RCRA PART B PERMIT REAPPLICATION

FOR THE
IDAHO NATIONAL LABORATORY

VOLUME 22
IDAHO NUCLEAR TECHNOLOGY & ENGINEERING CENTER

CALCINED SOLIDS STORAGE FACILITY

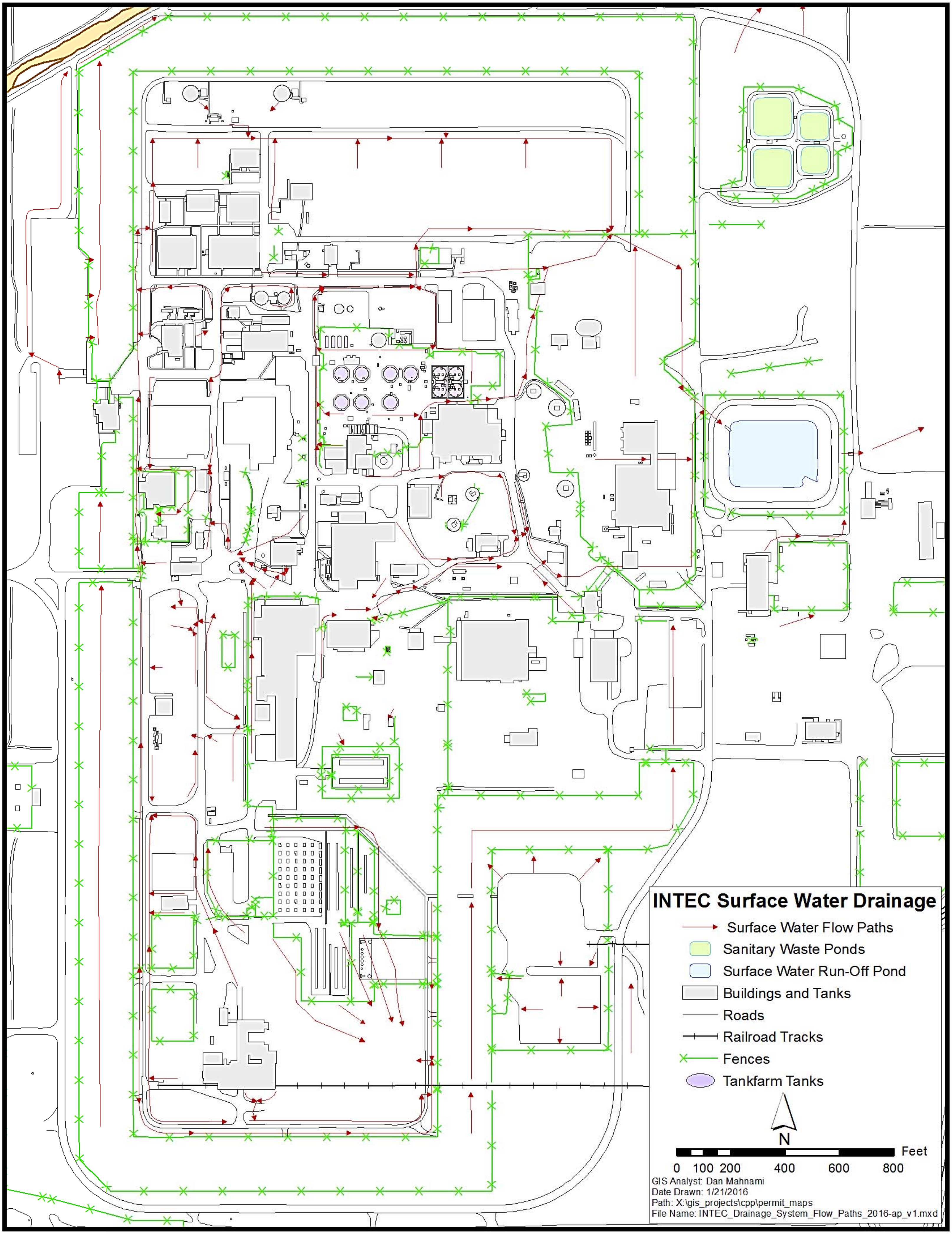
APPENDIX 1

CSSF FACILITY DRAWING LIST
AND DRAWINGS

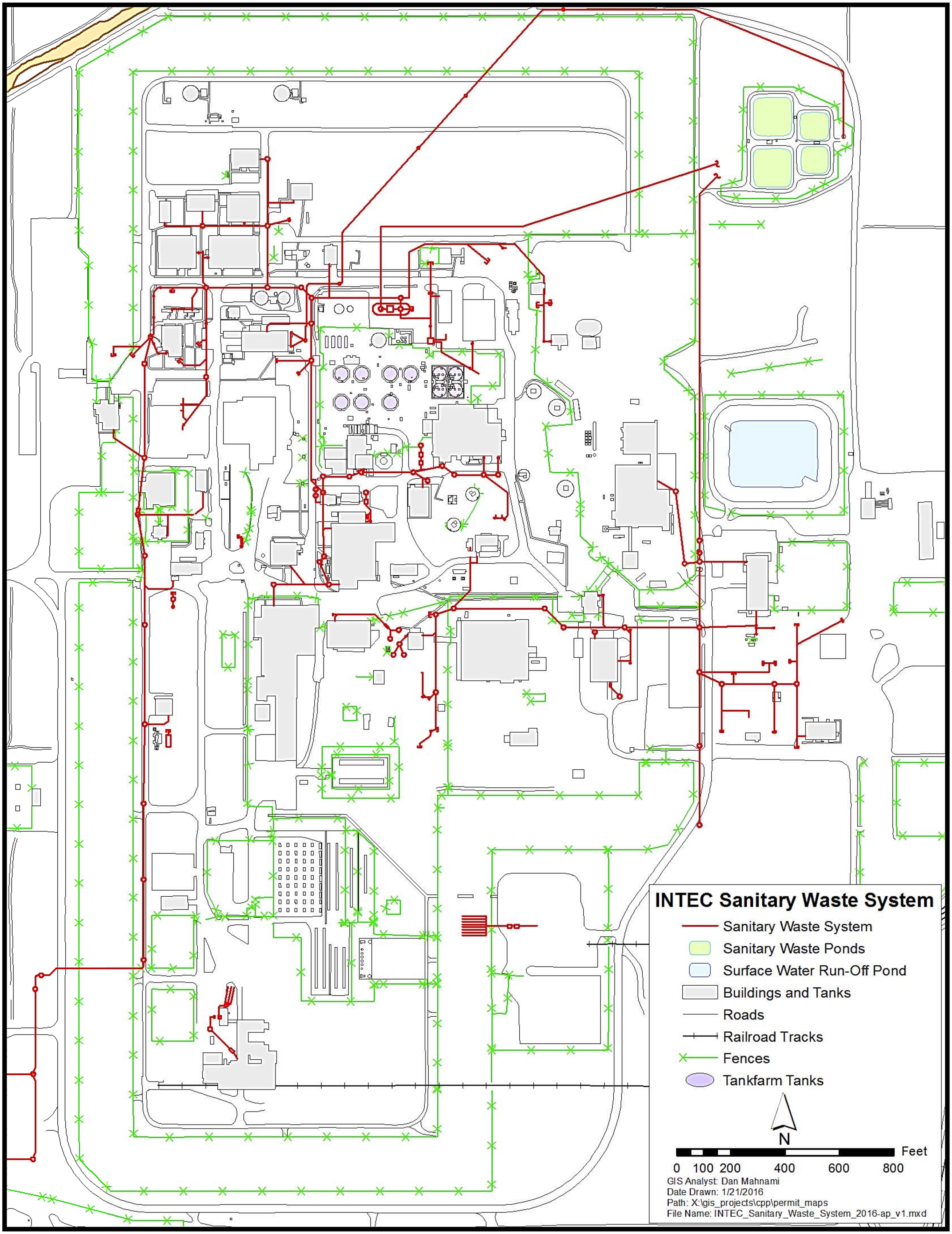
MAY 2016

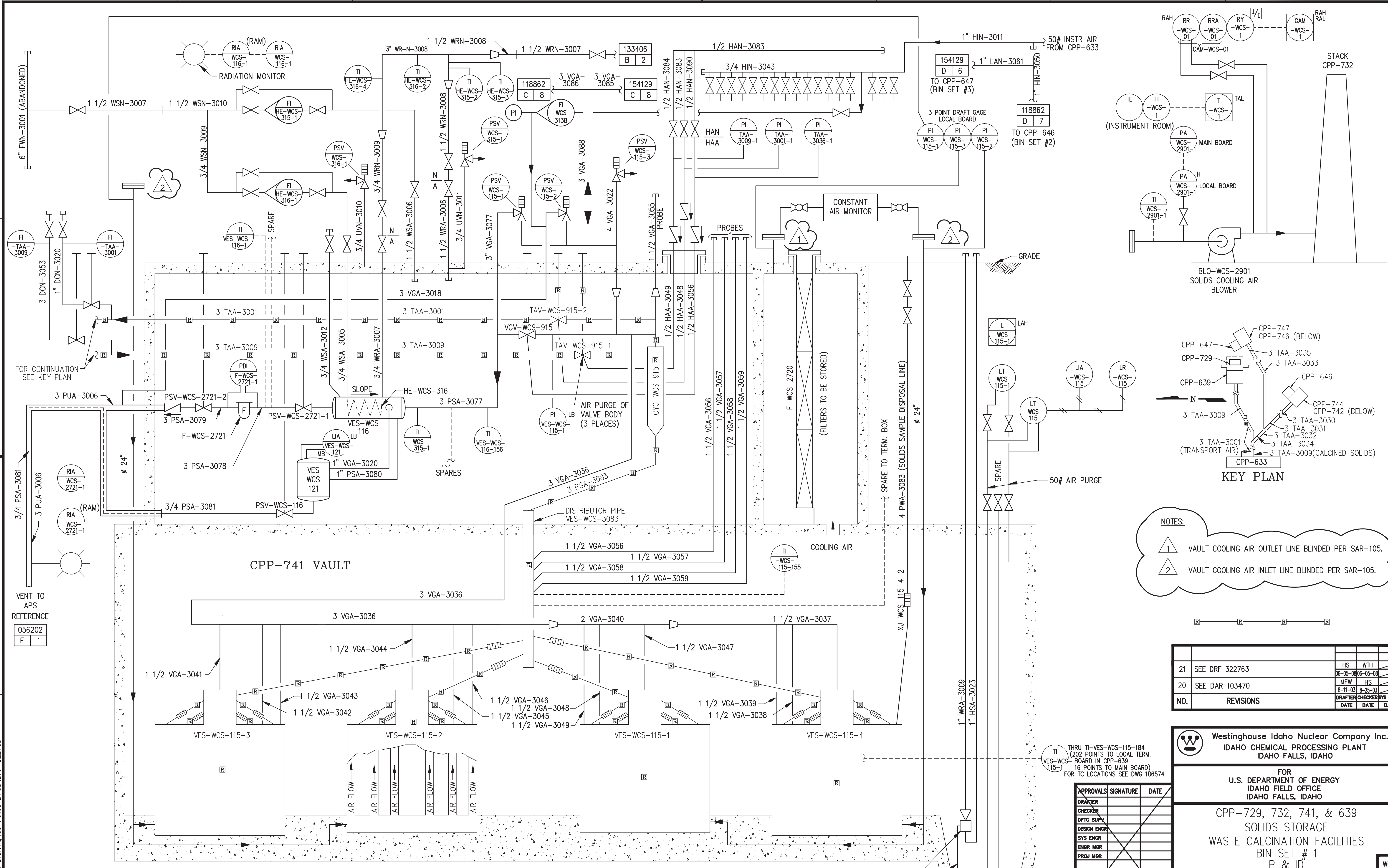
Drawing List

Drawing No.	Building/Drawing Description	Revision No.
N/A	INTEC Surface Water Drainage System	1/21/2016
N/A	INTEC Sanitary Waste System	1/21/2016
106576	CPP-741 (CSSF 1)	21
106577	CPP-741 (CSSF 1)	8
106574	CSSF-1 Thermocouples	13
118862	CPP-742 (CSSF 2)	12
118871	CPP-742 (CSSF 2)	5
118888	CSSF-2 Thermocouples	6
153510	CPP-746 (CSSF 3)	6
154129	CPP-746 (CSSF 3)	9
154127	CSSF-3 Thermocouples	4
155750	CPP-760 (CSSF 4)	5
157798	CPP-760 (CSSF 4)	20
157814	CSSF-4 Thermocouples	5
158491	CPP-765 (CSSF 5)	31
158510	CPP-765 (CSSF 5)	3
158523	CSSF-5 Thermocouples	5
160283	CPP-791 (CSSF 6)	7
161425	CPP-791 (CSSF 6)	20
161448	CSSF-6 Thermocouples	3
099162	CPP-795 (CSSF 7)	5
165772	CPP-795 (CSSF 7)	5
168211	CSSF-7 Thermocouples	2



INTEC Surface Water Drainage
Surface Water Flow Paths
Sanitary Waste Ponds
Surface Water Run-Off Pond
Buildings and Tanks
Roads
Railroad Tracks
Fences
Tankfarm Tanks
N
Feet
0 100 200 400 600 800
GIS Analyst: Dan Mahnami
Date Drawn: 1/21/2016
Path: X:\gis_projects\cpp\permit_maps
File Name: INTEC_Drainage_System_Flow_Paths_2016-ap_v1.mxd


INTEC Sanitary Waste System
Sanitary Waste System
Sanitary Waste Ponds
Surface Water Run-Off Pond
Buildings and Tanks
Roads
Railroad Tracks
Fences
Tankfarm Tanks
N
Feet
0 100 200 400 600 800
GIS Analyst: Dan Mahnami
Date Drawn: 1/21/2016
Path: X:\gis_projects\cpp\permit_maps
File Name: INTEC_Sanitary_Waste_System_2016-ap_v1.mxd



NOTES:

1. VAULT COOLING AIR OUTLET LINE BLINDED PER SAR-105.
2. VAULT COOLING AIR INLET LINE BLINDED PER SAR-105.

NO.	REVISIONS	DRAFTER DATE	CHECKER DATE	SYS ENGR DATE
21	SEE DRF 322763	HS 06-05-08	WTH 06-05-08	
20	SEE DAR 103470	MEW 8-11-03	HS 8-25-03	

Westinghouse Idaho Nuclear Company Inc.
IDAHO CHEMICAL PROCESSING PLANT
IDAHO FALLS, IDAHO

FOR
U.S. DEPARTMENT OF ENERGY
IDAHO FIELD OFFICE
IDAHO FALLS, IDAHO

APPROVALS	SIGNATURE	DATE
DRAFTER		
CHECKER		
DFTG SUPV		
DESIGN ENGR		
SYS ENGR		
ENGR MGR		
PROJ MGR		

CPP-729, 732, 741, & 639 SOLIDS STORAGE WASTE CALCINATION FACILITIES BIN SET # 1 P & ID

WCS

SCALE
DATE ISSUED

DWG. SIZE	AREA	DWG TYPE	CL	ORIG.	DRAWING NUMBER	REV.
D	200	0729	24	287	106576	21

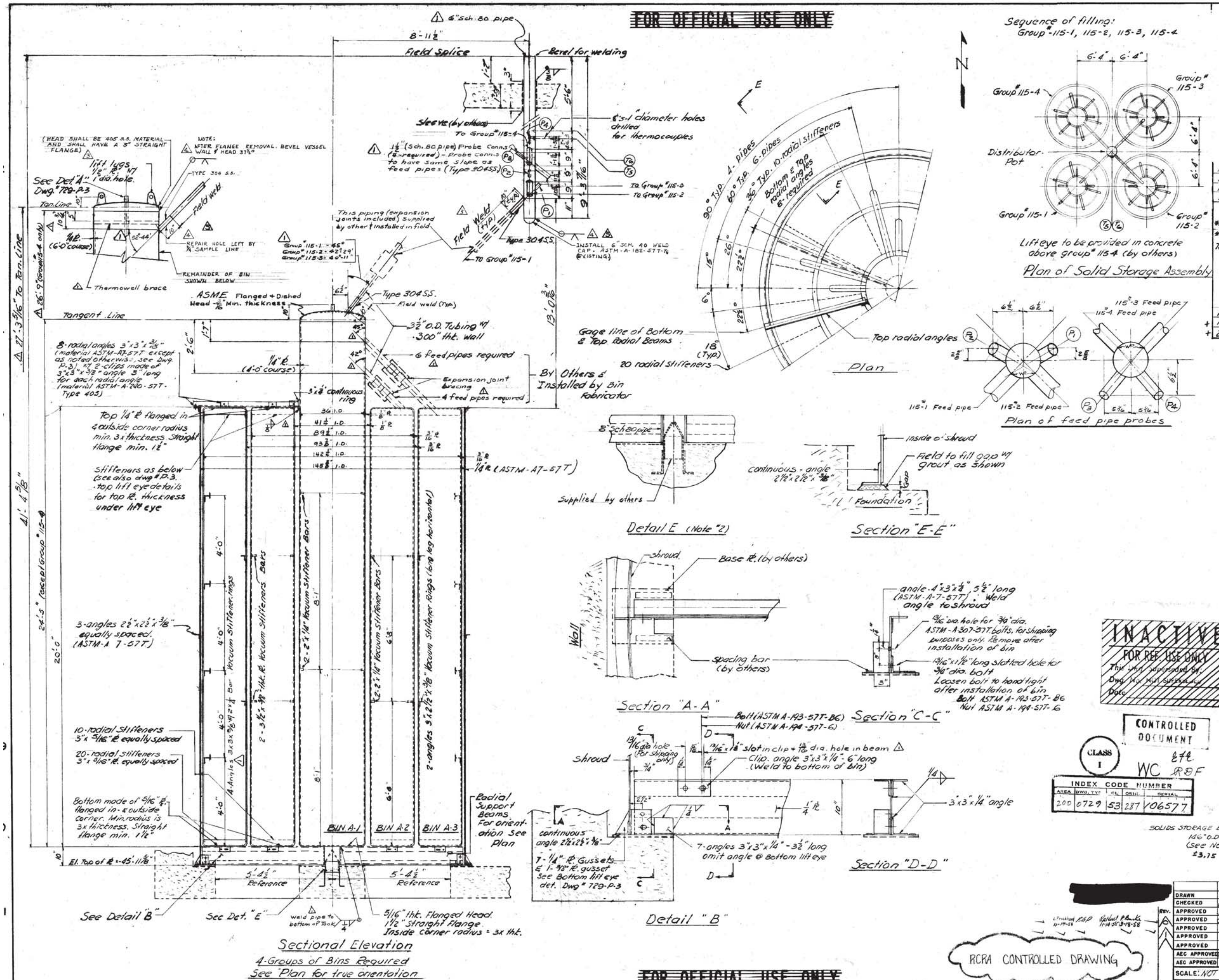
INDEX CODE NUMBER				
AREA	DWG TYPE	CL	ORIG.	SERIAL
200	0732	24	936	106576
200	0741	24	936	106576
200	0639	24	936	106576

JOB NUMBER 155754 TAKEN FROM DRAWING NO. REDRAWN

CAD GENERATED – AUTOCAD

File: 106576-21.dwg Date: 06/05/08 – 12:47 PM Layout Name: Model By: HSPENCER
Path: K:\INTEC Misc Drafting\Controlled DWGS\DRF-322763

FOR OFFICIAL USE ONLY



INDEX	CODE	NUMBER			
AREA	DWG. TYP	CL	ORIG.	SERIAL	
200	0729	53	287	Y06577	

SOLIDS STORAGE BINS
146" O.D. x 20'-0"
(See Note #10)
£3.15 650

NONE - ASME CONSTRUCTION
Spec. # 5775-CPP-P10
+ or - 3.75 650
+ or - 3.3 850

NO
SEE Specifications
80 80

None None

unless otherwise noted on Dwg.

14. Plate: ASTM A-240-57T type 405 *
15. Tubing: ASTM A-268-57T type 405 *
16. Bolts: ASTM A-193-57T - B6
17. Nuts: ASTM A-194-57T-6

* Hot rolled, heat treated, blast cleaned or pickled.
** Bins assumed 100% full.
Testing: Bins shall be subjected to a pneumatic test pressure of 4 psig, (external & internal) (see Specifications)
\+ Weights are for complete Assembly of 4 Groups, distributor pot & piping

18. Inspected by Fluor's & Customer's inspectors
19. Total estimated Fabrication Weight 113,000 LBS
20. Estimated operating weight 528,000** LBS

INACTIVATED

Notes:
1. Gaskets for "Trial Run" to be Garlock #7022 or equal
2. Slide Ꝑ & centering cone supplied by others
3. Bolts are 3/4" ɸ
4. Material of bolts used for shipping only = ASTM-A-7-57T
5. Top radial angles for shipping & installation purposes only. Remove after installation.
6. Clips connecting shroud to bottom radial beams for shipping & installation purposes only. Remove bolts after installation of Bins.
7. After installation remove shipping bolts in clips connecting bins to bottom radial beams; then loosen bolts in slotted holes (hand tight)
8. Cut bracings of expansion joints after installation
9. For connections & Lift eye details see Dwg. #-CPP-729-P-3
10. One name plate req'd for each of the four Groups. Group numbers to be:
5775-WC-115-1
5775-WC-115-2
5775-WC-115-3
& 5775-WC-115-4
11. All nozzle openings to be 100% reinforced except thermo wells. (See thermo-well detail)
12. Field welding shall be in accordance w/ Paragraph P10-7 of specification 5775-CPP-P10

AS BUILT

NO.	DATE	DESCRIPTION	DWN	CHK	APPVD
8	6-24-94	REVISED PER DCN 155754-AB6	MW		
7	4-1-94	ACTIVATED PER DCN# 155754-AB6	JPD	RSA	

REVISIONS

CPP-729 BIN SET I VESSEL
VES-WC-115-1,2,3+4
SOLIDS STORAGE BINS
WASTE CALCINATION FACILITIES

THE FLUOR CORPORATION LTD.
ENGINEERS AND CONSTRUCTORS
LOS ANGELES CALIFORNIA

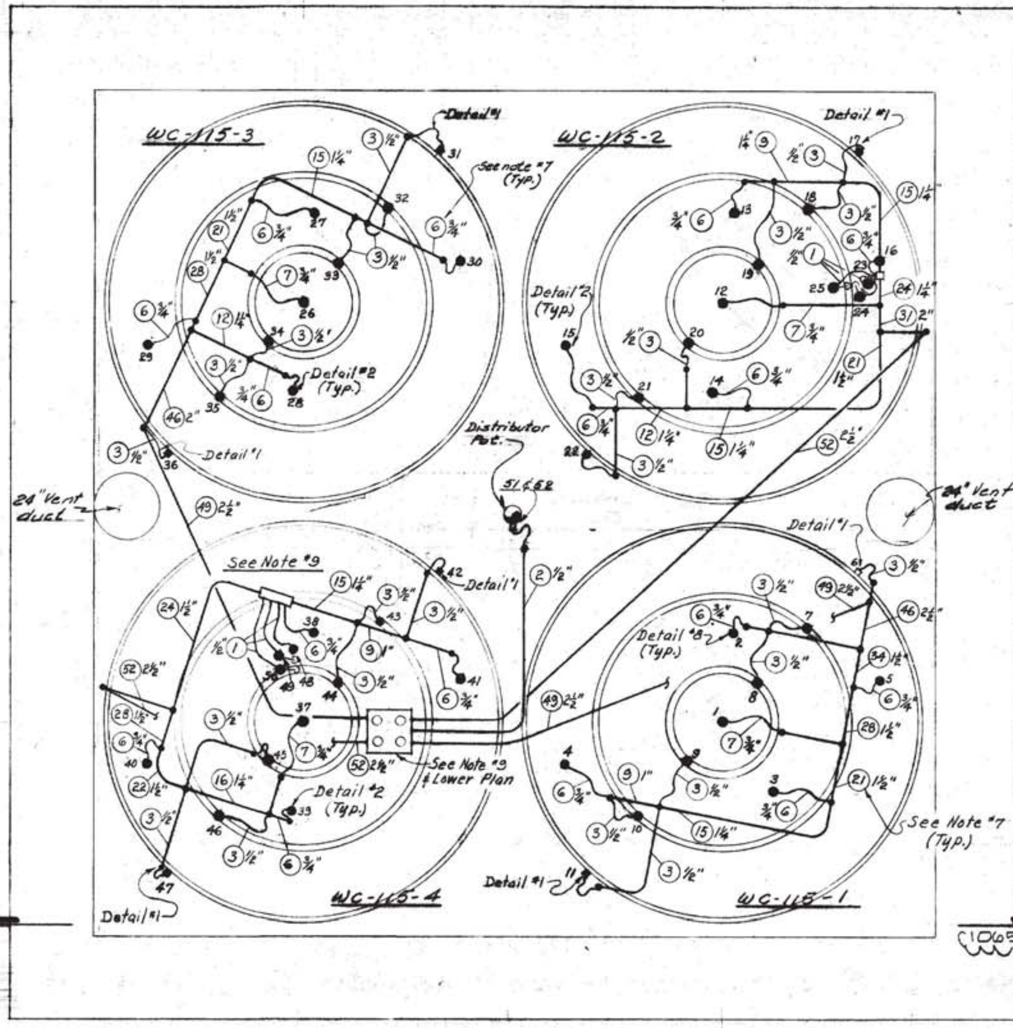
FOR
U.S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
IDAHO FALLS, IDAHO

[redacted]

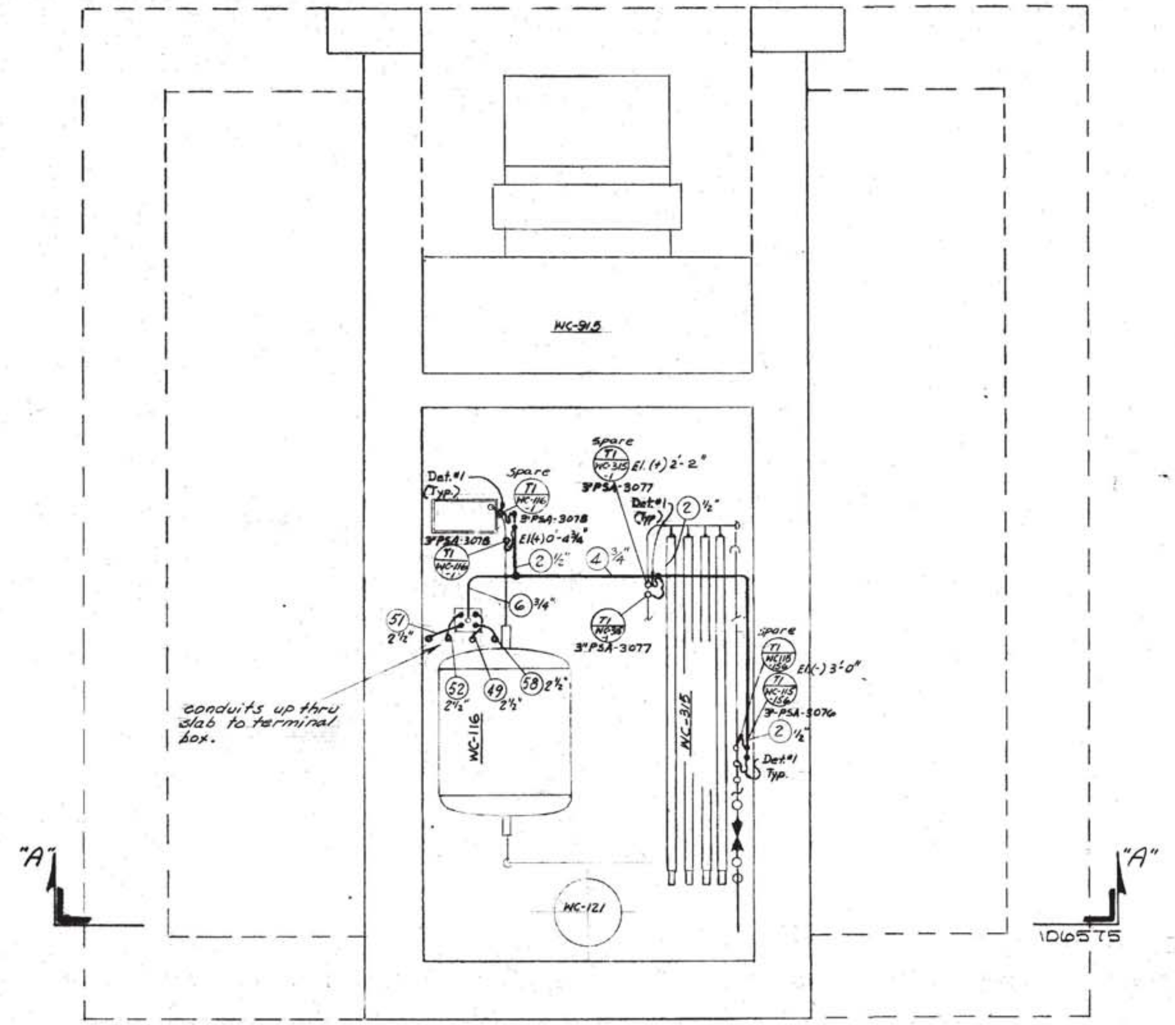
	BY	DATE
DRAWN		6-4-58
CHECKED		11-4-58
APPROVED		9-22-58
APPROVED		9-23-58
APPROVED		
APPROVED		
AEC APPROVED		11-14-58
AEC APPROVED		

SCALE: NOT TO SCALE
DATE: 11-14-58
DWG. No. 5775-CPP-729-P-2 REV. 6

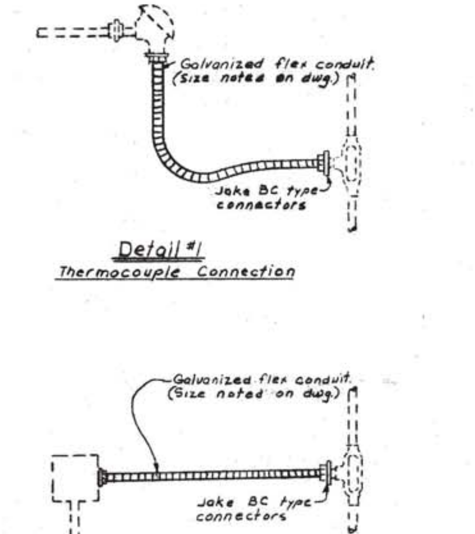
FOR OFFICIAL USE ONLY



Plan Of Solids Storage Bins
(Indicating thermocouple connections)
Scale: 3/8" = 1'-0"



Lower Plan El(+) 4'-10" to (-) 4'-11"
Scale: 1/8" = 1'-0"



Detail #1
Thermocouple Connection

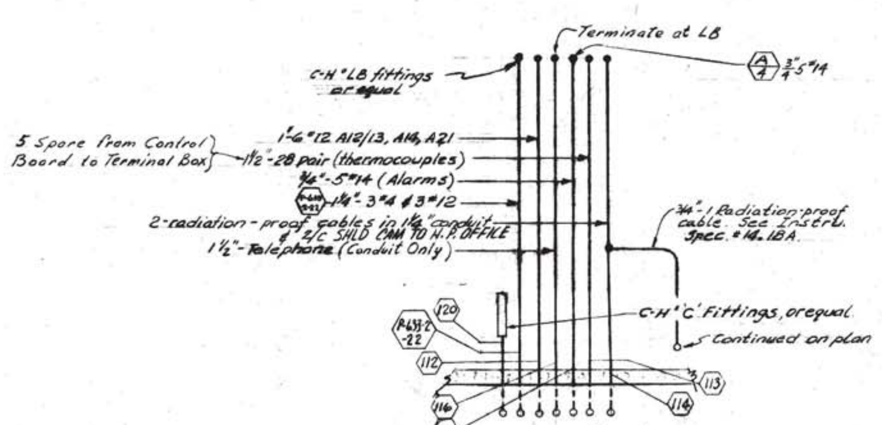
Detail #2
Thermocouple Connection

Notes

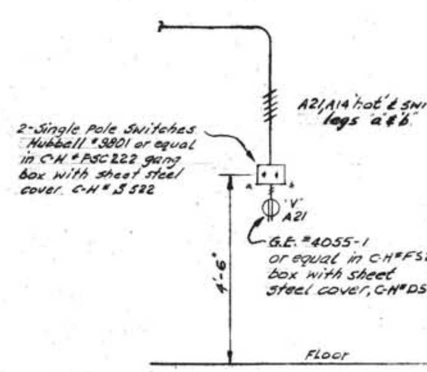
1- For material see Bill of material #729-E-1 (Separate sheet)
2- For Ltg. panel schedule, see dwg. # 633-E-6
3- Numbers shown refer to thermocouples' location.
For the number and tag of thermocouples in each location see Instru. spec. #5775-CPP-TI sheet #2.01F
4. All conduit to be rigid steel, galvanized, unless noted.
5. All conduit fittings to be Crouse-Hinds Obround, or equal.
6. All thermocouple wire to be #16 Ga.
7. ④½" Signifies 4 pair thermocouple wire in ½" conduit. typical.
8. For notes & symbols see dwg. #401-5.
9. Continue Conduits to Pull Box Shown in Section "A-A" on Drawing 106575, Where Wires Shall be Rearranged To Enter Thermocouple Terminal Box in Correct Order.

CONTROLLED DOCUMENT

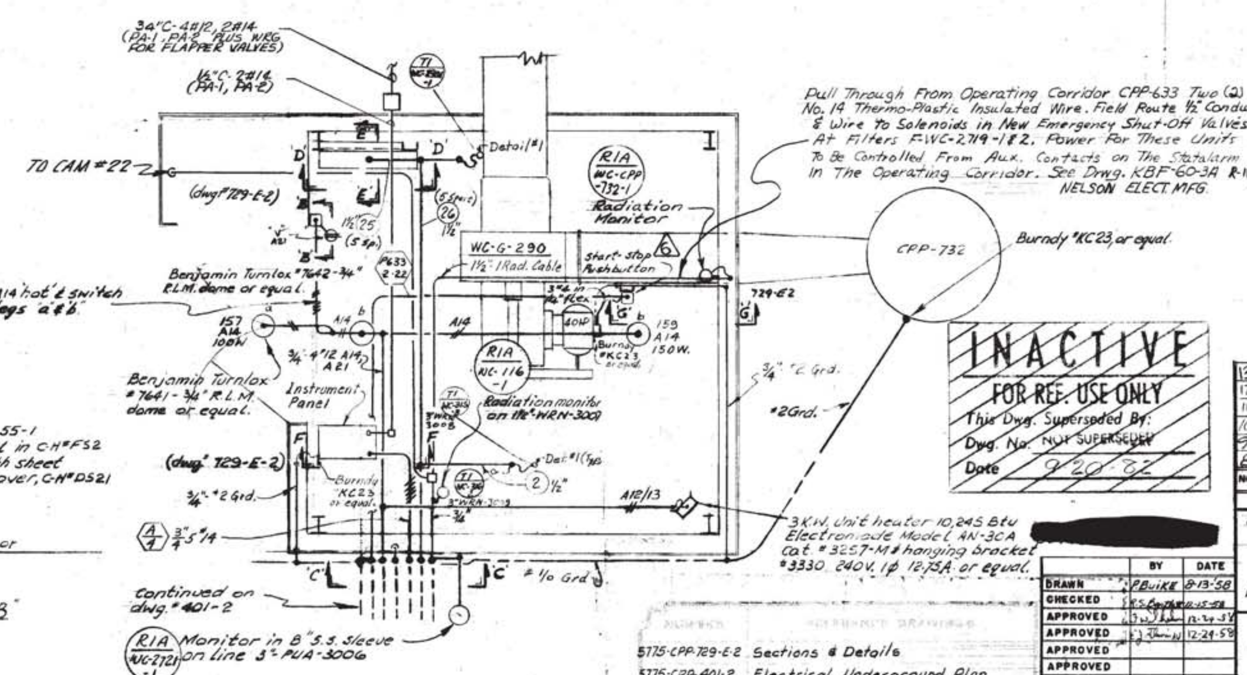
CLASS I



Section "C-C"
No Scale



Section "B-B"
No Scale



Upper Plan El(+) 4'-10" And Above
Scale: 1/8" = 1'-0"

INDEX CODE NUMBER
DWG. TY.	DWG. NO.	SH.	ORIG.	SERIAL
200	0729		10	287 106574

RCRA CONTROLLED DRAWING

AS BUILT

INACTIVE
FOR REF. USE ONLY
This Dwg. Superseded By:
Dwg. No. NOT SUPERSEDED
Date 9-20-82

[redacted]

NO.	DATE	DESCRIPTION	LOC.	APPVD	AEC APPVD
13	6-23-94	REVISED PER DCN #155754-AB40 MW			
12	5-26-94	REVISED PER DCN #155754-AB22			
11	9-20-82	INACTIVATED KWS			
10	3-31-80	SEE DCN 79-0227 G. Cee			
9	10-28-75	SEE DCN			
8	8-26-74	SEE DCN REV BY DCP			

REVISIONS

NUMBER	REFERENCE DRAWINGS
5775-CPP-729-E-2	Sections & Details
5775-CPP-401-2	Electrical Underground Plan
5775-CPP-729-S2	Plans & Elev. (+) 4'-10" to (-) 4'-11"
5775-CPP-729-P-10	Piping Plan "D"
5775-CPP-401-4	Electrical conduit schedule
5775-CPP-401-5	Electrical Notes & Symbols

	BY	DATE
DRAWN	P. Buike	8-13-58
CHECKED	R.S.	12-15-58
APPROVED		12-24-58
APPROVED		12-24-58
APPROVED		
APPROVED		
APPROVED		
AEC APPROVED		1-15-59
AEC APPROVED		

SCALE: AS NOTED
DATE: 1-15-59

CPP-729 BIN SET #1

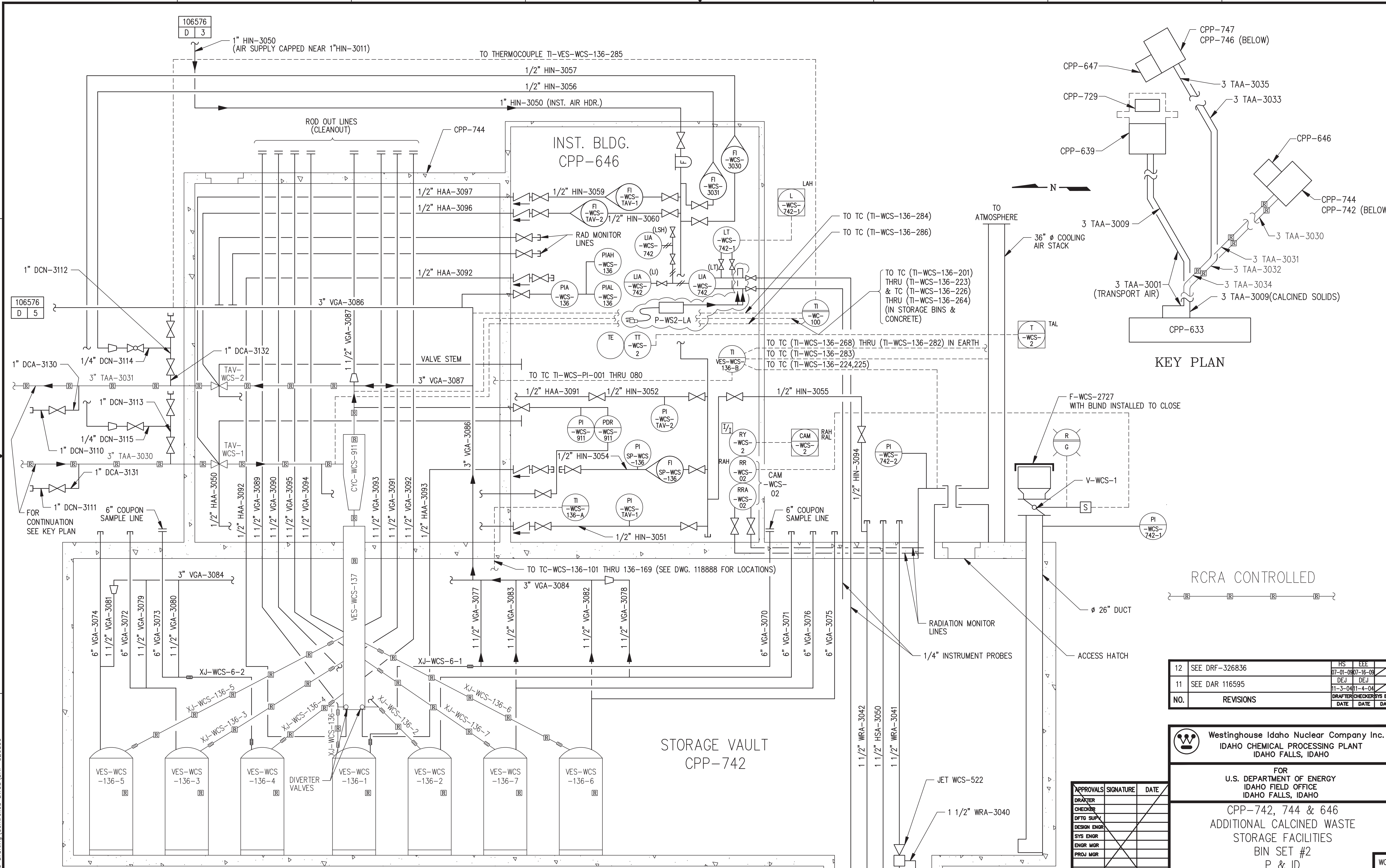
ELECTRICAL PLANS AND THERMOCOUPLE CONNECTIONS
WASTE CALCINATION FACILITIES

THE FLUOR CORPORATION LTD.
ENGINEERS AND CONSTRUCTORS
LOS ANGELES CALIFORNIA

FOR

U.S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
IDAHO FALLS, IDAHO

DWG. No. 5775-CPP-729-E-1 REV. 13



NO.	REVISIONS	DRAFTER DATE	CHECKER DATE	SYS ENGR DATE
12	SEE DRF-326836	HS 07-01-09	EEE 07-16-09	
11	SEE DAR 116595	DEJ 11-3-04	DEJ 11-4-04	

Westinghouse Idaho Nuclear Company Inc.
IDAHO CHEMICAL PROCESSING PLANT
IDAHO FALLS, IDAHO

