARE
STD. ON CLASS I AND II
SIZE 1320 AND UP AND
ON ALL CLASS III SIZES.
NOT AVAILABLE ON
DOWN BLAST DISCHARGE.

2.) "DIM'S. GIVEN TO
FLOOR - LINE HSG
EXTENDS BELOW
FLOOR - LINE.

Size	AA	AB	BB	CA	TH	BH	UB	DB	TAU	TAD	BAU	LL
115	16 1/2	16 1/2	16 1/2	16 1/2	22 1/4	24 1/4	24 1/4	23	30 1/2	31 1/2	9 1/2	11 1/2
130	16 1/2	16 1/2	16 1/2	16 1/2	25 1/4	26 1/4	26 1/4	25 1/4	32 1/2	33 1/2	10 1/2	12 1/2
145	16 1/2	16 1/2	16 1/2	16 1/2	27 1/4	29 1/4	29 1/4	30 1/2	34 1/2	35 1/2	11 1/2	14 1/2
160	18 1/2	18 1/2	18 1/2	18 1/2	29 1/4	31 1/4	32 1/4	30 1/2	37 1/2	38 1/2	12 1/2	15 1/2
175	18 1/2	18 1/2	18 1/2	18 1/2	31 1/4	33 1/4	35 1/4	33 1/2	41 1/2	42 1/2	14 1/2	16 1/2
200	18 1/2	18 1/2	18 1/2	18 1/2	35 1/4	39 1/4	39 1/4	36 1/2	44 1/2	46 1/2	15 1/2	18 1/2
225	22 1/2	22 1/2	22 1/2	22 1/2	39 1/4	43 1/4	43 1/4	40 1/2	49 1/2	50 1/2	17 1/2	20 1/2
250	22 1/2	22 1/2	22 1/2	22 1/2	43 1/4	47 1/4	47 1/4	44 1/2	54 1/2	55 1/2	18 1/2	22 1/2
275	22 1/2	22 1/2	22 1/2	22 1/2	47 1/4	52 1/4	52 1/4	49 1/2	59 1/2	60 1/2	20 1/2	24 1/2
300	40	40	40	40	53 1/4	58 1/4	58 1/4	55	72 1/2	74	23 1/2	27 1/2
325	42 1/2	42 1/2	42 1/2	42 1/2	58 1/4	64 1/4	64 1/4	60 1/2	79 1/2	80 1/2	25 1/2	30 1/2
350	46 1/2	46 1/2	46 1/2	46 1/2	64 1/4	70 1/4	70 1/4	66 1/2	86 1/2	87 1/2	27 1/2	33 1/2
375	48 1/2	48 1/2	48 1/2	48 1/2	70 1/4	78 1/4	78 1/4	73 1/2	95 1/2	96 1/2	30 1/2	36 1/2
400	54 1/2	54 1/2	54 1/2	54 1/2	77 1/4	85 1/4	85 1/4	80 1/2	104 1/2	106 1/2	33 1/2	40 1/2
425	58 1/2	58 1/2	58 1/2	58 1/2	84 1/4	94 1/4	94 1/4	88 1/2	114 1/2	115 1/2	37 1/2	44 1/2
450	63 1/2	63 1/2	63 1/2	63 1/2	93 1/4	104 1/4	104 1/4	97 1/2	125 1/2	127 1/2	41 1/2	49 1/2
475	70 1/2	70 1/2	70 1/2	70 1/2	107 1/4	115 1/4	115 1/4	108 1/2	138 1/2	140 1/2	45 1/2	54 1/2
500	76 1/2	76 1/2	76 1/2	76 1/2	117 1/4	126 1/4	126 1/4	118 1/2	149 1/2	149 1/2	49 1/2	59 1/2
525	83 1/2	83 1/2	83 1/2	83 1/2	129 1/4	139 1/4	139 1/4	130 1/2	164 1/2	164 1/2	54 1/2	65 1/2
550	93 1/2	107 1/2	117 1/2	139 1/2	142 1/4	154 1/4	154 1/4	144 1/2	181 1/2	-	60 1/2	72 1/2
575	102 1/2	118 1/2	126 1/2	152 1/2	157 1/4	170 1/4	170 1/4	159 1/2	199 1/2	-	66 1/2	80 1/2
600	111 1/2	129 1/2	138 1/2	167 1/2	173 1/4	187 1/4	187 1/4	175 1/2	219 1/2	-	73 1/2	88 1/2
625	121 1/2	142 1/2	152 1/2	178 1/2	191 1/4	207 1/4	207 1/4	194 1/2	242 1/2	-	81 1/2	97 1/2

MIXED AIR TEMP FOR

MAA AREA

DESIGNED BY LLQ DATE 2/12/95

CHECKED BY TTJ DATE 2/26/95

$$T_{MA} = \frac{(T_{oa})(CFM_{oa}) + (T_{ea})(CFM_{ea})}{CFM}$$

$$\frac{(87^{\circ}F)(3417) + (19,248)(75^{\circ}F)}{22,782 CFM} = 76.4^{\circ}F$$

$$ADD RETURN FAN HEAT = \frac{122,045 BTUH (TRANCE 600)}{(19,248)(0.821)}$$

$$= 7.7^{\circ}F$$

$$T_{MA} = (76.4^{\circ}F + 7.7^{\circ}F) = 84^{\circ}F$$

COOLING COIL LOADS &
PSYCHROMETRICS
FOR SYSTEM

DESIGNED BY CLKP DATE 1/27/9
CHECKED BY TJT DATE 2/26/9

COOLING COIL LEAVING AIR TEMP. =
55 °F DB (FROM TRACE 600 ANALYSIS)

SENSIBLE HEAT GAIN RATIO:

SPACE SENSIBLE HEAT = 374,134 BTUH (TRACE 600)

SPACE TOTAL HEAT = 379,658 BTUH (TRACE 600)

$$\begin{aligned} \text{SHGR} &= \text{SPACE SENSIBLE HEAT} / \text{SPACE TOTAL HEAT} = \\ &= 374,134 \text{ BTUH} / 379,658 \text{ BTUH} = \\ &= \underline{0.98} \end{aligned}$$

$$\begin{aligned} \text{CHANGE IN ENTHALPY (DELTA H)} &= \text{FROM PSYCHROMETRICS} \\ &30.0 \text{ BTU/LB OF DRY AIR} - 22.45 \text{ BTU/LB OF DRY AIR} \\ &= 7.55 \text{ BTU/LB OF DRY AIR} \end{aligned}$$

$$\text{TOTAL CHILLER LOAD} = (\text{CFM}) (\text{DELTA H}) (\text{SPECIFIC VOLUME FACTOR})$$

$$\begin{aligned} \text{SPECIFIC VOLUME @ 70 DEG F 50\% RH @ 7500 FT ELEV} &= \\ &= 18.01 \text{ FT}^3/\text{LB} \end{aligned}$$

$$\begin{aligned} \text{SPECIFIC VOLUME FACTOR} &= (60 \text{ MIN/HR}) (18.01 \text{ FT}^3/\text{LB}) = \\ &= 3.33 \text{ LB OF DRY AIR MIN/FT}^3\text{HR} \end{aligned}$$

$$\begin{aligned} \text{TOTAL CHILLER LOAD} &= (22,782) (7.55) (3.33) \\ &= \underline{\underline{572,774 \text{ BTUH} \approx 7.8 \text{ TONS}}} \end{aligned}$$

GPM FOR COOLING COIL:

$$\text{TOTAL COOLING LOAD} = 572,774 \text{ BTUH}$$

$$\text{GPM} = \text{TOTAL COOLING LOAD} / (\text{DELTA T}) (500) =$$

$$= 572,774 \text{ BTUH} / ((T_{\text{LWT}} - T_{\text{EWT}}) (500)) =$$

$$572,774 \text{ BTUH} / ((55^\circ \text{F} - 45^\circ \text{F}) (500)) = 115 \text{ GPM}$$

115 115 GPM

HVA-1 FAN STATIC PRESSURE

DESIGNED BY CLQ DATE 1/29/91

CHECKED BY TJ DATE 2/26/91

EXTERNAL STATIC PRESSURE

1. OUTSIDE AIR LOUVER	0.15
2. OUTSIDE AIR DAMPER:	0.02
3. ROUGHING FILTER (DIRTY)	0.3
4. PRE HEAT COIL	0.2
5. COOLING COIL	6.6
6. 130' OF DUCTWORK (0.1/100FT)	0.18
7. TERMINAL HEATING COIL	0.2
8. SUPPLY AIR REGISTER.	0.1
9. RETURN AIR REGISTER	0.1
10. RETURN DUCT 130. FT	0.18
11. MIXING DAMPER.	0.02
	<hr/>
	2.05" W9 @ SL
12. 1070 SF	0.21
	<hr/>
	2.26

13. CORRECTION FOR ALTITUDE = $(2.26)/(0.76) = 1.7$ " WG

LKE 1.75" SP @ 7500 FT ELEV.

HVA-1 EQUIPMENT SELECTION
FOR SUPPORT AREA

DESIGNED BY CLR

DATE 2/12/95

CHECKED BY TJ

DATE 2/24/95

STATIC PRESSURE = 1.75"
REQUIRED CFM = 2502

CFM	BHP	RPM
300 { 2400 } ₁₀₂	1.25 {	1105 {
2502	X 0.2	X 12
2700	1.45	1117

$$BHP(X) = \left(\frac{102}{300} \right) (0.2) + 1.25 = 1.32 \text{ BHP}$$

$$\begin{aligned} \text{CORRECT FOR BELT LOSS} &= (1.32) / (0.95) \\ &= 1.4 \text{ BHP} \end{aligned}$$

$$\text{CORRECT FOR 750 FT ELEV} = (1.1) (0.76) = 1.1 \text{ BHP}$$

USE 1-1/2 HP MOTOR

$$RPM(X) = \left(\frac{102}{300} \right) (12) + 1105 = 1109 \text{ RPM}$$

SELECTION:

MANUFACTURER: TRANE

MODEL: SIZE 6 12.25" HDT

CFM = 2500

SP = 1.75"

HP = 1 1/2 HP

COOLING COIL LOADS &
PSYCHROMETRICS FOR
SYSTEM 3

DESIGNED BY CLQ DATE 1/29/91
CHECKED BY TJ DATE 2/26/91

COOLING COIL LEAVING AIR TEMP =
= 52.2°F DB (FROM TRACE 600 ANALYSIS)

SENSIBLE HEAT GAIN RATIO:

SPACE SENSIBLE HEAT = 41,084 BTU/H (TRACE 600)

SPACE TOTAL HEAT = 40,589 BTU/H " "

SHGR = SPACE SENSIBLE HEAT / SPACE TOT HEAT =
41,084 BTU/H / 40,589 BTU/H ≈ 1.0

MIXED AIR TEMP:

$$T_{MA} = \frac{((CFM_{OA}) \times T_{OA}) + ((CFM_{RA}) \times T_{RA})}{CFM} = \frac{(375 \times 87) + (2126 \times 75)}{2502} + \text{Fan Heat}$$

$$T_{MA} = 76.8^\circ\text{F} + \text{Fan Heat} = 76.8 + (1,134) / ((.821)(2126)) = \underline{77.4^\circ\text{F}}$$

CHANGE IN ENTHALPY (DELTA H) = FROM PSYCHROMETRICS
28.1 BTU/LB OF DRY AIR - (21.9 BTU/LB OF DRY AIR)
= 6.2 BTU/LB OF DRY AIR

TOTAL CHILLER LOAD = (CFM)(DELTA H)(SPECIFIC VOL FAC)
SPECIFIC VOLUME @ 70°F 50% RH @ 7500 FT ELEV = 18.21 FT³/LB
SPECIFIC VOLUME FACTOR = (60 MIN/HR)(18.01 FT³/LB) =
= 3.33 LB OF DRY AIR MIN/FT³HR

$$\text{TOTAL CHILLER LOAD} = (2502)(6.2)(3.33) =
= \underline{51,656 \text{ BTU/H} = 4.3 \text{ TONS}}$$

GPM FOR COOLING COIL:

TOTAL COOLING LOAD = 51,656 BTU/H

$$\text{GPM} = \text{TOTAL COOLING LOAD} / (\text{DELTA T} \times 500) =
= (51,656 \text{ BTU/H}) / ((55^\circ\text{F} - 45^\circ\text{F})(500)) \approx 11 \text{ GPM}$$

USE 11 GPM

DESIGN CONDITIONS

OPERATING CONDITIONS

JOB NAME NMSE

CFM 2500
SP 1.75

RPM 1109
BHP 1.1

UNIT TAG HVA-1
ORDER NO. _____

Size 6A Horizontal
12 1/4" FC
Without Inlet Vanes

SIZE 6 12.25" HDT

CFM Out-		Total Static Pressure																													
Std	Let	0.25		0.50		0.75		1.00		1.25		1.50		1.75		2.00		2.25		2.50		2.75		3.00		3.25					
Air	Vel	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP		
2100	1105	493	0.24	627	0.34	739	0.45	837	0.56	930	0.68	1019	0.81	1104	0.94	1185	1.08	1262	1.22	1335	1.37										
2400	1263	529	0.33	646	0.44	757	0.56	852	0.68	938	0.81	1020	0.94	1100	1.08	1177	1.23	1252	1.38	1323	1.54	1392	1.70								
2700	1421	580	0.45	672	0.55	775	0.69	870	0.83	953	0.96	1030	1.10	1105	1.25	1177	1.40	1248	1.56	1316	1.73	1383	1.90								
3000	1579	632	0.59	699	0.69	796	0.83	888	0.99	972	1.14	1047	1.30	1117	1.45	1185	1.61	1251	1.78	1316	1.95	1379	2.12								
3300	1737	682	0.77	733	0.86	822	1.01	907	1.17	990	1.34	1065	1.51	1134	1.68	1199	1.85	1262	2.02	1323	2.20	1383	2.38								
3600	1895	728	0.96	783	1.08	851	1.21	930	1.38	1008	1.56	1083	1.75	1153	1.94	1217	2.12	1278	2.31	1336	2.49	1393	2.68								
3900	2053	773	1.19	835	1.34	878	1.44	958	1.63	1029	1.82	1102	2.01	1171	2.22	1236	2.42	1296	2.62	1353	2.82										
4200	2211	821	1.46	887	1.63	924	1.74	985	1.90	1055	2.11	1122	2.31	1189	2.52	1253	2.74	1314	2.96	1372	3.18										

2502

Quick Select

40 OF 117

Unit selection procedure may be found on page 40.

Table Q-1 — Module Dimensions (Inches) and Weights (Lbs.)

		Unit Size									
		3	6	8	10	12	14	17	21	25	30
		24¾	27¼	31	34	38	40	44	48½	54¾	54¾
Module	H	31	44	48	60	64	68	74	76	78	91
	W										
A	Intake Module	L	15½	15½	15½	15½	15½	15½	15½	15½	15½
	Weight	94	124	141	187	208	224	252	273	301	337
B	Mixing, Filter-Mixing Box		24¾	27¼	31	34	34	34	34	40	40
		197	194	237	325	349	415	469	494	567	631
C	Economizer		24¾	27¼	31	34	34	34	34	40	40
		167	194	237	325	349	415	469	494	567	631
D	Air Filter		40¼	42¾	46½	49½	49½	49½	49½	55½	55½
		160	201	233	299	322	340	369	397	458	493
E	Open Return Filter		4	4	4	4	4	4	4	4	4
		8	13	14	25	25	28	30	32	33	38
F	Flat Filter		11	11	11	11	11	11	11	11	11
		64	80	87	113	120	127	137	145	152	167
G	Bag Filter		24¾	27¼	31	34	34	34	34	40	40
		103	135	158	204	218	260	282	297	340	373
H	Bag Filter		36	41	44	34	38	40	44	48½	54¾
		123	164	188	216	244	269	307	346	395	432
I	Cartridge Filter		24¾	27¼	31	34	34	34	34	40	40
		102	133	156	216	229	245	265	282	327	358
J	Small Inspection/Blank		11	11	11	11	11	11	11	11	11
		56	67	73	87	93	98	105	111	118	127
K	Medium Access/Blank		15½	15½	15½	15½	15½	15½	15½	15½	15½
		64	77	85	104	112	118	127	134	146	156
M	Large Access/Blank		24¾	27¼	31	34	34	34	34	40	40
		87	112	134	172	184	193	209	220	264	282
N	Extra Large Access/Blank		36	41	44	34	38	40	44	48½	54¾
		105	140	161	172	199	217	251	284	332	356
O	Small Horiz. Coil w/2 row UA		11	11	11	11	11	11	11	11	11
		84	109	122	154	174	182	201	219	239	265
P	Medium Horiz. Coil w/4 row UW		15½	15½	15½	15½	15½	15½	15½	15½	15½
		159	228	270	343	409	454	515	614	693	1029
R	Large Horiz. Coil w/10 row W		24¾	27¼	31	34	34	34	34	40	40
		243	333	441	573	704	744	857	985	1157	1324
S	Vertical Coil Module		24¾	27¼	31	34	34	34	34	40	40
		87	112	134	172	184	193	209	220	264	282
T	Moisture Eliminator		11	11	11	11	11	11	11	11	11
		68	91	105	163	184	200	222	247	272	308
		36	41	44	34	38	40	44	48½	54¾	54¾
		249	335	409	471	549	591	758	840	1027	1211
U	Bl Fan		N/A	N/A	N/A	611	782	846	1046	1267	1409
	Plug Fan		N/A	N/A	N/A	N/A	N/A	N/A	1112	1269	1421
V	Front Mounted or Down Discharge Plenum		36	41	44	34	34	34	34	40	40
		119	163	198	225	248	265	294	317	377	412
W	Top Mounted or Plug Fan L,H Discharge Plenum		36,24¾	41,27¼	44,31	34,34	38,34	40,34	44,34	48½,34	54¾,40
		145	209	236	274	301	320	354	379	452	499
X	Diffuser		15½	15½	15½	15½	15½	15½	15½	15½	15½
		70	87	96	111	122	130	144	156	167	186
Y	Internal Face and Bypass		15½	15½	15½	15½	15½	15½	15½	15½	15½
		85	115	129	184	200	230	252	274	300	336
Z	External Face and Bypass/Face Damper	L,H	15½,29¾	15½,32¼	15½,36	15½,39	15½,43	15½,45	15½,49	15½,53½	15½,59¾
		102	136	163	211	243	258	300	332	370	396
AA	Multizone/Dbl.Duct Coil W/8 row UW, 1 row WC	L,H	N/A	46½,44¼	46½,48	46½,53	65,57	65,59	65,63	65,71½	71,77¾
			594	679	894	1035	1112	1224	1370	1531	1951
AB	Base Rail/Integral Housekeeping Pad	H	6	6	6	6	6	6	8	8	8
		106	138	151	171	182	191	206	282	299	333

1 Weights are for single wall construction (except for discharge plenums). Fan weights include largest ODP motor. Coil module weights include the coil noted with 144 aluminum fins per foot, standard tubes and no water. Base rail weight is for units with a fan, medium coil, and a mixing box. Refer to page 116 for weight equation.

2 Modules are the same height except as noted. Heights do not include optional base rail (AB) or unit mounting legs (approx. 2 inches).

3 For vertical draw-thru configuration double the height.

5 Size 3 filter mixing box is 36" in length. Filter mixing boxes for all other sizes are the same as the mixing box.

EQUIP SELECTION FOR
FS-3

DESIGNED BY CLD

DATE 2/13/95

CHECKED BY TJ

DATE 2/26/95

CFM=1994

SP CALCS

1. ISOLATION DAMPER 0.02

2. HEPA FILTER (DIRTY) 3.0

3. TERMINAL HEATING COIL 0.3

4. 50' DUCTWORK - (0.1/100FT) 0.05

5. SUPPLY AIR REGISTER 0.1

3.38" SP

6. 10% SAFETY FACTOR 0.34"

3.72" SP

7. CORRECTION FOR ALTITUDE = $(3.72)(.76) = 2.82" SP$

BHP = 2.97 @ SL + 5% FOR BHT LOSS = 2.7 BHP

CORRECT FAN 7500 FT ELEV = $(2.7)(0.76) = 2.07 HP$

SELECTION:

MANUFACTURER: GREENHECK

MODEL: ORB SIZE 9-

CFM: 2038

SP: 3.0

HP: 3 HP

RPM 2640

TS = 10,797 RPM

SIZE 9 MODEL ORB

OPEN RADIAL WHEEL

Wheel Diameter = $15\frac{5}{8}"$
 Outlet Area = .44 SQ. FT.
 ip Speed, FPM = $4.09 \times \text{RPM}$

Performance Data

CFM	OV	VP	Static Pressure																			
			2.00		3.00		4.00		5.00		6.00		7.00		8.00		9.00		10.00		11.00	
			RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP
620	1400	0.12	1222	0.31	1485	0.45	1672	0.60	1856	0.75	2024	0.90	2180	1.06								
709	1600	0.16	1245	0.36	1484	0.52	1690	0.69	1873	0.86	2039	1.02	2191	1.19	2338	1.37	2472	1.55				
797	1800	0.20	1275	0.42	1506	0.60	1709	0.78	1891	0.97	2055	1.16	2208	1.35	2350	1.53	2483	1.72	2612	1.92	2735	2.13
886	2000	0.25	1308	0.49	1531	0.69	1730	0.88	1910	1.09	2074	1.29	2224	1.50	2367	1.71	2500	1.92	2626	2.13	2746	2.34
975	2200	0.30	1344	0.57	1560	0.78	1753	0.99	1930	1.21	2093	1.44	2244	1.66	2384	1.89	2517	2.12	2643	2.35	2763	2.58
1063	2400	0.36	1382	0.65	1593	0.88	1780	1.11	1953	1.35	2113	1.59	2263	1.83	2404	2.08	2535	2.32	2659	2.57	2780	2.82
1152	2600	0.42	1423	0.74	1629	0.99	1811	1.24	1979	1.49	2136	1.75	2283	2.01	2422	2.27	2555	2.54	2679	2.81	2797	3.07
1240	2800	0.49	1464	0.84	1666	1.11	1845	1.37	2008	1.64	2161	1.92	2306	2.19	2443	2.47	2573	2.76	2696	3.04	2817	3.33
1329	3000	0.56	1506	0.94	1705	1.23	1881	1.52	2040	1.80	2189	2.09	2331	2.39	2466	2.68	2595	2.98	2718	3.29	2836	3.60
1418	3200	0.64	1550	1.05	1746	1.37	1918	1.68	2075	1.98	2220	2.28	2359	2.60	2491	2.91	2618	3.23	2739	3.54	2856	3.87
1506	3400	0.72	1594	1.17	1787	1.51	1956	1.84	2111	2.17	2254	2.49	2390	2.82	2519	3.15	2643	3.48	2763	3.82	2878	4.15
1595	3600	0.81	1640	1.29	1829	1.66	1997	2.02	2148	2.37	2290	2.71	2423	3.05	2549	3.40	2671	3.75	2788	4.10	2902	4.45
1683	3800	0.90	1688	1.43	1872	1.82	2037	2.21	2187	2.57	2326	2.94	2457	3.30	2581	3.66	2701	4.03	2816	4.40	2927	4.77
1772	4000	1.00	1736	1.58	1916	2.00	2079	2.40	2227	2.79	2364	3.18	2494	3.58	2618	3.94	2733	4.32	2848	4.71	2955	5.10
1861	4200	1.10	1784	1.73	1961	2.18	2121	2.61	2268	3.02	2403	3.43	2531	3.83	2652	4.23	2767	4.63	2878	5.03	2986	5.44
1949	4400	1.21			2007	2.37	2164	2.82	2309	3.27	2443	3.70	2569	4.12	2688	4.54	2803	4.96	2912	5.38	3017	5.79
2038	4600	1.32			2055	2.57	2208	3.05	2351	3.52	2484	3.98	2608	4.42	2726	4.86	2839	5.30	2948	5.74	3052	6.17
2126	4800	1.44			2103	2.79	2253	3.29	2393	3.78	2525	4.27	2649	4.74	2765	5.19	2877	5.66	2984	6.12	3087	6.57
2215	5000	1.56			2151	3.01	2299	3.54	2437	4.06	2567	4.56	2690	5.08	2805	5.55	2915	6.02	3021	6.51	3123	6.98
2304	5200	1.69					2346	3.80	2481	4.35	2609	4.88	2731	5.40	2846	5.91	2955	6.41	3059	6.91	3160	7.41
2481	5600	1.96					2442	4.37	2572	4.96	2697	5.55	2814	6.11	2928	6.68	3036	7.23	3138	7.77	3236	8.31
2658	6000	2.25							2668	5.84	2787	6.26	2902	6.89	3012	7.50	3118	8.11	3220	8.70	3317	9.28
2835	6400	2.55							2763	6.37	2881	7.05	2992	7.72	3099	8.39	3202	9.03	3302	9.68	3399	10.3
3012	6800	2.88									2977	7.90	3085	8.61	3189	9.33	3290	10.0	3387	10.7	3482	11.4

CFM	OV	VP	Static Pressure																			
			12.00		13.00		14.00		15.00		16.00		17.00		18.00		19.00		20.00		22.00	
			RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP
975	2200	0.30	2878	2.81	2987	3.04	3094	3.28	3199	3.53	3300	3.77	3398	4.02								
1063	2400	0.36	2895	3.08	3005	3.33	3110	3.58	3212	3.83	3311	4.08	3409	4.35	3504	4.62	3596	4.89	3686	5.16		
1152	2600	0.42	2911	3.34	3021	3.62	3127	3.89	3229	4.17	3328	4.44	3423	4.71	3516	4.98	3607	5.26	3697	5.55	3871	6.13
1240	2800	0.49	2930	3.62	3038	3.91	3143	4.20	3246	4.49	3345	4.79	3441	5.09	3533	5.38	3624	5.67	3711	5.96	3881	6.55
1329	3000	0.56	2950	3.90	3058	4.21	3162	4.52	3263	4.83	3361	5.14	3457	5.46	3550	5.78	3641	6.09	3729	6.41	3898	7.03
1418	3200	0.64	2968	4.19	3077	4.52	3182	4.85	3283	5.18	3380	5.51	3474	5.84	3566	6.17	3657	6.51	3745	6.85	3916	7.53
1506	3400	0.72	2989	4.50	3098	4.84	3201	5.19	3302	5.54	3400	5.89	3494	6.24	3585	6.59	3674	6.93	3761	7.29	3932	8.00
1595	3600	0.81	3012	4.81	3118	5.17	3221	5.54	3321	5.90	3418	6.27	3513	6.64	3605	7.01	3694	7.38	3781	7.75	3948	8.49
1683	3800	0.90	3036	5.14	3141	5.52	3243	5.90	3342	6.28	3438	6.67	3532	7.06	3624	7.45	3714	7.84	3801	8.23	3968	9.01
1772	4000	1.00	3062	5.49	3165	5.88	3266	6.28	3364	6.67	3460	7.07	3553	7.48	3643	7.89	3732	8.30	3820	8.71	3988	9.53
1861	4200	1.10	3090	5.85	3192	6.26	3291	6.67	3388	7.09	3483	7.50	3575	7.92	3665	8.34	3753	8.77	3839	9.20	4007	10.1
1949	4400	1.21	3121	6.22	3220	6.65	3318	7.08	3413	7.51	3507	7.94	3598	8.38	3687	8.81	3775	9.26	3860	9.70	4025	10.6
2038	4600	1.32	3152	6.61	3251	7.06	3347	7.50	3441	7.95	3533	8.41	3622	8.86	3711	9.31	3798	9.77	3882	10.2	4047	11.2
2126	4800	1.44	3187	7.02	3283	7.48	3378	7.94	3470	8.41	3561	8.88	3650	9.35	3736	9.82	3822	10.3	3908	10.8	4069	11.7
2215	5000	1.56	3222	7.46	3318	7.93	3410	8.40	3502	8.89	3591	9.37	3678	9.86	3764	10.4	3848	10.8	3930	11.3	4093	12.3
2304	5200	1.69	3258	7.91	3353	8.40	3445	8.89	3534	9.38	3622	9.88	3708	10.4	3793	10.9	3876	11.4	3958	11.9	4117	12.9
2481	5600	1.96	3333	8.85	3425	9.39	3516	9.92	3604	10.4	3690	11.0	3774	11.5	3855	12.0	3937	12.6	4016	13.1	4171	14.2
2658	6000	2.25	3411	9.86	3501	10.4	3590	11.0	3677	11.6	3761	12.2	3844	12.7	3924	13.3	4003	13.9	4080	14.4	4232	15.6
2835	6400	2.55	3492	10.9	3581	11.6	3668	12.2	3753	12.8	3836	13.4	3916	14.0	3996	14.6	4074	15.2	4150	15.8	4296	17.1
3012	6800	2.88	3574	12.1	3663	12.8	3748	13.4	3832	14.1	3913	14.7	3992	15.4	4071	16.0	4147	16.7	4222	17.3	4368	18.6
3190	7200	3.23	3657	13.3	3745	14.0	3830	14.7	3913	15.5	3993	16.2	4071	16.8	4147	17.5	4223	18.2	4297	18.9	4441	20.3
3367	7600	3.60	3743	14.6	3829	15.4	3913	16.1	3995	16.9	4075	17.6	4152	18.4	4228	19.1	4302	19.9	4374	20.6	4518	22.0
3544	8000	3.99	3832	16.0	3916	16.8	3997	17.6	4078	18.4	4157	19.2	4234	20.0	4309	20.8	4383	21.6	4454	22.3	4593	23.9

BHP does not include drives losses.

EQUIP SELECTION FOR
FE-4

DESIGNED BY CLO

DATE 2/13/95

CHECKED BY TJT

DATE 2/26/05

CFM = SUPPLY AIR - HOOD EXHAUST
= 590'

SP.

1. FUME HOOD

1.0

2. DUCTWORK 50' (0.1/100 FT)

0.05

3. ISOLATION DAMPER

0.02

4. HEPA FILTER (DIRTY)

3.0

5. ISOLATION DAMPER

0.02

6. 10% SAFETY FACTOR

4.09"

0.41

4.5"

7. CORRECTION FOR ALTITUDE = $(4.5)(0.76) = 3.42$ SP

BHP = 0.64 @ SL + 5% FOR BELT LOSS = 0.672 BHP

CORRECT FOR 7500 FT ELEV = $(0.672)(0.76) = 0.51$

USE 3/4 HP MOTOR

SELECTION:

MANUFACTURER: GREENHEIL

MODEL: GRA SIZE 7

CFM: 600

SP: 4.5

RPM: 2282

TS: 7,234 rpm

HP: 3/4 HP

SHEET 45 OF 117

DESIGNED BY CLO DATE 5/15/95

CHECKED BY TJT DATE 5/22/95

SP

1. EXHAUST AIR REGISTER.	0.1
2. DUCTWORK 50' (0.1/100 FT)	0.05
3. ISOLATION DAMPER	0.02
4. PRE-FILTER (DIRTY)	0.3
5. HEPA FILTER (DIRTY)	3.0
6. ISOLATION DAMPER	0.02
	3.49
7. 10% SAFETY FACTOR	0.35
	3.84
8. CORRECTION FOR 7500 FT ELEV = $(3.84)(.76) = 2.92'' \text{ SP.}$
- BHP = $(1.37 \text{ C.S.L.} + 570 \text{ FAN BELT LOSS}) = 1.44 \text{ BHP}$
- CORRECT FOR 7500 FT = $(1.44)(0.76) = 1.1$

USE 1-1/2 HP MOTOR

SELECTION:

MANUFACTURER: GREENHECK

MODEL: ORB SIZE 9

CFM: 1418

SP: 3.00" SP

RPM: 1746

TS: 7,141 Fpm

EXHAUST FAN EQUIPMENT
SELECTION (FE-6)

DESIGNED BY CLL DATE 5/15/95

CHECKED BY TJ DATE 5/22/95

CFM = 250 CFM
SP = 0.25"

CORRECTION FOR 7500 FT ELEV = $(0.024)/(0.76) = 0.02$

BHP = $(0.02) + 5\%$ FOR BELT LOSS = 0.021

CORRECT FOR ALTITUDE $(0.021)/(0.76) = 0.0266$

USE 1/4 HP.

SELECTION:

MANUFACTURER: GREENHECK

MODEL: GBB0-4

CFM: 265

SP: 0.25

HP: 0.25

TS: 2548

SONES: 3.5.

EQUIP SELECTION FOR
FE-3.

DESIGNED BY CLD DATE 2/13/95

CHECKED BY TJ DATE 2/26/95

CFM = 480

SP

1. EXHAUST AIR REGISTER	0.1
2. ISOLATION DAMPER	0.02
3. DUCT 100 FT (0.1/100 FT)	0.1
4. PRE FILTER (DIRTY)	0.3
5. HEPA FILTER (DIRTY)	3.0
6. ISOLATION DAMPER	0.02
7. DUCTWORK 50' (0.1/100 FT)	0.05
	<hr/> 3.59"
8. 10% SAFETY FACTOR	0.36
	<hr/> 3.95

9. CORRECTION FOR ALTITUDE = $(3.95)(0.76) = 3.0"$

BHP = 0.52

DRIVE LOSS $(0.52)(0.95) = 0.55$

CORR FOR ALT = $0.55(0.76) = 0.418$

SELECTION:

MANUFACTURER: GREENHECK

MODEL: OCB SIZE 5

CFM: 500

SP: 3.0

RPM: 3265

HP: 1/2 HP

TS: 7477 fpm

USE 1/2 HP

SIZE 5 MODEL ORB

OPEN RADIAL WHEEL

Wheel Diameter = $8\frac{3}{4}$ "
 Outlet Area = .12 SQ. FT.
 Tip Speed, FPM = $2.29 \times \text{RPM}$

Performance Data

CFM	OV	VP	Static Pressure																			
			2.00		3.00		4.00		5.00		6.00		7.00		8.00		9.00		10.00		11.00	
			RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP
175	1400	0.12	2156	0.09	2593	0.13	2965	0.17	3297	0.21												
200	1600	0.16	2189	0.10	2623	0.15	2992	0.19	3320	0.24	3617	0.29	3896	0.34								
225	1800	0.20	2229	0.12	2653	0.17	3021	0.22	3347	0.27	3643	0.33	3915	0.38								
250	2000	0.25	2276	0.13	2689	0.19	3052	0.25	3376	0.30	3670	0.36	3943	0.42	4173	0.43	4417	0.49				
275	2200	0.30	2329	0.15	2729	0.21	3085	0.27	3407	0.34	3699	0.40	3969	0.47	4224	0.53	4482	0.60	4686	0.66	4901	
300	2400	0.36	2387	0.17	2775	0.24	3122	0.30	3439	0.37	3731	0.44	4000	0.51	4249	0.58	4488	0.65	4714	0.72	4928	
325	2600	0.42	2448	0.20	2827	0.27	3164	0.34	3475	0.41	3762	0.48	4031	0.56	4281	0.63	4516	0.71	4740	0.79	4955	
350	2800	0.49	2512	0.22	2883	0.30	3211	0.37	3514	0.45	3797	0.53	4062	0.61	4312	0.69	4548	0.77	4770	0.85	4981	
375	3000	0.56	2577	0.25	2941	0.33	3263	0.41	3558	0.49	3836	0.57	4097	0.66	4344	0.74	4578	0.83	4802	0.92	5013	
400	3200	0.64	2644	0.27	3003	0.36	3319	0.45	3608	0.53	3879	0.62	4135	0.71	4378	0.80	4610	0.89	4832	0.98	5044	
425	3400	0.72	2712	0.30	3067	0.40	3378	0.49	3661	0.58	3926	0.67	4177	0.77	4417	0.86	4645	0.96	4864	1.05	5074	
450	3600	0.81	2783	0.34	3132	0.44	3438	0.54	3718	0.63	3976	0.73	4222	0.83	4458	0.93	4683	1.03	4899	1.13	5108	
475	3800	0.90	2855	0.37	3198	0.48	3500	0.58	3776	0.69	4032	0.79	4272	0.89	4502	0.99	4724	1.10	4938	1.21	5143	
500	4000	1.00	2929	0.41	3265	0.52	3565	0.63	3836	0.74	4089	0.85	4326	0.96	4552	1.06	4769	1.17	4978	1.29	5182	
525	4200	1.10	3006	0.44	3334	0.57	3631	0.69	3898	0.80	4147	0.91	4382	1.03	4603	1.14	4817	1.25	5023	1.37	5223	
550	4400	1.21	3083	0.48	3405	0.61	3697	0.74	3962	0.86	4208	0.98	4440	1.10	4659	1.22	4867	1.33	5071	1.46	5267	
575	4600	1.32	3160	0.53	3477	0.66	3764	0.80	4028	0.93	4270	1.05	4498	1.18	4716	1.30	4923	1.42	5121	1.55	5315	
600	4800	1.44			3550	0.72	3832	0.86	4094	0.99	4334	1.12	4560	1.25	4774	1.39	4979	1.51	5175	1.64	5365	
625	5000	1.56			3626	0.77	3903	0.92	4160	1.06	4399	1.20	4622	1.34	4834	1.47	5037	1.61	5231	1.74	5419	
650	5200	1.69			3703	0.83	3974	0.99	4227	1.14	4465	1.28	4686	1.42	4895	1.56	5096	1.71	5289	1.85	5474	
700	5600	1.96			3857	0.96	4121	1.12	4367	1.29	4598	1.45	4817	1.61	5023	1.76	5218	1.91	5408	2.07	5590	
750	6000	2.25					4274	1.28	4511	1.48	4736	1.63	4950	1.80	5154	1.97	5348	2.14	5532	2.30	5710	
800	6400	2.55					4428	1.45	4660	1.64	4879	1.83	5087	2.01	5287	2.19	5479	2.37	5661	2.55	5836	
850	6800	2.88							4815	1.83	5025	2.03	5229	2.24	5424	2.43	5612	2.63	5793	2.82	5966	

CFM	OV	VP	Static Pressure																			
			12.00		13.00		14.00		15.00		16.00		17.00		18.00		19.00		20.00		22.00	
			RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP
275	2200	0.30	5111	0.80	5312	0.87	5505	0.94														
300	2400	0.38	5132	0.87	5329	0.94	5522	1.01	5709	1.09	5889	1.18										
325	2600	0.42	5160	0.94	5356	1.02	5544	1.09	5726	1.17	5906	1.25	6081	1.33	6251	1.42	6416	1.50				
350	2800	0.49	5186	1.01	5383	1.10	5572	1.18	5754	1.26	5930	1.35	6100	1.43	6268	1.51	6433	1.60	6594	1.69	6905	1.87
375	3000	0.56	5214	1.09	5409	1.18	5599	1.27	5782	1.36	5958	1.45	6129	1.54	6294	1.62	6455	1.71	6612	1.80	6921	1.99
400	3200	0.64	5246	1.17	5439	1.26	5625	1.36	5808	1.45	5984	1.55	6156	1.64	6322	1.74	6483	1.83	6640	1.92	6942	2.11
425	3400	0.72	5277	1.25	5471	1.35	5657	1.45	5837	1.55	6010	1.64	6182	1.75	6348	1.85	6510	1.95	6668	2.05	6970	2.25
450	3600	0.81	5307	1.33	5501	1.44	5689	1.54	5869	1.65	6042	1.75	6211	1.85	6374	1.96	6536	2.07	6694	2.17	6998	2.39
475	3800	0.90	5342	1.42	5533	1.53	5719	1.64	5899	1.75	6074	1.86	6243	1.97	6406	2.08	6565	2.19	6720	2.30	7024	2.52
500	4000	1.00	5378	1.51	5568	1.62	5751	1.74	5930	1.85	6104	1.97	6274	2.08	6438	2.20	6597	2.31	6752	2.43	7050	2.66
525	4200	1.10	5416	1.60	5604	1.72	5786	1.84	5964	1.96	6135	2.08	6304	2.20	6468	2.32	6628	2.44	6784	2.56	7082	2.81
550	4400	1.21	5458	1.70	5643	1.82	5824	1.94	5999	2.07	6170	2.19	6336	2.32	6498	2.44	6658	2.57	6814	2.70	7114	2.95
575	4600	1.32	5502	1.80	5685	1.93	5863	2.05	6037	2.18	6206	2.31	6371	2.44	6533	2.57	6690	2.70	6844	2.84	7144	3.10
600	4800	1.44	5550	1.90	5730	2.04	5905	2.17	6078	2.30	6245	2.43	6408	2.57	6568	2.70	6725	2.84	6878	2.98	7174	3.25
625	5000	1.56	5600	2.01	5778	2.15	5950	2.29	6120	2.42	6284	2.56	6447	2.70	6606	2.84	6760	2.98	6913	3.12	7207	3.41
650	5200	1.69	5653	2.12	5828	2.26	5998	2.41	6164	2.55	6328	2.69	6488	2.84	6644	2.98	6799	3.13	6949	3.27	7242	3.57
700	5600	1.96	5766	2.37	5936	2.51	6102	2.66	6264	2.82	6423	2.97	6577	3.12	6731	3.28	6881	3.43	7028	3.59	7317	3.90
750	6000	2.25	5883	2.63	6051	2.79	6214	2.94	6372	3.11	6527	3.27	6678	3.43	6828	3.59	6974	3.76	7117	3.92	7399	4.25
800	6400	2.55	6005	2.90	6170	3.07	6330	3.25	6487	3.42	6639	3.59	6787	3.76	6933	3.93	7074	4.10	7216	4.28	7490	4.63
850	6800	2.88	6133	3.19	6294	3.37	6452	3.56	6605	3.74	6755	3.93	6902	4.11	7045	4.29	7185	4.47	7323	4.65	7590	5.02
900	7200	3.23	6264	3.50	6423	3.70	6578	3.89	6728	4.09	6876	4.28	7020	4.48	7161	4.67	7300	4.87	7435	5.06	7699	5.44
950	7600	3.60	6396	3.83	6554	4.04	6708	4.25	6856	4.46	7000	4.66	7142	4.87	7282	5.07	7418	5.28	7552	5.49	7812	5.89
1000	8000	3.99	6530	4.17	6687	4.40	6839	4.62	6987	4.84	7130	5.06	7270	5.28	7405	5.49	7540	5.71	7672	5.93	7929	6.37

BHP does not include drives losses.

CHILLER SELECTION

CWAC-1 & CWAC-2

DESIGNED BY CLO

DATE 1/30/94

CHECKED BY JJ

DATE 2/26/94

CHILLER SUMMARY:

CHILLER LOAD FOR AHU-1 = 572,774 BTUH (SEE SHT 33 OF 117)

CHILLER LOAD FOR AHU-3 = 51,656 BTUH (SEE SHT 37 OF 117)

TOTAL CHILLER LOAD = 624,430 BTUH

TOTAL TONS = $624,430 \text{ BTUH} / 12,000 \text{ BTUH/TON} =$
= 52 TONS.

$\Delta T = (T_{\text{EWT}} - T_{\text{CWT}}) = (55^\circ\text{F} - 45^\circ\text{F}) = 10^\circ\text{F}$

LEAVING CHILLED WATER TEMPERATURE 45°F

CONDENSER/EXAPORATOR FOLLING FACTOR = 0.00025

SUPPLY VOLTAGE = 460/60/3

* PERATED FOR 40% GLYCOL

50 OF 117

TRANE**Air-Cooled Series R® Chillers**

Version 1.0

Job Name
Location
Client
User
Comments

Input Conditions for **RTAA070**

Model Number	RTAA70	Entering Evap Temp	55 deg F
Minimum Capacity		Leaving Evap Temp	45 deg F
Evap Fouling Factor	0.00025 hr-sq ft-deg F/Btu	Ambient Temperature	89.0 deg F
Evap Flow Rate			

Output Data

Full Load Capacity	68.6 tons	Leaving Evap Temp	45.0 deg F
Compressor Power	67.3 kW	Evap Flow Rate	188.4 gpm
Fan Power	8.6 kW	Entering Evap Temp	55.0 deg F
Total Power	76.2 kW	Pressure Drop	19.0 ft H2O
Unit Performance	10.8 EER	Evap Fouling Factor	0.00025 hr-sq ft-deg F/Btu
Compressor Load Circuit 1	34.3 tons	Brine Freeze Point	-10.8 deg F
Compressor Load Circuit 2	34.3 tons		
Brine Type	ETHYLENE GLYCOL		
Percent Brine	40		

Product Information

Length	16 ft. 2 1/2 in.	Width	7 ft. 4 3/16 in.	Height	7 ft. 3 1/2 in.
Ship. Weight	6025 lb.	Operating Weight	6375 lb.	Refrigerant Charge	58/58 lb.
Rated Voltage	460	Number Fans	8	Blue Fin	NO
Frequency	60	Fan FLA (each)	2.5		

	Refrigerant Circuit One		Refrigerant Circuit Two		
	<u>Comp. 1</u>	<u>Comp. 2</u>	<u>Comp. 1</u>	<u>Comp. 2</u>	
RLA	50		50		
LRA	330		330		
					MCA
					133

----- Electrical -----
Circuit One Circuit Two

CHILLED WATER GPM SUMMARY.

DESIGNED BY CLQ DATE 2/12/9.

CHECKED BY _____ DATE _____

- CHILLED WATER REQUIREMENTS FOR
SYS # 1 = 115 GPM

- CHILLED WATER REQUIREMENTS FOR
SYS # 3 = 11 GPM

TOTAL GPM REQUIRED = $115 + 11 = 126$ GPM.

SIZE 3 CHILLED WATER PUMPS FOR 63GPM EA.
(2-WORKING 1-STANDBY)

JOB

DESCRIPTION: CHILLED WATER PUMP SELECTION (PCW-1,2,3)

JOB # 41552-056

SHEET

DESIGNED: CLG

CHECKED BY: JT

DATE

DATE

27-Feb-95

2/27/95

GPM =

63 GAL/MIN

GATE VALVE ELBOW EQUIV.

0.5

			FRICION (PER 100 FT)	QUANTITY	EQUIV LENGTH (ELBOW)	FT OF HEAD
			A	B	C	D
HEAD LOSS	1	PIPE	2.00	600.00		18.00
	2	GATE VALVE(S)		4.00	5.5	0.22
	3	THREE WAY VALVE		1.00		10.00
	4	COIL		1.00		10.00
	5	CHILLER				20.00
	6	SUCTION DIFFUSER				1.6

SUBTOTAL 59.82

10% SF 5.98

TOTAL 65.80

PUMP SELECTION: MANUFACTURER: BELL & GOSSETT
 SERIES: 1510
 MODEL # 1-1/4 BC
 GPM: 63
 PIPE SIZE:
 PUMP SIDE 1-1/4"
 SUCTION SIDE 1-1/2"
 HP: 3 HP
 RPM: 1750
 EFF. 56%
 QUANTITY: 3 (2-WORKING, 1-STANDBY)

SUCTION DIFFUSER SELECTION:

MANUFACTURER: BELL & GOSSETT
 MODEL No. DC-3
 PIPE SIZE:
 PUMP SIDE: 1-1/4"
 SYSTEM SIDE: 3"

EQL TIONS

$D_1 = 1.5 \cdot (A_1/100)$

$D_2 = B_2 \cdot C_2 \cdot 0.5 \cdot (A_1/100)$

1750 RPM PUMP CURVES

53 OF 117
B-260E

65.3

63

HEAT LOSS CALCULATIONS FOR -
MEZZANINE (NDA LAB)

DESIGNED BY CLO DATE 1/25/93

CHECKED BY TJ DATE 2/26/93

HEAT LOSS: WALLS FROM GRADE TO 10 FT BELOW GRADE

- HEAT LOSS THROUGH WALLS FROM GRADE TO 8 FT BELOW GRADE.

$$H = L_p Q (t_b - t_{oa}) \text{ SEE ATTACHED}$$

H = HEAT LOSS

L_p = PERIMETER OF WALL, FT = 223 FT

Q = PERIMETER FACTOR (TABLE 36) = 1.2

t_b = MEZZANINE DRY-BULB TEMP = 70°F

t_{oa} = OUTDOOR DESIGN DRY-BULB TEMP, °F = 5°F

$$H = (223 \text{ FT})(1.20)(70^\circ\text{F} - 5^\circ\text{F}) = 17,394 \text{ BTU/HR}$$

- HEAT LOSS THROUGH WALLS BELOW 8 FOOT LINE.

$$= (\text{AREA OF WALL BELOW 8 FOOT LINE})(U \text{ VALUE FROM TABLE 35})$$

(BASEMENT - GROUND TEMP FROM TABLE 37) =

$$\text{AREA} = (223 \text{ FT} \times 2 \text{ FT}) = 446 \text{ SQFT}$$

$$H = (446 \text{ SQFT})(0.08)(57.5^\circ\text{F}) = 2052 \text{ BTU/HR}$$

$$\text{TOTAL HEAT LOSS FOR NDA LAB} = 17,394 + 2052$$

$$= \underline{\underline{19,446 \text{ BTU/HR}}}$$

HEAT LOSS CALCULATIONS FOR
BASEMENT AND NORTH TUNNEL

DESIGNED BY CLQ

DATE 2/23/95

CHECKED BY JT

DATE 2/24/95

1. HEAT LOSS: WALLS FROM GRADE TO 10 FT
BELOW GRADE

- HEAT LOSS THROUGH WALLS FROM GRADE TO 8 FT BELOW GRADE.

$$H = L_p Q (t_b - t_{oa}) \text{ SEE ATTACHED.}$$

$$H = \text{HEAT LOSS}$$

$$L_p = \text{PERIMETER OF WALL, FT} = 560 \text{ FT}$$

$$Q = \text{PERIMETER FACTOR (TABLE 36)} = 1.2$$

$$t_b = \text{BASEMENT / TUNNEL DRY-BULB TEMP} = 72^\circ \text{F}$$

$$t_{oa} = \text{OUTDOOR DESIGN DRY-BULB TEMP, } ^\circ \text{F} = 5^\circ \text{F}$$

$$t_g = \text{GROUND TEMP, } ^\circ \text{F, (TABLE 37)} = 57.5^\circ \text{F}$$

$$H = (560 \text{ FT})(1.2)(72^\circ \text{F} - 5^\circ \text{F}) = 45,024 \text{ BTUH}$$

- HEAT LOSS THROUGH WALLS BELOW 8 FOOT LINE
= (AREA OF WALL BELOW 8 FOOT LINE)(U VALUE FROM TABLE 35)
(BASEMENT - GROUND TEMP FROM TABLE 37) =

$$\text{AREA} = (560 \text{ FT} \times 2 \text{ FT}) = 1120 \text{ FT}^2$$

$$H = 1120 \text{ FT}^2 (0.08)(57.5^\circ \text{F}) = 5152 \text{ BTUH}$$

$$\text{TOTAL HEAT LOSS THROUGH WALLS} = 45,024 + 5152 =$$

$$= \underline{\underline{50,176 \text{ BTUH}}}$$

2. HEAT LOSS: SLAB.

HEAT LOSS THROUGH FLOOR

$$H = UA (t_b - t_g)$$

$$H = (0.05)(6780 \text{ FT}^2)(72^\circ \text{F} - 57.5^\circ \text{F}) = \underline{\underline{4916 \text{ BTUH}}}$$

$$\underline{\underline{55,092 \text{ BTUH}}}$$

BOILER SELECTION

BHW-1 BHW-2

DESIGNED BY CLP

DATE 2/12/9

CHECKED BY JJS

DATE 2/26/95

MAA AREA (SYSTEM #1)

1ST FLOOR TOTAL HEATING LOAD = 365,800 BTUH (TRANCE 600)

NDA LAB TOTAL HEATING LOAD = 19,446 BTUH

BASEMENT TOTAL HEATING LOAD = 55,092 BTUH

TOTAL FOR SYSTEM #1 = 440,338 BTUH

SYSTEM #2

TOTAL HEATING LOAD = 13,131 BTUH

SYSTEM #3

TOTAL HEATING LOAD = 35,647 BTUH

SYSTEM #4 TOTAL HEATING LOAD = 12,972 BTUH

TOTAL REQUIRED = 502,088 BTUH @ 7500 FT

OUTPUT REQUIRED AT SL = $(502,088 \text{ BTUH}) / (0.7)$

717,270 BTUH @ SL

JOB NUCLEAR MATERIALS STORAGE FACILITY

JOB # 41552-056

DESCRIPTION: BOILER SELECTION

ELEVATION: 7500 FT

SHEET 57 OF 117
DESIGNED: CLQ

DATE: 27-Feb-95

CK JT

2/27/95

REQUIREMENTS

HEATING LOAD: 502,088 BTUH @ 7500 FT ELEV

EQUIPMENT SELECTION:

QUANTITY: 2 (1 for standby)
MANUFACTURER: AJAX
MODEL: WG-900
INPUT BTUH: 900 MBH
OUTPUT BTUH: 720 MBH @ SEA LEVEL
SQFT HEATING SURFACE: 100.7 SF
WEIGHT: 1800 LBS

COMBUSTION AIR LOUVERS:

REQUIRED: 1 SQUARE INCH OF FREE AREA PER 2000 BTUH

FREE AREA = $720,000 \text{ BTUH} \times 1 \text{ IN}^2 / 2000 \text{ BTUH} = 450 \text{ IN}^2$

LOUVER AREA AT 50% FREE AREA = $450 \text{ IN}^2 / 0.5 = 900 \text{ IN}^2$

EQUIPMENT SELECTION:

QTY: 2
CONSIDER 50% FREE AREA
SQUARE INCHES = 900
LOUVER SIZE: 30" x 30"
ONE LOUVER HIGH AND ONE LOUVER LOW

AJAX

MODELS AND CAPACITIES

MODEL Water—Gas (See Note)	INPUT BTU/HR.	GROSS OUTPUT BTU/HR.	GROSS E.D.R.	HEAT EXCHANGER		WATER VOLUME GALLONS	SQ. FT. HEATING SURFACE	APPROX. SHIPPING WGT. LBS.
				G.P.H. 60°F. RISE (1)	G.P.H. 100°F. RISE (1)			
*WG-100	100,000	80,000	534	160	96	9	14.2	550
*WG-150	150,000	120,000	800	240	144	10	17.9	600
*WG-200	200,000	160,000	1,067	320	192	11	23.4	680
*WG-250	250,000	200,000	1,333	400	240	13	28.9	750
*WG-300	300,000	240,000	1,600	480	288	14	34.4	820
*WG-350	350,000	280,000	1,867	560	336	15	39.9	900
*WG-400	400,000	320,000	2,133	640	384	18	43.2	980
*WG-450	450,000	360,000	2,400	720	432	19	45.2	1,050
*WG-525	525,000	420,000	2,800	840	504	21	53.8	1,250
*WG-600	600,000	480,000	3,200	960	576	23	62.5	1,390
*WG-675	675,000	540,000	3,600	1,080	648	25	71.1	1,470
*WG-750	750,000	600,000	4,000	1,200	720	28	79.8	1,600
*WG-850	850,000	680,000	4,533	1,360	816	43	91.4	1,700
*WG-900	900,000	720,000	4,800	1,440	865	45	100.7	1,800
*WG-1050	1,050,000	840,000	5,600	1,600	960	47	108.1	1,900
*WG-1125	1,125,000	900,000	6,000	1,800	1,080	49	115.0	2,050
*WG-1250	1,250,000	1,000,000	6,667	2,000	1,200	52	129.0	2,300
*WG-1375	1,375,000	1,100,000	7,333	2,220	1,320	54	138.2	2,450
*WG-1500	1,500,000	1,200,000	8,000	2,400	1,440	57	149.9	2,850
*WG-1750	1,750,000	1,400,000	9,333	2,800	1,680	62	170.7	3,000
*WG-2000	2,000,000	1,600,000	10,667	3,200	1,920	95	230.7	3,550
*WG-2250	2,250,000	1,800,000	12,000	3,600	2,160	101	255.7	3,850
*WG-2500	2,500,000	2,000,000	13,333	4,000	2,400	105	272.3	4,050
*WG-2750	2,750,000	2,200,000	14,666	4,400	2,640	112	297.2	4,350
*WG-3000	3,000,000	2,400,000	16,000	4,800	2,880	118	322.2	4,650
*WG-3250A	3,250,000	2,600,000	17,333	5,200	3,120	124	347.1	4,950
*WG-3500	3,500,000	2,800,000	18,667	5,600	3,360	165	362	5,350
*WG-3750	3,750,000	3,000,000	20,000	6,000	3,600	173	394	5,700
*WG-4000	4,000,000	3,200,000	21,333	6,400	3,840	178	414	5,900
*WG-4250	4,250,000	3,400,000	22,667	6,800	4,082	184	438	6,150
*WG-4500	4,500,000	3,600,000	24,000	7,200	4,320	189	457	6,400
*WG-4750	4,750,000	3,800,000	25,333	7,600	4,562	197	489	6,750
*WG-5000	5,000,000	4,000,000	26,667	8,000	4,800	202	510	7,000
WG-5500	5,500,000	4,400,000	29,333	8,800	5,282	253	618	9,100
WG-6000	6,000,000	4,800,000	32,000	9,600	5,763	266	674	9,900
WG-6500	6,500,000	5,200,000	34,667	10,400	6,242	283	743	10,700
WG-7000	7,000,000	5,600,000	37,333	11,200	6,723	296	798	11,500
WG-7500	7,500,000	6,000,000	40,000	12,000	7,203	312	867	12,200
WG-8000	8,000,000	6,400,000	42,600	12,805	7,683	318	896	12,500
WG-8500	8,500,000	6,800,000	45,333	13,605	8,163	325	923	12,800
WG-9000	9,000,000	7,200,000	48,000	14,405	8,643	335	965	13,300
WG-9500	9,500,000	7,600,000	50,800	15,205	9,123	342	1,005	13,800

*A.G.A. CERTIFIED

Boiler input is based on natural gas 1000 BTU/cf. Boiler ratings are based on 80% efficiency.

(1) Maximum heat exchanger capacity (if used), based on 200°F. boiler water.

NOTE: See Form AX-115 for Forced Draft Gas Fired Information.

When Heat Exchangers are used prefix becomes WGE.

EQUIPMENT SUBMITTED FOR APPROVAL

DATE:

BY:

"SERIES W" WATER HEATING BOILERS DIMENSION TABLE

5901 117

MODEL Water-Gas (See Note)	A Length	B Width	C Height	D Overall Height	E Vent-Stub Height	F Draft Hood Clearance	G Vent Diameter	H Vent Location	J Outlet Height	L Outlet Location	M Inlet Height	N Inlet & Outlet	P Gas Inlet	Q Tube Length
WG-100	31	23	45	65	10½	13	5	℄	2½	5	23	1½	¾	14
WG-150	35	23	45	65	10½	13	5		2½	5	23	1½	¾	18
WG-200	41	23	45	66	9½	13	6		2½	5	23	1½	¾	24
WG-250	47	23	45	67	9½	13	7		2½	5	23	1½	¾	30
WG-300	53	23	45	68	8	13	8		2½	5	23	1½	¾	36
WG-350	59	23	45	68	8	13	8		2½	5	23	1½	¾	42
WG-400	46	28	48	76	11½	17	9		2½	5	25½	1½	¾	28
WG-450	48	28	48	76	11½	17	9		2½	7	25½	1½	¾	30
WG-525	54	28	48	77	11½	17	10		2½	7	25½	1½	1	36
WG-600	60	28	48	77	11½	17	10		2½	7	25½	1½	1	42
WG-675	66	28	48	79	10	17	12		2½	7	25½	1½	1	48
WG-750	72	28	48	79	10	17	12		2½	7	25½	1½	1	54
WG-850	59	35	53	87	12½	20	12		5	7½	24½	3 fl.	1	38
WG-900	63	35	53	87	12½	20	12		5	7½	24½	3 fl.	1	42
WG-1050	66	35	53	89	11½	20	14		5	7½	24½	3 fl.	1¼	45
WG-1125	69	35	53	89	11½	20	14		5	7½	24½	3 fl.	1¼	48
WG-1250	75	35	53	91	9½	20	16		5	7½	24½	3 fl.	1¼	54
WG-1375	79	35	53	91	9½	20	16		5	7½	24½	3 fl.	1¼	58
WG-1500	84	35	53	91	9½	20	16		5	7½	24½	3 fl.	1¼	63
WG-1750	93	35	53	93	9½	20	18		5	7½	24½	3 fl.	1¼	72
WG-2000	79	45	61	101	8½	20	18		5	9	28	3 fl.	1½	54
WG-2250	85	45	61	103	8½	20	20		5	9	28	3 fl.	2	60
WG-2500	89	45	61	103	8½	20	20		5	9	28	3 fl.	2	64
WG-2750	95	45	61	99	7	20	2-16	18	5	9	28	3 fl.	2	70
WG-3000	101	45	61	99	7	20	2-16	19	5	9	28	3 fl.	2	76
WG-3250A	107	45	61	99	7	20	2-16	20	5	9	28	3 fl.	2	82
WG-3500	96	53	62	103	7	20	2-18	18	5	11	25	4 fl.	2	66
WG-3750	102	53	62	103	7	20	2-18	18	5	11	25	4 fl.	2½	72
WG-4000	106	53	62	103	7	20	2-18	18	5	11	25	4 fl.	2½	76
WG-4250	110	53	62	103	7	20	2-18	19	5	11	25	4 fl.	2½	80
WG-4500	114	53	62	105	7	20	2-20	21	5	11	25	4 fl.	2½	84
WG-4750	120	53	62	105	7	20	2-20	21	5	11	25	4 fl.	2½	90
WG-5000	124	53	62	105	7	20	2-20	22	5	11	25	4 fl.	2½	94
WG-5500A	122	70	70	109	7	20	2-20	22	5	10	32	6 fl.	2	88
WG-6000A	130	70	70	109	7	20	2-20	24	5	10	32	6 fl.	2	96
WG-6500	140	70	70	111	7	20	2-22	26	5	10	32	6 fl.	2	106
WG-7000	148	70	70	111	7	20	2-22	28	5	10	32	6 fl.	2	114
WG-7500	158	70	70	114	7	20	2-24	31	5	10	32	6 fl.	2	124
WG-8000	162	70	70	114	7	20	2-24	32	5	10	32	6 fl.	2	128
WG-8500	166	70	70	114	7	20	2-24	34	5	10	32	6 fl.	2	132
WG-9000	172	70	70	114	7	20	2-24	36	5	10	32	6 fl.	2	138
WG-9500	178	70	70	114	7	20	2-24	38	5	10	32	6 fl.	2	144

Roughing in dimensions only (in inches) — Wiring diagrams, and gas train schematics furnished upon request.

OUTSIDE AIR LOUVER
SELECTION

DESIGNED BY CLD

DATE 2/12/95

CHECKED BY

TJ

DATE 2/26/95

SIZE FOR 1000 FPM ACROSS FACE OF LOUVER

$$3417 \text{ CFM} / 1000 \text{ FPM} = 3.5 \text{ SQ FT}$$

LOUVER FREE AREA = 51.67% OF AREA

$$3.5 \text{ SQ FT} (144 \text{ SQ IN} / \text{SQ FT}) = 504 \text{ SQ IN}$$

$$\text{LOUVER SIZE} = (504) / (51.67\%) = 978 \text{ SQ IN}$$

USE 1-32" X 32" LOUVER

HOT WATER HEATING GPM
FOR Sys #1

DESIGNED BY CLQ DATE 2/12/95

CHECKED BY JT DATE 2/26/95

- GPM REQUIRED FOR PRE HEAT COIL.

$$BTUH = CFM (T_{LAT} - T_{EAT})(AF)$$

$$CFM = 3,417 ; T_{LAT} = 55^{\circ}F ; T_{EAT} = 5^{\circ}F ; AF = 0.821$$

$$BTUH = 3,417 CFM (55^{\circ}F - 5^{\circ}F)(0.821) = 140,268 BTUH$$

$$GPM = BTUH / ((T_{EWT} - T_{LWT})(500))$$

$$T_{EWT} = 180^{\circ}F ; T_{LWT} = 160^{\circ}F$$

$$GPM = (140,268 BTUH) / ((180^{\circ}F - 160^{\circ}F)(500)) = 14 GPM$$

- GPM REQUIRED FOR TERMINAL HEAT FOR Sys #1

$$BTUH = CFM (T_{LAT} - T_{EAT})(AF)$$

$$CFM = 22,782$$

$$T_{LAT} = 90^{\circ}F ; T_{EAT} = 55^{\circ}F$$

$$BTUH = (22,782)(90^{\circ}F - 55^{\circ}F)(0.821) = 654,641 BTUH$$

$$GPM = (654,641) / ((180^{\circ}F - 160^{\circ}F)(500)) = 65.5 GPM \approx 66 GPM$$

$$TOTAL GPM FOR Sys \#1 = 14 + 66 = \underline{\underline{80 GPM}}$$

HOT WATER HEATING GPM
FOR SYS# 3

DESIGNED BY C LQ

DATE 2/13/95

CHECKED BY

TJ

DATE 2/26/95

- GPM FOR PREHEAT COIL. FOR SYS# 3

$$BTUH = CFM (T_{LAT} - T_{ENT}) (AF)$$

$$CFM = 375 CFM; T_{LAT} = 55^{\circ}F; T_{ENT} = 5^{\circ}F; AF = 0.821$$

$$BTUH = 375 (55^{\circ}F - 5^{\circ}F) (0.821) = 15,394 BTUH$$

$$GPM = BTUH / ((T_{ENT} - T_{LWT}) (500))$$

$$T_{ENT} = 130^{\circ}F; T_{LWT} = 160^{\circ}F$$

$$GPM = (15,394 BTUH) / ((130^{\circ}F - 160^{\circ}F) (500)) = 1.6 GPM$$

- GPM REQUIRED FOR TERMINAL HEAT FOR SYS# 3

$$BTUH = CFM (T_{LAT} - T_{ENT}) (AF)$$

$$CFM = 2502 CFM; T_{LAT} = 90^{\circ}F; T_{ENT} = 55^{\circ}F$$

$$BTUH = (2502 (90^{\circ}F - 55^{\circ}F) (0.821)) = 71,895 BTUH$$

$$GPM = (71,895 / ((130^{\circ}F - 160^{\circ}F) (500))) = 7.2 GPM$$

$$TOTAL GPM FOR SYS# 3 = 1.6 + 7.2 = 8.8 GPM$$

$$\underline{\underline{9.0 GPM}}$$

HOT WATER HEATING GPM FOR
SYS # 2 & SYS # 4

DESIGNED BY CLP

DATE 2/13/9.

CHECKED BY TJ

DATE 2/26/95

GPM REQUIRED FOR UNIT HEATER. FOR SYS #2

BTUH = 13,131 (FROM TRACE 600)

$$GPM = (13,131 \text{ BTUH}) / ((180^\circ\text{F} - 160^\circ\text{F}) / (500)) \approx 2 \text{ GPM}$$

GPM REQUIRED FOR UNIT HEATER FOR SYS # 4

$$BTUH = (12,972 \text{ BTUH}) / ((180^\circ\text{F} - 160^\circ\text{F}) / (500)) \approx 2 \text{ GPM}$$

$$\text{TOTAL GPM FOR SYS \# 2 \& 4} = \underline{\underline{4 \text{ GPM}}}$$

HOT WATER HEATING GPM
SUMMARY

DESIGNED BY CLW DATE 2/13/91

CHECKED BY JT DATE 2/24/91

SYSTEM #1 = 80 GPM

SYSTEM #3 = 9 GPM

SYSTEM #2 & 4 = 4 GPM

93 GPM

JOB NMSF

DESCRIPTION: HOT WATER PUMP SELECTION

JOB # 41552-056

SHEET

DESIGNED: CLQ

CHECKED BY

DATE

DATE

15-May-95

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PHW-1, 2, & 3 GPM = 47 GAL/MIN

GATE VALVE ELBOW EQUIV.

0.5

			FRICTION (PER 100 FT)	QUANTITY	EQUIV LENGTH (ELBOW)	FT OF HEAD
			A	B	C	D
HEAD LOSS	1	PIPE	2.5	600.00		22.50
	2	GATE VALVE(S)		4.00	5.5	0.28
	3	THREE WAY VALVE		1.00		10.00
	4	COIL		1.00		8.00
	5	SUCTION DIFFUSER				1.6

SUBTOTAL 42.38

10% SF 4.24

TOTAL 46.61

PUMP SELECTION: MANUFACTURER: BELL & GOSSETT
SERIES: 1510
MODEL # 1-1/4AC
GPM: 47
PIPE SIZE:
PUMP SIDE 1-1/4"
SUCTION SIDE 1-1/2"
HP: 1-1/2 HP
RPM: 1750
EFF. 58%
QUANTITY: 3 (2-WORKING 1-STANDBY)

SUCTION DIFFUSER SELECTION:

MANUFACTURER: BELL & GOSSETT
MODEL No. DC-3
PIPE SIZE:
PUMP SIDE: 1-1/4"
SYSTEM SIDE: 2-1/2"

EQUATIONS

D1 = B1 * 1.5 * (A1/100)

D2 = B2 * C2 * 0.5 * (A1/100)

86 OF 117

1750 RPM PUMP CURVES

TRUCK LOADING AREA EXHAUST FAN

DESIGNED BY CLQ

DATE 2/7/95

FE-6

CHECKED BY TJ

DATE 2/26/95

GIVEN: 2530 SQ FT 21 FT HIGH CEILING

$$(2530)(21) = 53,130 \text{ ft}^3$$

REQUIRED VENTILATION = 4 AC/HR

$$(4 \text{ AC/HR})(53,130 \text{ ft}^3) / (60 \text{ min/HR}) = \underline{\underline{3542 \text{ CFM}}}$$

SELECT SIDEWALL EXHAUST FAN GREENHECK MODEL
No. GWB-1E 1HP @ 0.5" WG, 120V, 1PH, 60 HZ, 1200RPM,
17.6 SONE.

PERFORMANCE DATA - MODEL GW

68 OF 117

MODEL	RPM	TS	STATIC PRESSURE / CAPACITY									
			0.000	0.100	0.125	0.250	0.375	0.500	0.625	0.750		
			Sone BHP	Sone BHP	Sone BHP	Sone BHP	Sone BHP	Sone BHP	Sone BHP	Sone BHP	Sone BHP	Sone BHP
GW-60 1/60 HP	E 1050	2234	133	94	80							
	G 1300	2765	1.9 .006	1.7 .006	1.7 .007							
	D 1550	3297	1.65 .012	1.34 .012	1.26 .012							
GW-65 1/30 HP	E 1050	2234	180	126	109							
	G 1300	2765	2.2 .008	2.0 .009	2.0 .009							
	D 1550	3297	2.23 .015	1.81 .016	1.70 .017	128						
GW-70 1/30 HP	E 1050	2234	250	193	172							
	G 1300	2765	2.5 .007	1.7 .008	1.5 .008							
	D 1550	3297	3.09 .013	2.67 .015	2.55 .015	152						
GW-75 1/25 HP	E 1050	2234	287	210	188							
	G 1300	2765	3.3 .012	2.8 .012	2.7 .012							
	D 1550	3297	3.56 .023	2.94 .023	2.79 .024	185						
GW-80 1/20 HP	E 1050	2234	424	371	359							
	G 1300	2765	6.1 .039	5.5 .039	5.4 .039	291	204					
	D 1550	3297	3.25 .012	2.65 .014	2.48 .015	133						
GW-85 1/20 HP	E 1050	2234	403	355	343							
	G 1300	2765	5.4 .022	5.4 .025	5.4 .026	5.4 .031	5.4 .031					
	D 1550	3297	4.80 .037	4.41 .041	4.31 .042	376	315	236				
GW-90 1/15 HP	E 1050	2234	389	323	305							
	G 1300	2765	3.6 .012	3.7 .016	3.7 .017	3.8 .018						
	D 1550	3297	4.82 .024	4.30 .027	4.16 .029	340	235					
GW-95 1/8 HP	E 1050	2234	574	532	520							
	G 1300	2765	7.5 .040	7.4 .044	7.4 .046	7.4 .052	7.5 .058	7.6 .061	7.7 .051			
	D 1550	3297	5.50 .019	4.70 .023	4.50 .024	3.06 .027						
GW-100-B 1/12 HP	E 1050	2234	680	616	600							
	G 1300	2765	5.4 .035	5.4 .041	5.4 .042	5.5 .048	5.5 .052					
	D 1550	3297	8.11 .060	7.4 .066	7.4 .068	7.4 .076	7.4 .083	7.4 .088	7.4 .084			
GW-120-B 1/12 HP	E 1050	2234	711	603	569							
	G 1300	2765	4.9 .032	4.6 .036	4.6 .037	4.5 .037						
	D 1550	3297	8.80 .061	6.9 .066	6.8 .067	6.5 .072	6.4 .071	6.4 .054				
GW-130-B 1/8 HP	E 1050	2234	1049	983	964							
	G 1300	2765	9.6 .103	9.4 .109	9.4 .111	9.1 .117	8.2 .121	8.0 .121	8.0 .106			
	D 1550	3297	10.02 .05	8.98 .06	8.68 .06	6.6 .07	6.4 .07					
GW-140-B 1/6 HP	E 1050	2234	1195	1086	1056							
	G 1300	2765	7.7 .07	7.6 .08	7.6 .08	7.5 .09	7.8 .09					
	D 1550	3297	15.40 .11	14.26 .12	13.98 .13	12.43 .14	10.54 .14	8.30 .14	3.74 .10			
GW-150-B 1/4 HP	E 1050	2234	1823	1684	1650							
	G 1300	2765	10.1 .16	10.3 .18	10.3 .18	9.9 .19	9.3 .20	8.8 .20	9.0 .19			
	D 1550	3297	21.54 .22	20.34 .24	20.04 .25	18.46 .27	16.80 .28	14.84 .26	12.52 .28	8.80 .25		

Performance shown is for Model GW without ducts and birdscreen. BHP does not include belt and pulley losses. The sound ratings shown are loudness values in fan zones at 5 ft. (1.5m) in a hemispherical free field calculated per AMCA Standard 301. Values shown are for installation Type A: free inlet some levels. The AMCA Certified Ratings Sound Seal applies to some ratings only.

PERFORMANCE DATA - MODEL GWB

MODEL	HP	RPM	TS	STATIC PRESSURE / CAPACITY									
				0.000	0.125	0.250	0.375	0.500	0.625	0.750	1.000	1.250	
				Sone BHP	Sone BHP	Sone BHP	Sone BHP	Sone BHP	Sone BHP	Sone BHP	Sone BHP	Sone BHP	Sone BHP
GWB-14-4 1 Phase (744-1090)	1/4	1090	4173	1975	1877	1763							
				10.7 .22	10.8 .23	10.5 .24	10.2 .25	9.9 .25	9.7 .24				
				2174	2088	1987	1875	1749	1603	1410			
GWB-14 (1140-1200)	1/3	1200	4594	121 .29	12.0 .30	11.5 .32	11.5 .33	11.0 .33	11.0 .34	10.8 .33			
				2537	2485	2382	2292	2196	2092	1974	1675		
				15.2 .46	14.8 .48	14.1 .49	13.3 .51	13.0 .52	12.5 .53	12.1 .53	11.0 .52		
GWB-14-5 1 Phase (1042-1400)	1/2	1400	5360	2881	2817	2748	2674	2592	2508	2420	2213	1954	
				19.9 .68	19.0 .70	17.9 .71	17.7 .73	15.9 .74	14.4 .76	13.6 .77	12.6 .78	11.4 .77	
				2795	2596	2422	2115	1723					
GWB-18 (545-960)	1/4	740	3584	9.1 .22	8.3 .24	7.6 .25	6.7 .25	6.6 .24					
				3135	2954	2799	2575	2315	1948				
				11.4 .31	10.4 .33	9.7 .35	8.9 .36	8.3 .36	8.2 .34				
GWB-18-7 1 Phase (764-1070)	1/2	960	4649	3628	3466	3323	3197	2981	2755	2487			
				14.2 .48	13.7 .50	13.3 .52	13.1 .55	12.5 .55	12.0 .55	11.4 .54			
				4042	3898	3765	3645	3533	3316	3113	2613		
GWB-18 (1135-1480)	3/4	1070	5182	16.4 .66	16.3 .69	16.0 .72	15.9 .74	15.7 .77	15.2 .77	14.7 .77	13.6 .73		
				4533	4405	4281	4168	4066	3965	3778	3411	2954	
				18.8 .93	18.6 .97	18.3 1.00	18.0 1.02	17.6 1.05	17.3 1.08	16.7 1.08	16.1 1.08	14.8 1.04	
	1	1200	5811	5137	5024	4911	4809	4710	4620	4531	4229	3913	
				22.0 1.38	22.0 1.39	22.0 1.43	22.0 1.46	21.0 1.49	20.0 1.52	19.7 1.56	18.3 1.58	19.1 1.58	
				5591	5487	5383	5284	5193	5102	5021	4845	4521	
	1 1/2	1480	7168	26 1.75	25 1.79	25 1.83	25 1.87	24 1.90	23 1.93	22 1.97	21 2.03	23.2 2.04	

Performance shown is for Model GWB without ducts and birdscreen. BHP does not include belt and pulley losses. The sound ratings shown are loudness values in fan zones at 5 ft. (1.5m) in a hemispherical free field calculated per AMCA Standard 301. Values shown are for installation Type A: free inlet some levels. The AMCA Certified Ratings Sound Seal applies to some ratings only.

(M) (Motors Mounted - See Stock Note Page 13)

STOCK All models in stock.

Model GW & GWB

Model GW and GWB exhausters are designed for sidewall mounted applications where roof mounted exhausters may be too costly or impractical to install. These models feature a spun aluminum housing, an aluminum, non overloading centrifugal wheel and positive motor cooling. A removable mounting ring is provided for ease of installation. Model GW and GWB fans are licensed to bear the AMCA Certified Ratings Seals for air and sound performance and are U.L. Listed.

Stock Notes: -- Model GW

Motors are 115/60/1

All stocked GW units can be used with Model 5W speed control for variable performance requirements.

Models GW-60 thru GW-120 can be shipped by UPS.

Model GWB

Motors 1/4 HP are 115/60/1

1/2 HP are 115/208-230/60/1

(wired for 115 volts)

3/4 HP are 115/208-230/60/1

(wired for 208-230 volt)

Units are also stocked less motor and drive for maximum flexibility.

Model GWB is U.L. 762 Listed for restaurant applications and for operation with air temperatures up to 300°F.

*Note: 2 inches minimum. 5 inches when motorized damper is required.

Greenheck certifies that the GW and GWB models shown herein are licensed to bear the AMCA Seal. The ratings shown are based on tests and procedures performed in accordance with AMCA Publication 211 and AMCA Publication 311 and comply with the requirements of the AMCA Certified Ratings Program.

CONSTRUCTION FEATURES

- Removable mounting ring for ease of installation.
- Spun aluminum hood, aluminum wheel, and galvanized steel frame.
- Easily removable cover for access to motor.
- Disconnect switch (standard).
- Vibration isolation for entire motor and drive assembly.
- Thermal overload protection (Model GW)
- Motors located out of airstream and cooled by ambient air.
- Models GW-60 thru GW-95 are equipped with 3 speed motors, field wired for either 1050, 1300, or 1550 RPM

ACCESSORIES

- Speed controls. See Page 48.
- Backdraft damper, Model WD-323 gravity or motorized. See Page 36-37.
- Interior wall grille.

DIMENSIONAL DATA

Model	A	B	C	Wall Opening	Damper Size	Damper Frame Size	Mtg. Bolt Circle
GW 60-75	19 1/4"	13 1/2"	15 1/4"	9 1/2" x 9 1/2"	8 x 8	10 x 10	11 1/4"
GW 80-90	22 1/4"	13 3/8"	18 1/4"	11 1/2" x 11 1/2"	10 x 10	12 x 12	15"
GW 95		15 1/4"	18 1/4"				
GW 100-120	24 1/4"	17 13/16"	20 1/4"	13 1/2" x 13 1/2"	12 x 12	14 x 14	16 1/4"
GW 130-150	28 3/4"	19 1/4"	23 3/4"	15 1/2" x 15 1/2"	14 x 14	16 x 16	20"
GWB 14	28 3/4"	22"	23 3/4"	15 1/2" x 15 1/2"	14 x 14	16 x 16	20 1/4"
GWB 18	35 3/4"	26 1/4"	29 1/4"	19 1/2" x 19 1/2"	18 x 18	20 x 20	25 1/4"

UL Listed
MH11745 - GWB

CSA Listed
LR-34470

PENTHOUSE EXHAUST
FAN

DESIGNED BY CLQ

DATE 2/27/95

CHECKED BY JT

DATE 2/27/95

COMPRESSOR = 40 HP MOTOR

HVA-1 = 1-1/2 HP MOTOR.

COMPRESSOR MOTOR IN DRIVEN EQUIPMENT IN

114,000 BTUH (FROM ASHRAE FUNDAMENTALS
PAGE 26.10 TABLE 4)

HVA-1 MOTOR IN DRIVEN EQUIPMENT OUT

1140 BTUH

$$12,600 + 1140 = 13,740 \text{ BTUH}$$

ROOM NOT TO EXCEED 100°F

$$\Delta T = 100^\circ\text{F} - 89^\circ\text{F} = 11^\circ\text{F} = \Delta T$$

$$\text{CFM} = \text{BTUH} / (\text{AF})(\Delta T) =$$

$$\text{CFM} = 13,740 \text{ BTUH} / (0.821)(11) = 15,21 \text{ CFM}$$

SELECT SIDEWALL EXHAUST FAN GREENHEIL
MODEL No. GWB-14 1/3 HP @ 0.5" W4, 120 V,
1 PH, 60 HZ. 1200 RPM, 11.0 SONE.

PERFORMANCE DATA - MODEL GW

MODEL	RPM	TS	STATIC PRESSURE / CAPACITY											
			0.000	0.100	0.125	0.250	0.375	0.500	0.625	0.750	0.875	1.000	1.125	1.250
GW-60 1/60 HP	E	1050	2234	133	94	80								
	G	1300	2785	165	134	128								
	D	1550	3297	197	170	164	128							
GW-65 1/30 HP	E	1050	2234	180	126	109								
	G	1300	2785	223	181	170	97							
	D	1550	3297	266	231	222	172	95						
GW-70 1/30 HP	E	1050	2234	250	193	172								
	G	1300	2785	309	267	255	152							
	D	1550	3297	369	334	325	269	160						
GW-75 1/25 HP	E	1050	2234	287	210	188								
	G	1300	2785	356	294	279	185							
	D	1550	3297	424	371	359	291	204						
GW-80 1/20 HP	E	1050	2990	325	265	248	133							
	G	1300	3701	403	355	343	272	173						
	D	1550	4413	480	441	431	378	315	236					
GW-85 1/20 HP	E	1050	2990	389	323	305	182							
	G	1300	3701	482	430	416	340	235						
	D	1550	4413	574	532	520	482	395	313	161				
GW-90 1/15 HP	E	1050	2990	550	470	450	306							
	G	1300	3701	680	616	600	518	391						
	D	1550	4413	811	757	744	677	603	501	347				
GW-95 1/8 HP	E	1050	2990	711	603	569	381							
	G	1300	3701	880	797	773	641	494	200					
	D	1550	4413	1049	983	964	881	746	616	443				
GW-100-B 1/12 HP	1140	3488		1002	888	868	697	487						
GW-120-B 1/12 HP	1140	3712		1195	1088	1056	884	659						
GW-130-B 1/8 HP	1140	4160		1540	1426	1398	1243	1054	830	374				
GW-140-B 1/8 HP	1140	4365		1823	1684	1650	1485	1298	1090	786				
GW-150-B 1/4 HP	1140	4775		2154	2034	2004	1846	1680	1484	1252	880			

Performance shown is for Model GW without ducts and birdscreen. BHP does not include belt and pulley losses. The sound ratings shown are loudness values in fan sones at 5 ft. (1.5m) in a hemispherical free field calculated per AMCA Standard 301. Values shown are for installation Type A: free inlet sone levels. The AMCA Certified Ratings Sound Seal applies to sone ratings only.

PERFORMANCE DATA - MODEL GWB

MODEL	HP	RPM	TS	STATIC PRESSURE CAPACITY											
				0.000	0.125	0.250	0.375	0.500	0.625	0.750	1.000	1.250	1.500	1.750	2.000
GWB-14-4 1 Phase (744-1000)	1/4	1090	4173	1975	1877	1783	1633	1476	1269						
	1/3	1200	4594	2174	2088	1987	1875	1749	1603	1410					
	1/2	1400	5360	2537	2485	2382	2292	2196	2092	1974	1675				
GWB-14-5 1 Phase (1042-1400)	1/2	1400	5360	15.2	0.46	14.8	0.48	14.1	0.49	13.3	0.51	13.0	0.52	12.5	0.53
	3/4	1590	6087	2881	2817	2748	2674	2592	2508	2420	2213	1954			
	1/4	740	3584	2795	2586	2422	2115	1723							
GWB-18 (545-960)	1/3	830	4019	9.1	0.22	8.3	0.24	7.6	0.25	6.7	0.25	6.6	0.24		
	1/2	960	4649	3135	2954	2799	2575	2315	1948						
	3/4	1070	5182	11.4	0.31	10.4	0.33	9.7	0.35	8.9	0.36	8.3	0.36	8.2	0.34
GWB-18-7 1 Phase (764-1070)	1/2	1400	5360	3626	3486	3323	3197	2981	2755	2487					
	3/4	1590	6087	4042	3888	3785	3645	3533	3316	3113	2613				
	1	1200	5811	16.4	0.68	16.3	0.69	16.0	0.72	15.9	0.74	15.7	0.77	15.2	0.77
WB-18 35-1480)	1	1200	5811	4533	4405	4281	4168	4066	3965	3778	3411	2954			
	1 1/2	1360	6586	18.8	1.03	18.6	1.07	18.3	1.10	18.0	1.12	17.6	1.15	17.3	1.18
	2	1480	7168	5137	5024	4911	4809	4710	4620	4531	4429	4313	4229	4133	4043

Performance shown is for Model GWB without ducts and birdscreen. BHP does not include belt and pulley losses. The sound ratings shown are loudness values in fan sones at 5 ft. (1.5m) in a hemispherical free field calculated per AMCA Standard 301. Values shown are for installation Type A: free inlet sone levels. The AMCA Certified Ratings Sound Seal applies to sone ratings only.

(M) (Motors Mounted - See Stock Note Page 13)

STOCK All models in stock.

TRUCK LOADING AREA UNIT HEATER.

SELECTION SYS # 4

HLW-2

DESIGNED BY CLW DATE 2/13/95

CHECKED BY TJ DATE 2/26/95

REQUIRED GPM = 2 GPM (SEE SHEET 73 OF 117)

EQUIPMENT SELECTION:

MANUFACTURER: RENZOR

MODEL# 36ER10

WATER TEMP DROP = 20°F

BTU/HR = 25,300 BTU/HR

GPM = 2.5

PRESSURE DROP = 0.12 FT OF H₂O

CFM 490 CFM

MOTOR HP = 9 WATT

RPM = 1450

HORIZONTAL DELIVERY TYPE

"T": Models ER8, 9, 10, 12, 14, & 16, two $\frac{3}{8}$ inch nuts for $\frac{3}{8}$ -16 N.C. hanger rods. Models ER18, 22, & 24, 26 two $\frac{1}{2}$ inch nuts for $\frac{1}{2}$ -13 N.C. hanger rods.

"O": Supply & return connections on opposite ends of units on models 19ER9, 28ER9, 39ER12, 56ER12, 66ER12, 63ER16, 98ER16, 163ER24, 256ER24, & 286ER24. All other ER model connections on left side only.

Horizontal models 12ER8 thru 158ER18 inclusive feature motors mounted on sturdy wire fan guards. Horizontal models 198ER22 and larger as well as all vertical & "Dyna-Jet" heaters are equipped with base mounted motors.

model	A	B	C	D	E	F	G	J	K	M	O†	shipping wt. (approx.) lbs.
12ER8	12	6	11	10	2	$\frac{5}{8}$	$10\frac{3}{4}$	$2\frac{3}{8}$	$2\frac{3}{4}$	3	1	14
19ER9	16	$7\frac{1}{8}$	$13\frac{9}{16}$	$13\frac{3}{8}$	$2\frac{1}{4}$	$3\frac{3}{8}$	$9\frac{1}{4}$	$2\frac{1}{4}$	4	$2\frac{1}{4}$	$1\frac{1}{2}$	28
28ER9												
36ER10	18	$8\frac{1}{8}$	$15\frac{9}{16}$	$14\frac{1}{2}$	$2\frac{3}{4}$	$3\frac{3}{8}$	$11\frac{1}{4}$	$2\frac{1}{4}$	4	$2\frac{1}{4}$	$1\frac{1}{2}$	34
44ER10												
39ER12	20	$8\frac{1}{8}$	$17\frac{9}{16}$	$14\frac{1}{2}$	$2\frac{3}{4}$	$3\frac{3}{8}$	$13\frac{1}{4}$	$2\frac{1}{4}$	4	$2\frac{1}{4}$	$1\frac{1}{2}$	45
56ER12				$14\frac{1}{2}$								45
66ER12				$15\frac{3}{8}$								50
51ER14	22	$8\frac{1}{8}$	$19\frac{9}{16}$	16	$2\frac{3}{4}$	$3\frac{3}{8}$	$15\frac{1}{4}$	$2\frac{1}{4}$	4	$2\frac{1}{4}$	$1\frac{1}{2}$	54
88ER14												54
63ER16	24	$10\frac{1}{8}$	$21\frac{9}{16}$	$18\frac{1}{4}$	$2\frac{3}{4}$	$3\frac{3}{8}$	$17\frac{1}{4}$	$2\frac{1}{4}$	4	$2\frac{1}{4}$	$1\frac{1}{2}$	70
98ER16												72
85ER18	26	$10\frac{1}{8}$	$23\frac{9}{16}$	$18\frac{3}{4}$	$2\frac{3}{4}$	$3\frac{3}{8}$	19	$2\frac{1}{4}$	4	$2\frac{1}{4}$	$1\frac{1}{2}$	77
134ER18												80
158ER18												80
107ER22	31	$12\frac{1}{8}$	$27\frac{9}{16}$	$20\frac{3}{8}$	$2\frac{3}{4}$	$3\frac{7}{8}$	23	$2\frac{3}{4}$	$4\frac{1}{2}$	$5\frac{1}{4}$	2	130
198ER22				$23\frac{3}{4}$								140
163ER24	35	$12\frac{1}{8}$	$31\frac{9}{16}$	$23\frac{1}{2}$	$2\frac{3}{4}$	$3\frac{7}{8}$	27	$2\frac{3}{4}$	$4\frac{1}{2}$	$5\frac{1}{4}$	2	154
256ER24			$31\frac{9}{16}$	$26\frac{1}{8}$								168
286ER24			$31\frac{9}{16}$	$26\frac{1}{8}$								168
326ER24			$35\frac{9}{16}$	$26\frac{1}{8}$								188
364ER24			$35\frac{9}{16}$	$26\frac{1}{8}$								230
404ER26			$35\frac{9}{16}$	$26\frac{1}{8}$								230

aries with motor characteristics.
ominal pipe size of supply & return.

horizontal delivery type with standard heating element (double coil)
at 200° F entering water temperature, 60°F entering air temperature

Model	Water Temp Drop	BTU/HR	Exit Air Temp.	Water Flow GPM	Pressure Drop Ft of Water	CFM Vol @ 70°F	CPM @ Exit Air Temp	Outlet Velocity FPM	Motor HP	Motor RPM	Type of Motor	Amp Range	Sound Classification
12ER8	10	10,400	90	2.1	.09		332	767	5 WATT	1450	SP	.40 to .70 115	II
	20	9,000	86	.9	.02	320	330	762					
	30	8,100	83	.5	.01		328	758					
28ER9	10	22,300	111	4.5	.27		431	637	6 WATT	1450	SP	.50 to .70 115	II
	20	19,400	105	1.9	.06	400	426	630					
	30	17,500	101	1.2	.03		423	625					
36ER10	10	29,100	115	5.8	.50		532	546	9 WATT	1450	SP	.60 to 1.0 115	II
	20	25,300	108	2.5	.12	490	525	538					
	30	22,800	103	1.5	.05		521	534					
44ER10	10	34,600	110	6.9	.65		688	706	40 MHP	1550	SP	1.0 to 2.0 115	II
	20	30,100	104	3.0	.16	640	681	698					
	30	27,100	99	1.8	.07		675	692					
56ER12	10	45,400	107	9.1	1.11		963	726	40 MHP	1550	SP	1.0 to 2.0 115	II
	20	39,500	101	4.0	.28	900	953	719					
	30	35,600	97	2.4	.12		946	713					
66ER12	10	54,300	102	10.9	1.80		1,272	959	1/12	1550	SP	2.0 to 3.0 115	III
	20	47,200	96	4.7	.30	1,200	1,259	949					
	30	42,500	93	2.8	.13		1,252	944					
88ER14	10	72,600	106	14.6	3.01		1,548	892	1/12	1550	SP	2.0 to 3.0 115	III
	20	63,100	100	6.3	.84	1,450	1,532	883					
	30	56,800	96	3.8	.38		1,521	876					
98ER16	10	82,100	102	16.5	4.80		1,909	870	1/10	1050	SP	.30 to 4.0 115	II
	20	71,400	97	7.2	1.40	1,800	1,892	862					
	30	64,300	93	4.3	.58		1,878	856					
134ER18	10	112,700	103	22.6	9.50		2,549	940	1/4	1140	PSC	4.0 to 4.5 115	III
	20	98,000	98	9.8	2.60	2,400	2,531	934					
	30	88,200	94	5.9	1.20		2,527	932					
158ER18	10	149,400	109	30.0	16.00		3,006	1,109	1/4	1140	PSC	4.0 to 4.5 115	III
	20	129,900	103	13.0	4.20	2,800	2,927	1,080					
	30	116,900	99	7.8	1.90		2,953	1,089					
198ER22	10	160,800	99	32.3	3.90		4,008	1,028	1/3	1140	PSC	4.5 to 5.5 115	IV
	20	139,800	94	14.0	.95	3,800	3,972	1,018					
	30	125,800	91	8.4	.42		3,951	1,013					
256ER24	10	226,800	109	45.5	8.10		4,616	870	1/2	1140	PSC	6.5 to 7.5 115	IV
	20	197,200	102	19.8	2.30	4,300	4,560	860					
	30	177,500	98	11.9	.98		4,527	854					
286ER24	10	247,000	109	49.6	9.54		5,046	951	1/2	1140	PSC	6.5 to 7.5 115	IV
	20	214,800	102	21.6	2.40	4,700	4,984	940					
	30	193,300	98	12.9	1.05		4,948	933					
326ER24	10	266,100	110	53.4	10.05		5,270	994	1/2	1140	PSC	6.5 to 7.5 115	IV
	20	231,400	104	23.2	2.60	4,900	5,214	983					
	30	208,300	99	13.9	1.20		5,168	974					
364ER24	10	314,000	117	63.1	10.44		5,552	1,047	3/4	1140	PSC	10.0 to 11.0 115	IV
	20	273,000	110	27.4	3.81	5,100	5,475	1,032					
	30	245,700	105	16.4	1.50		5,437	1,025					
404ER26	10	348,500	111	70.0	16.00		6,787	1,280	1	1140	3PH	3.5 to 4.5 230	IV
	20	303,000	105	30.4	4.40	6,100	6,716	1,266					
	30	272,700	100	18.3	1.85		6,657	1,255					

**ICF KAISER
ENGINEERS**

JOB No. 41552-056

SHEET 75 OF 117

COLD MECH ROOM UNIT HEATER
SELECTION SYS # 2
HLW - 1

DESIGNED BY CLB DATE 2/13/95
CHECKED BY TJT DATE 2/26/95

REQUIRED GPM (SEE SHEET 73 OF 117) = 2 GPM

EQUIPMENT SELECTION:

MANUFACTURER: KENZOR

MODEL # 36 ER10

WATER TEMP DROP = 20°F

BTU/HR = 25,300 BTU/HR

GPM = 2.5

PRESSURE DROP = 0.12 FT OF H₂O

CFM 490 CFM

MOTOR HP = 9 WATT

RPM = 1450.

HORIZONTAL DELIVERY TYPE

"T": Models ER8, 9, 10, 12, 14, & 16, two $\frac{3}{8}$ inch nuts for $\frac{3}{8}$ -16 N.C. hanger rods. Models ER18, 22, & 24, 26 two $\frac{1}{2}$ inch nuts for $\frac{1}{2}$ -13 N.C. hanger rods.

"O": Supply & return connections on opposite ends of units on models 19ER9, 28ER9, 39ER12, 56ER12, 66ER12, 63ER16, 98ER16, 163ER24, 256ER24, & 286ER24. All other ER model connections on left side only.

Horizontal models 12ER8 thru 158ER18 inclusive feature motors mounted on sturdy wire fan guards. Horizontal models 198ER22 and larger as well as all vertical & "Dyna-Jet" heaters are equipped with base mounted motors.

Model	A	B	C	D	E	F	G	J	K	M	O†	Shipping wt. (approx.) lbs.
12ER8	12	6	11	10	2	$\frac{5}{8}$	10 $\frac{3}{4}$	2 $\frac{3}{8}$	2 $\frac{3}{4}$	3	1	14
19ER9 28ER9	16	7 $\frac{1}{8}$	13 $\frac{9}{16}$	13 $\frac{3}{8}$	2 $\frac{3}{4}$	3 $\frac{3}{8}$	9 $\frac{1}{4}$	2 $\frac{1}{4}$	4	2 $\frac{1}{4}$	1 $\frac{1}{2}$	28
36ER10 44ER10	18	8 $\frac{1}{8}$	15 $\frac{9}{16}$	14 $\frac{1}{2}$	2 $\frac{3}{4}$	3 $\frac{3}{8}$	11 $\frac{1}{4}$	2 $\frac{1}{4}$	4	2 $\frac{1}{4}$	1 $\frac{1}{2}$	34
39ER12				14 $\frac{1}{2}$								45
56ER12	20	8 $\frac{1}{8}$	17 $\frac{9}{16}$	14 $\frac{1}{2}$	2 $\frac{3}{4}$	3 $\frac{3}{8}$	13 $\frac{1}{4}$	2 $\frac{1}{4}$	4	2 $\frac{1}{4}$	1 $\frac{1}{2}$	45
66ER12				15 $\frac{3}{8}$								50
51ER14 88ER14	22	8 $\frac{1}{8}$	19 $\frac{9}{16}$	16	2 $\frac{3}{4}$	3 $\frac{3}{8}$	15 $\frac{1}{4}$	2 $\frac{1}{4}$	4	2 $\frac{1}{4}$	1 $\frac{1}{2}$	54
63ER16 98ER16	24	10 $\frac{1}{8}$	21 $\frac{9}{16}$	18 $\frac{1}{4}$	2 $\frac{3}{4}$	3 $\frac{3}{8}$	17 $\frac{1}{4}$	2 $\frac{1}{4}$	4	2 $\frac{1}{4}$	1 $\frac{1}{2}$	70
85ER18												77
134ER18 158ER18	26	10 $\frac{1}{8}$	23 $\frac{9}{16}$	18 $\frac{3}{4}$	2 $\frac{3}{4}$	3 $\frac{3}{8}$	19	2 $\frac{1}{4}$	4	2 $\frac{1}{4}$	1 $\frac{1}{2}$	80
107ER22 198ER22	31	12 $\frac{1}{8}$	27 $\frac{9}{16}$	20 $\frac{3}{8}$ 23 $\frac{1}{4}$	2 $\frac{3}{4}$	3 $\frac{7}{8}$	23	2 $\frac{3}{4}$	4 $\frac{1}{2}$	5 $\frac{1}{4}$	2	130
163ER24			31 $\frac{9}{16}$	23 $\frac{1}{2}$								154
256ER24			31 $\frac{9}{16}$	26 $\frac{1}{8}$								168
286ER24	35	12 $\frac{1}{8}$	31 $\frac{9}{16}$	26 $\frac{1}{8}$	2 $\frac{3}{4}$	3 $\frac{7}{8}$	27	2 $\frac{3}{4}$	4 $\frac{1}{2}$	5 $\frac{1}{4}$	2	168
326ER24			35 $\frac{9}{16}$	26 $\frac{1}{8}$								188
364ER24			35 $\frac{9}{16}$	26 $\frac{1}{8}$								230
404ER26			35 $\frac{9}{16}$	26 $\frac{1}{8}$								230

with motor characteristics.
all pipe size of supply & return.

77 012 117

Horizontal delivery type with standard heating element (double coil)

at 200° F entering water temperature, 60°F entering air temperature

Model	Water Temp Drop	BTU/HR	Exit Air Temp	Water Flow GPM	Pressure Drop Ft of Water	CFM Vol at 70°F	CPM at Exit Air Temp	Outlet Velocity FPM	Motor HP	Motor RPM	Type of Motor	Amp Range	Sound Class Location
12ER8	10	10,400	90	2.1	.09		332	767	5 WATT	1450	SP	.40 to .70 115	II
	20	9,000	86	.9	.02	320	330	762					
	30	8,100	83	.5	.01		328	758					
28ER9	10	22,300	111	4.5	.27		431	637	6 WATT	1450	SP	.50 to .70 115	II
	20	19,400	105	1.9	.06	400	426	630					
	30	17,500	101	1.2	.03		423	625					
36ER10	10	29,100	115	5.8	.50		532	546	9 WATT	1450	SP	.60 to 1.0 115	II
	20	25,300	108	2.5	.12	490	525	538					
	30	22,800	103	1.5	.05		521	534					
44ER10	10	34,600	110	6.9	.65		688	706	40 MHP	1550	SP	1.0 to 2.0 115	II
	20	30,100	104	3.0	.16	640	681	698					
	30	27,100	99	1.8	.07		675	692					
56ER12	10	45,400	107	9.1	1.11		963	726	40 MHP	1550	SP	1.0 to 2.0 115	II
	20	39,500	101	4.0	.28	900	953	719					
	30	35,600	97	2.4	.12		946	713					
66ER12	10	54,300	102	10.9	1.80		1,272	959	1/12	1550	SP	2.0 to 3.0 115	III
	20	47,200	96	4.7	.30	1,200	1,259	949					
	30	42,500	93	2.8	.13		1,252	944					
88ER14	10	72,600	106	14.6	3.01		1,548	892	1/12	1550	SP	2.0 to 3.0 115	III
	20	63,100	100	6.3	.84	1,450	1,532	883					
	30	56,800	96	3.8	.38		1,521	876					
98ER16	10	82,100	102	16.5	4.80		1,909	870	1/10	1050	SP	.30 to 4.0 115	II
	20	71,400	97	7.2	1.40	1,800	1,892	862					
	30	64,300	93	4.3	.58		1,878	856					
134ER18	10	112,700	103	22.6	9.50		2,549	940	1/4	1140	PSC	4.0 to 4.5 115	III
	20	98,000	98	9.8	2.60	2,400	2,531	934					
	30	88,200	94	5.9	1.20		2,527	932					
158ER18	10	149,400	109	30.0	16.00		3,006	1,109	1/4	1140	PSC	4.0 to 4.5 115	III
	20	129,900	103	13.0	4.20	2,800	2,927	1,080					
	30	116,900	99	7.8	1.90		2,953	1,089					
198ER22	10	160,800	99	32.3	3.90		4,008	1,028	1/3	1140	PSC	4.5 to 5.5 115	IV
	20	139,800	94	14.0	.95	3,800	3,972	1,018					
	30	125,800	91	8.4	.42		3,951	1,013					
256ER24	10	226,800	109	45.5	8.10		4,616	870	1/2	1140	PSC	6.5 to 7.5 115	IV
	20	197,200	102	19.8	2.30	4,300	4,560	860					
	30	177,500	98	11.9	.98		4,527	854					
286ER24	10	247,000	109	49.6	9.54		5,046	951	1/2	1140	PSC	6.5 to 7.5 115	IV
	20	214,800	102	21.6	2.40	4,700	4,984	940					
	30	193,300	98	12.9	1.05		4,948	933					
326ER24	10	266,100	110	53.4	10.05		5,270	994	1/2	1140	PSC	6.5 to 7.5 115	IV
	20	231,400	104	23.2	2.60	4,900	5,214	983					
	30	208,300	99	13.9	1.20		5,168	974					
364ER24	10	314,000	117	63.1	10.44		5,552	1,047	3/4	1140	PSC	10.0 to 11.0 115	IV
	20	273,000	110	27.4	3.81	5,100	5,475	1,032					
	30	245,700	105	16.4	1.50		5,437	1,025					
404ER26	10	348,500	111	70.0	16.00		6,787	1,280	1	1140	3PH	3.5 to 4.5 230	IV
	20	303,000	105	30.4	4.40	6,100	6,716	1,266					
	30	272,700	100	18.3	1.85		6,657	1,255					

WATER HEATER SELECTION

DESIGNED BY LLC

DATE 7/7/95

HUW-1

CHECKED BY TJJ

DATE 2/26/05

HOT WATER DEMAND PER FIXTURE (GAL OF WATER / HR / FIXTURE)

9 - LAVATORIES X 2 gph = 18 gph

5 - SHOWERS X 150 gph = 750 gph

1 - KITCHEN SINK X 20 gph = 20 gph

POSSIBLE MAXIMUM DEMAND = 788 gph

PROBABLE MAXIMUM DEMAND = $788 \times (1.3)$ (FROM ASHRAE EQUIPMENT 1991 Pg 44, 14 TABLE 8.)

HEATER CAPACITY = 236 gph

STORAGE TANK CAPACITY = $(236 \text{ gph}) / (1.25) = 295 \text{ GAL}$

SELECTION

MANUFACTURER: A. O. SMITH.

MODEL #: BC-300

INPUT RATING = 300,000 BTU/H

TEMP RISE $\Delta T = 90^\circ \text{F}$

gal/hr = 303 gph

gal/min = 5.1 gpm

PROVIDE WITH CIRCULATING
PUMP

VACUUM PUMP SELECTION

DESIGNED BY CLP

DATE 2/16/95

CHECKED BY TJ

DATE 2/24/95

CFM REQUIRED;

VACUUM PUMPS ARE USED
FOR THE CONTINUOUS AIR MONITORS (CAMs)
AND THE (FAS) FIXED AIR SAMPLERS
A TOTAL OF 50 FAS AND 40 CAMs ARE
ANTICIPATED (FROM F&OR). DESIGN FOR
25-30% EXCESS CAPACITY

ASSUME 2 CFM / CAM OR FAS

50 FAS + 40 CAMS = 90 TOTAL

$(90)(2 \text{ CFM}) = 180 \text{ SCFM}$

$(180)(30\%) = \underline{234 \text{ SCFM}}$

HEAD LOSS

PIPE & FITTING LOSS

80"

CAM OR FAS LOSS

69"

149" H₂O

$(149" \text{ H}_2\text{O}) / (0.07355" \text{ H}_2\text{O} / \text{ft}) = 10.9" \text{ H}_2\text{O}$

USE 11" H₂O

SELECTION:

MANUFACTURE: INTER VAC

MODEL #: C50-500-15-1A

QTY: 2

PRICE: \$23,000 EA.

HP 5 HP

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CSO System Performance Data

System Model Chart

SYNseal System Schematic

Single Stage Pump Units

SYSTEM MODEL	NOM. CAP. ACFM	HP	MAX. END VACUUM	PUMP MODEL
CSO 015/1	15	1.5	26"HG	PLT 3103
CSO 035/1	35	3	26"HG	PLT 3106
CSO 075/1	75	5	26"HG	TRS 40-100
CSO 100/1V	100	7.5	29"HG	TRV 40-150
CSO 150/1V	155	10	29"HG	TRV 50-220
CSO 200/1V	200	15	29"HG	TRV 65-300
CSO 300/1V	300	20	29"HG	TRV 65-450
CSO 400/1	380	25	27"HG	TRS 100-550
CSO 500/1	500	30	27"HG	TRS 100-700
CSO 700/1	700	50	26"HG	PLM 72/5C
CSO 1000/1	950	60	26"HG	PLM 73/5C

Two Stage Pump Units

SYSTEM MODEL	NOM. CAP. ACFM	HP	MAX. END VACUUM	PUMP MODEL
CSO 015/2	15	2	29"HG	PLT 3203
CSO 035/2	32	3	29"HG	PLT 3206
CSO 075/2	75	7.5	29.5"HG	TRH 40-110
CSO 100/2	100	7.5	29.5"HG	TRH 40-140
CSO 140/2	130	10	29.5"HG	TRH 40-190
CSO 200/2	200	15	29.5"HG	PL 51/2C
CSO 250/2	250	20	29.5"HG	PL 52/2C
CSO 300/2	290	25	29.5"HG	PL 53/2C/F
CSO 375/2	375	30	29.5"HG	TRH 80-600/1600
CSO 475/2	475	40	29.5"HG	TRH 80-750/1600
CSO 650/2	650	40	29.5"HG	PL 72/880
CSO 750/2	750	50	29.5"HG	PL 72/950
CSO 1000/2	950	60	29.5"HG	PL 73/950

* PUMPS ARE BELT-DRIVEN

CONSULT FACTORY FOR WEIGHTS AND DIMENSIONS

1. VACUUM PUMP
2. SEPARATOR/RESERVOIR
3. SEPARATOR ELEMENT
4. SIGHT GAUGE
5. DRAIN VALVE
6. FILTER
7. OIL CIRCULATING PUMP (OPTIONAL)
8. HEAT EXCHANGER (AIR OR H₂O COOLED)
9. TEMPERATURE GAUGE
10. VACUUM GAUGE
11. CHECK VALVE
12. FLEXIBLE CONNECTOR (OPTIONAL)
13. STARTER
- TS. TEMPERATURE SWITCH
- VS. VACUUM SWITCH

INTERVAC
Vacuum System Specialists

125 Rawson Road
Victor, NY USA 14564
716-824-7080
716-824-5697 fax
1-800-433-8487

1215 East U.S. Highway 12
Michigan City, IN USA 46360
219-874-6572
219-874-5513 fax
1-800-462-7411

Triplex Vacuum System for vacuum plastic moldings.

Stacked Triplex SYNseal System with 200 gallon vacuum receiver for hospital industry.

CSO-100 System used in vacuum chucking in the aircraft industry, furniture and high-tech manufacturing.

Synseal at a Glance

Features and Advantages

• Proven, reliable, and easy to maintain
• Proven, reliable, and easy to maintain

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Optional Accessories

• Proven, reliable, and easy to maintain
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SYNseal Applications

• Proven, reliable, and easy to maintain
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INTERVAC'S AIR COOLED
SYNSEAL LIQUID RING
VACUUM SYSTEMS
OPERATE WITHOUT WATER
IN A WIDE VARIETY OF
APPLICATIONS.

SYNSEAL SYSTEMS USE
SPECIFICALLY DEVELOPED,
REASONABLY PRICED,
SYNTHETIC FLUIDS AS
SEALANTS. A
CONTINUOUS FLOW OF
COOL, CLEAN WATER IS
UNNECESSARY.
CORROSION AND
SCALING ARE NEVER A
PROBLEM, DAMAGE FROM
CAVITATION IS REDUCED;
MAINTENANCE COSTS
ARE THE LOWEST IN THE
INDUSTRY.

SYNSEAL systems are versatile

SYNSEAL systems can be designed to meet virtually every vacuum requirement, from very complex applications to very simple.

Intervac's application engineers will design a system to meet your specific process needs. Our standard SYNSEAL systems are compact and very easy to operate. Should you require a custom package to meet specific vacuum needs, our engineering staff will design the equipment in a timely fashion using our network of AUTO-CAD Systems.

Every SYNSEAL system uses iron constructed liquid ring vacuum pumps, but you can specify 316 Stainless, 316 L Stainless or Bronze materials of construction when necessary.

Optional accessories such as inlet filters, vacuum relief valve, and special electrical controls are available. If a vacuum level below 10 torr is required, a rotary lobe blower can be added, allowing .5 torr operation.

SYNSEAL systems are dependable

SYNSEAL offers the high reliability of a liquid ring vacuum pump without many of the common disadvantages associated with water sealed systems or rotary vane and reciprocating type pumps. Damage resulting from foreign soft solids or liquids entering our pump is minimal, or nonexistent.

Standard SYNSEAL systems use an air cooled heat exchanger virtually eliminating the need for water. A variety of water cooling options are available where excessive ambient temperatures exist.

The proprietary seal fluids are never used as lubricants for bearings or other moving parts. The bearings are external to the pumping chamber and are easily changed out when necessary without disassembly of the pump. Our seal fluids operate at high temperatures (180° F) and will boil off many condensed fluids pulled over into the pump during operation. The higher temperatures also prevent bacteria growth within the system.

SYNSEAL systems reduce toxic emissions

Intervac systems contain the sealants in a closed loop. Pollutants and toxic gas emissions are minimized through the use of a highly efficient separation design that reduces the release of sealant aerosols into the atmosphere (less than 5 ppm).

SYNSEAL systems are complete

SYNSEAL systems are the most reliable, rugged vacuum systems manufactured anywhere in the world. Every SYNSEAL system is fully assembled, pre-piped, skid mounted and factory tested, ready for installation. All SYNSEAL systems are backed by Intervac's five-year pump warranty, the best in the business.

Our Worldwide Response Network of sales and application engineering and service personnel is ready to respond to any situation in less than a day.

Why You Should Choose an Intervac SYNseal™ System

When most people think of liquid ring, they think of a pump sealed with water. Indeed, one of the biggest criticisms of liquid ring pumps is that they require vast amounts of cool (less than 60° F) water in order to pull and maintain the desired level of vacuum.

One way that many liquid ring manufacturers have tried to combat this excessive water use is to develop vacuum packages that recirculate the seal water. These systems are designated as either partial or full recovery.

Partial recovery systems can reduce the amount of water used by up to 70%. The quantity of water that is not recirculated is "made up" by the primary water source. However, the amount of water that can be saved by utilizing a partial recovery system is dependent on the temperature of the make up water. The higher the temperature of the make up water, the lower the water savings.

Full recovery systems recirculate 100% of the water used to seal the pump. Some external water is still required to make up for water lost to evaporation. This closed-loop system does reduce the total amount of water required to run the system, but does not eliminate the need for cool water. This is because in a full recovery water sealed system, water is not only required as a seal fluid, but as a cooling source as well.

In a liquid ring pump, the heat of compression is dispelled into the liquid ring which, in this case, is made up of water. As the temperature of the seal water increases, so does its vapor pressure. As a result of the higher vapor pressure, the capacity of the pump is effectively decreased. Therefore, it is necessary to cool the seal fluid. The only practical way to accomplish this is to use a shell and tube style heat exchanger that uses water (either from a mechanical chiller or a cooling tower) as its cooling source.

Another common criticism of liquid ring pumps that are sealed on water is that they are limited in how deep a vacuum they can pull. As a general rule of thumb, liquid ring pumps can attain a level of vacuum equal to 2 times the vapor pressure of the seal fluid. As was mentioned above, the vapor pressure of water changes dramatically as its temperature increases.

For example, if the seal water is at 60° F, the vapor pressure is 13 torr. Using our rule of thumb, the ultimate vacuum that could be attained is approximately 26 torr (28.9 " HgV). At 70° F seal water temperature, the ultimate vacuum changes to 38 torr (28.5 " HgV). Using 80° F seal water, the maximum attainable vacuum is 53 torr (27.6 " HgV).

The temperature of the seal fluid not only affects the maximum level of attainable vacuum, but it also adversely affects capacity. In the example cited above, there would be a capacity loss of approximately 15% in going from 60° F seal water to 80° F temperature seal water.

Capacity losses due to high temperature seal water can be overcome by using a larger vacuum pump, but this increases the required horsepower and, in turn, the cost of operation.

The last negative associated with using water as a seal fluid is that the performance of the pump is limited by the quality of the seal water. Scale build up or mineral plating inside the pump adversely affect the pumps performance and accelerate maintenance schedules.

What Intervac has developed in order to overcome the problems associated with using water as a seal fluid is the SYNseal package. It is a closed loop system that utilizes a low vapor pressure synthetic hydrocarbon as a seal fluid, and uses ambient air as a cooling source.

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The low vapor pressure of the sealant allows for deep vacuum over a wide range of temperatures. Additionally, since the vapor pressure is so low, you can attain the desired capacity with a smaller pump as compared to a pump sealed with water. This reduces the horsepower requirement and therefore reduces the cost of operation.

Maintenance costs are also reduced with the SYNseal package since the threat of mineral plating and scale build up is eliminated. It is not unusual to get 10,000 hours use out of the sealant before it has to be changed.

Since there is an option to cool the SYNseal package with ambient air, the need for water is not just reduced, it is eliminated.

In short, with the SYNseal package, you get exceptional reliability, low operating costs, low maintenance costs, and operation over a wide range of temperatures.

COMPRESSOR EQUIPMENT
SELECTION
CA-1, CA-2

DESIGNED BY CLR DATE 2/14/95
CHECKED BY JT DATE 2/26/95

COMPRESSED AIR USED FOR INSTRUMENTS, HVAC
CONTROL SYSTEM, PNEUMATIC TOOLS AND
GENERAL USE.

TOOL REQUIRE 8.0 SCFM @ 100 PSI / TOOL

ASSUME 10 TOOLS @ 8 SCFM = 80 SCFM

HVAC CONTROLS @ 0.52 SCFM / DEVICE WITH
A 50% DIVERSITY FACTOR.

USE 60 DEVICES

$$(60)(0.52)(0.5) = 15.6 \text{ CFM}$$

$$15.6 \text{ SCFM} + 80 \text{ SCFM} = 95.6 \text{ SCFM}$$

USE 100 SCFM @ 100 PSI. SELECT TWO
AIR COMPRESSOR ONE FOR USE AND ONE
FOR STANDBY.

SELECTION:

MANUFACTURER: COPCO

MODEL #: 2T18-30

118 CFM WORKING @ 7500 FT.

PRICE: \$36,230 EA

QTY: 2

HP: 40 HP

DESICANT DRYER

160 SCFM

\$5124

PROFILTIC

\$726

AFTER FILTEIC

\$424.00

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Atlas Copco**ZT18-30**
Oil-Free Rotary
Lobe CompressorsProduct Data: Z18-30.PD010Page: 1 of 2Effective: 10/1/92**STANDARD EQUIPMENT DESCRIPTION**

The ZT18-30 Series compressors are fully enclosed, two-stage aircooled rotary lobe compressors. They include the compressor, drive motor and starter, oil system, regulation system and controls. The unit is offered in the 25, 30, and 40 horsepower range.

AIR CIRCUIT:

- A two-stage oil-free compressor block consisting of separate low and high pressure rotary lobe compressor elements flanged to a common step-up gearbox. The compressor elements are aircooled
- Dry type air intake filter
- Venturi type air intake silencer with filter replacement indicator
- Air intake valve
- Unloading valve housed together with the intake valve
- Low pressure element outlet temperature indicator/switch
- Safety valves for low and high pressure circuit
- Discharge damper
- Check valve
- High pressure element outlet temperature indicator/switch
- Moisture trap with automatic and manual drain valve after the aftercooler
- Manual compressor air outlet valve
- Aircooled intercooler
- Aircooled aftercooler

OIL SYSTEM

- Oil sump which forms an integrated part of the gearbox
- Oil pump driven by main drive shaft
- Full-flow oil filter
- Oil by-pass valve which regulates the oil pressure
- Oil piping to all lubricating points
- Oil drain (flexible hose)
- Oil level sight-glass
- Aircooled oilcooler

DRIVE SYSTEM:

- Flange-mounted ODP motor (460v) with 1.25 service factor
- Direct drive through a flexible coupling
- Full voltage starter mounted and wired (460v)

VENTILATION AND COOLING AIR CIRCUIT

Axial flow fan driven by a separate fan motor draws ventilation air through the package and coolers.

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Atlas CopcoProduct Data: Z18-30.PD010Page: 2 of 2Effective: 10/1/92**CONDITION MONITORING SYSTEM**

- Four SPM points, one on each side of both elements, to monitor bearing conditions
- Six sensor points to measure temperature at the following points: low pressure element inlet, low pressure element outlet, high pressure element inlet, high pressure element outlet, oil cooler outlet and compressor pack discharge
- Three quick points to measure pressures at the following points: low pressure element inlet, high pressure element inlet and compressor pack discharge

REGULATING SYSTEM:

- The regulating system is of the full-load/no-load type. Unloading is carried out by closing the intake valve. Loading or unloading of the unit is controlled by an adjustable air pressure switch which will actuate the loading solenoid valve
- The compressor is also provided with a start/stop regulator which will stop the compressor after an adjustable time period (minimum time is determined by the maximum allowed number of motor starts per hour). The unit will restart automatically when the discharge pressure has dropped below its minimum pre-set level

CONTROL AND INDICATOR CUBICLE:

- Pressure switch
- Discharge pressure gauge
- Intercooler pressure gauge
- Intercooler pressure gauge
- Oil pressure switch and shut-down indicator lamp
- Oil pressure gauge
- Low pressure element outlet temperature switch and shut-down indicator lamp
- High pressure element outlet temperature switch and shut-down indicator lamp
- Toggle switch for manual unloading
- Motor overload relay and shut-down indicator lamp
- Hourmeter indicating total running time
- Voltage-on indicator lamp
- Automatic operation indicator lamp
- Start/stop push buttons

ENCLOSURE

- Sound attenuated steel cabinet with full access doors
- Base frame with forklift slots

BB OK 117

Atlas CopcoNo.: Z18-30.PD020Page: 1 of 2Effective: 10/1/92**ZT18-30**
Oil-Free Rotary
Lobe Compressors**OPTIONAL EQUIPMENT DESCRIPTION****1. Full Voltage Starter (230v/3ph/60Hz)**

The motors are connected 460V as standard. This option provides the unit reconnected for 230V and capability to start across the line with the proper starter and overloads.

2. Alarm Horn

An audible alarm will be mounted and wired. It will be activated by any shutdown function. A re-set/silence button is provided.

3. Auto-Re-start after Power Failure

Enables the unit to automatically re-start after a power outage due to accidental power loss or planned power switch-over to a back-up system. Upon restoration of power, unit will restart automatically after a factory set time interval.

4. Flanged Inlet Connection

The air compressor air inlet is extended to the exterior of the unit to allow an outside air source to be connected. This connection is for the air to be compressed and not the cooling circulating air.

5. Health Care Facilities Package

This package consists of Items 2, 3 and 4. It is offered at a discount due to pre-engineering.

6. Fused Disconnect Switch

The fused disconnect switch enables the unit to be isolated from the main power grid and also is fused for added system protection.

7. Additional Instrumentation

Additional temperature, pressure gauges, pre-alarms and shutdown are available. A maximum of any 3 (total) can be added.

- pressure gauge will be 2-1/2 inch (psi)
- temperature gauge will be 2-1/2 inch (Deg.F and Deg.C)
- a shutdown switch will be pre-set at a factory level. A red light will be illuminated on the instrument panel.

8. Software Submittal**• Approval Drawing**

Drawings are submitted for customer approval. Submitted drawings must be reviewed within two weeks. Any drawing not returned in that period may affect compressor delivery. Production times and compressor units are not allocated until drawings are returned approved. The price indicated is for each review. If customer requires extra changes not noted in the original purchase order/specification, additional charges will be incurred.

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Atlas Copco**ZT18-30**
Oil-Free Rotary
Lobe CompressorsNo.: Z18-30.PD020Page: 2 of 2Effective: 10/1/92

- **Reproducibles**

Reproducible type drawings are supplied (per set).

- **Submittal Set**

A set consists of:

- General Arrangement Drawing
- Electrical Service Diagram
- P & ID Flow Schematic
- Instruction Book
- Parts Book

9. Tests and Certificate**Mechanical Run Test Certificate**

A mechanical run test is conducted in Holyoke, one hour unloaded and one hour loaded. Mechanical and electrical performance are checked and verified.

Performance Test Certificate

A complete test is conducted for capacity and power.

Witness Test

The mechanical run test and/or performance test are witnessed. Three days notice will be given prior to testing. This charge is in addition to above charges.

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Atlas CopcoProduct Data: Z18/30.PDTPage: 1 of 2Effective: 4/30/94**ZT18/30 SERIES**Two Stage Oil-Free
Air Cooled

MODEL		ZT18-125	ZT22-125	ZT30-125
Compressor Speed	rpm	3540	3535	3555
Maximum Pressure	psig	125	125	125
Minimum Pressure	psig	58.0	58.0	58.0
Maximum Ratio		9.6 : 1	9.6 : 1	9.6 : 1
Number of Stages		2	2	2
Flow Capacity				
② 125 psig	ACFM	88	109	156
② 115 psig	ACFM	89	111	157
② 110 psig	ACFM	89	111	158
② 100 psig	ACFM	90	111	158
② 80 psig	ACFM	90	112	159
② 75 psig	ACFM	90	112	159
② 60 psig	ACFM	90	112	160
Shaft Power Input¹				
② 125 psig	Bhp	28.3	33.6	46.1
② 115 psig	Bhp	27.3	32.2	44.3
② 110 psig	Bhp	26.6	31.6	43.5
② 100 psig	Bhp	25.4	30.2	41.9
② 80 psig	Bhp	22.9	27.6	38.8
② 75 psig	Bhp	22.3	26.9	38.1
② 60 psig	Bhp	.6	25.0	35.9
② Unloaded	Bhp	5	6	8
Separate Cooling Fan HP:	Bhp	0.8	0.8	1.0
Specific Power Consumption¹				
② 125 psig	Bhp/100 ACFM	32.33	30.69	29.45
② 115 psig	Bhp/100 ACFM	30.62	29.15	28.15
② 110 psig	Bhp/100 ACFM	29.85	28.49	27.59
② 100 psig	Bhp/100 ACFM	28.34	27.17	26.49
② 80 psig	Bhp/100 ACFM	25.45	24.64	24.40
② 75 psig	Bhp/100 ACFM	24.77	24.05	23.91
② 60 psig	Bhp/100 ACFM	22.77	22.29	22.47

¹ Standard Operating Conditions: Ambient Pressure 14.5 PSIA
Ambient Temperature 80°F
Relative Humidity 60%

Performance Guarantee: Unit performance complies with ASME PTC-9 within ±4% for capacity and ±5% for specific power.

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Atlas Copco

Product Data: Z18/30.PDT

Page: 2 of 2

Effective: 4/30/94

ZT18/30 SERIESTwo Stage Oil-Free
Air Cooled

MODEL		ZT18-125	ZT22-125	ZT30-125
Maximum Standard Operating Limits				
Ambient Temperature	°F	104	104	104
Cooling Duct Suction Restriction* in. W.C.		0 to - 0.12	0 to - 0.12	0 to - 0.12
Cooling Duct Outlet Restriction* in. W.C.		0 to + 0.12	0 to + 0.12	0 to + 0.12
Operating Data				
LP Male Rotor	rpm	5198	6039	7809
LP Female Rotor	rpm	5198	6039	7809
HP Male Rotor	rpm	5198	6039	7809
HP Female Rotor	rpm	5198	6039	7809
LP Male Rotor Tip Speed	ft/s	131.3	152.5	197.2
LP Female Rotor Tip Speed	ft/s	131.3	152.5	197.2
HP Male Rotor Tip Speed	ft/s	84.8	98.6	127.4
HP Female Rotor Tip Speed	ft/s	84.8	98.6	127.4
Gyratic Mass (WR ²) incl. Cplng.	lb-ft ²	0.66	0.74	0.96
Sound Level with Motor Enclosure* dB(A)		70	72	75
Aftercooler Terminal Approach	°F	14	16	18
Cooling Air				
Cooling Air Flow Requirement CFM		2100	2100	2500
Heat Rejection @ 100 psig BTU / Hr		68000	81000	112000
Physical Data				
Suction Air Inlet in.		17.5x17.2	17.5x17.2	17.5x17.2
Cooling Air Inlet in.		17.5x17.2	17.5x17.2	17.5x17.2
Cooling Air Outlet in.		32.9x12.5	32.9x12.5	32.9x12.5
Air Discharge Connection		1-1/4" NPT	1-1/4" NPT	2" NPT
Aftercooler Condensate Connection(s)		1/4" NPT	1/4" NPT	1/4" NPT
Oil Sump Capacity US gal.		5.5	5.5	5.5
Length in.		63.6	63.6	63.6
Width in.		39.0	39.0	39.0
Height in.		61.4	61.4	61.4
Estimated Package Weight lbs.‡		2404	2434	2508
Approximate Shipping Weight lbs.‡		2800	2900	2900
Recommendations				
Drive Motor Size HP‡		25	30	40
Air Receiver Volume cu. ft.		33	33	33
Typical Receiver Size Ins. Ø x Ht.		30 x 84	30 x 84	30 x 84

* Operating Sound Level: Sound levels for machines equipped with recommended standard motors and enclosures are guaranteed ± 3 dB(A) when measured in free field conditions at a distance of one meter (1m) in accordance with CAGI PNEURO® Test Code.

‡ Recommended Motor Size: Package weight includes Atlas Copco's standard motor at the size recommended for typical applications.

* Duct restriction: Inches water column average static pressure measurement, free of velocity effects, taken in the duct immediately outside the compressor package ventilation grille.

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TWO-STAGE AIRCOOLED OIL-FREE ROTARY LOBE COMPRESSOR SPECIFICATION

1.0 SCOPE

- 1.1 This document specifies requirements for general operation, design, construction, performance, and installation for a rotary lobe compressor package.
- 1.2 The Vendor shall state, in his quotation any and all exceptions to this specification.

2.0 GENERAL

Vendor shall supply a positive displacement rotary lobe compressor capable of delivering 100% oil-free air. There shall be no lubricant within the compression chamber. Unit to be delivered fully packaged including air compressor, electric motor, coolers, lubrication system, regulation, and control system mounted on a common base frame and fully enclosed steel sound-dampening canopy.

3.0 DESIGN AND CONSTRUCTION

- 3.1 The compressor shall be Manufacturer's standard oil-free rotary lobe compressor package designed as a two-stage unit to meet performance requirements. The compressor shall consist of two compressor stages flanged to an integral gear box. Each stage is to be driven from a common bull gear to ensure optimum speed and highest possible efficiency. Compressors shall have an intercooler placed between stages and an aftercooler installed in the package. A common base frame for compressor system and driver is to be furnished. The Manufacturer shall also provide a sound enclosure over compressor and driver.
- 3.2 **Compressor and Casing**
The compressor stage shall be of three-piece cast iron construction housing two precision made stainless steel single lobe rotors. Cooling fins shall be provided. Radial inlet and double axial discharge ports shall be provided to eliminate any axial thrusts.
Compressor element shall be completely removable as an independent part with rotors, all rotor bearings, seals, and timing gears. This is to assure proper rotor alignment and timing at time of changeout.
- 3.3 **Rotors**
Rotors and shaft shall be of one-piece stainless steel construction. Rotors shall be supported on both sides by anti-friction type bearings. Rotors are to have a corrosion-resistant coating. The rotors shall have a profile that keeps leakage losses at a minimum to ensure high efficiency. Rotors must be balanced dynamically to provide vibration-free operation.
- 3.4 **Timing Gears**
Timing gears shall be fitted on the rotor shafts to maintain the rotors in correct position relative to each other. Timing gears shall have straight cut gear teeth to prevent any axial thrust.
- 3.5 **Bearings**
Bearings shall be of the high precision anti-friction type. They shall be on both sides of the rotor for proper alignment. There shall be one set of roller bearings on the drive end, and one set of double row angular contact bearings for proper axial positioning on the timing gear end.
- 3.6 **Gear Box**
The gear box shall be an integral part of the compressor unit and include the main drive shaft and bull gear. The bull gear and pinion gears shall have straight

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cut gear teeth so that no axial thrusts are created. It should be supported by its own bearings and connected to the driver by a flexible coupling.

3.7 Seals

Air seals shall consist of carbon rings guided in steel rings. The carbon rings are to be free floating for radial self-adjustment along the rotor shaft. The oil seal shall be a threaded screw seal, which creates an air circulation through the thread toward the bearings. There shall be a vent to atmosphere between the oil and air seal.

3.8 Gaskets

All gaskets shall be asbestos free.

3.9 Coolers

The compressor package shall be equipped with all required coolers as follows:

3.9.1 An oil cooler, intercooler and aftercooler shall be provided and mounted. All coolers will receive the same temperature of cooling air (one pass design) for optimal efficiency and ease of maintenance.

3.9.2 The cooling fan shall be mounted adjacent to the coolers.

3.9.3 There shall be direct cooling of the compressed air and lubricating oil, eliminating the need for an intermediate closed loop coolant system, for optimal efficiency.

3.10 Driver

The driver shall be flange-mounted to the gear casing via a standard NEMA D flange. The motor shall be direct-coupled to the compressor via a flexible coupling only, so that no compression forces are transmitted to the motor. On units 50 H.P. and above, a high efficiency rated motor shall be used.

3.11 Lubricating System

3.11.1 The lubrication oil for the compressor shall be contained in an integral sump.

3.11.2 The lubrication system shall consist of an oil pump, oil bypass regulation system, spin-on oil filter and all necessary piping.

3.11.3 A direct-driven gear type oil pump shall be fitted to the main drive shaft. No auxiliary oil pump shall be required.

3.11.4 Drive gear, bearings, and timing gear in each stage are to be spray lubricated.

3.12 Regulating System

The regulating system shall be of the full load/no load type for maximum efficiency.

3.13 Control System

The control system shall be integral to the compressor package and is to consist of an electro-pneumatic regulator designed to provide manual and automatic running. The control system is to provide circuits for loading delay on starting and an adjustable idling delay on shut-off. Control system shall also provide for automatic shut-off of the compressor during periods of low demand and excessive idling to conserve energy. A stepdown transformer will be provided for control voltage.

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3.14 Monitoring Equipment

The compressor package shall have the appropriate gauges, controls, and indicators to monitor operation as specified below.

- Intercooler pressure gauge
- Discharge pressure gauge
- Oil pressure gauge
- First stage outlet air temperature gauge
- Second stage outlet air temperature gauge
- High air inlet filter vacuum indicator
- Low oil pressure light
- High 1st-stage outlet air temperature light
- High 2nd-stage outlet air temperature light
- Hourmeter for running time
- Auto operation light
- Power on-light
- Motor overload light

3.15 Safety Devices

The compressor package shall have automatic shut-off switches as specified below:

- Low oil pressure
- High 1st-stage outlet air temperature
- High 2nd-stage outlet air temperature
- Motor overload

3.16 Condition Monitoring System

In order to facilitate preventative maintenance check-ups, the package is to be provided with a set of connection points to monitor various pressures, temperatures, and vibrations.