FOR
U.S. DEPARTMENT OF ENERGY
IDAHO FIELD OFFICE
IDAHO FALLS, IDAHO

CPP-742, 744 & 646 ADDITIONAL CALCINED WASTE STORAGE FACILITIES BIN SET #2 P & ID

INDEX CODE NUMBER				
AREA	DWG TYPE	CL	ORIG.	SERIAL
200	0646	24	613	118862
200	0744	24	613	118862

APPROVALS	SIGNATURE	DATE
DRAFTER		
CHECKER		
DFTG SUPV		
DESIGN ENGR		
SYS ENGR		
ENGR MGR		
PROJ MGR		

SCALE NONE
DATE ISSUED

DWG. SIZE	AREA	DWG TYPE	CL	ORIG.	DRAWING NUMBER	REV.
D	200	0742	24	613	118862	12

WCS

JOB NUMBER 155754 TAKEN FROM DRAWING NO. REDRAWN

CAD GENERATED - AUTOCAD

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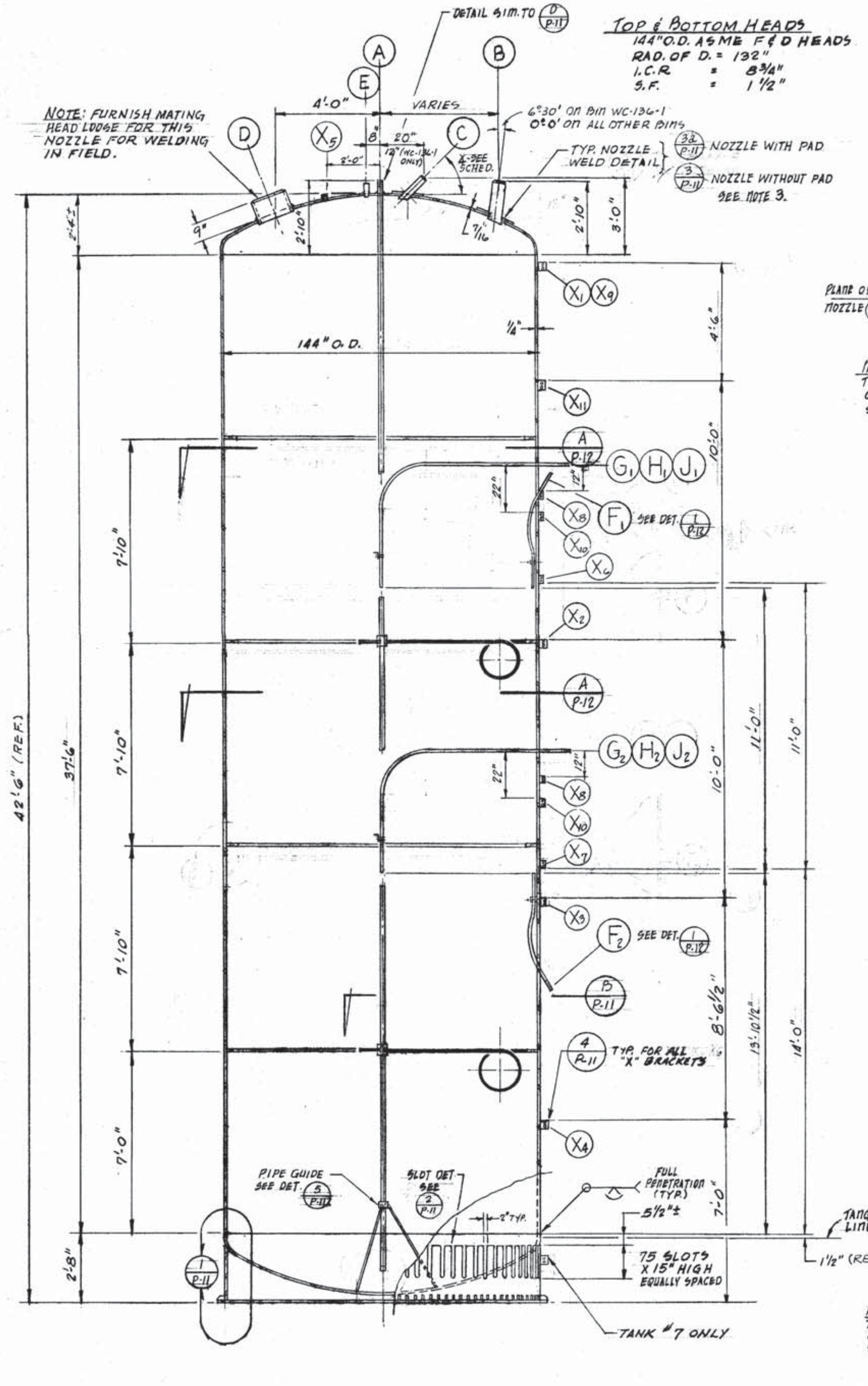
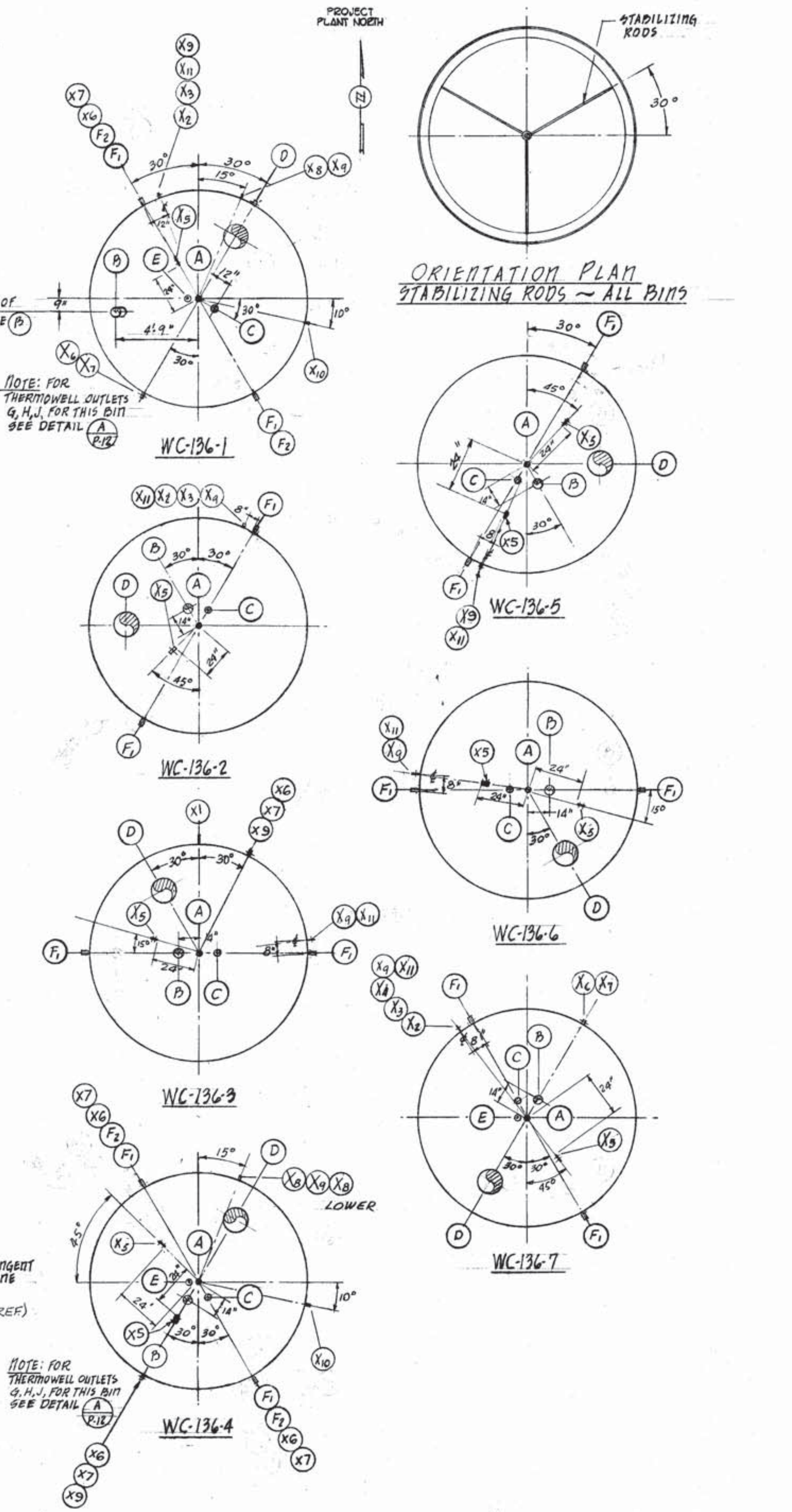
Path: K:\INTEC Misc Drafting\Controlled DWGS\DRF-326836



SOLIDS STORAGE BIN
SCALE: 3/8" = 1'-0"
FOR NOZZLE ORIENTATION SEE INDIVIDUAL STORAGE BIN PLAN



NOZZLE ORIENTATION PLANS
NO SCALE

NOZZLE SCHEDULE

ITEM	IDENTITY	SIZE	BIN NO.	REMARKS
A	THERMO-WELL	1½" SCH. 160 S	ALL BINS	LOCATED ON CENTER LINE OF BIN
B	SOLIDS REMOVAL	6" SCH. 40 S	ALL BINS	TANK VENTED THRU THIS NOZZLE.
C	FILL LINE	3" SCH. 40 S	ALL BINS	FOR ANGLE OF NOZZLE SEE SCHEDULE BELOW
D	MANWAY	18" O.D. x ¼" WALL	ALL BINS	18"x¼" WALL ASME. F&D (W/ BEVEL EDGE) HEAD W/ 1½" STRAIGHT FLANGE. FURNISH LOOSE.
E	THERMO-WELL		WC-136-1 WC-136-4 WC-136-7	TRINITY THERMOCOUPLE WELL CAT. NO. T-141-3"-304 SS OR EQUAL.
F1 F2	THERMO-WELL	½" SCH. 160 S	F1 - ALL BINS F2 - WC-136-1, WC-136-4	SEE DETAIL 1/P-12
G1 H1 J1 G2 H2 J2	THERMO-WELL	½" SCH. 160 S	WC-136-1 WC-136-4	SEE SECTION A/P-12 FOR ORIENTATION USED ON BINS 136-1 & 4 ONLY
X	SUPPORT BRACKET		ALL BINS	SEE DETAIL 4/P-11

NOZZLE 'C' SCHEDULE

NOTE: THE VERTICAL ANGLE OF NOZZLE "C" IS MEASURED WITH THE HORIZONTAL AND IN THE PLANE OF THE NOZZLE & THE BIN ℄. ANGLE TOLERANCE IS ± ½ DEGREE.

BIN NO.	ANGLE
WC-136-1	90°-0'
WC-136-2	45°-0'
WC-136-3	51°-0'
WC-136-4	49°-0'
WC-136-5	52°-30'
WC-136-6	55°-30'
WC-136-7	54°-0'

NOTES.

1. BINS SHALL BE FURNISHED IN ACCORDANCE WITH SPECIFICATION P-7
2. SUPPORT BRACKET "X" NOS. SIGNIFY LOCATION ON BINS
3. WHERE NOZZLES REQUIRING REINFORCING PADS HAVE ℄'S LESS THAN 18" APART, USE A COMMON PAD BETWEEN NOZZLES. PADS MAY BE SEGMENTED PROVIDED THAT THEY ARE MADE INTEGRAL BY MEANS OF FULL PENETRATION WELDS OF THE RADIAL JOINTS TO THE HEAD MATERIAL.

RCRA CONTROLLED DRAWING

CONTROLLED DOCUMENT

CLASS I

NO.	DATE	DESCRIPTION	LOC.	APPVD.	AEC APPVD.	PPCO. APPVD.
5	6-24-94	REVISED PER DCN#155754-AB43	MW	GS 6-28-94	DBJ 6-28-94	JW 6-28-94
4	4-1-94	PER DCN #155754-AB7	JPD		RSA	DMJ
3	9-22-82	INACTIVATED	KWG			
2	3-7-66	AS BUILT				
1	3/25/65	CHANGED SOME SUPPORT BRACKET LOCAT.				

REVISIONS

	BY	DATE
DRAWN	D. LEWIS	11/30/64
CHECKED	O. SCHR	12-4-64
APPROVED		12-4-64
APPROVED		12-4-64
APPROVED		
APPROVED		
PPCO. APPVD.	K.W.R.	1-22-65
AEC APPROVED	A.L.B.	1-22-65
AEC APPROVED	D.O.O.	1-22-65

SCALE: NOTED
DATE: 1-22-65

WCS

INDEX CODE NUMBER

AREA	DWG. TYPE	CL	ORIG.	SERIAL
200	0742	51	613	118 871

ADDITIONAL CALCINED WASTE STORAGE FACILITIES
SOLIDS STORAGE BINS

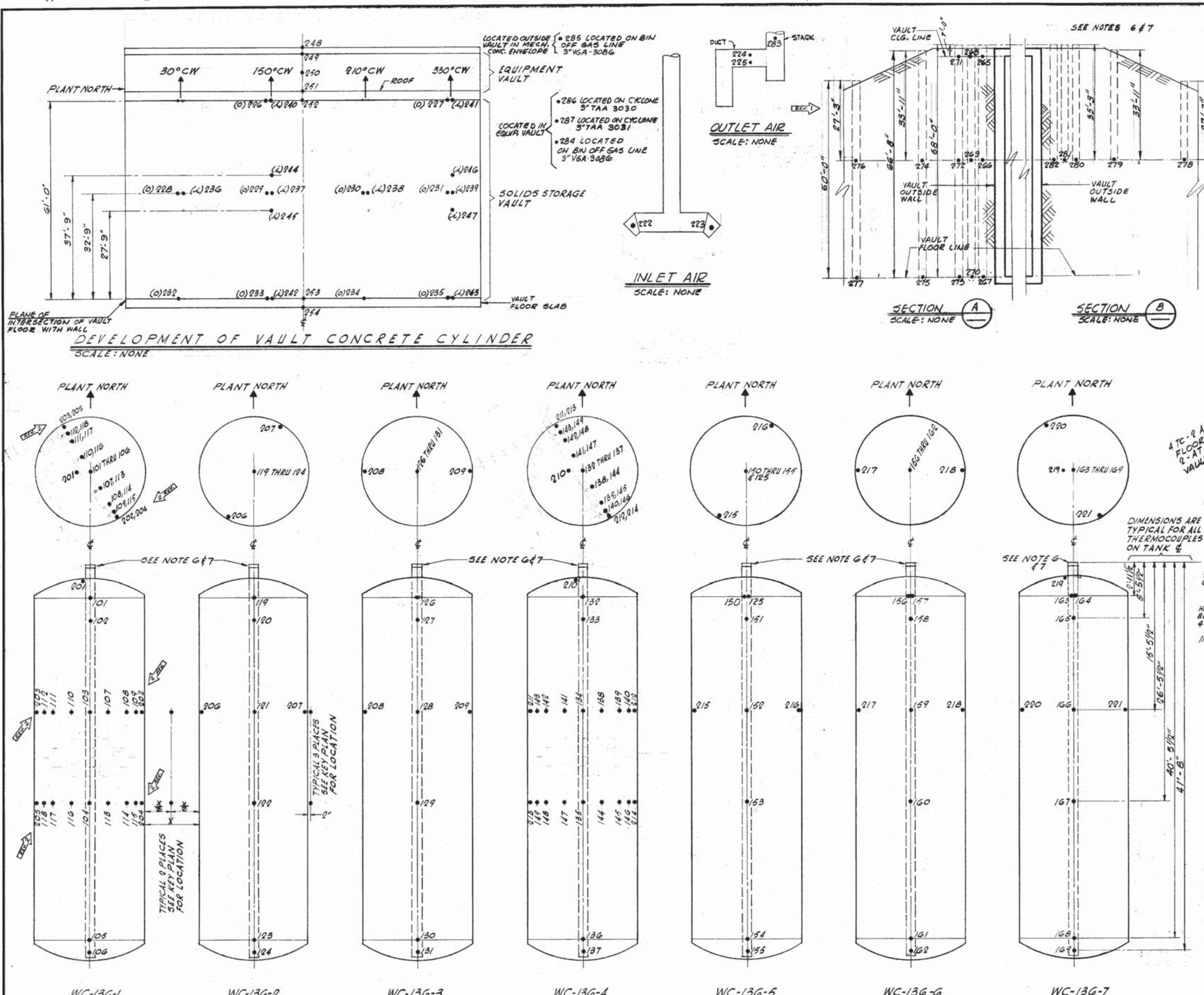
NORMAN ENGINEERING CO.
consulting engineers
LOS ANGELES, CALIFORNIA

FOR

U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
IDAHO FALLS, IDAHO

DWG. NO. 1200-CPP-742-P-10   REV. 5

CONTRACT AT (10-1)-1180



NOTES:

1- ONLY THE LAST THREE NUMBERS OF EACH THERMOCOUPLE NUMBER ARE USED. A COMPLETE THERMOCOUPLE NUMBER IS TI-WC-136-101.

2- ALL 100 SERIES THERMOCOUPLES ARE CONNECTED TO TEMPERATURE INDICATOR TI-WC-136-1 WITH A SCALE OF 0-2000°F.

3- ALL 200 SERIES THERMOCOUPLES ARE CONNECTED TO TEMPERATURE INDICATOR TI-WC-136-2 WITH A SCALE OF 0-800°F.

4- THERMOCOUPLE NUMBER WITH PREFIX (i) MEANS THAT THE THERMOCOUPLE IS LOCATED APPROXIMATELY 2" INSIDE THE INSIDE EDGE OF CONCRETE.

5- THERMOCOUPLE NUMBER WITH PREFIX (o) MEANS THAT THE THERMOCOUPLE IS LOCATED APPROXIMATELY 2" INSIDE THE OUTSIDE EDGE OF CONCRETE.

6- MULTIPOINT THERMOCOUPLE ASSEMBLY. ALL DIMENSIONS ARE SHOWN FROM THREADED END OF THERMO WELL. THERMOCOUPLE ASSEMBLY TO BE SUPPLIED WITH MATCHING UNION.

7- MULTPOINT THERMOCOUPLES IN VERTICAL CENTER LINE OF BIN TO BE 1/4". ALL OTHERS TO BE 1/8" OUTSIDE DIAMETER.

8- FOR SCHEDULE OF TC 255 THRU 264 SEE DWG# 1200-CPP-742-E-1.

9- FOR LEGEND SEE DWG# 1200-CPP-401-1.

RCRA CONTROLLED DRAWING

INACTIVE
FOR REF. USE ONLY
This Dwg. Superseded By:
Dwg. No. NOT SUPERSEDED
Date 9-22-82

CONTROLLED DOCUMENT CLASS I

NO.	DATE	DESCRIPTION	LOC.	APPVD.	AEC APPVD	PPCO. APPVD.
6	6-2494	REVISED PER DCN# 155754-AB44	MW	GS 6-28-94	DBJ 6-28-94	JW 6-28-94
5	5-26-94	REVISED PER DCN #155754-AB25	[illegible]	H.S.	RSA	DBJ
4	9-22-82	INACTIVATED KWG				
3	4-4-66	AS BUILT				
2	9-28-65	CHG'D TC NOS. ON BIN WC-136-1				KWR
1	6-2-65	CHGD DIM. SECT. A & B				KWR

REVISIONS

	BY	DATE
DRAWN	G.Gonzalez	12-19-64
CHECKED	W.GEMMELL	2-19-65
APPROVED	[illegible]	2-15-65
APPROVED	[illegible]	4-8-65
APPROVED		
APPROVED		
PPCO. APPVD.	KWR	4-22-65
AEC APPROVED	O.Bledsoe	4-23-65
AEC APPROVED	DDD	4-23-65

SCALE: NONE
DATE: 4-23-65

CPP-742
ADDITIONAL CALCINED WASTE STORAGE FACILITIES
BIN SET #2
THERMOCOUPLE LOCATIONS

NORMAN ENGINEERING CO.
consulting engineers
LOS ANGELES, CALIFORNIA

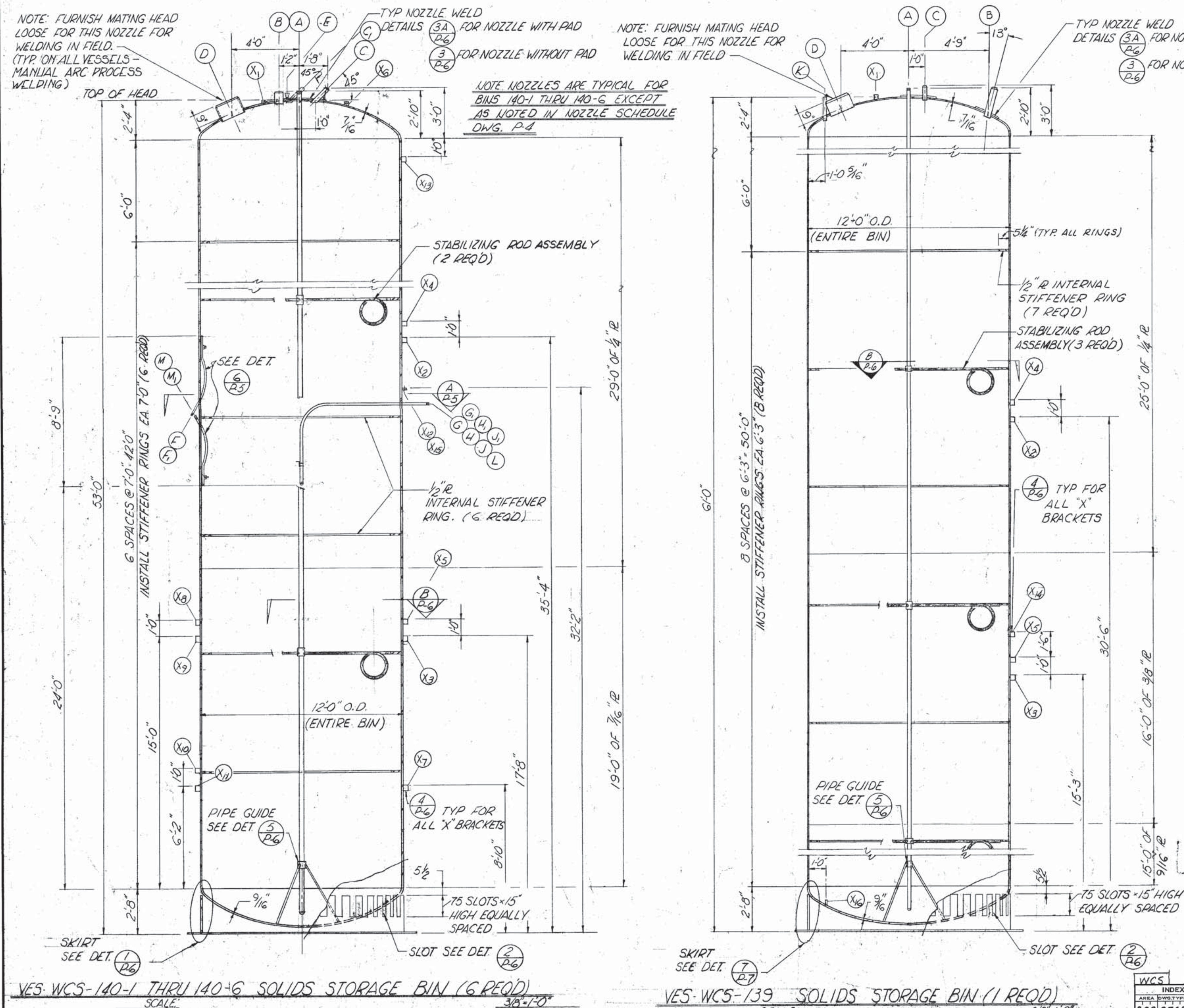
FOR
U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
IDAHO FALLS, IDAHO

DWG. NO. 1200-CPP-742-T-1 REV. 6

WCS

INDEX CODE NUMBER				
AREA	DWG. TYPE	CL	ORIG.	SERIAL
200	0742	25	613	118888

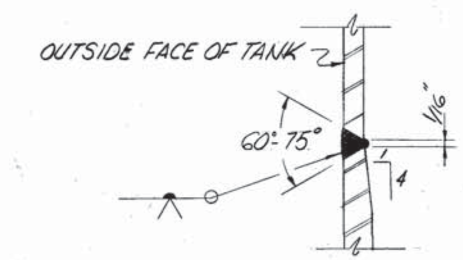
CONTRACT AT (10-1)- 1180



RCRA CONTROLLED DRAWING

TOP & BOTTOM HEADS

144" O.D. ASME F & D HEADS
RAD OF D = 132"
I.C.R. = 8 3/4"
S.F. = 1 1/2"



TYP JOINT DETAIL WHERE SHELL THICKNESS CHANGES

NOTES

1. SEE SPECIFICATIONS FOR MATERIALS AND PROCEDURES USED IN TANK FABRICATION.
2. BRACKET "X_{16}" IS TO BE LOCATED DIRECTLY UNDER NOZZLE "K"
3. BINS SHALL BE GOVERNMENT FURNISHED & CONTRACTOR INSTALLED. DRAWINGS P-3 THRU P-7 ARE FOR INSTALLATION ONLY.
4. FOR NOZZLE ORIENTATION SEE INDIVIDUAL STORAGE BIN PLAN DWG. P-4
5. ALL NOZZLES AND THERMOCOUPLE WELL AT HEAD ARE TO PENETRATE THRU HEAD 1/2".
6. BIN WORKING TOLERANCES ARE TO BE: OVERALL HEIGHT ± 1/8", MISALIGNMENT OF ℄ W/ REFERENCE TO TOP & BOTTOM ± 1/8" & NOZZLE LOCATION ± 1/8"
7. WELD SYMBOLS PER ASA Y32.3

NO.	DATE	REVISIONS
6		REVISED PER DCN #155754-AB45 MN

CONTROLLED DOCUMENT

IDAHO NUCLEAR CORPORATION
IDAHO FALLS, IDAHO
FOR
U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
IDAHO FALLS, IDAHO

CPP-AREA
PHASE III
CALCINED SOLIDS STORAGE FACILITY ADDITION
STORAGE BINS

	BY	DATE
DESIGNED		3-7
DRAWN	W.L. MILLER	5-7-69
CHECKED		
APPROVED		

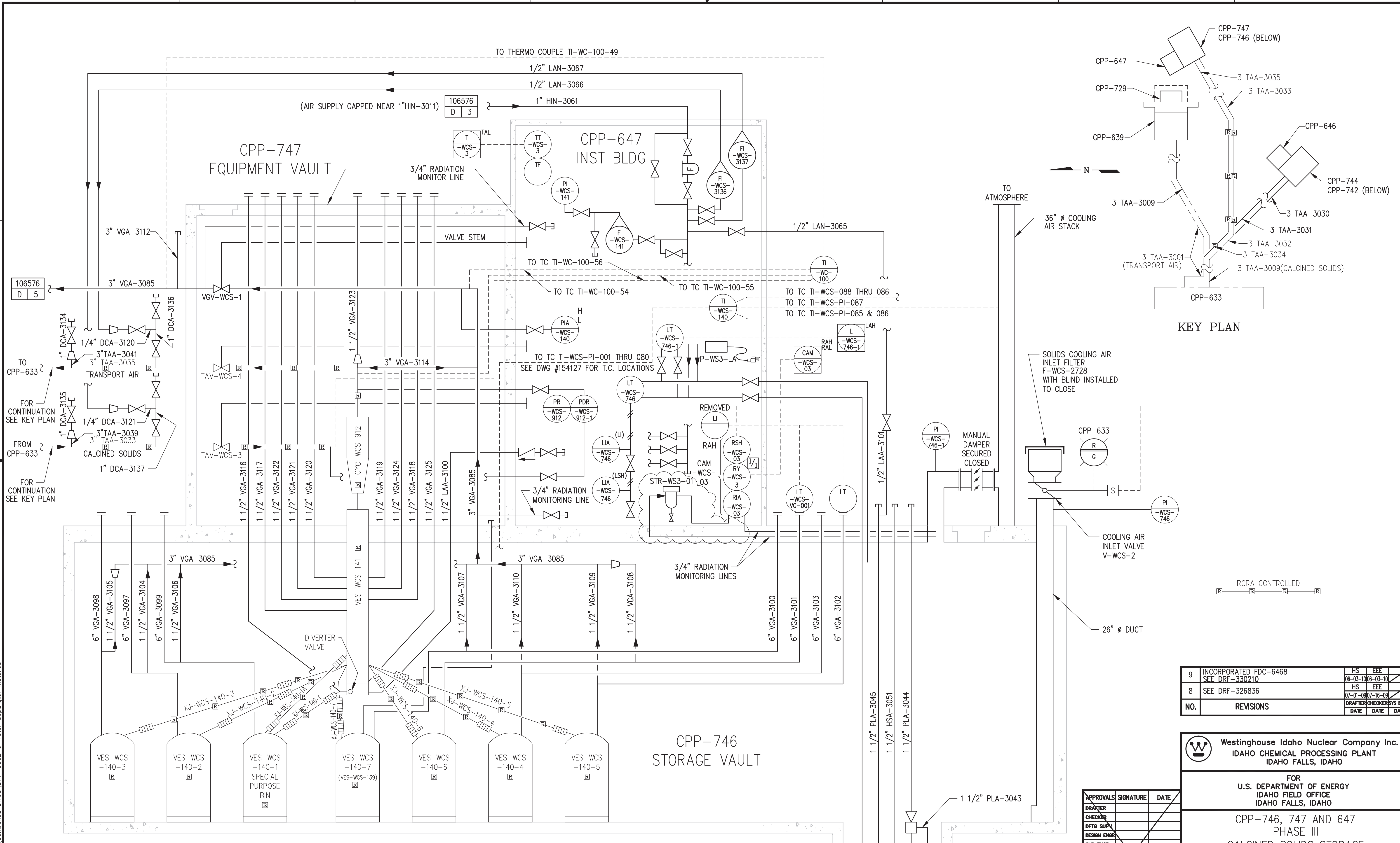
WCS
INDEX CODE NUMBER

AREA	DWG.TYPE	CL.	ORIG.	SERIAL
200	0746	53	400	153510

SCALE: AS NOTED
DATE ISSUED: 10-5-70
DWG. NO. 1230-CPP-746-P-3
REV. 6

1317

NUCLEAR QUALITY ASSURANCE ESSENTIALITY LEVEL: III



NO.	REVISIONS	DRAFTER DATE	CHECKER DATE	SYS ENGR DATE
9	INCORPORATED FDC-6468 SEE DRF-330210	HS 06-03-10	EEE 06-03-10	
8	SEE DRF-326836	HS 07-01-09	EEE 07-16-09	

Westinghouse Idaho Nuclear Company Inc.
IDAHO CHEMICAL PROCESSING PLANT
IDAHO FALLS, IDAHO

FOR
U.S. DEPARTMENT OF ENERGY
IDAHO FIELD OFFICE
IDAHO FALLS, IDAHO

CPP-746, 747 AND 647
PHASE III
CALCINED SOLIDS STORAGE
FACILITY ADDITION BIN SET #3
P & ID

WCS

APPROVALS	SIGNATURE	DATE
DRAFTER		
CHECKER		
DFTG SUPV		
DESIGN ENGR		
SYS ENGR		
ENGR MGR		
PROJ MGR		

SCALE NONE
DATE ISSUED

INDEX CODE NUMBER				
AREA	DWG TYPE	CL	ORIG.	SERIAL
200	0747	24	400	154129

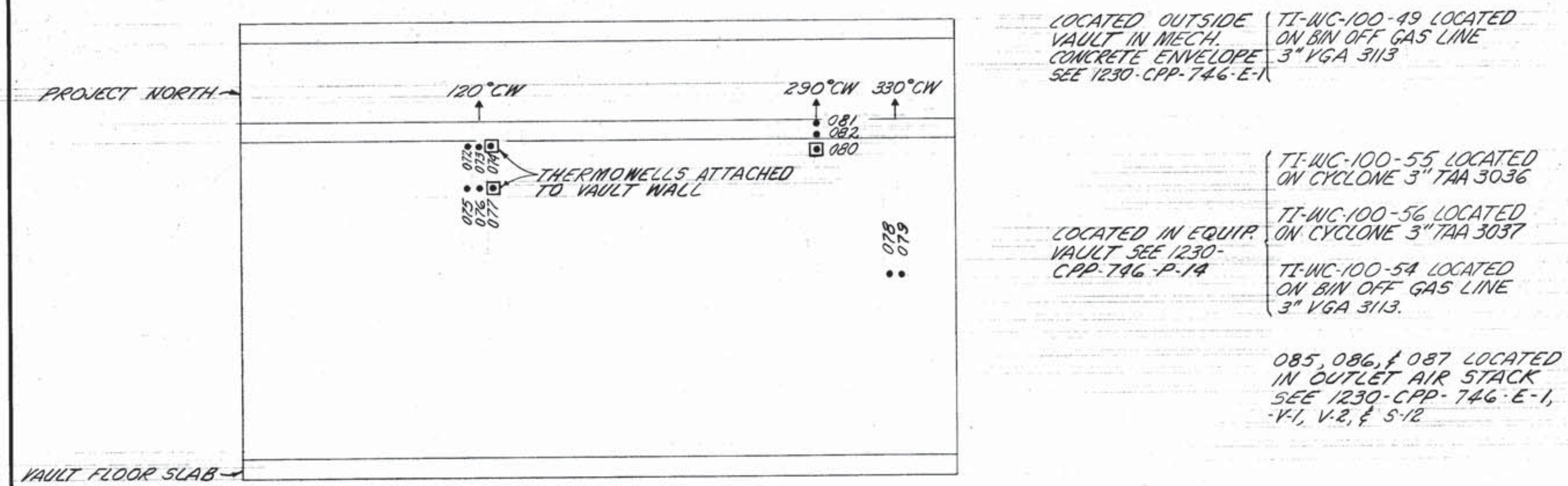
INDEX CODE NUMBER				
AREA	DWG TYPE	CL	ORIG.	SERIAL
200	0647	24	400	154129

DWG. SIZE	AREA	DWG TYPE	CL	ORIG.	DRAWING NUMBER	REV.
D	200	0746	24	400	154129	9

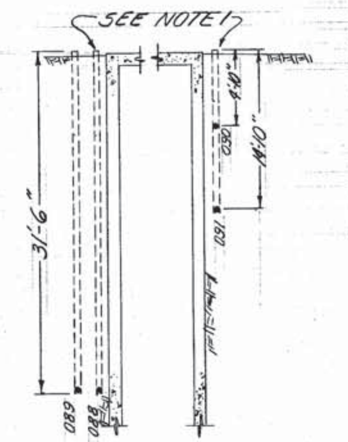
JOB NUMBER 155754
TAKEN FROM DRAWING NO. REDRAWN

CAD GENERATED - AUTOCAD

File: 154129-9.dwg Date: 06/03/10 - 9:41 AM Layout Name: Model
Path: K:\INTEC Misc Drafting\Controlled DWGS\DRF-330210 Water Separator Installed
By: HSPENCER



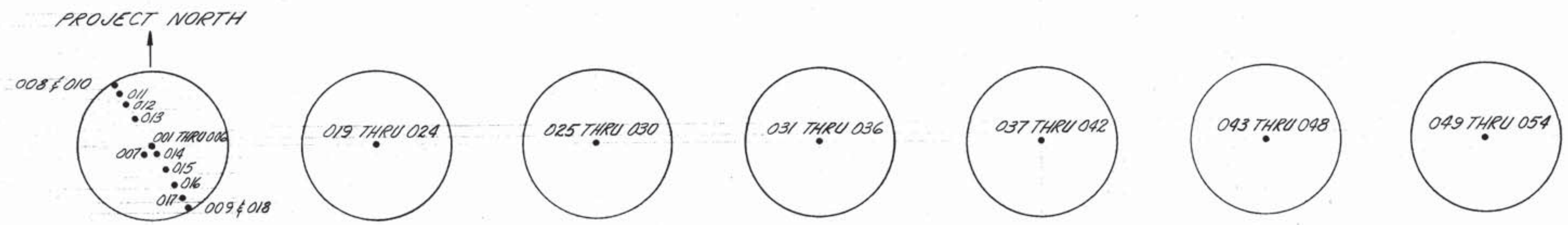
DEVELOPMENT OF VAULT CONCRETE CYLINDER

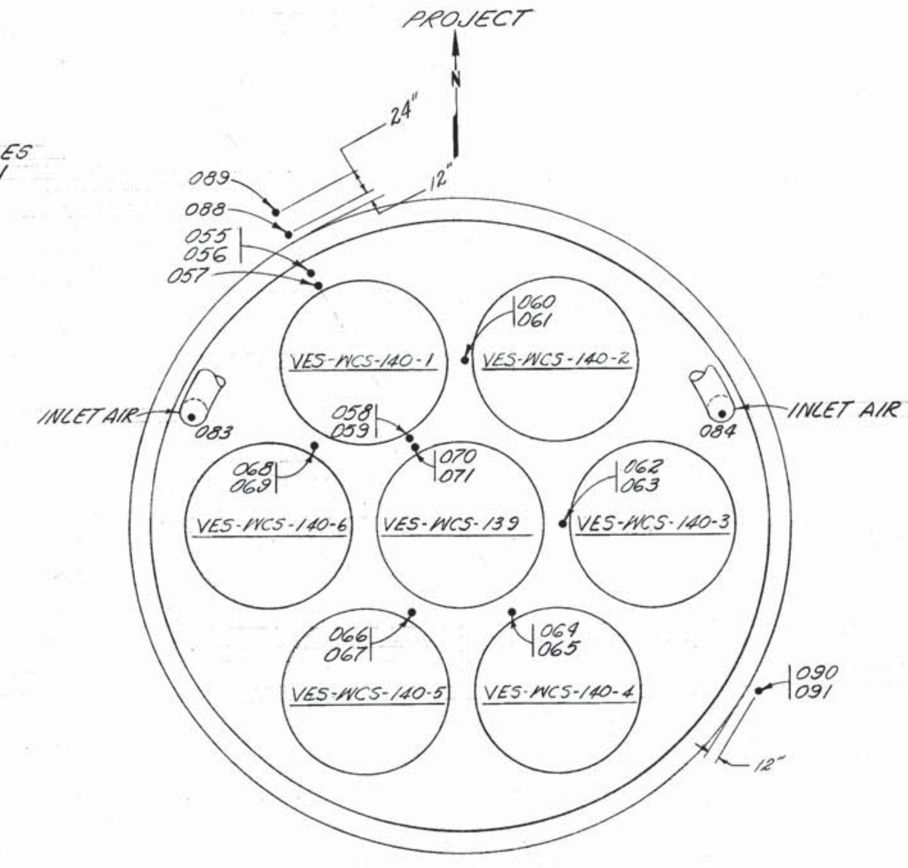


ELEVATION-THERMOCOUPLES OUTSIDE VAULT LOCATION

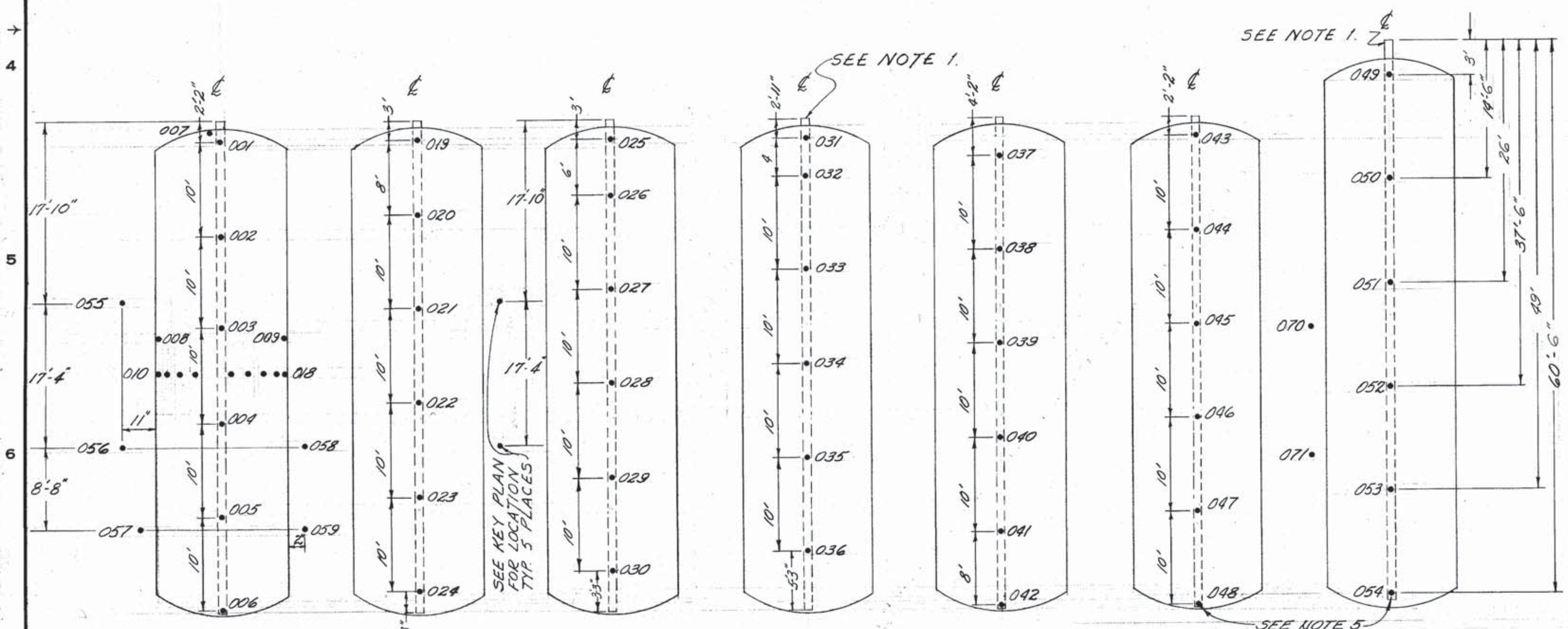
NOTES

1. MULTIPOINT THERMOCOUPLE ASSEMBLY, ALL DIMENSIONS ARE SHOWN FROM THREADED END OF THERMOWELL.
2. MULTIPOINT THERMOCOUPLES IN VERTICAL CENTER LINE OF BIN TO BE GROUP MOUNTED W/SPRING LOADED TIPS. ALL THERMOCOUPLES TO BE 1/8" OUTSIDE DIAMETER.
3. ONLY THE LAST THREE NUMBERS OF EACH THERMOCOUPLE NUMBER ARE USED. A COMPLETE THERMOCOUPLE NUMBER IS TI-WCS-PI-001, THRU -091.
4. ALL THEMOCOUPLES GOVT. FURNISHED.
5. BOTTOM THERMOCOUPLES IN VESSEL 140-1, 140-5 140-6 & 139 ARE 1" OFF THE BOTTEM OF THE THERMOWELL, OTHERS AS SHOWN.





KEY PLAN



RCRA CONTROLLED DRAWING

NO.	DATE	REVISIONS	APPVD. INC	CHECK	APPVD.	APPVD. AEC	APPVD. AEC H&S	APPVD. AEC E&C
4	6-24-94	REVISED PER DCN# 155754-AB46	MW					
3	5-23-94	REVISED PER DCN #155754-AB27	BUBBA					
2	11-2-71	AS BUILT DAS	GVM					
1	7-26-71	REVISED DIM. & ADDED NOTE 5.						

	BY	DATE
DESIGNED	JBO	6-9-69
DRAWN	GDJ	6-12-69
CHECKED	JBO	7-28-70
APPROVED	JEL	7-31-70

APPROVALS

ORGAN.	BY	DATE
INC	GVM	7-31-70
	MJR	7-31-70
NOS	THS	8-3-70
AEC		
AEC		
AEC H&S		
AEC E&C		

IDAHO NUCLEAR CORPORATION
IDAHO FALLS, IDAHO
FOR
U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
IDAHO FALLS, IDAHO

CPP-746
PHASE III BIN SET #3
CALCINED SOLID STORAGE FACILITY ADDITION
THERMOCOUPLE LOCATION

CONTROLLED DOCUMENT

CLASS I

WCS

INDEX CODE NUMBER

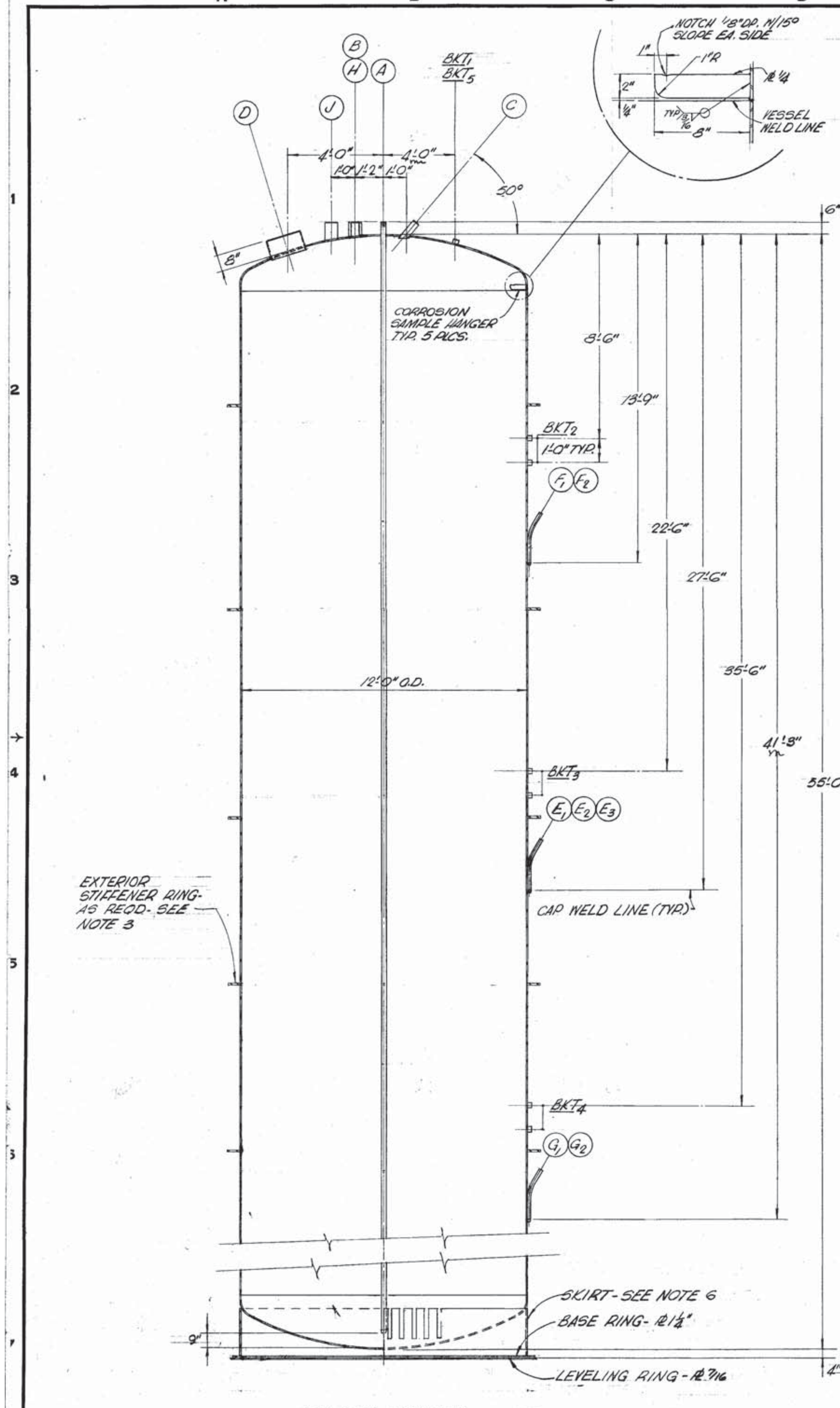
AREA	DWG.TYPE	CL.	ORIG.	SERIAL
200	0746	25	400	154127

IDAHO NUCLEAR QUALITY ASSURANCE ESSENTIALITY LEVEL: III

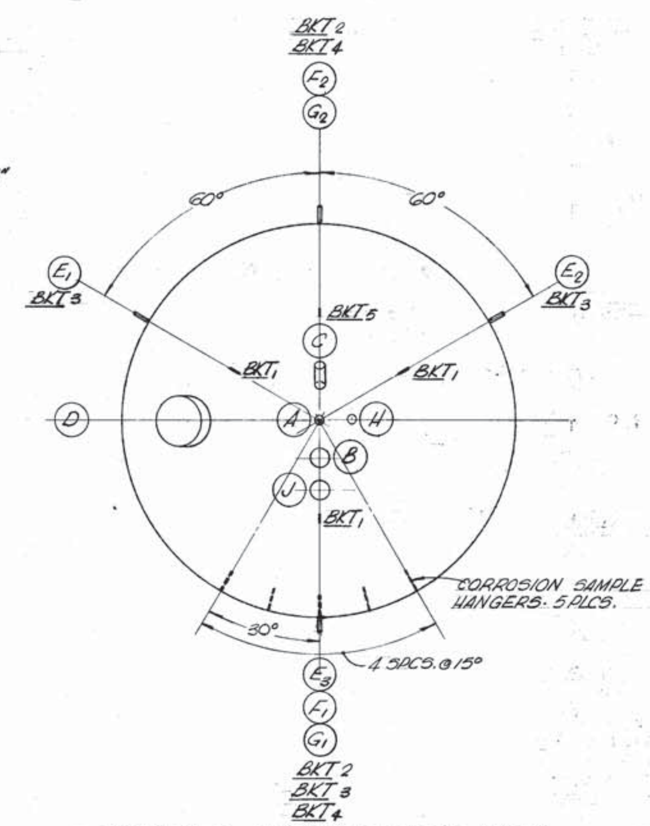
SCALE: NONE
DATE ISSUED: 10-5-70

DWG. NO. 1230-CPP-746-T-3 REV. 4

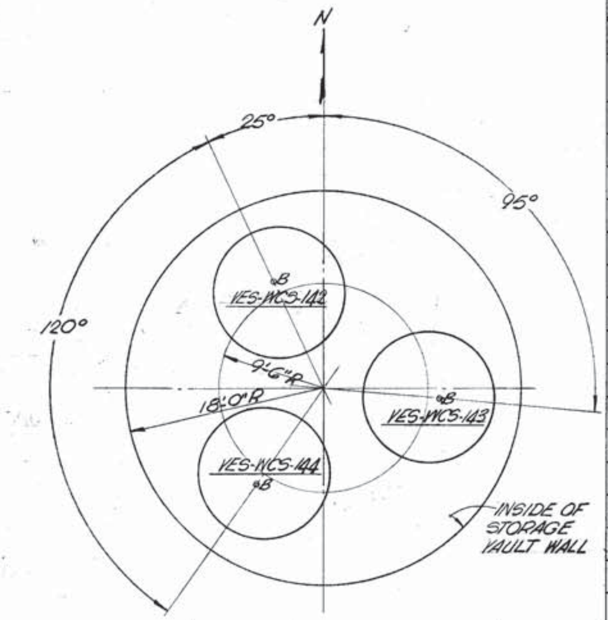
1317 PROJECT NO.



ELEVATION
TYP. FOR 3 BINS
SCALE: 3/8"=1'-0"



NOZZLE ORIENTATION PLAN
TYP. FOR 3 BINS
SCALE: 3/8"=1'-0"

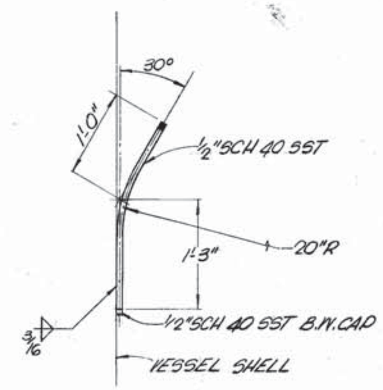


BIN ORIENTATION PLAN
SCALE: 1/8"=1'-0"

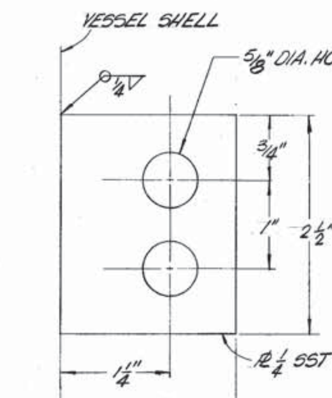
FITTING SCHEDULE

MK.	SERVICE	SIZE	BIN NO.	REMARKS
A	THERMOWELL	2"SCH80S	ALL BINS	SEE NOTE 4 & 9
B	SOLIDS REMOVAL	6"SCH40S	"	SEE NOTE 8
C	FILL LINE	3"SCH40S	"	SEE NOTE 8
D	MANWAY	18"STD.WT.	"	SEE NOTE 5&8
E_1	THERMOWELL	1/2"SCH.40S	"	SEE DETAIL 1 & NOTE 9
E_2	"	"	"	" " " " "
E_3	"	"	"	" " " " "
F_1	"	"	-142	" " " " "
F_2	"	"	"	" " " " "
G_1	"	"	"	" " " " "
G_2	"	"	"	" " " " "
BKT_1	SUPPORT BRACKET		ALL BINS	SEE DETAIL 2
BKT_2	" "			" " "
BKT_3	" "		ALL BINS	" " "
BKT_4	" "		-142	" " "
BKT_5	" "		"	" " "
H	VESSEL VENT	3"SCH40S	ALL BINS	SEE NOTE 8
J	SOLIDS REMOVAL	6"SCH40S	"	SEE NOTE 8

NOTES:
1- UNLESS NOTED, ALL MATL. TO BE TYPE 304 SST.
2- BIN WORKING TOLERANCES ARE AS FOLLOW: OVERALL HEIGHT ± 3/4"; MISALIGNMENT OF ℄ W/ REFERENCE TO TOP ℄ BOTTOM ± 1/2"; NOZZLE LOCATION ± 1/4".
3- THE BIN SUBCONTRACTOR SHALL DETERMINE VESSEL SHELL & HEAD THICKNESS & PROVIDE NECESSARY PIPE GUIDES & VESSEL STABILIZING COMPONENTS.
4- MISALIGNMENT OF NZL. 'A' FROM VESSEL ℄: ± 1/4"
5- BIN SUBCONTRACTOR TO FURNISH MATING HEAD FOR NZL. 'D' (WELD CAP) FOR FIELD INSTALLATION BY GTAW WELDING.
6- SKIRT TO PROVIDE APPROX. 20% OPEN AREA FOR VENTILATION.
7- ANCHORAGE FOR ANCHOR BOLTS CONSISTS OF A 4'-6" THICK REINFORCED CONCRETE SLAB OF 4000 PSI CONCRETE. THICKNESS OF SLAB MAY BE INCREASED IF NECESSARY.



THERMOWELL DETAIL 1
SCALE: 1"=1'-0"



SUPPORT BRACKET DETAIL 2
SCALE: FULL

NOTES: (CONT'D.)
8- VESSEL NOZZLES SHALL HAVE A WELD PREP IN ACCORDANCE WITH ANSI B-16.25.
9- THERMOWELL NOZZLES SHALL BE THREADED WITH A NATIONAL PIPE THREAD (NPT).

RCRA CONTROLLED DRAWING

CONTROLLED DOCUMENT CLASS I

NO.	DATE	REVISIONS	APPVD. INC	APPVD.	APPVD.	APPVD. AEC	APPVD. AEC H&S	APPVD. AEC E&C
5	6-24-94	REVISED PER DCN#155754-A847 MW	G.S. 6-28-94	6-28-94	6-28-94			
4	10-20-82	SEE DCN # 4 KHG	DTS					
3	10-28-77	AS BUILT DRB	RWM	RRH				
2	2-2-76	CHANGED STIFFENER RINGS TO EXTERIOR	RRH					
1	9-29-75	CHANGED BIN HT. & NZL. LOC. TOLERANCES	DDH					

	BY	DATE
DESIGNED	L. Tony	6-20-75
DRAWN		10-2-74
CHECKED	JPB	6-20-75
APPROVED	RRH	8-28-75

APPROVALS

ORGAN.	BY	DATE
INC		
ACC	ARB	8-29-75
AEC		
AEC		
AEC H&S		
AEC E&C		

AEROJET NUCLEAR COMPANY
INCORPORATED
IDAHO FALLS, IDAHO
FOR
U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
IDAHO FALLS, IDAHO

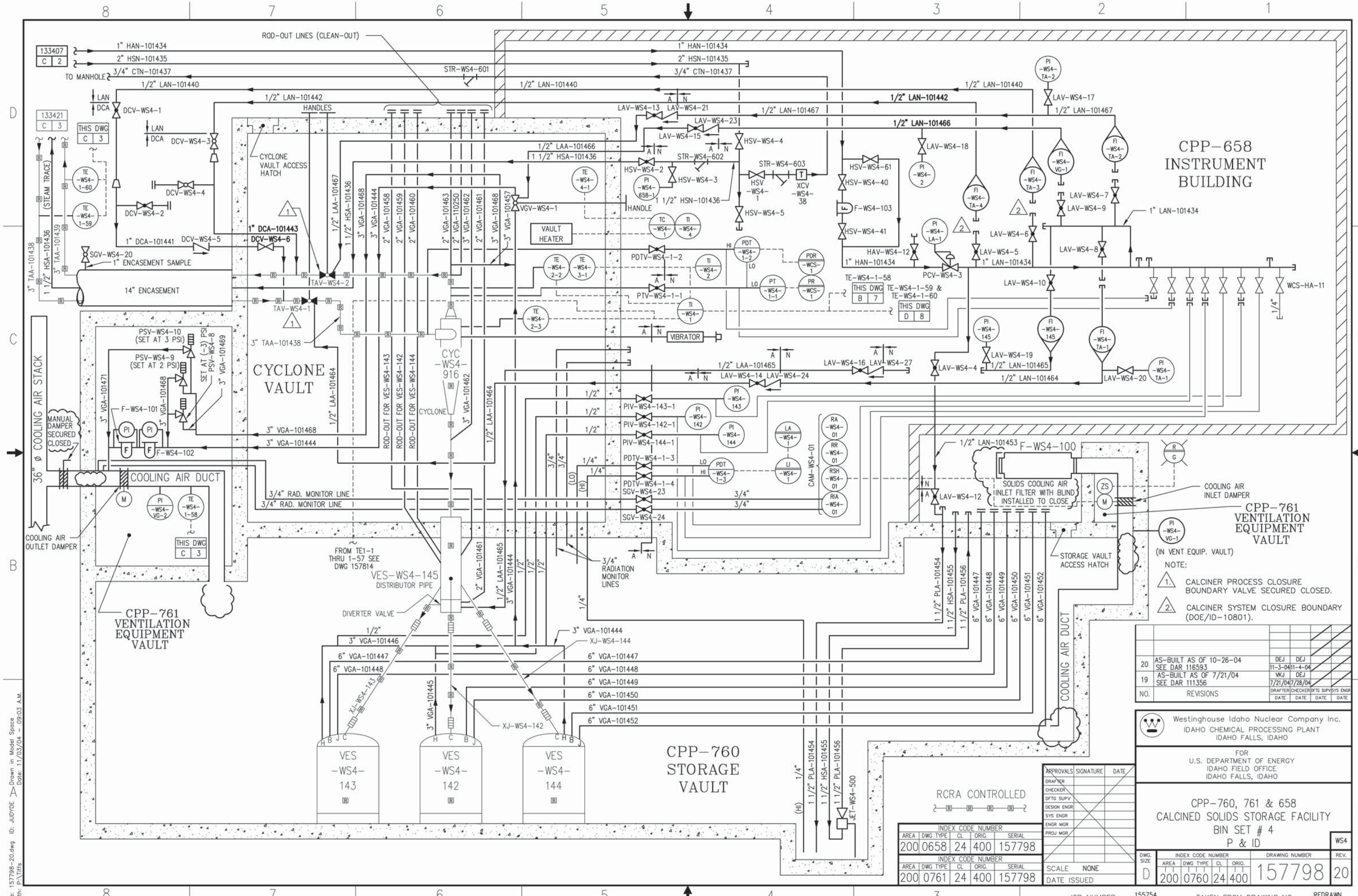
CPP AREA
CALCINED SOLIDS STORAGE FACILITY FOURTH ADDITION STORAGE BINS

NCS

INDEX CODE NUMBER

AREA	DWG.TYPE	CL.	ORIG.	SERIAL
200	0760	3	3900	155750

SCALE: NOTED
DATE ISSUED: 8-29-75
DWG. NO. 1375-CPP-760-M-1
REV. 5
PROJECT NO.


ROD-OUT LINES (CLEAN-OUT)
TO MANHOLE
1" HAN-101434
2" HSN-101435
3/4" CTN-101437
1/2" LAN-101440
1/2" LAN-101442
1/2" LAN-101466
1/2" LAN-101467
HANDLES
CYCLONE VAULT ACCESS HATCH
CYCLONE VAULT
14" ENCASEMENT
1" ENCASEMENT SAMPLE
(STEAM TRACE)
VAULT HEATER
HANDLE
VIBRATOR
CYC -WS4- 916
CYCLONE
36" Ø COOLING AIR STACK
MANUAL DAMPER SECURED CLOSED
COOLING AIR DUCT
COOLING AIR OUTLET DAMPER
PSV-WS4-10 (SET AT 3 PSI)
PSV-WS4-9 (SET AT 2 PSI)
SET AT (-3) PSI PSV-WS4-8
3/4" RAD. MONITOR LINE
FROM TE1-1 THRU 1-57 SEE DWG 157814
VES-WS4-145 DISTRIBUTOR PIPE
DIVERTER VALVE
3/4" RADIATION MONITOR LINES
CPP-761 VENTILATION EQUIPMENT VAULT
VES -WS4- 143
VES -WS4- 142
VES -WS4- 144
CPP-760 STORAGE VAULT
CPP-658 INSTRUMENT BUILDING
F-WS4-100
SOLIDS COOLING AIR INLET FILTER WITH BLIND INSTALLED TO CLOSE
COOLING AIR INLET DAMPER
CPP-761 VENTILATION EQUIPMENT VAULT
(IN VENT EQUIP. VAULT)
STORAGE VAULT ACCESS HATCH
COOLING AIR DUCT
RCRA CONTROLLED
NOTE:
1. CALCINER PROCESS CLOSURE BOUNDARY VALVE SECURED CLOSED.
2. CALCINER SYSTEM CLOSURE BOUNDARY (DOE/ID-10801).
20 AS-BUILT AS OF 10-26-04 SEE DAR 116593 DEJ DEJ 11-3-04 11-4-04
19 AS-BUILT AS OF 7/21/04 SEE DAR 111356 VKJ DEJ 7/21/04 7/28/04
NO. REVISIONS DRAFTER CHECKER DFTG SUPV SYS ENGR DATE DATE DATE DATE
Westinghouse Idaho Nuclear Company Inc.
IDAHO CHEMICAL PROCESSING PLANT
IDAHO FALLS, IDAHO
FOR
U.S. DEPARTMENT OF ENERGY
IDAHO FIELD OFFICE
IDAHO FALLS, IDAHO
CPP-760, 761 & 658
CALCINED SOLIDS STORAGE FACILITY
BIN SET # 4
P & ID
WS4
INDEX CODE NUMBER AREA 200 DWG TYPE 0658 CL 24 ORIG. 400 SERIAL 157798
INDEX CODE NUMBER AREA 200 DWG TYPE 0761 CL 24 ORIG. 400 SERIAL 157798
APPROVALS SIGNATURE DATE
DRAFTER
CHECKER
DFTG SUPV
DESIGN ENGR
SYS ENGR
ENGR MGR
PROJ MGR
SCALE NONE
DATE ISSUED
DWG. SIZE D
INDEX CODE NUMBER AREA 200 DWG TYPE 0760 CL 24 ORIG. 400
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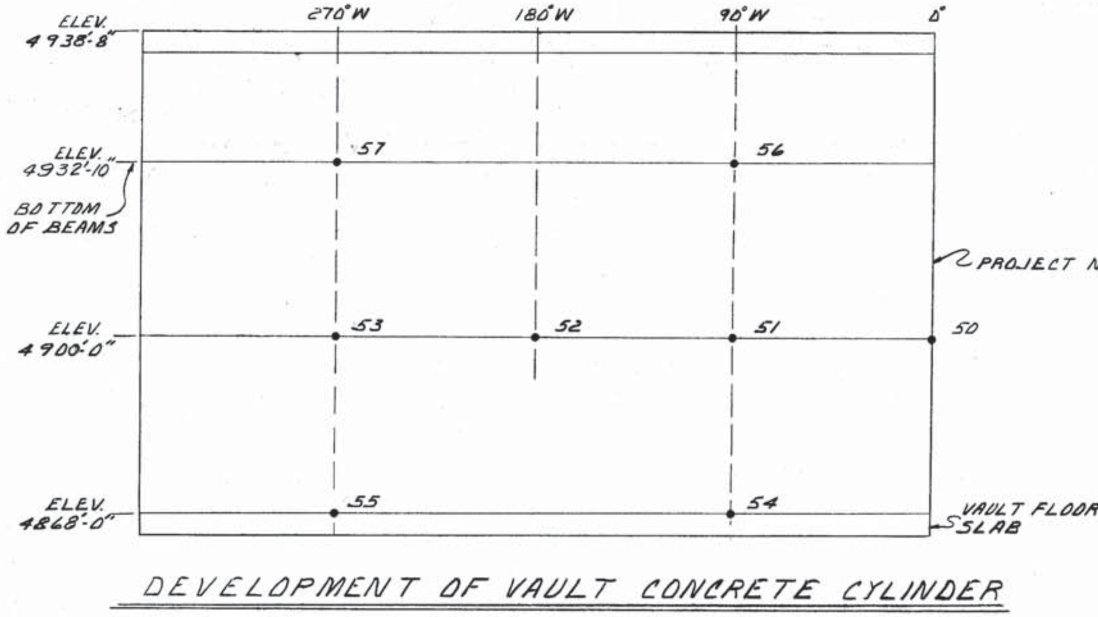
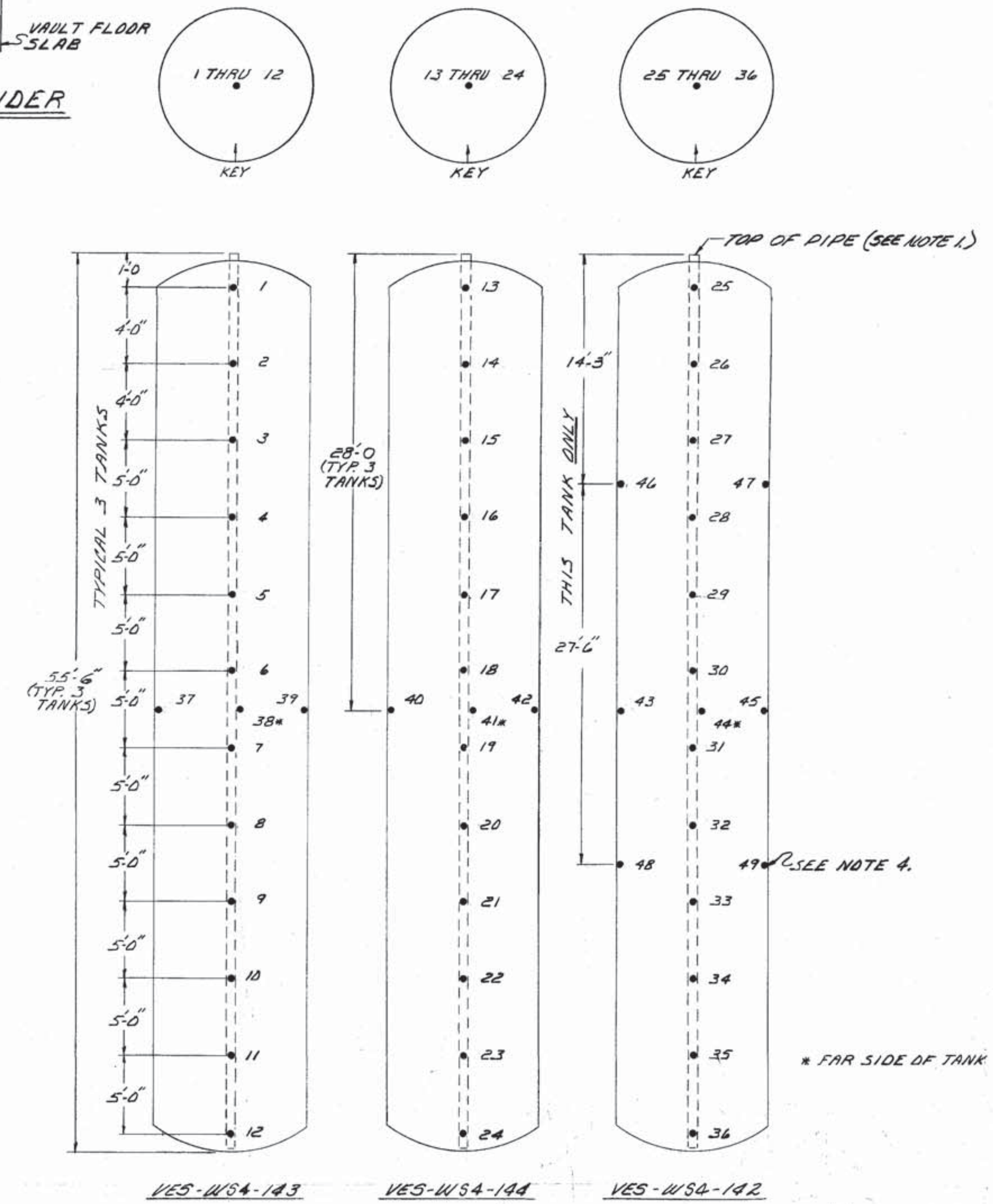
REV. 20
JOB NUMBER 155754
TAKEN FROM DRAWING NO. REDRAWN
CAD GENERATED - AUTOCAD
File: 157798-20.dwg Path: P:\Tiffs
ID: JUDYDE
Drawn in Model Space Date: 11/03/04 - 09:03 A.M.

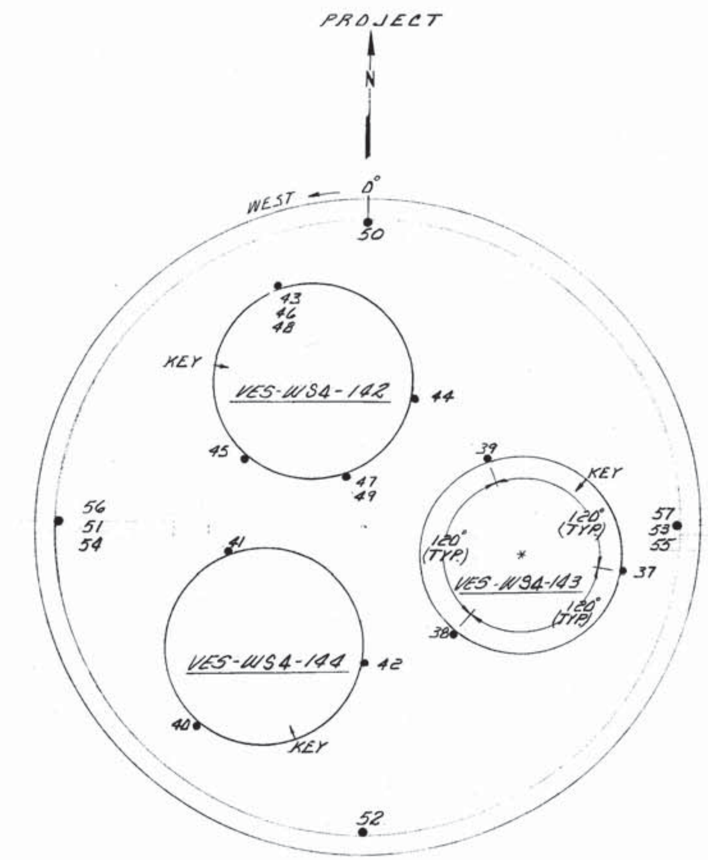
NOTES

1. ALL DIMENSIONS ARE SHOWN TO THERMOCOUPLE TIP
2. MULTIPOINT THERMOCOUPLES IN VERTICAL CENTER LINE OF BIN GROUP MOUNTED W/SPRING LOADED TIPS. ALL THERMOCOUPLES TO BE 1/8" OUTSIDE DIAMETER.
3. ONLY THE LAST TWO DIGITS OF EACH THERMOCOUPLE NUMBER ARE USED. A COMPLETE THERMOCOUPLE NUMBER IS TE-WS4-1-1 THRU-1-57.
4. SEE "KEY PLAN" FOR LOCATION OF ALL EXTERNAL BIN THERMOCOUPLES.



DEVELOPMENT OF VAULT CONCRETE CYLINDER





KEY PLAN

RCRA CONTROLLED DRAWING

CONTROLLED DOCUMENT CLASS I

NO.	DATE	REVISIONS	APPVD. ANC	APPVD. AEC	APPVD.	APPVD. AEC	APPVD. AEC H&S	APPVD. AEC E&C
5	6-24-94	REVISED PER DCN# 155754-AB48	MW	GS 6-28-94	JW 6-28-94	DRH 6-28-94		
4	6-23-94	REVISED PER DCN # 155754-AB30	DUBBA	DRS	RSA 6-3-94	DRJ		
3	5/23/83	SEE DCN 83-003 ADG						
2	3-12-78	AS BUILT CRL	RWM	RRH				
1	9-27-76	CHANGED T.C. DIM. (SEE ECR#6)	G.D.J.	RGD	RDH			

	BY	DATE
DESIGNED	JBO	9-1-74
DRAWN	T. WOODS	9-26-74
CHECKED	JPB	11-7-75
APPROVED	RRH	11-7-75

APPROVALS

ORGAN.	BY	DATE
INC		
ACC	a & B	11-14-75
AEC		
AEC		
AEC H&S		
AEC E&C		

AEROJET NUCLEAR COMPANY
INCORPORATED
IDAHO FALLS, IDAHO
FOR
U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
IDAHO FALLS, IDAHO

CPP-760 BIN SET #4

CALCINED SOLIDS STORAGE FACILITY FOURTH ADDITION

THERMOCOUPLE LOCATION

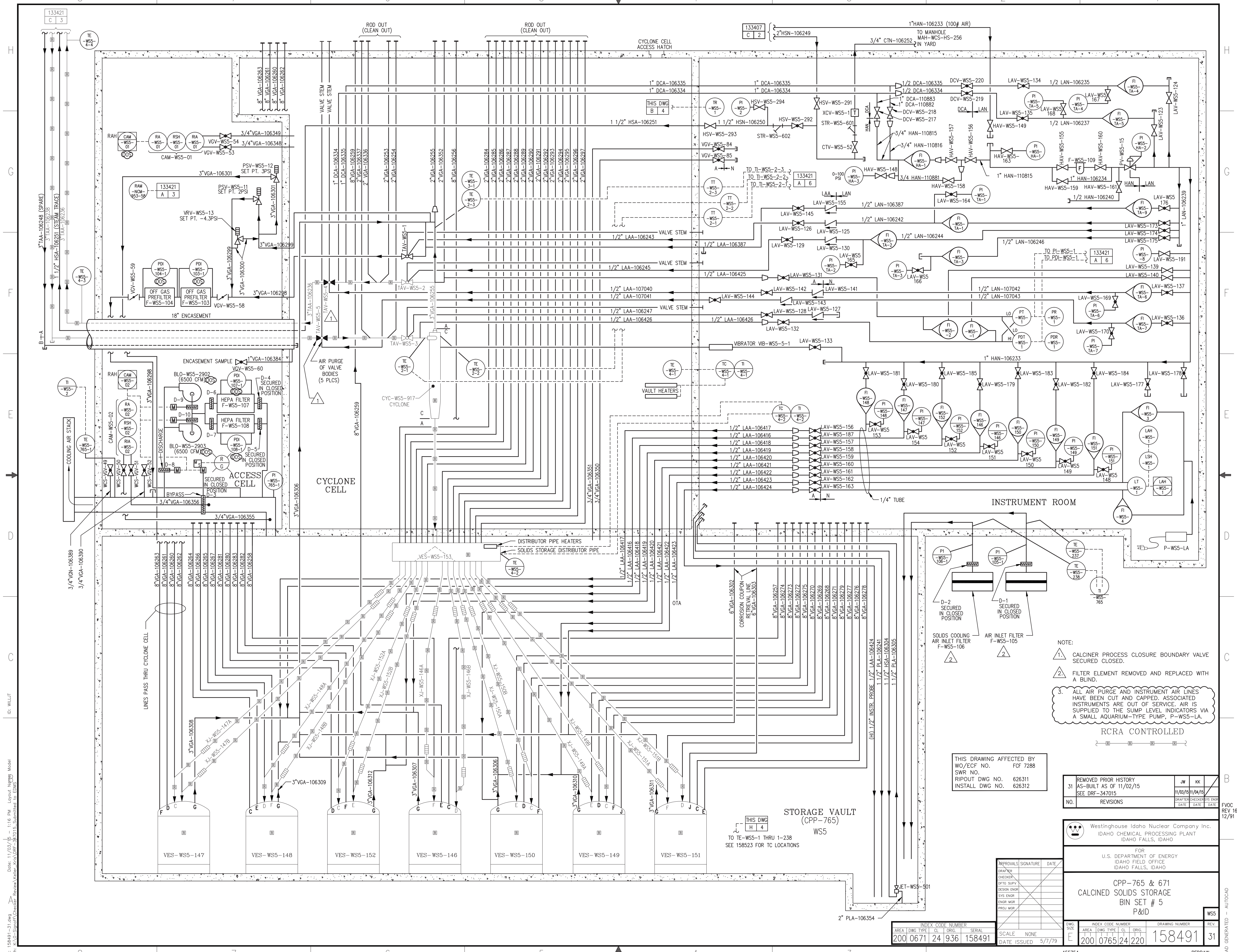
WS4

INDEX CODE NUMBER				
AREA	DWG.TYPE	CL.	ORIG.	SERIAL
200	0760	10	400	157814

SCALE: NONE
DATE ISSUED: 1-14-76
DWG. NO. 1375-CPP-760-T-3
REV. 5

E-(10-1)-1548

PROJECT NO.


CYCLONE CELL
ACCESS CELL
INSTRUMENT ROOM
STORAGE VAULT
(CPP-765)
WS5
18" ENCASEMENT
ENCASEMENT SAMPLE
COOLING AIR STACK
CYCLONE CELL ACCESS HATCH
ROD OUT (CLEAN OUT)
VALVE STEM
VAULT HEATERS
VIBRATOR VIB-WS5-5-1
DISTRIBUTOR PIPE HEATERS
SOLIDS STORAGE DISTRIBUTOR PIPE
VES-WS5-153
CYC-WS5-917 CYCLONE
AIR PURGE OF VALVE BODIES (5 PLCS)
OFF GAS PREFILTER F-WS5-104
OFF GAS PREFILTER F-WS5-103
HEPA FILTER F-WS5-107
HEPA FILTER F-WS5-108
BLO-WS5-2902 (6500 CFM)
BLO-WS5-2903 (6500 CFM)
LINES PASS THRU CYCLONE CELL
CORROSION COUPON RETRIEVAL LINE
1/4" TUBE
D-2 SECURED IN CLOSED POSITION
D-1 SECURED IN CLOSED POSITION
SOLIDS COOLING AIR INLET FILTER F-WS5-106
AIR INLET FILTER F-WS5-105
P-WS5-LA
JET-WS5-501
2" PLA-106354
TO TE-WS5-1 THRU 1-238
SEE 158523 FOR TC LOCATIONS
VES-WS5-147
VES-WS5-148
VES-WS5-152
VES-WS5-146
VES-WS5-150
VES-WS5-149
VES-WS5-151
NOTE:
1. CALCINER PROCESS CLOSURE BOUNDARY VALVE SECURED CLOSED.
2. FILTER ELEMENT REMOVED AND REPLACED WITH A BLIND.
3. ALL AIR PURGE AND INSTRUMENT AIR LINES HAVE BEEN CUT AND CAPPED. ASSOCIATED INSTRUMENTS ARE OUT OF SERVICE. AIR IS SUPPLIED TO THE SUMP LEVEL INDICATORS VIA A SMALL AQUARIUM-TYPE PUMP, P-WS5-LA.
RCRA CONTROLLED
THIS DRAWING AFFECTED BY
WO/ECF NO. FCF 7288
SWR NO.
RIPOUT DWG NO. 626311
INSTALL DWG NO. 626312
31 REMOVED PRIOR HISTORY
AS-BUILT AS OF 11/02/15
SEE DRF-347015
JW KK
11/03/15 11/04/15
REVISIONS
Westinghouse Idaho Nuclear Company Inc.
IDAHO CHEMICAL PROCESSING PLANT
IDAHO FALLS, IDAHO
FOR
U.S. DEPARTMENT OF ENERGY
IDAHO FIELD OFFICE
IDAHO FALLS, IDAHO
CPP-765 & 671
CALCINED SOLIDS STORAGE
BIN SET # 5
P&ID
INDEX CODE NUMBER 200 0671 24 936 158491
SCALE NONE
DATE ISSUED 5/7/79
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REV. 31
JOB NUMBER 155754
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FVOC REV 16 12/91
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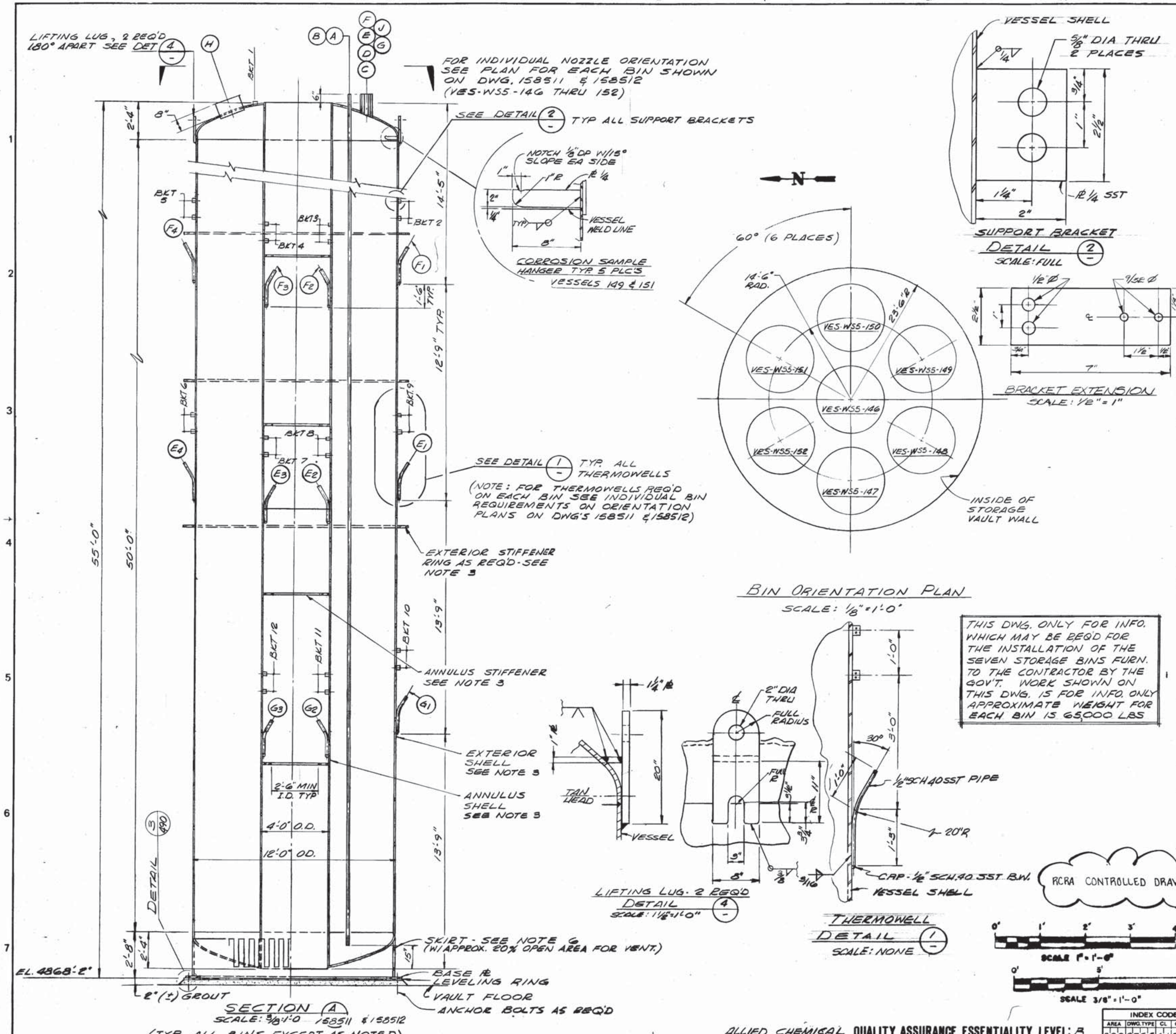


FITTING SCHEDULE

MK	SERVICE	SIZE	BIN NO.	REMARKS
A	THERMOWELL	2" SCH. 80S	146-152	SEE NOTES 4 & 9
B	THERMOWELL	2" SCH. 80S	146-152	SEE NOTES 4 & 9
C	RETRIEVAL	8" SCH 40S	146-152	SEE NOTE 8
D	RETRIEVAL	8" SCH 40S	146-152	SEE NOTE 8
E	RETRIEVAL	8" SCH 40S	146-152	SEE NOTE 8
F	RETRIEVAL	8" SCH 40S	146-152	SEE NOTE 8
G	VENT	3" SCH 40S	146-152	SEE NOTE 8
H	MANWAY	18" STD. WT.	146-152	SEE NOTES 5 & 8
J	COUPON SAMP.	6" SCH 40S	149, 151	SEE NOTE 8
E_1	THERMOWELL	1/2" SCH 40S	ALL BINS	SEE DETAIL 1 & NOTE 9
E_2				
E_3				
E_4				
F_1				
F_2				
F_3			ALL BINS	
F_4			146	
G_1			147-152	
G_2			ALL BINS	
G_3	THERMOWELL	1/2" SCH 40S	ALL BINS	SEE DETAIL 1 & NOTE 9
BKT-1 THRU BKT-12	SUPPORT BRACKET	DETAIL 2 THIS DWG.	PER EA BIN PLAN	LOCATE EACH BKT AS REQ'D ON PLANS DWG'S. 158511 & 158512

GENERAL NOTES

1. UNLESS NOTED, ALL MAT'L TO BE TYPE 304L SST.
2. BIN WORKING TOLERANCES ARE AS FOLLOWS: OVERALL HEIGHT ± 3/4"; MISALIGNMENT OF ℄ REFERENCE TO TOP & BOTTOM ± 1/2"; NOZZLE LOCATION ± 1/4"; BASE LEVELING RING, BASE PLATE AND ANCHOR BOLT HOLES ± 1/8".
3. THE BIN SUBCONTRACTOR SHALL DETERMINE VESSEL SHELL & HEAD THICKNESS & PROVIDE NECESSARY PIPE GUIDES & VESSEL STABILIZING COMPONENTS.
4. MISALIGNMENT OF NZL "A" & "B" FROM VESSEL ℄: ± 1/4"
5. BIN SUBCONTRACTOR TO FURNISH MATING HEAD FOR NZL'D (WELD CAP) FOR FIELD INSTALLATION BY GTAW WELDING.
6. SKIRT TO PROVIDE APPROX. 20% OPEN AREA FOR VENTILATION.
7. ANCHORAGE FOR ANCHOR BOLTS CONSISTS OF A 5'-0" THICK REINFORCED CONCRETE SLAB OF 4000 PSI CONCRETE.
8. VESSEL NOZZLES SHALL HAVE A WELD PREP. IN ACCORDANCE WITH ANSI B-16.25.
9. THERMOWELL NOZZLES SHALL BE THREADED WITH A NATIONAL PIPE THREAD (NPT).
10. SUPPORTS FOR NOZZLES A & B SHALL NOT INTERFERE WITH LINE OF SIGHT THRU RETRIEVAL NOZZLES C, D, E OR F.
11. 6" & 8" NOZZLE SCHEDULES SHOWN ARE MINIMUMS. THE BIN SUBCONTRACTOR SHALL DETERMINE SCHEDULE IN HIS DESIGN.