3.17 Air Filter System

3.17.1 Air intake filters are to be enclosed in package.

3.17.2 Filters shall be paper cartridge type.

3.18 Compressor Elements

The compressor unit including motor shall be enclosed in a steel sound-insulating canopy to meet a 75dB(A) noise level when measured according to CAGI-Pneurop standards. It shall also have large doors for easy access during normal maintenance.

4.0 PERFORMANCE REQUIREMENTS

The capacity and specific power quoted shall be guaranteed per modified ASME PTC-9 with the following tolerances:

capacity +/- 5% and specific power +/- 5%

5.0 GENERAL INSTALLATION REQUIREMENTS

Compressor shall be of design to facilitate simple installation. No special foundations are to be required other than a weight-supporting floor. Compressors shall not require bolting to the floor. Unit to be delivered with all internal piping and wiring completed at time of delivery. Compressor and motor shall be vibration isolated from the main frame.

ACID WASTE PUMPING STATION

95.0K 117

Simplex acid waste pump station.

Automatic pumping stations economically collect and transfer corrosive wastes from production machines or laboratory sinks where gravity drains cannot be used.

SIMPLEX OPERATION

As liquid waste enters the holding tank, its level is sensed by the Flowline level control. The liquid will rise to a pre-determined level where the control actuates the pump. As the liquid level drops, the level control sensor shuts the off pump. To install, you simply connect the incoming liquid waste line to the inlet (an optional basket strainer is recommended) and the discharge line to the outlet, and have a qualified electrician wire power to the pump.

DUPLEX OPERATION

As liquid waste enters the holding tank, the primary pump is activated at the high level position of the level controller, and turns on to empty the tank. Should the incoming flow be greater than the output capacity of the primary pump, or should the primary pump fail, the secondary level control will activate the secondary pump. Pumping will continue until the tank level drops to the low-level sensor position of the controller.

MATERIALS OF CONSTRUCTION

The holding tanks are molded of high density polyethylene, while the seal less and bearing-less pumps are made of high temperature CPVC for maintenance-free operation. The standard wetted portions of Flowline level controls are polypropylene, and the fasteners and vapor seal gaskets are non-metallic. The standard 115V, 1-ph motors run at 3,450 rpm; other motor and tank combinations are available.

ORDER INFORMATION:

8970-(Size No.) SIMPLEX PUMPING STATION

Size No.	Price Each	Approx. Tank Size (gal.)*	Pump Motor (hp)**	Max. Pump Flow (gpm at 1 ft. head)
-210	1168.25	16	1/8	18
-220	1196.32	32	1/8	18
-620	1451.30	32	3/4	50
-645	1534.21	63	3/4	50

*Usable volume of tank is less than tank volume listed.

**All motors are 115 Vac, 1-ph, TEFC, 3450 rpm.

DIMENSIONS

Simplex

Duplex

Size No.	Dimensions (in.)							Tank Inlet (NPT)	Pump Outlet (NPT)	Simplex Max. Usable Volume (Gal)	Duplex Max. Usable Volume (Gal)
	A	B	C	D	E	F	G				
-210	18	21	12	15	18	14	5-3/4	1-1/2"	1/2"	9	13
-220	24	28	18	22	18	13	5-3/4	2"	1/2"	10-1/2	15
-620	24	28	18	22	18	13	12	2"	3/4"	18 1/2	16
-645	36	41	20	25	20	15	12	2"	1"	48-1/2	40-1/2

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ACID WASTE PUMPING STATION

75-(Size No.) DUPLEX PUMPING STATION

Size No.	Price Each	Approx. Tank Size (gal.)*	Pump Motor (hp)**	Max. Flow (gpm at 1 ft. head)	Dual Pump Normal Flow
-030	2,585.04	55	1/3	50	25

PRICE NOTE: The above prices are based on pump stations with features described and do not include crating charges. Smaller or larger tank units can be assembled to your requirements.

OPTIONS: Additional inlet fittings, high-low alarm relays and acrylic sight glasses.

* The usable volume of the tank is less than the tank volume listed. See the above table for maximum usable volume.

** All motors are 115 Vac, 1-ph. TEFC, 3,450 rpm

Duplex acid waste pumping station.

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FLOWLINE™ LIQUID-LEVEL SENSORS

N-TANK INTRUSIVE RF CAPACITANCE SENSOR

Flowline's intrusive RF capacitance sensor delivers accurate and reliable liquid detection with a FET switch and 4 or 20 mA signal output. The unique RF capacitance technology provides the highest level of dielectric sensitivity, including resistance to coating and scaling. The sensor is available in two lengths and may be mounted in any orientation, through the tank wall (outside in or inside out), or inside the tank (Smart Trak), wet or dry.

Accuracy: $\pm 1\text{mm}$ in water
 Wetted Materials: Polypropylene or PFA
 Max. Temp. Rating: 80°C
 Max. Voltage Input: 12-36VDC
 Signal Output: 4 or 20mA and selectable NO or NC FET switch
 Dimensions: 3" or 4.5" L x 1.05" (3/4" NPT)
 Cable Length: 8' standard. Longer lengths available.
 Max. Signal Distance: 1000'

ORDER: 0007-(Size No.) INTRUSIVE RF CAPACITANCE
SENSOR

Size No.	Wetted Materials	Length (in.)	FET Switch Voltage (Vdc)	Max. FET Switch Current (mA)	Version	Price Each
-121	Polypro	4.50	0-36	100	NPN	195.00
-221	PFA	4.50	0-36	100	NPN	295.00
-123	Polypro	4.50	0-36	100	PNP	195.00
-223	PFA	4.50	0-36	100	PNP	295.00

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FLOWLINE LIQUID-LEVEL CONTROLLERS

SENSOR AND SMART TRAK™ MOUNT CONTROLLERS

Flowline's sensor mount controller family provides convenient integration of the controller with either a single sensor or Smart Trak. The terminal strip provides conduit termination for up to four sensors. The single-point switch provides a switch/alarm control capability and conduit termination for a single sensor input, while the single-channel controller provides latching, automatic fill or empty control capability with conduit termination for two sensor inputs. The enclosures are designed to NEMA 4X standards and are constructed of UL-approved, fire-retardant PP.

ORDER: 6908-(Size No.)

Size No.	Product Description	Selectable Power	Output	Price Each
-001	Smart Trak Mount Controller	120 or 240	(1) 12A, SPDT, NO or NC	170.00
-002	Single Sensor Controller	120 or 240	(1) 12A, SPDT, NO or NC	170.00
-012	Compact Single Sensor DC Controller	14 to 36 VDC	(1) 6A, SPDT, NO or NC	160.00

Sensor mount controller without sensor installed shown above.

MAY 17 '95 9:20AM RYAN HERCO PRODUCTS MARATHON SEAL-LESS VERTICAL CENTRIFUGAL PUMPS

8845394

F.7

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ORDER INFORMATION

S1 SERIES

Motors are 1/15 Hp, 3200 RPM*, 1-ph, 60 Hz, TFFC with on/off switch.

6531-010 MARATHON 10, CPVC, 115V ...	\$270.00
6533-010 MARATHON 10, natural polypro, 115V	290.00
6525-011 MARATHON 10, PVDF, 115V ...	420.00

SS1 SERIES

Motors are 1/8 Hp, 3400 RPM*, 1-ph, 50/60 Hz, TEFC.

6531-110 MARATHON 15, CPVC, 115/230V .	\$360.00
6533-110 MARATHON 15, natural polypro, 115/230V	370.00
6525-110 MARATHON 15, PVDF, 115/230V .	520.00

S2 SERIES

SS6 SERIES

All motors are 3/4 Hp, 3450 RPM*, 50/60 Hz, TEFC. 1-ph motors are 115/230V; 3-ph motors are 208 230/480V.

6531-060 MARATHON 60, CPVC, 1-ph ...	\$720.00
6531-062 MARATHON 60, CPVC, 3-ph ...	730.00
6533-062 MARATHON 60, GF polypro, 3-ph .	750.00
6525-062 MARATHON 60, PVDF, 3-ph ...	950.00

SS7 SERIES

All motors are 1 Hp, 3450 RPM*, 50/60 Hz, TEFC. 1-ph motors are 115/230V; 3 ph motors are 208-230/480V.

6531-070 MARATHON 70, CPVC, 1-ph ...	\$780.00
6531-072 MARATHON 70, CPVC, 3-ph ...	790.00
6533-072 MARATHON 70, GF polypro, 3-ph .	810.00
6525-072 MARATHON 70, PVDF, 3-ph ...	990.00

Culligan

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DEIONIZATION SERVICE

THE SENSIBLE, CONVENIENT WAY TO OBTAIN HIGH PURITY WATER

YOU BENEFIT SEVERAL WAYS:

- **No capital investment.** You rent instead of buy, and conserve your capital. Rental fees are part of your operating costs, spread over the time you use the service. Rental charges can be arranged to suit your needs - per tank, per gallon, or per regeneration.
- **No labor cost.** No operator is required, yet you get high purity water.
- **No maintenance cost.** There is no equipment to operate, repair, or replace and no equipment downtime. Your local independently operated Culligan dealer owns and maintains the equipment.
- **No chemicals, no hazardous wastes.** Your local Culligan dealer handles all resin regenerations. Your personnel do not handle regenerant chemicals, making OSHA standards easier to meet. You do not have to dispose of wastes to meet EPA requirements or government pollution control ordinances.
- **The right quality, the right quantity, the right cost.** Culligan exchange systems provide water quality up to 18 megohms specific resistivity, with intermediate qualities available, in quantities from a few gallons per day to several hundred gallons per minute. You control cost by using only the quality and quantity you need. Systems can be expanded or reduced as your needs change.
- **Simplicity of operation.** Exchange tanks operate on line pressure; no pumps, motors or pressure vessels are needed.
- **System capability.** Your Culligan dealer can add other processes such as softening, filtration and sterilization to the DI exchange tank system to meet special needs. Deionization service can also be used as a low-cost back-up for automatic demineralizers.

Culligan

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THE CULLIGAN FAMILY OF DEIONIZATION SERVICE PRODUCTS

ACCESSORIES

1. **Water Quality Instrumentation** - monitors water quality (resistivity) or controls poor quality end points.

Wide selection of monitors controllers, indicators from several manufacturers (Culligan, Thornton, Rosemount, Myron L. Foxboro).

2. **Recirculation Systems** - keep high purity water in motion to maintain water quality.

3. **Automatic Safety Shut-off Valve** - shuts down the system to prevent delivery of low quality water to points of use.

4. **Automatic Bank Switch-over System** - switches from exhausted tanks to stand-by tanks to provide uninterrupted flow of high purity water.

5. **Alarm System** - alerts customer personnel of the need to call for a tank exchange.

6. **Telemetry Device** - monitors and signals the Culligan dealership when service is required.

If you use water in any industrial or manufacturing process, you should investigate the practicality of a high purity deionized water system by Culligan. For the location of your nearest Culligan dealer, call 800-451-3260.

NOTE: Operational, maintenance and replacement requirements are essential for this product to perform as advertised.

Culligan

Commercial/Industrial Systems
CULLIGAN INTERNATIONAL COMPANY
 One Culligan Parkway, Northbrook, IL 60062 USA
 Sheridan Park, Mississauga, Ontario L5K 1A5 CANADA
QUALITY WATER AT WORK.

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HIGH PURITY WATER SYSTEMS - FROM A SINGLE TANK TO A COMPLETE SYSTEM.

Culligan high purity water systems using exchange tanks are available in several system configurations. Your Culligan dealer selects the sizes and capacities to create the system that most closely matches your water quality and quantity needs, including options, consistent with lowest cost. Tanks are available in Tripl-Hull™ steel or fiberglass; all tanks and components are completely compatible.

TWO-BED

A cation exchanger and anion exchanger connected in series. The cation exchange unit removes positively charged ions from water, including calcium, sodium, magnesium, iron, manganese and potassium. The anion exchange unit removes negatively charged ions, including sulfates, chlorides, carbonates, bicarbonates, nitrates, and silica. May use weak base or strong base resin, depending on application.

Strong base systems have typical water quality of 0.2 megohm and pH of 8-9. Weak base systems have lower quality, do not remove silica or CO₂ and low pH of 6-7.

MIXED-BED

Cation and anion resins are combined and mixed in a single tank, permitting thousands of cation and anion exchange processes to take place as water passes through the resin beds. Typical water quality of 5 megohm or more with neutral pH.

MULTIPLE-TANK SYSTEMS

Three tanks or more, connected in series or parallel or a combination of the two, to produce highest purity water in any desired quantity. Systems may be a cation-anion-mixed-bed, cation-cation-weak base anion, cation-strong base-strong-base, or any of several combinations, depending on the specific water problem. Typical quality of 15 megohm or more with neutral pH systems with mixed beds.

COMPLETE MULTIPLE-PROCESS TREATMENT SYSTEMS

Exchange service tanks using other water treatment processes may be added to create a more complete high purity water system. Typically, a system may include one or more of the following processes: softening, depth filtration, carbon adsorption, UV sterilization, submicron filtration, or other processes.

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Culligan**WRITTEN SPECIFICATION**

PORTABLE EXCHANGE DEIONIZATION SERVICE	CUSTOMER: <u>ICF ENGINEERING</u>
	PROPOSAL DATE: <u>5/16/95</u>

The equipment described is being offered by SOUTHWEST WATER CONDITIONING, INC.
an independently operated franchisee of Culligan International Company. C/O Culligan

PURPOSE

The purpose of the deionizer system will be to reduce the total dissolved solids of the water so that the specific resistance of the water is not less than 1-1,800,000 ohm-cm.

- ☒ The system will reduce soluble silica to less than .02 ppm.
→ ☒ The system will not remove silica or carbon dioxide.

SYSTEM

The system will be assembled using Culligan portable exchange tanks to handle a flow rate of 12 gallons per minute. The system will have a total exchange capacity of 23,500 grains per exchange, based on standardized conditions.

The system will consist of 3 tanks in series. These tanks will include (check all applicable)

- ☐ multi-media depth filtration for turbidity removal.
☐ activated carbon for chlorine removal and organic reduction
→ ☐ two bed deionizer ☒ Strong Base ☐ Weak Base
→ ☒ mixed bed deionizer
→ ☒ two bed deionizer plus mixed bed polisher
☐ (other) _____

There will be — of these series systems in parallel. A total of 3 tanks will be in service at one time.

- ☐ (Optional) There will be _____ tanks included as standby units to assure continuous, proper water quality.

TANKS

CATION: RESIN - 2.1 ANION: RESIN - 2.1 50,000 GRS. CAPACITY

Tanks will be 12 inches in diameter. Tanks will be 56 inches in height.
Tanks will contain .7 ft³ of cation 1.4 ft³ of anion 2.1 ft³ of mixed bed.

Tanks will be of (check one)

- ☒ Tripl-Hull, steel construction (plastic inner liner, steel tank, and plastic outer shell)
☐ fiberglass construction

INSTRUMENTATION

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Water quality will be monitored by (check one)

- ☐ a quality indicator light which will remain lighted as long as the water quality exceeds _____ ohm-cm.
- ☒ a temperature-compensated resistivity cell and monitor which gives a direct reading of water quality on a continuous basis.
- ☐ a temperature-compensated resistivity cell and controller which measures the water quality and will indicate and activate internal relay to send signal when water quality is no longer at the preset level.

OTHER ACCESSORIES - NO

- ☐ Recirculation System - to maintain quality during low flow and no-flow conditions
- ☐ Safety shut-off valve - to shut off the deionized water supply when water quality drops below preset level
- ☐ Alarm bell - to signal that the quality of deionized water is below the preset valve.
- ☐ Automatic Bank Switchover System - to place standby system in service and take exhausted system off line when water quality drops below preset value
- ☐ Telemetry Device - to check various operating parameters and report their condition to the Culligan dealership when service is required, also monitors flow rate and total gallonage.

SERVICE

Filters will be exchanged (check one)

- ☐ every _____ days
- ☒ as needed, per customer request
- ☐ every _____ gallons, per meter reading
- ☐ (other) _____

WATER MAIN TO BUILDING PIPE SIZE

DESIGNED BY CLQ

DATE 2/7/95

CHECKED BY TJ

DATE 2/26/95

QTY	DESCRIPTION	FIXTURE UNITS	TOTAL FIXTURE UNITS
5	SHOWERS	4	20
1	SINK	4	4
			15
5	WATER CLOSETS	3	1
1	ELECTRIC WATER COOLER	1	4
1	MOP SINK	4	5
1	URINAL	5	18
9	LAVATORIES	2	

TOTAL FIXTURE UNITS = 67

USE 2" MAIN TO BUILDING

SANITARY SEWER MAIN PIPE SIZE,
ACID/RAD WASTE LINE, & FIRE PROTECTION
MAIN

DESIGNED BY **CLQ** DATE **2/7/95**

CHECKED BY **TJ** DATE **2/8/95**

QTY	DESCRIPTION	FIXTURE UNITS	TOTAL FIXTURE UNITS
5	WATER CLOSETS	6	30
1	URINAL	2	2
5	SHOWERS	2	10
1	SINK	2	2
1	MOP SINK	3	3
2	FLOOR DRAINS	3	6
1	ELECTRIC WATER COOLERS	1	1
9	LAVATORIES	1	9

63 UNITS

USE 4" SANITARY SEWER MAIN

USE 4" RAD/ACID WASTE LINE

USE 10" FIRE PROTECTION LINE (SEE PRELIMINARY
FIRE PROTECTION
ANALYSIS).

NATURAL GAS PIPING MAIN LINE
SIZE

DESIGNED BY CLR

DATE 3/7/95

CHECKED BY JT

DATE 2/24/95

1- BOILERS INPUT = 900,000 BTUH EACH

1- WATER HEATER = 300,000 BTUH

USE MEDIUM PRESSURE GAS FROM METER TO BUILDING.
200 FT OF PIPE 5.0 PSIG W/ A 10% PRESSURE DROP AND
A SPECIFIC GRAVITY OF 0.6 SG (FROM TABLE 10-9 OF
NFPA 54 1992 EDITION.)

1000 BTU = 1 CUFT OF GAS

1,200,000 BTU = 1,200 CUFT/HR OF GAS

USE 1-1/4" PIPE

LOW PRESSURE GAS INTO BUILDING USE 50 FT
PIPE OF 0.5 PSIG W/ PRESSURE DROP OF 0.3 INCH OF
WATER. GAS OF 0.6 SG.

USE 2" PIPE INTO BUILDING

USE 1-1/2" PIPE TO BOILERS

USE 1-1/2" PIPE TO WATER HEATER.

FAN SELECTION FOR
ALT #1

DESIGNED BY CLQ DATE 12/13/9
CHECKED BY TJ DATE 2/26/9

EXTERNAL STATIC PRESSURE

1. BIRDSCREEN & DAMPER	0.1
2. GOOSENECK	0.05
3. 50' DUCT WORK (0.1/100FT OF DUCT)	0.05
4. SUPPLY GRILLE -	0.021
5. COOLING CIRCUIT (TUBES)	0.0006
6. EXHAUST PLENUM	0.04
	<u>0.262</u>
7. 10% SAFETY FACTOR =	<u>0.027</u>
	0.289 @ SL

8. CORRECTION FOR 7500FT ELEV

$$= (0.289)(0.76) = 0.22$$

USE 0.25" SP.

9. FAN SELECTION

MANUFACTURER:	GREENHECK	0.25 BHP
MODEL #:	SBE1L-20-4	(.25BHP)(0.7457KW)
HP	1/4 HP.	
RPM	1085	= 0.19 KW
CFM	1673 CFM	USE 12 KW
TS	5679	
COST	\$566 ⁰⁰	

* USE 3 FANS 1-PRIMARY FAN 1-BACKUP FAN AND
1-FAN FOR MAINTENANCE BACKUP.

FAN REQUIRES 0.21/KW/HR

$$(0.2KW/HR)(24HR/DAY)(365DAY/YR) = 1,752 KW/YR$$

FAN SELECTION FOR AIT #2

DESIGNED BY CJP DATE 12/19/98

CHECKED BY TJ DATE 2/26/99

EXTERNAL STATIC PRESSURE

1. BIRD SCREEN & DAMPER	0.1
2. GOOSENECK	0.05
3. 50' DUCTWORK (0.1/100FT OF DUCT)	0.05
4. SUPPLY GRILLE	0.021
5. COOLING CIRCUIT (TUBES)	0.0004
6. EXHAUST PLENUM	0.04
7. PREFILTER (DIRTY)	0.3
8. TEST SECTION	0.25
9. HEPA FILTER (DIRTY) 1ST STAGE	3.0
10. TEST SECTION	0.25
11. HEPA FILTER (DIRTY) 2ND STAGE	3.0
12. INLET HEPA FILTERS (DIRTY)	3.0
	<hr/> 10.1" @ SL
13. 10% SAFETY FACTOR	1.1
	<hr/> 11.1
14. CORRECTION FOR 7500 FT ELEV = $(11.1)/(0.76) = 8.5" SP$	

USE 9.0" SP

FAN SELECTION FOR
ALT #2

DESIGNED BY CLP DATE 12/19/9.

CHECKED BY JT DATE 4/26/9

MANUFACTURER: GREENHECK

MODEL # ORB SIZE 11

HP 2-1/2 HP

RPM 2100

CFM 1842

TS 10,531

COST \$ 2200.00

BRAKE HP = 4.09 @ SEA LEVEL.

CORRECTION FOR 7500 FT ELEV =

$$(2.84)(1.76) = 3.1$$

USE 5 HP FAN.

$$\begin{aligned} \text{KW USAGE OF FAN } (5.1 \text{ BHP})(0.7457 \text{ kW}) \\ = 2.32 \text{ kW} \end{aligned}$$

$$(2.32 \text{ kW/HR})(24 \text{ HR/DAY})(365 \text{ DAY/YR}) = 20,323 \text{ kW/YR}$$

ASSUMPTIONS FOR MAINTENANCE
COSTS FOR ALT #1

DESIGNED BY CLP

DATE 12/14/

CHECKED BY JT

DATE 2/24/91

1. LIFE OF FANS = 10 YRS.

2. INSPECT AND MAINTAIN FANS EVERY SIX MONTHS
(INSPECTION AND MAINTENENCE TAKES 1 PERSON
4 HOURS EVERY 6 MONTHS AT \$30.00/HR)

$$= (4 \text{ HR})(2/\text{YR})(\$30.00/\text{HR})$$

$$= \$80.00/\text{YR} \text{ (FOR EACH FAN)}$$

3. CHANGE BELTS 1/YR

(TO CHANGE BELTS ON ALL 3 FANS TAKES 1
PERSON 4 HOURS ONCE PER YEAR AT
\$30.00/HR)

$$(4 \text{ HR})(1/\text{YR})(\$30.00/\text{HR}) =$$

$$= \$120.00/\text{YR}$$

4. MATERIAL COSTS/YR.

ASSUME BELTS COST \$15.00/BELT @ 3 BELTS/YR

$$= 45.00/\text{YR}$$

5. TOTAL MAINTENENCE COSTS/YR

$$\begin{array}{r} \$240.00/\text{YR} \\ + \$120.00/\text{YR} \\ + \$45.00/\text{YR} \\ \hline \underline{\underline{\$405.00/\text{YR}}} \end{array}$$

LIFE CYCLE COST ANALYSIS
CAPITAL REPLACEMENT COSTS
ALT # 1

DESIGNED BY CLQ DATE 12/16/94
CHECKED BY JJ DATE 2/21/95

	LABOR	MAT
PROPELLER FANS REPLACEMENT	\$ 360 ⁰⁰	\$ 4056
DEMOLITION OF OLD FANS	\$ 270 ⁰⁰	
RECONNECT ELECTRICAL	\$ 108 ⁰⁰	
NEW STARTERS	\$ 189 ⁰⁰	\$ 345 ⁰⁰
TOTAL	\$ 927	\$ 4,401
	<u>\$ 5328⁰⁰</u>	

ASSUMPTIONS FOR MAINTENANCE
COSTS FOR ALT # 2

DESIGNED BY CLD

DATE 2/20/90

CHECKED BY JT

DATE 2/26/90

1. LIFE OF FANS = 20 YRS

2. INSPECT AND MAINTAIN FANS EVERY SIX MONTHS
(INSPECTION AND MAINTENANCE TAKES 1 PERSON 4
HOURS EVERY 6 MONTHS AT \$30.00/HR)
 $= 4 \text{ HR} (2/\text{YR}) (30.00/\text{HR}) = 80.00/\text{YR}$ (FOR EACH FAN)

3. CHANGE BELTS 1/YR
(TO CHANGE BELTS ON ALL 3 FANS TAKES 1 PERSON
4 HOURS ONCE PER YEAR AT \$30.00/HR)
 $(4 \text{ HR}) (1/\text{YR}) (\$30.00/\text{HR}) = \$120.00/\text{YR}$

4. MATERIAL COSTS/YR

A. BELTS COST \$15.00/BELT @ 3 BELTS/YR = \$45.00/YR

B. PREFILTERS ARE CHANGED OUT EVERY 26 WEEKS
(16 PREFILTERS/YEAR) (10.00/FILTER) = 160.00/YR
(AS PER BILL RADINSKI)

C. HEPA FILTERS ARE CHANGED ONCE/YR
(24 HEPA FILTERS/YR) (250.00/YR) = 6000.00/YR

5. LABOR COSTS FOR FILTER REPLACEMENTS.

A. PREFILTERS (0.5 HRS/FILTER) (16 FILTERS) (\$30.00/HR) =
\$240.00/YR

B. HEPA FILTERS (1 HR/FIL) (24 FIL) (30.00) =
\$720.00/YR

6. TOTAL MAINTENANCE COST/YR

\$80.00 + \$120.00 + \$45.00 + \$160.00 + \$6000.00 + \$240.00 + \$720.00
= \$7365.00/YR

LIFE CYCLE COST ANALYSIS
CAPITAL REPLACEMENT COSTS
ALT #2

DESIGNED BY CLP DATE 12/20/95
CHECKED BY JJ DATE 2/24/96

UTILITY FANS REPLACEMENT
DEMOLITION OF OLD FANS
RECONNECT ELECTRICAL
NEW STARTERS

MAT	LABOR
6,600 ⁰⁰	360 ⁰⁰
-	180 ⁰⁰
-	180 ⁰⁰
1737	412.5
8,337	1,132
<div style="border-top: 1px solid black; width: 100%; margin-top: 5px;"></div> \$ 9469 ⁰⁰	

BREATHING AIR CALCULATION

DESIGNED BY CLL

DATE 3/16/95

CHECKED BY TJ

DATE 3/10/95

BREATHING AIR SYSTEM SIZED FOR FOUR PEOPLE FOR
2 HOURS.

- EACH PERSON REQUIRES 8 CFM OF AIR FLOW (4 PEOPLE / 8 CFM) = 32 CFM
- EACH BOTTLE CONTAINS 200 CUFT / CYLINDER OF AIR
- BOTTLES ARE SPENT AT 25% FULL $\therefore (200 \text{ CUFT} * 0.75) = \underline{175 \text{ CUFT}}$

$$\text{TIME TO EMPTY ONE CYLINDER} = 175 \text{ CUFT} / 32 \text{ CUFT/MIN} =$$

$$\underline{5.46 \text{ MIN / CYLINDER}}$$

$$\# \text{ OF BOTTLES REQUIRED} = (2 \text{ HR}) / \left(\frac{60 \text{ MIN}}{\text{HR}} \right) = \underline{120 \text{ MIN}}$$

$$120 \text{ MIN} / (5.46 \text{ MIN / CYLINDER}) = \underline{22 \text{ CYLINDERS}}$$

USE A 22 TUBE TRAILER

116 OF 117

Los Alamos

NATIONAL LABORATORY

memorandum

NMT-8 Group Office
TA-55 Facilities Management

To / MS: Leroy Martinez, FSS-6, MS E512
Thru / MS: David J. Post, NMT-8 Group Leader *David J. Post*
From / MS: David Rael, NMT-8, MS E583 *David Rael*
Phone / Fax: 5-7351 / 5-8463
Symbol: NMT-8:95-100
Date: March 2, 1995

POSITION PAPER ON WALK-IN PLENUMS FOR NMSF

NMT-8 was recently asked by the FSS-6 project development team for the NMSF to evaluate the need for standard bag-in/bag-out HEPA filter plenums versus walk-in plenums. This position paper will discuss NMT-8's views on this subject.

We have determined that the walk-in style of HEPA plenums best suit our needs for the following reasons:

- Walk-in plenums allow us to radiologically survey the air inlet face of the HEPA filters and plenum before any handling occurs. Normal operations within NMSF will result in the HEPA filters being non-contaminated, but this cannot be assumed, it must be confirmed with an actual survey. Given that no contamination exists, then the filters will be removed and disposed of as low-level contaminated waste. The bag-in/bag-out HEPA filter plenums will not allow access to the inlet face of the filters, thus the removal procedure will default to the worst case scenario and be removed as contaminated filters utilizing the bag-out method. The filters will also have to be disposed of as TRU waste. Reinstallation of clean filters will also require the bag-in method because the radiological condition of the plenum cannot be confirmed with survey swipes.

If contaminated filters are encountered within the walk-in plenums, the following measures will be taken:

- In all cases the RCT and filter crew will enter the plenum with necessary PPE/E (personal protective clothing/equipment). The plenum will be placed in a condition that puts it under a negative pressure relative to the occupied space (infiltration of air into the exhaust system through the opened plenum door). The RCT will enter the plenum, the plenum door is closed, and the RCT performs the required surveys to determine the radiological condition of the filters and plenum. As in this scenario, the filters have been found to be contaminated. The RCT will leave the plenum per the established procedure of removing contaminated booties and so forth. The filter crew will enter the plenum, remove the filters and bag them out as the filters exit the plenum. The area, equipment, and bagged filters will be surveyed and decontaminated prior to removal from the plenum work area (secondary containment area between the redundant plenums). The filters will be disposed of as TRU waste.

Keep in mind that no radiological contamination of the filters should ever occur. NMSF is not a processing facility, thus contaminated filters are the resultant of a failed operational system associated with the storage activities.

Leroy Martinez, FSS-6
NMT-8:95-100

page 2

117 OF 117
March 2, 1995

The bag-in/bag-out process can also be analyzed from an economic standpoint. Consider the following:

- The bag-in/bag-out process is time consuming, thus resulting in added cost of labor to perform the task of filter maintenance.
- The bag-in/bag-out bags are expensive, thus resulting in added costs for operational equipment components.
- The bag-in/bag-out system will result in larger plenums, taller plenums, and the need for stage platforms at three filter high intervals. This is especially true of the recirc plenums.
- Redundant bag-in/bag-out systems require absolute sealing isolation systems in order to work with the confinement bags. Any negativity on the plenum undergoing filter change will collapse the bag making it impossible to extract the filter into the bag. The installation of absolute sealing systems will significantly increase the first cost of the bag-in/bag-out plenums.
- Disposal of filters as TRU waste is more costly than disposal as low-level waste. It makes good economic and engineering sense to survey and pre-determine the method of disposal than just assuming contamination levels and disposing as TRU waste. NMT-8 cannot afford this assumption.

From a DOE Order perspective:

- DOE Order 6430.1A, Section 1550-2.5.5.; Air Cleaning Devices: Requires only that in-place testing of the filters be performed without need for personnel to enter the plenum. As far as I know there is no order eliminating the use of walk-in plenums. I recommend that we research in-depth documents ASME N509, UL 586, ASME N510, and ERDA 76-21 to find discussion with respect to walk-in plenum criteria.

From a testing perspective:

- The need to survey the inlet face of the HEPA filters eliminate the ability to individually challenge each filter unit. Individually challengeable plenums are a manufacturers design feature, not an industry mandate. Again, the filter train must pass the DOS challenge as a unit without the need for personnel to enter the plenum.

Many discussions relevant to NMSF have resulted in comparisons to PF-4 operations. The PF-4 Zone 1 HEPA filters are considered contaminated, thus do not require a pre-removal radiological survey. Filters from this system are removed through a bag-out process. Filters from Zone 2, 2A, and 3 are normally non-contaminated or contamination levels are below maximum threshold levels and therefore handled without the need to "bag-out".

I hope that this paper is of value and answers concerns related to our decision to request walk-in plenums be used in NMSF. Please feel free to contact me if further discussions are necessary.

xc: Jim Corll, NMT-8, MS E583
David Romero, NMT-8, MS E583
Scott Salisbury, ESH-5, MS K486
Carolyn Zerkle, FSS-6, MS E512
Author File
NMT-8 File
IRMC (2)

NMSF CDR

ELECTRICAL SHORT CIRCUIT CURRENT
AT MAIN SWITCHGEAR BUSESDESIGNED BY D. VELARDE DATE 5/11/95CHECKED BY J. ELLERBROCK DATE 5/13/95

ASSUME UNLIMITED MVA AVAILABLE
(WORST CASE)

MAX. FAULT CURRENT IS APPROX. 16,000 AIC AT EACH
SWITCHGEAR BUS. ASSUMING INFINITE PRIMARY SOURCE.

∴ EXISTING 25,000 AIC RATING OF SUBSTATION SWITCHGEAR
BUS IS ADEQUATE.

∴ EXISTING 22,000 AIC RATING OF SWB-A, MCC-A, AND MCC-B
BUSES ARE ADEQUATE.

PROJECT: NMSF CDR
 CALC. TYPE: ELECTRICAL LOAD ESTIMATE
 PERFORMED BY: D. VELARDE
 CHECKED BY: J. ELLERBROCK
 DATE: MAY 23, 1995
 FILE: q:\jae\nmsf\le1

ITEM NO.	LOAD TYPE	LOAD (KVA)		PF (%)	NOTES
		CONNECTED	DEMAND		
1	GENERAL	152.0	126.0	90	1
2	LIGHTING	36.0	36.0	95	1
3	RECEPTACLES	31.0	21.0	95	1
4	OFFICE EQUIPMENT	14.0	14.0	85	1
5	MCC-A:				
5a	VP, 50 HP	51.8	51.8	80	2
5b	FR-2, 40 HP	41.4	41.4	80	2
5c	FE-2, 5 HP	6.1	6.1	80	2
5d	FS-2, 7.5 HP	8.8	8.8	80	2
5e	FE-4, 0.75 HP	1.1	1.1	80	2
5f	FE-5, 1.5 HP	2.1	2.1	80	2
5g	PCW-1, 3 HP	3.8	3.8	80	2
5h	PCW-2, 3 HP	3.8	3.8	80	2
5i	PCW-3, 3 HP	3.8	3.8	80	2
5j	COMP-2, 40 HP	41.4	41.4	80	2
5k	PHW-1, 1.5 HP	2.1	2.1	80	2
5l	PHW-2, 1.5 HP	2.1	2.1	80	2
5m	PHW-3, 1.5 HP	2.1	2.1	80	2
5n	HVA-1, 1.5 HP	2.1	2.1	80	2
5o	CWAC-2, 70 TON	95.3	95.3	80	2
	SUBTOTAL MCC-A	267.7	267.7	N/A	
6	MCC-B:				
6a	VP, 50 HP	51.8	51.8	80	2
6b	FE-1, 5 HP	6.1	6.1	80	2
6c	FS-1, 7.5 HP	8.8	8.8	80	2
6d	FE-3, 0.5 HP	0.8	0.8	80	2
6e	FR-1, 40 HP	41.4	41.4	80	2
6f	COMP-1, 40 HP	41.4	41.4	80	2
6g	CWAC-1, 70 TON	95.3	95.3	80	2
6h	FS-3, 3 HP	3.8	3.8	80	2
6i	VP (OLD), 50 HP	51.8	51.8	80	2
6j	PHW-4, 0.5 HP	0.8	0.8	80	2
	SUBTOTAL MCC-B	301.9	301.9	N/A	
	TOTAL	802.6	766.6		

NOTES:

1. NON-MOTOR LOADS ARE ESTIMATED ACCORDING TO EXISTING BUILDING REQUIREMENTS. FOR CONSERVATIVE ESTIMATING PURPOSES, IT ASSUMED THAT THESE LOADS ARE ALL SERVED FROM SWB-A.
2. MOTOR LOADS ARE ESTIMATED PER UNIT FLA IN ACCORDANCE WITH NEC TABLE 430-150.
3. MAXIMUM DEMAND LOAD ON ONE EXISTING SUBSTATION TRANSFORMER IS THE SUM OF THE DEMANDS ON SWB-A AND MCC-A, OR 464.7 KVA. THIS IS 62% OF EXISTING TRANSFORMER BASE CAPACITY RATING.

JOHNSON CONTROLS WORLD SERVICES LOS ALAMOS SUPPORT SERVICES SUBCONTRACT		FILE NAME		DRAWING NUMBER	
UTILITIES DEPARTMENT		VECADVCKTS/S-9		ES-10	
ELECTRICAL SYSTEM ONE-LINE		S-9 138KV DISTRIBUTION		REVISION DATE	
CHECKED		APPROVED		08/19/93	

ICF KAISER ENGINEERS

1900 Diamond Drive
Los Alamos, New Mexico 87544

DESIGN CALCULATION INDEX

CALC NO SHEET NO

1

JOB NUMBER 41552-056-00

AREA OR BUILDING

CALCULATION DESCRIPTION

DISCIPLINE

JOB TITLE NMSF CDR

TA-55

STORAGE EQUIPMENT INFO.

CALCULATIONS APPLY TO DRAWINGS AND REVISIONS SHOWN

DRAWING	REV	DRAWING	REV	DRAWING	REV	DRAWING	REV

DESIGN ENGINEER

(SIGNATURE)

(DATE)

JOB ENGINEER

(SIGNATURE)

(DATE)

CALCULATIONS CHECKED

(SIGNATURE)

(DATE)

DESIGN SUPERVISOR

(SIGNATURE)

(DATE)

CALCULATIONS AGREE WITH DESIGN CRITERIA

(SIGNATURE)

(DATE)

CALCULATIONS AGREE WITH APPVD. VENDOR DWGS.

(SIGNATURE)

(DATE)

CALCULATION KEYS

DATES

DATES

DATES

DATES

REVISION DESCRIPTION

90 CDR

3/95

100% DRAW CDR

5/95

DESIGN ENGINEER

DWP

5/95

DESIGN SUPERVISOR

C.A.E.

5/95

STATUS

PRELIMINARY

FINAL

CHECK

VOID

HOLD

OTHER

REASON FOR VOID OR HOLD:

INDEX

SHEET NO.

DESCRIPTION

1.

Index

2-6

STORAGE EQUIPMENT INFORMATION & NOTES
including container info & sketches

7-39

Calculations and Estimate Notes for the following:
STORAGE BASKETS, SHIELD PLUGS, DRYWELLS, charge deck
ETC.

40-49

Crane and Hoist Information

50-52

Tube Handling Machine and other
BFE QUOTE

53-58

Facility Monitoring System
Estimate Notes

**STORAGE EQUIPMENT
INFORMATION AND NOTES**

**PRODUCT CONTAINER INFORMATION
AND SKETCHES**

A.Pu OXIDE CONTAINER

- ALREADY DESIGNED AND IN USE. (SS 304L)
- WILL BE PRIMARY STORAGE CONTAINER @ NMSF
- NEED TEST DOCUMENTATION
- PROVIDES CONFINEMENT & LIMITED PHYSICAL PROTECTION.

- PRODUCT CONTAINER IS NOT RESTRAINED INSIDE BOUNDARY
- WEIGHT OF CONTENTS IN EACH IS NOT UNIFORM.
- STORE IN TUBES

B. PIT CONTAINER

- AT 400 A - WEAPONS MATERIAL
- CURRENTLY IN USE @ SANDIA & PANTEX
- LOUISE O'BRIEN MAY HAVE TEST DOCUMENTATION, SOME IS CONTAINED IN WESTINGHOUSE DATA.

- 400°F / 100 PSIG DESIGN LIMITS
- STORE IN TUBES

DESIGNED BY

DROF

DATE

4/2

CHECKED BY

DATE

C. URANIUM CONTAINER

- 1/2 CONTAINER @ OAK RIDGE
- NO DATA AVAILABLE YET
- NO PROBLEMS W/
 - CRITICALITY
 - HEAT
- MAY BE STORED IN
 - TUBES
 - SHELVES
- NO PACKAGING PROGRAM FOR URANIUM EXISTS YET.

**STORAGE BASKETS, SHIELD PLUGS,
DRYWELLS, CHARGE DECK, ETC.**

CALCULATIONS AND ESTIMATE NOTES

SHEET 8 OF

DATE _____

DATE _____

NHSE

JOB NO. 41552-030

SHEET 9 OF

DESIGNED BY NHSE DATE 2/95

CHECKED BY _____ DATE _____

21" WELDED

CONCRETE
FIN-
CAST
PAPERES
ERECTION

1" ϕ
BETWEEN

21" x 2"
FLANGE
WELDED TO
DECK

2'-0"

2'-0"

2'-6"

SECTION - CHARGE FACE DECK

SHEET 10. OF

DESIGNED BY

DATE _____

CHECKED BY

DATE _____

[illegible]

NEW INFILTR
BETWEEN
COLUMNS
ON 1ST FLOOR

201-0113
N

EXIST 11/4"

Q. 7281

١٠٠٠

28-41

DESIGNED BY VGS DATE 11/1/01

CHECKED BY _____ DATE _____

NMSE

DRYWEAR RAIL

SHEET 12 OF

CHECKED BY _____ DATE _____

O-RING
SEAL

FLANGE /
WELDED
TO CARTRIDGE
W/ THREADED
HOLES

15" O.D. x 1/4" t_w
CAPSULE

LENGTH VARIES
7'-0" MAX.

FBI
ONLY -
will
NOT VAS

8th

 $3\frac{1}{2}$

TERTIARY CAPSULE

$$(QTY = 7020)$$
[illegible]

NMSP

JOB NO. 4152-056

SHEET 13 OF

DESIGNED BY DROP DATE 2/95

CHECKED BY _____ DATE _____

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PIPE PLUG &
MONITORING
PORT

THREADED INSERT
FOR 1" ϕ LIFTING
LUG.

CONCRETE/CAST IRON
SHIELD PLUG.

SECTION

(SEE "P." DWGS IN PART IV FOR
FINAL DIMENSIONS)

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JOB NO. 41552-056

SHEET 15 OF

DESIGNED BY

DATE _____

CHECKED BY

DATE _____

CHARGE DECK - WELD DETAILS

- JOIN ① & ② IN FIELD
- WELD ERECTION PL'S IN SHOP.
- DECK SECTIONS 8'-0" WIDE ± (130LF/18)

ENVIRONMENT & ENERGY GROUP

JSIN

JOB NO. 41552-056

17 SHEET OF

DESIGNED BY 1054 DATE 1/13

CHECKED BY _____
DATE _____

ESTIMATE # PASSES FOR $3\frac{1}{8}"$ RUN

6 PASSES PER WELD

6 STOP WORDS FOR WEB JOINT

36 PASSES PER LF OF WEB JOINT IN SHOP.

$$DEC = 28^{\circ} - 4^{\circ} = 24^{\circ}$$
$$102048 / \text{POINT} = (36) (33' 32'')$$

81 SECTIONS 218 TO 219

$$1020 \times 81 = 83604$$

JOINT WORKS

SHEET 18 OF

DATE.

DATE _____

1/8" ELECTRODE

$20 \times 3 = 60$ PASSES

$$(64 \text{ PASSES})(28.33 \text{ FT/JOINT})(18 \text{ JOINTS})$$

= 32,686, LF OF WORD
PASSAGE

13 782 55541815 111111 55541815
42 881 505151511111 55541815
42 881 105151511111 55541815
47 883 205151511111 55541815
47 883 305151511111 55541815
42 882 405151511111 55541815
42 882 505151511111 55541815

20
DWR 2/95

JOINT DETAIL

FROM MEANS - 1995 -
CONSTRUCTION COST DATA -
PAGE 130

$$\frac{1}{8}'' \text{ PASS} = 0.033 \text{ HRS/FT.}$$

$$\frac{414''}{12''/\text{FT}} = 34.5 \text{ FT}$$

$$(34.5)(0.033) = 1.139 \text{ HRS -}$$

PER WELD.

SAY IT TAKES 4 HRS, INCL. NDT
TESTING - PER LOCATION

$$(509 \text{ WELDS})(4) \left(\frac{\$}{50/\text{hr}} \right) = \underline{\underline{\$101,800}}$$

LABOR

MATERIAL 0.1# LF.

$$(0.1)(34.5)(509) = 1760\#$$

$$(1760\#)(0.10) = \underline{\underline{\$176}}$$

22
~~2195~~

EQUIPMENT

$$\$0.32/\text{FT} \times 34.5 \times 509 = \$5619.4$$

$$\text{LABOR} = \$101,800$$

$$\text{MAT'L} = \$176 -$$

$$\text{EQUIP} = \underline{5619.40}$$

$$\$107,595$$

(COULD BE \$250,000 w/ CONTINGENCY)

SEE PART VII - ESTIMATE FOR
FINAL COST

CONCEPTUAL ESTIMATE

PASSIVE COOLING
STORAGE ARRAY ESTIMATE

NOT FOR PUBLIC DISSEMINATION

May contain unclassified nuclear information "UC/NF" subject to
to Section 148 of the Atomic Energy Act of 1954, as amended (42 USC
2186). Approval by Department of Energy prior to release is required.

ITEM NO.	DESCRIPTION	WBS	QUANTITY	UNITS	UNIT COST MATERIALS	LABOR FACTOR	* LABOR RATE	LABOR TYPE	EQUIPMENT RENTAL	TOTAL COST
SPECIAL FACILITIES EQUIPMENT										
1.	CHARGE FACE DECK									
	STEEL - READY TO ASSEMBLE, IN PCS		420000.00	LBS	0.70	0.000	0.00	0.00	0.00	294,000
	WELD ASSEMBLY - AUTO WELDED (20"/MIN)		18357.84	LF	0.10	0.100	27.93	85	0.25	57,699
	FIT AND ALIGN		420000.00	LBS	0.00	0.003	27.93	85	0.25	140,192
	WELD AND FIT INSPECTION		18357.84	LF	0.00	0.050	27.93	85	0.10	27,473
	FILL DECK WITH CONCRETE (SHIELDING)		238.60	CY	100.00	0.500	17.02	504	2.00	26,368
	DELIVER STEEL VIA TRUCK (10 DAYS)		18.00	EA	0.00	0.000	0.00		3500.00	63,000
	RIGGING & ERECTION THRU END WALL		1.00	EA	0.00	160.000	27.93	85	0.00	4,469
	RIGGING - CRANE OPERATOR		1.00	EA	0.00	40.000	18.84	53	13800.00	14,354
	FIELD WELD TOP SECTIONS W/ FULL PEN WELD USING 1/8" ROD (8'x28' SECTIONS)		32636.16	LF	0.10	0.033	27.93	85	0.32	43,788
	64 PASSES PER LF OF JOINT, SEMI-AUTO									
	FIEL WELD BOTTOM SECTIONS W/ FULL PEN WELD WITH 1/8" ROD (8'x28' SECTIONS)		32636.16	LF	0.10	0.050	27.93	85	0.32	58,828
	64 PASSES PER LF OF JOINT - OH WELD									
	USE SEMI-AUTOMATIC MACHINE									
	FIELD WELD INSPECTION		65272.32	LF	0.00	0.025	27.93	85	0.10	52,104
	MISCELLANEOUS GRINDING/FITTING/ETC.		60000	LF	0.00	0.010	27.93	85	0.10	22,758
2.	BRIDGE CRANE - 20 TON									
	INSTALL CRANE		1.00	EA	100000.00	420.000	27.93	85	0.32	111,731
	INSTALL CRANE BEAMS		280.00	LF	75.00	1.500	27.93	85	5.00	34,131
	INSTALL BRACKETS		56.00	EA	100.00	6.000	27.93	85	1.00	15,040
	FORKLIFT TO ERECT BEAMS AND BRACKETS		2.00	WKS	0.00	40.000	18.84	53	600.00	2,707
	SCISSOR LIFT - MAKE CONNECTIONS/PAINT		3.00	WKS	0.00	0.000	0.00		300.00	900
	PAINT CRANE RAILS AND BRACKETS		5100.00	SF	0.20	0.012	21.79	57	0.02	2,456
	FIT AND ALIGN CRANE		1.00	WKS	0.00	240.000	27.93	85	0.00	6703
3.	TUBE HANDLING MACHINE & ASSOC. EQUIP									
	TUBE HANDLING MACHINE		1.00	EA	1000000.00	0.000	0.00		0.00	1,000,000
	PLUG PULLERS		2.00	EA	25000.00	0.000	0.00		0.00	50,000
	SHIELDING VALVE		2.00	EA	300000.00	0.000	0.00		0.00	600,000
	CCTV/ILLUMINATION/BAR CODE READER		1.00	EA	100000.00	0.000	0.00		0.00	100,000
4.	MATERIAL X-FER AIRLOCKS - BASEMENT		1.00	EA	100000.00	0.000	0.00		0.00	100,000
5.	CONTAINER BASKETS (W/ EXTRAS)		550.00	EA	1000.00	0.000	0.00		0.00	550,000
6.	ALUMINIZED STEEL STORAGE DRYWELLS									
	18" DIA X 17'-1" (825#/EA @ \$1.90/#)		550.00	EA	3135.00	0.000	0.00		0.00	1,724,250
	FLANGES - 1"x2"x18 I.D WELDED TO TUBE		550.00	EA	20.00	3.000	27.93	85	12.00	63,685
	SOCKETS/PINS & FASTEN TO FLOOR		550.00	EA	75.00	0.500	15.71	45	1.56	46,428
	CONC SH'LD PLUGS (800 #/EA)		550.00	EA	225.00	0.000	0.00		0.00	123,750
	INSTALL TUBES		550.00	EA	0.00	0.250	27.93	85	5.00	6,590
	WELD/FASTEN TUBES TO DECK		550.00	EA	3.00	3.000	27.93	85	12.00	54,335
SUBTOTAL SPECIAL FAC. EQUIP.										\$5,397,736

ESTIMATE WAS
REVISED IN COST-PRO

41174717471

(4)

23

VENDOR QUOTE

JOB TITLE: UNISE

DISCIPLINE: STORAGE AREA

NAME: CRAIG H.

DATE: 3/13/95

VENDOR: LABARGE PIPE & STEEL CO.

NAME: MIKE KELLEY

PHONE: (800) 522-2743

DESCRIPTION:

ITEM:

COST: (\$)

18" ϕ x 1/4" ASTM 53, 515 @ 17'3" = \$375 ea = \$21.74/LF

\$21.74/LF

18" ϕ x 1/2" ASTM 53, 515 @ 17'3" = \$782 ea = \$45.33/LF

\$45.33/LF

COMMENTS:

1/4" WALL FROM ALABAMA OR ST. LOUIS

1/2" WALL FROM ST LOUIS

ICF KAISER ENGINEERS

1900 Diamond Drive
Los Alamos, New Mexico 87544

VENDOR QUOTE

25

JOB TITLE: NMSE RENOVATION

DISCIPLINE: SFE- CHARGE DEUT

NAME: DKOP

DATE: 3/95

VENDOR: USX (US STEEL)

NAME: NANCE PARKS

PHONE: 219-888-7250

GARY WORKS

DESCRIPTION:

ASTM A36 STEEL PLATE ~ 1" THICK
IN 9'-0" WIDE SECTIONS X 28' LONG.

ITEM:

COST: (\$)

ASTM A36 PLATE

\$0.235/

WILL COME W/ CERTS &
PEDIGREE

LB

COMMENTS:

ADD \$ 0.20/LB FOR FABRICATION - CUT &
PUNCH HOLES - BASED ON MEANS
FABRICATE PRICE OF \$0.50/LB - HOWEVER
PLATE WILL BE EASIER - ELONGMENT
OR SCALE

ADD \$ 0.10/LB FOR NO. 4-1 CERTS AS
A CONTINGENCY - UNKNOWN.

ICF KAISER ENGINEERS

1900 Diamond Drive
Los Alamos, New Mexico 87544

Dec 26
7/13/74
41552-044-00

- VENDOR QUOTE -

5% TUBES @ \$3/5

VMI, INC. ALSO NY.
1-800-234-7675

- 5% \$3/5 #1.65/ #1.90/ #

- TUBE SHOULD NOT BE MUCH MORE
EXPENSIVE.

- SC# 10 B 1/4" W/ALU.

- WITH S&P QUOTE VIA FAX.

SHEET 27 OF

CHECKED BY _____ DATE _____

CHECK SHEAR AROUND TOP OF
PLUG = (SEE ATTACHED SECTION)

[illegible]

SECTION A A

SEE
PART IV - DWGS
FOR FINAL DIMENSIONS

SHEET 30 OF

DESIGNED BY

DATE _____

CHECKED BY

DATE _____

DWIKOS5	HWA01EDJRI002	FAC-27
DWIKOS5	HWA01EDJRI001	RES-27
DWIKOS5	FY1A1SIBR5WR	GNE-27
DWIKOS5	FY1A1SIBR5WH	ZOT-28
DWIKOS5	FY1A1SIBR5W	HR-28
DWIKOS5	HIN031DSCRF	07Z-FI

WT OF STEEL. = APPX 490 LB/FT³

$$V_{\text{I}} = \left(\frac{8.5}{12} \right)^2 \pi \times 1.16 = 1.83$$

$$V_{II} = \left(11.5/12\right)^2 \pi \times 0.67 = \frac{1.933}{3.76 \text{ ft}^3}$$

$$3.76 \times 490 = 1843^{\#}$$

TOO HEAVY. - TRY SOMETHING
ELSE.

JOB NO.

SHEET 31, OF

DESIGNED BY.

DATE.

CHECKED BY

DATE

TRY CONCRETE ?

INCREASE $V(I)$ THOUGH W/ LENGTH OF $Z^I - Z^H$

$$V_I = \left(\frac{8.5}{2}\right)^2 \pi \times 2.16 = 341$$

$$V_{\text{TOTAL}} = 3.41 + 1.93 = 5.34 \text{ m}^3$$

$$(5.34)(150 \#/\pi^3) = 301 \#/ea.$$

$$5.34/27 = 0.20 \times 10^3$$

Marshall S. A.

NMSE

JOB NO. 41552-052

SHEET 32 OF

DESIGNED BY DDE DATE 2/95

CHECKED BY DATE

EVALUATE OVERTURNING ON MACHINE
(PRELIMINARY)

$$M = 8 \times 40 \times 0.30 = 96 \text{ ft-k}$$

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NMSEF

JOB NO. 41552-056

SHEET 33 OF

DESIGNED BY

DJP

DATE

2/95

CHECKED BY

DATE

FIND LOAD ON LEG =

$$96 \text{ FT} - K / 4 \text{ FT} = 24K \text{ (MAX)}$$

USE 30K MAX LOAD.

ON PLUG COVER

EVALUATE LOAD ON LIP OF PLUG ?

$$r_o = 11 \frac{1}{2}$$

$$r_i = 9"$$

$$r_{AVG} = 10.25$$

$$\text{BEARING AREA ON LIP} = (2)(\pi)(10.25)(2.5)$$

$$A_{BRG} = 161 \text{ in}^2$$

(ANNULAR RING)

BEARING STRESS ON RING σ_c

$$\frac{30,000 \text{ lb}}{161 \text{ in}^2} = 186.3 \text{ psi}$$

(low)

PER AISC ALLOWABLE BEARING FROM
STEEL TO CONCRETE = $0.35 f'_c$

$$U_{\alpha} = f'_c = 5,000 \text{ psi}$$

$$F_p = (0.35)(5000) = 1750 \text{ psi.}$$

BEARING B OR.

CHECK SHEAR ?

$$\phi V_c = (0.75)(2)\sqrt{f'_c} \text{ bwd}$$

$$b_w = z^{1/2} z^w$$

$$\phi V_c = (0.75)(2)(5000)^{1/2}(2.5)(8)$$

$$\phi V_c = 2121 \text{ psi (UNREINFORCED)}$$

JOB NO.

SHEET 35 OF

DESIGNED BY

DATE _____

CHECKED BY

DATE _____

SHEAR B OZ.

CONCRETE RUG ($f'_c = 5000$)
WILL BE SATISFACTORY.

42 762	42 762 15	141111	5 554111
42 761	42 761 15	141111	5 554111
42 760	42 760 15	141111	5 554111
42 759	42 759 15	141111	5 554111
42 758	42 758 15	141111	5 554111
42 757	42 757 15	141111	5 554111
42 756	42 756 15	141111	5 554111

May 2011 2 A

SHEET 36 OF

DATE _____

DATE _____

SHIELD: RUC ESTIMATE

<u>ITEM</u>	<u>MAT'L</u>	<u>LAB</u>	<u>EQUIP</u>	<u>TOTAL</u>
a.) BUILD FORM	1000 ^{sq}	1340.64	700 ^{sq}	3040.64
b.) CONDUIT	4125 ^{sq}	3840.38	0	7965.38
c.) REINF.	16,500 ^{sq}	0	0	16500.00
d.) FAB REINF	0	1536.50	2750 ^{sq}	18,111.50
e.) INSERT	27,300	0	0	27,500
f.) INSTALL INSERT	550 ^{sq}	7680.75	0	8230.75
g.) ALIGN/CHECK	0	7680.75	0	7680.75
h.) OIL	550 ^{sq}	1468.89	0	2018.89
i.) POUR	825 ^{sq}	6028	0	14,278
j.) STRIP	550 ^{sq}	4320.25	0	4870.25
k.) GRIND	0	6028	550	6578
l.) LOAD	0	864.05	0	864.05

\$ 117,638.24

BRWRS5	INVA 1112.1	606.2
BRWRS4	INVA 1112.0	616.4
BRWRS3	INVA 1112.1	606.2
BRWRS2	INVA 1112.1	606.2
BRWRS1	INVA 1112.1	606.2
BRWRS0	INVA 1112.1	606.2

1.5.

DATE: 3/5/95

1907 Diamond Drive
Los Alamos, New Mexico 87544

ICF KAISER ENGINEERS

W
O

ASSUMES THAT PLUGS ARE FABRICATED IN A SHOP &
PRECAST.

سفر 2

DATE: 3/5/95

1900 Diamond Drive
Los Alamos, New Mexico 87544

ICF KAISER ENGINEERS

39

CRANES AND HOISTS

COST ESTIMATING TAKEOFF FORM

JOB TITLE: NMSF RENOVATION

NAME: D. J. K.

DATE: 3/95

ESTIMATE DESCRIPTION: JIB CRANE & HOIST

JOB #: 41552 - 076 - 000

ICF KAISER ENGINEERS

1900 Diamond Drive
Los Alamos, New Mexico 87544

ITEM #	CSI WBS	DESCRIPTION	QTY.	UNITS	MATERIALS (COST/UNIT)	MAN HRS PER UNIT	LABOR ID	EQUIP. RENTAL
	ECLL	PACK/UNPACK ~ STAGING AREA						
1.		JIB CRANE (FRAME) (QUOTE)	2	ea	1300-			
2.		1 TON ELECT HOIST.	2	ea	1300-			
3		TROLLEY	2	ea	200-			
4.		INSTALL CRANE & ASSEMBLE FRAME	2	ea	100	16	85/ 29.62	-
5.		POWER TO CRANES	2	ea	500	16	65/ 30.31	-

COMMENTS:

ELECTRIC CHAIN HOISTS AND TROLLEY

MATERIAL HANDLING

ISTS

ry cycle
ches
t control cord

3/4"D x 12 3/4" L

ic Chain Hoists are suit-
es, castings, heavy parts,
odel is double-chained.
olling "UP-OFF-DOWN"
duty cycle provides 6
cadroom requirement is
42811. Includes 12", 3-
tallation to 115V, 60 Hz
95). Dayton brand.

List	Each	Shpg. Wt.
342.71	\$439.20	23.0
634.21	\$537.47	30.0

a variety of shop loads
" headroom. Includes
ple installation. Ther-
e permanent split ca-
id. Intermittent
time per hour.
latch-type safety
60 Hz pushbutton
operation. Made in

Min. Dist. Between Hooks	Motor HP	Amps
14 1/2"	1/6	3.0

ING DATA

List	Each	Shpg. Wt.
10.83	\$492.23	20.0

to be used for lifting
people, or lifting loads.

INERS

Each	Shpg. Wt.
\$28.64	2.9

31.61	4.1
61.58	6.1

1/2, 1, 2-TON ELECTRIC CHAIN HOISTS

1/2 and 1-Ton
Models Feature
Single Chain Lift

2-Ton Models
Equipped with
Double Chain Lift

- Lubricated for life
- Case-hardened steel chain
- Latch-type hooks on top and bottom
- 24V pushbutton control
- Motors available in 1/2 or 1-HP and single or 3-phase

These hoists have construction feature usually found only in the most expensive industrial models. Overload limiting clutch. Totally enclosed motors meet rigid hoist requirements. Quick connect terminals and wiring diagrams enable easy voltage change. Housing and frame of tough die-cast aluminum alloy constructed in sections to permit easy access to electrical controls. Oil-filled transmission provides optimum lubrication and heat dissipation. Dayton brand.

CAUTION: Hoists listed below are not to be used for lifting, supporting or transporting people, or lifting loads over people.

Maximum Capacity	Motor HP	Phase	Volts* 60 Hz	Amps at Low Voltage	Chain Lift	Lift Speed Ft/Min	Control Cord	Min. Dist. Between Hooks	Housing Dimensions L W D	Stock No.	List	Each	Shpg. Wt.
1/2 Ton	1/2	1	115/230	9.8	10 Ft	16	6 Ft	18"	21 3/4" 8 3/4" 7 1/2"	32370	\$1150.73	\$975.19	77.0
1/2	1/2	1	115/230	9.8	15	16	11	18	21 3/4" 8 3/4" 7 1/2"	32923	1286.30	1090.09	80.0
1/2	1/2	1	115/230	9.8	20	16	16	18	21 3/4" 8 3/4" 7 1/2"	32924	1324.67	1122.60	83.0
1/2	1	1	115/230	18.0	10	32	6	18	23 3/4" 8 3/4" 7 1/2"	42579	1335.39	1131.69	88.0
1	1	1	115/230	18.0	10	16	6	18	23 3/4" 8 3/4" 7 1/2"	32372	1306.83	1107.48	91.0
1	1	1	115/230	18.0	15	16	11	18	23 3/4" 8 3/4" 7 1/2"	42580	1463.06	1239.88	96.0
1	1	1	115/230	18.0	20	16	16	18	23 3/4" 8 3/4" 7 1/2"	32874	1533.15	1299.28	101.0
1	1	3	230/460	3.3	10	8	6	22	21 3/4" 8 3/4" 7 1/2"	32373	1306.83	1107.48	84.0
1	1	3	230/460	3.3	15	8	11	22	21 3/4" 8 3/4" 7 1/2"	32925	1463.06	1239.88	80.0
2 Ton	2	1	115/230	18.0	10	8	6	22	23 3/4" 8 3/4" 7 1/2"	32374	1605.98	1361.00	100.0
2	2	1	115/230	18.0	15	8	11	22	23 3/4" 8 3/4" 7 1/2"	32926	1915.25	1623.09	108.0
2	2	1	115/230	18.0	20	8	16	22	23 3/4" 8 3/4" 7 1/2"	32927	2055.19	1741.69	116.0
2	2	3	230/460	3.3	10	8	6	22	21 3/4" 8 3/4" 7 1/2"	32375	1605.98	1361.00	90.0
2	2	3	230/460	3.3	15	8	11	22	21 3/4" 8 3/4" 7 1/2"	32928	1915.25	1623.09	98.0

*Single phase hoists are wired for 115V, 60 Hz operation; three phase hoists for 460V, 60 Hz operation. Hoist easily reconnects for use at 230VAC.

FREE WHEELING TROLLEYS FOR HOISTS

- Adjustable to fit standard dimension I-beams
- Wheels are smooth running and resist wear

Dayton low headroom trolleys are designed for use with electric, air, and manual overhead hoists. Hardened pressed steel wheels have carburized treads to resist wear. Wheels run on ball bearings for smooth operation. Side plates extend beyond wheels to act as bumpers. Adjustable to fit standard dimension I-beams. Refer to dimensions below. Dayton brand.

FREE WHEELING TROLLEY SPECIFICATIONS AND ORDERING DATA

Capacity	Clearance Dimensions in inches										Fits I-Beam		Min. Radius	Stock No.	List	Each	Shpg. Wt.
	A	B	C	D	E	F	G	H	K Dia	M	Vert. H	Horiz. W					
1/2 Ton	4 1/2"	6"	4 1/4"	3 1/4"	1 1/4"	1 1/4"	3 1/4"	3 1/4"	7 1/4"	9 1/4"	4-10"	2.66-4.66"	24"	22615	\$98.63	\$85.88	20.0
1 Ton	5 1/2"	8 1/4"	5"	4 1/4"	1 1/4"	1 1/4"	2 1/4"	4 1/4"	1 1/4"	11 1/4"	5-12"	3.00-5.25"	36"	22616	132.41	116.80	30.0
2 Ton	6 1/2"	7 1/4"	5 1/4"	4 1/4"	1 1/4"	1 1/4"	2 1/4"	4 1/4"	1 1/4"	13 1/4"	6-18"	3.33-6.00"	48"	22617	191.95	168.05	44.0

SEE WARRANTY INFORMATION ON PAGE OPPOSITE INSIDE BACK COVER

**MATERIAL
HANDLING**
**300 AND 500 LB ELECTRIC HOISTS
AND CHAIN CONTAINERS**
Dayton 300 AND 500 LB ELECTRIC CHAIN HOISTS

No. 42811
500 Lb Capacity

No. 42358
300 Lb Capacity

MOTOR
1/6 HP, 3.0 Amp,
3300 RPM,
115V, 60 Hz,
Ball Bearing,
Permanent Split
Capacitor

**90-DAY DAYTON
LIMITED
WARRANTY**

Text of warranty available
on request. See
"Manufacturers' Warranties" on page
opposite inside back
cover.

- Standard 10 ft lift
- Intermittent duty—10% duty cycle
- Upper and lower limit switches
- Pushbutton control with 6 ft control cord
- 7/32" steel chain
- Latch-type swivel hooks
- Overall dimensions: 6W x 4½D x 12¾"L

Dayton Compact Multi-Purpose Electric Chain Hoists are suitable for rapid lifting and spotting of dies, castings, heavy parts, assemblies, and other loads. 500 lb model is double-chained. 115V, 60 Hz pushbutton switch for controlling "UP-OFF-DOWN" operation. Reliable disc brake. 10% duty cycle provides 6 minutes "ON" time per hour of use. Headroom requirement is 14½" for No. 42358, and 16" for No. 42811. Includes 12", 3-conductor cord for simple plug-in installation to 115V, 60 Hz outlets. Made in USA. UL Listed (SA5495). Dayton brand.

Load Rating	Full-Load Lift Speed Ft/Min	Min. Dist. Between Hooks	Stock No.	List	Each	Shpg. Wt.
300 lbs	16	14½"	42358	\$542.71	\$439.20	23.0
500	8	16	42811	634.21	537.47	30.0

Dayton 500 LB ELECTRIC WIRE ROPE HOIST

PARTS AVAILABLE
CALL
1-800-323-0628

- Lightweight, compact 1/8" steel wire rope
- 115V, 60 Hz, 1/6 HP motor and disc brake
- 10 ft lift with 10 ft/min lift speed
- Upper travel limit switch
- Intermittent duty—10% duty cycle
- Permanent split capacitor motor

**90-DAY DAYTON
LIMITED WARRANTY**

Text of warranty available on request. See
"Manufacturers' Warranties" on page
opposite inside back cover.

Dayton Electric Wire Rope Hoist handles a variety of shop loads with cost effective ease. Needs only 14½" headroom. Includes 12" power cord and 3-prong plug for simple installation. Thermally protected, 3300 RPM, ball bearing, permanent split capacitor motor draws only 3 amps under full load. Intermittent duty rated at a maximum of 6 minutes "ON" time per hour. Standard features include: top and bottom latch-type safety hooks; 10-ft lift with 6-ft control cord; 115V, 60 Hz pushbutton switch for controlling "UP-OFF-DOWN" operation. Made in USA. UL Listed (SA5495). Dayton brand.

SPECIFICATIONS

Load Rating	Type Lift	Full-Load Lift-Speed	Lift Feet	Min. Dist. Between Hooks	Motor HP	Amps
500 lbs	1/8" Steel wire rope	10 ft/min	10	14½"	1/6	3.0

WIRE ROPE HOIST ORDERING DATA

Load Rating	Dimensions L W D	Stock No.	List	Each	Shpg. Wt.
500 lbs	12¾" 6" 4¾"	22668	\$580.83	\$492.23	20.8

CAUTION: Hoists listed above are not to be used for lifting, supporting or transporting people, or lifting loads over people.

For Use with Dayton
1/2, 1, & 2-Ton
Electric Chain Hoists
Listed on Page 1233.

Keeps Surplus Chain
Away from Work Area

Suspended from
Bottom of Hoist

Dayton COIL CHAIN CONTAINERS

Bucket Height	Recommended For Use With: Hoist Capacity	Chain Lift in Feet	Stock No.	List	Each	Shpg. Wt.
11½"	1/2-Ton 1-Ton 2-Ton	10-15-20-25 10-15-20 10	22618	\$37.23	\$28.64	2.9
18½"	1-Ton 2-Ton	25 15	22619	41.10	31.61	4.1
27"	2-Ton	20-25	22620	80.05	61.58	6.1

ELECT

Maximum Capacity	Motor HP	Ph
1/2 Ton	1/2	1
1/2	1/2	1
1/2	1/2	1
1	1	1
1	1	1
1	1	1
2	2	1

(*) Single phase hoists

Capacity Tons	A
1/2	4½"
1	5½"
2	6½"

VENDOR QUOTE

44

JOB TITLE: NMSE

DISCIPLINE:

NAME: CRAIGER

DATE: 3/13/95

VENDOR: NCCI

NAME: RON LUDY

PHONE: 1-800-366-7560

DESCRIPTION:

513 CRANE

ITEM:

COST: (\$)

513 CRANE 1 TON, 8' REACH.

1,292.00

COMMENTS:

SEE ATTACHED FAX.

ICF KAISER ENGINEERS

1900 Diamond Drive
Los Alamos, New Mexico 87544

SERVING YOU WORLDWIDE

NORTH AMERICAN HEADQUARTERS

NATIONAL CRANE AND COMPONENTS INC.

7248 COMMERCE DRIVE TEL 216-975-8560
P.O. BOX 479 TOLL FREE 1-800-388-6560
MENTOR, OHIO 44031 USA TELEFAX 216-951-4334

DATE: 3-13-95

COMPANY: KISER ENG

FAX NUMBER: 505-661-5222

NUMBER OF PAGES (Including This Page): 3

PLEASE FORWARD THIS MESSAGE TO: MR HERLEY

MESSAGE: AS REQ

3802-0810 @ 1,292.00 FOB FRT COLLECT MENTOR, OH.
2 WEEKS A.R.O.

Ron Ivory

FROM:

NATIONAL CRANE AND COMPONENTS INC.

"SERVING YOU WORLDWIDE"

JIB CRANES

MODEL 360-B

NORTH AMERICAN HEADQUARTERS

7249 COMMERCE DRIVE

P.O. BOX 479

MENTOR, OHIO 44061 U.S.A.

NATIONAL CRANE AND COMPONENTS, INC.

SCALE:

APPROVED BY

DRAWN BY

DATE:

JIB CRANE CONCRETE FOUNDATION

DRAWING NUMBER

USED ON 3B02-0810

NIMSE

JOB NO. 41552-056

SHEET 48 OF

DESIGNED BY

DVDF

DATE

3/95

CHECKED BY

DATE

BRIDGE CRANE SUPPORT

- REFERENCE STRUCTURAL / SEISMIC CALCULATIONS
- LOCATED IN CHARGE HALL
- REVISE BEAM SIZES ASSUMING DESIGN WILL BE REFINED.

WEST WALL

EAST WALL

COST ESTIMATING TAKEOFF FORM

JOB TITLE: NMSE RENOVATION

NAME: DVD #

DATE: 3/95

ESTIMATE DESCRIPTION: BRIDGE CRANE INSTAL.

JOB #: 41552-056-00

ICF KAISER ENGINEERS

1902 Diamond Drive
Los Alamos, New Mexico 87544

ITEM #	CSI WBS	DESCRIPTION	QTY.	UNITS	MATERIALS (COST/UNIT)	MAN HRS PER UNIT	LABOR ID	EQUIP. RENTAL
		WEST SIDE BRIDGE CRANE BEAM						
1.	E2311	INSTALL CRANE BEAMS HORIZONTAL BRACE 2 - W 27x 14's (INSTEAD (WEST WALL) OF x 27)	260	LF	58.50	1.50	85/29.62	2.50
2		1 - W 24x 131 BEAM (130LF)	130	LF	67.00	1.50	85/29.62	2.50
3		1 - 60# RAIL (130LF)	260	LF	15.00	0.50	85/29.62	1.00
4.		W 24x 131 (EAST WALL)	130	LF	67.00	1.50	85/29.62	2.50
5.		INSTALL BRACKETS	50	ea.	100.00	6.00	85/29.62	1.00
6		INSTALL CRANE - PER QUOTE FROM VENDOR	1	ea	100,000			

COMMENTS:

49

**CONTAINER HANDLING MACHINE AND
OTHER SFE - QUOTES AND MISC INFO**

**SEE MATERIAL HANDLING SECTION
FOR EQUIPMENT DESCRIPTIONS**

ICF KAISER ENGINEERS, INC.
1900 DIAMOND DRIVE
LOS ALAMOS, NM 87544
505/661-5200
FAX: 505/661-5222

FAX MEMORANDUM

FAX NUMBER: (303) 790-7757

NO. PAGES: 2

Date: February 7, 1995

To: Cliff Noll, Foster Wheeler

From: David O'Flynn, (505) 661-5274

Subject: TUBE HANDLING MACHINE

Copies To: File

41552-056-00

We are making painful progress on the CDR, but are moving forward and hope to be done soon. I think we got the criticality and thermal issues solved. I am moving into the estimating phase and am also describing the special facilities equipment.

I would like to get a quote (informal, but something in writing to provide credibility) from FW on a tube handling machine. The tube handling machine should be capable of:

1. Neutron Shielding - I will find out specifics if you need, but it has to be a hydrated material (polyurethane, polyethylene?) equivalent to 3 ft. of concrete supplemented with about 4-1/2% boron 10.
2. Has to operate remotely and also from a pendant.
3. Will be supported and moved via a bridge crane (capacity of crane will be determined when weight of tube handling machine is finalized).
4. Has to haul up a basket with 5 containers, total length of assembly on the order of 7'-6". The diameter of the basket, will be about 17".
5. The machine can be bolted to the charge face deck
6. Provide a shielding valve on the bottom.
7. The maximum headroom in the Hall is 16'-9". I will need room for the crane (say 5 ft.) and room for a shield valve (2'-6"?), so that leaves about 9'-3" for the machine. I can adjust the dimensions somewhat. I can also provide 3'-5" from the centerline

2/14/95
CLIFF NOLL
2/14/95

200,000 TO 1,500,000 (CONSERVATIVE)

CONFIRMED
QUOTE w/ CLIFF NOLL
FW ON 2/14/95

of the drywell to the face of the interior walls.

Please also provide pricing for the following options:

1. Airtight shielding valve on the bottom of the machine. (INCLUDED.)
2. CCTV, low level illumination, and barcode reader on the inside. \$100K - 200K
3. Shielding valves and plug pullers, similar to what I saw at Ft. St. Vrain.
VALVE = 300K - 400K, PLUG PULLER \$25K - 50K
4. HEPA filter on the machine to pressurize the drywell.
\$20,000

As I mentioned, I am not looking for to the penny numbers, but something I can be relatively confident in for LANL to establish a budget. If you have doubts, please add contingency. If possible, please provide this information by February 15, 1995.

Thanks. Call me with any questions.

NOTE: FROM CLIFF NOEL, PW:

- o ALL PRICES ARE CONSERVATIVE AND INCLUDE CONTINGENCY.
- o PRICE COULD COME DOWN WHEN MORE SPECIFICS ARE KNOWN.

FACILITY MONITORING SYSTEM

ESTIMATE NOTES

Legend

P = PRICE LIST
 E = ESTIMATE
 M = MERICK+6%
 A = ALLOWANCE

LANL NMSF CDR
 Instrumentation and Control
 Cost Estimate

3/6/95

DESCRIPTION	QTY	UNIT	MATERIAL / EQUIPMENT UNIT PRICE	EQUIP. EXT'D TOTAL	ESTIMATE BASIS	HOURS	LABOR RATE	EXT'D COST	TOTAL COST
FMS PLC SYSTEM									
- PLC CARDS (61)	1	LOT	56944	56944	P	0	NA		56944
- PLC RACKS (5)	1	LOT	10880	10880	P	0	NA		10880
- PLC PROCESSORS (2)	1	LOT	23052	23052	P	0	NA		23052
- PLC ENCLOSURE	4	LOT	5000	20000	E	16	ELEC	#VALUE!	#VALUE!
- PLC LADDER LOGIC PROGRAMMING	480	HRS	65	31200	E	0	NA		31200
- PLC PORT. TERMINAL	1	EA	5911	5911	P	0	NA		5911
- PLC PROGRAM / DOC. PACKAGE	1	EA	2500	2500	P	0	NA		2500
- PLC TERMINATION	2400	EA	0	0	E	480	ELEC	#VALUE!	#VALUE!
FMS COMPUTER SYSTEM									
-IBM INDUSTRIAL (OP. ST.)	8	EA	7955	63640	P	2	ELEC	#VALUE!	#VALUE!
-IBM SERVER	2	EA	0	0	P	8	ELEC	#VALUE!	#VALUE!
-TAPE DRIVE	8	EA	700	5600	P	0	NA		5600
- E-NET Card	16	EA	100	1600	P	0	NA		1600
- PRINTER	8	EA	685	5480	P	2	ELEC	#VALUE!	#VALUE!
- OS/2 V. 3.x	8	EA	325	2600	P	0	NA		2600
- TAPES/DISK	1	EA	500	500	A	0	NA		500
- DOCUMENTATION	1	EA	500	500	A	0	NA		500
- SERVER NETWORK SOFTWARE	2	EA	1900	3800	E	0	NA		3800
- STATION NETWORK SOFTWARE	8	EA	295	2360	E	0	NA		2360
- ICOM MMI	7	EA	6000	42000	P	0	NA		42000
- ICOM BASE	1	EA	9500	9500	P	0	NA		9500
- CONFIGURATION	240	HRS	65	15600	E	0	NA		15600
- PROGRAMMING	2000	HRS	65	130000	E	0	NA		130000
BREATHING AIR MONITORING									
- FLOW MONITORS	2	EA	2120	4240	M	8	ELEC	#VALUE!	#VALUE!

*LABOR Hours
Per Unit*

*ELC. or Fitter
Rate*

*UNITS x Hour
x Rate*

Legend

P = PRICE LIST

E = ESTIMATE

M = MERICK+6%

A = ALLOWANCE

LANL MSF CDR
Instrumentation and Control
Cost Estimate

3/6/95

- PRESSURE MONITORS	2	EA	2120	4240	M	8	ELEC	#VALUE!	#VALUE!
- CO2 MONITORS	2	EA	3180	6360	M	8	ELEC	#VALUE!	#VALUE!
REMOTE AREA MONITORS									
REMOTE AREA MONITOR	1	LOT	10600	10600	M	0	NA		10600
CONTINUOUS AIR MONITOR									
CONTINUOUS AIR MONITOR	18	EA	7420	133560	M	8	ELEC	#VALUE!	#VALUE!
OIU'S	5	EA	4240	21200	M	12	ELEC	#VALUE!	#VALUE!
PERSONNEL COMPUTERS	2	EA	4240	8480	M	8	ELEC	#VALUE!	#VALUE!
SOFTWARE	1	EA	10600	10600	M	0	NA		10600
FIXED AIR SAMPLER									
FIXED AIR SAMPLER	72	EA	212	15264	M	1	PIPEFITTER	#VALUE!	#VALUE!
VACUUM EXHAUSTER	2	EA	31800	63600	M	160	PIPEFITTER	#VALUE!	#VALUE!
CRIT. MONITOR AND ALARM SYSTEM									
CRITICALITY HEAD	6	EA	1590	9540	M	10	ELEC	#VALUE!	#VALUE!
ALARM SYSTEM	1	EA	21200	21200	M	100	ELEC	#VALUE!	#VALUE!
UPS SYSTEM	1	EA	6360	6360	M	16	ELEC	#VALUE!	#VALUE!
STACK MONITORING SYSTEM									
STACK MONITORING SYSTEM	4	EA	7420	29680	M	20	ELEC	#VALUE!	#VALUE!
UPS	4	EA	1060	4240	M	10	ELEC	#VALUE!	#VALUE!
PUMP	4	EA	1060	4240	M	10	ELEC	#VALUE!	#VALUE!
FLOW SENSOR	2	EA	2120	4240	M	8	PIPEFITTER	#VALUE!	#VALUE!
CONTROL SYSTEM MECH									
1 1/2" COPPER TUBING	4000	LF	4.2718	17087.2	M	0.2	PIPEFITTER	#VALUE!	#VALUE!
1/2" COPPER TUBING	900	LF	1.3568	1221.12	M	0.13	PIPEFITTER	#VALUE!	#VALUE!
5/8" TYGON TUBING	340	LF	0.371	126.14	M	0.07	PIPEFITTER	#VALUE!	#VALUE!
CONTROL SYSTEM VALVES									

Legend

P = PRICE LIST

E = ESTIMATE

M = MERICK+8%

A = ALLOWANCE

**LANL JMSF CDR
Instrumentation and Control
Cost Estimate**

3/6/85

1/2" BALL VALVES	88	EA	35	3080 E	0.5	PIPEFITTER	#VALUE!	#VALUE!
VACUUM EXH. PIPE	1	LOT	12720	12720 M	160	PIPEFITTER	#VALUE!	#VALUE!
CONTROL SYSTEM WIRE								
TW,SH PAIR	3000	LF	1.3	3900 E	0.08	ELEC	#VALUE!	#VALUE!
#14 WIRE	22000	LF	0.0424	932.8 M	0.08	ELEC	#VALUE!	#VALUE!
#12 WIRE	7000	LF	0.0848	593.6 M	0.08	ELEC	#VALUE!	#VALUE!
CONTROL SYSTEM CONDUIT								
3/4" CONDUIT	10000	LF	1.6642	16642 M	0.13	ELEC	#VALUE!	#VALUE!
SUBTOTAL			\$ 263,048	\$ 847,614			#VALUE!	#VALUE!

ICF KAISER ENGINEERS, INC.
FOUR GATEWAY CENTER
PITTSBURGH, PENNSYLVANIA 15222-1207
TELEPHONE: 412/497-2800
TELEX: 199121
FAX: 412/497-2212

FAX NO: 505-661-5222
DATE: 3-6-95
KE REF: 41552-056-02
PAGE 1 OF 4

COMPANY/LOCATION: ICF K&E LOS ALAMOS

ATTENTION: DAVID O'FLYNN

FROM: BILL LITTON

DEPT: _____

** PLEASE NOTIFY RECEPTIONIST IF TRANSMISSION IS INCOMPLETE/ILLEGIBLE. **

MESSAGE

ATTENTION IS HARD COPY OF
INSTR. & CONTROL TEST. I E-MAILED
THIS AFTERNOON

CALL IF ANY QUESTIONS OR
PROBLEMS,

NMSE

JOB NO. 41552-056

SHEET 58 OF 58

DESIGNED BY DVDF DATE 2/95

CHECKED BY. DATE

HEALTH & SAFETY MONITORS (PERSONNEL)

(SEE JIM BLAND DWG 2/23/95
EIA 12, 665-7643)

<u>EQUIPMENT</u>	<u>LOCATION</u>	<u>TOTAL</u>
------------------	-----------------	--------------

PCM	MEN'S CONTROLLED	1
-----	------------------	---

	WOMEN'S CONTROLLED	1
--	--------------------	---

1/2 PCM	HALLWAY FROM AIR LOCK	1
---------	--------------------------	---

	HALLWAY TO DP'S AREA	1
--	-------------------------	---

FRISKER	PACK/UNPACK	1
---------	-------------	---

	LOADING DOCK	1
--	--------------	---

HEPA SLOTTED HOOD	PACK/UNPACK AREA	1
----------------------	------------------	---

NO MONITORS NEEDED ON BASEMENT
OR SECOND FLOOR LEVELS.

ICF KAISER
 ENVIRONMENT & ENERGY GROUP
 12000 WEST 16TH AVENUE
 DENVER, CO 80202
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Los Alamos
NATIONAL LABORATORY
memorandum

Technology and Safety Assessment Division
TSA-8, Advanced Reactor Safety

To/MS: L. M. Martinez, FSS-6, MS E512
Thru: C. R. Bell, TSA-8, MS K575 *CB*
From/MS: T. D. Knight, TSA-8, MS K575 *TK*
Phone/FAX: 7-5517/5-4322
Symbol: TSA-8:95-37
Date: March 8, 1995

Thermal Analysis Section for NMSF Renovation CDR

I have attached the original of our contribution describing the thermal analysis in support of the NMSF Renovation CDR. I have also enclosed a diskette in Macintosh format containing the Microsoft Word file for the document. The document contains one page (page 7) with three color figures pasted up; I suggest that you be careful in handling this page. The rest of the figures are incorporated directly into the Word file.

If you have questions or require additional information, please call me at the above number.

TDK:rl0

Att: a/s
Encls: a/s

Cy: w/o Atts. & Encls.

C. E. Zerkle, FSS-6, MS E512 (w/ att.)
T. J. Trapp, NMRT-NM, MS E580 (w/ att.)
C. R. Bell, TSA-8, MS K575
J. F. Martin, TSA-8, MS K575
T. D. Knight, TSA-8, MS K575
CIC-10, MS A150
TSA-8 File

NMSF CDR INPUT

X HEAT REMOVAL ASSESSMENT

X.1 Requirements

Reference 1 establishes the following requirements for heat removal for the NMSF:

- 1) up to 20 kW to be removed from the storage area during normal operation;
- 2) up to 15 W to be removed from any storage location in the storage area during normal operation;
- 3) the temperature of nuclear material stored in NMT nested containers not to exceed 176°F (80°C) during normal operation;
- 4) the temperature of nuclear material stored in NMT nested containers not to exceed 212°F (100°C) during design-basis accidents;
- 5) the surface temperature of pits stored in AT-400A containment vessels not to exceed 149°F (65°C) during normal operation;
- 6) the surface temperature of pits stored in AT-400A containment vessels not to exceed 212°F (100°C) during design-basis accidents; and
- 7) storage equipment and structure not to exceed their temperature design conditions.

These requirements must be met by the NMSF design for the bounding operating conditions and design-basis accidents. The bounding operating condition for the NMSF is the passive, air-cooled heat removal mode with a typical 24-hour temperature cycle for the ambient air having a peak temperature equal to the maximum historical temperature at the NMSF location. Based on the recorded meteorological data in Ref. 2 and 3, the bounding ambient air conditions should be adequately represented by a sinusoidal temperature curve with a maximum of 95°F (35°C), a minimum of 75°F (23.9°C), and a period of 24 hours. The bounding design-basis accident should be adequately represented by a complete loss of air flow through the storage area for up to one week (the assumption being that lack of air flow would be detected and corrective actions taken in a 1-week time period).

X.2 Analysis Approach

The analysis approach was to subdivide the heat-removal assessment into its component parts, to analyze parametrically each part to obtain the effects of boundary-condition variations and modeling uncertainties, and to assemble a bounding assessment to compare with the requirements of Section X.1.

X.2.1 Analysis Approach for Normal Operation

The analysis of heat removal from stored materials in the NMSF during normal operations was split into four parts:

- 1) heat transport from the storage arrays by natural convection air flow through the facility;
- 2) conduction, convection, and radiation heat transfer from the heat-generating nuclear material in the NMT nested containers to the air outside the drywell;
- 3) conduction, convection, and radiation heat transfer from the heat-generating nuclear material in pits stored in containment vessels of AT-400A shipping/storage containers to the air outside the drywell; and

- 4) the transient response of the stored material to the ambient air temperature diurnal cycles.

Facility Heat Transport: The steady-state transport of heat from the facility by natural convection was analyzed with a 3-dimensional model of the NMSF storage system using the CFD3 FLOW3D code. The model included the three parallel storage bays, the inlet downcomer and flow baffle, and the exhaust chimney. The drywell arrays were modeled as heat generating, porous media with flow resistances representative of flow across rows of cylindrical tubes. The air flow and its associated heat up were calculated in accordance with the buoyancy pressure head developed between the ambient air in the inlet downcomer and the heated air in the chimney and in accordance with the flow resistances of the flow paths. For the reference calculation, a uniform and equal heat generation was assumed in each of the three bays. A steady-state inlet air temperature of 70°F (21.1°C) was assumed. From this model, air temperature distributions through out the storage arrays, including maximum local air temperature, were obtained as functions of inlet air temperature, material loading distributions, and modeling uncertainties. The details of the model are given in Ref. 4.

Steady-State Heat Transfer from Material in NMT Nested Containers: The steady-state heat transfer from the nuclear material in the NMT nested containers to the air flowing around a drywell was analyzed with a detailed 2-dimensional, lumped-parameter model that evaluated conduction, convection, and radiation. For the reference calculation, it was assumed that the nested containers are supported on carbon steel circular shelves that are spaced 12 inches apart vertically and attached to a cylindrical-cage storage unit. From this model, the temperatures of the stored materials and associated storage components were obtained as functions of design details, temperature and flow rate of the air surrounding the drywell, and material and model uncertainties. The details of the model are given in Ref. 5-7.

Steady-State Heat Transfer from Pits in AT-400A Containment Vessels: The steady-state heat transfer from the nuclear material in typical pits in AT-400A containment vessels to the air flowing around a drywell was assessed by combining two pieces of information. The first part is the calculated temperature rise from the air to the containment vessel outer surface. The second part is the measured temperature rise from the containment vessel outer surface to the pit surface for the highest powered pit. A one-dimensional lumped-parameter model evaluated conduction, convection, and radiation heat transfer. The measured temperatures were based on prototypical experiments. Best-estimate average and worse-case temperature increases were determined. The details of the model are given in Ref. 8.

Transient Heat Transfer from Material in NMT Nested Containers: The transient heat transfer from the nuclear material in the NMT nested containers to the air flowing around the drywell was analyzed with the detailed 2-dimensional, lumped-parameter model described above. A sinusoidally varying air temperature was used as a boundary condition to determine the transient response of the stored material to 24-hour air temperature cycles. A step change in air temperature also was analyzed to determine basic response time constants. The details of the model are given in Ref. 9.

X.2.2 Analysis Approach for Accidents

The assumed abrupt loss of all air flow through the NMSF storage bay to the environment with the accompanying transient heat up of the facility components and structures was selected as the bounding accident for thermal challenges. The facility heat up was analyzed with a detailed two-dimensional, lumped-parameter model that treated conduction, convection, and radiation within and from the facility through its perimeter structures to the surrounding soil and

air. For the reference calculation, it was assumed that the heat transfer to the ends of the storage bays was minimal and was conservatively neglected. It was assumed that the facility had been operating normally with the stored material generating 20 kW of power and that an effective steady state had been established in the drywell assemblies, the facility's structures, and the surrounding soil at the time the accident occurred. From this model, the temperature transients for the stored materials, associated drywell components, and structures were obtained as functions of design details and material and model uncertainties. The details of the model are given in Ref. 10.

X.3 Analysis Results

The results of the reference analyses are summarized in this section. From these results, a composite, conservative temperature response for the stored material in the NMSF was formulated to compare with temperature limit requirements. This formulation is presented in Section X.4.

X.3.1 Analysis Results for Normal Operations

Facility Heat Transport: The temperature distribution in a vertical plane along the center of the middle storage bay is shown in Fig. 1. The temperature increases along the bay and reaches a maximum near the exit. With inlet air at 69.5°F (20.9°C), the maximum air temperature is 80.6°F (27.0°C) and is located in the region where the air exits the bay, resulting in a maximum increase in air temperature of 11.0°F (6.1°C). The velocity distribution in this same vertical plane is shown in Fig. 2. The high velocities are calculated at the restricted inlet and exit regions. The flow distributes vertically over the height of the bay within a short distance from the inlet before encountering the drywell pipes [the first row of drywells is 5.5 feet (1.68 m) downstream from the inlet baffle]. The differences in temperature distributions among the three bays are shown in Fig. 3. In this model, the outer bays are wider than the middle bay, and they have an unrestricted flow space along the outer walls. The air is cooler in these regions because the flow is higher and the volumetric heat generation is less. For uniform loading, the results are relatively insensitive to changes in the hydraulic loss coefficient because of compensating effects of reduced velocity, higher air temperatures, and increased buoyancy head. Parametric results indicate that the calculated temperature rise through the bay may have an uncertainty of ~20%. Calculations with material loaded only in the center bay indicate that the bay separation walls need to be extended up the chimney to prevent the heated and unheated air from mixing in the chimney and thereby reducing the buoyancy head driving the flows. The detailed results are given in Ref. 4.

Steady-State Heat Transfer from Material in Nested NMT Containers: The calculated temperature distribution from the material (metal, although the container is intended also to store oxides or stabilized residues) stored in the NMT nested containers to the air surrounding the drywell is shown in Fig. 4. The radial temperature profile shown is distorted because the cage structure is heated via conduction from the product and boundary containers through the carbon-steel plates of the cage structure to the mesh of the cage. This conduction path results in the cage temperature shown in Fig. 4 being higher than the calculated air temperatures on both sides. With a local air temperature of 80°F (26.7°C), the temperature of the stored material for average best-estimate conditions was calculated to be 145.8°F (63.2°C), which results in a temperature rise above the surrounding air of 65.8°F (36.6°C). Parametric results indicate that for the worst-case conditions and model uncertainties taken simultaneously, the calculated temperature rise from the air to the stored material has an upper bound value of 73.9°F (41.1°C). Because there are clear design aspects to be optimized that relate to material selection, surface finish, and support fixtures and because the assumed power of 15 W is conservative by at least 10%, the

calculated results are expected to be sufficiently bounding. The detailed results are given in Ref. 6 and 7.

Steady-state Heat Transfer from Pits in AT-400A Containment Vessels: The temperature rise from the air surrounding the drywell to the highest-powered pit in an AT-400A containment vessel was estimated by combining the calculated temperature rise from the surrounding air to the side surface of the containment vessel with the measured temperature rise from the side surface of the containment vessel to the maximum temperature of the pit surface. With an air temperature of 80°F (26.7°C), the maximum temperature of the pit surface for average best-estimate conditions was estimated to be 111.8°F (44.3°C), which results in a temperature rise above the surrounding air of 31.8°F (17.7°C). The worst case condition and model-uncertainty temperature rise has an upper bound value of 37.2°F (20.7°C), or a bounding pit surface temperature of 117.2°F (47.3°C). For the same reasons listed above for the nested NMT containers, the calculated results for the AT-400A containment vessel are expected to be conservative. The detailed results are given in Ref. 8.

Transient Heat Transfer from Material in Nested NMT Containers: The transient response of the material stored in NMT nested containers in the NMSF drywells is shown in Fig. 5. The air temperature transient was assumed to be sinusoidally varying about a nominal value of 80°F (26.7°C) with maximum change being 9°F (5°C). The results indicate that the stored material does not respond immediately (because of the thermal resistances and heat capacities) to the changes in air temperature. The peak temperature of the stored material is delayed approximately 3.45 hours relative to that for the air and, as a result, does not incur the same magnitude of temperature variation. The stored material experiences an amplitude variation that is only 0.74 of that in the outside air. Thus, on a day in which the outside air varies 20°F (11.1°C) from minimum to maximum, the stored material would experience less than a 15°F (8.3°C) variation. The detailed results are given in Ref. 9.

X.3.2 Analysis Results for Accidents

The transient temperature response of the central region of the NMSF storage bays is shown in Fig. 6. The rapid temperature rise in the first few days is the result of the large thermal resistances associated with rejecting heat from the drywells into and through the concrete structures surrounding the storage arrays. The net heat flows into various parts of the facility are shown in Fig. 7. The net heat flow into the drywells decreases rapidly as they heat up. The heat then begins to flow into the interior walls of the storage bay and into the perimeter walls. In the long term, the primary path for heat flow is upward through the loading floor and out through the ceiling of the loading bay. Results of parametric studies indicate that the bay separation walls play an important role in delaying the heat up of the stored material. The parametric studies also indicate that the results (increases in temperature) may be uncertain by on the order of 100% during the time frame of interest (~10 days). The detailed results are given in Ref. 10.

X.4 Facility Thermal Performance

To assess the thermal performance of the NMSF, a conservative assessment of the maximum temperatures of the stored material during normal operations and postulated accidents was made and then compared to the specified temperature limits.

X.4.1 Thermal Performance for Normal Operations

The conservative assessment of the temperature of material stored in NMT nested containers during normal operation was formulated as follows:

1. Use worst case ambient air as specified in Section X.1 [sinusoid with an average of 85°F (29.4°C), a minimum of 75°F (23.9°C), a maximum of 95°F (35.0°C), and a period of 24 hr].
2. Add a conservative temperature increment associated with air heat up as it flows through the storage bay [use 11.0°F (6.1°C)].
3. Add a bounding temperature increment associated with heat transfer from the stored material in the drywell to the local air [use 65.8°F (36.6°C)].
4. Apply the 0.74 amplitude reduction factor to the magnitude of the time variation of the temperature.

The result of this formulation is shown in Fig. 8 along with the temperature limit [176°F (80°C)]. A residual margin of 6.8°F (3.8°C) exists between peak predicted temperature and the limit. The result contains an additional conservatism in that the thermal mass of the bay will damp out significantly the daily temperature oscillation, and the full combined effects of items 2 and 4 will not be observed at any one location.

The conservative assessment of the temperature of pits stored in AT-400A containment vessels during normal operation was formulated as for the NMT nested containers except the temperature increment used in item 3 was based on pit and AT-400A considerations [31.8°F (17.7°C)]. The result of this formulation is shown in Fig. 9 along with the temperature limit [149°F (65°C)]. A substantial residual margin of 13.8°F (7.7°C) exists between peak predicted temperature and the limit.

The margins to the temperature limits can be increased by optimizing the design of the fixtures holding the materials inside the drywells to reduce the ΔT between the drywell wall and the storage container. The selection of materials and surface finishes and the extent of the fixtures can have significant impacts on the conduction, convection, and radiation heat transfer processes and therefore increase the margins to the temperature limits.

X.4.1 Thermal Performance for Accidents

The conservative assessment of the temperature of material stored in NMT nested containers during the postulated bounding accident was formulated as follows:

1. Use the reference transient heat up results as a basis;
2. Add an uncertainty factor of 100% (double the ΔT increase at 10 days);
3. Add a conservative temperature increment associated with heat transfer from the stored material in the drywell to the drywell wall (use 66°F (36.7°C))

The result of this formulation is shown in Fig. 10 along with the accident temperature limit for stored material [212°F (100°C)]. The time interval before the temperature limit for the stored material is reached is 35 days, which is well in excess of the requirement of 7 days.

The conservative assessment of the temperature of pits stored in AT-400A containment vessels during the postulated bounding accident was formulated as for the NMT nested containers except the temperature increment used in item 3 was based on pit and AT-400A considerations. The result of this formulation is shown in Fig. 11 along with the accident temperature limit for pits. The time interval before the temperature limit for the stored material is reached is >45 days, which is well in excess of the requirement of 7 days.

X.5 Conclusions

Based on the comparison of the bounding temperatures predicted for the materials and pits to be stored in the NMSF against the respective temperature limits, the natural convection

heat removal capability for the reference NMSF concept is sufficient and acceptable. Margins exist in the heat removal capability to permit design optimization during subsequent design phases and to consider "stretch" storage capacity in the facility if needed in the future. However, the margin for the plutonium metal stored in the NMT nested containers is the most limiting from a heat removal perspective. In subsequent design phases, both the temperature limit and the thermal analyses will need to be addressed further to ensure confidence in the margin and its adequacy. Furthermore, the margin to the limits can be increased through optimizing the design concepts for the holding fixtures. In particular, the choice of materials and surface finishes and the physical extent of the fixtures can have significant impacts on the conduction, convection, and radiation heat transfer processes and therefore increase the margins to the temperature limits.

X.6 References

1. "Nuclear Materials Storage Facility Functional and Operational Requirements," Los Alamos National Laboratory draft report, October 1994.
2. Brent M. Bowen, "Los Alamos Climatology," Los Alamos National Laboratory report LA-11735-MS, May 1990.
3. Brent M. Bowen, "Los Alamos Climatology Summary Including Latest Normals from 1961-1990," Los Alamos National Laboratory report LA-12232-MS, March 1992.
4. William S. Gregory, "NMSF Heat Removal Analysis" Los Alamos National Laboratory letter report, to be published.
5. Robert G. Steinke, "Heat-Transfer Modeling of the Drywell Pipe in the Nuclear Material Storage Facility," Los Alamos National Laboratory letter report, to be published.
6. Robert G. Steinke, "Two-Dimensional Heat-Transfer Analysis of the Drywell Pipe for the Nuclear Material Storage Facility," Los Alamos National Laboratory Letter report, to be published.
7. Robert G. Steinke, "Two-Dimensional Heat-Transfer Analysis of the Drywell Pipe for the Nuclear Material Storage Facility—Supplement: Revised Model with a Storage Cage rather than a Storage Pipe," Los Alamos National Laboratory letter report, to be published.
8. Robert G. Steinke, "Heat-Transfer Analysis of the Containment Vessel from an AT-400A Container in a Drywell Pipe for the Nuclear Material Storage Facility," Los Alamos National Laboratory letter report, to be published.
9. Robert G. Steinke, "Two-Dimensional Heat-Transfer Transient Response of the Drywell Pipe Components in the Nuclear Material Storage Facility," Los Alamos National Laboratory letter report, to be published.
10. William R. Bohl, "Transient Heatup of the NMSF," Los Alamos National Laboratory letter report, to be published.

Fig. 1. Longitudinal temperature distribution in the middle storage bay (temperature in K).

Fig. 2. Longitudinal velocity distribution in the middle storage bay (velocity in m/s).

Fig. 3. Transverse temperature distributions across all bays (temperature in K).

Fig. 4. Radial temperature distribution for NMT nested containers in NMSF drywells.

Fig. 5. Transient response of stored material in NMT nested containers in NMSF drywells to 24-hour air temperature cycles.

Fig. 6. Transient heat up of the stored material following loss of air flow through the NMSF.

Fig. 7. Transient heat flows following loss of air flow through the NMSF.

Fig. 8. Bounding temperature of material stored in NMT nested containers in the NMSF for normal operation.

Fig. 9. Bounding temperature of pits stored in AT-400A containment vessels in the NMSF for normal operation.

Fig. 10. Bounding temperature of material stored in NMT nested containers in the NMSF for accidents.

Fig. 11. Bounding temperature of pits stored in AT-400A containment vessels in the NMSF for accidents.

Los Alamos

NATIONAL LABORATORY

memorandum

Environment, Safety and Health Division
Nuclear Criticality Safety

To/MS: L. M. Martinez, E512
Thru: T. P. McLaughlin
From/MS: J. A. Schlessor, F691
Phone/FAX: 5-2815/5-4970
Symbol: ESH-6-95-88
Date: May 12, 1995

SUBJECT: RESPONSES TO COMMENTS ON THE NUCLEAR MATERIAL STORAGE FACILITY CDR

- References:
1. Memo from J. A. Schlessor to D. M. Romero. "Criticality Safety - Conceptual Design for the Nuclear Material Storage Facility," ESH-6-95-35, February 28, 1995.
 2. Memo from J. A. Schlessor to D. M. Romero, "Criticality Safety - Material Handling in the Nuclear Material Storage Facility," ESH-6-95-43, March 10, 1995.

A review of the Nuclear Material Storage Facility (NMSF) by DOE/DP-31 resulted in two comments regarding criticality safety. They were numbers 109 and 110 (attached for reference). It appears they were generated without referring to Part III, Section 7. Criticality, where the initial criticality safety analyses were included.

I have attached the two referenced memos describing the criticality safety analyses performed for the conceptual design. You, and the commentators, are reminded that these analyses were performed for normal conditions **ONLY** and that credible, abnormal conditions will be evaluated for criticality safety following the development of a Preliminary Hazards Assessment for the NMSF.

We, in ESH-6, will interact with you and others as necessary to perform criticality safety analyses to assist in the further development of the facility for handling and storing nuclear material(s).

Att: a/s

Cc: C. E. Zerkle, FSS-6, MS E512 w/o att.
D. M. Romero, NMT-8, MS E583 w/o att.
ESH-6 Files w/o att.

Los Alamos

NATIONAL LABORATORY

memorandum

Environment, Safety and Health Division
Nuclear Criticality Safety

To/MS:	D. M. Romero, MS E583
Thru:	T. P. McLaughlin
From/MS:	J. A. Schlesser, F691
Phone/PAX:	5-2815/5-4970
Symbol:	ESH-6-95-43
Date:	March 10, 1995

SUBJECT: CRITICALITY SAFETY — MATERIAL HANDLING IN THE NUCLEAR MATERIAL STORAGE FACILITY

Ref: Memo from J. A. Schlesser to D. M. Romero, *Criticality Safety - Conceptual Design for the Nuclear Material Storage Facility*, ESH-6-95-35, March 1, 1995.

Summary

At a recent Thursday facility meeting, Criticality Safety was asked to determine the critical number of material containers that could be accumulated in the material handling area. We have performed several analyses aimed at determining the number of containers that could be present before criticality safety was compromised. The basis for this number was the maintenance of a multiplication factor on the order of 0.80-0.85.

Discussion

Prepackaged fissile material bearing cans will be received at the staging area in the NMSF. Following arrival they (the containers) will be inserted into the storage baskets for eventual long-term storage. During their presence and before loading into the storage baskets, criticality safety controls will have to be in place. What these controls are depend on the material flow sheet for the facility.

Several conceptual models were developed and are discussed below. They all were based on the proposed product/boundary storage container concept.

Calculational Model

The storage cans modeled are the same as used in the referenced memo. The fissile material content was based on 4,500 g of Pu (95 w% ^{239}Pu at 19.86 g/cc density). Four forms were used: ingots (~3-inches in diameter by ~2 inches high); 2 g/cc Pu oxide; and metal chunks represented as being 9.93 and 14.895 g/cc (1/2 and 3/4, respectively of full density metal).

To conservatively represent the staging area, a corner with three-sided concrete reflection was established. Several arrangements of storage cans were placed in the corner. These arrangements are described in Table 2 and illustrated in Figures 1-5.

The arrangements of storage containers can be construed as an extreme upset condition, if the

procedural staging requirements were totally ignored. In addition, the most reactive of the models were subjected to a credible upset condition, that of water moderation because of the presence of a fire sprinkler system. Because a full density-water moderating condition cannot occur instantaneously, the density of the water was varied in steps from 0.001 to full density to determine the optimum moderating condition.

Material atom densities used in the models are provided in Table 1.

Calculational Method

The computer code KENO 5.a and the Hansen-Roach 16-group cross sections were utilized for these analyses. Each case was executed until 100,000 neutron histories were analyzed. The corresponding statistical uncertainty (σ , + or -) for any case was less than 0.005.

Results

For the models described above, the calculational results are provided in Table 2. They show that the most reactive form of fissile material is metal in ingot shape for the un-moderated situation. Five containers, neatly positioned and stacked in the corner (Fig. 5) result in a multiplication factor of 0.87.

For the upset condition of fire water moderation, the multiplication factor increases to a maximum of 0.92 at a moderating condition with equivalent water densities of 0.75 and 1.0 (full density).

These calculational results will be maintained in ESH-6 files and are available for review.

Conclusion

The critical number of fissile bearing storage containers was not determined. However, consistent with a philosophy of maintaining a maximum multiplication factor on the order of 0.80-0.85, we recommend that up to four storage containers be present in the staging area without any additional controls.

As with any process operation additional controls, such as one container "per yellow Bisco box" might permit an unlimited number of containers in the material handling area along with, for example, a maximum of 4 out of the boxes at one time.

In summary, we welcome the opportunity to interact with you, have you describe your desired material handling options, and develop appropriate criticality controls for you to incorporate into your operating procedures. We realize that some of this information may be somewhat premature, but we will assist with future design development of the NMSF renovation.

JAS:cjm

ESH-6-95-43

3

March 10, 1995

Distribution:

T. J. Trapp, NMRT-NM, MS F628
W. T. Wood, NMRT-NM, MS E524
V. Longmire, NMT-4, MS E513
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L. M. Martinez, FSS-6, MS E512
C. A. Bollig, TSA-11, MS K557
ESH-6 Files

Table 1. Material Specifications

Material	Density, g/cc	Element or Isotopic wt %	Atom Density, Atoms/barn-cm
α -Pu metal	19.86	^{239}Pu - 95 ^{240}Pu - 5	0.04753 0.00249
Plutonium Oxide (PuO_2)- Dry	2.0	O - 11.8 ^{239}Pu - 83.8 ^{240}Pu - 4.4	0.0089 0.00422 0.00022
Stainless Steel - 304L	7.92	Cr - 19.0 Fe - 69.5 Ni - 9.5 Mn - 2.0	0.01743 0.05935 0.00772 0.00174
Carbon Steel	7.82	C - 1.0 Fe - 99.0	0.00392 0.08348
Concrete	2.3	H - 1.0 O - 53.2 Na - 2.9 Al - 3.4 Si - 33.7 Ca - 4.4 Fe - 1.4	0.01374 0.04606 0.00175 0.00175 0.01662 0.00152 0.00035

Table 2. Multiplication Factors for Material Staging Area

Case	Ingot	Oxide	1/2 Density Metal	3/4 Density Metal	Description
1	0.796	0.237	0.516	0.596	Single unit located in corner of 2-sided concrete reflection (Fig. 1).
2	0.816	0.295	0.661	0.638	Two units located along one wall of 3-sided concrete reflection (Fig. 2).
3	0.839	0.343	0.690	0.666	Three units in square pitch with 3-sided concrete reflection (Fig. 3).
4	0.863	0.379	0.620	0.691	Four units in square pitch with 3-sided concrete reflection (Fig. 4).
5	0.848	0.365	0.601	0.669	Same as case 3, but stacked two units in corner (Fig. 4a).
6	0.870	0.396	0.638	0.695	Four units in square pitch in corner with a 5 th unit stacked in corner (Fig. 4b).
7	0.874	-	-	-	Same as Case 6 but added water flooding, density = 0.001 of full.
8	0.871	-	-	-	Same as Case 6 but added water flooding, density = 0.01 of full.
9	0.888	-	-	-	Same as Case 6 but added water flooding, density = 0.1 of full.
10	0.904	-	-	-	Same as Case 6 but added water flooding, density = 0.25 of full.
11	0.913	-	-	-	Same as Case 6 but added water flooding, density = 0.5 of full.
12	0.919	-	-	-	Same as Case 6 but added water flooding, density = 0.75 of full.
13	0.919	-	-	-	Same as Case 6 but added water flooding, density = full.

Elevation View

Concrete

Plan View

Figure 2. Two Units with 3-Sided Concrete Reflection

Plan View

Elevation View

Figure 3. Three Units with 3-Sided Concrete Reflection

Figure 4. Four Units with 3-Sided Concrete Reflection

Plan View

Elevation View

Figure 4a. Four Units with 3-Sided Concrete Reflection

Figure 5. Five Units with 3-Sided Concrete Reflection

Los Alamos

NATIONAL LABORATORY

memorandum

Environment, Safety and Health Division
Nuclear Criticality Safety

To/MS: D. M. Romero, NMT-8, E583
Thru: T. P. McLaughlin
From/MS: J. A. Schlessner, F691
Phone/FAX: 5-2815/5-4970
Symbol: ESH-6-95-35
Date: February 28, 1995

SUBJECT: CRITICALITY SAFETY — CONCEPTUAL DESIGN FOR THE NUCLEAR MATERIAL STORAGE FACILITY

Summary

At your verbal request, we have performed several criticality safety evaluations for different forms of fissile material that may conceivably be stored in two different types of containers in the facility. The initial request was to evaluate several forms of plutonium as oxide and metal (as pieces and compact ingots).

Our goal was to perform evaluations which would provide criticality safety guidance for worst case loading configuration. These evaluations did not consider other possible facility constraints such as heat loading or mass loading. In addition, we attempted to provide guidance which would minimize administrative controls and maximize the use of engineered controls. The calculations were performed considering normal conditions only. Credible abnormal conditions will require analysis at a future date.

Our preliminary evaluations indicate that the following may be stored anywhere in the facility with generous criticality safety margins: 1) up to 4,500 grams of plutonium oxide per container; 2) up to 4,500 grams of plutonium metal as broken pieces (equivalent density of 9.93 g/cc) per container; 3) up to 4,500 grams of plutonium metal as "rings" per container; or, 4) one complete pit of unspecified type per AT400A containment vessel.

Plutonium, as metal in ingots, may be stored in the array, however, *only one ingot container may be stored in a vertical storage tube (i.e., one ingot container in every 14 containers in a vertical storage tube).*

The above mass values are nominal and consistent with a multiplication factor of 0.85. This value does not include allowance for upset conditions. As vault designs become finalized, sensitivity studies will be made to determine the controls necessary to maintain a safe storage configuration.

Previous studies performed on other conceptual designs are listed under References.

Discussion

The fissile material is to be stored in two stainless steel containers, the inner called the

product container and the outer called the boundary container (See Figure 1). After loading, each container is to be seal welded. The container(s) are to be identified for accountability purposes.

While the redesign of the nuclear material storage facility has not been finalized, for these evaluations, a conceptual design for the facility was assumed. The storage space was configured so that three arrays, each separated by a concrete wall (~18-inches thick), would fit in the facility. Each array had the dimensions of 7.5 ft x 126 ft x 14 ft (See Figures 2 and 3), based on 24-inch spacing (center-to-center) between storage locations. A three-foot thick concrete "charging face" was modeled on the top of the array. This allows access to the storage locations through access holes. Plugs will be inserted when access is not required. The charging face also provides radiation shielding to workers above the charging face. Above the charging face is space required for equipment to load and unload the storage locations. Surrounding the storage and equipment spaces, 18 inches of concrete were modeled as the walls, floor and ceiling.

The storage space was configured as three arrays each of 3 x 63 x 14 size. The array size was determined from the dimensions of the individual storage locations: 18-inch Schedule XS mild steel pipe located on 24-inch centers. The rows (63) were arranged in a square pitch arrangement such that the spacing across and along the array was 24 inches. The array in the vertical direction was 14 feet and was determined by the stacking of 14 12-inch containers.

Based on the array configuration provided above and assuming a 12-inch vertical center-to-center spacing of the fissile material, 7,938 storage locations are possible. This number does not take into account facility limitations, i. e., 20 kW heat loading and 6,600 kg material loading. The criticality safety evaluations were modeled to maximize storage as the only consideration. Other safety or operational issues might well dictate the storage limits of the facility.

Calculational Model

The product container is to be constructed of stainless steel (Type 304) with the following dimensions:

Container Type	Inside Diameter, In.	Wall Thickness, In.	Height, In.
Product	4.5	0.065	9.35
Boundary	5.0	0.065	10.0

The storage tubes are to be constructed of commercially available, mild-steel pipe. The length will be dependent on height of the storage array (~14 feet). They have the following dimensions:

Size and Schedule	Inside Diameter, In.	Wall Thickness, In.	Outside Diameter, In.
16, XS	15.0	0.5	16.0
18, XS	17.0	0.5	18.0

The fissile material to be stored in the product and boundary containers will be of two forms: metal and/or oxide. The mass limit for either form was taken to be 4,500 g. The oxide was taken to be PuO_2 with a material density of 2 g/cc. This represents oxide in an "as poured" state, that is, not compacted in the product container. The other form, metal, was taken to consist of 95 wt% ^{239}Pu and 5 wt% ^{240}Pu . The metal was analyzed with two shapes: broken pieces with an equivalent density of 9.93 g/cc and ingots (~2.875 in diameter x ~2.12 inches tall) with a density of 19.86 g/cc.

One of the capabilities of the computer code used is the ability to stack units in an array and then stack arrays to form another array. This feature was utilized by modeling the fissile material inside the product container which was then surrounded by the boundary container. The 16-inch pipe was then added followed by the 18-inch pipe. Void spaces were inserted in the appropriate spaces.

The fissile material (metal) was modeled as being in the center of the product and boundary containers. Although this provided some modeling convenience, the vertical separation of the material (12 inches) was maintained. Inserting the material in the bottom of the product container would have negligible effect on the array multiplication factor.

The basic unit (See Figure 4) was then stacked vertically to achieve the desired height or number of vertical units. This array was then placed in the large array so that there were three arrays, each 3 x 63 x 14 units, inserted in the facility model. Assumptions for facility construction were provided earlier.

Since it was determined that storing ingots is the limiting condition, several variations of the arrays were modeled so as to accommodate the ingots on hand. The results of these and other calculations performed are discussed in the Results section of this memo.

The material atom densities for the several materials used in the modeling are presented in Table 1.

It should be noted that the analyses performed for this conceptual design were only for normal conditions of storage. Credible abnormal, or upset, conditions will be addressed

when and as the design becomes finalized.

This memo emphasizes the calculational results reported in Table 2. However, numerous other calculations were performed prior to the facility design described above. These calculational models are described on the Appendix to this memo along with their respective results. They are relevant in that they lead the way to the design concept currently being considered.

Calculational Method

The computer code KENO V.a was used in evaluating the several models developed. Two sets of cross sections were employed during the execution of the models. The first was the Hansen-Roach 16-energy group. The second was the 27 group called for in a SCALE sequence CSAS25. The second set of cross sections were used to provide confidence that the results from using the Hansen-Roach cross sections were reasonable. Each of the cases were executed until 100,000 histories were executed with the result that the statistical deviation was no greater than 0.004 for any case.

Validation

The cross section sets were not explicitly validated against benchmark experiments for this series of calculations because appropriate experiments do not exist. Based on historical use of the Hansen-Roach cross sections, we expect that the multiplication factor uncertainties due to cross sections alone will be no more than a few percent. For the final design, analyses will be conducted to evaluate this uncertainty as accurately as practical.

Results

The results of the several calculations are reported in Table 2.

They indicate that containers with up to 4,500 g of plutonium oxide or half-density metal may be stored in any position in the array(s). Containers with up to 4,500 g as ingots may also be stored in the arrays, however administrative controls must be imposed to ensure their proper storage. This administrative control is: *only one container with an ingot may be stored in any one storage tube, that is, one container with an ingot per 14 vertically stored containers.*

Containment vessels from the AT-400A shipping container with their contents may be stored anywhere in the arrays. The effect of storing the containment vessels is to decrease the number of storage locations in the facility.

References

1. Memo from J. A. Schlessor to K. O. Ellard, *Criticality Safety for the Nuclear Material*

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2. Memo from J. A. Schlesser to K. O. Ellard, *Criticality Safety - Parameter Survey for the Nuclear Material Storage Facility, TA-55, PF-41, HS-6-93-210, October 19, 1993.*

3. Schlesser, J. A. , *Next Generation Storage Facility*, Los Alamos Report LA-UR-1461, May 11, 1994.

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Table 1. Calculational Material Descriptions

Material	Density, g/cc	Element or Isotopic wt%	Atom Density, atoms/barn-cm
α -Pu metal	19.86	^{239}Pu - 95.0 ^{240}Pu - 5.0	0.04753 0.00249
Plutonium Oxide(PuO_2)- dry	2.0	O - 11.8 ^{239}Pu - 83.8 ^{240}Pu - 4.4	0.0089 0.0044 0.00022
Stainless Steel - 304L	7.92	Cr - 19.0 Fe - 69.5 Ni - 9.5 Mn - 2.0	0.01743 0.05935 0.00772 0.00174
Carbon Steel	7.82	C - 1.0 Fe - 99.0	0.00392 0.08348
Concrete	2.25	H - 1.0 O - 53.2 Na - 2.9 Al - 3.4 Si - 33.7 Ca - 4.4 Fe - 1.4	0.01374 0.04606 0.00175 0.00175 0.01662 0.00152 0.00035

Table 2. Calculational Results

Case No.	Effective Multiplication Factor, k_{eff}	Case Description
1	0.907	4.5 kg Pu as metal ingots, 3 arrays of 3x63x14, storage units on 24" x 24" centers (square pitch), 7,938 storage locations, facility as described in Figs. 3 & 4. Material density is 19.86 g/cc.
2	0.875	Same as Case 1 except that storage units are on 24" x 30" centers, 6,300 storage locations.
3	0.861	Same as case 1 except that storage units are on 24" x 36" centers, 5,292 storage locations.
4	0.453	Same as Case 1 except that fissile material is dry Pu oxide at 2 g/cc.
5	0.465	Same as Case 4 except that fissile material is moist oxide (~1.5 wt% water) at 2 g/cc.
6	0.677	Same as case 1 except that fissile material is one-half density metal at 9.93 g/cc to simulate broken metal pieces.
7	0.740	Same as Case 6 except fissile material density is 14.985 g/cc to simulate 'packed' broken metal pieces in product container.
8	0.409	Same as case 1 except that fissile material is 4.5 kg in the shape of annular rings at 19.86 g/cc (3" ID, 4" OD by ~2.5" tall).
9	0.791	3 arrays of 3x63x14 units, 6 layers of oxide, 1 layer of ingots, 7 layers of oxide, 7,371 units of oxide, 567 units of ingots.
10	0.802	3 arrays of 3x63x14 units, 1 layer of ingots, 13 layers of 1/2 density metal.
11	0.821	Same as Case 10 except that concrete between arrays replaced by empty space.
12	0.789	Same as Case 11 but full density water replaces remaining concrete.
13	0.798	Same as Case 9 but oxide replaced with 1/2 density metal.
14	0.809	Same as Case 9 but oxide replaced with 3/4 density metal.
15	0.464	Same as Case 5 except code executed using 27-group cross sections.
		All Standard Deviations ≤ 0.005

Figure 1. Fissile Material Storage Containers

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Figure 3. Elevation View of Storage Bays

Figure 4. Unit cell for array

Appendix A

This appendix provides a listing of the results of calculational models performed on a variety of storage configurations. The purpose of their attachment is to indicate the level of effort expended in determining a storage arrangement which would satisfy storage requirements and, at the same time, eliminate the need for, or reduce the number of, administrative controls needed to ensure subcriticality of the storage arrays.

Case	k_{eff} 18" Centers	k_{eff} 12" Centers	k_{eff} 2 arrays	Description
nmsf8	0.742	-	-	Pu at 4500 g at 9.93 g/cc, triangular pitch, 18" CTC between Pu, 60x13x10 array, concrete walls, floor and ceiling.
nmsf8a	0.794	-	-	Pu at 4500 g at 14.895 g/cc, triangular pitch, 18" CTC between Pu, 60x13x10 array, concrete walls, floor and ceiling.
nmsf81	-	0.846	-	Pu at 4500 g at 9.93 g/cc, triangular pitch, 12" CTC between Pu, 60x13x15 array, concrete walls, floor and ceiling.
nmsf81a	-	0.906	-	Pu at 4500 g at 14.895 g/cc, triangular pitch, 12" CTC between Pu, 60x13x15 array, concrete walls, floor and ceiling.
nmsf82	-	-	0.751	Pu at 4500 g at 9.93 g/cc, triangular pitch, 12" CTC between Pu, 2 arrays of 60x6x15, concrete walls, floor and ceiling, and separator wall.
nmsf82a	-	-	0.807	Pu at 4500 g at 14.895 g/cc, triangular pitch, 12" CTC between Pu, 2 arrays of 60x6x15, concrete walls, floor and ceiling, and separator wall.
nmsf9	0.496	-	-	PuO ₂ at 4500 g at 2 g/cc, triangular pitch, 18" CTC between Pu, 60x13x10 array, concrete walls, floor and ceiling.
nmsf9a	0.510	-	-	PuO ₂ w/ 1.5 w% water at 4500 g at 2 g/cc, triangular pitch, 18" CTC between Pu, 60x13x10 array, concrete walls, floor and ceiling.
nmsf91	-	0.628	-	PuO ₂ at 4500 g at 2 g/cc, triangular pitch, 12" CTC between Pu, 60x13x15 array, concrete walls, floor and ceiling.
nmsf91a	-	0.650	-	PuO ₂ w/ 1.5 w% at 4500 g at 2 g/cc, triangular pitch, 12" CTC between Pu, 60x13x15 array, concrete walls, floor and ceiling.
nmsf92	-	-	0.522	PuO ₂ at 4500 g at 2 g/cc, triangular pitch, 12" CTC between Pu, 2 arrays of 60x6x15, concrete walls, floor and ceiling, and separator wall.
nmsf92a	-	-	0.531	PuO ₂ w/ 1.5 w% at 4500 g at 2 g/cc, triangular pitch, 12" CTC between Pu, 2 arrays of 60x6x15, concrete walls, floor and ceiling, and separator wall.
nmsf10	0.948	-	-	Pu at 4500 g at 19.86 g/cc as ingots, triangular pitch, 18" CTC between Pu, 60x13x10 array, concrete walls, floor and ceiling.

nmsf10a	0.928	-	-	Pu at 4500 g at 19.86 g/cc, triangular pitch, 18" CTC between Pu, 60x13x10 array, concrete walls, floor and ceiling. Gadolinium added to product can.
nmsf101	-	1.03	-	Pu at 4500 g at 19.86 g/cc as ingots, triangular pitch, 12" CTC between Pu, 60x13x15 array, concrete walls, floor and ceiling.
nmsf101a	-	1.02	-	Pu at 4500 g at 19.86 g/cc as ingots, triangular pitch, 12" CTC between Pu, 60x13x15 array, concrete walls, floor and ceiling. Gadolinium added to product can.
nmsf101b	-	0.843	-	Same as nmsf101 except water added at full density in regions outside 18" shroud.
nmsf101c	-	1.03	-	Same as nmsf101 except water added at 0.001 of full density in regions outside 18" shroud.
nmsf101d	-	0.981	-	Same as nmsf101 except water added at 0.01 of full density in regions outside 18" shroud.
nmsf101e	-	0.821	-	Same as nmsf101 except water added at 0.25 of full density in regions outside 18" shroud.
nmsf101f	-	0.826	-	Same as nmsf101 except water added at 0.5 of full density in regions outside 18" shroud.
nmsf101g	-	0.837	-	Same as nmsf101 except water added at 0.75 of full density in regions outside 18" shroud.
nmsf102	-	-	0.956	Pu at 4500 g at 19.86 g/cc as ingots, triangular pitch, 12" CTC between Pu, 2 arrays of 60x6x15, concrete walls, floor and ceiling, and separator wall.
nmsf102a	-	-	0.937	Pu at 4500 g at 19.86 g/cc as ingots, triangular pitch, 12" CTC between Pu, 2 arrays of 60x6x15, concrete walls, floor and ceiling, and separator wall. Gadolinium added to product can.
nmsf102b	-	-	0.900	Pu at 4500 g at 19.86 g/cc as ingots, triangular pitch, 12" CTC between Pu, 2 arrays of 48x5x15, concrete walls, floor and ceiling, and separator wall, 6480 units on 30" CTC horizontally.
nmsf102c	-	-	0.850	Pu at 4500 g at 19.86 g/cc as ingots, triangular pitch, 12" CTC between Pu, 2 arrays of 40x5x15, concrete walls, floor and ceiling, and separator wall, 4200 units on 36" CTC horizontally.
nmsf102c1			0.827	Pu at 4500 g at 19.86 g/cc as ingots, triangular pitch, 18" CTC between Pu, 2 arrays of 40x5x15, concrete walls, floor and ceiling, and separator wall, 2800 units on 36" CTC horizontally.
nmsf102d	-	-	0.935	Pu at 4500 g at 19.86 g/cc as ingots, triangular pitch, 12" CTC between Pu, 2 arrays of 60x6x15, concrete walls, floor and ceiling, and separator wall, Boron Carbide above and below Pu.
nmsf102e	-	-	0.896	Pu at 4500 g at 19.86 g/cc as ingots, triangular pitch, 12" CTC between Pu, 2 arrays of 48x5x15, concrete walls, floor and ceiling, and separator wall, 6480 units on 30" CTC horizontally, w/ 4" concrete cylinders between shrouds.
nmsf102e1	-	-	0.854	Pu at 4500 g at 19.86 g/cc as ingots, triangular pitch, 18" CTC between Pu, 2 arrays of 48x5x10, concrete walls, floor and ceiling, and separator wall, 4320 units on 30" CTC horizontally, w/ 4" concrete cylinders between shrouds.

nmsf102f	-	-	0.890	Pu at 4500 g at 19.86 g/cc as ingots, triangular pitch, 12" CTC between Pu, 2 arrays of 48x5x15, concrete walls, floor and ceiling, and separator wall, 6480 units on 30" CTC horizontally, w/ 6" concrete cylinders between shrouds.
nmsf102f1	-	-	0.842	Pu at 4500 g at 19.86 g/cc as ingots, triangular pitch, 18" CTC between Pu, 2 arrays of 48x5x10, concrete walls, floor and ceiling, and separator wall, 4320 units on 30" CTC horizontally, w/ 6" concrete cylinders between shrouds.
nmsf102g	-	-	0.869	Pu at 4500 g at 19.86 g/cc as ingots, triangular pitch, 12" CTC between Pu, 2 arrays of 48x5x15, concrete walls, floor and ceiling, and separator wall, 6480 units on 30" CTC horizontally, w/ 6" concrete cylinders between shrouds.
nmsf102g1	-	-	0.839	Pu at 4500 g at 19.86 g/cc as ingots, triangular pitch, 18" CTC between Pu, 2 arrays of 48x5x10, concrete walls, floor and ceiling, and separator wall, 4320 units on 30" CTC horizontally, w/ 6" concrete cylinders between shrouds.
nmsf104	0.806	-	-	Pu at 6000 g at 19.86 g/cc as rings, triangular pitch, 18" CTC between Pu, 60x13x10 array, concrete walls, floor and ceiling.
nmsf105	-	0.943	-	Pu at 6000 g at 19.86 g/cc as rings, triangular pitch, 12" CTC between Pu, 60x13x15 array, concrete walls, floor and ceiling.
nmsf106	-	-	0.817	Pu at 6,000 g at 19.86 g/cc as rings, triangular pitch, 12" CTC between Pu, 2 arrays of 60x6x15, concrete walls, floor and ceiling, and separator wall.
nmsf107	0.896	-	-	Pu at 4,500 g at 19.86 g/cc as ingots, 18 " CTC between Pu, 2 arrays of 60x6x10, and concrete walls, floor and ceiling, and separator wall.
nmsf108	0.842	-	-	Pu at 4,500 g at 19.86 g/cc as ingots, 18 " CTC between Pu, 2 arrays of 60x6x10 w/ Pu in odd rows, and concrete walls, floor and ceiling, and separator wall.
nmsf109	0.870	-	-	Pu at 4,500 g at 19.86 g/cc as ingots, 18 " CTC between Pu, 60x13x10 w/ Pu in odd rows, and concrete walls, floor and ceiling.
nmsf111	0.807	-	-	Pu at 4,500 g at 19.86 g/cc as ingots, 36" CTC between Pu, 2 arrays of 60x6x5 w/ Pu in odd rows, and concrete walls, floor and ceiling, and separator wall, 1,800 units, 8.1 T.
nmsf112	0.814	-	-	Pu at 4,500 g at 19.86 g/cc as ingots, 36" CTC between Pu, 60x13x5 array w/ Pu in odd rows, and concrete walls, floor and ceiling, 1,950 units, ~8.8 T.
nmsf15a	-	-	0.955	Pu at 4,500 g at 19.86 g/cc as ingots, 12" CTC between Pu, 2 arrays of 60x6x15, and concrete walls, floor and ceiling, and separator wall, concrete around shrouds at .023 g/cc.
nmsf15b	-	-	0.933	Same as Case nmsf15a except concrete density = .23 g/cc
nmsf15c	-	-	0.894	Same as Case nmsf15a except concrete density = .46 g/cc
nmsf15d	-	-	0.871	Same as Case nmsf15a except concrete density = .69 g/cc
nmsf15e	-	-	0.855	Same as Case nmsf15a except concrete density = .92 g/cc
nmsf15f	-	-	0.843	Same as Case nmsf15a except concrete density = 1.15 g/cc

nmsf15g	-	-	0.843	Same as Case nmsf15a except concrete density = 1.38 g/cc
nmsf15h	-	-	0.831	Same as Case nmsf15a except concrete density = 1.61 g/cc
nmsf15i	-	-	0.827	Same as Case nmsf15a except concrete density = 1.84 g/cc
nmsf15j	-	-	0.815	Same as Case nmsf15a except concrete density = 2.185 g/cc (95%) and added ~5% Boron
nmsf20a	-	0.781	-	Pu at 4,500 g at 19.86 g/cc as ingots, 12"CTC between Pu, 1x1x15 array, and concrete walls, floor and ceiling.
nmsf20b	-	0.795	-	Pu at 4,500 g at 19.86 g/cc as ingots, 12"CTC between Pu, 2x2x15 array, and concrete walls, floor and ceiling.
nmsf20c	0.833	-	-	Pu at 4,500 g at 19.86 g/cc as ingots, 18"CTC between Pu, 63x10x10 array, and concrete walls, floor and ceiling, w/ 4.56" of Boral around Pu.
nmsf20ca	0.945	-	-	Pu at 4,500 g at 19.86 g/cc as ingots, 18"CTC between Pu, 63x10x10 array, and concrete walls, floor and ceiling.
nmsf20d	-	0.854	-	Pu at 4,500 g at 19.86 g/cc as ingots, 12"CTC between Pu, 63x10x15 array, and concrete walls, floor and ceiling, w/ 4.56" of Boron Carbide around Pu, B4C between 16 & 18" pipes.
nmsf20da	-	0.855	-	Pu at 4,500 g at 19.86 g/cc as ingots, 12"CTC between Pu, 63x10x15 array, and concrete walls, floor and ceiling, w/ 4.56" of B4C around Pu.
nmsf20e	-	0.804	-	Pu at 4,500 g at 19.86 g/cc as ingots, 12"CTC between Pu, 63x10x15 array, and concrete walls, floor and ceiling, w/ 4.56" of BPE around Pu, BPE between 16 & 18" pipes.
nmsf20ea	-	0.809	-	Pu at 4,500 g at 19.86 g/cc as ingots, 12"CTC between Pu, 63x10x15 array, and concrete walls, floor and ceiling, w/ 4.56" of BPE around Pu.
nmsf20f	-	0.855	-	Pu at 4,500 g at 19.86 g/cc as ingots, 12"CTC between Pu, 63x10x15 array, and concrete walls, floor and ceiling, w/ 4." of Gd2O3 around Pu.
nmsf20g	-	0.926	-	Pu at 4,500 g at 19.86 g/cc as ingots, 12"CTC between Pu, 63x10x15 array, and concrete walls, floor and ceiling, B4C (18") located every 7th position, no B4C around Pu..
nmsf20ga	-	0.836	-	Pu at 4,500 g at 19.86 g/cc as ingots, 12"CTC between Pu, 63x10x15 array, and concrete walls, floor and ceiling, w/ 4.5" of B ₄ C around Pu, Boron Carbide (18" & no CS) located every 7th position.
nmsf20h	-	0.915	-	Pu at 4,500 g at 19.86 g/cc as ingots, 12"CTC between Pu, 63x10x15 array, and concrete walls, floor and ceiling, BPE (18" in CS) located every 7th position.
nmsf20ha	-	0.808	-	Pu at 4,500 g at 19.86 g/cc as ingots, 12"CTC between Pu, 63x10x15 array, and concrete walls, floor and ceiling, w/ 4.5" of BPE around Pu, Borated Polyethylene (18" in CS) located every 7th position.
nmsf20i	-	0.905	-	Pu at 4,500 g at 19.86 g/cc as ingots, 12"CTC between Pu, 63x10x15 array, and concrete walls, floor and ceiling, 18" concrete in CS every 7th position.
nmsf20ia	-	0.806	-	Pu at 4,500 g at 19.86 g/cc as ingots, 12"CTC between Pu, 63x10x15 array, and concrete walls, floor and ceiling, w/ 4.5" of BPE around Pu, Concrete in 18" shroud located every 7th position.

nmsf20id	-	0.905	-	Pu at 4,500 g at 19.86 g/cc as ingots, 12" CTC between Pu, 63x10x15 array, and concrete walls, floor and ceiling, Concrete in 18" shroud located every 4th position.
nmsf20ie	-	0.884	-	Pu at 4,500 g at 19.86 g/cc as ingots, 12" CTC between Pu, 63x10x15 array, and concrete walls, floor and ceiling, Borated (~4.5 w%) Concrete in 18" shroud located every 4th position.
nmsf30a	-	0.655	-	PuO ₂ w/ 1.5 w% at 4500 g at 2 g/cc, triangular pitch, 12" CTC between Pu, 63x10x15 array, concrete walls, floor and ceiling.
nmsf30b	-	0.847	-	Pu at 4500 g at 9.93 g/cc (.5 of full), triangular pitch, 12" CTC between Pu, 63x10x15 array, concrete walls, floor and ceiling.
nmsf30b2	-	0.780	-	Same as nmsf30b except Pu density is 4.965 g/cc (.25 of full)
nmsf30c	-	0.681	-	Pu at 4500 g at 14.895 g/cc (.75 of full), triangular pitch, 12" CTC between Pu, 63x10x15 array, concrete walls, floor and ceiling.
nmsf30da	-	0.825	-	Pu sphere at 4,500 g, in containment vessel, 63x10x9 array, concrete walls, floor and ceiling.
nmsf30db	-	0.695	-	Pu sphere at 6,500 g, in containment vessel, 63x10x9 array, concrete walls, floor and ceiling.
nmsf30db2	-	1.103	-	6000g Pu at hemishell (2.54 cm IR), 63x10x15 array, concrete walls, floor and ceiling.
nmsf30db2 a	-	0.741	-	Single unit of nmsf30db2
				All Standard Deviations <0.005

Los Alamos

NATIONAL LABORATORY

memorandum

Health and Safety Division
HS-8, Nuclear Criticality Safety

To: Memo-To-File
Thru: T. P. McLaughlin
From: J. A. Schlesser
Symbol: HS-6-93-210
Date: October 19, 1993

**SUBJECT: CRITICALITY SAFETY — PARAMETER SURVEY FOR THE
NUCLEAR MATERIAL STORAGE FACILITY, TA-55, PF-41**

Ref: J. A. Schlesser to K. O. Ellard, *Criticality Safety for the Nuclear Material Storage Facility, TA-55, PF-41*, HS-6-93-209, October 19, 1993.