CONTROLLED DOCUMENT CLASS I

RCRA CONTROLLED DRAWING

NO	DATE	REVISIONS	APPVD EG&G	APPVD	APPVD ACC	APPVD DOE-ID	APPVD DOE-ID H&S	APPVD DOE-ID E&C
3	6-24-94	REVISED PER DCN# 155754-AB49 MW	6-21-94	6-28-94	6-28-94			
2	11-7-83	SEE DCN #2 83-269 JWR						
1		AS BUILT JWT						

	BY	DATE
DESIGNED	CRL	11-17-77
DRAWN	CRL	11-17-77
CHECKED	JPB	2-3-78
APPROVED	JEL	2-3-78

APPROVALS

ORGAN	BY	DATE
EGG		
ACC		2-3-78
DOE-ID		
DOE-ID		
H&S		
E&C		

EG&G Idaho, Inc.

FOR

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
IDAHO OPERATIONS OFFICE
IDAHO FALLS, IDAHO

CPP AREA
5TH SET CALCINE SOLIDS STORAGE BINS
BINS SECTION, DETAILS & BIN ORIENTATION PLAN

SCALE: AS SHOWN
DATE ISSUED: 5-7-79
DWG. NO. 158510
REV. 3

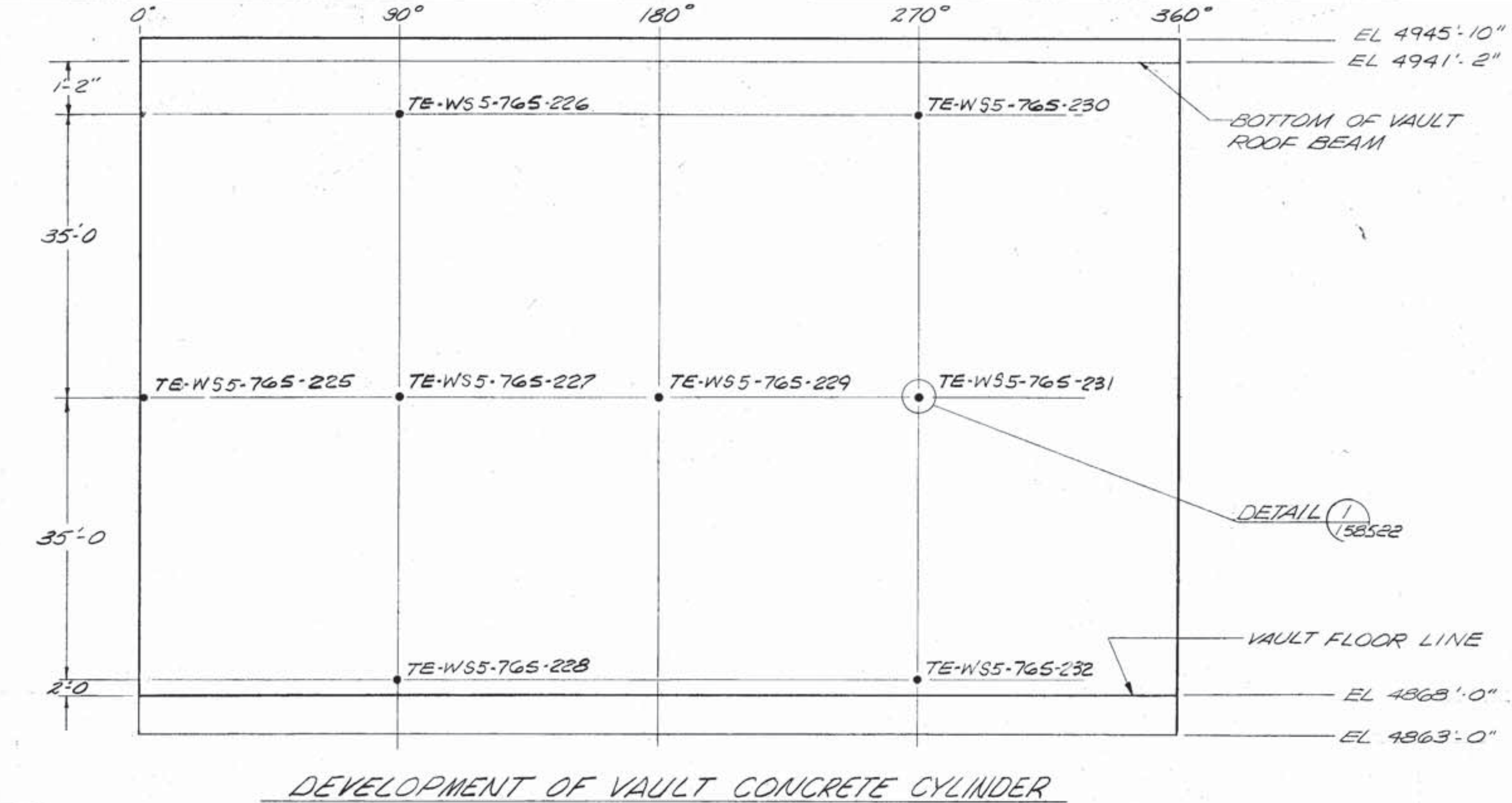
WS5

INDEX CODE NUMBER				
AREA	DWG. TYPE	CL	ORIG.	SERIAL
200	0765	61	220	158510

ALLIED CHEMICAL QUALITY ASSURANCE ESSENTIALITY LEVEL: B

K PROJECT NO. 27 S-218

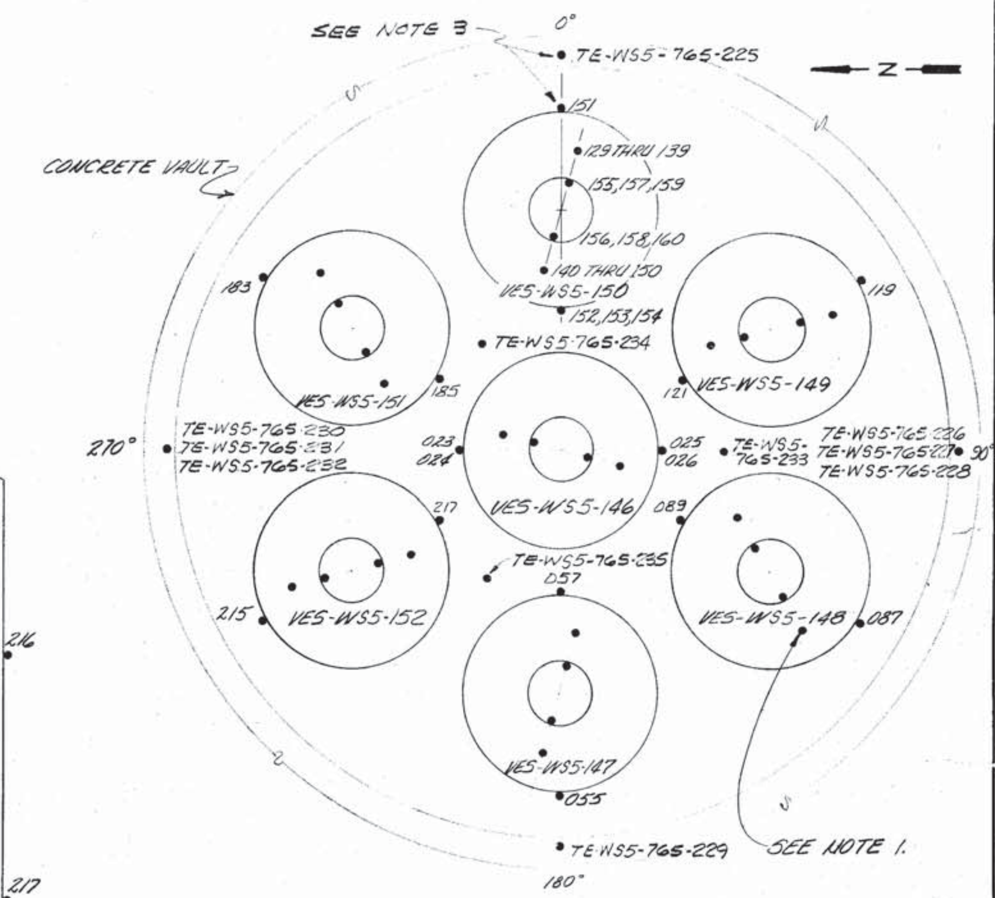
158510



DEVELOPMENT OF VAULT CONCRETE CYLINDER

NOTES:

1. FOR THERMOCOUPLE NUMBERS SEE TANK ELEVATIONS
2. MULTIPOINT THERMOCOUPLE ASSEMBLY. DIMENSIONS ARE SHOWN FROM THREADED END OF THERMOWELL
3. ONLY THE LAST THREE NUMBERS OF EACH TE ON EACH BIN ARE SHOWN. COMPLETE NUMBERS ARE: TE-WS5-146-001 THRU TE-WS5-146-032, TE-WS5-147-033 THRU TE-WS5-147-064, TE-WS5-148-065 THRU TE-WS5-148-096, TE-WS5-149-097 THRU TE-WS5-149-128, TE-WS5-150-129 THRU TE-WS5-150-160, TE-WS5-151-161 THRU TE-WS5-151-192, TE-WS5-152-193 THRU TE-WS5-152-224. OTHER TE'S ARE CALLED OUT IN FULL.



KEY PLAN

TANK ELEVATIONS

RCRA CONTROLLED DRAWING

CONTROLLED DOCUMENT CLASS I

NO.	DATE	REVISIONS	APPVD ANC	APPVD ERDA	APPVD	APPVD AEC	APPVD AEC H&S	APPVD AEC E&C
5	6-28-94	REVISED PER DCN #155754-AB50	MW					
4	5/12/94	REVISED PER DCN #155754-AB32						
3	4/11/83	SEE DCN #3 83-216 4/6						
2		AS BUILT JWT						
1		REV TE NO'S & NOTE 3						

	BY	DATE
DESIGNED		
DRAWN	GDJ	
CHECKED	JKGRAY	
APPROVED		

APPROVALS

ORGAN	BY	DATE
ANC ACC		5-7-79
AEC		
AEC		
AEC H&S		
AEC E&C		

EG&G Idaho, Inc.
FOR
U. S. ENERGY RESEARCH & DEVELOPMENT ADMINISTRATION
IDAHO OPERATIONS OFFICE
IDAHO FALLS, IDAHO

CPP 765
5TH SET CALCINED SOLIDS STORAGE BINS
THERMOCOUPLE LAYOUT WS5

INDEX CODE NUMBER				
AREA	DWG. TYPE	CL	ORIG.	SERIAL
200	0765	2	8220	158523

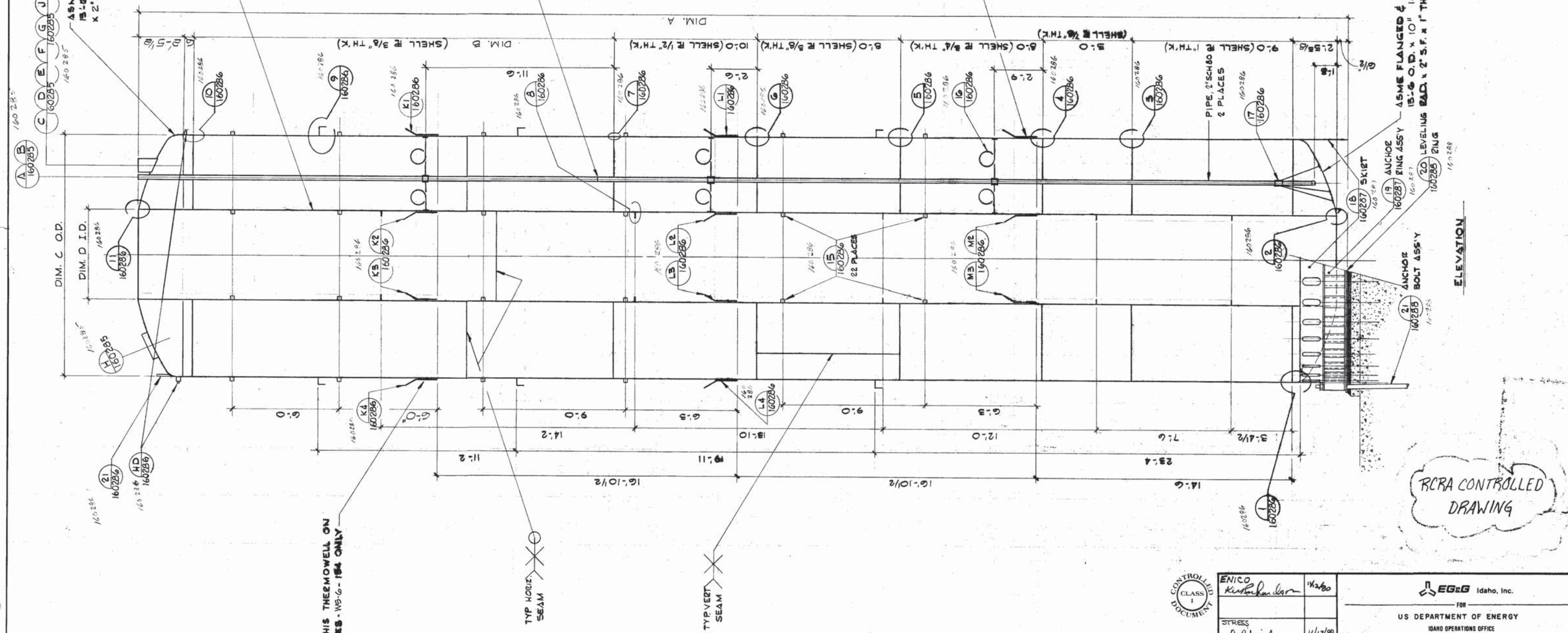
SCALE: NONE
DATE ISSUED: 5-7-79
DWG. NO. 158523
REV. 5

REVISIONS						
ZONE	LTR	DESCRIPTION	DWN	CHK	DATE	APPROVED
	6	ACTIVATED PER DCN# 155754-AB8	JPD		4-1-94	
	7	REVISED PER DCN# 155754-AB51	MW 6-24-94	GS 6-28-94		6-28-94

VES. NO.	DIM. A	DIM. B	DIM. C	DIM. D
154	67'-11 1/2"	21'-11 5/8"	13'-5 1/4"	5'-0 1/4"
155	67'-11 7/8"	21'-11 7/8"	13'-6 3/8"	5'-0 1/4"
156	67'-11 3/8"	22'-0 1/4"	13'-6 1/16"	5'-0 1/8"
157	67'-11 5/8"	21'-11 1/2"	13'-5 7/8"	5'-0"
158	67'-11 7/8"	22'-0 1/2"	13'-6 1/4"	5'-0"
159	68'-0"	22'-0 3/8"	13'-6"	5'-0"
160	68'-0"	22'-0 3/8"	13'-6"	5'-0"

NOTES:

1. UNLESS NOTED OTHERWISE ALL MAT'L SHALL BE 304L SST.
2. BIN WORKING TOLERANCES
   OVERALL HEIGHT ± 1"
   OD OF BINS ± 1"
   MISALIGNMENT OF ℄ TOP TO BTM ± 1/2"
   NOZZLE POSITION ± 1/4"
   MISALIGNMENT OF NOZZLES A & B FROM BIN ℄ ± 1/4"
   LEVELING RING ± 1/8" ON I.D. & O.D. ONLY - NOT FLATNESS
   ANCHOR BOLT ASS'Y ± 1/8"
   ANCHOR RING ASS'Y ± 1/8"
   ALL OTHERS ± 1/8" UNLESS NOTED
3. SUPPORTS FOR NOZZLES A & B SHALL NOT BLOCK LINE OF SIGHT THRU RETRIEVEL NOZZLES C, D, E & F.
4. SEE MASON STEEL DWG. NO. P-4790-81



CONTROLLED DOCUMENT CLASS I

ENICO	11/12/80	EG&G Idaho, Inc. — FOR — US DEPARTMENT OF ENERGY, IDAHO OPERATIONS OFFICE, IDAHO FALLS, IDAHO	
STRESS D. P.	11/12/80		
DESIGN SUPRV.	11/12/80	TITLE CPP AREA	STRUCT 791
DESIGN D E Judy	11-12-80	6th SET CALCINED SOLIDS STORAGE BINS	
CHECKED J. P.	11-12-80	ELEVATION (SECTION)	
DRAWN A. BEINGHUEST	DATE 9-5-80		W56

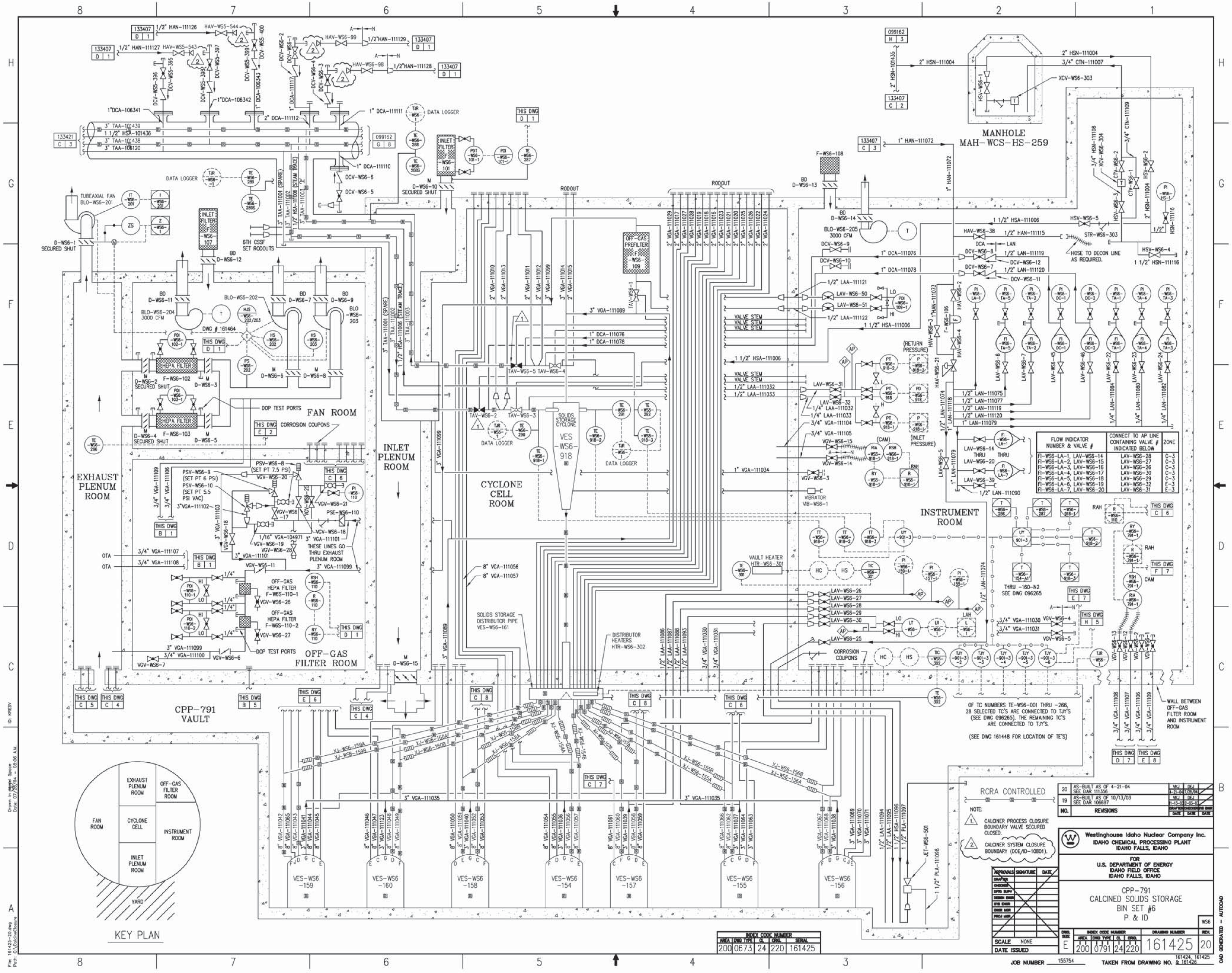
INDEX CODE NUMBER					
AREA	DWG. TYPE	CL	ORIG.	SERIAL	
2000	791	6	1220	160283	

SCALE: 3/8" = 1'-0

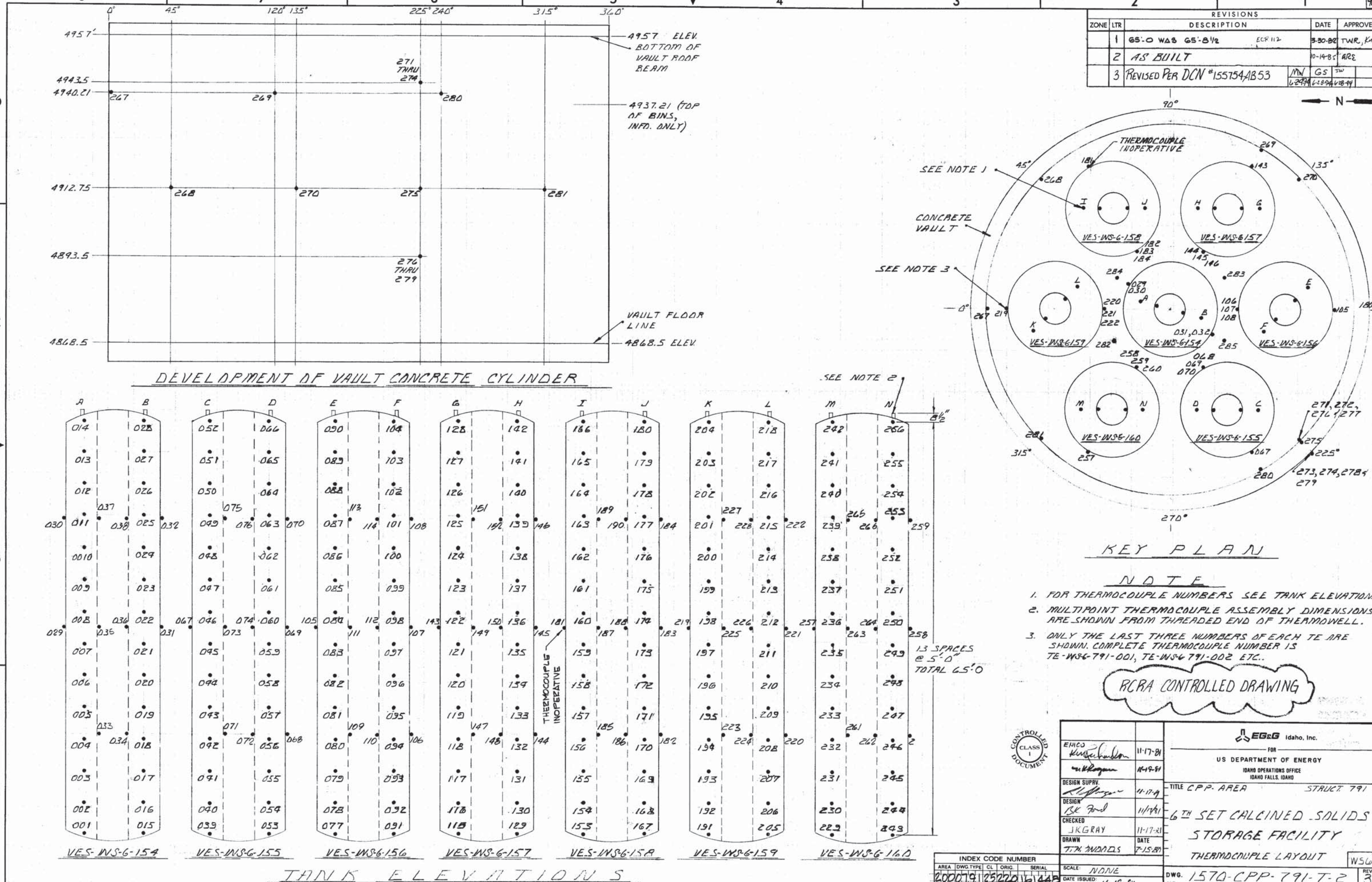
DATE ISSUED: 11/12/80

DWG. NO. 1570-CPP-791-S1 REV 7

Subcontract No. 3289 PROJECT NO.



MANHOLE
MAH-WCS-HS-259
FAN ROOM
EXHAUST PLENUM ROOM
INLET PLENUM ROOM
CYCLONE CELL ROOM
INSTRUMENT ROOM
OFF-GAS FILTER ROOM
CPP-791 VAULT
KEY PLAN
YARD
RODOUT
VES-WS6-918
VES-WS6-159
VES-WS6-160
VES-WS6-158
VES-WS6-154
VES-WS6-157
VES-WS6-155
VES-WS6-156
SOLIDS STORAGE DISTRIBUTOR PIPE VES-WS6-161
DISTRIBUTOR HEATERS HTR-WS6-302
TUBEAXIAL FAN BLO-WS6-201
BLO-WS6-204 3000 CFM
BLO-WS6-205 3000 CFM
DATA LOGGER
DOP TEST PORTS
CORROSION COUPONS
6TH CSSF SET RODOUTS
HOSE TO DECON LINE AS REQUIRED.
THESE LINES GO THRU EXHAUST PLENUM ROOM
FLOW INDICATOR NUMBER & VALVE #
CONNECT TO AP LINE CONTAINING VALVE # INDICATED BELOW
ZONE
FI-WS6-LA-1, LAV-WS6-14 | LAV-WS6-28 | C-3
FI-WS6-LA-2, LAV-WS6-15 | LAV-WS6-27 | C-3
FI-WS6-LA-3, LAV-WS6-16 | LAV-WS6-26 | C-3
FI-WS6-LA-4, LAV-WS6-17 | LAV-WS6-30 | C-3
FI-WS6-LA-5, LAV-WS6-18 | LAV-WS6-29 | C-3
FI-WS6-LA-6, LAV-WS6-19 | LAV-WS6-32 | C-3
FI-WS6-LA-7, LAV-WS6-20 | LAV-WS6-31 | C-3
OF TC NUMBERS TE-WS6-001 THRU -266, 28 SELECTED TC'S ARE CONNECTED TO TJY'S (SEE DWG 096265). THE REMAINING TC'S ARE CONNECTED TO TJY'S.
(SEE DWG 161448 FOR LOCATION OF TE'S)
WALL BETWEEN OFF-GAS FILTER ROOM AND INSTRUMENT ROOM
RCRA CONTROLLED
NOTE:
1. CALCINER PROCESS CLOSURE BOUNDARY VALVE SECURED CLOSED.
2. CALCINER SYSTEM CLOSURE BOUNDARY (DOE/ID-10801).
20 AS-BUILT AS OF 4-21-04 SEE DAR 111356
19 AS-BUILT AS OF 10/13/03 SEE DAR 106697
NO. REVISIONS
Westinghouse Idaho Nuclear Company Inc.
IDAHO CHEMICAL PROCESSING PLANT
IDAHO FALLS, IDAHO
FOR
U.S. DEPARTMENT OF ENERGY
IDAHO FIELD OFFICE
IDAHO FALLS, IDAHO
CPP-791
CALCINED SOLIDS STORAGE
BIN SET #6
P & ID
WS6
SCALE NONE
DATE ISSUED
E 200 0791 24 220 161425 20
INDEX CODE NUMBER
200 0673 24 220 161425
JOB NUMBER 155754
TAKEN FROM DRAWING NO. 161424, 161425 & 161426
CAD GENERATED - AUTOCAD



REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	1	65'-0 WAS 65'-8½ ECR 112	3-30-82	TWR, KMR
	2	AS BUILT	10-14-85	ARE
	3	REVISED PER DCN #155754, AB53	MW 6-24-94	GS 6-28-94

NOTE

1. FOR THERMOCOUPLE NUMBERS SEE TANK ELEVATIONS.
2. MULTIPOINT THERMOCOUPLE ASSEMBLY DIMENSIONS ARE SHOWN FROM THREADED END OF THERMOWELL.
3. ONLY THE LAST THREE NUMBERS OF EACH TE ARE SHOWN. COMPLETE THERMOCOUPLE NUMBER IS TE-WS6-791-001, TE-WS6-791-002 ETC..

RCRA CONTROLLED DRAWING

CONTROLLED DOCUMENT CLASS I

EG&G Idaho, Inc.
FOR
US DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE
IDAHO FALLS, IDAHO

ENGIN.	[signature]	11-17-81
	[signature]	11-19-81
DESIGN SUPRV.	[signature]	11-17-81
DESIGN	BK Ford	11/17/81
CHECKED	JKGRAY	11-17-81
DRAWN	T.M. WOODS	DATE 7-15-81
SCALE:	NONE	
DATE ISSUED:	11-19-81	

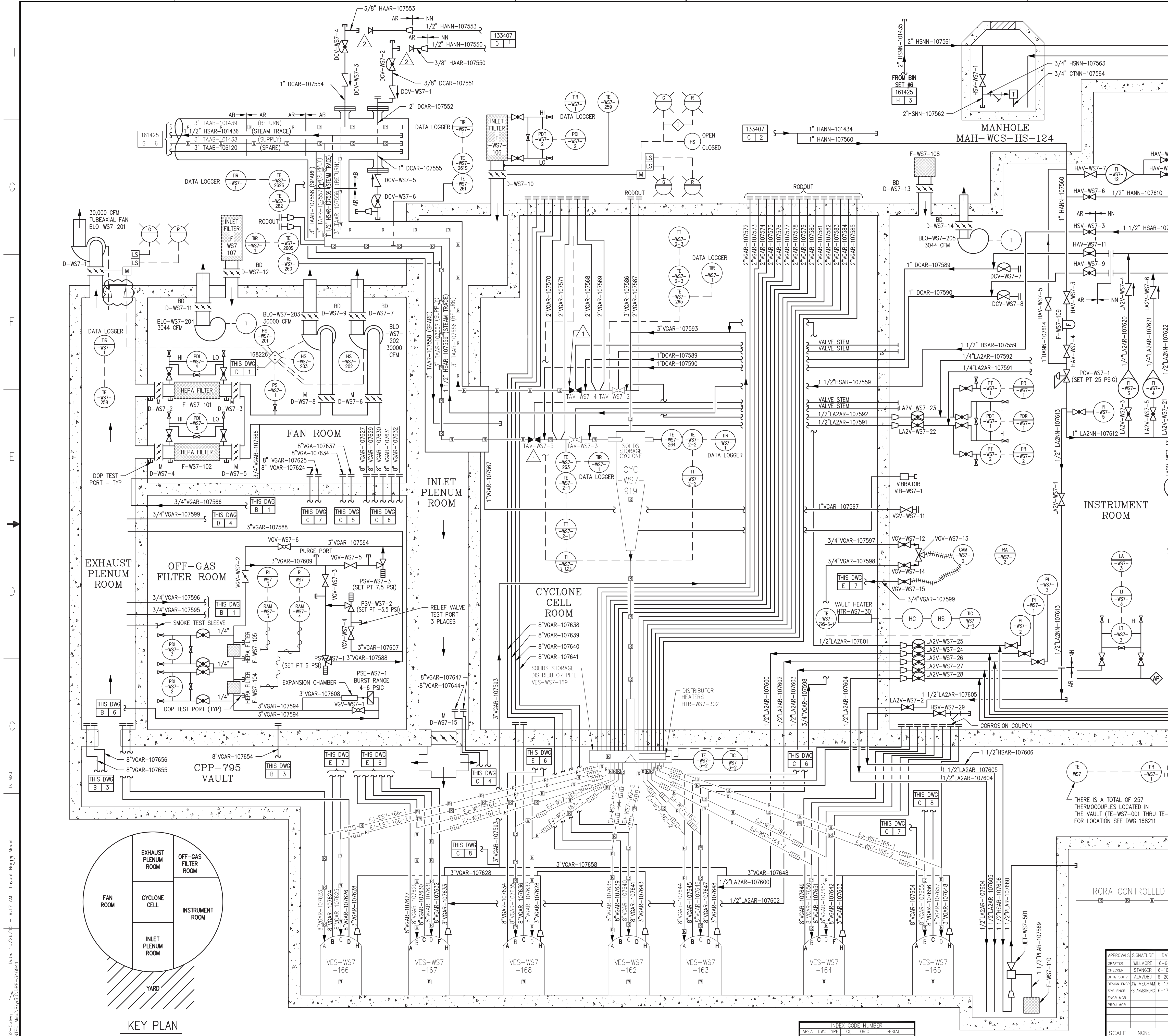
TITLE CPP-AREA STRUCT. 791
6TH SET CALCINED SOLIDS STORAGE FACILITY
THERMOCOUPLE LAYOUT
WS6
DWG. NO. 1570-CPP-791-T-2 REV 3

INDEX CODE NUMBER

AREA	DWG. TYPE	CL	ORIG.	SERIAL
200	0791	25	220	14144B

PROJ. NO.

U.S. GPO NO. 697-601



NO.	REVISIONS	DRAFTER DATE	CHECKER DATE	SYS ENGR DATE
5	AS-BUILT AS OF 10/21/2015, INCORP'D FDC-7293, FDC-4677 MADE NO CHANGES TO DWG, REMOVED PRIOR HISTORY, SEE DRF-346941	JM 10/26/2015	KK 10/26/2015	

Westinghouse Idaho Nuclear Company Inc.
IDAHO CHEMICAL PROCESSING PLANT
IDAHO FALLS, IDAHO

FOR
U.S. DEPARTMENT OF ENERGY
IDAHO FIELD OFFICE
IDAHO FALLS, IDAHO

APPROVALS	SIGNATURE	DATE
DRAFTER	WILLMORE	6-6-94
CHECKER	STANGER	6-16-94
DFTG SUPV	ALR/DBJ	6-20-94
DESIGN ENGR	DW MECHAM	6-17-94
SYS ENGR	RS ARMSTRONG	6-17-94
ENGR MGR		
PROJ MGR		

SCALE NONE
DATE ISSUED ALR/DBJ 6-20-94

CPP-795 CALCINED SOLIDS STORAGE BIN SET #7 P & ID

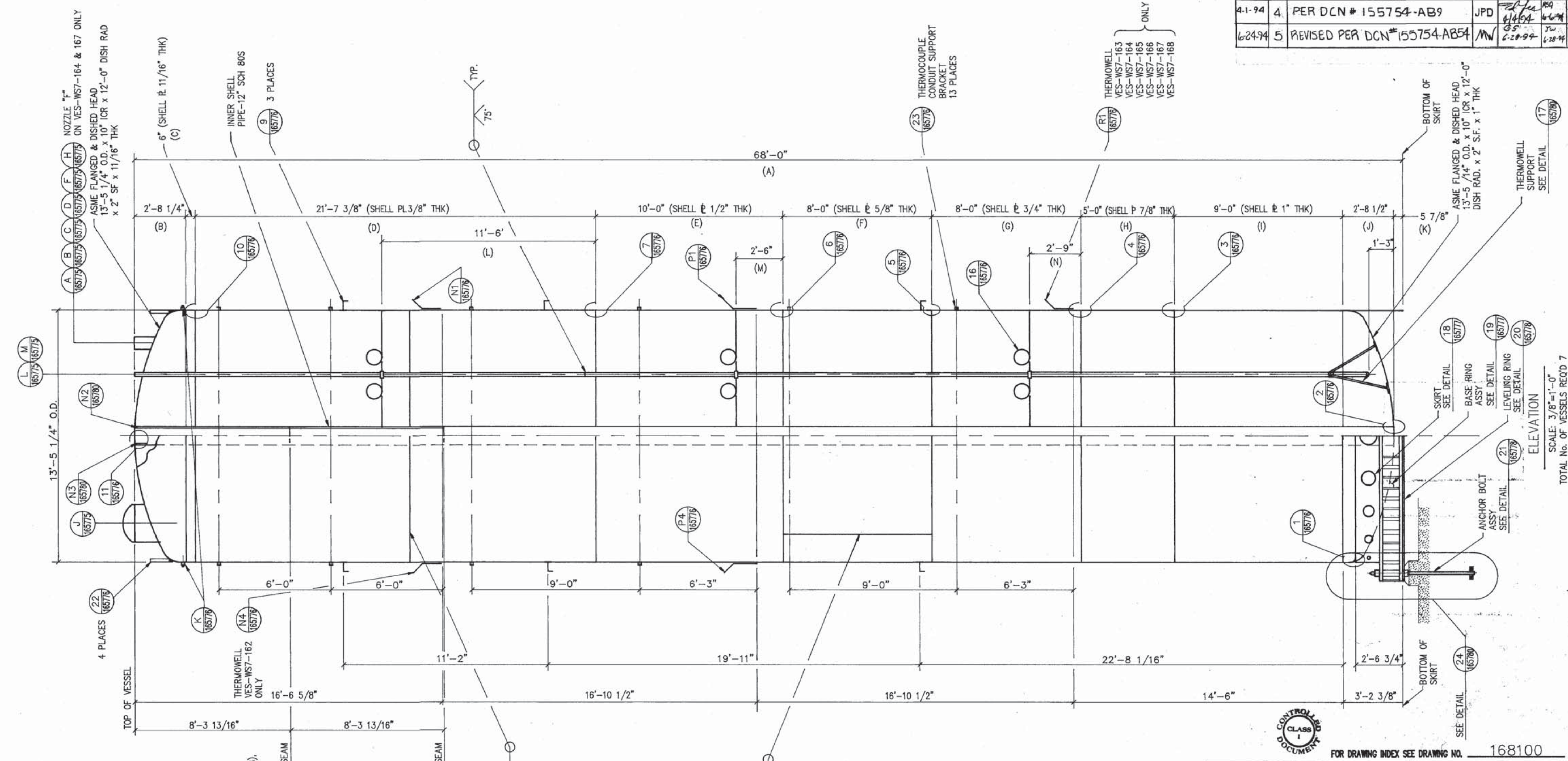
WS7

DWG. SIZE	AREA	DWG TYPE	CL	ORIG.	DRAWING NUMBER	REV.
E	200	0795	24	936	099162	5

JOB NUMBER 155754
TAKEN FROM DRAWING NO. 168166,168167, 168168,168169 & 168170
CAD GENERATED - AUTOCAD

REVISIONS

DATE	REV.	DESCRIPTION	BY	CHK'D	APPROVED
4-1-94	4	PER DCN # 155754-AB9	JPD	[illegible] 6-6-94	[illegible] 6-6-94
6-24-94	5	REVISED PER DCN # 155754-AB54	MW	6-28-94	6-28-94



CONTROLLED DOCUMENT CLASS I

FOR DRAWING INDEX SEE DRAWING NO. 168100

GENERAL NOTES:

1- UNLESS NOTED OTHERWISE ALL MAT'L SHALL BE 304L SST

2- VESSEL WORKING TOLERANCES:
OVERALL HEIGHT ±1"
O.D. OF BINS +1 3/4" -1/4"
MISALIGNMENT OF TOP TO BTM 1/2"
NOZZLE POSITION ±1/4"
MISALIGNMENT OF NOZZLES L & M FROM BIN ±1/4"
LEVELING RING ±1/8"
ANCHOR BOLT ASSY ±1/8"
BASE RING ASSY ±1/8"
HEAD TOLERANCES PER ASME CODE
ALL OTHERS ±1/8" UNLESS NOTED OTHERWISE

3- SUPPORTS FOR NOZZLES L&M SHALL NOT BLOCK LINE OF SIGHT THRU RETRIEVEL NOZZLES A,B,C,& D

4- PREASSEMBLE VESSEL W/SKIRT (DETAIL 18), BASE RING ASSY (DETAIL 19), LEVELING RING (DETAIL 20) & ANCHOR BOLT ASSY (DETAIL 21) INDEX AND MATCH MARK. SEE DWG. 165779 FOR MATCH MARK LOCATION.

5- CONSTRUCTED I.A.W. ASME SECTION VIII DIVISION 2 WINTER ADD. OF 84.

6- AS-BUILT DIMENSION ARE SHOWN ON AS-BUILT DIMENSION TABLE ON DWG. 165779

RCRA CONTROLLED DRAWING

SCALE: 1"= 1" IN 1/10"

SCALE: 1"= 1" IN 1/16"

DO NOT SCALE DRAWING

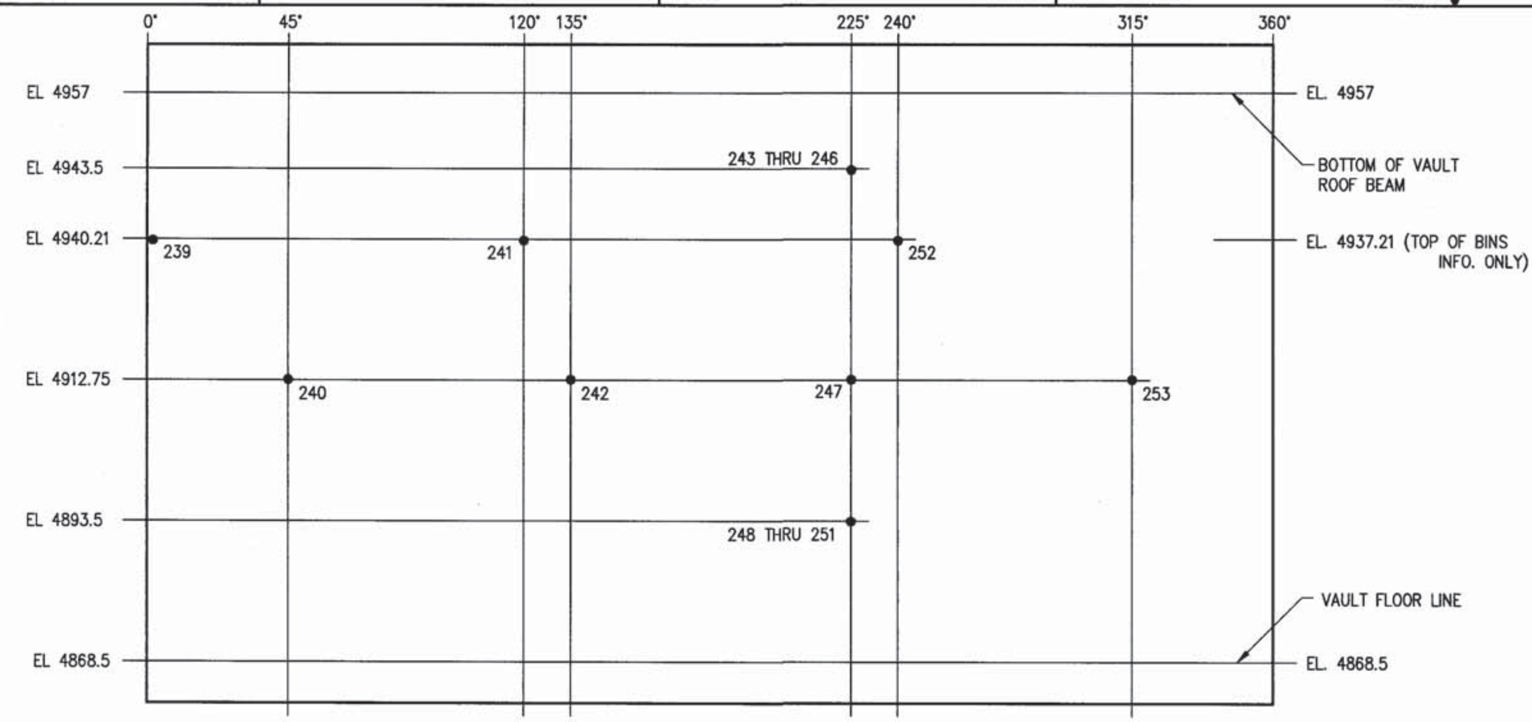
DESIGN PHASE	DATE APPROVED
TITLE I	
TITLE II	
APPROVED FOR CONSTRUCTION	

QUALITY LEVEL I

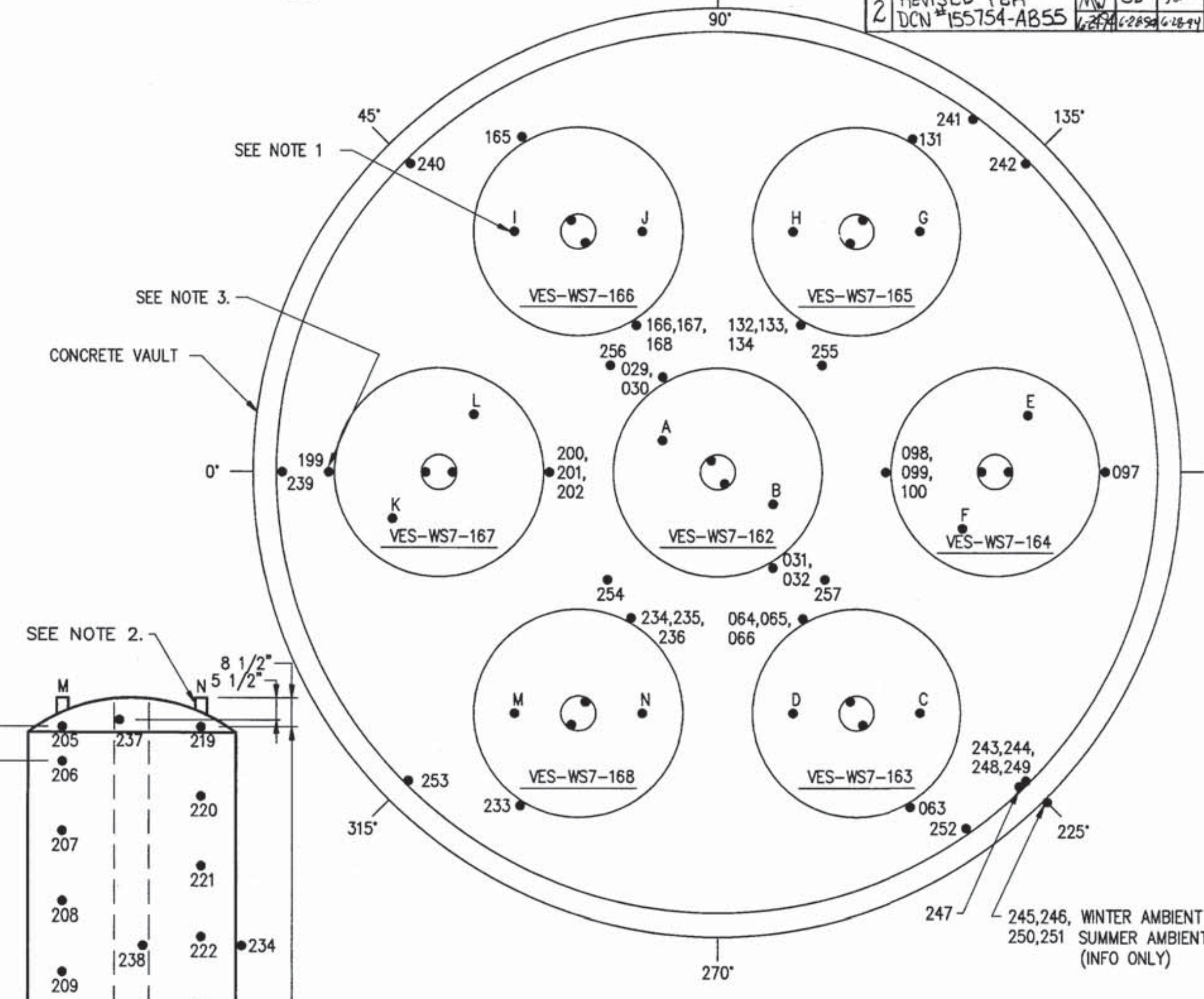
WINCO A.R. EBERLE	4-2-85	EG&G Idaho, Inc. A/E CONTRACT NO. 1570 FOR U.S. DEPARTMENT OF ENERGY IDAHO OPERATIONS OFFICE IDAHO FALLS, IDAHO
DESIGN MGR L.D.T.	4-2-85	CPP STRUCT. 795
DESIGN D.E. JUDY	4-2-85	7TH SET CALCINED SOLIDS STORAGE FACILITY BINS
CHECKED C.R. LEAVITT	4-2-85	
DRAWN T.G. BESERIS	DATE 4-2-85	ELEVATION SECTION WS7
PROJECT NO. EA 95510		SIZE D; INDEX CODE NUMBER: AREA 200, DWG. TYPE 0795, CL 53, ORIG 220; DRAWING NO. 165772; REV. 5
SUBCONTRACT NO. S-2514		
ISSUED FOR CONSTRUCTION 4/2/85		SCALE NOTED; SPEC. CODE; A/E SHEET NO. M-1

112

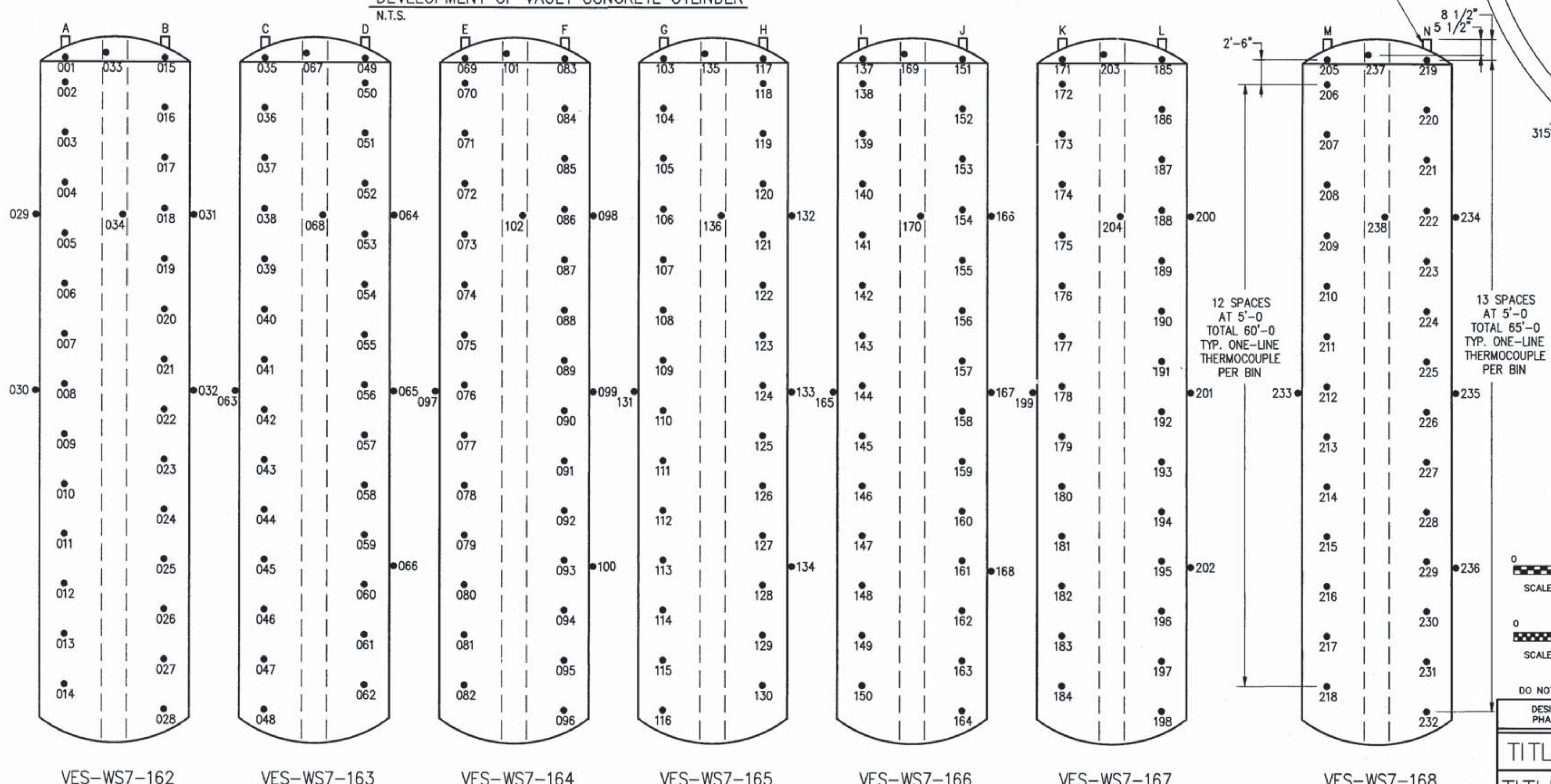
REV	DESCRIPTION	DATE	APPROVED
1	ASBUILT CRP	02 Nov 1989	[illegible]
2	REVISED PER DCN 155754-AB55	6-28-94	[illegible]



DEVELOPMENT OF VAULT CONCRETE CYLINDER
N.T.S.



KEY PLAN
SCALE: NONE



TANK ELEVATIONS
N.T.S.

NOTES:
1– FOR THERMOCOUPLE NUMBERS SEE TANK ELEVATIONS.
2– MULTIPOINT THERMOCOUPLE ASSY. DIMENSIONS ARE SHOWN FROM THREADED END OF THERMOWELL.
3– ONLY THE LAST THREE NUMBERS OF EACH T.E. ARE SHOWN. COMPLETE THERMOCOUPLE NUMBER IS TE-WS7-795-001, TE-WS7-795-002, ETC.

RCRA CONTROLLED DRAWING

CONTROLLED DOCUMENT CLASS I

FOR DRAWING INDEX SEE DRAWING NO. 168100

SCALE: 1"= 1" IN 1/10"

SCALE: 1"= 1" IN 1/16"

DO NOT SCALE DRAWING

DESIGN PHASE	DATE APPROVED
TITLE I	
TITLE II	
APPROVED FOR CONSTRUCTION	

QUALITY LEVEL

WINCO A.R. EBERLE	6/6/86
DESIGN MGR J.E. DUGGAN	6-6-86
DESIGN T.H. WOODS	6-6-86
CHECKED J.K. GRAY	6-6-86
DRAWN T.G. BESERIS	DATE 6-6-86
PROJECT NO. EA 95510	
SUBCONTRACT NO. S-2514	
ISSUED FOR CONSTRUCTION 6/6/86	

EG&G Idaho, Inc.
A/E CONTRACT NO. 1570
FOR
U.S. DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE
IDAHO FALLS, IDAHO

CPP STRUCT. 795

7TH SET CALCINED SOLIDS STORAGE FACILITY

THERMOCOUPLE LAYOUT

SIZE	AREA	DWG. TYPE	CL	ORIG	DRAWING NO.	REV.
D	200	0795	25	220	168211	2

SCALE NONE | SPEC. CODE | A/E SHEET NO. 1-2

DATE ISSUED 1-23-90 SYS. ENG. [illegible]

112891

RCRA PART B PERMIT REAPPLICATION

FOR THE
IDAHO NATIONAL LABORATORY

VOLUME 22
IDAHO NUCLEAR TECHNOLOGY & ENGINEERING CENTER

CALCINED SOLIDS STORAGE FACILITY

APPENDIX 2

TANK SYSTEM INTEGRITY ASSESSMENT FOR THE
CALCINED SOLIDS STORAGE FACILITY BIN SETS AT THE
IDAHO NUCLEAR TECHNOLOGY AND ENGINEERING CENTER

MAY 2016

TANK SYSTEM INTEGRITY ASSESSMENT FOR THE CALCINED SOLIDS STORAGE FACILITY BIN SETS AT THE IDAHO NUCLEAR TECHNOLOGY AND ENGINEERING CENTER

REVISION 1
FINAL

Completed for
Bechtel BWXT Idaho
Under
Blanket Master Contract No. 00000118,
Release No. 3, Amendment No. 1

June 2003

Prepared by
Jason Associates Corporation
Idaho Falls, Idaho
Under
Work Order 2336-001-3

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	3.4 Tank Ages	13
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1. CERTIFICATION

Tanks Systems Being Certified

The tank systems being addressed by this attestation are the hazardous waste tank systems located within the seven (7) Calcined Solids Storage Facility Bin Sets at the Idaho Nuclear Technology and Engineering Center (INTEC) within the Idaho National Engineering and Environmental Laboratory (INEEL). These tank systems are further described in Sections 2 and 3 of this document.

Attestation

The calcine storage bin elements of the tank systems are adequately designed and have sufficient structural strength and compatibility with the wastes being stored to provide reasonable assurance that they will not collapse, rupture, or fail.

The vaults that contain the bins, if considered part of the tank system, are adequately designed and have sufficient structural strength to provide reasonable assurance that they will not collapse or fail.

This attestation is also contingent upon certain conditions and limitations, which are identified in this assessment.

Certification

Relying in part upon documentation and statements of fact provided by INEEL personnel and in attached assessments provided by other qualified, registered professional engineers, I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Keith D. Davis, P.E.
Idaho P.E. Registration #6831
Jason Associates Corporation

Date: June 25, 2003

2. INTRODUCTION

Hazardous waste regulations promulgated pursuant to the Resource Conservation and Recovery Act (RCRA) and the corresponding Idaho Hazardous Waste Management Act (HWMA) address the operation of hazardous waste tank systems (40 CFR Part 265, Subpart J). The tank system regulations include a requirement [40 CFR 265.191(a)] that the owner or operator of an existing tank system without secondary containment obtain and keep a written assessment that attests to the tank system's integrity. It is further required that this assessment be reviewed and certified by an independent registered professional engineer. The preceding certification attests to the integrity of the hazardous waste tank systems located within the seven Calcined Solids Storage Facility (CSSF) Bin Sets at the Idaho Nuclear Technology and Engineering Center (INTEC) within the Idaho National Engineering and Environmental Laboratory (INEEL). The remainder of this section presents additional background on the CSSF Bin Sets and their usage as well as on an earlier version of this document. The subsequent sections of this document present the written assessment of the tank systems upon which the certification is based.

The U.S. Department of Energy (DOE) processed spent/irradiated nuclear fuel at INTEC from 1952 to 1992 in order to recover enriched uranium. In simple terms, spent nuclear fuel units were dissolved and the enriched uranium was extracted from the solution, with the remaining material being managed as waste. This process generated an acidic, highly radioactive liquid waste that was stored in large underground tanks at the INTEC Tank Farm. When spent fuel reprocessing was discontinued, other highly radioactive liquid waste, from processes such as subsequent extraction cycles and decontamination activities, continued to be generated and stored in the Tank Farm. From December 1963 through May 2000, liquid radioactive waste from the Tank Farm was converted to a dry, stable granular form by periodically processing (in campaigns) the liquid through a calciner treatment process. In this process, the waste was injected into a high-temperature (400 to 600° C) air-fluidized bed of granular solids where the liquid portion of the radioactive waste evaporated and solids adhered to the granular material, or calcine. This material was actually produced from two separate calciner facilities: the Waste Calcining Facility (WCF) operated from 1963 to 1981, and the New Waste Calcining Facility

(NWCF) operated from 1982 to 2000. In both facilities, the calcine was collected from the off-gas and bed build-up as the treatment proceeded and was moved pneumatically to stainless steel bins for storage. Storage in this form has always been intended to be interim in nature. Though the bins were designed with a 500-year life (Berreth 1988), the calcine is considered retrievable for ultimate disposal in a repository or other site when available.

The bins that received the calcine are located in groups or sets with each group housed within a vault. Over the years, there have been seven different Bin Sets constructed, each containing a grouping of stainless steel bins. The tanks that are the subject of this assessment are the stainless steel bins that are located within the CSSF Bin Sets as described below:

CSSF Designation	Bin Set Description
Bin Set #1	Contains 4 composite bins. Each composite bin consists of two concentric, ring (annular) tanks with a third, right-circular cylindrical tank located in the middle. There are gaps, several inches in width, between the two annular tanks and between the inner annular tank and the cylindrical tank to support movement of cooling air between the tanks. The annular tanks are 20-feet tall and the outer one has an outside diameter of 142 inches and an inside diameter of 94 inches. The inner annular tanks have a similar annular thickness of about 50 inches. The cylindrical tank in the center is 25 feet tall and has a 36-inch inside diameter. The tanks are constructed of Type-405 stainless steel. The four composite bins have a combined capacity of about 8,000 cubic feet and contain about 7,700 cubic feet of calcine. The rectangular concrete vault that houses the Bin Set is underground.
Bin Set #2	Contains 7 bins or tanks, each a right circular cylinder about 42 feet tall and 12 feet in diameter. The vertical tanks are arranged with six of them in a circular pattern that is centered on the seventh. The tanks are

constructed of Type-304 stainless steel and have a combined capacity of about 30,200 cubic feet. They are filled to capacity with calcine. The cylindrical concrete vault that houses the Bin Set is predominantly below ground level with earth banked up against the portion that is above ground level.

Bin Set #3 — Contains 7 bins or tanks, with a design and layout very similar to that of Bin Set #2. Except that the six bins arranged in the circular pattern are about 53-feet tall and the inner, central bin is 61 feet tall. (Each bin has a diameter of about 12 feet.) The 7 bins have a combined capacity of about 38,700 cubic feet and are filled to near-capacity with calcine. The concrete vault that houses Bin Set #3 has a configuration similar to that described for Bin Set #2.

Bin Set #4 — Contains 3 bins or tanks, each a right circular cylinder about 55 feet tall and 12 feet in diameter. The tanks are constructed of Type-304 stainless steel and have a combined capacity of about 17,200 cubic feet. They are filled to capacity with calcine. The cylindrical concrete vault that houses the Bin Set is partially below ground level.

Bin Set #5 — Contains 7 bins or tanks, each a right circular cylinder about 50 feet tall, with an outer diameter of 12 feet. These tanks are annular in design with the open interior annulus being 4 feet in diameter (i.e., this is the inner diameter of the annular tank). The 7 tanks are arranged in the same pattern as are the tanks in Bin Sets #2 and #3 (i.e., six of them in a circular pattern centered on the seventh). The tanks are constructed of Type-304L stainless steel, have a combined capacity of about 35,000 cubic feet, and are filled to capacity with calcine. About half of the cylindrical concrete vault that houses the Bin Set is below ground level.

Bin Set #6 Contains 7 bins or tanks, with a design and layout very similar to that of Bin Set #5. Except that each of the seven annular tanks is about 68 feet tall with 13.5-feet outer and 5-feet inner diameters. The 7 bins have a combined capacity of about 53,200 cubic feet and are only partially full containing about 26,200 cubic feet of calcine. Based on the CSSF filling timelines presented in Appendix B of Staiger (1999), it is believed the calcine in this Bin Set is fairly evenly distributed among the 7 bins. The concrete vault that houses this Bin Set has a configuration similar to that described for Bin Set #5.

Bin Set #7 Contains 7 bins or tanks which are laid out in the same pattern as are the bins in Bin Sets #5 and #6. The bins have the same outer dimension as those in Bin Set #6 (i.e., 68 feet tall and 13.5 feet in diameter), but the annular space is limited to a 12-inch schedule 80 pipe extended through the (long axis) center of each bin. These bins are constructed of Type-304L stainless steel, have a combined capacity of about 63,000 cubic feet, and are empty (i.e., no calcine has been added). The concrete vault containing this Bin Set has a configuration similar to those for Bin Sets #5 and #6.

This document was originally issued in November 2002. The findings of the structural analysis performed at that time included potential concerns with regard to loading capacities of Bin Set #1 and its vault. The concerns, however, included the caveat that conservative assumptions had been made as necessary to fill information gaps on the Bin Set and Bin Set vault designs. Subsequent to the initial report, INEEL personnel indicated that additional design information could be located and requested that the structural analysis be performed again to incorporate the additional information. The current document, Revision 1 of the Tank System Integrity Assessment, has been revised to incorporate the new Structural Engineering Evaluation and its results, including corresponding changes to the certification statement in Section 1. There have been no significant changes to the other elements of this Assessment compared to the original November 2002 version.

3. TANK SYSTEM INTEGRITY ASSESSMENT

The hazardous waste regulations that require a written assessment of a tank system's integrity, as described in Section 2 of this document, establish a minimum set of tank system elements that must be considered by the assessment. This minimum set of tank system elements is presented in Table 1 along with the applicable federal regulatory citation.

Table 1. Minimum set of tank system elements to be considered in tank integrity assessment.

Citation	Designation	Assessment Consideration
265.191(b)(1)	Design Standards	The assessment must consider the design standard(s), if available, according to which the tank and ancillary equipment were constructed.
265.191(b)(2)	Waste Characteristics	The assessment must consider the hazardous characteristics of the waste(s) that have been or will be handled.
265.191(b)(3)	Corrosion Protection	The assessment must consider the tank system's existing corrosion protection measures.
265.191(b)(4)	Tank Age	The assessment must consider the documented age of the tank system or, if not available, an estimated age of the tank system.
265.191(b)(5)	Integrity Examination	The assessment must consider results of a tank system integrity examination, which must be either (1) a leak test capable of taking into account the effects of temperature variations, tank end deflection, vapor pockets, and high water table effects, or (2) an internal inspection and/or other tank integrity examination certified by an independent, qualified, registered professional engineer that addresses cracks, leaks, corrosion, and erosion.

The tank system integrity examination requirements (see Table 1) described in the regulations vary depending on whether the tank is a non-enterable underground tank. Though the vaults containing the Bin Sets are partially or wholly underground, it is believed that the tanks or bins themselves do not meet the definition of underground tanks. Accordingly, the "Integrity Examination" requirement or consideration shown in Table 1 is based on the regulatory citation for "other than non-enterable underground tanks."

The remainder of this section addresses each of the assessment considerations identified in Table 1 with one difference. The first tank system consideration shown in Table 1 is being modified to include results of a structural analysis of the tank systems rather than simply identifying the design standards under which the tank systems were constructed. In order to adequately assess whether the tank systems have sufficient structural strength, it is reasoned that some structural analysis is appropriate to account for an incomplete record of design standards over time and to consider the potential for current design standards to be more conservative.

3.1 DESIGN STANDARDS AND STRUCTURAL ANALYSIS

A qualified (and certified) independent structural engineer evaluated design information made available on the bin structures and performed a conservative initial analysis with simplifying assumptions (also termed a "threshold analysis") to develop an overall general picture of the existing facilities with respect to current building codes. The analysis is intended to assist administrators and decision-makers to determine if there is a sufficient level of concern with respect to Bin Set structural elements to warrant further, more detailed analysis. The structural analysis effort and its results are documented in a separate report, developed and certified by the structural engineer, which is provided as Attachment A to this document. This section provides a summary of the structural engineer's analysis and findings from the structural integrity evaluation.

The structural evaluation considered both the stainless steel bins containing the calcine material and the buried, or partially buried, concrete vaults in which the bins are contained. Analyses were performed to identify structural responses to normally expected, everyday loads and also to seismic events reasonably predicted to occur at the INEEL site. With respect to analysis of the stainless steel bins, a temperature factor was added to the normal load analysis to account for the elevated storage temperatures generated by the radioactive decay of the calcine. The structural evaluation identifies the Uniform Building Code (UBC) as the governing code in Idaho for the past half-century, but recognizes that it has now been replaced by the International Building Code (IBC), which was adopted by the State of Idaho and by local jurisdictions beginning this year (January 2003). Accordingly, the current version (2000) of the IBC is the standard used in the structural evaluation.

The structural analysis report incorporates carefully considered language on the limitations associated with the evaluation results. Some of the most important limitations are summarized as follows:

- The structural evaluation was conducted based solely on drawing information and reports; no site visit or physical inspection of the structures was performed as part of the effort. (The structural engineer was not precluded from a site inspection, but it was concluded that such an inspection would have no additional benefit because it would be severely limited by the high radiation fields associated with the Bin Sets.)

- Not all structures were evaluated. Similar structures were compared, and those that would generate worst-case results were selected by the structural engineer for analysis. Results of the limited analyses were then applied to the similar structures.

- The study is intended to provide a "threshold analysis" with conservative, simplifying assumptions, which establishes a beginning point for decision-making as to whether further investigation is warranted. This evaluation provides a "snapshot" of current conditions with respect to reasonably expected performance predicted by current building code.

Results of the structural analyses are detailed in the report along with appended calculations. A summary of those results are presented as follows for both the outer vaults and the stainless steel bins:

Concrete Vaults

- With respect to normal (non-seismic) loads, predicted stresses in all concrete vaults meet the provisions of the current 2000 IBC.

- With respect to earthquake loads, predicted stresses in all concrete vaults meet the provisions of the current 2000 IBC. Therefore, earthquake loadings will not be a problem for the concrete vaults of Bin Sets #1 through #7.

Stainless Steel Bins

- All bins are acceptable with respect to normal (non-seismic) loads, including when the temperature loading caused by the radioactive decay of the calcine is considered.

- With respect to earthquake loads, all stainless steel bins for Bin Sets #1 through #7 are acceptable in relation to the 2000 IBC.

The overall conclusion of the structural analysis is that the concrete vaults and stainless steel bin structures pass the threshold integrity assessment based on conservative assumptions. Since stresses in the structures meet current building code and no other structural concerns have been identified, it is also the conclusion of the effort that there is no need for further, more rigorous analysis.

3.2 WASTE CHARACTERISTICS

The tanks or bins within the 7 Bin Sets were all fabricated for the purpose of storing dry, granular calcine resulting from the treatment of liquid radioactive waste. Characteristics of the calcine produced by the treatment changed in accordance with the changes in the liquid waste feed that went into the treatment process. When the calcining process was put into operation at the INTEC, the primary waste feed was the liquid that resulted from processing and recovering enriched uranium from spent nuclear fuel. The spent fuels routinely processed involved aluminum, stainless steel, or zirconium as the primary fabrication material. INEEL documents present chemical characteristics of the calcine based on these different feed materials. In more recent years, since spent fuel processing was discontinued, the calcine has been characterized based on other types of waste feed. Liquid radioactive wastes generated from activities such as decontamination and subsequent (after first cycle) processing of spent nuclear fuel solutions are generally high in sodium and potassium nitrates and are referred to as Sodium Bearing Wastes (SBW).

Berreth (1988) considered the nature of the liquid radioactive waste processed over time and which Bin Sets were receiving calcine during the corresponding time to develop estimates of the calcine composition by Bin Set for the first five sets. This information is shown in Table 2. The notably different characteristics of the calcine in Bin Set #1 is the due to the fact that the liquid waste processed during its filling was totally from processing the aluminum-based spent fuel. The contribution from this type of liquid waste decreased in the next two Bin Sets. Chemical characteristics of calcine generated more recently than shown in Table 2 are shown in Table 3. The reference in this case (DOE 2002), presents the information in a little different format, showing the primary elements rather than compounds. If it is assumed that the elements are contained in the same compounds shown in Table 2 (e.g., all Al is in the form of Al_2O_3), then simple calculations can be performed to show that the data in Table 3 is generally within the range of values shown in Table 2. Notable exceptions to this are that Table 3 shows much lower amounts of zirconium and fluoride than does Table 2 for Bin Sets #2 through #5, and a much higher amount of sodium than for any of the Bin Sets in Table 2. This is consistent with the fact that the most recent waste processed through the calciner was not generated from processing spent nuclear fuel; rather the liquid waste consisted of SBW.

The bulk density of the calcine is estimated to vary between 1.0 and 1.7 grams per cubic centimeter (g/cm^3), but is most generally near 1.4 g/cm^3 (Berreth 1988). The "zirconium-based" calcine is at the upper end of the density range, while the "aluminum-based" calcine is at the lower end of the range. Calcine generated from the SBW is estimated to have a density of about 1.2 g/cm^3 (Russell et al. 1998).

Table 2. Approximate calcine composition by Bin Set (for Bin Sets #1 to #5). [a]

Component	Weight %				
	Bin Set #1	**Bin Set #2**	**Bin Set #3**	**Bin Set #4**	**Bin Set #5**
Al_2O_3	90.6	39.5	23.8	14.2	14.2
ZrO_2	- - -	14.8	17.3	19.4	19.9
CaF_2	- - -	34.1	40.3	45.2	46.4
B_2O_3	0.6	2.1	2.3	2.6	2.6
Na_2O	3.1	1.0	1.9	4.2	3.6
K_2O	- - -	- - -	0.1	0.9	0.7
CaO	- - -	2.5	5.9	8.0	10.9
Fe_2O_3	0.6	0.3	0.2	0.3	0.2
Hg	2.9	1.0	- - -	- - -	- - -
SO_4	1.2	0.4	0.1	0.3	0.3
PO_4	- - -	- - -	0.1	0.1	0.2
Cl	- - -	0.1	0.1	0.1	0.1
Other	1	4 [b]	8.0 [b]	4.8 [b]	1.0
NO_3 [c]	1	1	~3.5	~5	~5

a. Source: Berreth (1988), Tables 4-3 and 4-4. Note: The referenced Table 4-3 also shows CdO and SnO_2, which are not depicted in Table 4-4 or in the table above.

b. Bin Sets #2, #3, and #4 includes about 3%, 7%, and 4%, respectively as dolomite ($CaMg(CO_3)_2$) start-up material.

c. NO_3 is presented as percent of total calcine composition

Table 3. Typical constituents of calcine produced in last calciner campaign (March through May 2000) [a]

Constituent [b]	Weight %	Constituent [b]	Weight %
Aluminum (Al)	33.4	Fluoride (F)	0.9
Oxygen (O)	33.2	Iron (Fe)	0.6
Sodium (Na)	17.0	Chloride (Cl)	0.5
Calcium (Ca)	3.7	Zirconium (Zr)	0.3
Nitrate (NO_3)	3.6	Boron (B)	0.1
Potassium (K)	3.2	Cadmium (Cd)	0.1
Sulfate (SO_4)	1.5	Other [c]	1.9

a. Source: DOE (2002), Table 1

b. Dominant compounds are metallic oxides and aluminates (Al_2O_3, $NaAlO_2$, etc.).

c. Minor species including radionuclides and trace components such as Hg, Cr, Ni, etc.

3.3 CORROSION PROTECTION

A qualified (and certified) independent corrosion engineer evaluated the existing corrosion protection measures found in the Bin Sets. The results of that effort, in the form of a letter report, are provided as Attachment B to this document. This section provides a summary of the corrosion engineer's analysis and findings from the corrosion protection evaluation.

The only corrosion control measure identified for the Bin Sets is the metallurgy, or selection of materials, used in the fabrication of the bins. The primary materials of construction for the bins are stainless steel, type-405, -304, and -304L. Based on the calcine characteristics provided (see Tables 2 and 3), the older and newer calcines are similar in their chemical compositions and their effects on the materials of construction. Of the chemical constituents identified, chlorides present the most troublesome element and, as a worse-case condition, are present at a concentration of 0.5 percent by weight. The primary conclusion of the corrosion evaluation is that none of the materials being stored should affect the integrity of the bin materials as long as they are kept dry. From a standpoint of uniform corrosion affects, the integrity of the bins is sound and the rate of material loss is expected to be negligible. This conclusion is supported by the results of INEEL efforts to evaluate the corrosion rate on sacrificial coupons removed from bins containing calcine. Two INEEL reports, reviewed by the corrosion engineer, concluded the corrosion that would be experienced during a 500-year design life is minimal based on the evaluation of retrieved corrosion coupons. This assumes, of course, the corrosion rate remains constant and uniform.

It was reported that the vault for Bin Set #1 contained water once, for a brief period during its active life (i.e., while calcine was being stored in the bins) as a result of a ruptured underground line. Though there is no evidence (see Section 3.5) to indicate such a condition ever existed, the corrosion engineer was asked to comment on potential corrosion concerns were any calcine to be present in the area outside the bins and inside the vault at the same time water/moisture was present. The primary corrosion concern under such a scenario would be the presence of wet chlorides which might cause pitting type corrosion on the outside of the stainless steel bins, and even stress corrosion cracking if stresses were involved. The potential for pitting corrosion would be primarily in the Type-405 stainless steel, to some extent the Type-304, and to a lesser degree the Type-304L. However, there is no accurate way to predict the time to failure as a result of pitting and the corrosion allowance designed into the wall thickness of the bins would not be considered as a reliable line of defense in such a case. The evaluation of uniform corrosion as has been done in determining coupon corrosion rates is not applicable to pitting corrosion. There are limits on what can be concluded beyond these concerns; it is not possible to properly postulate the pitting potential of the bin materials under the hypothetical scenario.

3.4 TANK AGES

As indicated in Section 2, the seven Bin Sets were constructed over time as they were needed to provide storage capacity for the continuing production of calcine from the waste calcining operations. Table 4 provides a summary of the bin fabrication dates and the periods during which they were filled with calcine. The table also provides a brief description of the type of calcine (based on the type of liquid waste being treated) put into the bin and the calciner campaign(s) producing the calcine.

3.5 INTEGRITY EXAMINATION

As described in Table 1, the regulatory requirement for the integrity examination is that it be in the form of (1) a leak test, or (2) internal inspection that addresses cracks, leaks, corrosion, and erosion. The regulations also allow for alternate methods of achieving the latter requirement as long as it is capable of examining for the same tank features (or flaws). The use of the bins in the Bin Sets does not support any reasonable type of internal inspection. The highly radioactive nature of the material stored does not even support a visual inspection of the exterior of the bins, other than possibly by remote camera (and some limited external inspection has been done in this manner), and the non-liquid character of the waste does not support easy movement/removal of the material to allow interior inspections. Since the bins of Bin Set #7 are empty, this argument does not apply to those tanks, but they have never been used and there would be no reason to suspect cracks, leaks, corrosion, or erosion issues. It is the INEEL's position, however, that the radioactive nature of the material being stored in the bins does support an efficient means of

Table 4. Summary of bin fabrication dates and fill periods. [a]

Bin Set/Bin	Fabrication Date	Approximate Dates of filling actions (Mo/Yr) and Material Received
Bin Set #1		2/61 to 11/62 - cold testing calcine – later removed
VES-WCS-115-1	1959	11/63 to 12/63 - cold alumina start-up bed material 12/63 to 3/64 - aluminum calcine from WCF Campaign 1`
VES-WCS-115-2	1959	3/64 to 5/64 - aluminum calcine from WCF Campaign 1`
VES-WCS-115-3	1959	4/64 to 8/64 - aluminum calcine from WCF Campaign 1`
VES-WCS-115-4	1959	12/63 to 10/64 - aluminum calcine from WCF Campaign 1`
Bin Set #2		
VES-WCS-136-1	1965	8/68 to 10/71 - mostly zirconium calcine primarily from WCF Campaign 4
VES-WCS-136-2	1965	8/68 to 12/71 - mostly zirconium calcine primarily from WCF Campaigns 3 & 5
VES-WCS-136-3	1965	11/66 to 8/67 - mostly aluminum calcine from WCF Campaign 2
VES-WCS-136-4	1965	3/66 to 1/67 - mostly aluminum calcine from WCF Campaign 2
VES-WCS-136-5	1965	11/66 to 3/68 - aluminum and zirconium calcine from WCF Campaign 2
VES-WCS-136-6	1965	6/66 to 2/72 - mostly zirconium calcine from WCF Campaigns 2, 3, 4, & 5
VES-WCS-136-7	1965	6/66 to 6/69 - mostly zirconium calcine from WCF Campaign 3
Bin Set #3		
VES-WCS-140-1	1969	3/72 to 3/81 - mostly zirconium calcine primarily from WCF Campaign 9
VES-WCS-140-2	1969	3/72 to 3/80 - various types of calcine from WCF Campaigns 5, 6, 7, 8, & 9
VES-WCS-140-3	1969	3/72 to 7/79 - various types of calcine from WCF Campaigns 5, 6, 7, 8, & 9
VES-WCS-140-4	1969	3/72 to 9/79 - various types of calcine from WCF Campaigns 5, 6, 7, 8, & 9
VES-WCS-140-5	1969	3.72 to 3/78 - various types of calcine from WCF Campaigns 5, 6, 7, & 8
VES-WCS-140-6	1969	3/72 to 8/79 - various types of calcine from WCF Campaigns 5, 6, 7, 8, & 9
VES-WCS-140-7	1969	3/72 to 6/78 - various types of calcine from WCF Campaigns 5, 6, 7, & 8
Bin Set #4		
VES-WS4-142	1976	8/82 to 5/83 - zirconium and zirconium-sodium calcine from NWCF Campaign 1
VES-WS4-143	1976	8/82 to 7/83 - zirconium and zirconium-sodium calcine from NWCF Campaign 1
VES-WS4-144	1976	8/82 to 5/83 - zirconium and zirconium-sodium calcine from NWCF Campaign 1
Bin Set #5		
VES-WS5-146	1978	7/83 to 8/91 - various types of calcine from NWCF Campaigns 1, 2, & 3
VES-WS5-147	1978	Same
VES-WS5-148	1978	Same
VES-WS5-149	1978	Same
VES-WS5-150	1978	Same
VES-WS5-151	1978	Same
VES-WS5-152	1978	Same
Bin Set #6		
VES-WS6-154	1983 [b]	1/93 to 5/00 - various, but mostly sodium calcine from NWCF Campaigns 3 and 4
VES-WS6-155	1983	Same
VES-WS6-156	1983	Same
VES-WS6-157	1983	Same
VES-WS6-158	1983	Same
VES-WS6-159	1983	Same
VES-WS6-160	1983	Same
Bin Set #7		
VES-WS7-162	1985 [c]	Empty
VES-WS7-163	1985	Empty
VES-WS7-164	1985	Empty
VES-WS7-165	1985	Empty
VES-WS7-166	1985	Empty
VES-WS7-167	1985	Empty
VES-WS7-168	1985	Empty

a. Source: Staiger (1999) unless noted otherwise.
b. Source: Telephone conversation with M. Swenson (see Attachment C).
c. Age of Bin Set #7 bins is based on an April 1985 drawing ("7th Set Calcined Solids Storage Facility Bins," Drawing No. 165779) that contains as-built bin dimensions.

continuous leak testing. The remaining portion of this section addresses the INEEL's use of radiation monitoring for verifying the bins and their ancillary equipment are not leaking.

The Bin Sets include air ventilation to prevent build-up of the heat that results from the decay of the radioactive materials in the calcine. As part of the ventilation system, continuous air monitors (CAMs) are positioned in each of the Bin Sets to monitor air exhausted from the facility. These CAMs pull air through a filter that picks up particulate in the ventilation air and a detection instrument constantly measures any radioactivity collected on the filter. Any loss of containment (provided by the bins) would cause radioactive materials to be carried by the ventilation air and to be picked up by the CAMs. The following Technical Procedures were provided by the INEEL for review as a means of verifying the presence of the CAMs and of describing their operation:

- INTEC-TPR-P8.3-B1 (Revision 2, Effective Date: 6/26/01) - Solids Storage 1, 2, and 3, Operations
- INTEC-TPR-P8.3-B4 (Revision 3, Effective Date: 9/15/99) - Operate Solids Storage No. 4
- INTEC-TPR-P8.3-B5 (Revision 8, Effective Date: 3/29/00) - Operate Solids Storage No. 5
- INTEC-TPR-P8.3-B6 (Revision 12, Effective Date: 1/24/01) - Operate Calcine Solids Storage Facility No. 6
- INTEC-EAR-P8.3-Y1 (Revision 2, Effective Date: 11/02/00) - Respond to CAM and Sump Alarms at Solids Storage I, II, III, IV and V

Radiation detectors are capable of detecting very small quantities of radioactive materials. According to the last Technical Procedure identified above (i.e., INTEC-EAR-P8.3-Y1), the Bin Set CAMs are set to alarm at 5,000 counts per minute (cpm). Using several assumptions, simple calculations can be made (see the text box on the next page) to show that it would take only about 5 one-billionths (5×10^{-9}) of a pound of the calcine material to trigger the CAM alarm. At such a small amount, it is reasonable to assume that any release of calcine in the Bin Sets would cause enough to be picked up in the ventilation air to be detected by the CAM.