SUMMARY

This memo documents several criticality safety parametric studies performed for the subject facility under a broader spectrum of storage conditions alluded to in the referenced memo (attached as Appendix 1). Several of these studies were at the request of the NMT-8 staff in their effort in determining a storage array design for plutonium material. The several studies discussed below are followed by the results of each. The analyses completed in the reference are included in this memo for consistency of documentation.

The TA-55, PF-41 Nuclear Material Storage Facility was designed and built to store fissile material. With the advent of dismantlement of nuclear weapons, the need for storage of the resulting fissile material is heightened. This report documents several storage configurations based on the storage concept of a water bath for passive heat removal. The results show that the water bath concept is viable and that the most abnormal, credible accident condition is such that system multiplication factors are greatest when the water has been removed from the bath. However, even when the water is removed, for the several fissile 'realistic' configurations, the system(s) are subcritical with generous criticality safety margins.

Storage of pits will be addressed in a separate study and memo.

CALCULATIONAL ASSUMPTIONS

ARRAYS

The NMSF proposed storage array area is illustrated in Figure 1. The storage bays each consist of a 'corridor' 13'8" wide by 100' long by 20' high (inside dimensions). There are additional rooms, work areas, and maintenance areas in the building on the same floor, but for the sake of a parametric survey, only these two bays were considered in the survey. Two identical bays are present separated by a wall of concrete, 12" thick. While there are walls with doors at each end of a bay, it was assumed that these walls were of solid concrete for calculational purposes — a reasonable assumption.

The exterior walls, floor, and ceiling of each bay were assumed to be constructed of 'ordinary' concrete 18" thick without either boron or re-bar steel, both of which are neutron absorbers. This assumption provides as much neutron reflection as possible from the concrete which adds conservatism to the results.

The array size(s) used were such that a whole number of units would be stored in both the x and y directions (width and length). The number of vertical units per x,y location was either 6 or 10 and was driven by the height constraint of ~10'. The number of vertical units per x,y location was then driven by the size of the secondary container used, i. e., the 20" container would allow ~6 units to be stacked while the smaller container would allow ~10 units to be stacked vertically. The total number of units in the arrays was determined by the spacing of the units — either 18" or 24" center-to-center — and the vertical number in the z (high) direction.

The array(s) were modeled inside a water bath tank such that the tank fitted around the array with the tank walls and bottom as 0.5"-thick stainless steel. A walkway was provided around the exterior of the tank and was modeled as being 30" wide. The tank was elevated above the floor by 6". This elevation was created by the presence of ~6" I-beams which support the tank. No credit was taken for the presence of these I-beams. There was an open space above the tank which modeled the distance between the top of the tank and the bottom of the ceiling.

SECONDARY CONTAINER

The secondary container intended to be used as a confinement vessel will be made of 14" diameter by ~20" tall, schedule 10, stainless steel pipe. The conceptual container is illustrated in Figure 2a while the computer model is illustrated in Figure 2b. Since no internal support structure concept was provided, it was assumed that the primary container was positioned in the center and on the bottom of the secondary container. The calculational model incorporated minor modeling approximations, such as the container being modeled as a right circular cylinder versus the design with curved end caps. These approximations were made in a manner that resulted in neutronic conservatism.

While this container can be used for large-sized shapes, for cost conservation, it was decided to build some of the computer models without the large secondary container. Instead, a smaller container of the same or approximate schedule was used to envelope the primary container. This choice allows more containers to be stored in the vertical direction and therefore allows more units to be stored in each of the arrays.

PRIMARY CONTAINER

The primary container will provide primary containment of plutonium metal or oxide. The metal will be in the form of solid buttons or other small-sized, irregular shapes. The oxide will be in the form of a low density powder. The container will be made of 304L stainless steel and have the following general dimensions: 5" inside diameter, schedule 40 pipe ~12" long with end caps of 3/4" thickness. The end caps will be welded in place providing an overall length of ~12".

Other fissile material geometries were modeled inside the primary container. One was where the fissile material was placed inside the primary container in the configuration of right circular cylinders (Figs. 2c and 2d). The height of the fissile material was determined by its density. As the density was decreased, the corresponding volume increased. The other modeling placed the fissile material in an annular ring configuration (Fig. 2e). Again, the height of the fissile material was determined by its density. The lowest density used was 0.11258 of full density which was the minimum used in all of the models where the density was varied.

FISSILE MATERIAL

The fissile material used in all of the models was taken to be 4,500 grams of alpha-phase plutonium with 95 wt% ^{239}Pu and 5 wt% ^{240}Pu at a density of 19.86 g/cc. Figure 3 illustrates the various shapes of fissile material modeled in the primary container. Various shapes of the fissile were utilized during the modeling to determine the most efficient (criticality-wise) use of the storage space and to store the maximum number of units in the defined array. The shapes various shapes used were: spherical — most conservative from a neutronic standpoint; annular rings — most neutron leaky; and circular slabs. The density of the rings and slabs was varied from full density which represents the metal form to a low density which approximates a loose oxide powder. In all cases, a constant mass of 4,500 g was maintained.

These variations simulate fissile material pieces which might be placed in the primary container but do not occupy the same volume as a full density (19.86 g/cc) single piece. For example, miscellaneous size and shape pieces from broken buttons and shells will generally pack in a can at less than one-half of full density. Also, a constant, uniform density is an excellent neutronic representation of full density pieces with void space between them. Similarly, a low density metal model is a good approximation to an oxide powder. Thus, this variation from a full density disc to a very low density medium spans the range of expected, actual storage conditions, which are as yet unspecified.

During the calculations, boron, reportedly present in the concrete separator wall, but not verified by the author, and steel as re-bar in the walls, were not included in any of the models. As the results will show, the inclusion of these two materials is not required for criticality control purposes.

The several materials used in the calculations are reported in Table 1 along with their corresponding atom densities.

CALCULATIONAL MODELS

Each of the calculational models developed will be described separately below.

. SINGLE CAN(S)

The first series of calculations were performed with 4,500 g of plutonium configured as a sphere with a spherical radius of 3.782 cm. The multiplication factor for a single can with the large secondary was calculated. The can was centered inside a hollow square tube of carbon steel with a wall thickness of 0.5" and an outside dimension of 18"(C211). A second model was developed utilizing a compact secondary container and thick water (~12") reflected (C212). In this model it was assumed that water or moderator was not present in the interior of either the primary or secondary containers.

12 x 66 x 6 ARRAY ON 18" CENTERS

The first of the array calculations modeled the fissile material as a sphere inside the primary container with a close-fitting secondary (C213, C214). Immediately surrounding the secondary container was stainless steel as a 'storage tube'. This single container was then stacked 6 high and inserted in an array of 12 x 66 x 6 units with the units on 18" centers and the array surrounded by the concrete walls of the storage bay. The multiplication factor of this single array was then calculated. A variation of this model was to add full density water around the single unit prior to stacking in the array. It was found that the dry condition was more reactive than the moderated. The array was arranged inside a stainless steel tank using water as a heat removal medium.

12 x 66 x 10 ARRAY ON 18" CENTERS

The configurations for this array size were the same as for the 12 x 66 x 6 array EXCEPT that 10 units were stacked vertically (C215, C216).

9 x 50 x 6 (and 10) ARRAY ON 24" CENTERS

These two models were repeats of the previous two EXCEPT that the unit spacing was increased to 24". Although this reduced the capacity of the array, it showed that increasing the unit spacing, the resulting multiplication factor was somewhat lower for the dry case (C217-C2110).

FISSILE MATERIAL IN ANNULUS CONFIGURATION

The fissile material in an annulus configuration allows greater neutron leakage as compared to the same mass in a spherical geometry. Varying the density of the fissile material encompasses those densities from full density metal to that which approximates an oxide as loose powder. The arrays modeled were for both 6 and 10 high units in the array configuration (C218a-e, C219a-e).

REFLECTIVE MATERIAL

In this model, which was the same as for the two just described, polyethylene was used to enclose the basic stacking unit of annulus configuration. Polyethylene was chosen to show that the array would be less reactive than a dry array and that with this material present, concern over the loss of moderator or coolant could be minimized. For heat removal, a passive system could be used (C2110a-e).

An additional array scheme was designed whereby the center-to-center spacing was reduced to 16" and the array size increased to 10 x 75 x 6 (or 10) [C2111a-e].

CYLINDERS

This geometrical representation of the fissile material is the basis for the calculations performed in the referenced memo, and is reported so that the reader does not have to refer to it.

OTHER VARIATIONS

Two additional models were developed. One included borated stainless steel as a thin cylinder immediately inside the primary container. The other inserted a cadmium liner on the inside of the stainless steel tank. These conditions were then applied to dry 12 x 66 x 6 and 12 x 66 x 10 arrays. The purpose was to determine the change, if any, in the array multiplication factor(s) [C2111-C2116].

CALCULATIONAL METHOD

The results reported in this analysis were performed with KENO 5.3 a Monte Carlo criticality code and utilized the Hansen-Roach 16-energy-group cross sections. Cases were executed for at least 30,000, but not more than 50,000, neutron histories, which resulted in a statistical uncertainty of less than 0.006 in the multiplication factor for any case. All of the calculations were performed on a SUN® SPARC station 10.

RESULTS

The results of the several calculations performed are reported on Tables 2 and 3 along with a brief description of each configuration.

Table 1. Material Atom Densities Used in Calculating Multiplication Factors

Material	Density g/cc	Element or Isotope	Weight Percent	Atom Density, atoms / barn-cm
Borated Stainless Steel	7.74	B	1.0	4.31E-03
		Fe	68.8	5.742E-02
		Cr	18.8	1.686E-02
		Ni	9.4	7.47E-03
		Mn	2.0	1.68E-03
Cadmium	8.65	Cd	100.0	4.634E-02
Carbon Steel (KENO Mix = 100)	7.82	C	1.0	3.92E-03
		Fe	99.0	8.349E-02
Concrete (KENO Mix = 301)	2.3	Al	3.4	1.75E-03
		Ca	4.4	1.52E-03
		Fe	1.4	3.5E-04
		H	1.0	1.374E-02
		O	53.2	4.606E-02
		Na	2.9	1.75E-03
Plutonium	19.86	²³⁹ Pu	95.0	4.753E-02
		²⁴⁰ Pu	5.0	2.49E-03
Polyethylene (KENO Mix = 402)	0.92	C	85.6	3.95E-02
		H	14.4	7.899E-02
Water (KENO Mix = 502)	0.9982	H	11.19	6.6742E-02
		O	81.81	3.3371E-02

Table 2. Case Descriptions and Calculational Results

Case	$k_{eff} \pm \sigma$	Case Description
The following cases were analyzed with plutonium configure as a solid sphere of 4,500 g.		
C211	0.80 ± 0.005	Pu as a sphere in a single primary container with Sch 40 and Sch 5 walls and end caps and 1/8" 304L storage tube, all close fitting stainless steel. Outer cuboid 14" square.
C211a	0.80 ± 0.004	Pu as a sphere in a single can in large secondary container with water filling the space to an 18" cuboid.
C212	0.85 ± 0.004	Same as C211 but with 12" of water reflection.
C213	0.84 ± 0.004	Pu as a sphere in C211 container, water in cuboid around container and 12 x 66 x 6 array with tank filled with water and units on 18" centers.
C214	0.98 ± 0.004	Same as C213 but water removed.
C215	0.85 ± 0.004	Same as C213 but array size is 12 x 66 x 10 units.
C216	1.04 ± 0.004	Same as C214 but array size is 12 x 66 x 10 units.
C217	0.84 ± 0.004	Pu as a sphere in C211 container, water in cuboid around container and 9 x 50 x 6 units in array on 24" centers. Tank is filled with water.
C218	0.90 ± 0.004	Same as C217 but water drained from tank.
C219	0.85 ± 0.004	Same as C217 but array size is 9 x 50 x 6 units.
C2110	0.94 ± 0.004	Same as C219 but water drained from tank.
C2111	0.97 ± 0.004	Same as C214 but ~1/8" radially thick borated stainless steel lining the primary can filling a 12 x 66 x 6 dry array
C2112	0.98 ± 0.005	12 x 66 x 6 dry array with ~1/8" thick cadmium liner on tank interior walls and bottom.
C2113	1.00 ± 0.004	Same as C2111 but array size is 12 x 66 x 10 units.
C2114	1.03 ± 0.004	Same as C2112 but array size is 12 x 66 x 10 units.
C2115	0.90 ± 0.004	Same as C2111 but array size is 9 x 50 x 6 units.
C2116	0.90 ± 0.004	Same as C2112 but array size is 9 x 50 x 6 units.

Table 3. Case Descriptions and Calculational Results

Case	$k_{eff} \pm \sigma$	Case Description
The following cases were analyzed with the plutonium in primary and large secondary containers with the density of plutonium varied from full to 0.11258 (of full) to simulate spectrum of densities.		
C218a	0.79 ± 0.004	Plutonium as annular ring, full density, in primary and large secondary containers, in 9 x 66 x 6 unit arrays, specular reflection to simulate two bays (arrays).
C218b	0.75 ± 0.004	Same as C218a except that plutonium is at 0.75 of full density.
C218c	0.68 ± 0.003	Same as C218a except that plutonium is at 0.5 of full density.
C218d	0.59 ± 0.003	Same as C218a except that plutonium is at 0.25 of full density.
C218e	0.53 ± 0.003	Same as C218a except that plutonium is at 0.11258 of full density.
C218f	0.82 ± 0.005	Plutonium as right circular cylinder, full density, in primary and large secondary containers, in 9 x 66 x 6 unit arrays, specular reflection to simulate two bays (arrays).
C218g	0.79 ± 0.006	Same as C218f except that plutonium is at 0.75 of full density.
C218h	0.73 ± 0.005	Same as C218a except that plutonium is at 0.5 of full density.
C218i	0.65 ± 0.004	Same as C218a except that plutonium is at 0.25 of full density.
C218j	0.56 ± 0.004	Same as C218a except that plutonium is at 0.11258 of full density.
C218k	0.80 ± 0.005	Plutonium as right circular cylinder, full density, in primary and large secondary containers, in 8 x 83 x 6 unit arrays in carbon steel shroud, specular reflection to simulate two bays (arrays).
C218l	0.76 ± 0.005	Same as C218k except plutonium at .75 of full density.
C218m	0.71 ± 0.004	Same as C218k except plutonium at .5 of full density.
C218n	0.61 ± 0.004	Same as C218k except plutonium at .25 of full density.
C218o	0.53 ± 0.003	Same as C218k except plutonium at .11258 of full density.
C219a	0.90 ± 0.004	Plutonium as annular ring, full density, in primary container on 18" centers, carbon steel shroud, in 9 x 66 x 9 unit arrays, specular reflection to simulate two bays (arrays).
C219b	0.85 ± 0.004	Same as C219a except plutonium is at .75 of full density.

Table 3. Case Descriptions and Calculational Results (Cont'd)

Case	$k_{eff} \pm \sigma$	Case Description
C219c	0.80 ± 0.003	Same as C219a except plutonium is at .5 of full density.
C219d	0.72 ± 0.003	Same as C219a except plutonium is at .25 of full density.
C219e	0.67 ± 0.003	Same as C219a except plutonium density is at .11258 of full density.
C219f	0.92 ± 0.005	Plutonium as right circular cylinder, full density, in primary and large secondary containers, in 9 x 66 x 9 unit arrays, specular reflection to simulate two bays (arrays).
C219g	0.89 ± 0.006	Same as C219f except plutonium is at .75 of full density.
C219h	0.85 ± 0.005	Same as C219f except plutonium is at .5 of full density.
C219i	0.76 ± 0.005	Same as C219f except plutonium is at .25 of full density.
C219j	0.69 ± 0.004	Same as C219f except plutonium is at .11258 of full density.
C2110a	0.66 ± 0.004	Plutonium as annular ring, full density, in primary container, surrounded by polyethylene and carbonsteel shroud, 18" centers, 9 x 66 x 9 unit array, specular reflection to simulate two bays (arrays).
C2110b	0.59 ± 0.003	Same as C2110a except plutonium is at .75 of full density.
C2110c	0.52 ± 0.003	Same as C2110a except plutonium is at .5 of full density.
C2110d	0.44 ± 0.003	Same as C2110a except plutonium is at .25 of full density.
C2110e	0.38 ± 0.003	Same as C2110a except plutonium is at .11258 of full density.
C2111a	0.66 ± 0.004	Plutonium as annular ring, full density, in primary container, 16" centers, with 4.5%B Bisco® forming 16" square, 10 x 75 x 9 unit array, specular reflection to simulate two bays (arrays).
C2111b	0.61 ± 0.003	Same as C2111a except plutonium is at .75 of full density.
C2111c	0.52 ± 0.003	Same as C2111a except plutonium is at .5 of full density.
C2111d	0.41 ± 0.003	Same as C2111a except plutonium is at .25 of full density.
C2111e	0.31 ± 0.002	Same as C2111a except plutonium is at .11258 of full density.

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Figure 2A. Conceptual Primary Storage Container

Figure 2B. Primary Storage Container Situated Inside Secondary Container — Plutonium Configured as a Sphere.

Figure 2C. Computer Model of Primary Container Inside Secondary Container — Plutonium Configured as a Right Circular Cylinder.

Figure 2D. Details of Plutonium as Right Circular Cylinders.

Figure 2E. Details of Plutonium as Annular Rings.

Figure 3. Storage Shroud

Figure 4. Graphical Representation of Calculational Results

Appendix 1

Memo: J. A. Schlessner to K. O. Ellard, *Criticality Safety for the Nuclear Material Storage Facility, TA-55, PF-41*, HS-6-93-209, October 19, 1993.

Los Alamos

NATIONAL LABORATORY

memorandum

Health and Safety Division
HS-6, Nuclear Criticality Safety

To/MS: K. O. Ellard, MS M711
Thru: T. P. McLaughlin
From/MS: J. A. Schlessner
Phone/FAX: 5-2815/5-4970
Symbol: HS-6-93-209
Date: October 19, 1993

SUBJECT: CRITICALITY SAFETY FOR THE NUCLEAR MATERIAL STORAGE FACILITY - TA-55, PF-41

Ref: J. A. Schlessner, Memo-to-File, *Criticality Safety — Parameter Survey for the Nuclear Material Storage Facility, TA-55, PF-41*, HS-6-93-210, October 19, 1993.

SUMMARY

We have performed several analyses to determine the state of criticality for various fissile material storage array configurations in the nuclear material storage facility. The array specifications were provided to us by Paul Smith of Merrick and Company. We have determined that there are generous criticality safety margins for the proposed 8 x 83 x 5 storage array in each bay. Details of the analyses and results are presented below.

Due to the large fixed costs associated with fissile material storage facilities, e. g., construction, safeguarding, accountability, etc., and the possible economic advantages of storing more fissile material in the same volume, let us elaborate briefly on the criticality safety margins. Should non-criticality safety considerations not prohibit items from being stored on smaller center-to-center spacings, then a doubling of the number of units beyond that represented by an 8 x 83 x 5 array in each bay (6,640 units for both bays) could be easily accommodated from a criticality safety standpoint. Further, with the innovative use of strong neutron absorbers and constraints on the average density of the fissile material in each can, then a factor of three, or even four, increase in the vault capacity is likely achievable.

The referenced memo provides the results of additional parameter surveys performed for the same facility under a broader spectrum of storage conditions.

CALCULATIONAL MODELS AND ASSUMPTIONS

There will be identical storage arrays fitted into each of the two bays of TA-55, PF-41. The following information was the basis for the computer model developed. Each array will have the approximate dimensions of 13 feet wide by 127 feet long by 10 feet tall (see Figure 1). The array will consist of square carbon steel shrouds of 18 inch sides with a length of approximately 10 feet. Each shroud will have a 14-inch diameter cavity essentially the full length of the shroud (See Figure 2). The size of the shroud determines the spacing in the array, i. e., the stored units will have an 18-inch center-to-center spacing since there will be no free space

between the shrouds.

In addition, the storage bay was modeled with the ceiling at a height of 20 feet. The walls, ceiling, and floor were modeled as ordinary concrete, 18-inches thick. A gap of ~6 inches was modeled between the fissile array and the concrete walls in the x (8) direction, and ~15 inches in the y (83) direction. Carbon steel (~3 inches) was modeled at the bottom of the array just above the concrete floor. The wall between the bays was modeled also as ordinary concrete but 12 inches thick.

Each storage container was modeled as being a 5-inch diameter Schedule 40 stainless steel pipe with end caps (also stainless steel) of 0.75-inch thickness with a total height of approximately 12 inches (See Figure 3). The secondary container was modeled as a 14-inch diameter Schedule 5 stainless steel pipe with end caps of Schedule 5 (0.188") thickness. The calculational model incorporated minor modeling approximations, such as, the secondary container being modeled as a right circular cylinder versus the design with curved end caps. These approximations were made in a manner that resulted in neutronic conservatism.

The fissile material used in the calculations was taken to be 4,500 g of alpha-phase plutonium with 95 wt% ^{239}Pu and 5 wt% ^{240}Pu at a density of 19.86 g/cc. The fissile material was initially modeled as a right circular cylinder with a diameter of 5 inches and a height of ~0.7 inches (See Figure 3). The other variations of the fissile material consisted of the same diameter but varying heights which model variations in the density of the fissile material (See Fig. 3A). In all cases, a constant mass of 4,500 g was maintained. These variations simulate fissile material pieces which might be placed in the inner container but do not occupy the same volume as a full density (19.86 g/cc) single piece. For example, miscellaneous size and shape pieces from broken buttons and shells will generally pack in a can at less than one-half of full density. Also, a constant, uniform density is an excellent neutronic representation of full density pieces with void space between them. Similarly, a low density metal model is a good approximation to an oxide powder. Thus, this variation from a full density disc to a very low density medium spans the range of expected, actual storage conditions, which are as yet unspecified.

Credit was not taken for the actual presence of boron, as a neutron poison, in the walls separating the two bays. Atom densities for the material(s) used are presented in Table 1.

For additional conservatism and consistency with previous analyses, six-unit-high arrays were modeled and calculated, although the planned array is only five-units high.

CALCULATIONAL METHOD

The results reported in this analysis were performed with KENO V.a, a Monte Carlo criticality code and utilized Hansen-Roach 16-energy-group cross sections. Each case was executed for 30,000 neutron histories, which resulted in a statistical uncertainty of less than 0.006 in the multiplication factor for any case.

RESULTS

The results of the several calculations performed are reported in Table 2 and plotted in Figure 4. It can be seen from Table 2 and Figure 4 that the highest multiplication factor results when the plutonium is at its maximum density and, therefore, its smallest volume. Conversely, expected storage conditions, whether as several, small pieces of metal in each can or as a loose oxide, would be consistent with a much lower average fissile density and thus afford larger safety margins for the same total vault inventory, or an increase in vault inventory (reduced can spacing) with still generous safety margins.

Results of the several performed calculations will be maintained in HS-6 Files and are available for review.

CONCLUSIONS

For the ~7,968 unit capacity of the arrays (8 x 83 x 6) which occupy the two storage bays, there are generous criticality safety margins. The number of units (7,968) represents a heat loading of ~79 kw based on a nominal 2.5 w/kg fissile.

However, due to the very high degree of subcriticality for the calculated (6-high) arrays, it would be possible to store at least twice as many units with still generous safety margins, and with innovative use of strong neutron absorbers such as boron, it could well be achievable to fit three or even four times as much fissile material into this vault before true criticality limits were approached.

if there are questions regarding this analysis or criticality safety of the facility, please do not hesitate to call on us.

CC: P. T. Cunningham, CM-NM, MS F628
W. T. Wood, NMT-DO, MS K524
C. H. Smith, NMT-8, MS E583
R. S. Sharp, WX-11
W. McNeese, E583
W. Merriman, E583
P. Smith, Merrick and Company.
HS-6 Files

Table 1.

Fissile Material Atom Densities

Material	Density	Element or Isotope	Weight Percent	Atom Density, atoms / barn-cm
Plutonium	19.86	²³⁹ Pu	95	0.04753
		²⁴⁰ Pu	5	0.00249
Stainless Steel (Keno mix = 200)	7.92	Cr	19.0	0.001743
		Fe	69.5	0.05935
		Ni	9.5	0.00772
		Mn	2.0	0.00174
Carbon Steel (Keno mix=100)	7.82	C	1.0	0.00392
		Fe	99.0	0.08349
Ordinary Concrete (Keno mix=301)	2.3	Al	3.4	0.0017
		Ca	4.4	0.00152
		Fe	1.4	0.00035
		H	1.0	0.01374
		O	53.2	0.04606
		Na	2.9	0.00175
		Si	33.7	0.01662

Table 2.

Multiplication Factors for Storage Array
Two 8 x 83 x 6 Arrays (7,968 units)

Density of Fissile Material in Inner Container, g/cc	Array Multiplication Factor $k_{eff} + 3\sigma$
19.86	0.81
14.895	0.77
9.93	0.72
4.965	0.62
2.23	0.54

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Figure 2. Storage Shroud, as Modeled

Figure 3. Single Storage Container Modeling Details

Figure 3A. Single Storage Container
Additional Modeling Details

Figure 4. Multiplication Factors for 8 by 83 by 6 (x, y, z) Arrays

Appendix

Calculations of Radiation Shielding Thicknesses for Storage Array

Dose calculated at top of layer representing Charge Deck

Top Layer of Shielding representing Charge Deck

Layer of Plutonium with Uniform Areal Density of
 16.953 g/cm^2 representing Top View of Storage Array

Bottom Layer of 4000-psi Concrete
representing Floor

Neutron sources were spontaneous fission and Pu-Be interface (α, n) reactions and were uniformly distributed in layer representing storage array.

Pu areal density of 16.953 g/cm^2 corresponds to 14 vertical units of 4.5 kg of Pu smeared over a 2'x2' unit cell.

Thickness of 4000-psi concrete bottom layer was calculated with ONEDANT Discrete-Ordinates Code (Ref. 1) at $k_{\text{eff}} = 0.8$ for a 61-cm thick shield layer.

Doses were calculated with ONEDANT Discrete-Ordinates Code (Ref. 1) and a 42 energy-group coupled neutron-(n, γ) cross-section set (Ref. 2), using fluence to effective-dose-equivalent conversion factors for Frontal (AP) exposure geometry (Ref. 3).

Fig. 1. Infinite-Slab Calculational Model for Estimating Neutron and Neutron-Induced Gamma (n, γ) Dose Rates at Top of Charge Deck.

Table I

Thickness of Shielding in Charge-Deck as determined with Infinite-Slab Model of Fig. 1

Shielding Material	Shielding Thickness *		Percent (n, γ) in Dose		Neutron Multiplication Factor, k_{eff}	
	10% ‡ occupancy	100% † occupancy	10% ‡ occupancy	100% † occupancy	10% ‡ occupancy	100% † occupancy
4000-psi Borated Concrete	61.4	87.8	4.9	7.1	0.800	0.800
4000-psi Concrete	67.2	100.8	27.6	53.2	0.800	0.800
5000-psi Concrete	64.4	96.4	28.5	53.7	0.800	0.800

* Listed thicknesses result in an annual dose of 500 mrem (the design limit) for the indicated occupancies.

† 100% occupancy is 2000 hours annual exposure time. Design dose-rate at 100% occupancy is 0.25 mrem/hour (2000 hours x 0.25 mrem/hour = 500 mrem annual design dose limit).

‡ 10% occupancy is 200 hours annual exposure time. Design dose-rate at 100% occupancy is 2.5 mrem/hour (200 hours x 2.5 mrem/hour = 500 mrem annual design dose limit).

Dose calculated outside layer representing East Wall

12"-thick 4000-psi Borated Concrete
representing existing East Wall

Added Shield Wall on inside of existing East Wall

Layer of Plutonium with Uniform Areal Density of
 21.797 g/cm^2 representing Side View of Storage Array

Layer of 4000-psi Borated Concrete
representing West Wall

Neutron sources were spontaneous fission and Pu-Be interface (α, n) reactions and were uniformly distributed in layer representing storage array.

Pu areal density of 21.797 g/cm^2 corresponds to 9 vertical units of 4.5 kg of Pu smeared over a 2'x1' unit cell.

Thickness of first layer of 4000-psi borated concrete was calculated with ONEDANT Discrete-Ordinates Code (Ref. 1) at $k_{\text{eff}} = 0.8$ for a 61-cm thick shield layer.

Doses were calculated with ONEDANT Discrete-Ordinates Code (Ref. 1) and a ⁴²energy-group coupled neutron-(n, γ) cross-section set (Ref. 2), using fluence to effective-dose-equivalent conversion factors for Frontal (AP) exposure geometry (Ref. 3).

Fig. 2. Infinite-Slab Calculational Model for Estimating Neutron and Neutron-Induced Gamma (n, γ) Dose Outside East Wall of Storage Array *without* Internal Borated Concrete Walls.

Table II

Thickness of Additional Shielding at East Wall of Storage Array *without* Internal Borated Concrete Walls as determined with Infinite-Slab Model of Fig. 2.

Shielding Material	Thickness of Additional Shielding *		Percent (n, γ) in Dose		Neutron Multiplication Factor, k_{eff}	
	10% ‡ occupancy	100% † occupancy	10% ‡ occupancy	100% † occupancy	10% ‡ occupancy	100% † occupancy
4000-psi Borated Concrete	32.7	59.2	4.8	7.0	0.800	0.800
4000-psi Concrete	33.8	64.4	9.1	33.0	0.802	0.806
5000-psi Concrete	32.5	61.9	9.4	33.2	0.801	0.805

* Listed thicknesses result in an annual dose of 500 mrem (the design limit) for the indicated occupancies.

† 100% occupancy is 2000 hours annual exposure time. Design dose-rate at 100% occupancy is 0.25 mrem/hour (2000 hours x 0.25 mrem/hour = 500 mrem annual design dose limit).

‡ 10% occupancy is 200 hours annual exposure time. Design dose-rate at 100% occupancy is 2.5 mrem/hour (200 hours x 2.5 mrem/hour = 500 mrem annual design dose limit).

Dose calculated outside layer representing East Wall

12"-thick 4000-psi Borated Concrete
representing existing East Wall

Added Shield Wall of 4000-psi Borated Concrete
on inside of existing East Wall

Layer of Plutonium with Uniform Areal Density of
 7.2656 g/cm^2 representing Side View of Storage Array

18"-thick 4000-psi Borated Concrete

Layer of Plutonium with Uniform Areal Density of
 7.2656 g/cm^2 representing Side View of Storage Array

18"-thick 4000-psi Borated Concrete

Layer of Plutonium with Uniform Areal Density of
 7.2656 g/cm^2 representing Side View of Storage Array

Layer of 4000-psi Concrete representing West Wall

Neutron sources were spontaneous fission and Pu-Be interface (α, n) reactions and were uniformly distributed in layer representing storage array.

Pu areal density of 7.2656 g/cm^2 corresponds to 3 horizontal units of 4.5 kg of Pu smeared over a 2'x1' unit cell.

Thickness of first layer of 4000-psi concrete was calculated with ONEDANT Discrete-Ordinates Code (Ref. 1) at $k_{\text{eff}} = 0.8$ for a 61-cm thick shield layer.

Thickness of 4000-psi concrete bottom layer was calculated with ONEDANT Discrete-Ordinates Code (Ref. 1) at $k_{\text{eff}} = 0.8$ for a 61-cm thick shield layer.

Doses were calculated with ONEDANT Discrete-Ordinates Code (Ref. 1) and a ⁴²energy-group coupled neutron-(n, γ) cross-section set (Ref. 2), using fluence to effective-dose-equivalent conversion factors for Frontal (AP) exposure geometry (Ref. 3).

Fig. 3. Infinite-Slab Calculational Model for Estimating Neutron and Neutron-Induced Gamma (n, γ) Dose Outside East Wall of Storage Array with Internal Borated Concrete Walls.

Table III

Thickness of Additional Shielding at East Wall of Storage Array *with* Internal Borated Concrete Walls as determined with Infinite-Slab Model of Fig. 3

Shielding Material	Thickness of Additional Shielding *		Percent (n, γ) in Dose		Neutron Multiplication Factor, k_{eff}	
	10% ‡ occupancy	100% † occupancy	10% ‡ occupancy	100% † occupancy	10% ‡ occupancy	100% † occupancy
4000-psi Borated Concrete	21.1	47.5	4.7	6.8	0.800	0.800

* Listed thicknesses result in an annual dose of 500 mrem (the design limit) for the indicated occupancies.

† 100% occupancy is 2000 hours annual exposure time. Design dose-rate at 100% occupancy is 0.25 mrem/hour (2000 hours x 0.25 mrem/hour = 500 mrem annual design dose limit).

‡ 10% occupancy is 200 hours annual exposure time. Design dose-rate at 100% occupancy is 2.5 mrem/hour (200 hours x 2.5 mrem/hour = 500 mrem annual design dose limit).

Dose calculated at top of layer representing Charge Deck

Layer of Concrete ($\rho=2.2 \text{ g/cm}^3$) representing Charge Deck

Layer of Plutonium with Uniform Areal Density of
 16.953 g/cm^2 representing Top View of Storage Array

Photon source is gamma rays emitted during decay of Pu isotopes, ^{241}Am , and their progeny.

Pu areal density of 16.953 g/cm^2 corresponds to 14 vertical units of 4.5 kg of Pu smeared over a 2'x2' unit cell.

Dose rates were calculated with the MicroShield Point Kernel Code (Ref. 4), using fluence to effective-dose-equivalent conversion factors for Frontal (AP) exposure geometry (Ref. 3).

Fig. 4. Infinite-Slab Calculational Model for Intrinsic Gamma Dose Rate at Top of Charge Deck.

Table IV

**Dose from Photons from Radioactive Decay of
Pu Isotopes and ²⁴¹Am (Intrinsic Gamma),
calculated using Infinite-Slab Model of Fig. 4**

The listed intrinsic gamma doses should be viewed as upper bounds. They are much greater than actual dose, particularly for small concrete thicknesses, because the plutonium density in the model is much smaller than typical densities of individual units of plutonium. Plutonium at typical densities provides high attenuation of photons, particularly those with low energy.

Results show that annual intrinsic gamma dose is miniscule in comparison with ~500 mrem neutron plus (n,γ) dose for the 2-3 ft (60-90 cm) thickness range.

Concrete Thickness (cm)	Annual Dose for 100% Occupancy * (mrem)
1	1.0×10^7
5	6.8×10^5
10	3.8×10^4
20	9.6×10^2
30	8.6×10^1
50	1.1×10^0
70	1.8×10^{-2}
90	5.8×10^{-4}

* 100% occupancy is 2000 hours annual exposure time.

Table V

**Nuclidic Composition of Plutonium used for
Generating Radiation Sources**
(Values are listed as wt%)

Nuclide	Radiation Source	
	Neutrons from Spontaneous Fission and Pu-Be Interface (α, n) Reactions	Photons from Radioactive Decay of Nuclides *
^{238}Pu	0.050	0.05 †
^{239}Pu	93.138	92.33
^{240}Pu	6.004	6.50 †
^{241}Pu	0.023	1.00 †
^{242}Pu	0.100	0.10 †
^{241}Am	0.685 (6850 ppm)	0.02 (200 ppm) †

* Nuclides were decayed using the MicroShield Code (Ref. 4) until maximum ^{241}Am content (9082 ppm) was achieved at 73 years. Photon emission from all parent nuclides and their progeny was included in the photon source.

† These are maximum values imposed by Rocky Flats Plant for receipt of plutonium feedstock (Ref. 5).

Table VI

Constituents of Concretes used in Neutron and (n, γ) Dose Calculations

Cement Type	Weight of Components per Cubic Yard of Concrete (lbs)				Water-to-Cement Weight Ratio	Density (g/cm ³)
	Cement	Fine Aggregate	Coarse Aggregate	Boron Frit		
4000-psi Borated Concrete	572	1355	1694	50	0.20 *	2.254
4000-psi Concrete	590	1230	1750	0	0.20 *	2.188
5000-psi Concrete	720	1110	1750	0	0.20 *	2.209

* Approximately the ratio of *nonevaporable* water to cement.

References:

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2. Los Alamos National Laboratory Memo X-6:RES-86-115 from R. C. Little and R. E. Seamon to R. D. O'Dell, "Coupled Cross-Section Sets from ENDF/B-V," dated March 18, 1986.
3. "American National Standard for Neutron and Gamma-Ray Fluence-to-Dose Factors," American Nuclear Society, ANSI/ANS-6.1.1-1991.
4. C. A. Negin and G. Worku, "MicroShield Version 4.10 User's Manual," Grove Engineering, Inc., October 1993.
5. "Plutonium Metal Feed Specification for Use in the Weapon Program Rocky Flats Plant," Vol. I, Rev. A, Rockwell International (1985).

ICF KAISER ENGINEERS

1900 Diamond Drive
Los Alamos, New Mexico 87544

DESIGN CALCULATION INDEX

CALC. NO.

SHEET NO.

JOB NUMBER 41552-056-00

AREA OR BUILDING

CALCULATION DESCRIPTION

DISCIPLINE

JOB TITLE HMMF CDR

TA-55

MATERIAL HANDLING

CALCULATIONS APPLY TO DRAWINGS AND REVISIONS SHOWN

DRAWING	REV	DRAWING	REV	DRAWING	REV	DRAWING	REV

DESIGN ENGINEER

(SIGNATURE)

(DATE)

JOB ENGINEER

(SIGNATURE)

(DATE)

CALCULATIONS CHECKED

(SIGNATURE)

(DATE)

DESIGN SUPERVISOR

(SIGNATURE)

(DATE)

CALCULATIONS AGREE WITH DESIGN CRITERIA

(SIGNATURE)

(DATE)

CALCULATIONS AGREE WITH APPVD. VENDOR DWGS.

(SIGNATURE)

(DATE)

CALCULATION KEYS

DATES

DATES

DATES

DATES

REVISION DESCRIPTION

90%
CDR

3/95

100% DATA
CDR

5/95

DESIGN ENGINEER

DOR

5/95

DESIGN SUPERVISOR

C.A.E

5/95

STATUS

PRELIMINARY

FINAL

CHECK

VOID

HOLD

OTHER

REASON FOR VOID OR HOLD:

INDEX

SHEET NO.

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REF. DATA ON MVDS Systems

MATERIAL HANDLING DATA

MATERIAL FLOW DIAGRAM

NMSF Project Material Handling Flow Diagram

Movement of Material from Truck Loading to NDA Laboratory

Figure 1

NMSF Project Material Handling Flow Diagram

Transfer Through NDA Laboratory

FIGURE 2

NMSF Project Material Handling Flow Diagram

Transfer from NDA Laboratory or PF-4 to NMSF Storage Array

FIGURE 3

**ESTIMATED MATERIAL HANDLING TIMES IN
CHARGE HALL W/ TUBE HANDLING
MACHINE**

**NOTE: TIMES BASED ON FT. ST. VRAIN SAR
(COPY ATTACHED, BUT REDUCED FOR THIS
APPLICATION)**

ICF KAISER ENGINEERS INC.

NMSF CONCEPTUAL DESIGN REPORT

JOB NO. 41552-056-00

10-Mar-95

TABLE 1

ESTIMATED THROUGHPUT TIMES FOR LOADING AND UNLOADING ARRAY MANUAL OPERATIONS

SCENARIO NO. 1:

A. MACHINE ALREADY OVER CASK IN CHARGE HALL

B. SHIELDING VALVE #1 IN POSITION OVER CASK, PLUG ALREADY REMOVED

C. SHIELDING VALVE #2 IN POSITION OVER DRYWELL, PLUG ALREADY REMOVED

ITEM NO.	ACTIVITY	EST. TIMES (MINUTES)
1	Put containers in baskets in NDA Lab	10.0
2	Lower baskets into tube transfer cask	1.0
3	Unhook hoist from basket	0.5
4	Close hatch door	0.5
5	Cask moves into array	1.0
6	Verify cask has been moved	1.0
7	Open valve on bottom of machine	2.0
8	Open valve on the shielding valve	2.0
9	Extract basket from cask	5.0
10	Close shielding valve	2.0
11	Close valve on bottom of machine	2.0
12	Remove restraints from machine at deck	15.0
13	Move Machine down Hall to drywell	15.0
14	Position machine over drywell	10.0
19	Secure Machine to deck	15.0
20	Open shielding valve already over drywell	2.0
21	Open valve at bottom of machine	2.0
22	Insert basket into drywell	5.0
23	Close shielding valve	2.0
24	Close valve at bottom of machine	2.0
25	Uncouple machine from deck	15.0
26	Move machine away to laydown area	15.0
	TOTAL	125.0

• SEE ASSUMPTIONS BELOW

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NMSF CONCEPTUAL DESIGN REPORT

JOB NO. 41552-056-00

10-Mar-95

TABLE 2

SCENARIO NO. 2:

- A. POSITION SHIELDING VALVES AND REMOVE PLUGS
- B. OVER DRYWELL TO ACCEPT BASKET
- C. ASSUME 1 SHIELD VALVE OVER CASK PERMANENTLY

ITEM NO.	ACTIVITY	ESTIMATED TIMES
1	Uncouple Tube Handling Machine from crane	15.0
2	Move crane trolley to plug puller	10.0
3	Rig / Hook plug puller	1.0
4	Move Plug Puller to valve	3.0
5	Attach Plug puller to shielding valve	5.0
6	Rig / Hook valve and plug puller	1.0
7	Lift and move plug puller/valve to drywell	10.0
8	Position Assembly over drywell	10.0
9	Secure assembly to deck	10.0
10	Disconnect assembly from crane	1.0
11	Pull Plug	5.0
12	Close shielding valve	2.0
13	Rig / Hook Plug Puller to crane	1.0
14	Move plug puller away to laydown area	10.0
15	Release plug puller	1.0
16	Move crane to Tube Handling Machine	10.0
17	Connect Crane to Machine	15.0
	TOTAL	110.0

- SEE ASSUMPTIONS BELOW

ASSUMPTIONS:

1. TWO PLUG PULLER AND TWO SHIELDING VALVES WILL BE PROVIDED
2. ONE CRANE WILL BE PROVIDED - 20 TONS MIN. CAPACITY
3. TIMES ARE BASED ON FT. ST. VRAIN SAR, BUT HAVE BEEN SPEEDED UP SOMEWHAT.
DUE TO THE FACT THAT THE ITEMS BEING MOVED ARE NOT AS HEAVY.
4. TWO MAN CREW ASSUMED. TWO CREWS MAY BE NEEDED FOR SIMULTANEOUS OPERATIONS.
5. REVERSE PROCESS TO UNLOAD ARRAY

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JOB NO. 41552-056-00

10-Mar-95

TABLE 3

ESTIMATED THROUGHPUT TIMES FOR LOADING AND UNLOADING ARRAY REMOTE OPERATIONS

ASSUME THAT MACHINE IS IN VICINITY OF CASK FOR STARTING POSITION

ITEM NO.	ACTIVITY	EST. TIMES (MINUTES)
1	Put containers in baskets in NDA Lab	10.0
2	Lower baskets into tube transfer cask	1.0
3	Unhook hoist from basket	0.5
4	Close hatch door	0.5
5	Cask moves into array	1.0
6	Verify cask has been moved	1.0
7	Move Bridge Crane/Machine over cask	2.0
8	Remove shielding plug w/ aux hook	2.0
9	Move Machine over cask	1.0
10	Fasten to deck/plugs (automatically)	1.0
11	Open valve on bottom of machine	1.0
12	Extract basket	5.0
13	Close valve on bottom of machine	1.0
14	Unfasten Machine from deck (automatically)	1.0
15	Move machine away from cask	1.0
16	Replace plug w/ aux hook on crane	2.0
17	Move Bridge Crane/Machine to drywell	10.0
18	Remove shielding plug w/ aux hook	1.0
19	Move Machine over drywell	2.0
20	Fasten to deck/plugs (automatically)	1.0
21	Open valve on bottom of machine	1.0
22	Insert basket	5.0
23	Close valve on bottom of machine	1.0
24	Unfasten Machine from deck (automatically)	1.0
25	Move machine away from drywell	1.0
26	Replace plug w/ aux hook on crane	2.0
27	Move Bridge Crane/Machine away	10.0
	TOTAL	66.0

FORT ST. VRAIN

**Independent Spent Fuel
Storage Installation**

SAFETY ANALYSIS REPORT

FOSTER WHEELER ENERGY CORPORATION

Perryville Corporate Park
Clinton, New Jersey 08809-4000

Non Proprietary Version

1.3. GENERAL STORAGE SYSTEM DESCRIPTION

The major structures, system, and components of the FSV ISFSI are addressed in this Section.

1.3.1. MVDS Structure - General

The general arrangement of the MVDS structure is shown in Figures 1.1-1, 1.1-2, and 1.1-3. The MVDS structure is comprised of: vault modules, a transfer cask reception bay, and a foundation structure.

Structural portions of the MVDS are designed to meet the requirements of ACI-349 (Ref. 7) and are constructed to ACI-318 (Ref. 8).

1.3.1.1. Vault Module

The vault module provides shielding around the array of fuel storage containers and provides for defined cooling air inlet/outlet flow paths. The vault module structure is supported by an integral foundation system. Cooling air enters the vault module (a common inlet plenum exists for all modules) through a mesh covered opening, which prevents the ingress of birds, small animals, large debris, and is also used as a security barrier. The labyrinth arrangement of the cooling air inlet structure provides radiological shielding for the stored fuel. Cooling air distribution across the outside of fuel storage containers is improved by means of precast concrete collimators that are set into grooves in the structure walls. The collimators also provide a contribution to the radiological shielding of the stored fuel. The cooling air leaves the vault module through a second set of concrete collimators, which serve the same functions as those at the inlet, and is exhausted to the atmosphere through a concrete cooling air outlet chimney.

A steel canopy is provided on the top of the cooling air outlet chimney to prevent the ingress of rain and snow. The opening of the outlet chimney is fitted with wire mesh. The ambient cooling air does not come into contact with the fuel in the fuel storage containers so that the internal walls of the vault module will remain radiologically non-contaminated.

The floor of the vault module is sloped for drainage and provided with drainage connections. Inset and grouted into the vault module floor are supports for the fuel storage containers.

A construction recess is provided in the top of the vault module walls, which supports the charge face structures. The charge face structure is set into each vault module to form the roof of the vault and provide lateral support for the array of fuel storage containers. Bearing pads are cast into the concrete vault module recess to transmit charge face structure vertical loads into the building structure.

1.3.1.4. Power Distribution and Lighting

Power is distributed to the MVDS crane, the container handling machine, power outlet sockets on the charge face edge, power outlet sockets in the transfer cask reception bay for MVDS heating and ventilation, and to a lighting system for the charge face and the transfer cask reception bay. Heating at the MVDS is accomplished using electric radiant space heaters. The incoming main breaker and the individual circuit breakers are in an enclosure inside the transfer cask reception bay.

1.3.2. MVDS Equipment

FSV fuel (including neutron source elements and reflector elements) is received at the MVDS via the transfer cask, which has an inner container (fuel storage container) designed to hold up to six FSV fuel elements or up to 12 keyed top reflector control rod elements. The fuel storage container is similar to the inner container used for shipping fuel off-site in the licensed shipping cask. In this way fuel will be loaded into the cask and the storage container in a manner nearly identical to that already established and licensed at the reactor using existing equipment and procedures.

The containerized fuel will be moved from the Reactor Building to the MVDS using an existing transfer cask trailer and tow vehicle. At the MVDS the transfer cask will be positioned in a manner similar to that at the reactor loading port location, and the storage container will be removed and positioned into the storage vault using the MVDS equipment.

Containerizing and sealing the fuel at the Reactor Building provides a safe and uncontaminated fuel handling route. The procedure makes maximum use of existing Reactor Building equipment and the related experience of trained staff for fuel transfer to the fuel storage containers.

The MVDS will have a short dedicated campaign of fuel transfers using one or more of the existing transfer casks. After loading of the fuel, the MVDS will be subject to routine security surveillance and minimal storage system monitoring.

During the active fuel handling phase, the MVDS charge face is covered by a travelling electric MVDS crane to effect movement of the transfer cask, fuel container handling machine and other MVDS equipment.

The structural design provides for storage of the fuel container handling equipment and the complete weather-proofing of the MVDS charge face and transfer cask reception bay during the years of passive fuel storage.

2. Raise/Lower Mechanism

The raise/lower mechanism provides a high integrity means by which the fuel storage container can be raised into or lowered from the machine using a grapple. The mechanism and grapple are designed to be single failure proof. Thus, failure of any single component will not result in the dropping of a fuel storage container.

This mechanism comprises an acme thread leadscrew, drive unit, trunnion mounted nut, guide system, duplex chains, sprockets and equalizing beam.

The fuel storage container grapple is raised/lowered by the leadscrew/nut through two duplex chains. The chains are connected at one end to the top of the grapple and at the other to an equalizing beam mounted at the top of the machine. Each chain runs over a sprocket mounted on the nut trunnion block and over two sprockets mounted on top of the machine body.

3. Container Handling Machine Controls

The container handling machine is controlled from a control panel located at the base of the machine, and the panel will contain all the necessary contactors and relays. Control push buttons, displays and warning lights are mounted on the face of the control panel.

Interlocks are provided between the container handling machine, the charge face isolation valve or cask load/unload port isolation valve and the MVDS crane such that:

- i) The machine cannot be lifted unless the isolation valves are closed.
- ii) The isolation valves cannot be closed unless the machine hoist is fully up.
- iii) The machine hoist cannot lower unless the isolation valves are open.
- iv) The machine hoist cannot lower if hoist weight sensing indicates that the winch load is less than the grapple weight.

In the unlikely event of failure of the MVDS crane hoist system while supporting the machine, the drop height onto the charge face structure is limited to minimize the risk of damage to the structure, fuel stored in the vault modules, and fuel that is contained in the container handling machine.

1.3.2.6. Shield Plug Handling Device

The shield plug handling device is designed to remove the charge face shield plugs using the MVDS crane and an isolation valve. The device provides necessary shielding during the shield plug removal operation. With the isolation valve gate open, the central lifting rod of the device can be lowered and screwed into the shield plug top face allowing the shield plug to be raised and the isolation valve gate closed. The device lifting rod is raised/lowered using the MVDS crane hoist.

1.3.2.7. Standby Storage Wells

Two standby storage wells are incorporated into the MVDS structure at the north end of the storage module. The standby storage wells are included so the MVDS has operational flexibility for all anticipated potential faults.

The functions of the standby storage wells are as follows:

1. Allows isolation of a defective fuel storage container from the vault cooling system after removal from the vault.
2. Allows total individual fuel storage container leak checking throughout the storage period in a location remote from the radiation fields associated with the storage vault(s).
3. Provides basic provision to change fuel elements from one fuel storage container to a spare unit in the unlikely event of fuel storage container failure.
4. Provides basic provision to move fuel elements from fuel storage containers and discharge these into a DOE shipping cask for ultimate movement to the Federal Repository if this should be required in the future.

A standby storage well comprises a simple closed ended liner tube set into an enclosure created by the MVDS structure, which provides necessary radiation shielding. The tube is designed to house a fuel storage container and support its base in a manner identical to that used in the storage vault. The charge face level top plate allows for the level positioning and bolting of an isolation valve at the standby storage well locations. The standby storage well can be closed using a charge face shield plug and sealed using a cover plate. A sampling point, at charge face level with a self sealing coupling, allows the storage well volume to be evacuated for total fuel storage container leak testing.

If the standby storage well is occupied by a loaded fuel storage container, the decay heat is dissipated to the surrounding air.

One standby storage well can be equipped with a spare fuel storage container. The second will normally remain empty unless a full defective fuel storage container is removed from the vault.

Therefore, the 4" drop of the CHM on to the charge face is bounded by the above calculations and does not result in unacceptable radiation doses, criticality does not occur, and the FSC/fuel remains readily retrievable.

Criticality and radiological aspects of accidents associated with failure of the MVDS crane have been analyzed and are discussed in ISFSI SAR Chapter 8.

1.3.2.10. Transfer Cask Load/Unload Port

The transfer cask load/unload port allows the transfer cask to be supported at the MVDS charge face level for fuel storage container loading/unloading operations. The port allows the loading port isolation valve to be located and bolted into position over the transfer cask. Within the transfer cask reception bay and below the port position, cask restraint clamps are used to restrain the cask lower end for the seismic event. The method of cask support and restraint is identical to that used at the Reactor Building.

1.3.3. ISFSI Facilities

The entrance building is on the west side of the MVDS. It consists of facilities to support ISFSI security. There are no MVDS design or safety requirements associated with the entrance building. See the ISFSI Security Plan for details of the entrance building.

Domestic water is supplied to the entrance building via a new line supplied from the Weld County Water District. A septic system and leach field is located west of the entrance building such that any required maintenance may be performed without entering the protected access area. This system will be designed in accordance with Weld County requirements.

The entrance building is propane heated and electrically cooled to provide comfort for the occupants.

Electrical power is adequately supplied from the 13KV overhead distribution line southeast of the ISFSI facility. This line is fed from the Vasquez Substation. The ISFSI facility is fed via an underground feeder to a 220 KVA 13KV/480V pad-mounted transformer located at the ISFSI. A propane fired standby generator is provided for security purposes only.

Table 7.4-3
(Page 1 of 2)NEUTRON DOSE SUMMARY FOR NEUTRON SOURCE ELEMENT LOADING

Operation	Time (Mins.)	Dose to Operators (mrem)		
		Driver	No. 1	No.2
1 Transfer cask to MVDS	14.5			
2 Cask arrives at MVDS	10.0	4.8		
3 Prepare cask load/unload port for transport cask	33.5			
4 Unload transport cask from trailer	26.0	15.5		
5 Load cask into cask load/unload port	27.0	5.0		6.9
6 Replace cask load/unload port hatch cover	33.5			
7 Remove cask closure	31.0		2.1	0.2
8 Fit shield ring	17.0		0.6	0.4
9 Fit uranium shield adaptor	33.5		1.1	0.4
10 Fit cask load/unload port adaptor around cask	34.5		0.3	
11 Fit port valve at cask load/unload port	42.5			
12 Fit uranium shield lifting device	17.0			
13 Remove uranium shield plug	8.5			
14 Remove uranium shield lifting device	16.0			
15 Fit container handling machine to valve at cask load/unload port	26.0			
16 Remove fuel storage container from cask	24.0		1.6	
17 Transfer container handling machine to vault position	42.0		8.1	3.0
18 Unload fuel storage container into vault position	24.5		1.6	
19 Return container handling machine to park	43.0			
20 Fit shield plug lift device	31.0			
21 Replace shield plug	9.0			
22 Return shield plug lift device to park	30.5			
23 Move charge valve to next channel	40.5			
24 Lift shield plug lift device to charge valve	30.5			
25 Remove shield plug	9.0			
26 Return shield plug lift device to park	30.5			

**DRUM LIFTER/PALLET HANDLING DATA
AND CUT SHEETS**

FOLDABLE PLATFORM AND HAND TRUCKS

MATERIAL
HANDLING

☐ SUPER FOLDAWAY PLATFORM TRUCK

Used by salesmen, delivery and repair people, and frequent travelers. 300 lb capacity. Telescoping aluminum frame has a dual length platform; closed 20L x 16"W or open 28L x 16"W. 32" high handle. Vinyl corner bumpers. Transports computers, copiers, tools, samples, and luggage completely supported. Easy steering with 4" rubber casters, two rigid and two swivel. Folded dimensions of 20L x 16W x 9 1/4"H allow the truck to fit into any vehicle. Shipped partially assembled. Wesco International brand (272020).

No. 5W684. Super Foldaway Platform Truck. Shpg. wt. 19 lbs.
List \$150.00. Each \$108.31

☐ FOLDING HANDLE PLATFORM TRUCK

Move supplies, forms, files, office equipment or almost anything around the office or shop. Compact size is also ideal for use on delivery vehicles. All-steel platform truck has vinyl perimeter bumper to protect walls and furniture. Vinyl covered platform keeps load from sliding. Easy locking 33 1/4" high handle fold flat against platform for compact storage or transporting. Equipped with easy rolling rubber casters; two rigid, two swivel. Shipped partially assembled. Sand color enamel with blue vinyl. Wesco International brand.

Load Capacity	Deck Size W	Deck Size L	Caster Size	Wesco Model	Stock No.	List	Each	Shpg. Wt.
400 lb	19"	29"	4"	272019	5W687	\$99.50	\$75.66	25.0
600	23	35	5	272035	5W688	168.00	127.53	41.0

☐ SUPER COLLAPSIBLE HAND TRUCK

For salesmen, traveling stockers, and servicemen who carry material from vehicle to building. Strong, yet lightweight and easy to load inside any vehicle. 200 lb capacity. Welded tubular steel construction. Handle folds from 43 1/4" to 23 1/4". Foldable nose plate is 6" deep x 14" wide. Folding nose extension increases nose length from 6 to 15" to accommodate larger packages and improve stability under load. Equipped with long wearing 5" diameter x 1 1/4" wide polyolefin wheels and channel stairclimbers. Bicycle type plastic hand grip. Folded dimensions 23 3/4"H x 18W x 7"D; fully extended overall dimensions 39 1/4"H x 18W x 21"D. Shipped partially assembled. Blue enamel. Wesco Mfg. brand (CT-401).

No. 2W669. Super Collapsible Hand Truck. Shpg. wt. 20 lbs. List \$90.60. Each \$72.48

☐ BAGGAGE CADDY AND CASE TRUCK

Designed for travelers, flight attendants, salesmen, or anyone who needs to transport luggage, cartons, and cases between the office, airports, hotels, customers. This rugged, lightweight truck has a 110 lb capacity and is made of durable aluminum and high impact plastic. Compact truck is only 20 x 10 1/4 x 3" deep when folded. Fits in any car trunk, under any airline seat, or overhead compartment. Telescopic handle locks open at 37 1/4" high. Nonskid nose is 10 1/4" wide x 8 1/4" deep. 2 1/4" diameter wheels are covered on top and front to prevent bags from rubbing, and have an open back for easy stair climbing. Special "Y" design nylon strap holds load better than an elastic cord and is permanently attached to truck nose. Posi-lock strap adjusts easily to any load size and quickly secures load to truck. Gray/silver color. Wesco International brand (272129).

No. 6W013. Baggage Caddy and Case Truck. Shpg. wt. 4.5 lbs. List \$85.00. Each \$47.37

NEED STORAGE EQUIPMENT?

We have pallet racks, bulk storage racks, open and closed shelving, cabinets, parts bins, nesting contain-

ers, tote boxes, and commercial and industrial lockers. Refer to Index at back of catalog for page listings.

SEE WARRANTY INFORMATION ON PAGE OPPOSITE INSIDE BACK COVER

1267

HYDRAULIC PALLET TRUCKS

MATERIAL
HANDLING

4500 LB CAPACITY HYDRAULIC PALLET TRUCK

Dayton

DAYTON LIMITED WARRANTY

Dayton Electric Mfg. Co. warrants hydraulic unit, frame, and mechanical components for 2 years. Wheels, bearings, and bushings are warranted for 90 days. Text of warranty available on request. See "Manufacturers' Warranties" on page opposite inside back cover.

- 4500 lb capacity
- Maneuvers easily in cramped areas

Dayton hydraulic lift pallet truck rolls easily, handles solidly, and maneuvers in cramped areas. All steel frame has reinforced forks with tapered ends and rugged slides for easy entry and exit from pallets.

Steering handle operates hydraulic lift, foot pedal selects up or down direction. Hydraulic system has hard chrome pump piston and lift ram with polyurethane seals.

Suspension system has heavy-duty thrust bearings. Adjustable push rods. Sealed, permanently lubricated ball bearings throughout. Polyurethane molded-on wheels. Red enamel finish. Dayton brand.

PALLET TRUCK SPECIFICATIONS AND ORDERING DATA

Load Capacity	Height of Fork Lowered	Height of Fork Raised	Width Across Forks	Width Between Forks	Fork Width	Fork Length	Roller Dia	Main Wheel Dia	Pivot Angle	Overall Length	Stock No.	List	Each	Shpg. Wt.
4500 Lbs	3 1/4"	7 1/4"	27"	14 1/4"	6 1/4"	48"	3 1/4"	8"	260°	60"	6W094	\$631.95	\$563.52	280.0

4500 LB CAPACITY HYDRAULIC HAND PALLET TRUCK

BT LIMITED WARRANTY

BT warrants hydraulic unit and fork frame against defective components or workmanship for 2 years. Wheels, axles, and bearings are warranted for 90 days. Text of warranty available on request. See "Manufacturers' Warranties" on page opposite inside back cover.

- 2 1/4" lowered height of forks for easy pallet entry
- Handle mounted control lever
- Comes fully assembled

BT

BT Hand Pallet Truck is designed and built for rugged use. Durable pressed steel fork frame and easy rolling poly wheels. Features nylon exit/entry rollers for easy pallet placement, and unique safety handle with lower and neutral control lever for fingertip lift and greater security since both feet are always on the ground.

Only minimum maintenance required due to solid steel push rods which need no adjusting. Eight grease fittings prolong truck life. Hydraulic system incorporates the seal in the cylinder not the piston for more reliable operation. Pallet truck is light enough to reduce operator fatigue yet strong enough to handle most loads up to 4500 lbs. Polyurethane wheels. Powder painted safety orange finish. BT brand (BTL2000).

PALLET TRUCK SPECIFICATIONS AND ORDERING DATA

Load Capacity	Height of Fork Lowered	Height of Fork Raised	Width Across Forks	Width Between Forks	Fork Width	Fork Length	Roller Dia	Main Wheel Dia	Pivot Angle	Overall Length	Stock No.	List	Each	Shpg. Wt.
4500 Lbs	2 1/4"	7 1/4"	27"	14 1/4"	6 1/4"	48"	2 1/4"	6 1/4"	180°	60"	6W060	\$669.00	\$589.55	163.0

MANY BRANDS OF OFFICE EQUIPMENT AVAILABLE

Bretford

Gbra

SHARP

TEXAS INSTRUMENTS

FANON

SAFCO

OMNIFAX

Invincible

SEE INDEX AT BACK OF CATALOG FOR COMPLETE LISTINGS

SEE WARRANTY INFORMATION ON PAGE OPPOSITE INSIDE BACK COVER

1269

MATERIAL HANDLING

HYDRAULIC TABLES AND ROLLER KITS

HYDRAULIC LIFT TABLES

No. 3W488

No. 3W489

No. 3W490

No. 4W478

Foot operated hydraulic lift tables for heavy-duty shop functions such as lifting dies and castings, transporting machine parts, positioning welder's work, leveling feed material for punch presses, conveyors and press brakes, and similar material handling jobs. 200, 500, and 1000 lb capacity models have table and base constructed of 7-gauge steel; 6000 lb capacity models have 1/4" thick steel table and base construction. All models reinforced at critical points for maximum strength. Foot operated hydraulic jack raises platform with each downstroke of the pedal. Hand operated lever releases jack and controls rate of descent. Casters, included, have been selected to match load capacity and provide good mobility for moving heavy loads. Blue enamel finish. Wesco Mfg. brand.

No. 3W488 200 Lb Capacity Table. Table top revolves 360° allowing loads to be positioned easily and accurately. Includes four 3" polyolefin chemical-resistant swivel casters. Shipped disassembled in components.

Nos. 3W489 and 3W490, 500 and 1000 Lb Capacity Tables, have two telescoping posts which help stabilize and support loads during operation. Includes bar handle and four 4" phenolic resin roller bearing

ing casters, two rigid and two swivel. Foot operated floor lock holds table in position. Shipped fully assembled.

Nos. 4W478 and 4W479, 6000 Lb Capacity Tables, have four telescoping posts which help stabilize and support heavier loads. Includes bar handle and four 6" phenolic resin roller bearing casters, two rigid and two swivel. Foot operated floor lock holds table in position. Shipped fully assembled.

Load Capacity	Height Range Lowered	Height Range Raised	Table Top L W	Wesco Model	Stock No.	List	Each	Shpg. Wt.
200 lb	28 1/4"	47"	16" 16"	LT-02-1616	3W488	\$358.00	\$259.79	48.0
500	30 1/4"	48 1/4"	18 18	LT-05-1818	3W489	601.00	429.72	114.0
1000	30 1/4"	48 1/4"	36 18	LT-10-1836	3W490	819.00	588.35	158.0
6000	37	60	36 24	LT-60-2436	4W478	1355.00	962.05	330.0
6000	37	60	48 32	LT-60-3248	4W479	1525.00	1082.75	495.0

ROLLER KITS

No. 6W041
3-Ton Capacity
Roller Kit

HILMAN ROLLERS

- Low height, low friction
- Triple strength chain rotates around center load plate
- Swivel turntables have corrosion-resistant Teflon bearings. No. 6W043 kit has chrome ball bearings

No. 6W043
40-Ton Capacity
Roller Kit

Easy, safe, and economical way to move heavy equipment. Chain action roller permits continuous movement over imperfect floor surfaces, and requires only minimal maintenance. High quality steel construction. Padded top eliminates need for separate pads on steel rollers, provides a nonslip surface, and acts as a shock absorber when going over uneven surfaces. Pads on 40-ton unit are made of 1/2" thick neoprene; rubber belting on 3 and 8-ton units. All kits include four swivel rollers, two steering handles, and a rugged steel carrying case. Hilman brand.

No. 6W041 3-Ton Capacity Roller Kit. 14" steering handles.

No. 6W042 8-Ton Capacity Roller Kit. 30" steering handles come unassembled in two pieces for easy handling and storage. Can handle majority of contractor applications and light industrial duty jobs.

No. 6W043 40-Ton Capacity Roller Kit. Two piece steering handles are 48" long. Assemble quickly and easily. Swivel rollers feature a locking device which provides choice of swivel for turns or rigid for straight line moving and locks into place every 45°. Carrying case has skids for transporting with a forklift.

Load Capacity	Capacity Per Roller	Roller Dimensions L W H	Hilman Model	Stock No.	List	Each	Shpg. Wt.
3 Tons	2 1/4 Ton	6 1/2" 3 1/2" 3 1/4"	K3RS-4	6W041	\$603.50	\$549.19	56.0
8	2	8 1/2" 3 1/2" 4 1/4"	K8RS-4	6W042	799.00	759.95	96.0
40	10	10 1/2" 5 1/2" 5 1/4"	KRS-40-SLP	6W043	1358.00	1290.18	218.0

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MATERIAL HANDLING

DRUM EQUIPMENT

VERTICAL DRUM LIFTERS/DISPENSERS

- Lift, transport, and pour from open and closed head drums.
- Models for steel and fiber drums.

WESCO
MANUFACTURING COMPANY

Economical drum lifters are suited for transporting both open and closed head drums for dumping and pouring operations. One man operation saves, time, reduces spilling waste, and improves productivity. Simply attach or hang lifter on hook from an overhead hoist or crane, cinch saddle around drum and raise to desired height and position. Capacity for all models is 800 lbs full drum or 500 lbs half-full drum. All lifters/dispensers come fully assembled. 39H x 28½W x 8"D. Orange color. Wesco Mfg. brand.

Manual models for low level pouring and dumping operations. Positive tilt locks on either side of drum saddle to hold drum upright in transit; when released operator can manually tilt drum to control pouring. Locks also hold drum in the horizontal position. When released, drum can be rotated 360 degrees in either direction.

Geared models for remote pouring operations. Geared chain control, low effort feature make lifter/dispensers usable at any height, and ideal for remote controlled dispensing and dumping. 6 foot control chain can be locked to secure drum in any position during transit and dispensing.

Drum Type	Lifter Type	Wesco Model	Stock No.	List	Each	Shpg. Wt.
55-Gallon Steel	Manual	DL-55	3W390	\$199.80	\$141.38	45.0
21-23" Diameter Fiber & Steel	Manual	DL-53FL	4W461	236.20	182.53	44.0
55-Gallon Steel	Geared	DGL-55	4W462	495.10	381.23	70.0
21-23" Diameter Fiber & Steel	Geared	DGL-53FL	4W463	531.60	409.33	69.0

VERTICAL DRUM LIFTER

Automatic drum lifter picks up vertical standing 55-gallon closed steel drums and sets them down without operator at pickup or delivery point. Lifter works with operator's overhead hoist or crane. Lift hook from crane engages lifter; grabs and holds drum securely until drum is set down in place. Lifter can be maneuvered over stacked drums and around obstacles to a selected drum, grab it, pick it up, and carry it to another location with the operator safely out of the way. Simple grab hook mechanism. Grip pads help align on drum chime for secure operation. Comes fully assembled. 18½H x 33W x 8"D. Orange enamel finish. Wesco Mfg. brand (DL-1).

No. 3W391. Shpg. wt. 50.0 lbs. List \$170.10. Each.....\$125.67

WESCO
MANUFACTURING COMPANY

- Handles 55-gallon closed steel drums weighing up to 1000 lbs.
- Use with overhead hoist or crane

FORK MOUNTED DRUM GRABS

- Automatic—No hydraulic or electrical connections

Enable forklift operator to singlehandedly lift, transport and deposit closed head steel drums. Drum grabs may be utilized for open head steel drums which are not out of round or damaged, or that contain materials that can spill. Driver simply approaches drum, lifts, transports, sets down, and backs truck away. Weight of drum holds grab jaws, preventing slippage. Mounts easily on forks of forklift. All welded construction. Jaws are formed from steel bar. Safety orange enamel finish. Wesco Mfg.

30/55-Gallon Drum Grabs adjust easily without tools to handle 30 or 55-gallon steel open or closed head drums. 1500 lb capacity units are secured to forks with hand-tightened lock screws mounted on each fork pocket. Fork pockets 22" center to center. Two drum model to be used only with two same size drums.

Standard 55-Gallon Drum Grabs. 1500 lb capacity per drum. Choose from single or double drum models. Both are secured to forks with hand-tightened lock screws mounted to each fork pocket. Fork pockets 22" center to center.

Drum Grab Type	No.	Drum Capacity Gallon	Diameter	Fork Pocket Size	Wesco Model	Stock No.	List	Each	Shpg. Wt.
Standard	1	55	22½"	5½ x 2"	DJ-55	4W053	\$384.70	\$274.06	127.0
Standard	2	55	22½"	7 x 2½"	DJ-255	4W466	514.30	411.44	230.0
Adjustable	1	30/55	18/22½"	5½ x 2"	ADJ-53	4W467	440.80	352.64	133.0
Adjustable	2	30/55	18/22½"	7 x 2½"	ADJ-253	4W468	536.50	429.20	213.0

1274

NET WHOLESALE PRICES—W.W.GRAINGER, INC.

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55-Gallon
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No.

DRUM EQUIPMENT

MATERIAL HANDLING

INDUSTRIAL DRUM CARRIERS

Industrial drum carrier enables one operator to perform five drum handling operations: lift, transport, tilt, rotate, and drain. Easy to maneuver and operate. Operator secures saddle around drum, lowers handle to lift drum, then can roll load to new location or tilt drum for dispensing. Drum carrier can be used with 800 lb full or 500 lb half full drums. Two sets of locks provided for safe operation: lift locks hold drum securely in raised position; tilt lock holds drum in horizontal or vertical position. Carrier rolls on two 8" polyolefin load wheels and one 4" polyolefin swivel caster. Transporting and dispensing heights are adjustable to a maximum drum-to-floor clearance of 11½" vertical and 18" horizontal drain height. All steel welded construction. Shipped partially assembled. 41½H x 35W x 37"D. Orange. Wesco Mfg. brand.

No. 3W398 is for 55-gallon steel drums.

No. 4W460 is for large 21 to 23" diameter fiber and steel drums.

DRUM CARRIER ORDERING DATA

Drum Capacity & Type	Wesco Model	Stock No.	List	Each	Shpg. Wt.
55-Gallon Steel	ML-55	3W398	\$474.30	\$343.29	105.0
21-23" Dia Fiber & Steel	ML-53FL	4W460	510.80	368.80	104.0

FORK MOUNTED DRUM LIFTER/DISPENSER

No. 4W464

- For 55-gallon steel or 21-23" diameter fiber and steel drums
- 800 lb full, 500 lb half full drum capacity

Turns your fork truck into a safe, easy drum lifter/dispenser. Geared design and 10 ft chain drop allow operator to remotely control dispensing and dumping of open and closed head drums without leaving fork truck. Simple operation: mount to lift truck by sliding forks into 5½ x 2" fork pocket and tightening screw locks: cinch saddle around drum. Capacity 800 lbs full drum, 500 lbs half full. Minimum inside width between forks. 24½" overall. 20½H x 38W x 32½"D. Orange. Wesco Mfg. brand.

DRUM LIFTER/DISPENSER ORDERING DATA

Drum Capacity & Type	Wesco Model	Stock No.	List	Each	Shpg. Wt.
55-Gallon Steel	DGF-55	4W464	\$736.30	\$581.88	180.0
21-23" Dia Fiber & Steel	DGF-53FL	4W465	772.80	610.51	179.0

ECONOMY DRUM LIFTER

- For 55-gallon closed head steel drums
- 700 lb lifting capacity

Vertical drum lifter is safe and simple to use on 55-gallon closed head steel drums. Attach hook of any overhead crane or hoist through 1½" diameter lifting eye mounted on top of four 1/4 x 1" hot rolled steel supports. Safety lock pin prevents accidental opening while transporting drums up to 700 lbs. Wesco Mfg. brand (EDL-5).

No. 5W683. Economy Drum Lifter. Shpg. wt. 15.0 lbs. List \$114.40. Each\$84.54

WESCO
MANUFACTURING COMPANY

No. 5W683

No. 1P893

No. 2P093

ROTARY DRUM PUMPS

Hand operated drum pumps for dispensing and transfer pumping fuel oil, lubricating oil, gasoline, anti-freeze. No. 1P893 delivers up to 10 gallons of fluid per 100 revolutions. Includes 22 to 40" telescoping suction pipe and 2" bung adapter. Pump body has 1" inlet and 3/4" outlet. No. 2P093 delivers 10 GPM at 135 RPM. 1" NPT inlet and 3/4" NPT discharge port. Bung adapter included. Requires 1" NPT pipe suction tube. For complete listings, see pages 1945 and 1948 respectively.

SEE WARRANTY INFORMATION ON PAGE OPPOSITE INSIDE BACK COVER

TELESCOPING FORK TRUCK BOOM, PALLET PULLERS AND PRY BAR

NEW ITEM ON THIS PAGE

MATERIAL HANDLING

TELESCOPING FORK TRUCK BOOM

No. 5Z153

- Extends up to 12 ft with 9 different hook positions
- Travel-limiting device prevents over-extension

MAXIMUM SINGLE HOOK LOAD CAPACITIES* IN LBS

HOOK POSITION									
A	B	C	D	E	F	G	H	I	J
3750	3450	3150	2850	2550	2450	2100	1800	1500	1200

(* Attaining maximum capacities depends on the size and fork capacity of the lift truck used.

Fork lift truck attachment expands versatility of the fork lift's carrying ability for moving long and awkward loads or rounded and odd-shaped loads, working in narrow aisles, or reaching over immovable barriers.

Telescopic boom extends forward up to 12 ft with nine different hook positions on 12" centers. Drop-forged, hardened steel locking pin with two-way, spring-loaded design. Locks in the "out" position for one-man adjustments and locks "in" to safely hold the boom in position. Safety latch swivel hooks and a travel-limiting device prevent over-extension or unexpected disassembly. Fork pockets are 7 1/2 x 2 1/2 x 24" centers. T & S brand (LM-EBT).

No. 5Z153. Shpg. wt. 375.0 lbs. List \$702.85. Each\$585.73

LIFTING CAPACITY GUIDELINES

Fork Truck Capacity†	Distance from Mast Face to Load Center			
	6 Ft	8 Ft	10 Ft	15 Ft
2000	590 lbs	500 lbs	410 lbs	325 lbs
3000	925	800	675	550
4000	1400	1200	1000	800
5000	1725	1500	1275	1050
6000	2125	1850	1575	1300
7000	2565	2225	1885	1550
8000	3000	2600	2200	1800
9000	3350	2900	2450	2000
10,000	3900	3400	2900	2400

(†) Consult your fork truck owner's manual to verify that truck meets or exceeds capacity listed.

PALLET PULLERS

No. 2A093

No. 3W663

Pallet pullers are used to pull pallets away from inaccessible areas such as narrow aisles and unblocked trailers, into areas where forks of a forklift truck can be used. These pullers are designed for stringers up to 4 1/4" (No. 2A093) and 4" (No. 3W663) thick. Rugged galvanized steel construction. 2 3/4" high heads are self-cleaning and unaffected by wood particles, paint or grease. 1/4" proof coil chain included for attaching pull chain. Recommended load is 1250 lbs. T&S brand.

No. 2A093. One-piece curved heads have integral spurs for gripping pallet stringers. Scissor action 30" long 30" chain.

No. 3W663. Cammed closing action provides maximum grip strength and reduced pinch points. Safety handle enables easier positioning and removal of separated heads. Grip both metal and wood with biting action. 15 1/2" long. Chain is 7 1/2" long.

Description	Length	T&S Model	Stock No.	List	Each	Shpg. Wt.
Scissor Action	30"	PAL-21	2A093	\$70.00	\$51.87	21.0
Cammed Action	15 1/2"	PAL-14	3W663	\$55.00	\$2.40	14.0

PRY BAR

- 72" long hardwood handle
- 4250 lb overall capacity

Provides dock workers, riggers, and freight handlers with the leverage to get underneath heavy objects for lifting with fork lift, hand truck, or other types of trucks. Hot rolled steel beveled nose plate is bolted to 72" long hardwood handle. Pry bar has 4250 lb overall capacity. Polyurethane wheels for long life. Beveled nose plate is painted yellow. T&S brand (PDL-72).

No. 4W944. Pry Bar. Shpg. wt. 34.0 lbs. List\$84.00.
Each\$82.92

SEE WARRANTY INFORMATION ON PAGE OPPOSITE INSIDE BACK COVER

REFERENCE DATA ON MVDS SYSTEM

AT FT. ST. VRAIN

(SIMILAR OPERATION FOR NMSF)

GEC ALSTHOM ENGINEERING SYSTEMS LTD

Modular Vault Dry Store

Nuclear Division

FOSTER WHEELER

ASME, KAERI, KNS and IAEA
1991 JOINT INTERNATIONAL WASTE MANAGEMENT CONFERENCE
SEOUL, KOREA - OCTOBER 1991

CURRENT STATUS OF MODULAR VAULT DRY STORE TECHNOLOGY
WITH PARTICULAR REFERENCE TO THE FORT ST VRAIN PROJECT

Authors:

C J EALING	Nuclear Division Director, GEC ALSTHOM Engineering Systems Ltd. Whetstone, Leicester, England, UK
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C NASH	Project Manager Fort St Vrain Project, Foster Wheeler Energy Coporation, Energy Applications Division, Livingston, New Jersey, US.

ABSTRACT

Over twenty years ago GEC ALSTHOM completed the world's first commercial scale air-cooled dry storage facility at the Wylfa Magnox Nuclear Power Station in North Wales. This dry storage technology was developed to suit fuels from other reactor types and in March 1988 the US NRC gave Topical Report Approval for the first dry vault storage system for LWR fuels, to be submitted for non site specific design approval.

This paper describes the development of the dry storage system which lead to the construction by GEC ALSTHOM/Foster Wheeler of the first commercial Modular Vault Dry Store (MVDS) in the US, for the Public Service Company of Colorado at the Fort St Vrain facility.

This application demonstrates the flexibility of the MVDS system for use with different reactor fuel types and the dry storage systems ability to operate totally independent of the existing reactor facility.

MVDS technology continues to be developed to suit site specific applications and this paper briefly reviews the status of the system design for LWR fuels.

INTRODUCTION

Formal generic approval in March 1988 by the US Nuclear Regulatory Commission (US NRC) of the Modular Vault Dry Store (MVDS) concept applied to light water reactor (LWR) fuels proved to be an essential step in securing the serious interest of American Utilities in the application of MVDS for providing additional on-site spent nuclear fuel storage capacity, independent from the existing facilities. MVDS is a dry vault storage design developed by GEC ALSTHOM Engineering Systems Limited of the United Kingdom. Reference (1) provides the background of experience and development of the design.

In August 1989 Public Service Company of Colorado (PSCC) became the first US Utility to select the MVDS for use as an on-site Independent Spent Fuel Storage Installation (ISFSI) at the Fort St Vrain (FSV) plant which has a single High Temperature Gas Cooled Reactor (HTGR). Public Service's need was to have a storage facility available for storage of fuel by the end of November 1991 to allow the defuelling of the Reactor by August 1992 prior to its full decommissioning. The Utility's economic justification for constructing an ISFSI depended strongly on an assured completion date and confidence that the site specific MVDS design would be readily licensable by the US NRC for this the first truly independent storage facility to be built in the US. Both schedule performance and licensability were therefore important to PSC in its selection of a storage technology Vendor. The GEC ALSTHOM MVDS was offered to PSCC by FOSTER WHEELER ENERGY CORPORATION (GEC ALSTHOM's US Licensee) and was selected on the basis of a competitive bidding process against other dry storage technologies.

This paper describes the FSV storage facility, reviews the experience of gaining the site specific license from the US NRC and achievements of the construction phases. The second part of the paper describes application of the MVDS to the management of irradiated LWR fuel assemblies in dry storage. References (2) and (5) provide further details of the Fort St Vrain MVDS design.

SYSTEM DESCRIPTION FOR THE FORT ST VRAIN MVDS

The FSV MVDS will store 1482 spent fuel blocks from the reactor core within six vault modules, each module storing forty-five storage tubes containing six spent fuel blocks. Figures 1 and 2 show the storage configuration and vault layout.

The MVDS is designed to comply fully with US Nuclear Regulatory Commission's requirements NUREG 10 CFR 72 and satisfies the acceptance criteria of US Regulatory Guide 3.60 (American National Standards Institute ANSI 57.9) (References 6 & 7).

The MVDS is typically designed for minimum life of 20 years and at FSV this will be extended to 40 years.

Photograph illustrating a single MVDS Vault Module. This model is representative of the six vault MVDS constructed by the Public

Figure 1.

- KEY**
- 1 COOLING AIR INLET
 - 2 CIVIL STRUCTURE OF THE
 - 3 STORAGE MODULE
 - 4 STORAGE CONTAINER
 - 5 CHARGEFACE STRUCTURE
 - 6 SHIELD PLUGS
 - 7 CASK LOAD/UNLOAD
 - 8 POSITION
 - 9 FACILITY CRANE
 - 10 WEATHER ENCLOSURE
 - 11 COOLING AIR OUTLET
 - 12 STACK
 - 13 COOLING AIR OUTLET

Storage Vault and Cooling

The MVDS design holds spent fuel in individual vertical sealed storage tubes retained within a concrete structure forming the storage vault. The storage tube provides a highly engineered mechanical barrier between the fuel and the environmental cooling circuit.

The storage vault is shown in section in Figure 1. The vault has a concrete floor and walls with inlet and outlet air cooling ducts. The roof of the vault is a composite steel and concrete structure called the Charge Face Structure which has holes to receive the storage tube. The Charge Face Structure combined with support stools in the vault floor maintain the fixed array of storage tubes optimised for sub-criticality and efficient cooling. Figure 3 shows the charge face structure during installation on site.

Removable shield plugs in the Charge Face Structure allows loading of the storage tubes into the vault. See Figures 4, 5A and 5B.

Figure 2. Plan View of the Fort St Vrain MVDS illustrating plant layout.

Cooling air enters through a protective bird mesh, flows through a labyrinth which prevents radiation streaming and enters the vault through concrete distribution louvres. The air picks up heat from the vault before passing through the exit louvres, up the concrete duct and out to atmosphere via the bird mesh and weather protected duct top - Figure 2.

The cooling air only contacts the outer surface of the storage tubes and not the spent fuel and therefore does not become contaminated. The cooling system is passive, self regulating and driven by the natural buoyancy of warm air. The cooling system maintains a wide margin on acceptable fuel and structural concrete temperatures for all site specific environmental conditions. The cooling system is insensitive to partial blockage of the inlet or outlet ducts and the design provides several days to recover from the very unlikely event of total blockage.

The natural thermal buoyancy cooling system has been validated by GEC ASLTHOM Engineering Systems Limited by the following:

- twenty years experience of continuous operation at existing UK dry fuel storage facilities;
- extensive thermo-hydraulic experimental testing on scale models at all operating conditions;
- two-dimensional computer air flow modelling using US NRC approved codes (reference 4);
- site specific wind tunnel testing to confirm the positive cooling effects of all environmental wind conditions which is a specific attribute of the design.

The massive concrete structure forming the vault and the cooling ducts provides radiation shielding.

The triangular spacing of the storage tubes within the vault is such that the stored fuel cannot become critical even in the unlikely event of the vault becoming fully flooded. No credit for burn-up is necessary to guarantee acceptable values for K effective in the MVDS design.

The civil structure is designed to the ACI 349-85N standard and constructed to ACI 318-83 requirements. The civil design caters for the site specific seismic condition, tornado generated missiles and tornado wind loads which dominate the civil design parameters. The overall foot print dimensions of the building are 21.3 metres (70 ft) wide by 46.3 metres (152 ft) long. All construction work was carried out to an enhanced quality assurance programme approved by the US NRC. Figures 6 and 7 show the building at two stages of construction.

Figure 3. Photograph showing the installation of the Charge Face Structure at the Fort St Vrain site.

Figure 4. Photograph showing the installation of Shield Plugs into the Charge Face Structure.

Figure 5A. Photograph of the Fuel Storage Containers located in the Charge Face Structure

Figure 5B. Photograph of the Fuel Storage Containers located in the Support Stool on the vault floor.

Figure 6. Photograph showing the civil structure during early stages of construction, with the placement of rebar.

Figure 7. Photograph illustrating the concrete structure at an advanced stage of completion.

Charge Hall

The enclosed area above the Charge Face Structure and the Cask Reception Bay is the Charge Hall which provides a weatherproof enclosure for the loading/unloading operations. The Charge Hall enclosure is insulated and also provided with limited space heating and simple ventilation to provide operator comfort during extremes of weather conditions.

The concrete structure extends up to the 9.2 metres (30 ft) elevation for protection of the Charge Hall equipment from the heavier regulatory (NUREG 0800) tornado missiles. The balance of the enclosure is a steel frame structure, clad with insulated aluminium sheeting. Careful design of the steelwork structure avoids the potential hazard of secondary missiles generated if the structure was to fail in the tornado.

The building crane operates along the length of the Charge Hall and provides all lifting operations for equipment handling. Equipment design limits and operational procedures control the potential drop heights of equipment on to the Charge Face Structure and into the Cask Reception bay. The bounding impact fault case will not allow a release of radioactivity. The crane is not categorised as an item of equipment, important to safety.

Fuel Storage Tube (FST) - Figures 5A and 5B and also Figures 8 through 10

The FST replaces the Inner Container of the existing FSV Shipping Cask (see Fig. 11) for fuel transfers to the MVDS and provides fuel confinement whilst the fuel is being handled and during the storage period. The FST may also be used with a Shipping Cask for the future fuel movements to the Federal MRS or Repository.

Carbon steel is used for the FST and it is designed to the code requirements of ASME 111 - Class ND. The exterior surfaces are protected from atmospheric corrosion by a flame sprayed aluminium coating. The bolted lid to the FST contains a removable depleted uranium insert used during lid bolting and leak checking procedures at the reactor building and at the MVDS whilst handling the shipping cask closure. Twin metal 'O' ring seals provide a high integrity seal between the container body and lid.

Figure 11. Fort St Vrain Transfer Cask

The lid design incorporates features to allow seal interspace and container body leak checking whilst stored in the vault. A spigot boss on the base of the FST serves to positively locate the FST in the floor of the storage vault. The atmosphere inside the FST is air.

Fuel Handling Machine (FHM) & Associated Equipment - Figure 14

The Fuel Handling Machine provides the means of raising/lowering a FST either from the FSV Shipping Cask or the vault storage location. The FST is fully shielded by the FHM during handling operations and the decay heat dissipated from the exterior surfaces of the machine. The hoist and FST grab system are designed to meet single failure proof standards for nuclear lifting applications. They provide the vertical motion for FST transfer operations and incorporate depth and weight sensing mechanisms.

The FHM is moved by the building crane using a special lifting yoke designed to limit the maximum possible lift height of the machine above the charge face level. A sliding valve at the base of the machine provides necessary gamma shielding. The valve cannot be operated unless it is coupled to the similar isolation valve on the Cask Load/Unload Port or the valve on the Charge Face. The base of the FHM has four outriggers designed to prevent toppling of the machine in the event of a drop incident.

The FHM can be adapted on a non-routine basis to safely handle single FSV fuel blocks.

Storage Wells

Three supplementary storage locations are provided at the end of the building. The storage wells provide a sealable, shielded and natural thermosyphon cooled containment for a FST in the unlikely event of a failure in service. They can be used to isolate a FST from the vault cooling system, to allow individual leak testing of a suspect FST, or to act as a temporary storage location whilst exchanging fuel blocks between FSTs or as part of the transfer process of fuel blocks in a DOE shipping cask. The Storage Wells provide the MVDS with an additional degree of independence from supporting site facilities during off normal events and during future MVDS defuelling operations.

A supplementary function of a Storage Well is to house the single FST holding six neutron source containing fuel blocks. This storage position, independent from the vaults provides the necessary additional neutron shield material.

Cask Reception Bay

The Bay is an enclosed reception area which is used for the receipt of the Shipping Cask trailer and for transferring the FST between the Shipping Cask and the FHM. The Bay location is indicated in Figures 12 and is an integral part of the building and

Figure 8. Photograph showing a completed Fuel Storage container after application of the aluminium spray coating.

Figure 9. Photograph showing the Fuel Storage Container Lid and flange joint.

Figure 10. Photograph showing a number of the 259 Fuel Storage Containers during manufacture at GEC ALSTHOM facility at Whetstone, Leicester.

covered by the Charge Hall. The Bay has a concrete floor, walls and ceiling with an access roller shutter door at one end for the shipping cask trailer to be backed into. A specially shaped aperture in the ceiling allows the Shipping Cask to be raised to the vertical and parked in the Load/Unload Port using the building crane. The arrangement limits the lift height of the Cask above the floor of the Bay. A Shipping Cask lower restraint is used to secure it whilst in the Load/Unload Port to prevent movement in the event of a seismic disturbance.

Principles of Operation

The fuel blocks or other items to be stored are loaded into Fuel Storage Tubes (FSTs) at the reactor building using the existing fuel handling equipment. The FSTs are transported from the reactor building to the MVDS building in the FSV Shipping Cask. In the Cask Reception Bay, the Shipping Cask is lifted from the site trailer and parked in a Cask Load/Unload port using the MVDS overhead crane, Figure 12A. In the Load/Unload Port the FSV Shipping Cask closure lid can be removed and parked. Use of a Fuel Handling Machine (FHM) and an independent shielded isolating valve mounted above the Shipping Cask allows the FST to be safely raised into the FHM, Figure 12B. The building crane moves the FHM to the selected storage location which has been previously prepared by removal of a shield plug and installation of a second shielded isolating valve. The FHM lowers the FST into the vault storage position, the FHM is removed, the shield plug replaced and the valve moved to the next storage location to be filled, Figure 12C. From this position the equipment is used to remove an empty FST from the vault and transfer it to the Shipping Cask.

Return of the FSV Shipping Cask to the reactor building with the empty FST allows the cycle to be repeated. Three Shipping Casks are available, therefore loading will normally be conducted simultaneously at the reactor building and the MVDS building.

Fort St Vrain Schedule

Preliminary release to commence the design, site specific safety case and environmental report was given in August 1989 and the full contract commitment made for the six module facility in February 1990. The overall schedule is illustrated in Figure 13 and illustrates the necessity of completing the design, safety case, equipment manufacture and civil construction in parallel with the US NRC review and approval programme. Confidence in the safety case allowed the contracting companies to take the commercial risks associated with such a procedure as part of the fixed price contract arrangement. The key date to allow commencement of field work was the US NRC clearance of the Environmental Report on February 1 1991. The resulting 9 months site construction and facility commissioning period was challenging.

The FSV storage facility was turned over to PSC on 19 September 1991, 11 weeks early to the schedule requirement, all milestones were met throughout the project. The US NRC operating licence will be issued in November 1991 after the statutory 30 day

◀ **Shipping Cask (TC) being unloaded from the TC Transporter within the Reception Bay**

The Fuel Assembly contained within the Storage Tube being removed by the Fuel Handling Machine for transfer to the Vault

◀ **Fuel Handling Machine positioned at the Vault Module and lowering the Storage Tube through the Charge Face**

Figure 12. Loading sequence for the Fort St Vrain - MVDS

day US NRC review period. Table 1 provides a summary of achieved dates. This schedule achievement was not only a tribute to the level of collaboration of the contracting parties but also to the efficiency and vigour of the US NRC in clearance of the Environmental Report and site specific licence.

Figure 13. Fort St Vrain MVDS Project Schedule

Licensing Experience

The MVDS Topical Report approved for LWR fuels in March 1988 provided a secure and referenceable basis for the FSV site specific licence application. As illustrated in Table 2 the FSV design parameters were bounded by the Topical Report parameters. Necessary adaptation for the MVDS design to suit the requirements for handling HTR fuel in a fuel storage tube which was to be loaded at the reactor, introduced the need to present site specific amendments to the general Topical Report with attendant licensing uncertainties at the start of the project.

In the event the US NRC generated 183 formal queries on the safety submissions, approximately 24% (43) of which related to the civil design details. Only two issues arose that caused a significant concern and that had the potential to delay the project schedule. These were:

1) Potential Dropped Fuel Storage Tube Incident

The original safety submission claimed that the single failure proof grab and hoist mechanism meeting the requirements of NUREG 0554 and ANSI/ASME NOG. 1 Type 1 (1983) used in the Fuel Handling Machine was of sufficient integrity to render the probability of dropping the FST into the vault during loading operations, incredible. The licensing authority could not accept this logic, deciding that the potential consequences of dropping and possibly rupturing the FST were sufficiently great to require an examination of these consequences. An analytical and experimental programme was mounted by GEC ALSTHOM to demonstrate that the loaded FST weighing 1.609 tonnes when dropped through the maximum distance of 6.985 metres (22.9 ft) would:

- a) remain leaktight
- b) not damage surrounding FSTs
- c) would be readily retrievable through the charge face structure after the incident.

Compliance with these criteria would demonstrate that no safety related hazard could result from this maximum credible accident. The programme was successfully completed within the requirements of the schedule and to the satisfaction of the US NRC. Figure 15 illustrates the type of damage that would be sustained by the FST when dropping through an equivalent distance of 11.277 metres (37 ft). Even at this bounding condition the three criteria could be met.

1) Monitoring of Fuel Storage Tubes and Outlet Cooling Duct

These issues related to the US Code of Federal Regulations 10CFR72.122(h)(4) which states "Storage confinement system must have the capability for continuous monitoring in a manner such that the licensee will be able to determine when corrective action needs to be taken to maintain safe storage conditions". The safety case was prepared on the basis of having the ability to monitor Fuel Storage Tubes on an intermittent basis for seal and or body leakage by making in situ tests in the storage vault via the charge face shield plugs. These simple and safe procedures were considered adequate in light of the very high integrity of the FST and the very low potential for radioactive release from the HTGR fuel block, even in the bounding fault case of FST leakage. The debate focused around the need to supplement these provisions with a system to continuously monitor the cooling air outlet from the vaults for radioactive releases. The impracticality of providing a monitoring system to detect and distinguish even the most pessimistic potential release from the MVDS above background, combined with the monitoring provisions provided on the FSTs, allowed the license authority to accept the case. The MVDS surveillance programme, which included conventional boundary monitoring of the MVDS perimeter fence and provision to monitor each FST, was considered sufficient to maintain a safe storage condition.

Figure 14. Photograph illustrating the Fort St Vrain Container Handling Machine during commissioning.

Figure 15. Photograph showing the consequences of the dropped Fuel Storage Containers onto the Support Stool

Figure 16. Photograph of a MVDS model showing a LWR vault cross-section.

APPLICATION OF THE MVDS TO LIGHT WATER REACTOR FUELS

General

The MVDS was developed in response to the needs of the nuclear generating utilities who require a safe and cost effective solution for the interim at-reactor storage of irradiated fuel assemblies. Use of the MVDS technology for the Fort St Vrain was a typical application. The MVDS is not designed to be an ultimate repository, but to act as a buffer in the fuel cycle. The concept is also very suitable for central away-from reactor applications.

The MVDS is designed to operate totally independent of existing reactor facilities, and as demonstrated at FSV will operate in a self sufficient manner, even when the reactor is decommissioned.

The flexibility to store a whole range of fuel types and irradiation histories is a key feature of the MVDS design. The MVDS design can be adapted to store all types of fuel, including PWR, BWR, AGR, magnox and CANDU fuel, as well as vitrified HLW. It was this unique flexibility that meant that the MVDS was the only licensed storage technology that could be readily adapted to store the highly enriched HTGR graphite fuel blocks.

The at-reactor MVDS designed to receive and store relatively newly discharged fuel, whose heat loading requires engineered cooling and oxidation prevention measures. The MVDS provides a total fuel management and monitoring capability over long storage periods, such that at the end of the storage campaign, the fuel can be recovered in as good condition as the day it started storage. The fuel assemblies may be recovered for reprocessing or for direct disposal, depending on the policies of the Government concerned. At the Wylfa dry store in the UK (Reference 1) the licence conditions permit recovery of the magnox fuel assemblies from the dry store and reloading of those fuel assemblies into the reactor for further use.

The fuel storage facilities provided by the MVDS ensure that fuel assemblies are maintained in the correct environment, throughout the storage period and give the best possible guarantee that the fuel will not deteriorate in storage.

A fundamental requirement of a fuel management system is to have an inspection and monitoring system which allows access to individual fuel assemblies for fuel accountability and inspection. The monitoring system designed into the MVDS is able to continually confirm that the fuel containment and fuel storage environment are maintained in accordance with the design condition.

Basis of the MVDS Licensed Design

A typical at-reactor site MVDS for LWR fuels is shown on Figure 17 and can be compared with the photographs of the FSV facility. The MVDS is a modular concrete vault, passively cooled,

inherently safe dry storage system. The complete storage facility consists of three main systems.

- i) The Reception Bay, where spent fuel is received and despatched.
- ii) The Storage Modules, where spent fuel is stored.
- iii) The Fuel Handling Machine, which picks up and transfers irradiated fuel assemblies from the cask in the Reception Bay to the Storage Tubes in the Storage Modules.

The operation of these systems is typified by the FSV operations described in the first part of this paper.

A typical LWR vault cross-section is illustrated in Figure 16 (photo model) and incorporates all the primary features of the MVDS applied at Fort St Vrain.

Figure 17. Illustration of a typical at reactor site MVDS for LWR fuels.

The MVDS cooling system was designed to give very low fuel storage temperatures. The design objective of the cooling system is in the longer term to allow the storage of irradiated LWR fuels in an air environment. The US NRC have not precluded this option but are presently awaiting further test results from fuel temperature degradation tests which are currently in progress in the USA, before granting final licensing approval of the option. For the FSV application, because of the nature of the HTGR graphite fuel blocks and the low temperatures achieved using the MVDS design, the use of an air environment for storage was licensed. Reference 3 provides details of the thermal hydraulic design aspects of the FSV MVDS design.

The design development of the MVDS has been carried out for a range of vault configurations and fuel heat outputs as well as different geometries. The MVDS vault design is not fuel type dependent. The variables in fuel geometry are accommodated within the Charge Face Structure (CFS) and the Fuel Storage Tubes. For the Fort St Vrain application a site specific Charge Face Structure and tube array was designed to accommodate the special HTGR graphite fuel blocks.

Figure 18. LWR - MVDS Fuel Storage Tube and Nitrogen System

Because each irradiated fuel assembly is housed in its own Storage Tube an efficient primary heat rejection mechanism is set up from the fuel to its storage tube by radiation and convection. Secondary heat rejection from the outside of the storage tube to the atmosphere is produced by a totally passive, inherently safe self-regulating natural thermosyphon buoyancy driven cooling flow as described for Fort St Vrain. The concrete surfaces inside of the Storage Vaults are not exposed to contaminated air and remain clean structures through the life of the store.

It is important to be able to monitor the condition of the fuel assemblies over long periods in store. The MVDS system is unique in having the provision to visually monitor the condition of individual fuel assemblies at any time during storage. This can be readily achieved by raising the fuel assemblies into the fuel handling machine and using a TV system for exterior examinations. The ability to monitor the fuel condition is an integral part of the waste management function. Not only can the visual condition of the fuel be checked, but also the containment boundary and storage environment. Each fuel storage tube is permanently connected up to the cover gas supply system Figure 18. The system can be designed to detect leakage from the fuel containment boundary. In addition by sampling of individual FST's evidence of fuel degradation such as may be witnessed by water vapour or activity within the cover gas can also be detected. The use of air for Fort St Vrain meant that it was not necessary to have a permanently piped supply to each tube as loss of a safe storage environment is not credible. The FSV storage tubes were however each fitted with valved access ports which permit the safe routine sampling and monitoring of each tube and its contents.

CONCLUSION

The MVDS claim as the main technology for the interim dry storage option offers the following attributes in its current design and licensed status and shows why it is the leading total fuel management system. The MVDS has been designed and licensed with public and operator safety as a prime consideration. The flexibility of the MVDS configurations, together with the comprehensive range of available fuel handling equipment, can be applied to any fuel storage application, anywhere in the world.

1. Independence of the System

The MVDS is a totally independent and comprehensive stand-alone system. All fuel handling operations, both for receipt and discharge, are accomplished using the equipment provided at the MVDS. The Fuel transfer operations take place directly from the fuel transfer flask into the fuel handling machine.

2. Passive Self Regulating Cooling System

The fuel assemblies are cooled by an inherently safe, passive self-regulating cooling system that induces buoyancy-driven ambient air to flow across the exterior of the individual Storage Tubes. Not only does this provide a totally passive cooling system, the storage temperatures for the fuel assemblies provide very high margins against the allowable temperatures.

3. Sub-Criticality

In the MVDS each fuel assembly is stored within its own Storage Tube. The fixed storage geometry ensures that criticality is not possible under all normal and fault conditions, including partial or total flooding. The design takes no credit for fuel burn-up and does not use borated materials. The inherent safety of the system is therefore easier to demonstrate and allows significant operational flexibility when having to store fuel with varying radiological characteristics and histories.

4. Diversity of Safety

The shielding, cooling and confinement functions for the fuel assemblies are provided by three diverse systems. The massive concrete walls provide the biological shielding, the Storage Tubes provide the confinement and the passive buoyancy driven air provides the cooling. The fuel handling machine is a heavily shielded transfer device which minimises personnel radiological dose uptake and provides a passive cooling system during fuel loading and unloading operations.

5. Monitoring of the Fuel Storage Condition

During the period of storage in the MVDS the storage environment is designed to prevent degradation of the fuel assemblies. A high purity inert gas is selected as the storage environment. The MVDS design allows the Storage Tubes to be connected to a high integrity source of inert gas and a monitoring system which allows the condition of the cover gas and the integrity of the store tube to be checked on a continuous basis. The method of loading the fuel assemblies into the MVDS provides the opportunity to check the condition of the fuel assemblies as received or to remove them for periodic inspection.

6. Loading Flexibility

The MVDS was designed as a modular system and thereby provides the ability to add capacity on a phased modular basis. The MVDS is designed to allow the loading operations to take place continuously through all weathers, seasons and during the day

or night. The MVDS Charge Hall is weatherproof, can be heated and illuminated, and is designed to withstand severe wind and snow loadings, thereby allowing the highest operational availability.

7. IAEA Safeguards

The nuclear security features of a fuel storage system must be commensurate with the nature of the materials being stored and the public and political demands for their safekeeping. The MVDS is a vault system, and as such sets the standard for nuclear safeguards and security considerations.

8. Achievements of the Fort St Vrain Project Figure 19

This first application of the MVDS technology in the United States has clearly demonstrated all of the important features of the dry storage system.

Independence The FSV ISFSI is the first US Commercial Storage facility to be totally independent of the reactor facilities.

Flexibility The Topical Safety Analysis Report design was readily modified to suit the site specific requirements of the HTGR fuel.

Licensing The FSV ISFSI confirmed that site specific licensing issues can be concluded in parallel with the project manufacture and construction schedule.

Construction Site construction and commissioning was concluded in under 8 months.

All construction easily handled by small local civil constructors.

Schedule Overall project duration was 2 years and 2 months, some 11 weeks ahead of schedule. When considering that this was the first MVDS to be built in the US and the first dry storage system to be fully licenced under 10CFR72, a 2 year schedule is achievable for future MVDS projects.

Safeguards The passive nature of the vault cooling system, Fuel Storage Container integrity and surveillance features have all been fully demonstrated to the satisfaction of the US NRC for this site specific application.

Figure 19. Photograph of the completed Fort St Vrain - MVDS.

Fort St Vrain Project Achievement Dates

Commenced Manufacture	5.2.90
Environmental Report (ER), Safety Analysis Report (SAR) and Licence Application Submitted to US NRC	22.8.90
US NRC Question regarding ER	26.10.90
Responses to ER Questions	30.11.90
US NRC Questions regarding SAR	7.2.91
Responses to SAR Questions	26.3.91
Civil Contractor Mobilises on site	5.2.91
Excavation complete	14.2.91
Replacement Fill complete	28.2.91
Foundation Concrete complete	9.3.91
Final concrete complete	27.8.91
Complete CHM in UK	28.6.91
Structural Steel started	24.7.91
Final Structural Steel completed	17.8.91
Charge Face Structures delivered	30.5.91
Mechanical and Electrical Equipment Installed and Tested	15.9.91
Handover	19.9.91

TABLE 2

Design Parameters

PARAMETER	FSV	TSAR
Heat Load/Storage Location	0.7kw (average)	1kw
Decay Period	600 days	5 years
Fuel Source - Normal assembly Gamma/Storage Location Neutron/Storage Location	1.52 x 10 ¹⁵ MeV/sec 2.08 x 10 ⁶ N/sec	9.32 x 10 ¹⁵ MeV/sec 5.17 x 10 ⁶ N/sec
Fuel Source - Neutron Source Assembly Gamma/Storage Location Neutron/Storage Location	1.52 x 10 ¹⁵ MeV/sec 5.61 x 10 ¹⁰ N/sec	
Ambient Temperatures	-32°F TO 102°F	-20°F to 100°F
Flood levels	6ft	Site specific
Seismic Ground Acceleration	0.1 Reg Guide 1.61	0.25 Reg Guide 1.61
Tornado Missile	NUREG 0800 II	NUREG 0800 II
Tornado Maximum Velocity	Reg Guide 1.75 (360 mph)	Reg Guide 1.75 (360 mph)
Snow Loading	30psf	100psf

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17.	Illustration of a typical at reactor site MVDS for LWR fuels.

18. LWR - MVDS Fuel Storage Tube and Nitrogen System
19. Photograph of the completed Fort St Vrain - MVDS.

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▼
G E C A L S T H O M

PROCESS FLOW

A process flow model using the Extend™ software on a MacIntosh computer was developed to simulate the process flow of nuclear materials in containers through the sequence of operations at NMSF. The model will be used to provide information on processes required to store the nuclear materials and to determine the throughput capacity as a function of nuclear material shipments from other locations within LANL, shipments from outside LANL, transfers from PF-4 operations, and handling of material canisters from NMSF storage as part of inventory inspection requirements.

Preliminary simulations indicate that the planned operations and operating times will result in accomplishing the required storage schedule.

1. System Description

Figure 1.11.1 is a block-flow diagram of the process flow for NMSF. Each block represents a major operation in the canister process flow. Figures 1.11.2 and 1.11.3 are diagrams that show more detail of the individual.

Table 1.11.1 lists the process times associated with these operations. The time associated with each operation can be varied to see the effect on the overall process.

TABLE 1.11.1
DELAY TIMES USED IN THE MODEL

<u>Operation</u>	<u>Time, Minutes</u>
Gate Entrance	15
Unload Truck	60
Airlock	10
Stage	16
Unpack	18
Elevator	10
Gamma Count	120
Calorimeter Preparation	20
Calorimeter Operation (Three Stations/Unit)	360
Shuffler (Uranium Measurement)	10
Storage Tube Loading	5
* Gantry Crane Operation (Place Storage Tube)	60

* This time is for the automated loading equipment described in Section *E.1.14*
OF PART I.

NMSF PROCESS FLOW DIAGRAM (Extend™ Model)

Figure 1.11.1 Block Diagram of NMSF Storage Flow Process

Figure 1.11.2 Simulation Block Flow Diagram - Complete Process

Figure 1.11.3 Simulation Block Flow Diagram - Calorimeter Section

The following assumptions and parameters were used to set up the simulations:

- Operations will be conducted on day shift only, five days per week except for the NDA process which is conducted on the back shifts.
- There will be a 30-min inventory period at the beginning of each day in which no processing occurs.
- Unpacking activities will not be permitted to start during the last two hours of each day.
- There will be three types of shipments of materials to NMSF; each of these will contain five pallets with four shipping containers per pallet. The types of shipments, their origination, and frequency of shipment are assumed to occur as follows:

Offsite	Pu	Once per month (28 days)
LLNL	Pu	Every two months (56 days)
LANL	U	Every two weeks (14 days)

- Storage canisters from PF-4 will be transferred via the tunnel at a rate of 12 per week. (This rate would empty the current PF-4 vault in one year.)
- Items in long-term storage will be inspected at a rate of 10 per week. All of those inspected will be processed through the NDA station.
- The NDA process equipment includes three calorimeters operated in parallel, two gamma/neutron stations operated in parallel, and one Shuffler station for processing uranium only canisters.
- A standard will be processed weekly through the NDA calorimeter equipment; this will require the same processing time as a regular material canister.
- Each storage location will contain two storage tubes, each holding seven material canisters

The parameters listed above were used in the preliminary simulations and represent the expected manner the facility will be operated. The simulation parameters and times can be easily changed.

2. Simulation Results

The model has been verified to represent the time delays and interactions of the process system at NMSF. Extend™ is ideal for representing discrete event operations, such the processes planned for NMSF.

Several simulations were made using the times given in Table 1.11.1. The number of stored canisters removed for inspection was varied to determine the level at which the crane system became backlogged.

The following summarizes the results of the simulation runs:

1. As expected, the calorimeter section and the gantry crane system are the points in the storage process that potentially delay the processing.
2. With the times shown in Table 1.11.1, a total of 1,544 canisters per year can be added to the storage array each year while removing and inspecting 10 stored canisters each week
3. There are no operations that backlog the system sufficiently to be a problem at the rates used.
4. The planned equipment for the NDA Section will adequately maintain the schedule as currently planned.

Figure 1.11.4 shows the results created by one of the simulation runs represented by the times in Table 1.11.1. The duration of the run was one year. No attempt was made to optimize shipments, transfers or inspections except to preclude two SST shipment arriving at the same time. Shown in the figure for some of the operations is the time for the longest delay caused by that operation as well as the average delay during the simulation run.

The simulation tool can be used in the future to determine optimum shipping schedules and overall filling rate as the equipment becomes better defined.

BLDG
PF-185

BLDG PF-4

PLAN
SCALE: NONE

BLDG PF-3

LAYOUT FOR PFHA
LOS ALAMOS

DRAWN BY: J.E. MATHEWS
CAD FILE: LOSALAM

FEB 27, 1995

SKETCH NUMBER #1

PLOT SCALE: 1=40 KEHCAD

ICM 6380.08 (8/3/94)
SYSTEM: 10040002.000

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PRELIMINARY FIRE HAZARDS ANALYSIS

**LOS ALAMOS NATIONAL LABORATORY
NUCLEAR MATERIALS STORAGE FACILITY
RENOVATION (BLDG PF-41)
CONCEPTUAL DESIGN REPORT**

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PRELIMINARY FIRE HAZARDS ANALYSIS
LOS ALAMOS NATIONAL LABORATORY
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CONCEPTUAL DESIGN REPORT

1.0 INTRODUCTION

1.1 Purpose

A Preliminary Fire Hazards Analysis (PFHA) for the Nuclear Materials Storage Facility (NMSF) at Los Alamos National Laboratory (LANL) has been prepared in response to, and in accordance with, the following requirements:

- **Functional and Operational Requirements Document (October 1994)**
- U.S. Department of Energy (DOE) orders:

6430.1A, General Design Criteria. A special fire protection design analysis shall be made for each facility vital to DOE mission accomplishment.

5480.7A, Fire Protection. Comprehensively assess the risk from fire within individual fire areas of a DOE facility in relation to existing or proposed fire protection to ascertain if the objectives of paragraph 4 (Section 1.3) are met.

1.2 Background

The facility includes the fuel storage system, piping and cooling systems, change rooms, and administrative offices. A Conceptual Design Report has been prepared by ICF Kaiser Engineers (ICF KE) in Los Alamos, New Mexico to determine the technical and cost baselines for the project.

1.3 Objectives

The PFHA evaluates the proposed fire protection for the NMSF to determine compliance with the fire protection criteria in DOE Order 5480.7A. The PFHA identifies special fire protection and prevention features required to meet the following objectives of the order:

- Minimize the potential for the occurrence of fire
- Ensure that fire does not cause an on-site or off-site release of radiological and other hazardous materials threatening to the public health and safety or to the environment
- Establish requirements that will provide an acceptable degree of life safety to DOE and contractor personnel
- Ensure that no undue hazards to the public exist from fire and its effects on DOE facilities
- Ensure that process control and safety systems are not damaged by fire or related perils
- Ensure that vital DOE programs will not suffer unacceptable delays as a result of fire and its effects
- Ensure that property damage from fire and related perils does not exceed an acceptable level

1.4 Limitations

The PFHA is based on the assumptions requirements of the NMSF Conceptual Design Report (CDR) and the **Functional and Operational Requirements Document (October 1994)**. It is valid only under those conditions. The PFHA uses preliminary information and excludes information unavailable during the conceptual design phase. The PFHA will need to be updated during design and again at the start of operations. Information not included here, but needed in the final FHA, must be provided by the party responsible for the final FHA.

1.5 Scope

This PFHA covers only the ICF KE-designed components of the NMSF. As required by DOE Order 5480.7A, the PFHA includes the following elements as they relate to the facility:

- Description of construction

- Protection of essential safety-class equipment
- Fire protection features
- Description of fire hazards
- Life safety considerations
- Critical process equipment.
- High value property
- Damage potential: The Maximum Credible Fire Loss (MCFL) and Maximum Possible Fire Loss (MPFL) are defined in DOE Order 5480.7A. The MPFL is the maximum possible loss that could occur in a single fire area, assuming the failure of both automatic and manual fire extinguishing. The MCFL is the property damage that would be expected from a fire, assuming that all installed fire protection systems function as designed and that the effect of emergency response is omitted except for post-fire actions such as salvage work, shutting down water systems, and restoring operation.
- Fire department/brigade response
- Recovery potential
- Potential for a toxic, biological, and/or radiation incident from a fire
- Emergency planning
- Security considerations related to fire protection
- Natural hazards (earthquake, flood, wind) and their impact on fire safety
- Fire exposure, from an exterior fire source and from inside the facility itself

1.6 Methodology

Although DOE Order 5480.7A requires an area-specific analysis, many required PFHA

elements relate to the entire facility and thus lend themselves to treatment at a general level. Section 2.0 of the PFHA addresses those elements for which this is true. Items that pertain to specific fire areas are addressed in individual sections of the PFHA, beginning with Section 3.0. The individual fire area sections of the PFHA are arranged to follow the required elements for each fire area. Common elements are covered in Section 2.0 only.

DOE Order 6430.1A, Section 1530-2.3, Criteria I through V, are applied on an area basis to ensure that minimum fire protection provisions should be present for each fire area in the Title I design of the support facility. The threshold value for additional fire protection features is based on the MPFL. Anticipated combustible loading and subsequent fire-loading results are the basis for determining the MPFL in each fire area. The MPFL provides a quantitative basis for estimating damage from a fire with given fire loads and equipment in the fire area.

2.0 GENERAL FACILITY DESCRIPTION

2.1 Site Location and Description

The existing NMSF (PF-41), located at Technical Area (TA)-55, will be remodeled for the storage of nuclear materials. Nuclear materials will be stored within drywells in stainless steel containers supplied to the facility from other locations. Material handling and support equipment will be provided to accept, inspect, transport, and store the nuclear materials.

The CDR will completely change the existing facility. Thus any existing condition or concerns will be eliminated, and are not evaluated at this time.

2.2 General Description of Construction

The NMSF building modifications and associated equipment will be designed in accordance with DOE Order 6430.1A. The project will be constructed using fire-resistant and noncombustible materials wherever practical. Support areas, such as change rooms, will contain or be constructed using limited- or non-combustible materials.

The facility has two fire areas that will be separated by a 2-hour fire-rated fire wall. New and existing penetrations will be provided with 2-hour fire-rated seals. Door openings will be provided with 1-1/2-hour fire-rated doors. Fire Area One is enclosed in a 2-hour fire-rated barrier. For the purpose of this PFHA, fire zones are defined as areas within a fire area that is treated as an area of analysis. Fire spread between zones is possible, but this fire spread would be limited by noncombustible construction or other features. The analysis review each fire zone within an area and for the area as a whole. The two fire areas will contain the following zones:

Fire Area One:

Zone

- 1) Storage array, basement
- 2) Charge deck, first floor
- 3) Materials receiving and handling, first floor

- 4) Support area, first floor
- 5) Support area, mezzanine
- 6) Support area, basement area

Fire Area Two:

Zone

- 1) Loading area (Garage), first floor
- 2) Support equipment not related to the nuclear materials storage area

The locations of the Fire Areas and Fire Zones are noted on Sketch No. 1.

2.3 Building Occupancy Classification

In accordance with National Fire Protection Association (NFPA) 101 (Life Safety Code, Chapter 28), NMSF has been classified as a Special Purpose Industrial Occupancy. The parts of the project to be provided with automatic sprinklers are classified as Ordinary Hazard, Group 2 occupancy in accordance with NFPA 13, Installation of Sprinkler Systems.

2.4 Identification of Fire Areas

DOE Order 5480.7A defines a fire area as "a location bounded by construction having a minimum fire resistance rating of 2 hours with openings protected by appropriately fire-rated doors, dampers, or penetration seals." Spatial separation may also be used to define fire areas.

The NMSF fire areas are to be separated by 2-hour fire-rated walls. Fire zones (located within a fire area) are also identified in the PFHA.

2.5 Identification of Safety-Class Systems

Safety classifications of systems, components, and structures are established in accordance with DOE Order 6430.1A. Safety-class designations are determined through

analyses of the consequences of system or component failures as indicated in the **Preliminary Hazards Analysis (PHA - July, 1995)**. Based on preliminary indications from the LANL personnel preparing the PHA, two of the safety class systems expected are:

- a. The HEPA filter system for the MAA.
- b. The structure surrounding the Material Access Area (MAA) which includes Fire Area One (areas used for handling and storage of nuclear materials). This system also includes the Charge Deck and Storage Array.

These are the safety class systems which have the most potential impact on this analysis. Refer to the PHA for further clarification of safety class requirements.

2.6 General Description of Fire Protection

Automatic sprinklers are currently installed in most areas of the building, but they are not provided in the old nuclear storage area. The existing automatic sprinkler system and fire hydrants are supplied from the 10-in. water loop (see attached sketches). New fire hydrants (if required at detailed design stage) will be located at least 50 ft from the building. The new sprinkler system, fire hydrants, and mains will not be designed to perform a safety-class function or as a safety-class system, if required, depending on the outcome of the PHA. Also see Section 1.9 of the CDR for fire protection requirements and systems proposed.

An appropriate number and type of fire extinguishers will be located throughout the facility in accordance with NFPA 10, Portable Fire Extinguishers, and site-specific requirements.

2.7 Water Supply to Fire Suppression System

The fire suppression infrastructure at TA-55 operates as an independent system, since it has adequate on-site storage. Underground mains exist and are assumed to meet the requirements of NFPA 24, Installation of Private Fire Service Mains and their Appurtenances. The 10-in. water loop in TA-55 provides for alternate flow paths. However, the 10-in. main that supplies the fire hydrants and sprinkler systems at the NMSF is not provided with alternate flow paths. The automatic sprinkler systems are assumed to meet the requirements of NFPA 13. Design of the water mains and sprinkler systems will be verified during the design phase and code compliance will be verified and

documented.

A new 10-in. loop will be needed around the NMSF to provide an alternate flow path. The existing sprinkler systems are hydraulically calculated. These systems are supplied through a manifold feed arrangement, which does not allow individual control of each riser with an outside control valve.

2.8 Life Safety Considerations

The project has been assigned a Low Hazard classification in accordance with NFPA 101. Emergency egress paths and exits will be provided from normally occupied areas of operation. Emergency egress will be arranged so that a single fire or incident will not block egress from the facility. However, the charge deck will have a single exit door.

2.9 Identification of Critical Process Equipment

No critical process equipment is foreseen in the NMSF. It will function as a long-term storage facility, not a processing facility.

2.10 Identification of High-Dollar-Value Equipment

High-value property for the PFHA is equipment having a value of more than \$1,000,000. At the current time, limited high-value equipment is foreseen. The cost of the nuclear materials is not included in this evaluation.

2.11 Fire Department Response

The Los Alamos Fire Department will respond to PF-41 from Fire Station West. The Fire Department's equipment, manpower, and timing were found to satisfactorily meet the conditions covered by this PFHA.

Method of Fire Department Notification

The building has been provided with a fire alarm system that provides notification of alarms and problems with the sprinkler systems and the manual pull stations. Alarms are sent to the Central Alarm Station and to the TA-55 Operations Center. The Central Alarm Station notifies the Los Alamos Fire Department. The TA-55 Operations Center is manned 24 hours a day, seven days a week.

Response Time

Expected response time to the facility should be less than 5 minutes because Fire Station West (also known as Fire Station One) is approximately 2 miles from the NMSF. The fire station is located directly west of the intersection of Diamond Drive and West Jemez Road. The response time is measured from the time the alarm is received at the fire station to the time the responders arrive at the scene. This is based on conversations with Fire Department personnel.

Building Accessibility

Fire-fighting accessibility will be provided on all sides because the NMSF is well separated from adjacent buildings.

Number and Qualifications of Fire Response Personnel

Two officers and more than seven firefighters are expected to respond to the NMSF on the first alarm. Fire Department personnel are qualified to NFPA codes and state and site-specific requirements.

Availability of Fire Response Equipment

Five Los Alamos fire stations will provide additional personnel and equipment to the area, if needed.

Pre-fire Plan

A pre-fire plan will be prepared for the NMSF and updated at least yearly by the Fire Department.

Mutual Aid

Mutual aid will be provided in accordance with established agreements and procedures.

2.12 Programmatic Recovery Potential in Case of Total Loss

The NMSF is being designed to minimize the potential for a radiation incident. The facility

will be constructed of noncombustible materials, which will minimize the potential of a fire or other accidents and, thus, a release. A total loss of the facility from a fire-related incident is not expected. An uncontrolled fire may consume the combustible materials in a fire area, but would not spread into other fire areas. Shield walls for the storage array and the charge hall are not fire-rated barriers. However, these concrete shield walls will keep a fire from spreading from the rest of the area into the storage array or the charge deck. In addition, the many other concrete walls that provide the zonal boundaries will reduce or eliminate the spread of fire between the fire and the rest of the area. If a fire were to destroy the usable equipment and space within the renovated facility, the cost to replace would be approximately \$55,000,000. The cost to construct an entirely new building, should the existing shell be destroyed is approximately \$80,000,000. **Part I** and **Part VII** contain more cost data.

2.13 Potential for Toxic, Biological, or Radiation Incidents

The facility is being designed to minimize the potential for a radiation incident resulting from a fire loss. Noncombustible construction materials will be used in areas that contain the nuclear materials, reducing the potential of a fire and, thus, a release. High-efficiency particulate air (HEPA) filter units are to be installed in areas that have release potential. The filter units will be provided with automatic deluge (water spray) systems in accordance with DOE Order 5480.7A and the DOE Fire Protection Resources Manual. A toxic or biological release is not expected because the facility will not handle these types of materials.

2.14 General Description of HVAC System Response to Fire

The HVAC system will be designed to provide personnel comfort in the office and support areas. The HVAC system in the areas of potential contamination will be designed to minimize the spread of contamination and/or to contain the materials. Air from these areas will pass through HEPA filter units. HVAC systems are not planned for the storage array area.

2.15 Handling of Discharged Sprinkler and Firehose Water

Water from firefighting operations in Fire Area One will need to be confined by an engineered containment system because of possible water contamination. Water from the sprinkler system and hose streams used for firefighting in Fire Area Two could be allowed to run out of the building; radioactive contamination is not anticipated in this fire

area.

2.16 Emergency Planning

Emergency planning will be provided for the facility in accordance with LANL guidelines.

2.17 Security Considerations Related to Fire Safety

Security considerations that relate to the NMSF will be the same as for other facilities at TA-55. Emergency egress will be provided in all areas, and alarms will be installed on some doors. Exiting will set off an alarm but will not affect emergency egress.

Firefighting activities in security areas at the NMSF will be handled the same as they are in other security areas. Additional problems are not expected.

2.18 Natural Hazards Impact on Fire Safety

The final PHA was not available prior to preparation of this document. However, it is expected to be completed by the time this document is issued. It should address the probability of fire cause by a natural event in more detail than is presented here.

Earthquake

According to the Uniform Building Code (UBC), the northern section of New Mexico is located in seismic zone 2B, a region of low-to-moderate seismic activity. This does not rule out the possibility of an earthquake. An earthquake with adequate strength to destroy the structures is possible. The facility was designed to the applicable requirements noted for the seismic area. Since the facility is designed to resist an earthquake, it is believed that an earthquake would not cause a fire in the structure. This will be further refined in a Final Fire Hazards Analysis and during Title design. (Refer to Part V for magnitude and probability of seismic events; see also the Preliminary Hazards Assessment.)

Flood

The TA-55 Operations Center is situated in a location where the building is not susceptible to even a probable maximum flood. Disposal of surface and drainage water

will be through natural percolation. The natural slope of the adjacent land is away from the site. The land immediately north is slightly higher, and surface drainage is channeled to the east and to the south site boundary. A flood is not expected to hamper fire response.

High Winds

Because this is an existing building, it is assumed to have been originally designed to withstand the winds in this area and to meet other wind loads. Since the building can resist wind loads adequately, it is not expected to damage the facility or severely hamper fire response.

Lightning

A direct lightning strike to a building could cause structural damage at the point of impact, and would also cause a voltage surge through the structural frame of the building and its grounding grid. Voltage surge could cause substantial damage to electronic components throughout the structure. Ample surge protection should be provided to protect any high-value electronic equipment in the building. A lightning protection system, if needed, will comply with NFPA 780, Lightning Protection Code. The grounding system will be replaced, however, and the design should include an analysis to verify the potential for fire caused by lightning strikes and should provide details to prevent the problem.

2.19 Exterior Exposure Potential

Exterior exposure potential is limited to natural cover fire. Other buildings are well separated from the facility, as shown on the attached sketch. The building separation meets the distances required by NFPA 80A, Exterior Exposure Protection, and FM Loss Prevention Data Sheet 1-20. Buildings PF-4 and PF-185 are more than 150 ft away from PF-41. Building PF-142 is less than 100 ft away; however, an earthen berm is located between the two buildings.

2.20 Assumptions

The following assumptions are used in the PFHA:

- Nuclear materials will be delivered in sealed stainless steel containers. These

containers are supplied items. The design of the containers is adequate to ensure that they are not a fire source and will not contribute to fuel loading.

- Combustible loading estimates are based on expected future occupancy (November 2002) and proposed equipment used in the areas. The estimates do not include operations equipment that may be installed at some future date.
- Noncombustible HEPA filters (UL listed or FM approved) and steel housings will be specified for the filter units. Additionally, the filters will be changed on a schedule so that buildup of radioactive material will not become a fire source or a fire hazard.
- The nuclear materials and containers are a supplied item and are not included in any cost estimates. The dollar value of the nuclear materials will not be included in the MCFL or MPFL calculations for the NMSF.
- Damage limits of the nuclear materials in the sealed stainless steel containers will be as noted in the **Functional and Operational Requirements Document (October 1994)** on this subject; 770°F is the point at which a dangerous reaction between the special nuclear material and the containers will occur.
- Damage that results from an electrical short, arc, or fault in the equipment or wiring is not considered a fire loss as defined by the fire insurance industry. This damage is considered to occur before any resulting fire and is not included in the MCFL or MPFL values.
- A simple two-dimensional model will be used to determine fire damage to the facility. The model will evaluate the fuel loading in an area and then determine if there is adequate fuel to damage the equipment and/or the building, if ignited. This model will represent the worst-case fire scenario. The fire loss in this model will be greater than a fire loss expected under actual conditions.

2.21 Site Conditions

- The existing support organizations (fire department response and equipment, site security interface, and maintenance interface) are adequate.
- An ALARA program will be implemented before the facility is commissioned to

control combustible materials in the NMSF. Such a program will be reviewed by LANL and DOE prior to implementation.