Estimate of the Amount of Calcine Needed to Trigger a CAM Alarm

Based on INEEL Technical Procedure INTEC-EAR-P8.3-Y1, the CAMs in the bin set facilities are set to alarm at 5,000 counts per minute (cpm). If it is assumed that the CAMs are only 10 percent efficient in counting radioactive disintegrations, there would have to be radioactive material present on the CAM air filter that provided 50,000 disintegrations per minute (dpm) to trigger the alarm. (This is taking no credit for contributions from background.) By definition, there are 2.2×10^{12} dpm per curie (Ci) of radioactive material. Accordingly, the CAMs are set to alarm if they reach:

$$(50{,}000 \text{ dpm}) / (2.2 \times 10^{12} \text{ dpm/Ci}) = 2.27 \times 10^{-8} \text{ Ci}$$

The bin sets contain varying amounts of activity, but based on the total activity and the volume of calcine, Bin Set #1 has the highest activity concentration of any of the bin sets. At a calculated total activity of 3.09×10^{6} Ci, at the start of the year 2016 and a total volume of 7,700 cubic feet (Staiger 1999), the activity concentration in Bin Set #1 would be about:

$$(3.09 \times 10^{6} \text{ Ci}) / (7{,}700 \text{ ft}^3) = 401 \text{ Ci/ft}^3$$

All that is needed to set the alarm (i.e., 2.27×10^{-8} Ci) is represented by a volume of:

$$(2.27 \times 10^{-8} \text{ Ci}) / (401 \text{ Ci/ft}^3) = 5.67 \times 10^{-11} \text{ ft}^3$$

At a density of 1.4 (Berreth 1988), this volume would weigh about:

$$(1.4)\ (62.4 \text{ lb/ft}^3)\ (5.67 \times 10^{-11} \text{ ft}^3) = 4.95 \times 10^{-9} \text{ lb}$$

Or about 5 one-billionths of a pound (about 2 micrograms), a very small number.

In addition to alarming at 5,000 cpm, the CAMs are routinely monitored and maintained, which includes the weekly collection of the air filters for a more detailed analysis than can be provided by the CAM. The analysis is performed for both gross alpha and gross beta activity. As part of the tank integrity assessment, six weeks of recent results from the analysis of the Bin Set CAMs were reviewed. The six weeks of data included computer printouts of numerous INTEC air sampling (CAM) stations identified by equipment/unit numbers. A key was also provided that linked the equipment numbers to facility locations so that the Bin Set CAMs could be located in the data. The equipment numbers also corresponded to numbers used in the Technical Procedures reviewed. The six weeks of data (August 20 and 28 and September 3, 10, 17, and 24 of 2002) are summarized in Table 5. It should be noted that the extremely small numbers [e.g., 10^{-15} micro curies per milliliter (µCi/ml)] are obtained by dividing the total count on the filters by the volume of air that passed through the filter over the week of measurement.

Table 5. Summary of Bin Set CAM filter analysis.

CAM Station	Radiological Analysis Results (in µCi/ml)					
	Alpha		Beta		Average	
	Low	High	Low	High	Alpha	Beta
Bin Set #1	1.7E-15	6.1E-15	2.1E-14	5.5E-14	2.9E-15	3.1E-14
Bin Set #2	2.5E-16	1.2E-15	1.2E-14	2.1E-14	6.9E-16	1.6E-14
Bin Set #3	1.5E-16	1.3E-15	2.0E-14	4.5E-14	7.1E-16	2.8E-14
Bin Set #4	0	7.8E-16	4.8E-15	1.2E-14	4.3E-16	8.8E-15
Bin Set #5	0	1.6E-15	3.2E-15	7.9E-15	7.0E-16	5.9E-15
Bin Set #6	0	9.9E-15	5.8E-16	2.9E-13	2.2E-15	6.2E-14

The data shown in Table 5 represent results of Bin Set air monitoring for only a limited period of time. However, it is reasonable to conclude that any loss or leak of calcine into the interstitial area where the ventilation air moves would result in continued CAM alarming and high filter counts as long as the material were present in that location. The individual performing this element of the tank integrity assessment was informed that the CAM results were continuously reviewed and there has never been readings that would indicate a leak of calcine from any of the bins. It was also noted that this does not mean that the CAMs have never alarmed. It is not unusual for the Bin Set CAMs or other site CAMs to occasionally provide false alarms. Whenever such an alarm occurs, response actions are taken to verify whether or not there is a release or some other type incident. The project participant was informed no Bin Set CAM alarm has ever been attributed to a leak or release of calcine from the bins.

It should be noted that there was evidence on drawings that the Bin Sets were required to be leak tested as part of specifications under which they were fabricated. However, results of these tests were neither provided to, nor pursued further by the assessment team. It is felt that such testing performed during vessel fabrication would not have met the regulatory requirement for a current integrity assessment.

4. SUMMARY ASSESSMENT

A summary of the manner in which tank integrity elements are met by the bins in Bin Sets #1 through #7 is presented in Table 6. The table presents the summary data according to the requirements' citation and designation as originally identified in Table 1.

The structural evaluation performed to address design standards resulted in some of the most significant findings presented in Table 6. Both the bins (or tanks by regulatory definition) in all seven Bin Sets and the seven vaults in which they are contained are considered to have adequate structural integrity with respect to normal and seismic loads using criteria from the 2000 IBC. Because of the high radiation fields associated with the Bin Sets, these conclusions are based solely on design drawings and reports provided by the INEEL (no site visit or first-hand observations were made of the structures).

Also of particular note is that no leak test or physical examination of the bins was performed as part of this assessment. The evaluator relied on records of radiological monitoring to reach the conclusion that the bins are not leaking. Though radiological monitoring is a very effective means of detecting any release of calcine, it does not provide any information as to whether or not there could be weak points in any of the tank systems. The design/structural and corrosion evaluations provide some assurance against the potential for weak points, but are not capable of identifying current, in-place conditions that might differ from the design and as-built information reviewed.

Table 6. Summary assessment for tank integrity elements.

Citation	Designation	Summary of Requirement Compliance
265.191(b)(1)	Design Standards	The stainless steel bins and the vaults in which they are contained were evaluated for their integrity based on normal and seismic loadings. The vaults and bins were found to have acceptable integrity based on criteria from 2000 IBC.
265.191(b)(2)	Waste Characteristics	Characterization information on the calcine material contained in the Bin Sets is presented in Tables 2 and 3 and is adequate for making a determination as to the waste's compatibility with the tank systems being assessed.
265.191(b)(3)	Corrosion Protection	The only corrosion control measure identified for the Bin Sets is the metallurgy, or selection of materials, used in the fabrication of the bins. The primary conclusion of the corrosion evaluation is that none of the materials being stored should affect the integrity of the bin materials as long as they are kept dry. From a standpoint of uniform corrosion affects, the integrity of the bins is sound and the rate of material loss is negligible.
265.191(b)(4)	Tank Age	Fabrication dates for the bins in each of the seven Bin Sets are provided in Table 4 and range from 1959 for those in Bin Set #1 to 1985 for those in Bin Set #7. All of the bins are young in comparison to their intended 500-year design life.
265.191(b)(5)	Integrity Examination	No leak test or physical examination of the bins was performed as part of this assessment. Results of radiological monitoring were reviewed as a means of verifying the current integrity of the bins.

5. CONDITIONS OF ATTESTATION

The hazardous waste tank systems evaluated for this registered professional engineering tank system integrity assessment, as required in 40 CFR 265.191, includes 42 stainless steel bins, or composite bins, located within 7 separate Bin Set vaults located at the INTEC. The following qualifications are a condition of the certification.

- Use of these tanks is limited to calcine material that is consistent with characterization data presented in this assessment.

- Design drawings and reports provided by the INEEL accurately reflect the as-built condition of the bins and the vaults in which they are contained.

- The bins or tank systems must be maintained in a dry condition (interior and exterior) to prevent the presence of wet chlorides that might cause pitting type corrosion of the stainless steel fabrication materials.

6. REFERENCES AND ATTACHMENTS OF CONFIRMATORY INFORMATION

6.1 REFERENCES

Berreth 1988	Berreth, J.R., 1988. *Inventories and Properties of ICPP Calcined High-Level Waste*, WINCO-1050, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho.
DOE 2002	DOE (Department of Energy) 2002, *Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement*, DOE/EIS-0287, Idaho Falls, Idaho
Russell et al. 1998	Russell, N.E., T.G. McDonald, J. Bannaee, C.M. Barnes, L.W. Fish, S.J. Losinski, H.K. Peterson, J.W. Sterbentz, D.R. Wenzel, 1998. *Waste Disposal Options Report*, Volume 2, INEEL/EXT-97-01145, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho.
Staiger 1999	Staiger, M.D., 1999. *Calcine Waste Storage at the Idaho Nuclear Technology and Engineering Center*, INEEL/EXT-98-00455, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho.

6.2 LIST OF ATTACHMENTS

Several documents key to this integrity assessment are included as attachments along with other supporting documentation. These attachments are identified as follows:

A. Structural Engineering Evaluation, Dyer Group LLC

B. Bin Set Integrity Assessment – Corrosion, Corrosion Control Specialist Inc.

C. Telephone Log

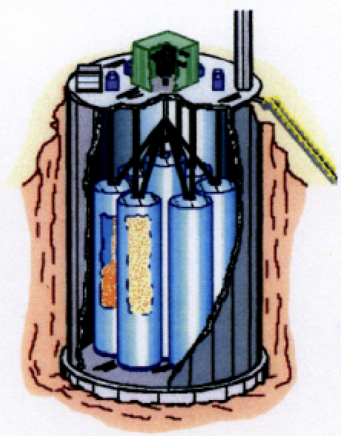
ATTACHMENT A

STRUCTURAL ENGINEERING EVALUATION
BY
DYER GROUP, LLC

STRUCTURAL ENGINEERING EVALUATION

CSSF Bin Set Storage Facilities 1-7

IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY



Final Report

DYER GROUP LLC

ENGINEERING • PLANNING • MANAGEMENT

208-656-8800

STRUCTURAL ENGINEERING EVALUATION

CSSF Bin Set Storage Facilities 1-7

IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

REGISTERED PROFESSIONAL ENGINEER
4315
23 June 03
STATE OF IDAHO
WINSTON R. DYER

Final Report
June 2003

DYER GROUP LLC

ENGINEERING • PLANNING • MANAGEMENT

208-656-8800

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Structure Data and Calculations

INTRODUCTION

Bin Sets 1 through 7 of the Calcined Solid Storage Facility (CSSF) are used to store spent radioactive material at the Idaho National Engineering and Environmental Laboratory (INEEL) site west of Idaho Falls. The radioactive material has been combined with calcium and other inert materials to form a granular substance that is easier to handle and store. The Bin Sets were constructed to facilitate handling of this material and provide for its safe, long-term storage. Figure 1 shows the typical configurations of Bin Sets 1-7 and provides an excellent visualization of the structures that are the subject of this report.

INEEL Site managers and the Idaho Department of Environmental Quality (IDEQ) carry the primary responsibility to see that the Bin Set storage facilities are properly operated and maintained. Accordingly, these entities monitor the ongoing condition and performance of the Bin Sets to assure the condition of the facilities is conducive to the environment and does not pose a threat to the health and welfare of the public.

As a part of this continual monitoring process, IDEQ and INEEL managers have considered federal government regulations requiring certain levels of due diligence with respect to the ongoing condition and operation of the CSSF hazardous waste facilities at the INEEL site. In particular, EPA regulations set forth in 40 CFR 265.191 state in part that an "... assessment must determine that the tank system is adequately designed and has sufficient structural strength and compatibility with the waste(s) to be stored or treated to insure that it will not collapse, rupture, or fail..."

IDEQ officials have considered this regulation with respect to Bin Set condition and performance and have specifically requested that a new analysis be conducted to determine the status of the Bin Sets with respect to current building and structural codes. Since the structures were designed and constructed at various times over the last 40 years, and since such work was conducted in accordance with then prevailing building and structural codes, some of which have long since been updated, it was determined to take a new look at the structures with respect to current codes.

Modern building and structural codes have evolved through the years as greater knowledge has become available, experience with the results of earlier codes has been more thoroughly evaluated, and new technology has provided for more rigorous analysis. The overriding question is whether such additional code enhancements now available would suggest any improvements or modifications to the existing facilities to improve their safety and operation.

No amount of structural analysis can guarantee that a structure "... will not collapse, rupture, or fail..." under any or all conditions. However, in satisfaction of this federal regulation, it is possible to conduct a conservative initial analysis with simplifying assumptions ("threshold analysis") to develop an overall general picture of the present facilities with respect to current codes. Such examination will assist administrators and decision-makers to determine if there is a sufficient level of concern to warrant further, more detailed analysis.

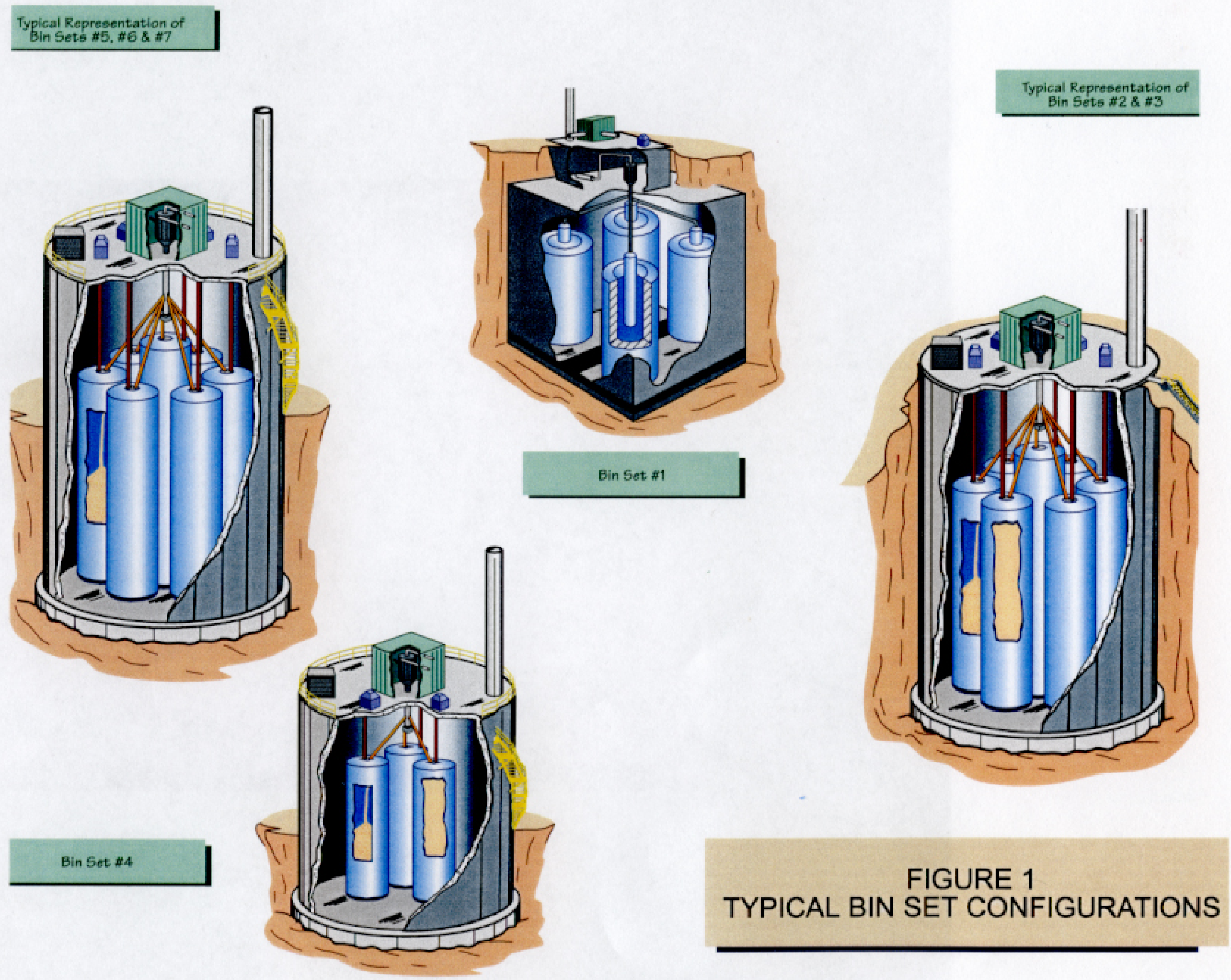


FIGURE 1
TYPICAL BIN SET CONFIGURATIONS

PURPOSE OF REPORT

The purpose of this report is to conduct and document a threshold structural analysis of the Bin Set structures with respect to current codes. Decision-makers can then decide if there are sufficient concerns to warrant a more in-depth analysis of any particular factor.

This report summarizes the approach and results arising from a structural analysis of the Bin Set structures with respect to current building codes. The analysis consisted of looking at the stainless steel bins containing the radioactive waste material and a separate look at the buried concrete vaults, which serve as a containment vessel for the stainless steel bins. In each case, analysis was made to identify structural response to normally expected, everyday loads and to seismic events reasonably predicted to occur at the INEEL site.

While state-of-the-art computer analysis techniques were employed where appropriate in conducting this threshold analysis, nevertheless simplifying assumptions were made where possible to keep the nature of the analysis to a reasonable budget and timeframe.

BIN SET BACKGROUND INFORMATION

Figure 1 provided an excellent overview of the nature of construction for Bin Sets 1-7. All of the bin set installations are similar in manner of construction. Each has a large concrete vault buried below ground (or partially below ground in some cases), inside of which individual stainless steel bins have been placed that serve as the actual storage vessels. The bins are freestanding and are secured to the floor of the concrete vault via anchor bolts around their lower perimeter.

The concrete vault for Bin Set No. 1 is square in cross-section and the remaining vaults are circular in cross-section. The concrete vaults have been excavated to a depth of 60-70 below the prevailing ground surface to where bedrock was encountered. The vaults are anchored to the bedrock via a concrete leveling slab and steel dowels.

Details of the stainless steel bins within the concrete vaults vary slightly with each bin set installation. The number of bins within a given vault varies from 3 to 7. The individual diameters range from 12.0 to 13.5 feet and heights of the bins range from 20.8 to 67.5 feet, with most sets being in the 53-67 foot range.

Bin Set No. 1 was constructed in the late 1950's and the other sets were constructed at various times over the succeeding 40 years.

PROJECT TEAM

The threshold analysis work for evaluating Bin Sets 1-7 with respect to modern building codes and updated seismic considerations was conducted by The Dyer Group, LLC. Winston R. Dyer, PE, Manager, is a registered professional structural engineer duly licensed and recognized by the State of Idaho to take responsible charge for such investigations.

For the purposes of this study, The Dyer Group is functioning as a subcontractor to Jason Associates Corporation, who in turn is under current contract directly to the INEEL site manager to assist with providing needed environmental information and related studies/analyses.

BUILDING CODE CONSIDERATIONS

The principal building codes approved and adopted by the State of Idaho include the Uniform Building Code (UBC) and the International Building Code (IBC). The UBC has been the governing code for the past half-century, being replaced by the IBC this year. Such codes are generally recognized by the industry as being an overall compilation of more specific, material-related building codes such as those issued by the American Concrete Institute (concrete structures) and the American Institute of Steel Construction (steel structures).

The UBC was first established in 1927 and has been regularly updated on a 3-5 year basis since that time. By the early 1960's, the code had a broad base of usage and contained state-of-the-art design information, including seismic considerations. While not specifically indicated on the construction drawings, it is highly likely that design of the CSSF Bin Set structures was governed either by the prevailing edition of the UBC at that time, or by the material-specific parent structural codes (ACI concrete and AISC steel) which the UBC would have incorporated.

Some innovations and refinements have been made to the codes through the years with respect to basic material properties and construction requirements. However, allowable stress and strain levels within structures under normally expected loadings have not changed significantly in the basic building code evolution over the past 3-4 decades. Consequently, it was expected that performance of the Bin Sets under normal, everyday loads would meet current building code standards.

Seismic considerations, on the other hand, have changed substantially from the benefit of additional data gathered during seismic events, greater understanding of the nature of seismic phenomena and corresponding structural responses, and substantially increased analytical capability provided by modern technology. Substantial increases (+33%) in seismic forces have been identified in building codes evolving over the past 2-3 decades. However, these have now been offset somewhat by a more rigorous, less conservative analysis of seismic forces allowed by the new IBC based on a vastly improved and expanded database of seismic site criteria throughout the country.

The end result was that a careful analysis of the Bin Sets needed to be made with respect to seismic forces predicted by the current building code, and the results obtained are a more accurate prediction of the likely performance of the structures during a seismic event than was ever before possible.

One last consideration with respect to building codes is in order. There is a general tendency among those outside the engineering and construction industry to expect that analysis of a given structure with respect to building codes is absolute and precisely predicts its expected behavior under the conditions being analyzed.

Such is clearly not the case. Uncertainties and inconsistencies with regard to site conditions, uniformity of materials, manner of construction, etc. have resulted in the building codes taking a more general approach to analysis and requiring adherence to certain factors of safety or probabilistic limits within the code. Analysis is then made either within a range of values or with safety factors employed to appropriately predict structural performance in response to various conditions to which the structure will be subjected over its design life.

Consequently, structural performance is predicted within a certain range of probability, but nothing is absolute. A given structure could experience failure long before predicted stress levels are reached if defective materials or workmanship is present, or may carry loads well in excess of predicted values under favorable circumstances. Thus, the key words in any analysis are, "... reasonably expected...".

ANALYSIS APPROACH

The structural evaluation of the CSSF Bin Sets 1-7 sought to conduct a threshold analysis of the concrete vault containment structures and the stainless steel bins within the vault structures. In general, the structural components were first examined with respect to normal, everyday loads such as earth pressure, self-weight, and stored contents. Then a second analysis was conducted subjecting the structural components to seismic forces predicted by application of current (IBC) building code requirements. The information that follows provides a more detailed review of the approach to analysis for this study.

Research: Archives were first researched to obtain copies of original drawings and previous studies that would provide information on the structures such as material properties, layout, dimensions, materials of construction, etc. Such information is necessary to properly understand the nature of the structure and correctly model it in the computer analysis programs. Pages 1-14 of the Appendix summarize design information gleaned from the available drawings for each Bin Set.

Simplifying Assumptions: To reduce the amount of required structural analysis to a manageable level, a general review was made by a structural engineer to compare various similar structures and identify those that would provide a "worst-case" result in the analysis and eliminate the other non-governing or redundant structures. For example, the concrete vault in Bin Set No. 3 is larger in diameter than the No. 4 vault and would therefore provide a look at the worst-case for wall stresses.

Structures selected for analysis were then modeled for computer analysis. Here again, assumptions were necessary to simplify the modeling and to account for uncertain information in some cases. For example, bolt holes in the ring around the base of the stainless steel bins are slotted, which could allow expansion/contraction in response to temperature changes of the vessel. The degree to which the anchor bolt nuts are tightened will affect the amount of stress in the base of the bin. Conservative assumptions were made about the degree of fixicity ("fixed" as opposed to "sliding") to simplify the analysis.

Seismic Design Criteria: Computer analyses were then performed. The first analysis determined the seismic load factors to be applied based on the 2000 IBC (Appendix, page 15). The new code uses site information such as soil type and proximity to known faults, structure geometry, and importance criteria to predict an acceleration coefficient the structure will likely experience during a probable earthquake. In comparison to earlier codes (UBC), the 2000 IBC has an extremely intensive seismic database that breaks such seismic information down into a much smaller grid, providing substantially improved prediction of probability.

Site engineers had provided a more rigorous analysis for seismic design criteria to be used for structures at the Site. This was provided along with data for the individual structures. This correlated closely with predictions made by the 2000 IBC. Since this structural evaluation will eventually be submitted to State of Idaho authorities for review and approval, and since the 2000 IBC is the adopted State code, the 2000 IBC seismic design criteria were used in the analyses.

Earth Pressure: Earth pressure was next investigated (Appendix, page 18). Data was provided from Site personnel that included a soil study of the particular site where the bin sets are constructed. Specific information from that study was used in this structural evaluation to reflect soil conditions at the site.

Since the structures are buried to considerable depths in many cases, the Janssen formula was used to compute soil pressure on the buried structures. This is a more precise approach than using conventional earth pressure equations, and helps account for certain conditions expected to be associated with the considerable bury depth of the structures.

Here again, some simplifying assumptions were made, such as using linear analysis in lieu of the more costly and time-consuming non-linear analysis the Janssen equation allows. This assumption produced stress results that are likely to be higher than what the more rigorous analysis would produce. However, this is entirely appropriate for the "threshold" nature of this particular evaluation.

Analysis of Steel Bins: Steel bins were then analyzed by computer modeling and analysis (Appendix, pages 19-54). A necessary assumption was to assume that the bins are, or would be, completely filled (though most aren't at present) in order to identify the "worst-case" situation. Forces were developed taking into account the bin content (calcine), temperature (194 degrees Fahrenheit, max), self-weight, and seismic considerations.

The temperature loading represents the highest temperature recorded in a bin surface other than a brief heat transfer experiment conducted when cooling fans were shut off for a few weeks. Although interior calcine temperatures are significantly higher, the calcine material has a very low thermal conductivity. Therefore, it takes weeks for the higher interior temperatures to reach the bin surface, and then only if the cooling ventilation has been shut off that long.

Three different load combinations were developed to separately investigate the combination of content load, content plus seismic forces, and content plus temperature loading. Using these load combinations, specific investigation was made into the hoop and vertical bending stresses in the walls of the bins. The worst-case combination of the stresses is referred to as the Von Mises stress which was then compared to allowable stresses for the stainless steel material from the IBC.

Seismic forces analysis investigated the shear force at the base of the bins and the potential for overturning during an earthquake. This latter condition was addressed by examining tension on the anchor bolts that tied the bins to the concrete floor in a freestanding, cantilever situation (Appendix, pages 55-59). An additional analysis looked at possible local buckling of the bin wall plate near the base during a seismic event (which was included with the information presented on pages 19-54 of the Appendix).

To simplify the above analyses, the steel bins for Bin Set Nos. 2, 3, and 6 were analyzed, with bins for Nos. 1, 4 and 5, and 7 considered to be similar, respectively.

Analysis of Concrete Vaults: Finally, the concrete vaults were analyzed by computer modeling and analysis (Appendix, pages 60-109). Forces were developed taking into account earth pressure, self-weight, and seismic considerations. Load combinations were developed to separately investigate normal earth pressures and earth pressures plus seismic forces.

Using these load combinations, specific investigation was made into bending and shear stresses in the walls of the concrete vaults. Stresses were then compared to allowable stresses for the reinforced concrete as established by the IBC.

To simplify the above analyses, only vaults Nos. 1 and 3 were analyzed. Vault No. 1 is square in cross-section and is unique from all others. Vault No. 3 was considered to adequately represent conditions and expected results for vaults Nos. 2, 4, 5, 6, and 7. Reasons for selecting Vault No. 3 as the "worst-case condition" are as follows: Vault No. 2 is similar to Vault No. 3 and differences are negligible, Vault No. 4 is smaller and not buried as deep as No. 3, and Vaults No. 5-7 are bigger but not buried as deep and the walls are twice as thick as No. 3.

DISCLAIMERS / QUALIFICATIONS

It is important for reviewers of this report to understand important factors affecting or limiting the accuracy of the results. To begin with, the analysis was conducted based solely on drawing information and reports about the facilities made available for review. No site visit was made and the structures have not in any way been inspected or reviewed on site by those responsible for conducting this analysis (security and safety reasons -- high radiation). Accordingly, no attempt could be made to verify that the structures were actually constructed per the information provided, or to determine the current condition of tank system components, other than reviewing some pictures of the interior of some vaults taken by remotely operated cameras.

Secondly, not all structures were evaluated. Similar structures were compared and analyzed to provide "worst-case" results for comparative purposes.

Lastly, this study is expressly intended to provide a "threshold analysis" which will establish a beginning point for decision-making about the results of analysis to see if further investigation is warranted. This evaluation provides a "snapshot" of current conditions with respect to reasonably expected performance predicted by current building code.

As earlier stated, no amount of structural engineering investigation or analysis can guarantee that a structure "... will not collapse, rupture, or fail..." under any or all conditions. What has been provided is a reasonable prediction of structural performance with respect to anticipated normal and seismic loads to which the structures may be subjected during their design life.

RESULTS OF ANALYSES

The following tables summarize results obtained from the analyses. Each Bin Set is listed along with the results obtained for the various conditions examined. Where an individual Bin Set was not specifically analyzed, reference is made to the results for a similar Bin Set that was analyzed instead. Such results are considered representative of the Bin Set that was not specifically analyzed.

CONCRETE VAULT WITHOUT SEISMIC FORCE				
Concrete Vault	**Vertical Rebar**	**Horizontal Rebar**	**Out of Plane Shear**	**In Plane Shear**
#1	Good	Good	Good	Good
#2	See #3	See #3	See #3	See #3
#3	Good	Good	Good	Good
#4	See #3	See #3	See #3	See #3
#5	See #3	See #3	See #3	See #3
#6	See #3	See #3	See #3	See #3
#7	See #3	See #3	See #3	See #3

CONCRETE VAULT WITH SEISMIC FORCE				
Concrete Vault	**Vertical Rebar**	**Horizontal Rebar**	**Out of Plane Shear**	**In Plane Shear**
#1	Good	Good	Good	Good
#2	See #3	See #3	See #3	See #3
#3	Good	Good	Good	Good
#4	See #3	See #3	See #3	See #3
#5	See #3	See #3	See #3	See #3
#6	See #3	See #3	See #3	See #3
#7	See #3	See #3	See #3	See #3

STEEL BIN WITHOUT SEISMIC FORCE		
Steel Bins	**Steel Thickness**	**Anchor Bolts**
#1	See #2	See #2
#2	Good	Good
#3	Good	Good
#4	See #3	See #3
#5	See #3	See #3
#6	Good	Good
#7	See #6	See #6

STEEL BIN WITH SEISMIC FORCE		
Steel Bins	**Steel Thickness**	**Anchor Bolts**
#1	See #2	See #2
#2	Good	Good
#3	Good	Good
#4	See #3	See #3
#5	See #3	See #3
#6	Good	Good
#7	See #6	See #6

Concrete Vaults: With respect to normal (non-seismic) loads, predicted stresses in all concrete vaults meet the provisions of the current 2000 IBC.

With respect to earthquake loads, predicted stresses in all concrete vaults appear to meet the provisions of the current 2000 IBC. Therefore, earthquake loadings will not be a problem for the concrete vaults of Bin Sets 1 through 7.

Stainless Steel Bins: All Bin Sets are acceptable with respect to normal (non-seismic) loads, including the temperature loading discussed earlier.

With respect to earthquake loads, all stainless steel bins for Bin Sets Nos. 1-7 are acceptable in relation to the 2000 IBC.

CONCLUSION

The concrete vaults and stainless steel bin structures comprising the CSSF Bin Set Storage Facilities 1-7 pass the threshold integrity assessment conducted, which was based on conservative assumptions. Since stresses in the structures meet current building code and no other structural concerns have been identified in the analysis, there is no need for further, more rigorous examination of any structure or component.

APPENDIX
Structural Analysis Results

Index of Calculations

Concrete Vault and Steel Bin Information..1-14

Seismic Calculation (2000 IBC)..15-17

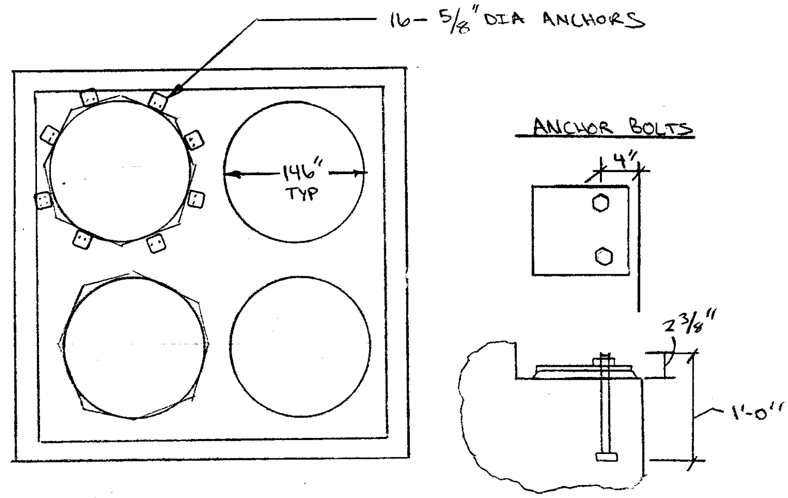
Janssen Equation (Ka= 0.5)..18

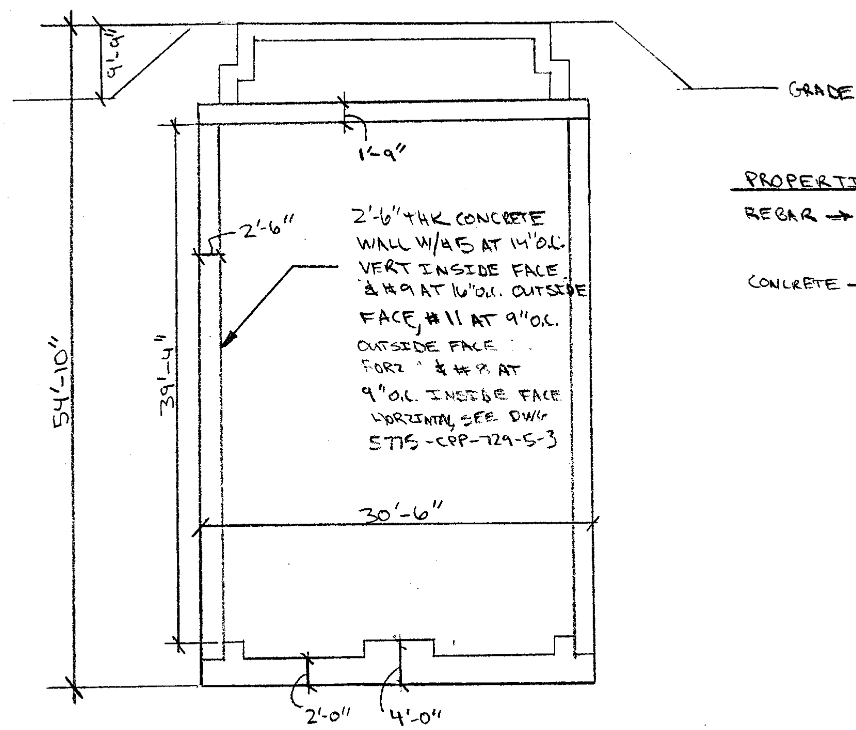
Steel Bin Check...19-54

Anchor Bolt Check...55-59

Concrete Vault Check...60-109

BIN #1 (VAULT #1)





PROPERTIES

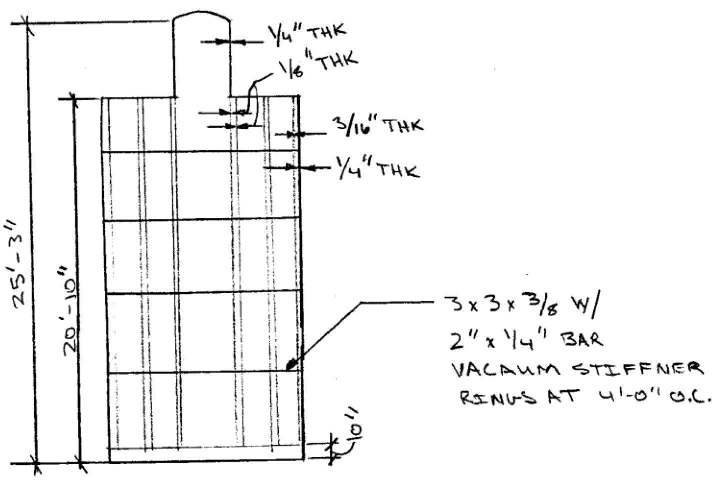
REBAR → NOT SPECIFIED
ASSUME $f_y = 60$ ksi

CONCRETE → $f'_c = 3000$ psi

Project Name:	Project #:	Initials:	Date:	Sheet: 1

BIN # 1

146" ø BIN (4)

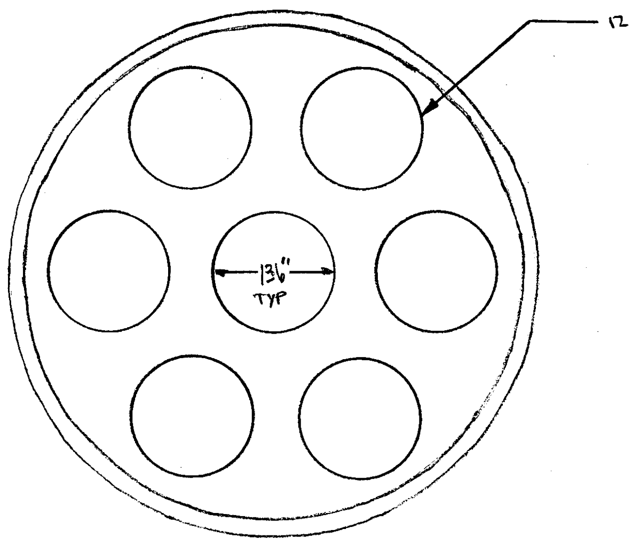


PROPERTIES

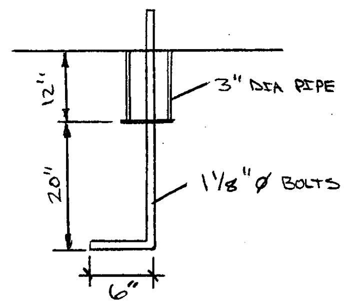
STEEL → ASTM - A7-57T

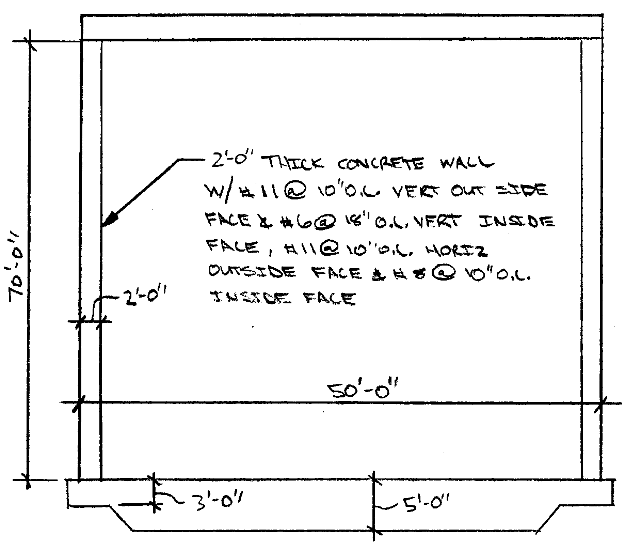
Project Name:	Project #:	Initials:	Date:	Sheet: 2

BIN #2 (VAULT #2)



ANCHOR BOLTS





PROPERTIES

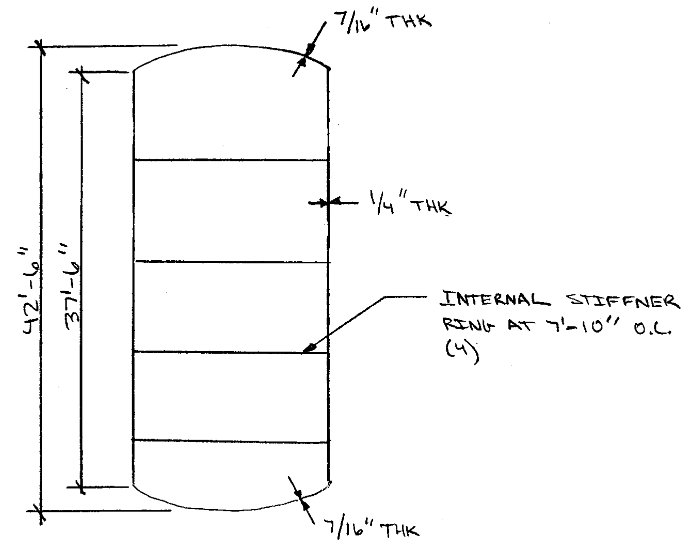
REBAR → INTERMEDIATE GRADE

CONCRETE → $f'_c = 4{,}000$ psi

Project Name:	Project #:	Initials:	Date:	Sheet:
				3

BIN # 2

144"ø BIN (7)



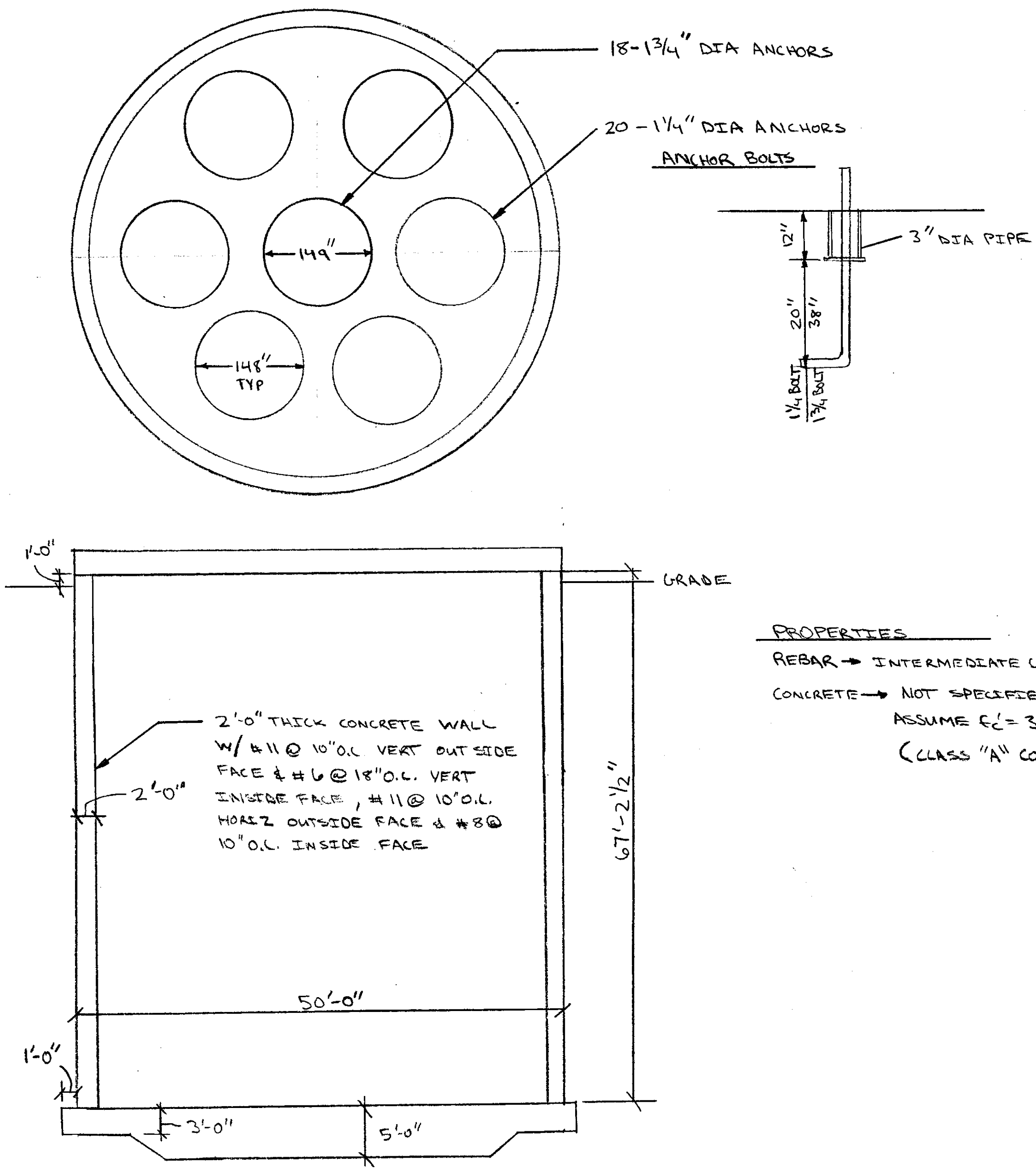
PROPERTIES

STEEL → NOT SPECIFIED

ASSUME A240-73 TYPE 304 (STAINLESS STEEL)

Project Name:	Project #:	Initials:	Date:	Sheet:
				4

BIN #3 (VAULT #3)



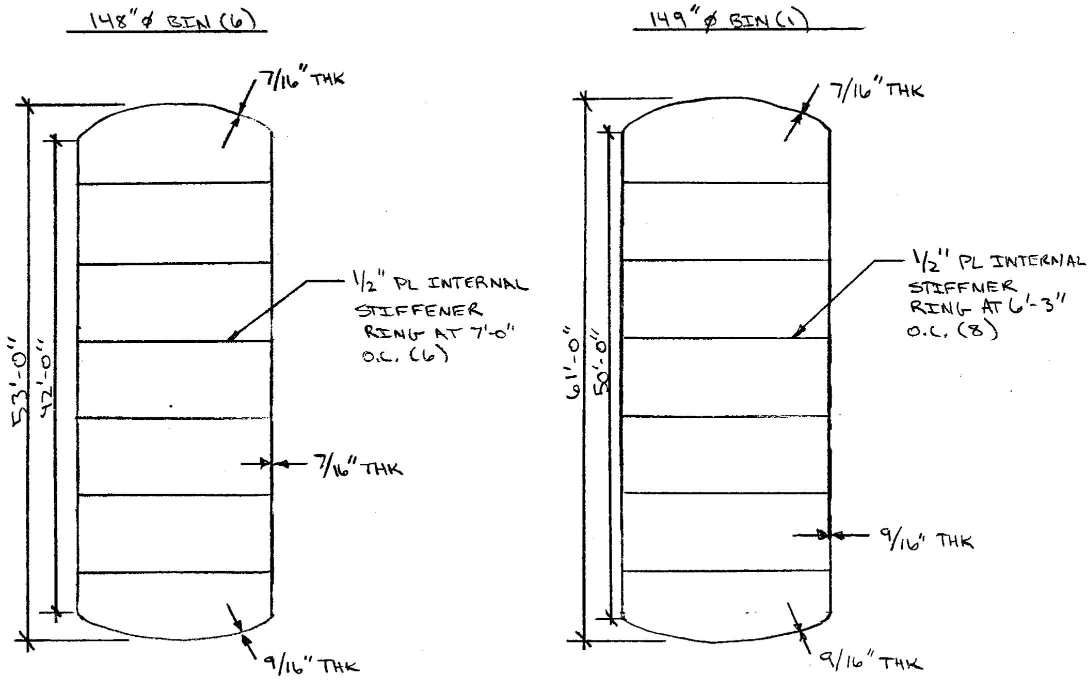
PROPERTIES

REBAR → INTERMEDIATE GRADE

CONCRETE → NOT SPECIFIED
ASSUME f'c = 3000 psi
(CLASS "A" CONCRETE)

Project Name:	Project #:	Initials:	Date:	Sheet: 5

BIN #3

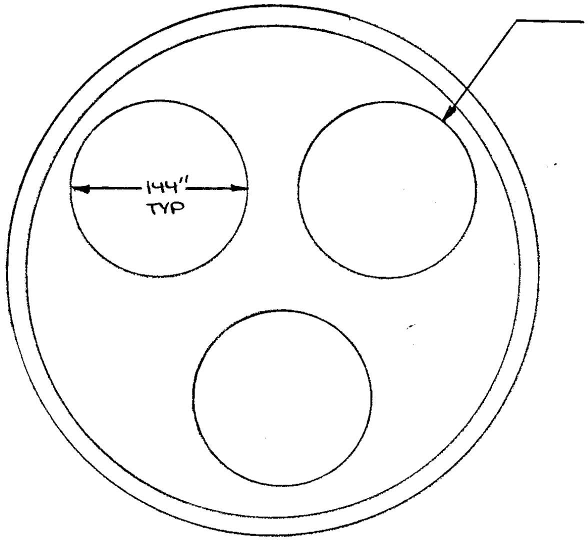


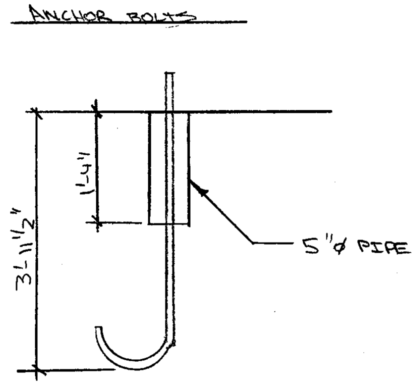
PROPERTIES

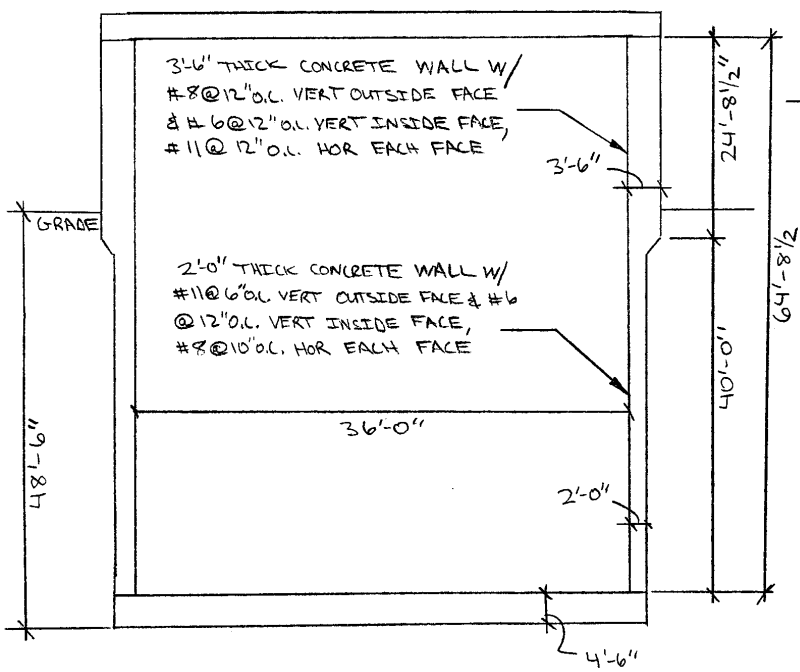
STEEL → A240-73 TYPE 304 (STAINLESS STEEL)

Project Name:	Project #:	Initials:	Date:	Sheet: 6

BIN #4 (VAULT #4)







PROPERTIES

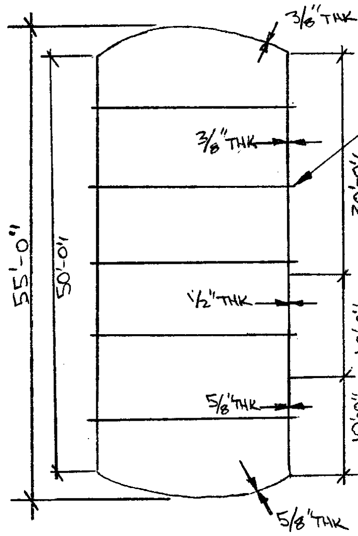
REBAR → NOT SPECIFIED
ASSUME f_y = 60KSI

CONCRETE → f_c' = 4000psi

Project Name:	Project #:	Initials:	Date:	Sheet:
				7

BIN # 4

144" ø BIN (3)

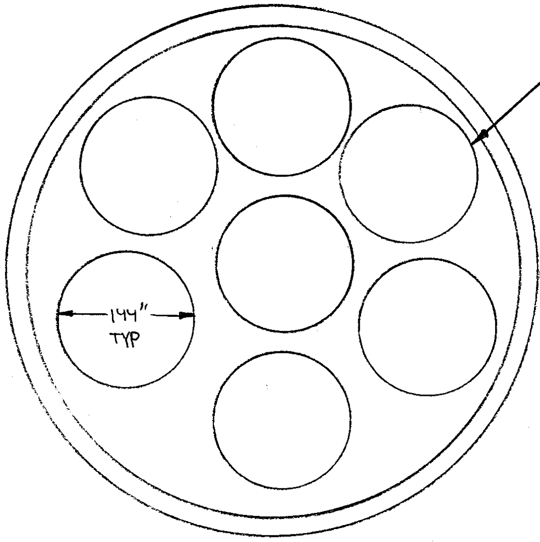


PROPERTIES

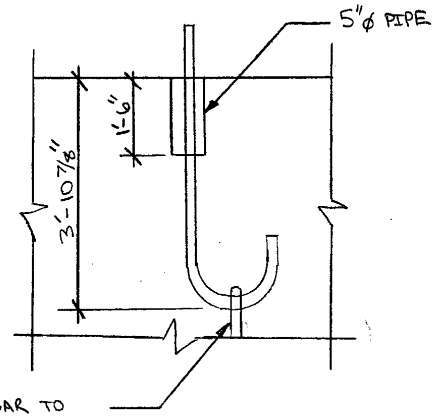
STEEL → A240-73 TYPE 304 (STAINLESS STEEL)

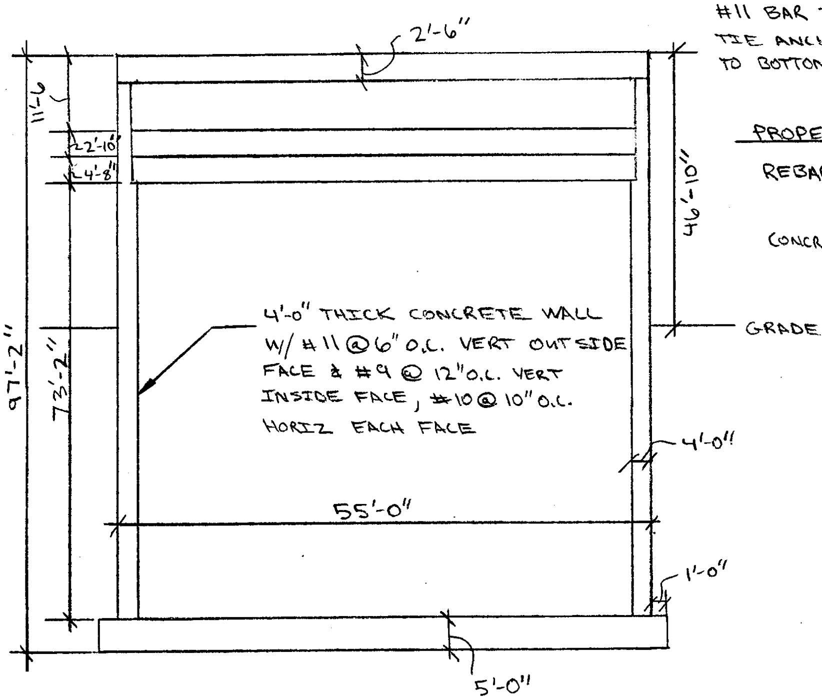
Project Name:	Project #:	Initials:	Date:	Sheet: 8

BIN # 5 (VAULT #5)



ANCHOR BOLTS





PROPERTIES

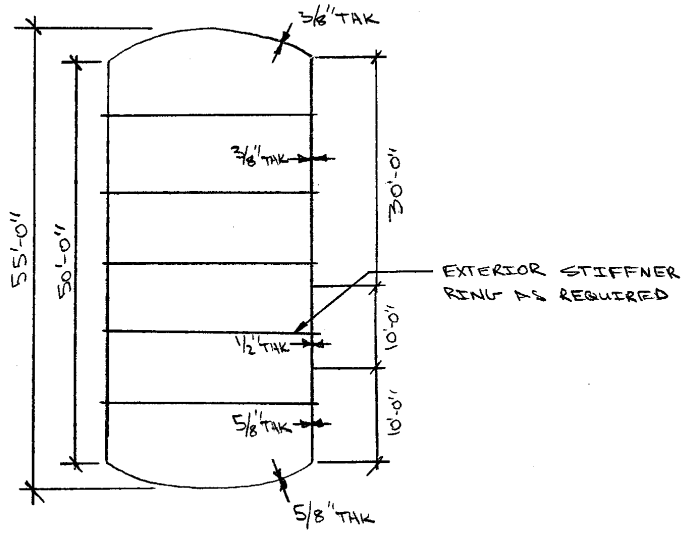
REBAR → NOT SPECIFIED
ASSUME f_y = 60 KSI

CONCRETE → f_c' = 4,000 psi

Project Name:	Project #:	Initials:	Date:	Sheet: 9

BIN # 5

144"ø BIN(7)

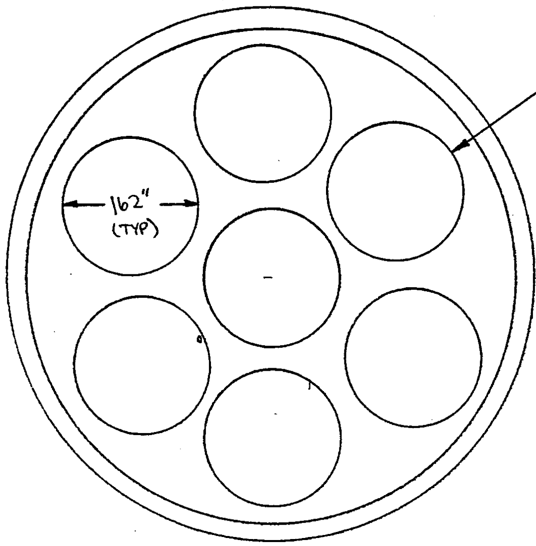


PROPERTIES

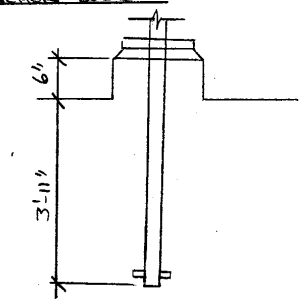
STEEL → TYPE 304L (STAINLESS STEEL)

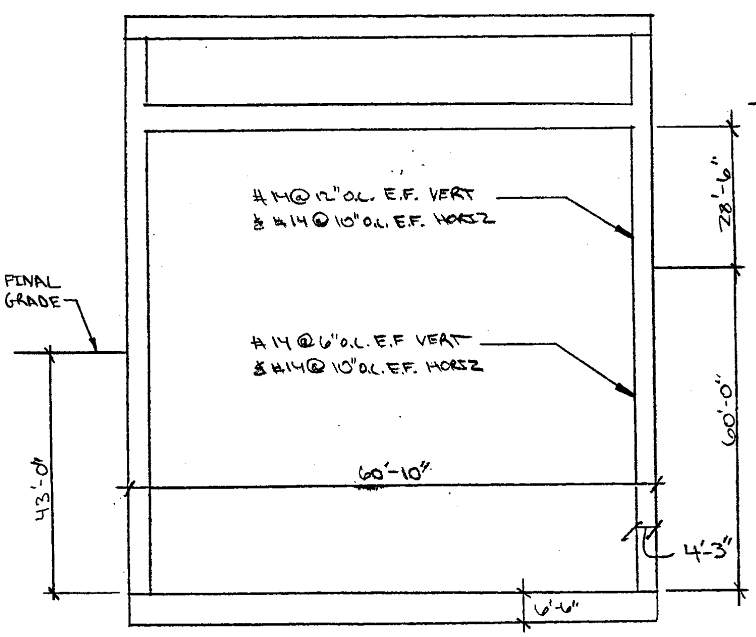
Project Name:	Project #:	Initials:	Date:	Sheet: 10

BIN #6 (VAULT #6)



ANCHOR BOLTS (SAME AS BIN #7)





PROPERTIES

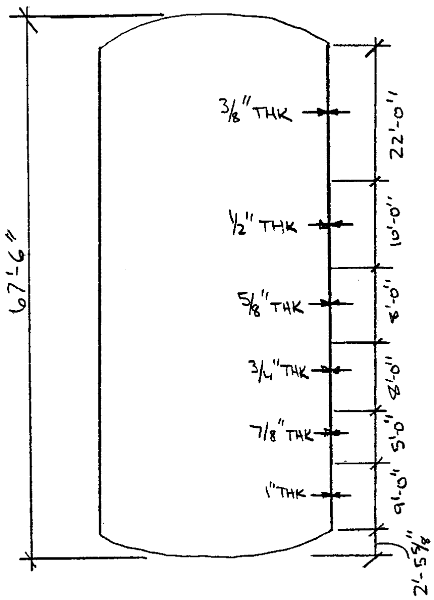
REBAR → NOT SPECIFIED
ASSUME $f_y = 60$ ksi

CONCRETE → NOT SPECIFIED
ASSUME $f_c = 3{,}000$ psi

Project Name:	Project #:	Initials:	Date:	Sheet: 11

BIN #6

162"ϕ BIN (7)

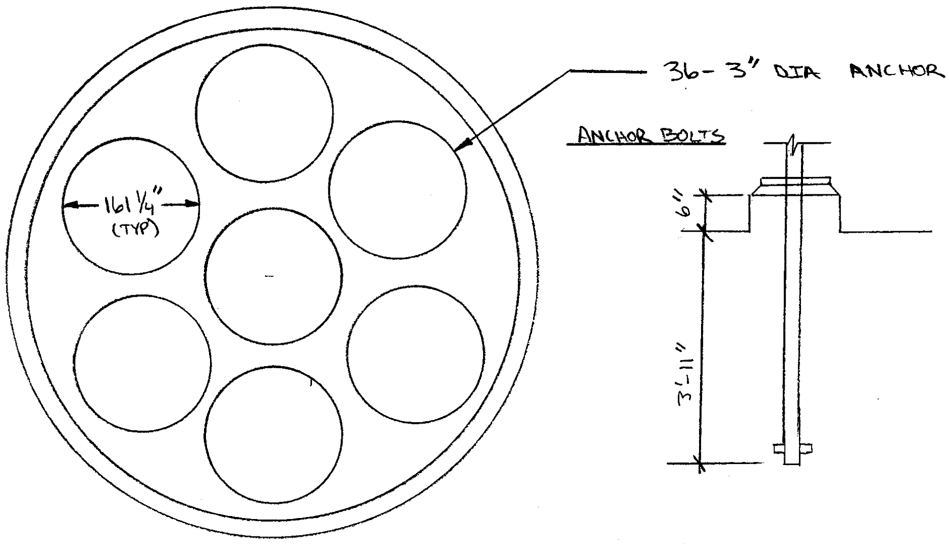


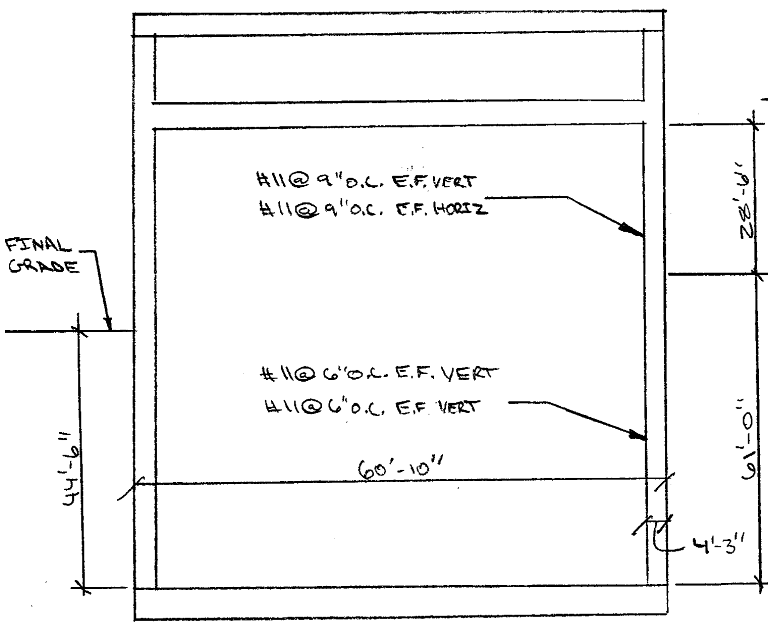
PROPERTIES

STEEL → TYPE 304L (STAINLESS STEEL)

Project Name:	Project #:	Initials:	Date:	Sheet: 12

BIN #7 (VAULT #7)





PROPERTIES

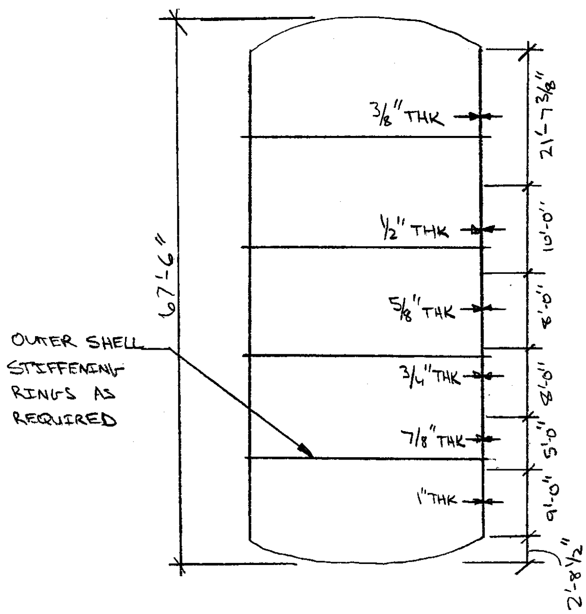
REBAR → NOT SPECIFIED
ASSUME $f_y = 60ksi$

CONCRETE → NOT SPECIFIED
ASSUME $f_c = 3,000psi$

Project Name:	Project #:	Initials:	Date:	Sheet: 13

BIN #7

161¼"ø BIN (7)



PROPERTIES

STEEL → TYPE 304L (STAINLESS STEEL)

Project Name:	Project #:	Initials:	Date:	Sheet: 14

INEEL SILO

MCE Ground Motion - Conterminous 48 States

Latitude = 43.5670, Longitude = -112.9330 ← LAT & LONG PROVIDED BY INEEL

Period (sec)	MCE Sa (%g)	
0.2	037.3	MCE Value of Ss, Site Class B
1.0	013.5	MCE Value of S1, Site Class B
Spectral Parameters for Site Class B		
0.2	037.3	Sa = FaSs, Fa = 1.00
1.0	013.5	Sa = FvS1, Fv = 1.00

Seismic Lateral Analysis

2000 International Building Code
Equivalent Lateral Force Procedure

PROJECT NAME: Concrete Vault Design

V: C_sW

C_s: $S_{DS}/(R/I)$
C_s: $S_{DI}/(R/I)T$ (Max)
C_s: $0.5S_1/(R/I)$ (Min, S_1 equal or greater than .6 and in Seismic Category E or F)
C_s: $0.044S_{DS}I$ (Min)

I_E(1604.5):	1.50	ap:	1	F_a:	1.00
Seis. Use Group (1604.5 & 1616.2):	III	R:	3	F_v:	1.00
Seis. Category (1616.3):	C	Ct:	0.02	S_{DS}:	0.2487
Site Class (1615.1.1):	B	acc (ultimate strength):	0.124	S_{DI}:	0.0900
S_S:	0.373	acc (service load):	0.087	T:	0.112 sec.
S_1:	0.135			Vbase:	0.0 k

CONCRETE VAULTS BEAR ON BED ROCK, SITE CLASS B WAS USED IN SEISMIC ANALYSIS.

SEISMIC LATERAL ANALYSIS

2000 International Building Code
Equivalent Lateral Force Procedure

PROJECT NAME: Steel Bin Design

V: C_sW

C_s: $S_{DS}/(R/I)$
C_s: $S_{DI}/(R/I)T$ (Max)
C_s: $0.5S_1/(R/I)$ (Min, S_1 equal or greater than .6 and in Seismic Category E or F)
C_s: $0.044S_{DS}I$ (Min)

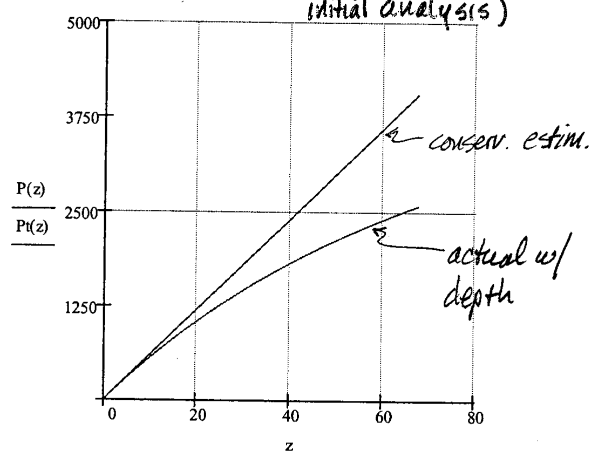
I_E (1604.5):	1.50	ap:	1	F_a:	1.00
Seis. Use Group (1604.5 & 1616.2):	III	R:	3	F_v:	1.00
Seis. Category (1616.3):	C	Ct:	0.02	S_{DS}:	0.2487
Site Class (1615.1.1):	B	acc (ultimate strength):	0.124	S_{DI}:	0.0900
S_S:	0.373	acc (service load):	0.087	T:	0.112 sec.
S_1:	0.135			Vbase:	0.0 k

CONCRETE VAULTS BEAR ON BED ROCK, SITE CLASS B WAS USED IN SEISMIC ANALYSIS.

External fill on silos

Bulk Density (pcf)	$\gamma := 120$	USED FOR STEEL & CONC. BINS TYP.
Pile Height (ft)	$z := 0, 2.5 .. 68$	
Silo Diameter (ft)	$D := 50$	$P = \gamma(0.5)H$
Wall Friction Angle (deg)	$\phi := 20deg$	
Friction Factor (ft)	$\mu := \tan(\phi)$	$\mu = 0.364$
V/H Ratio (unitless)	$K_j := .5$	
Wall Pressure Janssen (psf)	$P(z) := \frac{\gamma \cdot D}{4 \cdot \mu} \cdot \left(1 - e^{-4 \cdot \mu \cdot K_j \cdot \frac{z}{D}}\right)$	
Wall Pressure Triangle (psf)	$Pt(z) := .5 \cdot z \cdot \gamma$	→ $k_j = .50$ (janssen coeff, conserv. estimate [linear] for initial analysis)

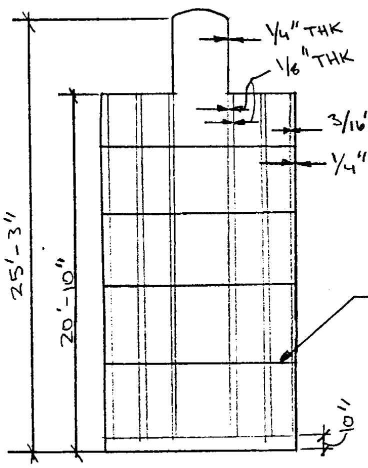
z =	P(z) =	Pt(z) =
0	0	0
2.5	147.303	150
5	289.341	300
7.5	426.302	450
10	558.368	600
12.5	685.714	750
15	808.508	900
17.5	926.912	$1.05\cdot10^{3}$
20	$1.041\cdot10^{3}$	$1.2\cdot10^{3}$
22.5	$1.151\cdot10^{3}$	$1.35\cdot10^{3}$
25	$1.257\cdot10^{3}$	$1.5\cdot10^{3}$
27.5	$1.36\cdot10^{3}$	$1.65\cdot10^{3}$
30	$1.458\cdot10^{3}$	$1.8\cdot10^{3}$
32.5	$1.554\cdot10^{3}$	$1.95\cdot10^{3}$
35	$1.645\cdot10^{3}$	$2.1\cdot10^{3}$
37.5	$1.734\cdot10^{3}$	$2.25\cdot10^{3}$
40	$1.819\cdot10^{3}$	$2.4\cdot10^{3}$
42.5	$1.901\cdot10^{3}$	$2.55\cdot10^{3}$
45	$1.981\cdot10^{3}$	$2.7\cdot10^{3}$
47.5	$2.057\cdot10^{3}$	$2.85\cdot10^{3}$
50	$2.131\cdot10^{3}$	$3\cdot10^{3}$



note: Janssen coefficient used as conservative value for loads on bins and vaults in initial analysis. Later replaced by 50 pcf equiv. earth pressure from site soils report.

BIN # 1

146" ϕ BIN (4)



PROPERTIES

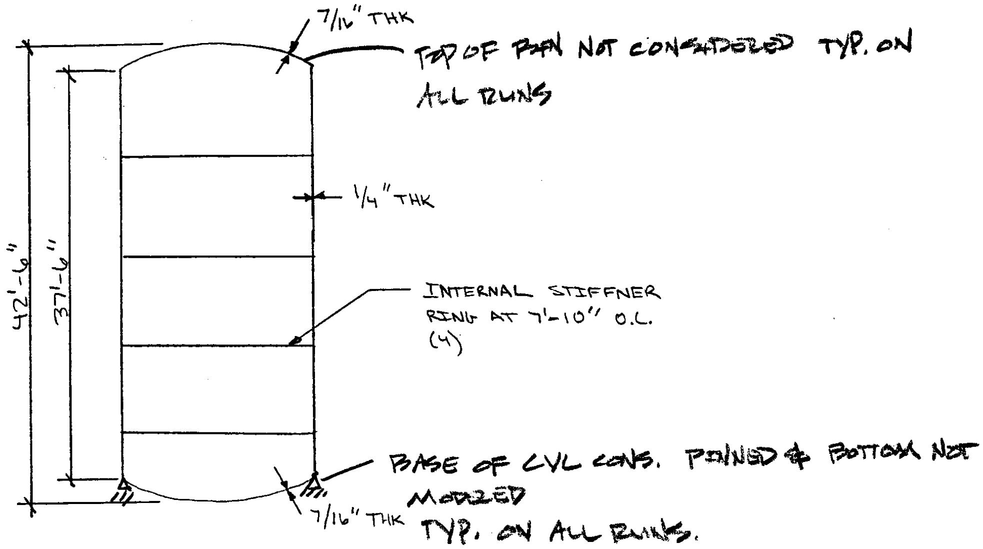
STEEL → ASTM - A7-57T

BIN # 1 SIM. TO BIN # 2 SEE CALCS FOR BIN # 2

Project Name:	Project #:	Initials:	Date:	Sheet: 19

BIN # 2

144"Ø BIN (7)



PROPERTIES

STEEL → NOT SPECIFIED

ASSUME A240-73 TYPE 304 (STAINLESS STEEL)

BIN #2 LOADING & ANALYSIS

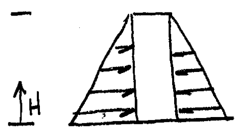
LOAD CASE #1 DL + PL

LOAD CASE #2 DL + PL + (SZ) LOAD

Project Name:	Project #:	Initials:	Date:	Sheet: 20

BIN #2

- LOAD CASE #1 DL + PL



VON MISES STRESS = 7.94E5 psf 5513 psi

YEILD = 33 ksi

ASSUME ALLOWABLE STRESS

$= F_y = 0.6(33 ksi) = 19.8 ksi$

19.8 > 5.5 ok

- LOAD CASE #2 SEE FOLLOWING PAGE FOR OVERTURNING FORCE

DL + PL + SZ

U.M. = 3.01E5 psf 2090 psi

19.8 > 2.1 + 5.5 ok

* NOTE THIS ASSUMES V.M STRESS WORST CASE FOR (DL + PL) ALIGNS W/ U.M. STRESS WORST CASE FOR (SZ)

Project Name:	Project #:	Initials:	Date:	Sheet: 21

BIN #2

- LOAD CASE 3
  DL + PL + TL

- TEMPERATURE
  $T_{max} = 194°F$ (worst case @ normal operation per INEEL)
  $T_{normal} \approx 65°F$
  $\Delta T = 129°F$

- EXPANSION
  $\varepsilon @ 194°F = (6.1 + 0.0019t) \times 10^{-6}$ $t = 194°F$
  $= 6.47 \times 10^{-6}$

  $D_{bin} = 144''$
  $Circum_{bin} = \pi D = 452''$
  $\Delta L = \varepsilon t l = 6.47 \times 10^{-6} (129°) 452 = 0.38''$

- INDUCED STRESS

  $$\Delta = \frac{Pl}{AE} \rightarrow P = \frac{\Delta A E}{l} = \frac{0.38\ in\ (0.25 \times 12)\ in^2\ (28 \times 10^6)\ \frac{lb}{in^2}}{452\ in}$$ (304 stainless)

  $$= 70.6\ kips$$

  $$\sigma = \frac{P}{A} = \frac{70.6}{0.25 \times 12} = 23.5\ ksi$$

- TOTAL STRESS

  $$\sigma_{DL+PL} = \frac{5.95 \times 10^5\ lb\ (1)\ ft^2\ (1)\ K}{ft^2\ 144\ in^2\ 1000\ lb} = 4.1\ ksi$$

  $\sigma_{TOTAL} = 23.5 + 4.1 = 27.6\ ksi \leq 30\ ksi$ allowable for 304 SS, **OK**

Note: Stress reduced further if any sliding of base in slotted anchor holes occurs.

BIN #2

- SECOND ORDER EFFECTS

VERT BUCKLING OF BIN

ALLOWABLE STRESS PER KAMPS T. & J. LIEB
TECH PAPER No CB1 5460
1985 INT. J BULK SOLIDS
MAY 1986

$$F_{a_{all}} = 1750\ t/R \left[1 + 50{,}000\,(t/R)^2\right] + \frac{0.15}{t}\sqrt{\frac{\sigma_i \times R}{E}} \times E \cdot \frac{t}{R}$$

$$F_{a\,all}\quad 1750\ \frac{0.25''}{72''}\left[1 + 50000\left(\frac{0.25''}{72''}\right)^2\right] + \left[\frac{0.15}{0.25''}\sqrt{\frac{1.14 \times 72}{29000\,ksi}}\right] \times 29000\,ksi\ \frac{0.25}{72''} = \underline{10.56\,ksi}$$

$$\sigma_i \approx R\gamma H q_c = \frac{120(50)(38')}{144}\ 72'' = \underline{1140/in}$$

$$A_{ct}\ F_a = -1.23E4\ psf \text{ or } \frac{12300}{12\,(0.25)} = 4100\,psi$$

10.57 4.1 OK.

Project Name:	Project #:	Initials:	Date:	Sheet:
				23

BIN # 2 VOL & SEISMIC FORCE CALC.

- 12'Ø X 37'-6" TALL
- * ASSUME FULL

$VOL = 12'^2 \pi/4 \; 37.5 = \underline{4241\ ft^3}$

- * ASSUME DENSITY 120 pcf
- MASS = $\dfrac{4241\ ft^3 \; 120\ lb/ft^3}{1000\ lbs} = \underline{\underline{509k}}$

- * PER ACI 313 80% MASS IS TAKEN IN
- SEISMIC ANAL.

$509 + 14k$ (SILO MASS) $= \underline{523k}$

$80\% = 523(.8) = \underline{419k}$

- DETERMINE ACC ON STEEL TANK TO PROVIDE EQ MASS

$\dfrac{x}{419} = \dfrac{32.2}{14}$ $x = \underline{\underline{963.7}}\ ft/s^2$

USE AS LATERAL BODY FORCE

SEISMIC ACC. $= (0.087)\ 963\ ft/s^2$

$= 83.8\ ft/s^2$

Project Name:	Project #:	Initials:	Date:	Sheet:
				24

BIN #2

PG(1) FEA

PG(2) GRANULAR LOADING & FEA (120pcF)(0.5) SEE JANSEN CALC PAGE 18

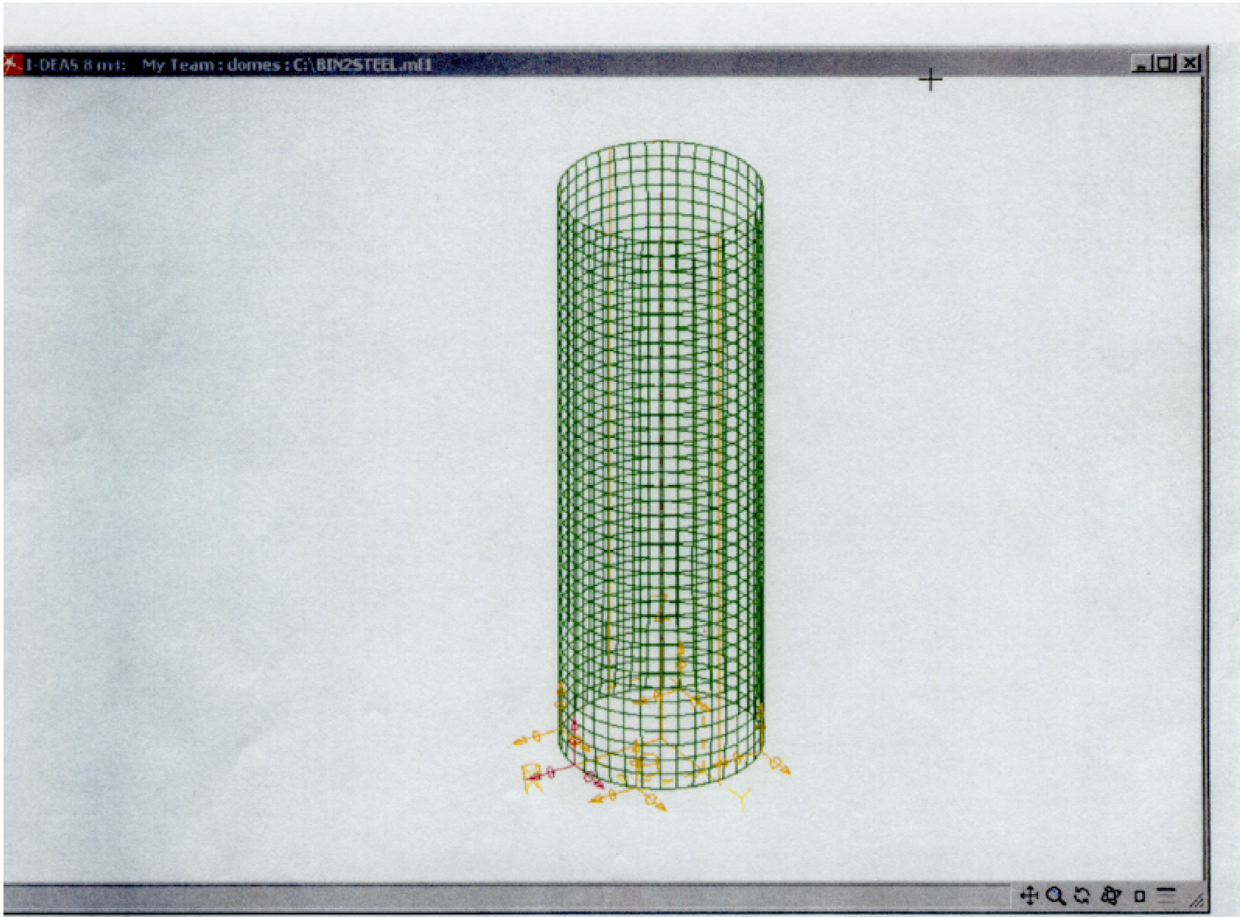
PG(3) VON MISES STRESS DL+PL (PSF)

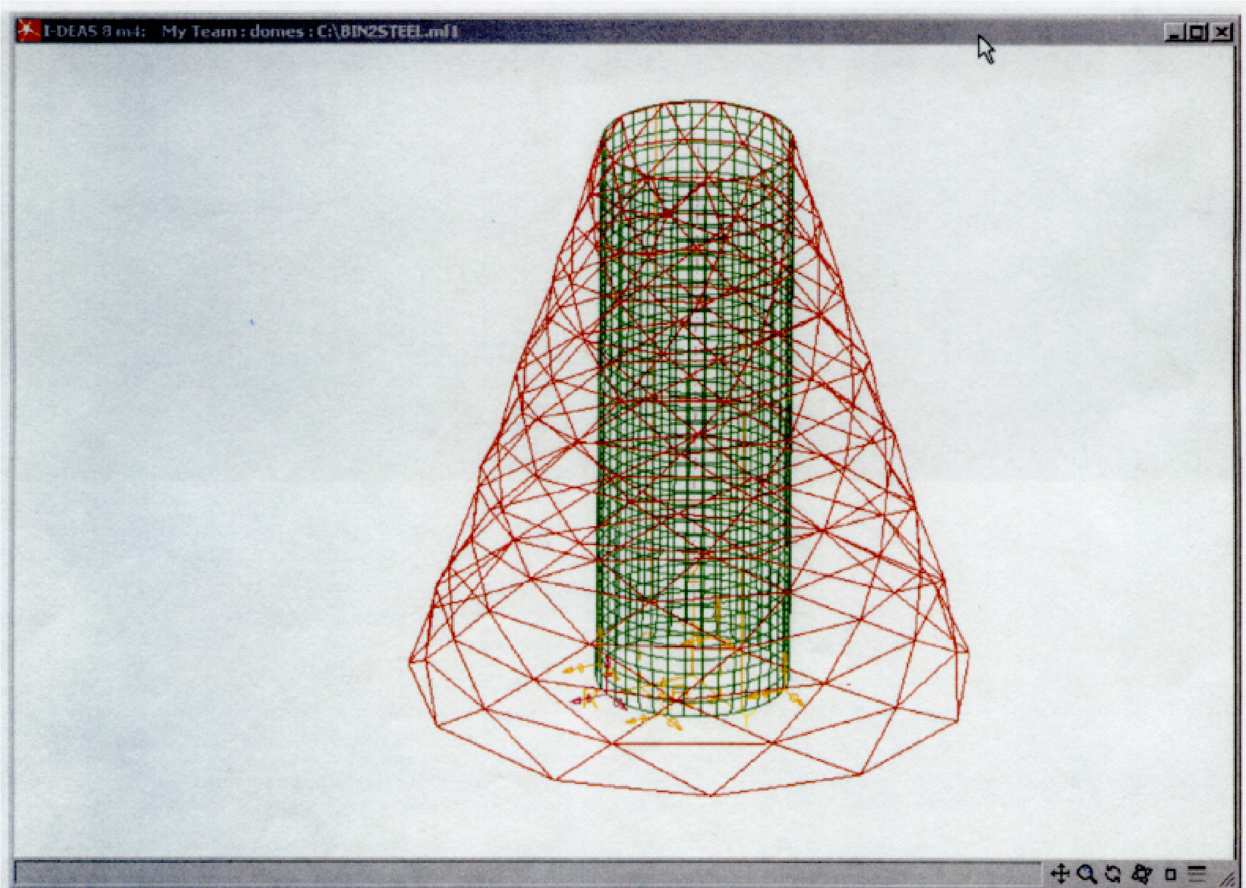
PG(4) VON MISES STRESS (S2)(PSF)