3.0 FIRE AREA ONE

3.1 Description of Fire Area

Fire Area One has six fire zones:

- 1) Storage array, basement
- 2) Charge deck, first floor
- 3) Materials receiving and handling, first floor
- 4) Support area, first floor
- 5) Support area, mezzanine
- 6) Support area, basement

3.2 Construction

Fire Area One will have concrete walls, floor, and roof. A 2-hour fire-rated barrier will separate this area from the rest of the building. The barriers will include some new walls and floors. Penetrations in the walls or floors will be sealed with 2-hour fire-rated seals. Door openings will be provided with 1.5-hour fire-rated doors.

The floor of the charge deck (the roof of the storage array) will consist of a 30- to 36-in.-thick composite steel-and-concrete slab. This slab will also provide support for the nuclear materials storage drywells. The drywells will consist of 18-in.-diameter steel tubes approximately 18 ft in length. Nuclear material, contained in sealed stainless steel assemblies, will be stored in the drywells. The stainless steel containers will be restrained in the drywell using steel baskets or other steel devices to meet the requirements for support of the storage arrangement.

The fire zones in the area will not be separated by fire-rated barriers. They will be provided with concrete walls to form compartments. These compartments will limit fire spread and provide containment. The storage array and the charge-deck fire zones will be separated from the rest of the fire zones by concrete shield walls with sealed penetrations and, as a result, will be isolated. The construction, while not fire-rated, will provide adequate fire separation between Zones 1 and 2 and the rest of Fire Area One.

3.3 Protection of Safety-Class Systems

The building structure surrounding the MAA has a safety-class designation, which is also

true for the drywells and storage array components. The HEPA filters and associated items joined structurally to the building are also safety class. An automatic fire-protection system will not be provided for the storage array and charge hall; a detection system will be provided for the charge hall. Pre-action sprinklers will be provided to protect the rest of Fire Area One. The omission of sprinklers is covered in the CDR document, Part I, Section 6.0, Safety Considerations.

3.4 Description of Fire Protection Features

Pre-action sprinkler systems will be provided for all fire zones in the fire area except for the storage array and the charge deck. HEPA filter units with an automatic-deluge water spray system will be provided. Existing sprinkler systems are provided with water-flow alarms to a local fire alarm panel that is connected to the Central Alarm Station. Other details are noted in Section 2.0.

3.5 Description of Fire Hazards

- The greatest potential for a fire will come from an electrical short in the storage array. However, this type of fire will not continue to burn because of the lack of combustible materials in the facility. The area will contain only the drywells and will be otherwise unoccupied.
- Any fire hazards on the charge deck will be associated with the crane or the electrical system and will result from a short in the wiring or lights. If a fire starts, it will not continue to burn because of the lack of combustibles.
- The materials receiving and handling fire zone on the first floor will have several fire hazards because of material handling. The hazards include those presented by the electrically powered forklift and other material-handling equipment, other electrical equipment, and combustible materials typical to these operations. Fire hazards in this zone are those that would be anticipated for the occupancy.
- The first-floor support-area fire zone will have fire hazards similar to those in the materials receiving and handling fire zone.
- Fire hazards in the support-area fire zone on the mezzanine level will be similar to those for the materials receiving and handling fire zone.

- The basement support-area fire zone will present hazards similar to those for the materials receiving and handling fire zone. However, the mechanical room containing the elevator's hydraulic oil system will be located in this fire zone. (The system is located in a separate room in the mechanical room.) The hydraulic system presents a fire hazard because of the pressurized oil and ignition sources, which could create a possible oil fire.

3.6 Resident Combustible Materials in Fire Area One

- Combustible materials are not expected to be found in the storage array.
- Fire loading for the charge hall (above the deck) will be higher than below the deck in the storage array area, but a sustained fire in this zone is not possible because of the very low fire loading. Combustible materials will consist of lights, monitors, and exposed wiring on the crane.
- The materials receiving and handling fire zone may include several hundred pounds of combustible materials. Combustible materials typical of those expected for this occupancy include packaging materials, electrical wiring and equipment, forklift batteries, and material-handling equipment. Some office equipment will also be in this area.
- The first-floor support-area fire zone will have fire loading similar to the materials receiving and handling fire zone.
- Fire loading for the support area on the mezzanine level will be similar to that for the materials receiving and handling fire zone.
- The basement support-area fire zone has fire loading similar to the materials receiving and handling fire zone. However, the mechanical room that contains about 200 gal. of hydraulic oil for the elevator is located in this fire zone.
- Computer fire modeling was not done at this time. Automatic sprinkler protection has been provided throughout these fire zones except in the storage array and charge deck.

3.7 Expected Transient Combustible Materials in Fire Area

Transient combustible materials could be present throughout Fire Area One. However, they are not expected to be found in the storage array. The level of transient combustible materials would be expected to increase during maintenance operations. Large amounts of combustible materials may be present during elevator maintenance. Combustible materials will include lubrication equipment and parts, paper, and cleaning supplies.

3.8 Special Life Safety Considerations

At least two emergency exits will be provided from each fire zone except for the charge deck and the storage array. The storage array is a "no access" area. Personnel will not be allowed in this area because of radiation concerns and lack of space. See Fire Zones 1 and 2 for additional information. Emergency egress complies with NFPA 101.

3.9 Analysis of Fire Hazard

	FIRE AREA 1 ZONE 1	FIRE AREA 1 ZONE 2	FIRE AREA 1 ZONES 3, 4, 5, & 6
VOLUME	75,600 ft ³ (room size: 4,200 ft ² * 18 ft high). Space minus drywells (est. 40% of volume is drywells) = 45,400 ft ³ .	79,800 ft ³ (room size: 4,200 ft ² * 19 ft). Space minus equipment (est. less than 0.1% of volume is equipment, not a factor).	304,000 ft ³ (4,100 ft ² basement and mezzanine zones * 10 ft high * 2 plus 14,800 ft ² first floor * 15 ft high). Space minus equipment (est. less than 3% of volume is equipment, therefore, not a factor).
SPACE TO BE HEATED	45,400 ft ³ of Space from 60°F to 700°F Under conditions of no heat loss to the concrete walls, ceilings, floors, drywells, no layering, heat removal through the vent system, etc. 700°F temperature would affect the drywell and stored fuel.	79,800 ft ³ of Space from 60°F to 700°F Under conditions of no heat loss to the concrete walls, ceilings, floors, drywells, no layering of the heat, etc. 700°F temperature would affect the drywell and stored fuel.	304,000 ft ³ of Space from 60°F to 500°F Under conditions of no heat loss to the concrete walls, ceilings, floors, drywells, no layering of heat, etc. At 500°F temperature, combustible materials will self-ignite and self-spreading fire is possible.

	FIRE AREA 1 ZONE 1	FIRE AREA 1 ZONE 2	FIRE AREA 1 ZONES 3, 4, 5, & 6
REQUIRE D ENERGY	Total 667,500 Btu (45,400 ft ³ * 0.01832 Btu to raise 1 ft ³ 1 640°F. ^a To keep the basement at 700°F for 10 minutes would take an additional 134,500 Btu. Estimate 25% heat loss to building structure).	Total 1,169,500 Btu (79,800 ft ³ * 0.01832 Btu to raise 1 ft ³ 1°F * 640°F ^a To keep the basement at 700°F for 10 minutes would take an additional 223,900 Btu. Estimate 25% heat loss to building structure).	Total 2,675,000 Btu (304,000 ft ³ * 0.01832 Btu to raise 1 ft ³ 1°F * 440°F ^a . To keep the four fire zones at 500°F for 5 minutes would take an additional 224,500 Btu. Estimate 10% heat loss to building structure).

^aHandbook of Air Conditioning, Heating, Ventilation, Load Calculations 2-7, Properties of Dry Air.

	FIRE AREA 1 ZONE 1	FIRE AREA 1 ZONE 2	FIRE AREA 1 ZONES 3, 4, 5, & 6
REQUIRE D ENERGY	<p>An exposing temperature of 1200°F lasting greater than 10 minutes will cause sagging or other damage to the steel.^{b,c}</p> <p>Damage to fuel storage will happen at 700°F, which set the limit for this evaluation.</p>	<p>An exposing temperature of 1,200°F lasting approximately 10 minutes will cause sagging or other damage to the steel.^{a,b}</p> <p>At 700°F, which sets the limit for study, combustible materials in this zone will auto-ignite and possible damage to the drywells will result.</p>	<p>A temperature of 500°F lasting approximately 5 minutes will cause auto-ignition of combustible materials and could involve all four zones.</p> <p>Auto-ignition of the combustible materials at 500°F was used as the limit for this study.</p>

^bFactory Mutual Loss Prevention Data Sheet 2-78, Protection of Steel, Figure 1.

^cThe Manual of Steel Construction, Part 6, Section 6-3.

	FIRE AREA 1 ZONE 1	FIRE AREA 1 ZONE 2	FIRE AREA 1 ZONES 3, 4, 5, & 6
FIRE LOADING	<p>FUEL IN AREA</p> <p>Wiring in conduits, not considered an exposed combustible material.</p> <p>Four light fixtures with 1/4 lb of combustible materials per unit, or 1 lb. No other fixed combustible materials expected.</p> <p>TRANSIT COMBUSTIBLE MATERIALS:</p>	<p>FUEL IN AREA</p> <p>Wiring in conduits is not considered an exposed combustible material. Twenty fixtures with 1/4 lb of combustible materials per unit, or 5 lb. Estimate 15 lb of combustible materials for the crane: wiring and lubrication.</p> <p>Estimate 15 lb of combustible materials for the monitor.</p> <p>TRANSIT COMBUSTIBLE MATERIALS:</p>	<p>FUEL IN AREA</p> <p>Wiring in conduits is not considered an exposed combustible material. Fifty light fixtures with 2 lb of combustible materials per unit, or 100 lb. Office-type equipment, electrical wiring and equipment, electrical forklift batteries, and other handling equipment; combustible materials are estimated to be about 1,000 lb or less. The mechanical room for the elevator has an associated fire loading of about 200 gal of hydraulic oil (10,400,000 Btu). Equipment not defined is estimated to be 1,000 lb of combustible materials.</p> <p>TRANSIT COMBUSTIBLE MATERIALS:</p>

	<p>FIRE AREA 1 ZONE 1</p> <p>Not expected in this area, as it is a non-operating area.</p> <p>OTHER FUEL OR HEAT SOURCES:</p> <p>None foreseen in this zone.</p>	<p>FIRE AREA 1 ZONE 2</p> <p>Can be expected in this area as it is an operations area, possibly 50 lb. Total 85 lb of combustible materials (680,000 Btu).</p> <p>OTHER FUEL OR HEAT SOURCES:</p> <p>None foreseen in this zone.</p>	<p>FIRE AREA 1 ZONES 3, 4, 5, & 6</p> <p>1,000 lb of transit combustible materials are expected in this area, as it is an operations area. Loading of 35,200,000 Btu.</p> <p>OTHER FUEL OR HEAT SOURCES:</p> <p>Cutting, welding, or other hot work. No other foreseen in this zone.</p>
<p>FIRE LOADING (Cont'd)</p>	<p>DESIGN BASIS FIRE — PROBABLE FIRE SOURCE</p> <p>Electrical short in lighting circuit; low energy release; no combustible materials in area; no sustained or spreading fire.</p>	<p>DESIGN BASIS FIRE — PROBABLE FIRE SOURCE</p> <p>Electrical short, crane, lighting or monitor circuit; low energy release, minimal or no combustible materials in area; no sustained or spreading fire.</p>	<p>DESIGN BASIS FIRE — PROBABLE FIRE SOURCE</p> <p>Electrical short in lighting circuit; low energy release; sustained or spreading fire possible. Electrical fire start is possible in all areas of the zones; medium to high energy source; fire start is possible with sustained or spreading fire.</p>

	FIRE AREA 1 ZONE 1	FIRE AREA 1 ZONE 2	FIRE AREA 1 ZONES 3, 4, 5, & 6
		<p>POSSIBLE FIRES</p> <p>Ignition of the transit combustible materials; moderate energy release; local fire possible; will not spread due to lack of continuous, combustible materials; no sustained or spreading fires.</p>	<p>POSSIBLE FIRES</p> <p>Ignition of the transit combustible materials. Hot work, or unknown fire start; moderate energy release; fire possible, will spread due to the combustible materials; sustained or spreading fire. Elevator equipment fire; moderate energy release; fire possible; will spread due to combustible materials, sustained or spreading fire.</p> <p>Fire loading of 35,200,000 Btu is possible in these areas. If a fire started, it would continue to spread due to continuous combustible materials. A fixed suppression system is needed.</p>

	FIRE AREA 1 ZONE 1	FIRE AREA 1 ZONE 2	FIRE AREA 1 ZONES 3, 4, 5, & 6
LIFE SAFETY	<p>Personnel will not be allowed in this zone due to radiation concerns. The arrangement of the drywells will not allow for access into the zone.</p> <p>There are no fire hazards in this zone.</p>	<p>One exit is provided; however, there will not be any objects to block the path of travel to the door. The door is located in the center of the east wall. Maximum travel distance is less than 150 ft, with the exit into an adjoining room and then into stairway and outside.</p> <p>There are no high fire hazards in this zone.</p>	<p>There are at least two exits from the zone. A common path of travel exists within the room only, and there is no common path of travel once out of the rooms. The maximum travel distance is less than 150 ft. Exit is through the security areas into an adjoining room and then outside, having passed through a 2-hr fire-rated barrier.</p> <p>An oil fire in the elevator hydraulic oil system would be high fire hazard.</p>

	FIRE AREA 1 ZONE 1	FIRE AREA 1 ZONE 2	FIRE AREA 1 ZONES 3, 4, 5, & 6
RESULTS	<p>Need 667,500 Btu for damage; have 1 lb of combustible materials (8,000 Btu). Fire damage will not be a factor.</p> <p>Automatic sprinklers are not needed because a fire with damage is not a credible event.</p> <p>Damage in the MCFL and MPFL are equal; see Sections 3.10 and 3.11.</p> <p>Travel distance is satisfactory. No access into this fire zone.</p> <p>Release of radioactive materials from a fire is not possible in this zone because of the use of sealed stainless steel storage containers. A fire in this zone will not raise the temperature</p>	<p>Need 1,169,500 Btu for damage; have 85 lbs of combustible materials (680,000 Btu).</p> <p>Automatic sprinklers are not needed because the MPFL is less than \$1,000,000.</p> <p>Damage in the MCFL and the MPFL is equal; see Sections 3.10 and 3.11.</p> <p>Travel distance is satisfactory.</p> <p>Release of radioactive materials from a fire is not possible in this zone because of the use of sealed stainless steel storage containers. Total combustion of combustible materials from a fire in this zone will not raise the temperature to a point of</p>	<p>Need 2,675,000 Btu for damage; have 35,200,000 Btu. Damage is possible in the four zones.</p> <p>Automatic sprinklers are needed because MPFL is greater than \$1,000,000.</p> <p>Damage, see Sections 3.10 and 3.11.</p> <p>Travel distance is satisfactory and complies with NFPA 101; however, the elevator hydraulic lift would limit egress and spread smoke throughout the building. Use Factory Mutual-approved less-hazardous hydraulic oil or noncombustible oil to reduce exposure.</p>

3.10 Maximum Credible Fire Loss

The MCFL for each fire zone in Fire Area One is as follows:

- The MCFL in the storage array fire zone will be small because of the lack of combustible materials. A fire will be of limited duration and will self-extinguish when a breaker trips. A fire will be confined to the area of origin. Minimal smoke and fire damage is expected. Damage to the building is not expected. Cleanup and firefighting costs will be limited. The MCFL, based on the replacement of an electrical circuit and cleanup, is expected to be less than \$10,000.
- The MCFL for the charge-deck fire zone will be small because of the low level of combustible materials. A fire will be of limited duration and will self-extinguish when a breaker trips or the limited fuel is consumed. A fire will be confined to the area of origin. Minimal smoke, fire, or water damage is expected. Damage to the building is not expected. Cleanup and fire-fighting costs will be limited. The MCFL, based on the replacement of an electrical circuit or equipment, a light cleanup, and repainting, is expected to be less than \$125,000.
- The MCFL in the materials receiving and handling fire zone will be small because of the limited amount of combustible materials and the installed automatic suppression system. A fire will be of limited duration and will be extinguished when the sprinkler system operates. Fire will be confined to the area of origin. Minor smoke, fire, and water damage is expected. Damage to the building is not expected. Cleanup and firefighting costs will be limited. The MCFL, based on the replacement of an electrical circuit, equipment, cleanup, or repainting, is expected to be less than \$100,000.
- The MCFL for the first-floor fire zone will be limited because of the installed automatic suppression systems, the limited amounts of combustible materials, and the many compartments in the zone. A fire will be of limited duration and will be extinguished upon operation of the sprinkler system. It will be confined to the area of origin. Minimal smoke, fire, and water damage is expected; damage to the building is not expected. A HEPA filter fire is not expected to damage the metal filter unit because of the installed suppression system. Cleanup and firefighting costs will be low. Cleanup of contamination may be expected in this zone because of the location of the HEPA filter units. The MCFL, based on replacement

of the HEPA filters or cleanup in another area, is expected to be less than \$150,000.

- The MCFL for the mezzanine support-area fire zone will be small because of the lack of combustible materials and the installed fire suppression system. A fire will be of limited duration and will be extinguished upon operation of the sprinkler system. It will be confined to the area of origin. Minimal smoke, fire, and water damage is expected. Damage to the building is not expected. Cleanup and firefighting costs will be limited. The MCFL, based on the replacement of an electrical circuit, cleanup, and repainting, is expected to be less than \$50,000.
- The MCFL for the basement support-area fire zone (except the elevator mechanical room) will be minimal because of the lack of stored combustible materials and the installed suppression system. A fire will be of limited duration and will be extinguished upon operation of the sprinkler system. It will be confined to the area of origin, except in the elevator mechanical room or shaft. A hydraulic-oil fire may cause smoke to spread throughout most of the fire zones in the fire area. Fire in any other area within this zone would result in minimal smoke, fire, and water damage. Damage to the building is not expected. Cleanup and firefighting costs will be greater than costs of direct fire damage. The MCFL, based on cleanup and the replacement of electrical or hydraulic elevator equipment, is expected to be less than \$250,000.

3.11 Maximum Possible Fire Loss

This analysis will consider the area of the fire start and possibility of the fire spreading into other zones.

- The MPFL for the storage array fire zone will be the same as for the MCFL, noted above. Fire spread from this zone or into this zone is not a credible event.
- The MPFL for the charging-floor fire zone will be the same as for the MCFL, noted above. Fire spread from this zone or into this zone is not a credible event.
- The MPFL in the materials receiving and handling fire zone will be small because of the limited amount of combustible materials. A fire will be of limited duration and will be extinguished when the fuel is consumed. A fire will be confined to the area of origin. Smoke and fire damage is expected. Damage to the building is

not expected. Cleanup and firefighting costs will be low. The MPFL, based on the replacement of equipment, cleaning, and repainting, is expected to be less than \$300,000.

- The MPFL in first-floor support area fire zone will be limited because of the limited amounts of combustible materials and the many compartments in this zone. Fire will be of limited duration and will be extinguished when the fuel is consumed. It will be confined to the area of origin. Minimal smoke and fire damage is expected. Damage to the building is not expected. A HEPA filter fire is not expected to damage the metal filter unit because of the noncombustible construction and the lack of combustible materials. Cleanup will be the major cost item. The MPFL is expected to be less than \$1,500,000, based on the replacement of HEPA filters or cleanup in another area. The high cost also includes cleaning up contamination in this zone.
- The MPFL for the mezzanine support-area fire zone will be small because of the lack of combustible materials. A fire will be of limited duration and will be extinguished when the fuel is consumed. A fire will be confined to the area of origin. Minimal smoke and fire damage is expected. Damage to the building is not expected. Cleanup and firefighting costs will be limited. The MCFL is expected to be less than \$50,000, based on cleanup and equipment replacement.
- The MPFL for the basement support-area fire zone will be the highest of the fire zones because of the elevator mechanical room and the oil in it. A large oil fire will continue until the oil has been consumed. A hydraulic-oil fire in the elevator mechanical room or shaft may cause smoke and heat to spread throughout most of the fire zones in this fire area. Damage to the concrete building is not expected. Cleanup and firefighting costs will be greater than the direct fire damage. The MPFL is expected to be less than \$1,500,000, based on fire-area-wide cleanup and replacement of elevator equipment.

3.12 HVAC System Response to Fire

The storage array fire zone will not have an HVAC system. Outside air will enter the canyon on one side and exit the area via a high-level exhaust port to provide cooling for the storage array. Adequate cooling will be provided according to calculations done by the HVAC design group. The ventilation system will have two unprotected openings that will breach the 2-hr fire-rated barrier.

A natural cover fire will not pose a fire exposure to the drywells. Heat from an exposure fire will not enter the drywells through the air intake because of the arrangement of the intake air port. In addition, a natural cover fire would be more than a quarter of a mile from the intake port. The location and design of the intake port will eliminate the possibility of flammable liquids being dumped into the storage array. The rest of the fire zone will be provided with a non-safety-class HEPA filter system.

3.13 Interior Exposure Potential

A fire in Zones 1 or 2 will not spread beyond the zones because of construction features. The shield walls will act as an effective fire separation, even if they are not fire-rated walls. A hydraulic oil fire could spread smoke into other fire zones, requiring a large area to be cleaned up. Spread of smoke into the storage array and charge deck is not expected, since these fire zones will be sealed from the rest of the fire zones.

3.14 Conclusions

- A fire that would cause release of radioactive materials from a sealed container does not appear to be a credible event. Release of radioactive material from other accidents is covered in the SAR or the preliminary safety evaluation.
- Loss potentials for this fire area are within the guidelines of DOE Order 5480.7A.
- Based in the MPFL for the storage array and the charge deck, automatic sprinkler protection is not required.

4.0 FIRE AREA TWO

4.1 Description of Fire Area Two

Fire Area Two has two fire zones:

- Zone including change rooms and building support equipment (not related to the nuclear materials storage area), first floor.
- Loading zone, including the truck unloading area, first floor.

4.2 Construction

The fire area will be contained within concrete walls, floor, and roof. A 2-hour fire-rated barrier separates this area from Fire Area One. New and existing penetrations will be provided with 2-hour fire-rated seals. Door openings will be provided with 1-1/2 hour fire-rated doors.

4.3 Protection of Safety-Class Systems

This area will not contain safety-class systems. However, the common wall between Fire Areas One and Two will be a safety-class structure.

4.3 Description of Fire Protection Features

The existing fire protection systems in Fire Area Two are fed from a single 10-in. main from the loop. The sprinkler systems were hydraulic calculated systems when they were installed. For additional information see Section 2.0.

4.4 Description of Fire Hazards

Fire hazards in these zones will be typical of change rooms and office occupancy. Hazards include electrical fires, heater malfunctions, and other incidents. Unusual hazards in this area are not anticipated.

4.5 Resident Combustible Materials in Fire Area

Combustible materials will vary within these zones, but will not exceed those expected to be found in this type of occupancy or area. Support areas will contain normal equipment and other combustible materials common to an office occupancy. The truck-loading zone will contain equipment common to that type of occupancy. The combustible materials (not including the truck) may be as great as 208,800,000 Btu. Existing boilers and associated equipment will be relocated in a new utilities building. A computer fire model was not prepared because no hazards are expected that would overburden the sprinkler system.

4.6 Expected Transient Combustible Materials in Fire Area

Transient combustible materials are expected throughout both fire zones and will include

paper, packaging materials, wood such as pallets, and maintenance equipment and supplies. However, the types and amounts are not expected to be excessive. The automatic sprinkler system is capable of controlling a fire of these combustible materials.

4.7 Analysis of Fire Hazard

4.7.1 Fire Area Two

	FIRE AREA 2 ZONE 1 & 2
VOLUME	Approximately 62,700 ft ³ . Space minus equipment (estimate less than 3% of volume is equipment; not a factor).
SPACE TO BE HEATED	<p>85,200 ft³ of space, from 60°F to 500°F, under conditions of no heat loss to the concrete walls, ceilings, floors, dry wells, no layering of the heat, etc. Combustible materials will self-ignite at 500°F.</p> <p>559,500 Btu of energy required for damage to occur in this area.</p> <p>$62,700 \text{ ft}^3 * 0.01832 \text{ Btu to raise } 1 \text{ ft}^3 \text{ } 1^\circ\text{F} * 440^\circ\text{F}^d$</p> <p>To keep the area at 500°F for five minutes would take an additional 50,500 Btu. Estimate 10% heat loss to building structure.</p> <p>An exposing temperature of 500°F lasting approximately 5 minutes will cause auto-ignition of combustible materials and could involve all four zones. Auto-ignition of the combustible materials of 500°F was used as the limit for this study.</p>

^dHandbook of Air Conditioning, Heating, Ventilation, Load Calculations 2-7, Properties of Dry Air.

	FIRE AREA 2 ZONE 1 & 2
FIRE LOADING	<p>FUEL IN AREA:</p> <p>Wiring in conduits not considered an exposed combustible material.</p> <p>Ten light fixtures with 2 lb of combustible materials per unit, or 20 lb.</p> <p>Office-type equipment, electrical wiring and equipment, the electrical forklift batteries, and other handling equipment. Combustible materials are estimated to be approximately 2,000 lb or less.</p> <p>Undefined miscellaneous equipment estimated to be 1,000 lb of combustible materials.</p> <p>SWP clothing estimated to be 1,000 lb of combustible materials.</p> <p>500 lb of transit combustible materials are expected in this area, as it is an operations area.</p> <p>Fuel loading of 36,160,000 Btu possible.</p>

	FIRE AREA 2 ZONE 1 & 2
	<p>OTHER FUEL OR HEAT SOURCES:</p> <p>Truck in the unloading area, including its fuel and tires. Cutting, welding, or other hot work operations in the building.</p> <p>DESIGN BASIS FIRE:</p> <p>Probable fire source: electrical short in lighting circuit. Low energy release, sustained or spreading fire possible.</p> <p>An electrical fire start is possible, resulting in a medium to high fire energy source. The fire will be sustained or spreading.</p> <p>POSSIBLE FIRES:</p> <p>Ignition of the transit combustible materials, hot work, or unknown fire start; moderate energy release; fire will spread because of combustible materials; sustained or spreading fire.</p> <p>If a truck fire started at the unloading dock, it would continue to spread as a result of the continuous combustible materials and the heat produced by an uncontrolled fire. A fixed suppression system is required.</p>
LIFE SAFETY	<p>Three exits: Common path of travel distance in the various rooms to the hallways; no common path of travel once out of the rooms; maximum travel distance less than 150 ft outside.</p>
RESULTS	<p>555,900 Btu are required for damage; 36,160,000 Btu exist; damage possible in area.</p> <p>Automatic sprinklers are needed, since dollar loss is greater than \$1,000,000.</p> <p>Satisfactory travel distance that complies with NFPA 101.</p>

4.8 Maximum Credible Fire Loss

The MCFL in either fire zone will be \$125,000, based on the loss of such items as paper and office equipment and smoke and water damage. A fire in this area will be controlled by the installed automatic sprinkler system and the excellent construction features (concrete construction).

4.9 Maximum Possible Fire Loss

The MPFL will be \$1,500,000, including the value of the truck if it is involved in a fire. Fire, water, and smoke damage is possible throughout the fire area. Loss of all combustible materials is expected with damage to the equipment. Fire and related damage will not spread beyond this fire area. Damage to the building will not be expected; however, equipment damage could be a major cost item requiring replacement of most equipment. Cleanup, building repair, equipment replacement, and repainting will be the major cost factors.

4.10 HVAC System Response to Fire

The HVAC system in this fire area will provide for building comfort. The system will be interlocked in accordance with NFPA 90A. Shutdown of the non-safety-class system will not affect contamination control.

4.11 Conclusions

- A fire that would cause a release of radioactive materials from a sealed container does not appear to be a credible event in Fire Area Two. Release of radioactive materials (from other accidents) is covered in the SAR or the preliminary safety evaluation. This would include a fire during the unloading process. A fire loss at this time is possible, but a release of radioactive materials is not because the fuel is in approved shipping containers.
- Fire loading as described in the CDR will not exceed the 2-hour fire-rated barrier between Fire Areas One and Two.
- A 2 hour fire rated wall will be provided between Fire Zone 1 and 2 in Fire Area 2.

5.0 FIRE AREA THREE

5.1 Description of Fire Area Three and Construction

Fire Area Three contains the penthouse and the roof-mounted support equipment such

as air compressors. Piping will run to the MAA and the support areas. The fire area will be separated from Fire Areas One and Two by the 2-hour fire-rated concrete roof. New and existing penetrations will be provided with 2-hour fire-rated seals. Walls and roof will be of noncombustible construction.

5.2 Protection of Safety-Class Systems

This area will not contain safety-class systems. However, the roof over Fire Area One will be a safety-class structure.

5.3 Description of Fire Protection Features

The existing fire protection systems in Fire Area Two will be extended into this area. This system is fed from a single 10-in. main from the loop. The sprinkler systems were hydraulic calculated systems when they were installed. For additional information, see Section 2.0.

5.4 Description of Fire Hazards

Fire hazards in these zones will be typical of a mechanical support area. Unusual hazards in this area are not anticipated.

5.5 Resident Combustible Materials in Fire Area

Combustible materials will vary within this area, but will not exceed those expected to be found in this type of occupancy or area. They will include electrical motors, wiring, and lube systems.

5.6 Expected Transient Combustible Materials in Fire Area

Transient combustible materials are expected throughout and will include paper, packaging materials, and maintenance equipment and supplies. However, the types and amounts are not expected to be excessive. The automatic sprinkler system is capable of controlling a fire of these combustible materials.

5.7 Analysis of Fire Hazard

5.7.1 Fire Area Three

	FIRE AREA 3
VOLUME	Approximately 21,000 ft ³ . Space minus equipment (estimate less than 3% of volume is equipment; not a factor).
SPACE TO BE HEATED	<p>21,000 ft³ of space, from 60°F to 500°F, under conditions of no heat loss to the concrete walls, ceilings, floors, drywells, no layering of the heat, etc. Combustible materials will self-ignite at 500°F.</p> <p>211,600 Btu of energy required for damage to occur in this area.</p> <p>$21,000 \text{ ft}^3 * 0.01832 \text{ Btu to raise } 1 \text{ ft}^3 \text{ } 1^\circ\text{F} * 440^\circ\text{F}^a = 169,300 \text{ Btu}$</p> <p>To keep the area at 500°F for five minutes would take an additional 42,300 Btu. Estimate 25% heat loss to building structure.</p> <p>An exposing temperature of 500°F lasting approximately 5 minutes will cause auto-ignition of combustible materials. Auto-ignition of the combustible materials of 500°F was used as the limit for this study.</p>
FIRE LOADING	<p>FUEL IN AREA:</p> <p>Wiring in conduits not considered an exposed combustible material.</p> <p>Four light fixtures with 2 lb of combustible materials per unit, or 8 lb.</p> <p>Undefined miscellaneous equipment estimated to be 200 lb of combustible materials.</p> <p>Lube oil for air compressors, about 40 gallons.</p> <p>500 lb of transit combustible materials are expected in this area, as it is an operations area.</p> <p>Fuel loading of 7,774,000 Btu possible.</p>

^aHandbook of Air Conditioning, Heating, Ventilation, Load Calculations 2-7, Properties of Dry Air.

	<p style="text-align: center;">FIRE AREA 3</p> <p>OTHER FUEL OR HEAT SOURCES:</p> <p>None</p> <p>DESIGN BASIS FIRE:</p> <p>Probable fire source: electrical short in lighting circuit. Low energy release, sustained or spreading fire possible.</p> <p>An electrical fire start is possible, resulting in a medium to high fire energy source. The fire will be sustained or spreading.</p> <p>POSSIBLE FIRES:</p> <p>Ignition of the transit combustible materials, hot work, or unknown fire start; moderate energy release; fire will spread because of combustible materials; sustained or spreading fire.</p>
LIFE SAFETY	One exit with a common path of travel within room less than 75 feet, maximum travel distance less than 150 ft outside. One exit acceptable per NFPA 101, Section 5-12.
RESULTS	<p>211,600 Btu are required for damage; 7,774,000 Btu exist; damage possible in area.</p> <p>Automatic sprinklers are needed, since dollar loss is greater than \$1,000,000.</p> <p>Satisfactory travel distance that complies with NFPA 101.</p>

5.8 Maximum Credible Fire Loss

The MCFL will be \$75,000, based on the loss of support equipment and smoke and water damage. A fire in this area will be controlled by the installed automatic sprinkler system and the excellent construction features (concrete construction).

5.9 Maximum Possible Fire Loss

The MPFL will be \$1,000,000, based on the loss of all the equipment. Fire, water, and smoke damage is possible throughout the fire area. Loss of all combustible materials is expected, with damage to the equipment. Fire and related damage will not spread beyond this fire area. Damage to the penthouse walls and roof is expected; however, equipment damage could be a major cost item requiring replacement of most equipment. Cleanup, building repair, equipment replacement, and repainting will be the major cost factors.

5.10 HVAC System Response to Fire

The HVAC system in this fire area will provide for building comfort. The system will be interlocked in accordance with NFPA 90A. Shutdown of the non-safety-class system will not affect contamination control.

5.11 Conclusions

- A fire that would cause a release of radioactive materials from a sealed container does not appear to be a credible event in Fire Area Three. Release of radioactive materials (from other accidents) is covered in the SAR or the preliminary safety evaluation.
- Fire loading as described in the CDR will not exceed the 2-hour fire-rated barrier between this area and Fire Area One.

6.0 FIRE AREA FOUR

6.1 Description of Fire Area Four and Construction

Fire Area Four will include the new utilities building located more than 50 feet southwest of the NMSF. This building will be 42 by 32 ft in size, with concrete block walls and a metal roof. This building will house a gas-fired boiler, water heaters, and various pumps. This fire area will be separated from Fire Area One by more than 50 feet of space and a 2-hour fire-rated concrete wall and roof.

6.2 Protection of Safety-Class Systems

This area will not contain safety-class systems.

6.3 Description of Fire Protection Features

A new automatic sprinkler system will be installed in this area.

6.4 Description of Fire Hazards

Fire hazards in this zone will be typical of a mechanical room that uses gas-fired equipment. Unusual hazards in this area are not anticipated.

6.5 Resident Combustible Materials in Fire Area

Combustible materials will vary within this area, but will not exceed those expected to be found in this type of occupancy or area. They will include electrical motors, wiring, lube systems, and gas-fired equipment.

6.6 Expected Transient Combustible Materials in Fire Area

Transient combustible materials are expected throughout and will include paper, packaging materials, and maintenance equipment and supplies. However, the types and amounts are not expected to be excessive. The automatic sprinkler system is capable of controlling a fire of these combustible materials.

6.7 Analysis of Fire Hazard

6.7.1 Fire Area Four

	FIRE AREA 4
VOLUME	Approximately 18,200 ft ³ . Space minus equipment (estimate less than 3% of volume is equipment; not a factor).
SPACE TO BE HEATED	<p>18,200 ft³ of space, from 60°F to 500°F, under conditions of no heat loss to the concrete walls, ceilings, floors, drywells, no layering of the heat, etc. Combustible materials will self-ignite at 500°F.</p> <p>183,400 Btu of energy required for damage to occur in this area.</p> <p>$18,200 \text{ ft}^3 * 0.01832 \text{ Btu to raise } 1 \text{ ft}^3 \text{ } 1^\circ\text{F} * 440^\circ\text{F}^a = 146,700 \text{ Btu}$</p> <p>To keep the area at 500°F for five minutes would take an additional 36,700 Btu. Estimate 25% heat loss to building structure.</p> <p>An exposing temperature of 500°F lasting approximately 5 minutes will cause auto-ignition of combustible materials. Auto-ignition of the combustible materials of 500°F was used as the limit for this study.</p>
FIRE LOADING	<p>FUEL IN AREA:</p> <p>Wiring in conduits not considered an exposed combustible material.</p> <p>Ten light fixtures with 2 lb of combustible materials per unit, or 20 lb.</p> <p>Undefined miscellaneous equipment estimated to be 200 lb of combustible materials.</p> <p>500 lb of transit combustible materials are expected in this area, as it is an operations area.</p> <p>The gas supply is not included in the combustible loading.</p> <p>Fuel loading of 5,760,000 Btu possible, plus natural gas supply.</p>

^aHandbook of Air Conditioning, Heating, Ventilation, Load Calculations 2-7, Properties of Dry Air.

	FIRE AREA 4
	<p>OTHER FUEL OR HEAT SOURCES:</p> <p>None</p> <p>DESIGN BASIS FIRE:</p> <p>Probable fire source: electrical short in lighting circuit. Low energy release, sustained or spreading fire possible.</p> <p>An electrical fire start is possible, resulting in a medium to high fire energy source. The fire will be sustained or spreading.</p> <p>A gas explosion in the gas-fired equipment, high fire energy source.</p> <p>POSSIBLE FIRES:</p> <p>Ignition of the transit combustible materials, hot work, or unknown fire start; moderate energy release; fire will spread because of combustible materials; sustained or spreading fire.</p>
LIFE SAFETY	One exit with a common path of travel within room less than 75 feet, maximum travel distance less than 150 ft outside. One exit acceptable per NFPA 101, Section 5-12.
RESULTS	<p>183,400 Btu are required for damage; 5,760,000 Btu exist; damage possible in area.</p> <p>Automatic sprinklers are needed, since dollar loss is greater than \$1,000,000.</p> <p>Satisfactory travel distance that complies with NFPA 101.</p>

6.8 Maximum Credible Fire Loss

The MCFL will be \$200,000, based on the loss of a boiler and support equipment and smoke and water damage. A fire in this area will be controlled by the installed automatic

sprinkler system and the excellent construction features.

6.9 Maximum Possible Fire Loss

The MPFL will be \$1,000,000, based on the loss of all the equipment. Fire, water, and smoke damage is possible throughout the fire area. Loss of all combustible materials is expected, with damage to the equipment. Fire and related damage will not spread beyond this fire area. Damage to the building will be expected; however, equipment damage could be a major cost item requiring replacement of most equipment. Cleanup, building repair, equipment replacement, and repainting will be the major cost factors.

6.10 HVAC System Response to Fire

The HVAC system in this fire area will provide for building comfort. The system will be interlocked in accordance with NFPA 90A. Shutdown of the non-safety-class system will not affect contamination control.

6.11 Conclusions

A fire that would cause a release of radioactive materials from a sealed container does not appear to be a credible event in Fire Area Four. Release of radioactive materials (from other accidents) is covered in the SAR or the preliminary safety evaluation.

7.0 OVERALL CONCLUSIONS

The following design changes are needed for the facility to comply with DOE Orders 6430.1A and 5480.7A:

- The elevator should be updated to the requirements of NFPA 101 and ASME 17.1-1993, Safety Code for Elevators and Escalators.
- The 10-in. feed needs to be extended and connected to the existing TA-55 fire main loop to provide for the alternate flow paths. Additional fire hydrants are needed in accordance with NFPA 24 and DOE Order 6430.1A.
- Additional sprinkler system lead-ins, system control valves, and sectional control valves are needed. The new valves will allow each automatic sprinkler system to be individually controlled in case of an underground main break. A break can take several sprinkler systems out of service simultaneously.
- To reduce smoke damage to the remaining fire zones in Fire Area One, the

existing elevator should be replaced with a unit that has an electrical hoisting mechanism or a hydraulic unit that uses a FM-approved Class I (HF-C) or II (HF-D) hydraulic fluid.

- The 2-hour fire-rated barriers with 1-1/2-hour fire-rated doors are needed in the tunnels to complete the fire separation between the facility and other facilities connected to the tunnel.
- An engineered firewater-retaining system is needed for areas that could be radioactively contaminated as a result of a fire.
- An evaluation of the existing water supply and sprinkler systems during Title II design is needed to ensure that these systems can meet the water demands for the new occupancies.

A DOE-approved exemption of DOE Orders 6430.1A and 5480.7A needs to be obtained to not install the following equipment:

- An automatic sprinkler in the storage array
- An automatic sprinkler in the charge deck
- Fire dampers in the ventilation system for the storage array (lack of fire dampers is allowed by 6430.1A, but needs to be documented)
- A second emergency door in the from the charge hall

These exemptions should be initiated prior to, or part of Title I design activities.

The estimate takes these modifications and upgrades into account, and the CDR addresses them in a preliminary fashion. During detailed design, these issues will be addressed more thoroughly to enable construction.

NMSF RENOVATION CONDITION SURVEY

FINAL REPORT

* * *

to
University of California
Los Alamos National Laboratory

* * *

by
Merrick & Company
Los Alamos, New Mexico

Merrick Job #490-8979

February 1995

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NMSF Renovation Condition Survey

1.0 EXECUTIVE SUMMARY

A Conceptual Design Report on the Nuclear Materials Storage Facility (reference 1) identified deficiencies in quality assurance records during construction. To ensure that the facility was constructed in accordance with the "as-built" drawings, a condition survey was undertaken. The condition survey results indicated that, in general, the facility is in conformance with the drawings. The survey indicates variations in the rebar concrete cover that exceed specifications. The consequence is that ultimate flexural capacity of the walls for out-of-plane bending is less than if the cover was within specifications. In addition, alkali-silica reaction (ASR) around the boron frit aggregate particles was detected. Although the ASR was described as superficial, further studies were proposed by Merrick to verify that the ASR will not lead to concrete deterioration in the future. After authorization and completion of this work, results will be documented in an addendum to this report.

2.0 BACKGROUND

To prepare the NMSF for the storage of nuclear materials, a Conceptual Design Report (CDR) was developed by Merrick under contract with the University of California (subcontract C-XP2-2092M-179/P.I. #11818). The existing facility was evaluated to identify any structural deficiencies. The structural evaluation of the facility is described in reference 1, section 3.2.1. The CDR identified a possible deficiency in construction surveillance and inspection during construction of the facility. Quality assurance regarding construction materials was also identified as deficient. As a result of these findings, the CDR recommended that a materials testing program be developed and conducted to verify the as-built quality of concrete and the placement of the reinforcing steel. The NMSF condition survey reported in appendix A was conducted in response to this CDR recommendation. Construction Technology Laboratories (CTL) of Skokie, Illinois, was subcontracted to assist Merrick in performing the work.

3.0 CONDITION SURVEY DESCRIPTION

The condition survey was divided into three phases, which are summarized below. A more detailed description of the tasks within each phase is contained in CTL's report in appendix A. The original project program phases are listed below.

Phase 1 - Field Investigation

A field investigation including visual inspection, concrete sample removal, nondestructive, and destructive testing of the structures.

Phase 2 - Laboratory Testing

Laboratory testing including compressive strength testing and petrographic examination of core samples.

Phase 3 - Analysis and Report

The results of the field and laboratory tests, findings, field inspection documents, and recommendations are presented in this report. The report by CTL was reviewed by concerned technical groups within Los Alamos National Laboratory (LANL). Their review comments and responses by Merrick (CTL) are given in appendix B.

The only deviation from the original plan was in the number of concrete core samples taken. Originally, ten concrete core samples were to be taken; however, during the field inspection, tests on an interior wall indicated a change in concrete properties along the walls' length. An additional core sample was taken so that a sample of each concrete type was available for laboratory tests.

4.0 FINDINGS AND RECOMMENDATIONS

The following findings and recommendations are based on the field investigation and the laboratory testing:

- 4.1 No evidence of significant structural distress was observed.
- 4.2 Values of tested compressive strengths, unit weights, and pulse velocities, as well as petrographic examination, indicate that the concrete is relatively uniform and of good quality. Concrete compressive strengths ranged from 5,780 to 9,070 psi and averaged 7,890 psi for boron frit concrete and 7,150 psi for other concrete.
- 4.3 Impulse radar and pachometer surveys indicate that reinforcing steel placement at tested areas is in general conformance with "as-built" construction drawings S1 through S11, with the primary exception that concrete cover over reinforcing steel was in excess of specified cover in several walls. Excess cover over the reinforcement does not affect the capacity of the structural walls for in-plane forces. However, the excess cover may decrease the flexural capacity for out-of-plane forces.
- 4.4 Evidence of alkali-silica reaction (ASR) was observed at surfaces of boron frit aggregates through petrographic examination. The reaction was only superficial and had not progressed to a harmful extent. However, a certain level of moisture in the concrete is necessary to induce harmful ASR. The petrographic sample was obtained from an interior wall that may be relatively dry. The exterior wall concrete may have a higher moisture content. Additional information and/or further testing is required for CTL to assess the potential for harmful progression of observed ASR. Additional useful information would relate to previous testing of boron frit aggregates or

performance of other structures with identical aggregates. If sufficient information cannot be identified to assure that ASR will not progress to a harmful extent, a testing program incorporating the following is recommended:

- 4.1.1 Testing of boron frit aggregates for chemical composition and reactivity. This would most easily be performed on raw aggregates, if aggregates of similar composition to those in this structure can be obtained. Chemical composition, however, may be obtained from aggregates removed from core samples if raw aggregate is not available.
- 4.1.2 Field measurement of relative humidities within exterior walls with boron frit concrete.
- 4.1.3 Removal of cores from exterior walls to examine petrographically and test (on an accelerated basis) for further reactivity. Accelerated test techniques can require up to a year or more to complete.

5.0 CDR ISSUES AND INVESTIGATION FINDINGS

The NMSF-CDR (ref. 1) recommended a condition survey to provide confidence that the NMSF was constructed in accordance with the "as-built" drawings. Confidence in the "as-built" drawings is enhanced by the following findings:

- The presence of boron frit in concrete at a location that was specified to contain boron frit concrete.
- The quantity and spacing of the steel reinforcement generally conformed to that specified in the drawings.
- At locations where measured, the wall thicknesses were as specified.
- At selected locations, dowel lengths and lap splices conformed to those shown in the drawings.
- From compression tests on core samples, the concrete strength was well in excess of the design strength of 4,000 psi.

The concrete cover over the reinforcing steel varied from 1 inch to 7.1 inches in the exterior walls. This is greater than the tolerances of $-1/4$, $+1/2$ inches specified in ACI 117. The significance of this is a possible lower out-of-plane ultimate strength of the walls. An analysis by Merrick based on conservative static and seismic lateral loads and the observed condition of the walls shows adequate strength without upgrade retrofits.

The primary continuing issue identified by this condition survey is the possible deterioration of the boron frit due to ASR and its accelerators, temperature, and moisture.

Merrick recommended to LANL that they initiate a test program to evaluate these effects.

6.0 REFERENCE

1. NMSF CDR: Nuclear Materials Storage Facility, Structural Narrative, Vol. 3 of 6, Merrick job #490-8907.

APPENDIX A

**Construction Technology Laboratories, Inc. (CTL)
Subcontract Report to Merrick & Company**

Report to
MERRICK & COMPANY
195 East Road
Los Alamos, New Mexico 87544

**CONDITION SURVEY OF NUCLEAR
MATERIALS STORAGE FACILITY,
LOS ALAMOS NATIONAL
LABORATORY,
LOS ALAMOS, NEW MEXICO**

by

Peter R. Kolf
John W. Gajda
Ralph G. Oesterle

Submitted by
CONSTRUCTION TECHNOLOGY LABORATORIES, INC.
5420 Old Orchard Road
Skokie, IL 60077

February 15, 1995

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CONDITION SURVEY OF NUCLEAR MATERIALS STORAGE FACILITY LOS ALAMOS NATIONAL LABORATORY, LOS ALAMOS, NEW MEXICO

by

Peter R. Kolf, John W. Gajda, and Ralph G. Oesterle*

1 INTRODUCTION

As authorized by Merrick & Company Subcontract No. LANL-007, Construction Technology Laboratories, Inc. (CTL) performed a condition survey at the Nuclear Materials Storage Facility (NMSF) PF-41 in TA-55 of Los Alamos National Laboratories, New Mexico.

The Nuclear Materials Storage Facility is a two-story reinforced concrete structure constructed between 1986 to 1988. The building is primarily a box shear wall structure with a basement to first floor level located below grade and first floor to roof located above finish grade. The exterior wall on the west side is bermed with soil backfill and the roof is covered with approximately two feet of soil.

A condition survey of the building's structural components was needed to support the seismic evaluation of the building performed by Merrick and Company in 1994.

2 FINDINGS AND RECOMMENDATIONS

Based on the field investigation and laboratory testing performed, the following findings and recommendations are presented:

1. No evidence of significant structural distress was observed.
2. Values of tested compressive strengths, unit weights, and pulse velocities, as well as petrographic examination indicate that the concrete is relatively uniform and of good quality.
3. Impulse radar and pachometer surveys indicate that reinforcing steel placement at tested areas is in general conformance with "As-Built" Construction Drawings S1 through S11, with the primary exception that concrete cover over reinforcing steel was in excess of specified cover in many areas. Excess cover over the reinforcement

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does not affect the capacity of the structural walls for in-plane forces. However, the excess cover may decrease the flexural capacity for out-of-plane forces.

4. Evidence of alkali-silica reaction (ASR) was observed at surfaces of boron frit aggregates through petrographic examination. The reaction was only surficial and had not progressed to a harmful extent. However, a certain level of moisture in the concrete is necessary to induce harmful ASR. The petrographic sample was obtained from an interior wall that may be relatively dry. The exterior wall concrete may have a higher moisture content. Additional information and/or further testing is required for CTL to assess the potential for harmful progression of observed ASR. Based on verbal information provided to CTL, the boron frit contains sufficient silica to potentially support a harmful level of ASR. Additional useful information would relate to previous testing of boron frit aggregates or performance of other structures with identical aggregates. If sufficient information cannot be identified to assure that ASR will not progress to a harmful extent, a testing program incorporating the following is recommended:
 - a. Testing of boron frit aggregates for reactivity. This would most easily be performed on raw aggregates, if aggregates of similar composition to those in this structure can be obtained.
 - b. Petrographic examination of Core D, removed from the west wall of Room 22.
 - c. Field measurement of relative humidities within exterior walls with boron frit concrete, and removal of cores from exterior walls to examine petrographically and test for further reactivity.

3 OBJECTIVE AND SCOPE OF WORK

As indicated in the Conceptual Design Report of the Nuclear Materials Storage Facility, prepared by Merrick & Company, a condition survey was recommended to evaluate as-built construction materials and details. To assist the Merrick engineers in the condition survey, CTL performed the following scope of work:

Phase 1 - Field Investigation

The field investigation phase of the work included visual inspection, concrete sample removal, as well as nondestructive and limited destructive testing of the structure. Work was performed within the following tasks:

1. A detailed visual survey of exposed portions of the structure was performed reviewing for the following items:
 - a. Locations, patterns, and surface width of concrete cracks.
 - b. Presence of other concrete defects such as spalling, scaling, rust staining, honeycombing, or efflorescence.
 - c. Evidence of rebar corrosion or water leakage.
 - d. Excessive structural deformations or misalignments, or evidence of foundation movement.

Visual observations were documented.

2. Reinforcing steel location and detailing was verified, as well as concrete member thickness and dimensions. This was performed at critical areas defined by Merrick and at other random areas. Methods included magnetic covermeter (pachometer) testing, ground penetrating radar testing, and exploratory concrete removal.
3. Concrete core samples required for laboratory testing were removed and core holes were repaired. Eleven (11) core samples were taken, primarily from wall sections.
4. Other nondestructive testing was performed as required to address other concerns such as uniformity and quality of concrete. Test methods included the following:
 - a. Mechanical sounding of concrete surfaces with a geologist's hammer to detect subsurface delamination.
 - b. Ultrasonic pulse velocity testing to assess relative quality of concrete.

Phase 2 - Laboratory Testing

Laboratory testing was conducted on core samples. Testing included the following:

1. Compressive strength testing of nine (9) concrete core specimens and two cylinder specimens according to ASTM C 42.
2. Visual examination of eleven (11) core specimens and petrographic examination of one concrete core specimen according to ASTM C 856 to confirm the presence of boron frit within concrete.

Phase 3 - Analysis and Report

The results of field and laboratory tests were analyzed and this report was prepared summarizing our findings.

The scope of work did not include structural calculations or evaluation of structural adequacy. Information concerning calibration of testing equipment is included in Appendix F of this report.

4 FIELD INVESTIGATION

CTL's field investigation was performed by Messrs. Peter Kolf, John Gajda, and James DiJohn on December 5-9, 1994. Work was coordinated with Mr. Elton Endebrock of Merrick and CTL was escorted at all times by Merrick staff. Criteria provided by Merrick for the investigation included the following:

1. Test areas were to include random interior areas of the original MAA/storage area and contiguous cast-in-place walls extending into the administrative area.
2. Test areas must include areas of specified boron frit concrete, as well as conventional concrete.
3. Test areas must include a sampling of shear walls as well as the cast-in-place roof slab over the MAA/storage area.
4. Core sample holes must be repaired with a good quality, low shrinkage concrete or grout incorporating coarse-sized aggregate.

A field investigation plan drafted on site by CTL and reviewed by Merrick and LANL is included at the beginning of Appendix A. Floor plans and room layouts are shown in Figures A.1 and A.2 of Appendix A.

In general, CTL used procedures and methods described in ACI 437R-91, "Strength Evaluation of Existing Concrete Buildings," for the condition survey and material testing. CTL's sampling plan was intended to obtain representative samples distributed throughout the structure based on areas of interest including components with a critical structural nature, areas representing different stages of construction, and areas containing different construction materials. The test plan included in Appendix A of the report defines the roof and east-west shear walls near intersections of north-south interior walls as areas of a critical structural nature for inspecting and testing. The other testing was distributed throughout the structure to investigate concrete with and without boron frit aggregate and to investigate various stages of

construction. Within regions considered to represent the same material and/or stage of construction, the testing locations for impulse radar, pachometer and pulse velocity testing typically covered large portions of the region. In general, locations were selected within each region without any motivation other than accessibility and therefore were considered to be as randomly selected as needed to obtain representative data. Additional pulse velocity measurements were taken in the region around concrete core samples in order to correlate pulse velocity with compressive strength and concrete quality.

For selection of core samples, the core locations were, in general, selected within each region of interest without any motivation other than accessibility and to miss the reinforcing steel embedded in the concrete. Presence of storage racks in Rooms 22 and 23 significantly hampered access to most wall areas in these rooms. One location, Core B, was intentionally centered on an approximately vertical crack that did not have a vertical reinforcing bar directly behind the crack.

4.1 Visual Survey

The following items were noted during visual review of the structure:

1. Areas of peeling surface coatings were observed throughout the original MAA/storage area. In some locations, the finish coat of paint was observed to be debonding from a layer of paint below. In other locations outer layers of paint were bonded to a white plaster-like (possibly gypsum-based) coating that was debonding from the concrete substrate.
2. Cracking was observed in concrete elements throughout the structure. Crack widths, measured at isolated locations where surface coatings were removed, were generally hairline (less than 0.010 inch) except at slab-on-grade floors outside the original MAA/storage area. Cracking was observed in various patterns as follows:
 - a. Repetitious north-south oriented cracks spaced approximately 1 ft on centers, were observed at the underside of the roof slab over Rooms D101 and D101E. These two rooms were the only rooms where scaffolding was available for review and testing of ceiling areas. Cracks were representative of flexural cracking in the positive moment region of the roof slabs.
 - b. Randomly oriented cracks were observed in top surfaces of floor slabs throughout the upper level of the MAA/storage area. Cracks were representative

of typical drying shrinkage cracks. Crack maps of several rooms are presented in Figure A.3 of Appendix A.

- c. Vertical-to-diagonally oriented cracks, were observed at cast-in-place walls. Spacing varied but was generally on the order of 10 ft or more along the length of the walls. Cracks were representative of typical drying shrinkage cracks. A crack map of observable wall surfaces at the west wall of Corridor 06 is presented in Figure A.4 of Appendix A.
 - d. Random isolated cracks, approximately 1/16 in. wide at some locations, were observed in the slab-on-grade floor slab outside the original MAA/storage area. In addition, a wide crack in the slab-on-grade was observed at the transition to structural slab in the corridor outside Room A117. Such cracks are not uncommon in slabs-on-grade and can be attributable to drying shrinkage and differential subgrade support.
 - e. Significant cracking was observed in drywall finishes outside Room 13. However, observed cracking is likely unrelated to concrete structural elements since no corresponding cracking was observed in these elements.
 - f. Interior wall thicknesses as specified on Construction Drawings were confirmed at doorways between the following rooms: Rooms 21 and 22 (12 in. wall); Rooms D101 and D101D (8 in. wall); A114B and A115 (12 in. wall); Rooms 21 and 21A (16 in. wall).
3. Localized rust staining, efflorescence, and evidence of previous water leakage were observed at an apparent horizontal construction joint in the exterior wall of the north stair. No delaminations were detected when adjacent concrete surfaces were sounded with a hammer.
 4. Floor staining representative of previous water leakage and ponding was observed in Corridor 06 outside Room 13, as well as in Rooms 22 and 23. Surface corrosion of the floor-mounted rails in Rooms 22 and 23 was also observed. No evidence of groundwater intrusion was observed at any of these locations. The source of water appeared to be water piping present above each location.

4.2 Pachometer Testing

R-meter pachometer testing was performed to evaluate location and spacing of reinforcement. A pachometer (also referred to as an R-meter or covermeter) is an instrument that uses magnetic

methods to locate steel reinforcement embedded in concrete. Through calibration, depth of concrete cover to reinforcement or bar size can be estimated. Results of pachometer tests are summarized in the following section of this report. Pachometer data sheets are included in Appendix B.

Concrete cover measurements were evaluated based on the reinforcement bar sizes specified on original construction drawings and by radar testing in some areas. Construction drawings specified 3/4 in. concrete cover to the first layer of reinforcing steel at interior wall and slab surfaces. Specified concrete cover shown on CTL data sheets for second layers of steel was computed by adding the bar diameter for the first layer to the 3/4 in. specified cover. In addition, ACI 117, "Standard Specifications for Tolerances for Concrete Construction and Materials," specifies standard construction tolerances for placement of reinforcing steel in these members to be -1/4, +3/8 in. for member thicknesses 12 in. and less, and -1/4, +1/2 in. for member thicknesses greater than 12 in. but less than 2 ft.

Pachometer surveys indicated the following relative to reinforcing steel placement:

1. At surveyed locations, spacing of reinforcing steel bars was in general conformance with spacings indicated "As-Built" Drawings S1 through S11. Surveyed locations included the following:
 - a. Floor areas adjacent to Core A (Room D101).
 - b. Wall areas adjacent to Core E (Room D101).
 - c. Selected areas of the roof soffit in Rooms D101 and D101E.
 - d. West walls of Rooms D101, D101B, and D101E (most vertical bars).
 - e. West wall of Corridor 06 (most vertical bars and random selected horizontal bars).
 - f. West wall of Room 21 (all vertical bars).
 - g. Central north wall of Room 21.
2. Dowel lengths at several tested locations at the west walls of Rooms D101 and D101B were approximately 4 ft as shown on referenced construction drawings.
3. Concrete cover to reinforcing steel varied significantly from that shown on referenced drawings in some tested location. Concrete cover data obtained includes the following:

- a. Concrete cover to vertical steel at the west walls of Rooms D101, D101B, and D101E, varied considerably along the length of wall between approximately 1.4 and 3.9 in. at measured locations. Refer to Appendix C for additional approximate cover data.
 - b. Concrete cover to reinforcing steel in the vicinity of Core A (Room D101 floor slab) was on the order of 3 in.
4. Wall Section X on Drawing S8 shows bottom reinforcing bars at the roof over Rooms D101, D101B and D101E terminating 7 ft - 6 in. from the exterior (west) wall. Reinforcing bar termination locations and spacings were confirmed at several random locations in Rooms D101 and D101E. Approximate concrete cover measurements are provided in Appendix B.

4.3 Impulse Radar Testing

Radar testing was performed to evaluate presence and location of steel reinforcement, and to evaluate presence and length of steel reinforcement laps in some locations. The radar technique is based on principles of electromagnetic wave reflection. A hand-held calculator-sized contacting transducer transmits electromagnetic pulses into the test element. In the case of a reinforced concrete element, these pulses are reflected by differences in dielectric properties between the concrete and reinforcement. Reflected pulses are received by the transducer, electronically processed, recorded for future analyses, and displayed on a color monitor. Results of radar tests are summarized in the following section of this report. Sample radar output and additional test methodology are included in Appendix C.

The impulse radar was used to determine the depth of cover, spacing, and lap lengths of vertical and horizontal reinforcing steel at selected locations throughout the building. Specified depth of cover and applicable tolerances were presented in Section 4.2. Survey results indicate the following:

1. In general, the quantity and spacing of the steel reinforcement in surveyed locations conform to the "As-Built" Drawings S1 through S11. It should be noted that spacing of vertical steel reinforcing in the north wall of Rooms 07 and 09 as well as the north wall of the mezzanine appeared to be approximately at the specified 5 in. spacing. However, the reinforcement was too congested to be measured accurately. Also, vertical steel in the west portion of the south wall of Room 21A was very congested. Spacing at this location could not be accurately determined.

2. Concrete cover to the reinforcing steel varied from the depth of cover specified on the drawings in most locations. Examples are as follows:
 - a. The depth of cover of the vertical steel in the west walls of Rooms D101, D101B, and D101E varied significantly along the length of the wall. The maximum cover was approximately 4.2 in. and the minimum cover was approximately 1 in. along the entire length of the wall.
 - b. The maximum cover noted in all areas surveyed was approximately 7.1 in. This occurred in the north wall of Room 07.
3. Lap lengths of steel reinforcement were investigated in selected areas of the building. The survey indicated the following:
 - a. The lap length of the vertical steel dowels in the wall between Rooms D101 and D101D was approximately 24 to 27 in. above the floor line.
 - b. The presence of some lap splices for horizontal steel in the north wall of the north stairs was verified. However, the lap length could not be determined because of the geometry of the reinforcing bars and intersecting walls.
 - c. Dowels extending into the east wall of Room D101A from the north wall extend approximately 18 in. into the east wall.
 - d. Dowels for lap splice of the vertical steel reinforcing in the west wall of Corridor 06 extend approximately 24-27 in. above the floor.
 - e. Dowels for lap splice of the vertical steel in the east wall of Room 18 extend approximately 38 in. above the floor.
 - f. Dowels for lap splice of the vertical steel reinforcing in the south wall of Room 21A extend approximately 60 in. above the floor.
 - g. Vertical bars lap spliced in the west wall of D101 did not appear to be in contact. Spaces of approximately 1 to 3 in. separated lapped steel bars.

Appendix C contains detailed information concerning spacing and the depth of cover from the impulse radar survey conducted through the building. Accuracy of the depth of cover is estimated to be $\pm 1/4$ in.

4.4 Pulse Velocity Testing

Ultrasonic pulse velocity testing was performed to assess general quality and uniformity of concrete elements. Rebound hammer testing was judged to be unsuitable for use because of the presence of surface coatings. The pulse velocity technique involves measuring the transmission time of mechanical impulses through a concrete element. The travel time of such mechanical impulses can be related to concrete quality and uniformity. Pulse velocity test data sheets are included in Appendix D. Results of pulse velocity tests are summarized in this section of the report.

Direct transmission pulse velocity testing, where transmitting and receiving transducers are on directly opposite faces of a member, is the preferred method since it provides maximum sensitivity and a well defined path length. However, since access was limited to one face of a member in many areas, indirect transmission (both transducers on the same face of a member) was also used. The indirect arrangement is relatively less sensitive and provides pulse velocity measurements which are usually influenced by the concrete layer near the surface. This layer may not be representative of the concrete in deeper layers. Furthermore, the length of the path is less well-defined.

For the purposes of comparing relative pulse velocities at areas near core samples to random areas throughout the structure, the distance between centers of transducers was used as a path length for computing pulse velocity. It is important to note, however, that such indirect measurements are not precisely comparable to direct measurements. Findings of the pulse velocity testing were as follows:

1. Direct transmission testing of core samples and of several wall sections indicated pulse velocities between 13,500 and 15,300 ft/s, with a coefficient of variation of approximately 4%.
2. Indirect transmission testing of wall areas immediately adjacent to core removal areas indicated an average pulse velocity of approximately 10,800 ft/s and a coefficient of variation of 8% for 12 in. center to center horizontal spacing of transducers.
3. Indirect transmission testing of random wall areas throughout the structure indicated an average pulse velocity of 10,900 ft/s and a coefficient of variation of 10% for 12 in. center to center horizontal spacing of transducers.

Research has shown that direct transmission pulse velocities in the range of 12,000 to 15,000 ft/sec are indicative of good quality concrete (Ref. 1). In addition, research indicates that

acceptable coefficients of variation for measured pulse velocities are on the order of 1.5% for a single load of concrete, 2.5% for several loads of concrete cast over a limited period, and 6 to 9% for concrete of a single mix design throughout an entire structure (Ref. 2). Therefore, direct transmission testing of core samples indicated uniformly good quality concrete. In addition, random testing indicated relative uniformity with wall areas from which cores were removed.

Conditions that could contribute to higher coefficients of variation in CTL's measurements include use of indirect transmission, presence of several mix designs, presence of surface coatings, presence of reinforcing steel, and variable moisture content of the concretes. Therefore, in CTL's opinion the indirect transmission testing also indicates that concrete at random areas tested is generally uniform and of relatively good quality.

4.5 Removal of Concrete Samples

Removal of eleven (11) concrete core samples was performed by Albuquerque Concrete Coring Co., a subcontractor to CTL. Coring was performed at locations marked by CTL and approved by Merrick. Core removal locations are shown in Figs. A.1 and A.2. Resulting holes were subsequently repaired with "Gilco Patch" (extended with pea gravel aggregate) manufactured by Cormix Construction Chemicals of Dallas, Texas. Repair material data sheets are included at the end of Appendix A. Two cylinders of the repair material were prepared by Albuquerque Concrete Coring Co. and tested for compressive strength by CTL in accordance with ASTM C42. Test results are discussed in Section 5.3.

Exploratory concrete removal was performed at the joint between the concrete floor slab and wall immediately west of the doorway to Room D101D. The intent of the concrete removal was to confirm presence of reinforcing steel dowels between the floor slab and concrete wall. Presence of the dowel was confirmed at the exposed location.

5 LABORATORY EXAMINATIONS AND TESTS

Laboratory examinations and tests were performed on concrete samples to evaluate presence of boron frit as well as overall condition and strength of the concrete. Results of laboratory examinations and tests are presented in Appendix E and summarized in the following sections of this report.

5.1 Visual Examinations

All core samples were visually examined to assess their general condition and presence of boron frit. Nearly all cores exhibited good quality concrete. Results of visual examination indicated the following:

1. All cores were nominal 4 in. diameter cores with retrieved lengths varying from 6 in. to 10-1/2 in.
2. Presence of fine aggregate-sized boron frit was confirmed in Cores A, B, C, D, and K. No boron frit was observed in the other cores. This is consistent with areas shown on construction drawings to be constructed with boron frit concrete.
3. All cores appeared generally well consolidated, with similar coarse aggregates and paste.
4. Isolated entrapped air pockets were present in cores, with a maximum size of approximately 3/8 in. diameter, except for one air pocket measuring approximately 1/2 in. x 1/2 in. x 1 in. in core G. (This isolated defect was removed from the tested sample for Core G.)
5. Multi-layered surface coatings were present on all samples.
6. A horizontal No. 5 reinforcing steel bar segment was present at a clear depth of 4-1/8 in. from the face of Core I.
7. Core B was centered on an approximately vertical wall crack in the west wall of Corridor 06.
8. Core E exhibited approximately 1/8 in. of wobble, caused by loss of rig anchorage during coring work. Only slight or no wobble was present in other cores.
9. Samples 1 and 2 represent cylinder samples of material used to repair core holes.

5.2 Petrographic Examination

Petrographic examination was performed on concrete from Core B to evaluate general quality, concrete characteristics, presence of crack repair material, and presence of boron frit.

Descriptions of petrographic examination methods are described in the laboratory report included in Appendix E. Results of the petrographic examination indicated the following:

1. Evidence of alkali-silica reaction was observed at surfaces of boron frit aggregates. Observed reaction was only surficial and had not progressed to a harmful extent.

2. The core was cracked through its entire length. No evidence of any crack repair was observed.
3. Concrete quality was good, with tight paste-aggregate bond, uniform aggregate distribution, water-to-cement ratio estimated at 0.40 to 0.45, and depth of carbonation of 0.5 to 1.5 mm.
4. Concrete was air entrained, although air content was low, estimated at 1 to 3% of volume.

Alkali-silica reaction (ASR) is a chemical reaction between alkalis present in cement paste and silica present in some aggregates that occurs in moist, high pH environments. Minor reactivity is common and is not harmful to concrete integrity. Severe reaction, however, can cause concrete disintegration. Factors that affect the reaction include the quantity of alkalis and silica available in the cement paste and aggregates, as well as the relative humidity, pH, and temperature of the concrete. ASR can progress and cease quickly in some instances, or progress slowly over the course of many years. Although the ASR observed in the petrographic examination had not progressed to a harmful extent, Core B was taken from an interior wall that may contain relatively dry concrete. The exterior walls may have a higher moisture content and therefore may contain conditions more conducive to harmful ASR. Additional information and/or further testing would be required for CTL to assess the potential for harmful progression of observed ASR. Recommendations for useful information and testing are provided in Section 2 of this report.

5.3 Compressive Strength Tests

Compressive strength tests according to ASTM Designation C 42 were performed on concrete cores removed during the field investigation. Specified compressive strength indicated on construction drawings was 4000 psi. Tested compressive strengths ranged from 5780 to 9070 psi and averaged 7890 psi for boron frit concrete and 7510 psi for other concrete. Measured pulse velocities for cores ranged from 13,600 ft/sec to 15,500 ft/sec and unit weight of core samples varied by approximately 2% between 143.7 and 146.7 pcf. Tests performed on two cylinders formed from concrete material used to repair core holes indicated compressive strengths of 4380 and 5100 psi, pulse velocities of 14,900 ft/s and unit weights of approximately 145 pcf. Test reports are included in Appendix E.

6 REFERENCES

1. E.A. Whitehurst, "Soniscope Tests Concrete Structures," Journal of American Concrete Institute, Feb. 1951, Vol. 22, No. 6, p. 433.
2. H.N. Tomsett, "The Practical Use of Ultrasonic Pulse Velocity Measurements in the Assessment of Concrete Quality," Magazine of Concrete Research, March 1980 Vol. 32, No. 110.

APPENDIX A

Field Information and Sketches

Construction Technology Laboratories, Inc.

5420 Old Orchard Road, Skokie, Illinois 60077-1030 Phone 708/965-7500

Project CTL 260600 Sheet _____ of _____
Initials PRK Date DEC '94
Checked _____ Date _____ Revised _____ Date _____

Title DE-41 TEST PLAN

- Roof Underside @ Several Areas Accessible via Scaffolding
 - R-Meter and/or Radar to Confirm Rebar Layout
 - V-Meter to Assess Concrete Quality
- E-W Shear Walls Near Intersection with N-S Interior Wall
 - R-Meter and/or Radar to Confirm Rebar Layout
 - V-Meter to Assess Concrete Quality
 - Coring for Compressive Strength Data
- Random Locations at Boron Frit Concrete and Elsewhere
 - R-Meter and/or Radar to Confirm Rebar Layout and Assess Rebar Lap Lengths
 - V-Meter to Assess Concrete Quality
 - Cores for Compressive Strength Data
- Overall: Visual Observations for Evidence of Water Damage, New Cracking, etc
- Coring Layout
 - 3 Cores: One at Each of three E-W Shear Walls Upstairs
 - 4 Cores: At Locations with Boron Frit Concrete
 - One at Each of 3 Long N-S Walls (with one core at a crack location at one wall)
 - One at the Main Level Floor Slab
 - 3 Cores: Exterior Walls - 2 downstairs
1 upstairs

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FIG. A.3 - CRACK MAP
PLAN VIEW

FIG. A.4 - CRACK MAP
ELEVATION VIEW OF WEST WALL OF CORRIDOR 06

GILCO PATCH®

Rapid strength gain and durability...Gilco Patch® provides a rapid setting, high strength, durable concrete patch for use on concrete floors, highway pavements, bridge decks and other applications requiring early resumption of traffic or use.

Gilco Patch is premixed, requiring only the addition of potable water. This unique mortar provides outstanding results and enables the project to be completed more rapidly than with conventional patches. Gilco Patch provides ease of placement and economy not found in products requiring liquid activators or primers.

Gilco Patch is non-metallic, contains no calcium chloride and can be used in areas where mortars containing halogens cannot be used.

APPLICATIONS

Gilco Patch is excellent for all types of concrete patching applications:

- Bridge Decks
- Concrete Pavements
- Concrete Joints
- Airport Runways and Taxiways
- Industrial Floors
- Loading Docks
- General Concrete
- Prestressed and Precast

YIELD

Mix with 1-1/4 to 1-3/8 gallons of clean, potable water per 55-lb. bag. Yield: approximately .5 cu. ft.

TYPICAL TECHNICAL DATA

SETTING TIME (Gilmore Needles ASTM C 266)

Initial Set	17 minutes
Final Set	27 minutes

COMPRESSIVE STRENGTH (ASTM C 109 Modified)

2 hour	1700 psi
3 hour	2000 psi
24 hour	5000 psi
14 day	7500 psi
28 day	7800 psi

FLEXURAL STRENGTH (ASTM C 78 Modified)

3 hour	290 psi
24 hour	690 psi

RESISTANCE TO FREEZING AND THAWING (ASTM C 666)

Durability Factor	90%
-------------------	-----

SCALING RESISTANCE TO DEICING CHEMICALS (ASTM C 672)

Will outperform air entrained concrete.

VOLUME CHANGE

Gilco Patch is virtually volume stable from time of placement.

RECOMMENDED FIELD PROCEDURES

When patching at depths of 1" or greater, or at temperatures below

50° F or above 90° F, special precautions should be taken. Refer to "Mixing with Pea Gravel," "Cold Weather Patching" and "Hot Weather Patching" below.

PREPARATION

1. The base slab on which the Patch is to be placed should be clean and soaked with clean water, preferably by ponding (18 to 24 hours). Just prior to patching, the water should be removed and the surface dried with clean rags or compressed air, free of oil and other lubricants and leaving only a damp film.

2. All concrete surfaces to come in contact with the Patch should be free of grease, oil, laitance and other debris.

3. Square edges by chipping or saw-cutting a minimum of 1/2" deep. Featheredging is not recommended.

4. All concrete of poor quality that is in contact with reinforcing steel should be removed. Minimum depth of removal shall be 3/4". Remove rust from exposed reinforcing steel by brushing or sandblasting prior to repairing with Gilco Patch. Do not use bonding agents on steel.

5. Have all necessary tools and materials as near work areas as possible to permit rapid and continuous placement of Gilco Patch.

MIXING THE PATCH

1. Prior to mixing the first batch of Gilco Patch, wash out mixer and determine the number of bags to be mixed at one time. Mix only the amount of Patch that can be placed in approximately 10 minutes.

2. Put into the mixer all the required water, then add the Patch slowly into the operating mixer (being careful not to overload to the point of stalling). Mix the Patch approximately 2 to 3 minutes, to uniform consistency.

PLACEMENT OF PATCH

Place the material immediately into thoroughly dampened area, at depths of not less than 1/2". Place from one side to the other, working material into sides and bottom of patch area to assist in satisfactory bonding.

Screed and level to proper elevation of existing concrete. Trowel and seal edges and saw cuts. Excessive trowelling is not required. Under no circumstances should Gilco Patch[®] be retempered, using water or other additives.

CURING

Exposed surfaces should be cured using standard concrete curing methods. Curing/sealing compounds meeting requirements of ASTM C 309, such as Cormix Sealco 309 or Sealco 800, will provide satisfactory results.

MIXING ONE BAG BATCHES

Mechanical mixing of small batches: It is recommended that no less than one bag be mixed at a time.

1. Obtain a clean five-gallon bucket or suitable container for mixing.

2. Using a marked pitcher or beaker, carefully measure the water required.

3. Add the premeasured water to the large container.

4. Slowly pour Gilco Patch into the container while mixing with a low rpm, high torque electric drill with a chuck capacity of not less than 1/2". The actual mixing device shall have paddles or impellers capable of thoroughly blending stiff mortar. (Epoxy compound mixers have been found suitable.) Care should be exercised not to form a downward-flowing vortex, as this can cause entrapment of air, resulting in a porous surface.

Hand mixing of small batches: Place small quantity of water into a container, add Gilco Patch and mix by hand using a spoon or paddle, until desired consistency is achieved.

MIXING WITH PEA GRAVEL

For patching depths and widths of 1" or less, Gilco Patch should be used as packaged. For depths of more than 1", it is recommended that 3/8" pea gravel or pea stone be added to the Patch. Due to the nature of Gilco Patch, the addition of 3/8" aggregate as specified below does not substantially affect performance or consistency, but will result in yield increase of approximately 40%. Follow basic mixing procedures for large batches as modified below:

1. Choose a clean (free of organic material) well-graded 3/8" aggregate. Soak in clean water for approximately 24 hours prior to mixing with Patch.

2. Drain off excess water prior to mixing.

3. The total mixing water for the batch shall be reduced by the amount of free water found in the aggregate.

4. Follow mixing procedures for large batches. After all water has been added and Patch has come to uniform consistency, add approximately one 5-gallon bucket of 3/8" aggregate for every two 55-lb. bags of Patch (30-35 lbs. of aggregate per 55-lb. bag of Gilco Patch).

5. Continue to mix until the aggregate is thoroughly dispersed throughout the Patch.

COLD WEATHER PATCHING

Mixing and Placing Procedures: When patching in cold weather, modify the basic procedures as follows:

1. Store the Patch bags in a warm building for 48 to 72 hours prior to mixing.

2. Heat mixing water to no more than 95° F. (Mixed Patch temperatures greater than 95° F could cause flash set; mixing water temperatures lower

than 80° F will have little effect on raising the Patch temperature.) The Patch at time of placement should be at least 50° F and no higher than 90° F.

3. The mixer should be warmed with hot water prior to mixing the first batch.

HOT WEATHER PATCHING

Mixing and Placing Procedures: In hot weather (95° F to 100° F), Gilco Patch may lose workability rapidly, causing flash setting. To overcome these problems, modify the basic procedures as follows:

1. Store Patch bags in a cool, shaded (preferably indoor) location until time of use.

2. Use chilled mixing water as close to 33° F as possible. This can be easily accomplished by placing a block of ice in a 55-gallon drum of water. At time of placement, Patch temperature should be 80° F, or less.

3. Be sure areas to be patched have been thoroughly saturated with cool water for 18 to 24 hours prior to patching. Just prior to placing the Patch, remove standing water with compressed air, free of oil and other lubricants, or mop with clean rags, leaving only a damp film.

4. Locate mortar mixer in a shaded area as close to the patching site as possible. Prior to mixing, cool mixer with the chilled water.

5. As soon as Patch has reached final set, apply soaked burlap or pond exposed surfaces to inhibit evaporation of moisture due to high ambient temperature. When using this technique, delay application of cure/seal compound for 24 hours after final set or until surface has reached suitable moisture content for application.

CONCRETE SOLUTIONS
TO REAL WORLD PROBLEMS

Cormix Construction Chemicals, P.O. Box 190970, Dallas, TX 75219-0970, Phone: 800/933-1329 or 214/224-0300, Fax: 214/224-7198
50 offices in the United States and locations around the world.

APPENDIX B
Pachometer Data Sheets

PACHOMETER TEST DATA					
TEST LOCATION: Roof Slab over Room D101					
East-West Reinforcement			North-South Reinforcement		
Concrete Cover at Measured Locations*			Concrete Cover at Measured Locations*		
1.5	1.3	Specified Reinforcing #7 @ 9"			Specified Reinforcing #4 @ 14"
1.3	1.4	Specified			Specified
1.3	1.6	Cover (in.) 0.75			Cover (in.)
1.5	1.3	Average			Average
1.5	0.8	Cover (in.) 1.1			Cover (in.)
	0.7	Maximum			Maximum
	0.8	Cover (in.) 1.6			Cover (in.)
	0.7	Minimum			Minimum
	0.9	Cover (in.) 0.7			Cover (in.)
	0.8	Total Bars Located*			Total Bars Located* 14
		Total Length Tested (ft)			Total Length Tested (ft)
		Approx. Bar Spacing(in) 9.0			Approx. Bar Spacing(in) 14.0
*Note: Concrete cover was not measured at all locations where reinforcement was located.					

PACHOMETER TEST DATA					
TEST LOCATION: Roof Slab over Room D101E					
East-West Reinforcement			North-South Reinforcement		
Concrete Cover at Measured Locations*			Concrete Cover at Measured Locations*		
1.2		Specified Reinforcing #7 @ 18"			Specified Reinforcing #4 @ 14"
1.1		Specified			Specified
1.2		Cover (in.) 0.75			Cover (in.)
1.1		Average			Average
1.2		Cover (in.) 1.1			Cover (in.)
1.1		Maximum			Maximum
1.2		Cover (in.) 1.2			Cover (in.)
		Minimum			Minimum
		Cover (in.) 1.1			Cover (in.)
		Total Bars Located* 7			Total Bars Located*
		Total Length Tested (ft)			Total Length Tested (ft)
		Approx. Bar Spacing(in) 18.0			Approx. Bar Spacing(in)
*Note: Concrete cover was not measured at all locations where reinforcement was located.					

TEST LOCATION: Room D101 - West Exterior Wall at Main Level

Clear Concrete Cover at Measured Locations (inches)*

*Note: Concrete cover was not measured at all locations where reinforcement was located.

TEST LOCATION: Room D101B - West Exterior Wall at Main Level

Clear Concrete Cover at Measured Locations (inches)*

*Note: Concrete cover was not measured at all locations where reinforcement was located.

PACHOMETER TEST DATA
TEST LOCATION: Room D101E - West Exterior Wall at Main Level

Vertical Reinforcement - North to South
Clear Concrete Cover at Measured Locations (inches)*

2.2	2.7	2.2	2.3			Specified Reinforcing #5 @ 9"
2.0	2.6	1.8	2.2			Specified Cover (in.) 0.75
2.0	2.6	2.0	2.2			Average Cover (in.) 2.3
-	2.5	2.0	2.0			Maximum Cover (in.) 2.8
2.2	2.5	2.0				Minimum Cover (in.) 1.8
2.3	2.5	2.1				Total Bars Located* 46
2.5	2.3	2.0				Approx. Length Tested (ft) 39
2.6	2.2	2.1				Approx. Bar Spacing(in) 10.0
2.8	-	2.2				
2.6	-	2.3				
2.5	-	2.3				
2.6	2.4	2.3				
2.6	2.3	2.3				
2.5	2.3	2.3				

*Note: Concrete cover was not measured at all locations where reinforcement was located.

APPENDIX. C
Radar Data Sheets

IMPULSE RADAR METHODOLOGY AND INSTRUMENTATION

A commercially available ground penetrating radar unit owned and operated by CTL was used to identify and locate embedded reinforcement and evaluate wall and slab thicknesses. The radar unit, SIR-System-10A, is manufactured and distributed by Geophysical Survey System, Inc. (GSSI) of North Salem, New Hampshire.

The GSSI radar system used in the evaluation included the following items:

1. Radar control unit
2. 1000 MHz transducer (antenna)
3. Color monitor
4. 90 ft transducer control cable
5. Remote marker switch

High frequency repetitive short-time duration electromagnetic pulses are propagated into the structure from the transducer (antenna) placed in direct contact with the surface to be tested. The electromagnetic pulse propagates through the structure until a discontinuity is encountered. A discontinuity is a boundary between materials of differing dielectric properties such as concrete to reinforcement, concrete to air, etc. At each boundary, a portion of the incident energy is reflected back to the receiver and a portion is refracted through the boundary.

The antenna has a relatively broad radiation pattern. This radiation pattern is conical in shape with the apex of the cone at the center of the antenna. The cone has an included angle of approximately 60°.

Objects embedded within the concrete can be determined by their "radar signature" when viewed on the radar's color monitor. For flat reflecting surfaces, such as concrete/air interfaces, it is the energy that is directed straight down and reflected from the interface that the antenna receives. Energy transmitted and reflected to the sides is not received. In other words, the two-way reflection sensitivity, or the field of view, of the antenna is small for surfaces at normal incidence. For round targets, i.e. steel reinforcement, the situation is different since a round target has surfaces that are normal to the antenna pattern as the antenna approaches and passes over the target at right angles. The antenna "sees" the round target before and after it has passed over. Figure C.1 illustrates how a round target "signature" is developed. Reflected waves are detected and electronically processed to permit nondestructive imaging of the test area. As the transducer moves along the reinforced structure surfaces, a real time graphic

recording is automatically generated showing location and relative depths of the reinforcement in the structure.

In locations where steel reinforcement is closely spaced, or near the surface of a tested element, multiple reflections of the radar signal by the steel reinforcement disrupt reflected signals from deeper embedded objects. It is for this reason that the second layer of reinforcement and the concrete member thickness were very difficult or impossible to accurately evaluate in tested areas.

FIG. C.1 SAMPLE RADAR DATA SHOWING EMBEDDED REINFORCING STEEL BARS.

Impulse Radar Summary

Room	Reinforcement Orientation	Test Surface	Survey Distance (ft)	Total Bars	Average Spacing (in.)	Specified Spacing (in.)	Concrete Cover, in.		
							Max / Min	Average	Specified
6	Horizontal	West Wall	7	7	12.0	12	2.7 / 1.5	2.0	1-3/8
6	Horizontal	West Wall	6	6	12.0	12	2.2 / 2.2	2.2	1-3/8
6	Vertical	West Wall	76	79	11.5	12	2.6 / 1.9	2.2	3/4
6	Vertical	West Wall	24	25	11.5	12	2.9 / 2.2	2.7	3/4
7	Vertical	North Wall	—	—	5†	5	4.9 / 3.3	4.1	3/4
7	Horizontal	North Wall	7	7	12.0	12	7.1 / 5.0	6.1	2-1/8
7	Horizontal	West Wall	6	6	12.0	12	4.2 / 4.1	4.2	2-1/8
7	Vertical	West Wall	18	24	9.0	9	3.8 / 3.3	3.6	3/4
9	Vertical	East Wall	7.5	12	7.5	9	3.5 / 2.7	3.1	3/4
9	Vertical	East Wall	4	5	9.6	9	3.1 / 3.0	3.0	3/4
9	Vertical	North Wall	9.5	23	5.0	5	3.7 / 3.4	3.6	3/4
13	Horizontal	East Wall	7	7	12.0	12	4.8 / 4.0	4.1	1-5/8
13	Vertical	East Wall	8	11	8.7	9	3.8 / 3.1	3.4	3/4
15	Horizontal	East Wall	6	6	12.0	12	4.2 / 3.9	4.1	1-5/8
15	Vertical	East Wall	8.5	12	8.5	9	3.5 / 3.0	3.4	3/4
20	Horizontal	East Wall	7	7	12.0	12	4.1 / 4.0	4.1	1-5/8
20	Vertical	East Wall	11	15	8.8	9	3.5 / 2.8	3.1	3/4
20	Vertical	East Wall	10.5	14	9.0	9	3.8 / 3.1	3.3	3/4
20	Vertical	South Wall	11	11	12.0	12	3.0 / 2.6	2.8	3/4
21	Vertical	East Wall	4	4	12.0	12	3.3 / 2.0	2.7	3/4
21	Horizontal	East Wall	7	7	12.0	12	2.9 / 2.9	2.9	1-1/2
21	Vertical	East Wall	6	7	10.3	12	2.7 / 1.3	2.3	3/4
21	Vertical	North Wall	9	9	12.0	12	2.4 / 1.9	2.3	3/4
21	Vertical	North Wall	6	6	12.0	12	2.6 / 2.6	2.6	3/4
21	Horizontal	North Wall	6	6	12.0	12	2.7 / 1.9	2.1	1-1/2
21	Horizontal	North Wall	6	6	12.0	12	2.0 / 2.0	2.0	1-1/2
21	Horizontal	West Wall	6	6	12.0	12	4.6 / 3.2	4.2	2
21	Vertical	West Wall	13	18	8.7	12	3.8 / 3.2	3.6	3/4
21-22	Horizontal	East*	5	5	12.0	12	2.7 / 2.2	2.6	1-3/8
21-22	Horizontal	West*	5	5	12.0	12	2.7 / 2.4	2.7	1-3/8
21A	Horizontal	East Wall	8	8	12.0	12	4.3 / 3.9	4.1	1-5/8
21A	Horizontal	East Wall	6	6	12.0	12	4.2 / 4.1	4.1	1-5/8
21A	Vertical	East Wall	17.5	23	9.1	9	4.2 / 3.3	3.9	3/4
21A	Horizontal	South Wall	8	8	12.0	12	5.0 / 4.1	4.6	2-1/8
21A	Horizontal	South Wall	9	9	12.0	12	6.1 / 4.1	5.2	2-1/8

Impulse Radar Summary

Room	Reinforcement Orientation	Test Surface	Survey Distance (ft)	Total Bars	Average Spacing (in.)	Specified Spacing (in.)	Concrete Cover, in.		
							Max / Min	Average	Specified
21A	Vertical	South Wall	7	12	7.0 **	5	4.7 / 4.0	4.2	3/4
21A	Horizontal	West Wall	7	7	12.0	12	4.1 / 1.9	3.0	1-1/2
21A	Vertical	West Wall	5	5	12.0	12	2.6 / 2.6	2.6	3/4
A114B	Horizontal	East Wall	7	7	12.0	12	2.9 / 2.9	2.9	1-3/8
A114B	Vertical	East Wall	16	16	12.0	12	2.6 / 2.4	2.5	3/4
A115	Vertical	South Wall	28	28	12.0	12	3.6 / 2.1	2.7	3/4
A115	Horizontal	South Wall	7	7	12.0	12	3.2 / 3.0	3.2	1-3/8
A115	Horizontal	South Wall	7	7	12.0	12	2.9 / 2.4	2.7	1-3/8
A115	Horizontal	South Wall	7	7	12.0	12	3.3 / 2.2	2.5	1-3/8
A115A	Vertical	South Wall	14	14	12.0	12	3.6 / 2.2	2.6	3/4
A115A	Horizontal	South Wall	7	7	12.0	12	3.4 / 2.9	3.1	1-3/8
D101	Horizontal	East Wall	9	9	12.0	12	4.3 / 3.8	4.1	1-1/4
D101	Vertical	East Wall	16	16	12.0	12	4.2 / 3.4	3.8	3/4
D101	N-S	Floor	49	40	14.7	14	5.4 / 2.9	3.5	1-1/2
D101	E-W	Floor	49	71	8.3	9	3.5 / 2.1	2.9	3/4
D101	E-W	Floor	52	72	8.7	9	3.4 / 2.1	2.8	3/4
D101	N-S	Floor	24	22	13.1	14	4.8 / 2.2	3.2	1-1/2
D101	Vertical	North Wall	29	35	9.9	10	2.7 / 1.7	2.0	3/4
D101	Horizontal	North Wall	13	13	12.0	12	2.6 / 1.9	2.1	1-3/8
D101	Horizontal	South Wall	10	10	12.0	12	2.0 / 1.0	1.4	1-3/8
D101	Horizontal	South Wall	10.5	11	11.5	12	2.9 / 2.1	2.3	1-3/8
D101	Vertical	South Wall	6	6	12.0	12	3.1 / 1.0	2.2	3/4
D101	Vertical	South Wall	11	11	12.0	12	1.8 / 1.2	1.6	3/4
D101	Horizontal	West Wall	9	9	12.0	12	4.3 / 2.9	3.6	1-3/8
D101	Vertical	West Wall	49	67	8.8	9	3.5 / 1.1	2.4	3/4
D101B	Horizontal	Column	7	6	14.0	16	2.2 / 1.7	2.0	1-1/2
D101B	E-W	Floor	43	65	7.9	9	3.6 / 2.9	3.2	3/4
D101B	E-W	Floor	44	67	7.9	9	3.5 / 2.8	3.3	3/4
D101B	Horizontal	West Wall	9	9	12.0	12	3.1 / 2.5	2.8	1-3/8
D101B	Vertical	West Wall	45	58	9.3	9	3.6 / 0.8	2.7	3/4
D101E	Vertical	East Wall	14	14	12.0	12	3.2 / 2.6	2.9	3/4
D101E	E-W	Floor	—	68	—	9	3.5 / 2.6	3.1	1-1/2
D101E	E-W	Floor	44	58	9.1	9	3.1 / 2.5	2.9	1-1/2
D101E	Vertical	South Wall	4	4	12.0	10	2.5 / 2.4	2.4	3/4
D101E	Horizontal	South Wall	7	7	12.0	12	3.1 / 2.6	2.8	1-3/8

Impulse Radar Summary

Room	Reinforcement Orientation	Test Surface	Survey Distance (ft)	Total Bars	Average Spacing (in.)	Specified Spacing (in.)	Concrete Cover, in.		
							Max / Min	Average	Specified
D101E	Vertical	South Wall	23	27	10.2	10	2.7 / 1.7	2.5	3/4
D101E	Vertical	West Wall	30	38	9.5	10	3.5 / 2.9	3.2	3/4
Hallway	Horizontal	East Wall	7	7	12.0	12	4.1 / 3.9	4.0	1-1/4
Hallway	Vertical	East Wall	22	22	12.0	12	4.0 / 2.7	3.6	3/4
Hallway	Vertical	West Wall	22	22	12.0	12	2.1 / 1.5	1.8	3/4
Mezzanine	Vertical	North Wall	—	—	5†	5	5.2 / 3.8	4.5	3/4
Mezzanine	Horizontal	North Wall	7	7	12.0	12	5.5 / 5.5	5.5	2-1/8
Mezzanine	Horizontal	South Wall	6	6	12.0	12	2.9 / 2.9	2.9	1-3/8
Mezzanine	Vertical	South Wall	7	7	12.0	12	2.9 / 2.4	2.6	3/4
Mezzanine	Horizontal	West Wall	7	7	12.0	12	3.6 / 2.8	3.1	2
Mezzanine	Vertical	West Wall	18	24	9.0	9	2.9 / 1.7	2.2	3/4

* Measurement on surface of Wing-wall between rooms

† Steel too congested to accurately measure. Bar spacing appeared to be approximately as specified.

** Bar spacing was approximately 5 in., however, the three bars closest to the southeast corner were spaced at approximately 12 in., therefore the average spacing was 7 in.

APPENDIX D
Pulse Velocity Data Sheets

DIRECT TRANSMISSION PULSE VELOCITY DATA FOR CORES								
CORE	DIAM	LENGTH	TRANSIT TIMES (microsec)			PULSE VELOCITIES (ft/sec)		
			HORIZ	VERT	LENGTH	HORIZ	VERT	LENGTH
A	3.7	7.3	20.3	20.5	42.4	15189	15041	14266
C	3.7	7.2	21.8	20.5	42.6	14144	15041	14104
D	3.7	5.8	21.2	21.9	35.6	14544	14079	13635
K	3.7	7.2	20.9	20.2	40.7	14753	15264	14742
E	3.7	7.2	22.1	21.4	43.7	13952	14408	13682
F	3.7	6.9	21.2	21.2	41.5	14544	14544	13946
G	3.7	5.9	21.4	21.5	34.1	14408	14341	14415
H	3.7	7.2	20.3	20.2	41.6	15189	15264	14323
I	3.7	3.6	22.6	22.0	19.4	13643	14015	15525
J	3.7	7.3	21.3	20.6	42.5	14476	14968	14225
MAX						15189	15264	14742
MIN						14144	14079	13635
AVG						14657	14856	14187
ST DEV						493	475	548
COEFF						3%	3%	4%

MISCELLANEOUS RANDOM DIRECT TRANSMISSION PULSE VELOCITY DATA			
LOCATION	PATH LENGTH	TRANSIT TIME	PULSE VELOCITY
Near Core E	8.0	46.6	14306
Rm 22 Wing Wall (NW Corner)	12.0	73.7	13569
Wall btw Rms 21 and 22	12.0	70.3	14225

SURFACE TRANSMISSION PULSE VELOCITY ADJACENT TO CORES								
CORE	TRANSIT TIMES (microsec)				PULSE VELOCITIES (ft/sec)			
	6" HORIZ	6" VERT	12" HORIZ	12" VERT	6" HORIZ	6" VERT	12" HORIZ	12" VERT
A	35.7	34.6	72.5	73.3	14006	14451	13793	13643
			72.6	75.4			13774	13263
B	94.4*	87.7*	93.0	100.7			10753	9930
			90.6	97.8			11038	10225
C	50.5	55.4	97.4	86.6	9901	9025	10267	11547
			188*	179.1*				
D	58.3	61.0	103.8	102.2	8576	8197	9634	9785
				101.6				9843
K	58.0	55.2	98.3	96.4	8621	9058	10173	10373
			97.5	94.2			10256	10616
E	52.0	41.3	91.5	100.3	9615	12107	10929	9970
			82.4	97.2			12136	10288
F	34.4	41.0	98.1	94.4	14535	12195	10194	10593
			93.5	90.1			10695	11099
G	48.0	40.5	95.5	97.5	10417	12346	10471	10256
			92.4	94.7			10823	10560
H	33.3	38.4	95.2	101.1	15015	13021	10504	9891
			90.1	95.3			11099	10493
I	39.3	38.3	91.8	96.2	12723	13055	10893	10395
			75.4	93.0			13263	10753
J	54.0	58.7	95.7	94.0	9259	8518	10449	10638
			94.5	92.0			10582	10870
MAX					15015	13055	13263	11547
MIN					8576	8197	9634	9785
AVG					10962	10836	10799	10403
ST DEV					2490	2068	831	455
COEFF					23%	19%	8%	4%

*Note: Data anomaly explainable by observed defect, eg. surface crack in wall.

SURFACE TRANSMISSION PULSE VELOCITY AT RANDOM LOCATIONS								
LOCATION	TRANSIT TIMES (microsec)				PULSE VELOCITIES (ft/sec)			
	6" HORIZ	6" VERT	12" HORIZ	12" VERT	6" HORIZ	6" VERT	12" HORIZ	12" VERT
Rm 07	55.5	54.4	93.2	94.1	9009	9191	10730	10627
			90.1	90.1			11099	11099
Rm 07	60.0	58.6	101.7	104.4	8333	8532	9833	9579
			97.4	97.7			10267	10235
Rm 09	55.5	59.2	94.4	112.8	9009	8446	10593	8865
			93.7	108.2			10672	9242
Rm 06	49.8	56.9	96.2	94.5	10040	8787	10395	10582
			94.3	94.0			10604	10638
Rm 18	50.7	35.2	101.4	91.7	9862	14205	9862	10905
			86.6	90.1			11547	11099
Rm 21A	53.1	54.1	90.6	92.6	9416	9242	11038	10799
			89.3	90.2			11198	11086
D101								
1	52.1		95.5		9597		10471	
2	49.8		90.5		10040		11050	
3	39.2		156.3*		12755			
3a			116.1				8613	
4	47.3		96.5		10571		10363	
5	160.6*		185.5*					
D101E								
1	46.4		100.7		10776		9930	
2	50.2		96.3		9960		10384	
3	44.5		92.3		11236		10834	
Hall 06								
1	39.8	60.0	99.4	103.8	12563	8333	10060	9634
2	38.4	40.2	78.6	173.4*	13021	12438	12723	
3	38.0		79.9		13158		12516	
Rm 21								
1	38.0	58.6	76.3	101.3	13158	8532	13106	9872
2	40.3	53.0	76.7	108.0	12407	9434	13038	9259
3	40.6	37.6	76.8	73.1	12315	13298	13021	13680
4	33.8	35.2	94.1	97.9	14793	14205	10627	10215
Rm 22	57.9	43.0	97.5	76.7	8636	11628	10256	13038
Rm 22	38.8	41.3	88.7	105.5	12887	12107	11274	9479
Hallway	51.6	40.8	91.0	102.3	9690	12255	10989	9775
Hallway	38.4	41.4	100.4	100.5	13021	12077	9960	9950

SURFACE TRANSMISSION PULSE VELOCITY AT RANDOM LOCATIONS (cont.)								
LOCATION	TRANSIT TIMES (microsec)				PULSE VELOCITIES (ft/sec)			
	6" HORIZ	6" VERT	12" HORIZ	12" VERT	6" HORIZ	6" VERT	12" HORIZ	12" VERT
A115	39.3	40.2	101.1	105.3	12723	12438	9891	9497
A114	42.8	44.7	90.2	85.4	11682	11186	11086	11710
A114A	37.7	38.3	93.9	102.0	13263	13055	10650	9804
A114B	45.6	41.8	107.4	93.3	10965	11962	9311	10718
D101E	32.0	40.3	91.6	101.1	15625	12407	10917	9891
D101D	44.8	38.6	86.7	78.4	11161	12953	11534	12755
D101	39.8	35.7	83.3	76.4	12563	14006	12005	13089
D101	46.7	44.3	109.6	121.4	10707	11287	9124	8237
D101	36.4	36.3	75.0	74.6	13736	13774	13333	13405
A102	54.6	56.4	96.3	91.3	9158	8865	10384	10953
A110	49.1	43.3	81.2	86.7	10183	11547	12315	11534
MAX					15625	14205	13333	13680
MIN					8333	8333	8613	8237
AVG					11372	11340	10917	10664
ST DEV					1841	1994	1110	1354
COEFF					16%	18%	10%	13%

*Note: Data anomaly explainable by observed defect, eg. surface crack in wall.

APPENDIX E
Laboratory Test Reports

PETROGRAPHIC SERVICES REPORT

CTL Project No.: 260600

Date: January 20, 1995

Re: Nuclear Materials Storage Facility, Los Alamos, New Mexico

Eleven cores representing concrete in the referenced structure were received January 10, 1995 from Dr. Ralph Oesterle, Senior Principal Engineer, CTL Structural Engineering. The cores were labelled alphabetically A through K. Core B, the only core with a significant visible longitudinal crack, was selected for detailed petrographic microscopical examination. All remaining cores were briefly examined to determine the presence of boron frits.

FINDINGS AND CONCLUSIONS

Cores A, B, C, D, and K contain fine-aggregate size boron frit glass, each particle of frit showing a thin surficial reaction with the cement paste. The reaction is presumably related to cement alkalis and the high pH typical for portland cement pastes, and can be described as an alkali-silica reaction (ASR).

Detailed examination of Core B reveals no significant damage resulting from the ASR. A few microcracks, observed at a magnification of 200X, extend from inside the paste-frit reaction zone into the paste. The longitudinal crack observed in Core B is interpreted to represent the effects of ordinary drying shrinkage, occurring after concrete hardening. Frit particles are estimated at 3 to 4% of the fine aggregate in cores A, B, D, and K, and 2 to 3% in Core C.

The crushed granite and sand aggregates are set in a light to medium grey, hard vitreous portland cement paste. Paste-aggregate bond is tight and aggregates are uniformly distributed. A few microcracks were observed in the middle of Core B. Water-to-cement ratio is interpreted at approximately 0.40 to 0.45. Observed depth of carbonation is 0.5 to 1.5 mm (0.02 to 0.06 in.) from the surface.

Details of the microscopical examination are given in the attached data form.

METHODS OF TEST

Petrographic examination of the sample was performed in accordance with ASTM C 856-83, "Standard Practice for Petrographic Examination of Hardened Concrete." The sample was cut longitudinally, and one of the resulting slices was lapped and examined using a stereomicroscope at magnifications up to 45X. Surfaces on freshly broken concrete were also studied with the stereomicroscope. A small rectangular block was cut from the sample, placed on a glass microscope slide with epoxy resin, and reduced to a thickness of approximately 20 micrometers (0.00079 in.). The thin section was examined using a polarized-light microscope at magnifications up to 400X to determine aggregate and paste mineralogy and microstructure. Uranyl acetate was applied to the freshly broken concrete to confirm the presence of alkali-silica gel.

Donald H. Campbell
Senior Principal Petrographer
Petrographic Services

DHC/cjd

260600

PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE, ASTM C 856**CTL PROJECT NO.:** 260600**DATE:** January 20, 1995**CLIENT:** Merrick & Company**STRUCTURE:** Nuclear Materials Storage Facility Wall**EXAMINED BY:** D. H. Campbell**LOCATION:** Los Alamos

Page 1 of 2

SAMPLE:**Identification:** Core B.**Dimensions:** Length = 215 mm (8.39 in.); diameter = 96 mm (3.74 in.).**Top Surface:** Off-white polymer membrane (0.5 mm, 0.02 in. thick) underlain by greenish "primer" mortar layer of equal thickness.**Bottom Surface:** Irregularly broken concrete, the surface passing through a few of the aggregates.**Cracks, Joints, Large Voids:** Longitudinal crack extends length of core, the crack surface passing through several hard coarse aggregates and a few fine aggregates. No evidence of repair attempts. Crack width is 0.6 mm (0.023 in.).**Reinforcement:** None.**Unit Weight:** 143.7 lb/ft³.**AGGREGATES (A)****Coarse (C):** Crushed granite, granite gneiss, and a few other igneous- and metamorphic-rock varieties.**Fine (F):** Sand containing ordinary quartz, feldspar, volcanic rock fragments (some very finely microcrystalline), pumice, basalt, granite, and other rocks and minerals. Frit particles are estimated at 3 to 4% of the fine aggregate.**Gradation & Top Size:** Evenly graded to a top size of approximately 20 mm (0.78 in.).**Shape & Distribution:** Angular, mostly equidimensional coarse and fine aggregate particles; uniform distribution.**PASTE****Color:** Light to medium gray.**Hardness:** Hard (resistance to dental pick scratch).**Luster:** Vitreous.**Depth of Carbonation:** 0.5 to 1.50 mm (0.02 to 0.06 in.) from top surface.**Air Content:** 1 to 3%; air entrained.

Paste-Aggregate Bond: Tight; numerous aggregates cross fractured on surfaces of freshly broken concrete.

Calcium Hydroxide*: 2 to 4%, occurring as medium-crystalline masses (15 μm) in paste.

Unhydrated Cement Clinker Particles*: 12 to 15%; typical cement clinker particles composed of alite, belite, and matrix.

Pozzolans*: None observed, except for glassy volcanic rock debris from fine aggregates.

Secondary Deposits: None observed.

MICROCRACKING: Microcracks are common at roughly midcore; the cracks appear oriented transverse to core length, possibly related to coring. Microcracks associated with the frit particles are rare.

ESTIMATED WATER-CEMENT RATIO: 0.40 to 0.45.

MISCELLANEOUS: A white zone of alteration (approximately 30 to 50 μm thick) occurs on the boron frit particles, in some occurring along conchoidal crack surfaces within the particles. The alteration is very finely microcrystalline to amorphous and believed to be water-rich. Under high magnification (400X) the zone is seen to be comprised of several thin layers (up to 7 layers, mostly 1 to 3 μm thick each); the layers appear to be of two alternating types: (1) clear, amorphous gel and (2) cloudy and a very finely microcrystalline material. Microcracks in one of the frit particles extend from the particle interior into the paste, but only for 10 to 12 μm .

*percent by volume of paste

Client: Merrick and Company
 Project: Compressive Strength Testing of Nuclear Materials
 Storage Facility Los Alamos, New Mexico
 Contact: Mr. Elton Endebrock
 Submitter: Mr. Peter Kolf

CTL Project No.: 260600
 CTL Project Mgr.: Mr. P. Kolf
 Technician: F. Blaul
 Approved: R. G. Burg
 Date: January 13, 1995

Test Results of ASTM C 42-90 Standard Test Method for
 Compressive Strength of Drilled Cores of Concrete

Core Identification	A	C	D	E
Nominal Maximum Aggregate Size (in.)	3/4	3/4	3/4	3/4
Concrete Age at Test (approximate years)	Not Stated	Not Stated	Not Stated	Not Stated
Moisture Condition at Test	Dry	Dry	Dry	Dry
Orientation of Core Axis in Structure	Perpendicular	Perpendicular	Perpendicular	Perpendicular
Diameter 1 (in)	3.66	3.74	3.74	3.67
Diameter 2 (in)	3.67	3.74	3.34	3.68
Average Diameter (in)	3.67	3.74	3.54	3.67
Cross-Sectional Area (sq in)	10.55	10.97	9.84	10.59
Length Trimmed (in)	7.3	7.2	5.8	7.2
Length Capped (in)	7.5	7.4	6.1	7.4
Weight in Air (lb)	6.3	6.7	5.4	6.3
Weight in Water (lb)	3.6	3.8	3.1	3.6
Calculated Unit Weight (pcf)	143.7	146.0	146.7	145.3
Loading Rate, psi/sec	35	35	35	35
Maximum Load (lbs)	61,000	91,000	91,400	80,500
Uncorrected Compressive Strength (psi)	5,780	8,300	9,290	7,600
Ratio of Capped Length to Diameter (L/D)	2.05	1.97	1.71	2.01
Correction Factor (ASTM C42)	1.000	1.000	0.977	1.000
Corrected Compressive Strength (psi)	5,780	8,300	9,070	7,600
Fracture Pattern	Columnar	Columnar	Conical	Conical
Notes:				

Client: Merrick and Company
 Project: Compressive Strength Testing of Nuclear Materials
 Storage Facility Los Alamos, New Mexico
 Contact: Mr. Elton Endebrock
 Submitter: Mr. Peter Kolf

CTL Project No.: 260600
 CTL Project Mgr.: Mr. P. Kolf
 Technician: F. Blaul
 Approved: R. G. Burg
 Date: January 13, 1995

Test Results of ASTM C 42-90 Standard Test Method for
 Compressive Strength of Drilled Cores of Concrete

Core Identification	F	G	H	I
Nominal Maximum Aggregate Size (in.)	3/4	3/4	3/4	3/4
Concrete Age at Test (approximate years)	Not Stated	Not Stated	Not Stated	Not Stated
Moisture Condition at Test	Dry	Dry	Dry	Dry
Orientation of Core Axis in Structure	Perpendicular	Perpendicular	Perpendicular	Perpendicular
Diameter 1 (in)	3.63	3.72	3.64	3.75
Diameter 2 (in)	3.66	3.71	3.62	3.74
Average Diameter (in)	3.64	3.71	3.63	3.74
Cross-Sectional Area (sq in)	10.43	10.83	10.33	11.01
Length Trimmed (in)	6.9	5.9	7.2	3.6
Length Capped (in)	7.2	6.0	7.3	3.7
Weight in Air (lb)	6.1	5.3	6.4	3.2
Weight in Water (lb)	3.5	3.0	3.7	1.8
Calculated Unit Weight (pcf)	144.4	143.6	146.4	145.6
Loading Rate, psi/sec	35	35	35	35
Maximum Load (lbs)	74,200	80,700	80,300	91,900
Uncorrected Compressive Strength (psi)	7,110	7,450	7,770	8,350
Ratio of Capped Length to Diameter (L/D)	1.96	1.62	2.02	0.99
Correction Factor (ASTM C42)	1.000	0.970	1.000	0.870
Corrected Compressive Strength (psi)	7,110	7,230	7,770	7,260
Fracture Pattern	Columnar	Shear	Conical	Columnar and Cone

Notes: Reinforcing steel in core "I" we could not get 2:1 ratio.

Client: Merrick and Company
 Project: Compressive Strength Testing of Nuclear Materials
 Storage Facility Los Alamos, New Mexico
 Contact: Mr. Elton Endebrock
 Submitter: Mr. Peter Kolf

CTL Project No.: 260600
 CTL Project Mgr.: Mr. P. Kolf
 Technician: F. Blaul
 Approved: R. G. Burg
 Date: January 13, 1995

Test Results of ASTM C 42-90 Standard Test Method for
 Compressive Strength of Drilled Cores of Concrete

Core Identification	J	K	Grout #1	Grout #2
Nominal Maximum Aggregate Size (in.)	3/4	3/4	3/8	3/8
Concrete Age at Test (approximate years)	Not Stated	Not Stated	Not Stated	Not Stated
Moisture Condition at Test	Dry	Dry	Dry	Dry
Orientation of Core Axis in Structure	Perpendicular	Perpendicular	Perpendicular	Perpendicular
Diameter 1 (in)	3.70	3.74	3.00	3.01
Diameter 2 (in)	3.70	3.74	3.01	3.01
Average Diameter (in)	3.70	3.74	3.01	3.01
Cross-Sectional Area (sq in)	10.75	10.98	7.09	7.10
Length Trimmed (in)	7.3	7.2	5.7	5.7
Length Capped (in)	7.5	7.4	6.0	6.0
Weight in Air (lb)	6.5	6.6	3.4	3.4
Weight in Water (lb)	3.7	3.7	1.9	1.9
Calculated Unit Weight (pcf)	144.1	144.1	144.8	144.9
Loading Rate, psi/sec	35	35	35	35
Maximum Load (lbs)	87,000	92,300	36,200	31,100
Uncorrected Compressive Strength (psi)	8,090	8,410	5,100	4,380
Ratio of Capped Length to Diameter (L/D)	2.03	1.98	2.00	2.00
Correction Factor (ASTM C42)	1.000	1.000	1.000	1.000
Corrected Compressive Strength (psi)	8,090	8,410	5,100	4,380
Fracture Pattern	Shear	Conical	Conical	Conical
Notes:				

Client: Merrick and Company
Project: Pulse Velocity Data for Nuclear Materials
Storage Facility Los Alamos, New Mexico
Contact: Mr. Elton Endebrock
Submitter: Mr. Peter Kolf

CTL Project No.: 260600
CTL Project Mgr.: P. Kolf
Technician: F. Blaul
Approved: R. G. Burg
Date: January 13, 1995

*Pulse Velocity Data for Cores Obtained from
Nuclear Materials Storage Facility - Los Alamos, New Mexico*

Core Identification	P.V. Reading 1	P.V. Reading 2	Average P.V.	Length 1, in.	Length 2, in.	Average Length	Pulse Velocity ft/second
A	43	42	42	7.250	7.250	7.250	14,266
C	43	43	43	7.210	7.210	7.210	14,104
D	36	36	36	5.825	5.825	5.825	13,635
E	44	44	44	7.175	7.175	7.175	13,682
F	42	42	42	6.945	6.945	6.945	13,946
G	34	34	34	5.890	5.890	5.890	14,415
H	42	41	42	7.150	7.150	7.150	14,323
I	20	19	19	3.605	3.605	3.605	15,525
J	43	42	43	7.255	7.255	7.255	14,225
K	41	41	41	7.200	7.200	7.200	14,742
Grout #1	32	32	32	5.720	5.720	5.720	14,919
Grout #2	32	32	32	5.715	5.715	5.715	14,906

APPENDIX F
Equipment Calibration

F.1 Pachometer Calibration

The instrument used for pachometer testing was the Soiltest Micro Covermeter. Initial calibration of the micro covermeter is taken from multiple measurements of standard reinforcing steels of various sizes and compositions for particular markets. In the case of micro covermeters marketed in the USA, the calibration was done on Grade 40 and 60 composition steels of common sizes in usage. These steels are traceable back to American Steel Rolling Mills having been obtained locally in the USA.

Once the measurements are translated into software driving the micro covermeter, it remains necessary to calibrate the instrument in the field prior to each use. This is done by holding the probe in air away from any magnetic influence. This balances the circuitry and is the only form of calibration necessary in the field.

F.2 Radar Calibration

Depth measurements by the GPR are presented in terms of time of flight of the radar signal. Two methods are available to accurately determine the depth of reinforcing steel in concrete. One method is to use the GPR to accurately determine the location and approximate depth of a section of reinforcing steel, then to physically expose the steel, and accurately measure its depth of cover. This method was initially used to calibrate the GPR data, but upon analysis, this method's accuracy was deemed to be unacceptable due to data storage media problems. An alternate method of calibration was then used. This method compared concrete cover measurements from the pachometer testing to depth measurements from the GPR. A total of 65 locations from the west wall of Room D101 were compared. Correlation of the data was reasonable and revealed a wave speed of the radar signal to be 0.72 in/ns. The wave speed of the radar signal is directly proportional to the dielectric constant of the concrete; thus knowing the wave speed, the dielectric constant of the concrete was calculated to be 8.2. ASTM D 4748-87 indicates that the dielectric constant of portland cement concrete can range from 6 to 11; thus, the value calculated for this calibration is reasonable.

F.3 Pulse Velocity Calibration

Calibration for pulse velocity test equipment is performed upon equipment start-up prior to each test sequence. Calibration is performed by adjusting equipment while transmitting through a calibration bar of known pulse transit time.

F.4 Uniaxial Testing Machine

Calibration of the compression testing machine used for this work is performed on a periodic basis by an independent testing laboratory. A recent certificate of calibration is attached.

Division of Instron Corporation
100 Royall Street • Canton, Mass 02021
1-800-695-4273 Fax: 617-575-5770
617-575-6000

CERTIFICATE OF CALIBRATION

Calibration

Date

4/6/94

Baldwin BTE 300, 300,000#

Compression Hydraulic Tester

Serial No. 82899

Company: CTL

5420 Old Orchard Rd

Skokie, IL 60077

Wilson Instruments certifies that the machine described above has been calibrated to ASTM designation E4-89 using calibrated weights and/or elastic devices calibrated to National Institute of Standards and Technology specification.

AS FOUND AS LEFT

Range	12,000#
<u>Reading</u>	<u>% Error</u>
1200	-.19
2400	+.77
4800	+.72
7200	+.41
9600	+.38
12000	+.23

Range	120,000#
<u>Reading</u>	<u>% Error</u>
12000	-.15
24000	+.34
48000	+.45
72000	-.52
96000	+.35
120000	+.42

Range	300,000#
<u>Reading</u>	<u>% Error</u>
30000	+.56
60000	+.63
120000	+.56
180000	+.39
240000	+.26
300000	+.05

The calibration and methods used for this calibration meet the requirements of MIL-STD-45662 A.

Calibrating apparatus used:		Morehouse Proving Rings	
<u>capacity</u>	<u>serial no.</u>	<u>cal. date</u>	<u>lab no.</u>
300,000#	619	2/19/93	SJT.01/105403
60,000#	1688	2/3/93	W13573
10,000#	1690	2/1/93	W13573

Handwritten signature

Calibration Engineer

APPENDIX B

Comments and Responses from LASL Review of CTL Report in Appendix A

Review Question

Response

SWEC NMSF TECHNICAL REVIEW TEAM

Section 4.1.2.d, apparently, Construction Technology Lab's understanding of the MAA boundary is not the same as the present "repair" project MAA boundary. The floor slab cracks outside room A117 are now in the MAA boundary. Does this fact change CTL's opinion of these cracks?

Section 4.1.2.d of the report concerned observed cracks in the slab-on-grade which CTL described as outside the MAA/Storage Area. CTL's understanding of the boundaries of the MAA/Storage Area was based on the original intended use of the structure. CTL is not aware of the "Repair" Project MAA boundaries. Apparently, the floor slab outside Room A117 is now within the MAA boundaries. Therefore, the report will be revised to reflect this information. However, this information does not change the opinion expressed by CTL concerning the cause of the cracks. CTL attributed the cracks to drying shrinkage and differential subgrade support. The drawings indicate this slab-on-grade as a 6-in.-thick slab reinforced with one layer of welded wire fabric. The drawings do not indicate any reinforcement around the perimeter of the slab to tie it to other components of the building. This slab-on-grade is a nonstructural slab that should not be counted on to provide any structural function. CTL is not aware of what other functions may be intended for the slab in the "Repair" Project. We reported on the presence of the observed cracks. The determination of the ramification of these cracks is not within the scope of CTL's work.

Section 4.1.2.a, why were the roof slabs in rooms D101 and D101E the only roof slabs examined?

CTL performed a visual inspection of all areas of the underside of the cast-in-place roof slab from the first floor level. Accessed portions of the ceiling areas of Rooms D101 and D101E encompassed a large portion of the area of the cast-in-place roof slab. Rooms D101B and D101D were congested and there is no reason to suspect that the quality of construction of the roof slab over these rooms is any different than over accessed portions of Rooms D101 and D101E. Inefficient use of time spent on less accessible areas would have resulted in less area included in the survey.

Page 2, Section 2.4, Alkali-Silica reaction (ASR) has manifested itself in only 7 years. ASR can become a serious condition over the life of a facility which is intended to last 40-50 years. It was discovered on an interior wall where the accelerator, moisture, should be less than on the exterior. We are removing the interior wall, and relying on the strengths of the exterior walls. Isn't it reasonable to project that in 50 years the reaction may have a deleterious effect on the wall strength?

The alkali-silica reaction (ASR) observed in the cores taken from walls containing boron frit aggregate has not manifested any deterioration of the concrete to date. Only a few microcracks were observed in the microscopic examination of Core B at a magnification of 200X. It is possible that this is the total extent of the effects that may occur in the life of the structure. The potential for deterioration is dependent on several factors including the availability of moisture, temperature, alkalinity of the cement and the quantity and reactivity of the aggregate. CTL currently does not have sufficient information on the specific conditions within the boron frit concrete in the NMSF structure to project what long term effects may occur. We therefore recommended obtaining further information on the boron frit aggregate, if available, and that further sampling and testing be carried out.

What national standards were used as the basis for the CTL sampling plan? What procedures were followed to assure randomness?

In general, CTL used procedures and methods described in ACI 437R-91, Strength Evaluation of Existing Concrete Buildings, for the condition survey and material testing. CTL's sampling plan was not intended to obtain pure random samples throughout the structure. Rather, it was intended to obtain representative samples distributed throughout the structure based on areas of interest including components with a critical structural nature, areas representing different stages of construction, and areas containing different construction materials. The test plan included in Appendix A of the report defines the roof and east-west shear walls near intersections of north-south interior walls as areas of a critical structural nature for inspecting and testing. The other testing was comprehensively distributed throughout the structure to investigate concrete with and without boron frit aggregate and to investigate various stages of construction. Within regions considered to represent the same material and/or stage of construction, the testing locations for impulse radar, pachometer and pulse velocity testing typically covered large portions of the region. In general, locations were selected within each region without any motivation other than accessibility and therefore were considered to be as randomly selected as needed to obtain representative data. Additional pulse velocity measurements were taken in the region around concrete core samples in order to correlate pulse velocity with compressive strength and concrete quality. For selection of core samples, the core locations were, in general, selected within each region of interest without any motivation other than accessibility and to miss the reinforcing steel embedded in the concrete. One location, Core B, was intentionally centered on an approximately vertical crack that did not have a vertical reinforcing bar directly behind the crack.

Page 1, Section 2.3 - Excessive cover over reinforcement reduces the effect on flexural capacity for out of plane forces. Does this also mean that a dynamic calculation may not be as forgiving as it ought to be? When mapping the cover on the reinforcing, it is really not just too thick, but a range of thicknesses, meaning that the flexural changes are not consistent. Could this introduce stress at the weaker points in a bending situation? Combined with the ASR problem, does it make any sense to save these walls?

The flexural capacity of reinforced concrete elements is a function of the distance between compression zone in the concrete and the tensile force provided by the reinforcing steel. The bending strength decreases as the distance decreases. Excess cover over reinforcing steel may or may not decrease the bending capacity dependent on the thickness of the member. However, CTL measurements of interior wall thicknesses did not indicate any excessive thickness as compared to thicknesses shown on the drawings. We did not drill through any exterior walls to measure thickness during the condition survey nor did we want to at this stage of the evaluation because of associated waterproofing problems. Based on current data, we recommend that the measured cover on reinforcement be used to determine out-of-plane bending capacity based on concrete thicknesses shown on the drawing for various components and a structural assessment be made of the possible ramifications of the as-found reinforcement locations. If out-of-plane bending is determined to be a problem using as-designed wall thicknesses, then further testing to determine as-built exterior wall thicknesses may be justified.

LANL, ESA-EA

The CDR prepared by Merrick and Company indicated that mix designs for the boron frit concrete had been found during their investigation. Although these mix designs were not approved, it is possible that these designs included reports on the chemical reactivity of the aggregates purposed for use. Unless suppliers were changed, it is likely that these aggregates were used in the actual construction. This should be investigated and included in the report.

The construction records were searched and no reports on the chemical reactivity of the aggregates were located.

With reference to the moisture content in the exterior walls: Do the concrete cores taken from the exterior walls not containing boron frit have an increased moisture content from those taken from interior walls? If so, can any correlation to the moisture content in the boron frit wall be made? The fact that existing storage racks along the exterior wall containing boron frit prevented samples from being taken in that area should be included in the report.

Moisture content in the core samples was not determined. The determination of moisture content and monitoring of moisture content is recommended as follow-on tests.

The report indicates the concrete cover as constructed, and, in some instances, indicates the specified cover. The specified cover for a given wall should be indicated in the body of the report along with the cover found in the field for each wall investigated. This information is contained in the data sheets but should be consistently addressed in the report. In addition, some discussion of cover tolerances as allowed by the ACI should be provided.

ACI tolerance information has been added in Section 4.2.

Concrete compression tests indicate relatively high strength concrete but there is no discussion or indication of what the specified concrete strengths were. This information should be presented in the report.

Compressive strengths are not listed in Section 2.2, a summary of the findings, but ranges and averages are discussed in Section 5.3.

Figures A.1, A.2, and A.3 were not found in Appendix A. In addition, Figures A.4 and A.5 were not labeled.

The report now includes Figures A.1 to A.4. The original figures were redrawn and combined such that Figure A.5 no longer exists.

The discussion in Appendix C references a Figure C.3. This figure was not included.

The figure number has been changed to C.1. The figure is now included in the report.

DRAFT

NUCLEAR MATERIALS STORAGE FACILITY

CONSTRUCTION PHASE

QUALITY ASSURANCE PROGRAM

1.0 QUALITY ASSURANCE PROGRAM

1.1 Introduction

The Contractor shall implement and maintain an effective Quality Assurance Program (QAP) for the construction phase of the Nuclear Materials Storage Facility (NMSF). The QA Program shall describe or reference the organization structure, functional responsibilities, levels of authorities and interfaces for the conduct of quality affecting activities. The QA Program shall include methods for the management, performance, and assessment of the adequacy of quality affecting activities, including items or services provided by outside organizations.

In developing the Quality Program for the NMSF, consideration shall be given to the scope of work; the quality affecting activities to be performed; the technical aspects of the activities affecting quality; the need for special controls over selected activities; the criticality of those activities to the operability, reliability, maintainability; and the safety and performance of the facility.

The quality program shall provide adequate quality throughout all areas of contract performance, including procurement, construction, installation, and test activities.

1.2 Graded Approach

The implementation of control measures to specific activities shall be consistent with a graded approach or a system of quality level classifications based on consideration of risk. The graded approach is intended to provide a practical and flexible quality program that is cost effective in the implementation of control measures during procurement, construction, installation, or test activities. Items or activities important to safety shall be subject to more stringent operational and verification requirements than those not important to safety.

1.4 Personnel Training

Personnel performing activities affecting quality shall receive indoctrination and training to the requirements of the QA Program with a focus on the individual's responsibility for quality. Training shall be provided to project procedures and/or work instructions, as appropriate, to assure that suitable proficiency is achieved and maintained.

Personnel performing activities that require specific qualification and certification requirements to industry codes or standards, i. e., non-destructive examination, welding, etc., shall be identified and appropriately "Certified" prior to performance of the activity.

2.0 Quality Improvement

2.1 The Quality Assurance Program shall have an objective of continuous quality improvement through the prevention of defects and the early identification of potential quality problems. Quality concerns or problems shall be identified promptly and effective corrective measures implemented to resolve deficiencies.

Nonconforming items or processes shall be identified, documented, evaluated by the responsible

organization, dispositioned, and followed-up to ensure completion. Nonconforming items shall be appropriately controlled to prevent their inadvertent installation, test, or use. Nonconforming items dispositioned "accept-as is" or "repair" will require technical justification from the cognizant engineering organization and submittal to LANL/DOE for review and approval of the disposition.

Items that cannot be reworked to acceptance requirements will be identified as nonconforming and dispositioned as "Reject", "Repair", or "Accept-as-is". Dispositions of Repair or Accept-As-Is will be submitted to LANL/DOE for approval. Repaired items shall be inspected and/or tested to requirements specified in the Repair disposition.

3.0 Documents and Records

3.1 Documents

Documents that establish policy, prescribe work, specify requirements, or establish requirements for construction, installation, or test activities shall be controlled to ensure that only correct documents are used in the performance of quality affecting activities. The preparation, review, approval, issuance, use, and revision of these documents shall be controlled. Control measures implemented shall assure the technical adequacy of documents and the inclusion of appropriate requirements for quality.

Controlled documents include drawings, calculations, specifications, computer codes, work procedures, and instructions.

3.2 Records

A system shall be established and implemented to ensure that sufficient records that furnish objective evidence of quality are identified, prepared, reviewed, approved, and maintained to accurately reflect completed work. Records shall be legible, identifiable, and retrievable. The requirements for maintenance of records include provisions for the retention, protection, preservation, traceability, and retrieval. Quality assurance records include the following:

- Design support documents, e.g., drawings, design analyses, specifications, design review reports.
- Supplier/subcontractor documents/records
- Inspection/test records
- Nondestructive Examination Reports
- Completed acceptance test procedures
- Certified Material Test Reports
- As-constructed or as-built drawings, (including red-lines)
- Welding and Nondestructive Examination Personnel certification records

Original entries on quality records shall not be erased or obliterated. Corrections or changes to quality records shall be made in ink by drawing a single line through the item to be corrected or deleted. The individual making the change shall initial and date the entry.

4.0 Procurement of Items and Services

4.1 Procurement Control

The procurement of items and services shall be controlled to assure conformance to project requirements. Control measures shall include the following as appropriate Source evaluation and selection, evaluation of

quality furnished by the Supplier, source inspection, audit, and examination of items or services upon receipt or completion.

Procurement documents shall include or reference applicable design bases and other technical requirements to assure adequate quality, including the following, as appropriate:

- Scope of work
- Technical Specifications/Requirements
- Applicable design bases
- Quality Program Requirements
- Subcontracting Requirements
- Documentation requirements

The selection of Supplier's of items important to safety shall be based on their capability to provide items or services in accordance with the requirements of procurement documents.

4.2 Acceptance of Items

The quality of purchased items and services shall be verified in consideration of the item's or service's complexity, importance to safety, or facility operational performance or risk. Acceptance of items will include appropriate controls for the selection, evaluation, and acceptance upon receipt of purchased items, including commercial grade items, as appropriate, to ensure items will perform as expected. Methods of acceptance include:

- process or acceptance test data
- inspection upon receipt
- source verification
- certificate of conformance
- post installation test at the facility, or
- a combination of the above

4.3 Supplier Nonconformances

Items or services furnished by Suppliers' that do not meet the requirements of the procurement documents shall be documented and submitted to the project for review. The submittal will include the recommended disposition (e.g., accept-as-is or repair), as well as technical justification of the disposition.

5.0 Work Processes

5.1 Procedures and Instructions

Quality affecting activities shall be performed in accordance with approved work procedures, instructions or drawings that include or reference qualitative or quantitative criteria for determining that activities have been satisfactorily accomplished. The contractor shall be responsible to ensure that appropriate drawings, procedures or work instructions are used to prescribe and control activities affecting quality. Training sessions should emphasize the importance and the responsibility of the individual in achieving acceptable levels of quality in their work.

5.2 Identification and Control of Items

The QA Program shall provide measures to assure that only correct and accepted items are used or installed in the facility. Identification shall be on the item, or on records traceable to the item, in a manner

which assures identification is established and maintained. Identification markings shall be applied using materials and methods which provide clear and legible identification and is not detrimental to the function or service life of the item.

5.3 Storage and Handling of Items

The quality assurance program shall incorporate measures to protect and control the handling, preservation, and storage of items to prevent damage, loss, or deterioration from their receipt through installation in the facility. Appropriate identification of items, including inspection status, shall be maintained.

5.4 Calibration of Measuring and Test Equipment

Tools, gages, instruments, and other measuring and test equipment used for activities affecting quality shall be controlled and calibrated to known national standards at specified intervals to maintain the required accuracy. The method and interval of calibration for each item shall be prescribed and uniquely identified to indicate the calibration status.

Measuring and test equipment found out-of-calibration or out-of-tolerance shall be tagged and removed from service. Items inspected and accepted with out-of-calibration equipment must be evaluated to determine the acceptability of previous inspections and tests.

5.5 Inspection and Acceptance Testing

5.1 Inspection

Inspections shall be performed to verify conformance of an item or activity to specified requirements. Inspection activities shall be documented and controlled by instructions, procedures, drawings, checklists, or other appropriate means. The QA Program shall provide for the performance of inspections, nondestructive examinations, and surveillance of quality affecting activities to verify compliance to project drawings and specifications. The QA Program shall identify when and the type of inspections required, e.g., receipt, source, in-process, final, etc.. The requirements for these activities should be delineated in inspection plans, checklists, and acceptance test procedures that provide both quantitative and qualitative criteria. Inspection and test personnel shall be qualified and certified, as appropriate, to requirements of applicable industry codes and standards. The QA Program shall also include measures for verification of contractor or subcontractor personnel qualifications and certifications.

Items not meeting the criteria for acceptance shall be identified and dispositioned as to rework, repair, accept, or reject, as appropriate. Reworked or repaired items shall be reinspected or retested to design requirements.

5.2 Acceptance Testing

Acceptance testing of specified items and processes shall be conducted using established acceptance and performance criteria. Equipment used for inspections and tests shall be calibrated and maintained.

6.0 Assessments / Audits

6.1 Management Assessment

Management shall periodically assess the QA Program and its performance. The assessments should be conducted of those quality affecting activities that most directly impact the attainment of project objectives for quality. Assessments should focus on improving output quality and includes evaluating work

performance and process effectiveness, identifying potential problems and potential improvements, and verification of satisfactory resolutions of reported problems. The results of assessments shall be reported to management for review and corrective action, as appropriate. Problems that may prevent the attainment of project goals shall be identified and corrected.

6.2 Quality Assurance Audits

Performance based audits shall be conducted to verify compliance with all aspects of the quality assurance program. Audits shall be performed in accordance with written checklists by qualified and certified personnel. Performance based audits evaluate the effectiveness of implementation of the quality program through the review of quality documentation, practices, procedures, and instructions. Audit results shall be documented and distributed to the audited organization and appropriate levels of management. Conditions adverse to quality require remedial action as well as corrective action to prevent recurrence. Follow-up to verify implementation of the planned corrective action and evaluate the effectiveness of the corrective action shall be performed.

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