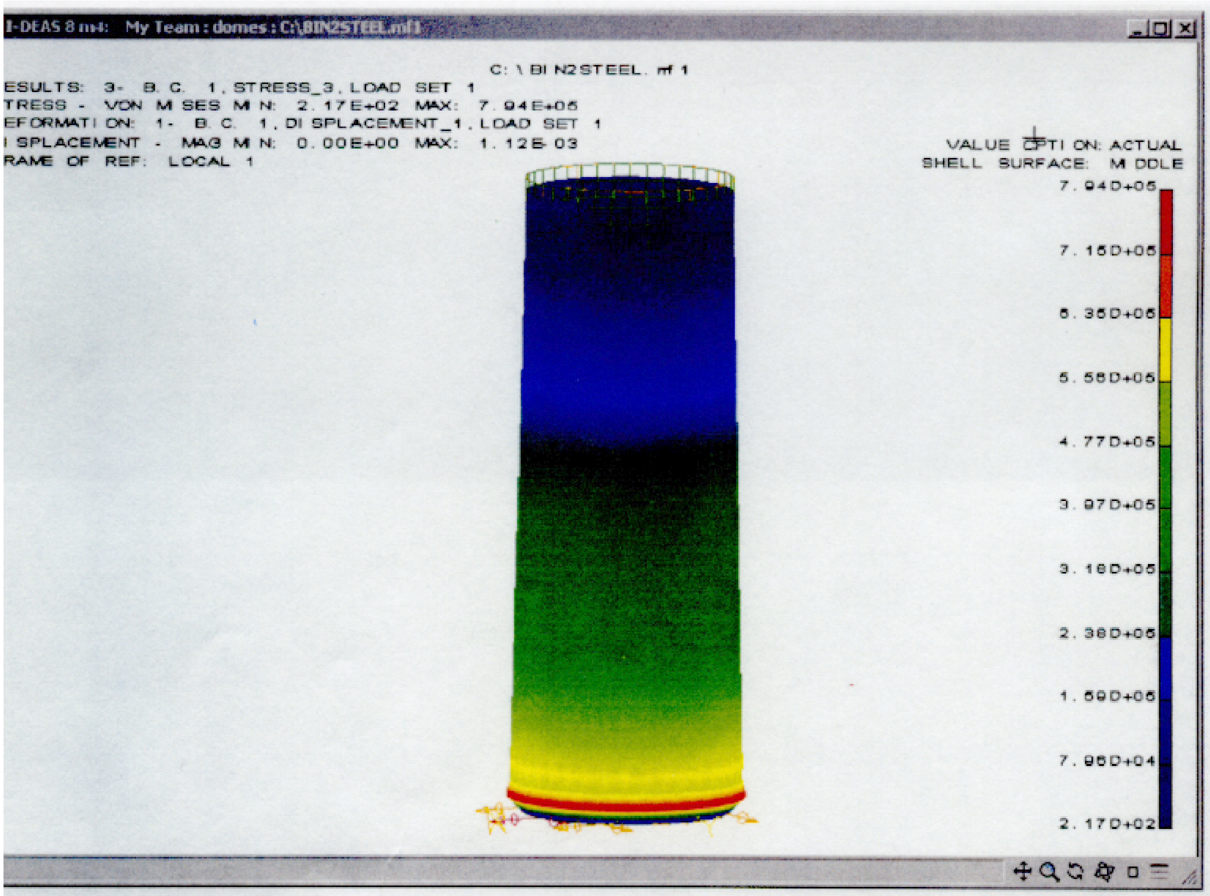
PG(5) REACTION FORCE (lb/Ft)

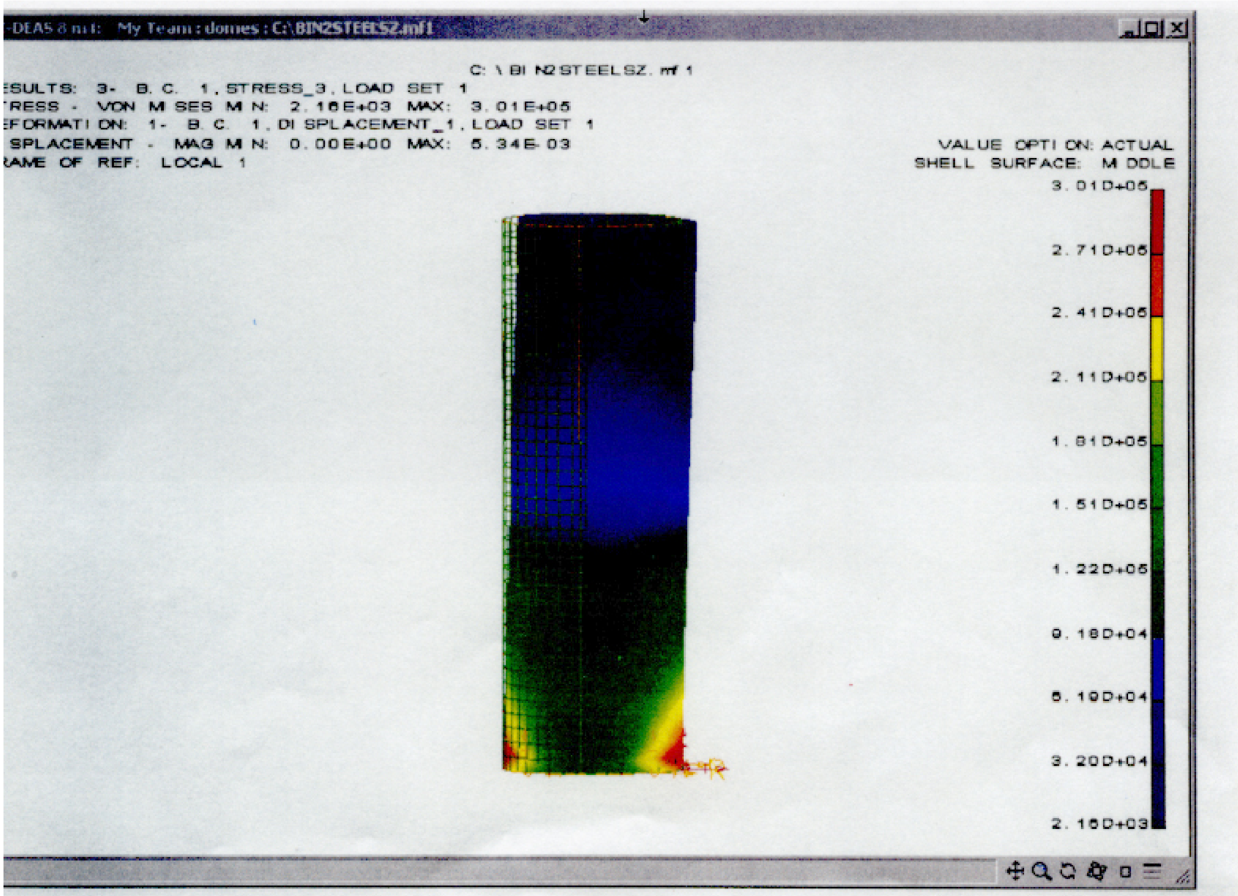
PG(6) VON MISES STRESS (TEMP)

Project Name:	Project #:	Initials:	Date:	Sheet: 25


I-DEAS 8 m1: My Team : domes : C:\BIN2STEEL.mf1
R
Y

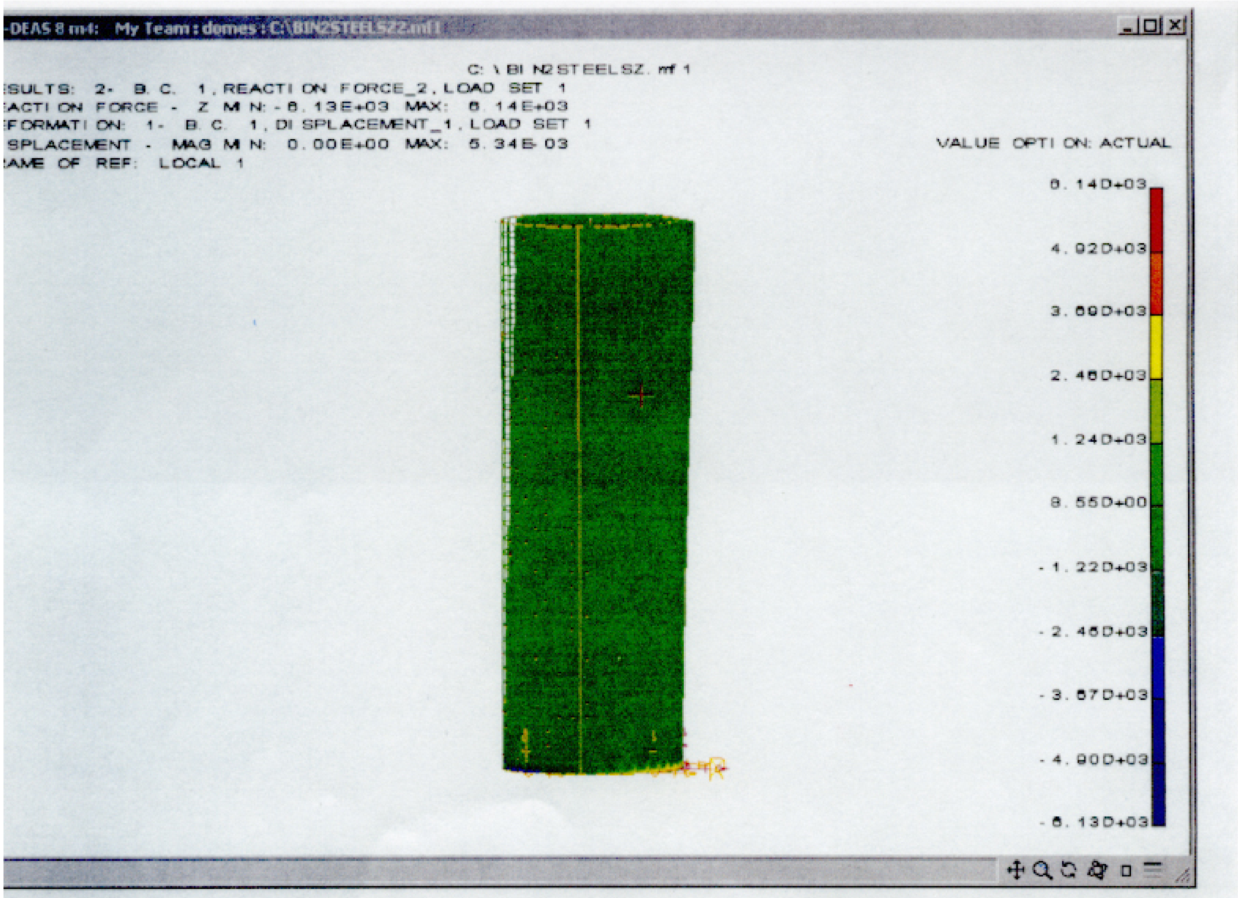

I-DEAS 8 m4: My Team : domes : C:\BIN2STEEL.mf1

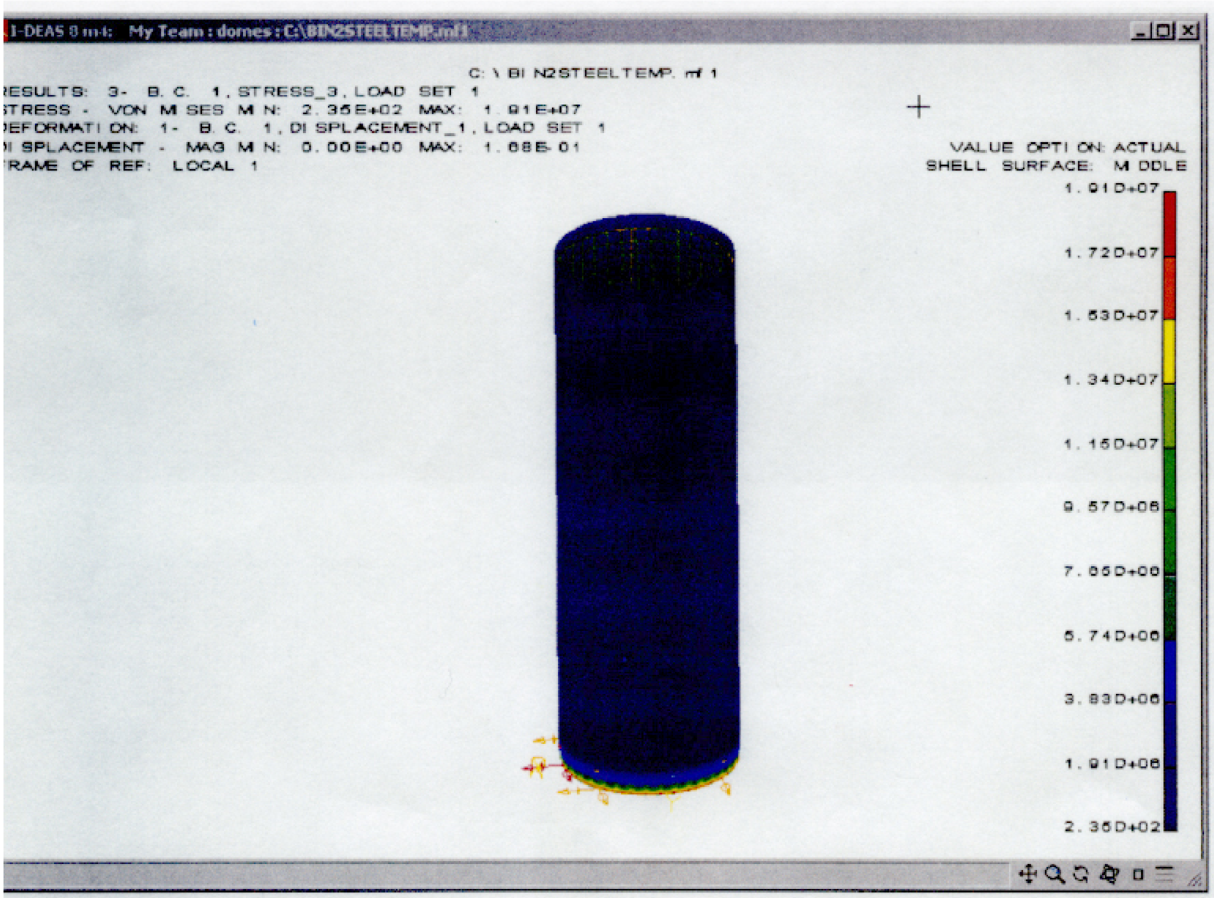

I-DEAS 8 m4: My Team : domes : C:\BIN2STEEL.mf1
C: \ BI N2STEEL. mf 1
ESULTS: 3- B. C. 1, STRESS_3, LOAD SET 1
TRESS - VON M SES M N: 2. 17E+02 MAX: 7. 94E+05
EFORMATI ON: 1- B. C. 1, DI SPLACEMENT_1, LOAD SET 1
I SPLACEMENT - MAG M N: 0. 00E+00 MAX: 1. 12E-03
RAME OF REF: LOCAL 1
VALUE OPTI ON: ACTUAL
SHELL SURFACE: M DDLE
7. 94D+05
7. 15D+05
6. 35D+05
5. 56D+05
4. 77D+05
3. 97D+05
3. 18D+05
2. 38D+05
1. 59D+05
7. 95D+04
2. 17D+02



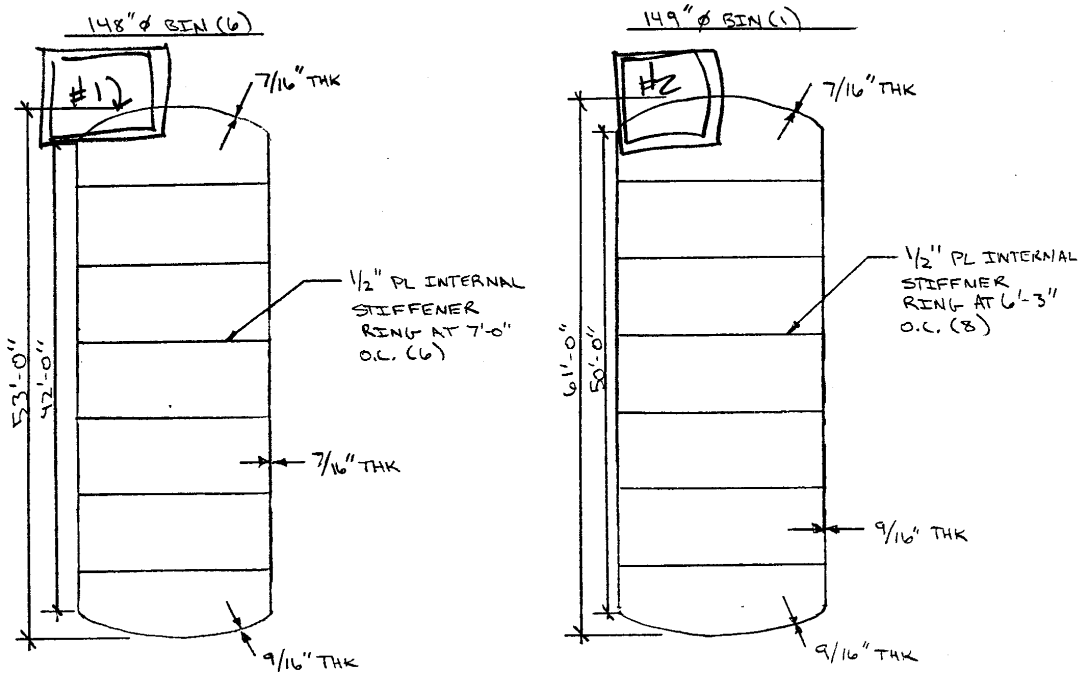
-DEAS 8 m1: My Team: domes: C:\BIN2STEELSZ.mf1
C: \ BI N2STEELSZ. mf 1
ESULTS: 3- B. C. 1, STRESS_3, LOAD SET 1
TRESS - VON MI SES MI N: 2. 16E+03 MAX: 3. 01E+05
EFORMATI ON: 1- B. C. 1, DI SPLACEMENT_1, LOAD SET 1
SPLACEMENT - MAG MI N: 0. 00E+00 MAX: 5. 34E-03
RAME OF REF: LOCAL 1
VALUE OPTI ON: ACTUAL
SHELL SURFACE: MI DDLE
3. 01D+05
2. 71D+05
2. 41D+05
2. 11D+05
1. 81D+05
1. 51D+05
1. 22D+05
9. 18D+04
6. 19D+04
3. 20D+04
2. 16D+03

29 (4)


-DEAS 8 m4: My Team : domes : C:\BIN2STEELSZ2.mf1
C: \ BI N2STEELSZ. mf 1
ESULTS: 2- B. C. 1, REACTI ON FORCE_2, LOAD SET 1
EACTI ON FORCE - Z MI N: -6. 13E+03 MAX: 6. 14E+03
EFORMATI ON: 1- B. C. 1, DI SPLACEMENT_1, LOAD SET 1
SPLACEMENT - MAG MI N: 0. 00E+00 MAX: 5. 34E-03
AME OF REF: LOCAL 1
VALUE OPTI ON: ACTUAL
6. 14D+03
4. 92D+03
3. 69D+03
2. 46D+03
1. 24D+03
8. 55D+00
-1. 22D+03
-2. 45D+03
-3. 67D+03
-4. 90D+03
-6. 13D+03


I-DEAS 8 m4: My Team : domes : C:\BIN2STEELTEMP.mf1
C: \ BI N2STEELTEMP. mf 1
RESULTS: 3- B. C. 1, STRESS_3, LOAD SET 1
STRESS - VON MI SES MI N: 2. 35E+02 MAX: 1. 91E+07
DEFORMATI ON: 1- B. C. 1, DI SPLACEMENT_1, LOAD SET 1
DI SPLACEMENT - MAG MI N: 0. 00E+00 MAX: 1. 68E-01
FRAME OF REF: LOCAL 1
VALUE OPTI ON: ACTUAL
SHELL SURFACE: MI DDLE
1. 91D+07
1. 72D+07
1. 53D+07
1. 34D+07
1. 15D+07
9. 57D+06
7. 65D+06
5. 74D+06
3. 83D+06
1. 91D+06
2. 35D+02

BIN #3



PROPERTIES

STEEL → A240-73 TYPE 304 (STAINLESS STEEL)

BIN #3 CONSIDERED FOR BIN 3 #2 BIN 4 BIN 5
#1

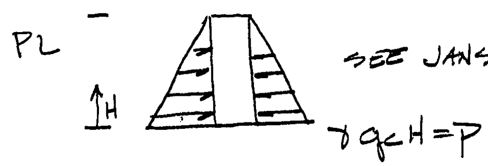
LOAD CASE 1 DL + PL

LOAD CASE 2 DL + PL + SZ

Project Name:	Project #:	Initials:	Date:	Sheet: 32

BIN #3

- LOAD CASE #1   DL + PL



VON MISES STRESS = 5.95E5 psf OR 4131.94 psi

YEILD = 33 KSI

ASSUME ALLOWABLE STRESS

$= F_y = 0.6(33 ksi) = 19.8 ksi$

19.8 > 4.1 ok

- LOAD CASE #2   SEE FOLLOWING PAGE FOR OVERTURNING FORCE

DL + PL + SZ

U.M. = 3.69 E5 psf OR 2563 psi

19.8 > 4.2 + 2.6 ok

* NOTE THIS ASSUMES V.M STRESS WORST CASE FOR (DL+PL) ALIGNS W/ U.M. STRESS WORST CASE FOR (SZ)

Project Name:	Project #:	Initials:	Date:	Sheet:
				33

BIN #3

- SECOND ORDER EFFECTS

VERT BUCKLING OF BIN

ALLOWABLE STRESS PER KAMPS T. & J. LIEB
TECH PAPER NO CB15460
1985 INT.J BULK SOLIDS
MAY 1986

$$F_{a_{all}} = 1750\ t/R\left[1+50{,}000\,(t/R)^2\right] + \frac{0.15}{t}\sqrt{\frac{\sigma_i \times R}{E}} \times E\cdot\frac{t}{R}$$

$$t/R = 0.4375''/74'' = 0.005912$$

$$1750\,(0.005912)\left[1+50\,000\,(0.005912)^2\right] = 28\text{ ksi}$$

2ND TERM NOT NEED BY INSPECTION

$$28\text{ ksi} > \frac{2190\text{ lb/ft}}{.4375(12)} \text{ OR } .417\text{ ksi}$$

OK

Project Name:	Project #:	Initials:	Date:	Sheet: 34

BIN #3 VOL & SEISMIC FORCE CALC.
SIM. TO BIN #2 CALC

- 12'Φ x 50' TALL 7/16" THK WALL

$VOL = 12^2/4\ \pi\ 50 = \underline{5634\ ft^3}$

$MASS = \frac{5635(120)}{1000} = \underline{678.6k}$

- SEISMIC ANAL.

$80\% = (678.6 + 33.5k)\,0.8 = \underline{\underline{569k}}$ (33.5k = STRUCT MASS)

- DETERMIN ACC ON STEEL TANK TO PROVIDE EQ MASS

$32.2/33.5 = \frac{X}{569} \quad X = 546.9\ ft/s^2$

$SEISMIC\ ACC = (0.087)\ 546.9\ ft/s^2$

$= 47.6\ ft/s^2$

Project Name:	Project #:	Initials:	Date:	Sheet: 35

BIN #3

PG(1) FEA

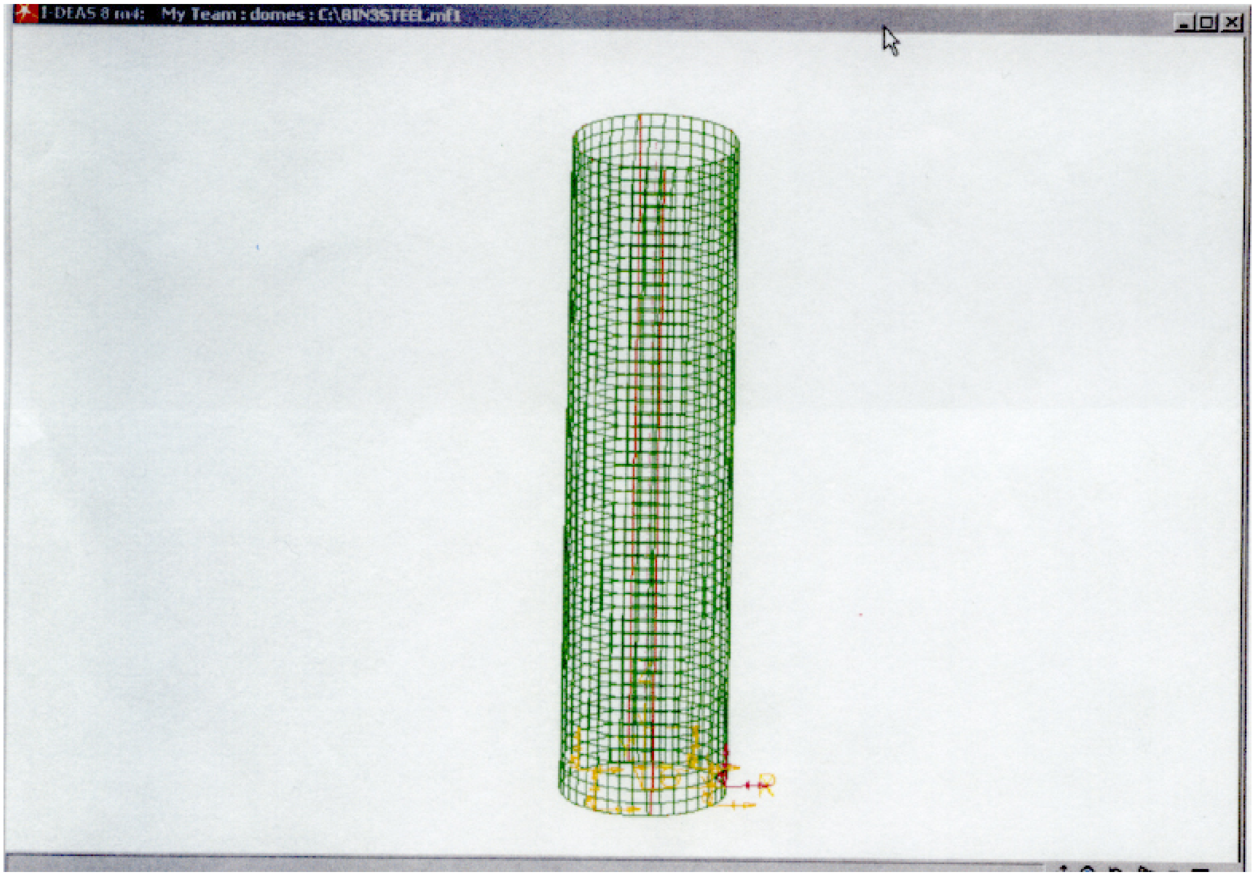
PG(2) GRANULAR LOADING & FEA (120 PCF)(0.5) SEE JANSEN CALC PAGE 18

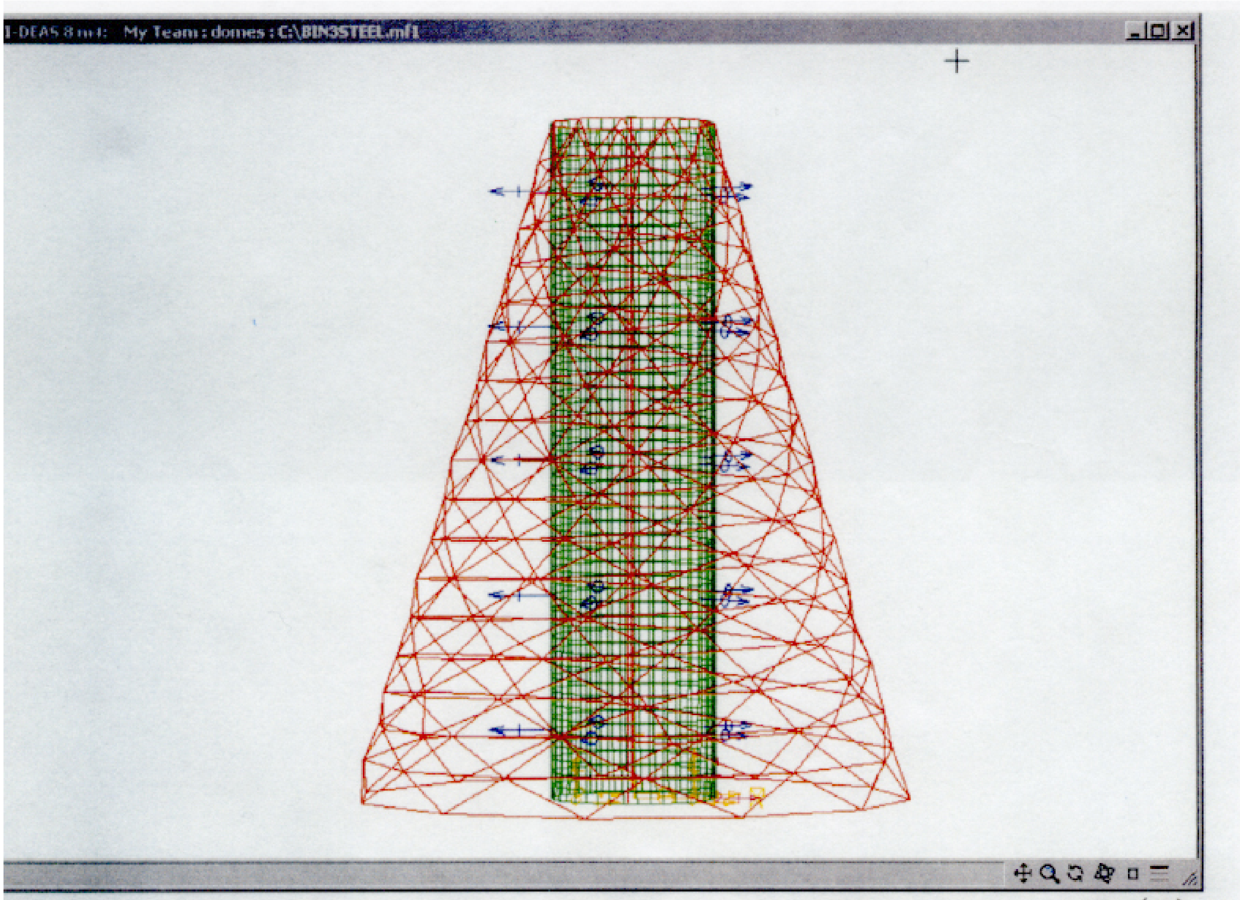
PG(3) VON MISES STRESS DL + PL (PSF)

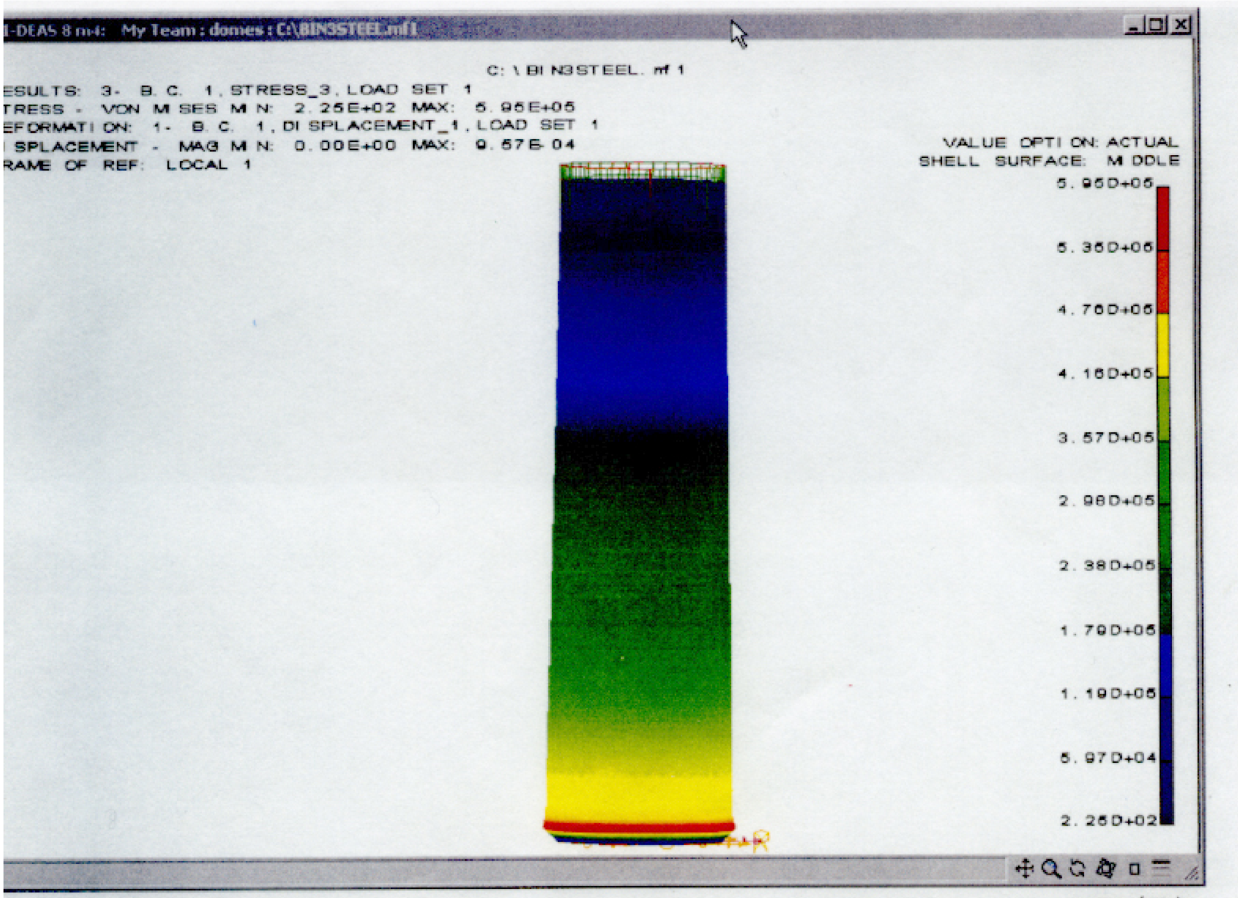
PG(4) VON MISES STRESS (S2)(PSF)

PG(5) REACTION FORCE (lb/ft)

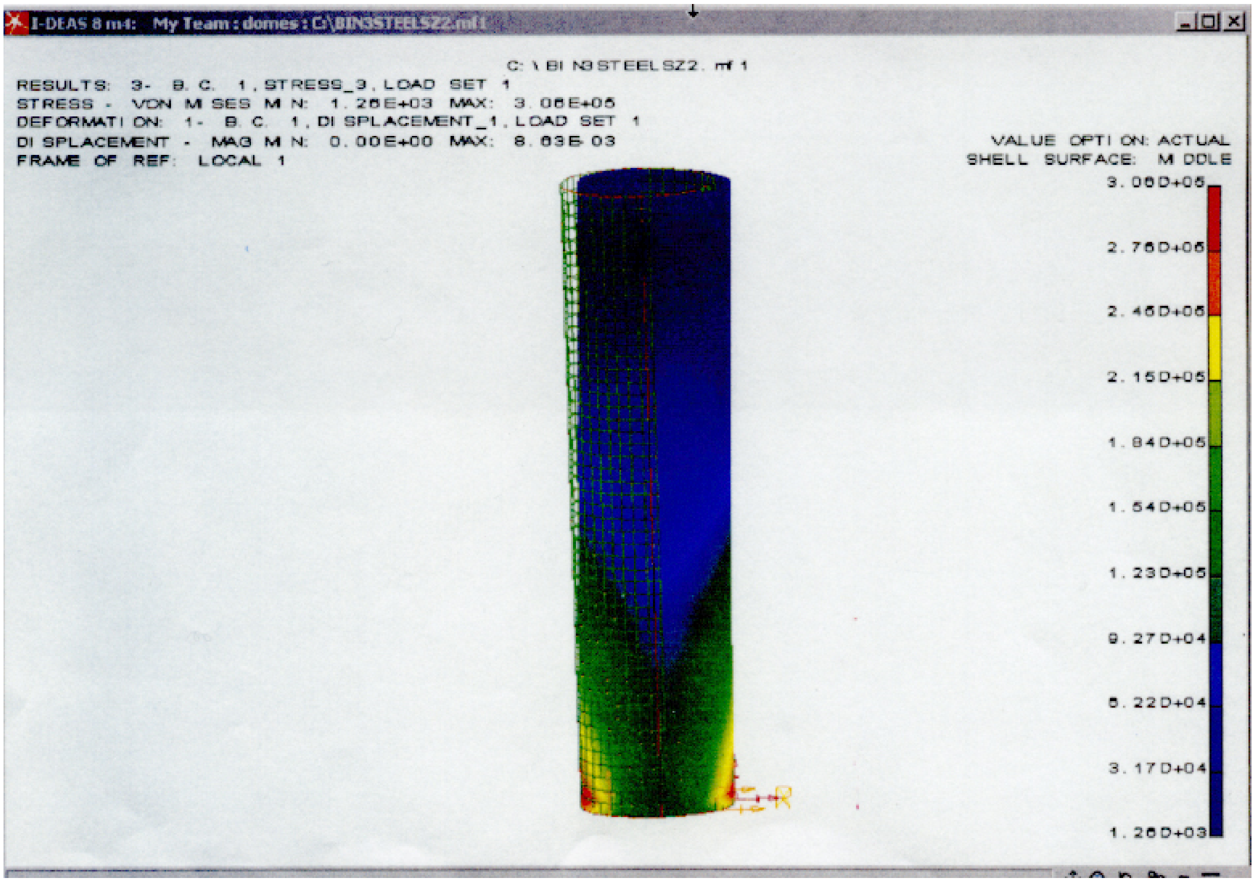
Project Name:	Project #:	Initials:	Date:	Sheet: 36

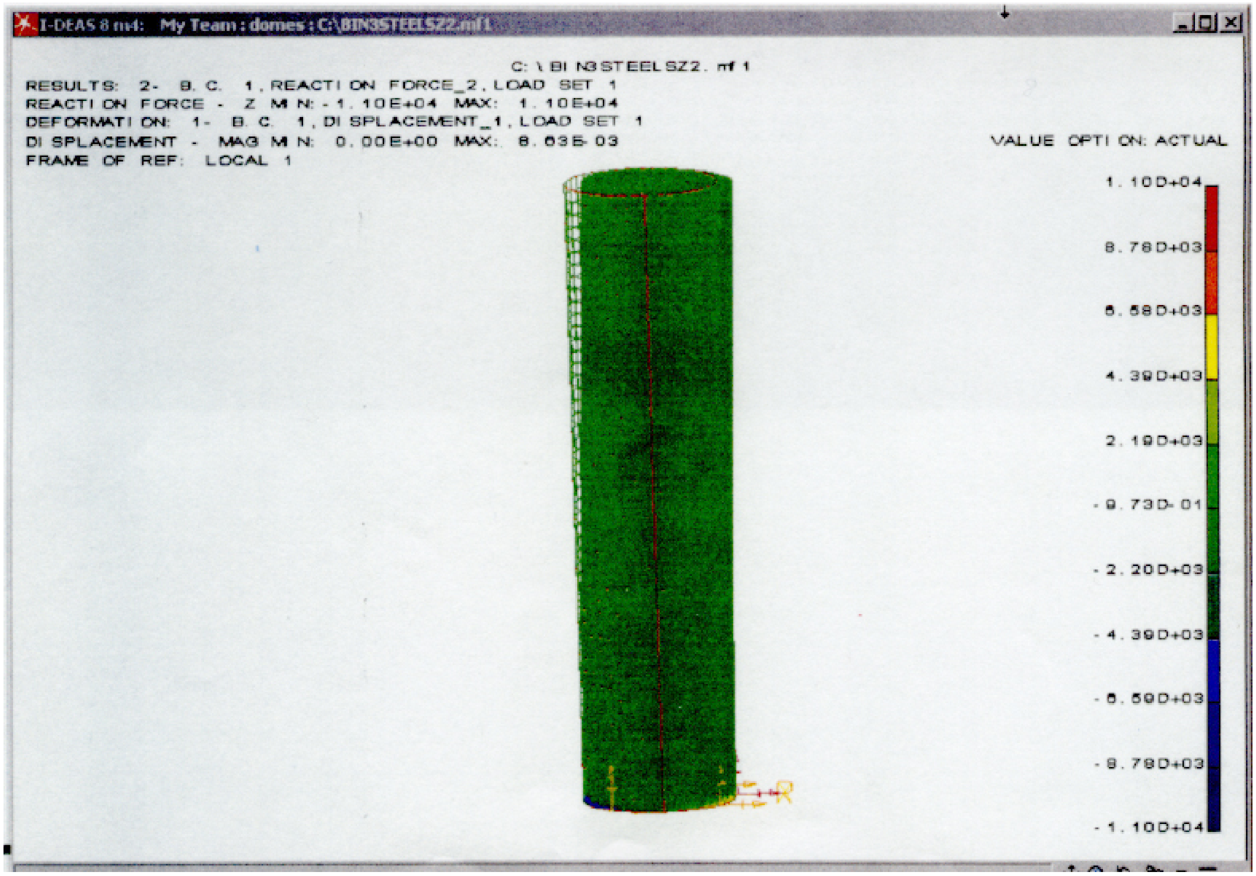

I-DEAS 8 m4: My Team : domes : C:\BIN3STEEL.mf1


I-DEAS 8 m1: My Team : domes : C:\BIN3STEEL.mf1


I-DEAS 8 nl4: My Team : domes : C:\BIN3STEEL.mf1
C: \ BI N3STEEL. mf 1
ESULTS: 3- B. C. 1, STRESS_3, LOAD SET 1
TRESS - VON MI SES MI N: 2. 25E+02 MAX: 5. 95E+05
EFORMATI ON: 1- B. C. 1, DI SPLACEMENT_1, LOAD SET 1
I SPLACEMENT - MAG MI N: 0. 00E+00 MAX: 9. 57E-04
RAME OF REF: LOCAL 1
VALUE OPTI ON: ACTUAL
SHELL SURFACE: MI DDLE
5. 95D+05
5. 36D+05
4. 76D+05
4. 16D+05
3. 57D+05
2. 98D+05
2. 38D+05
1. 79D+05
1. 19D+05
5. 97D+04
2. 25D+02

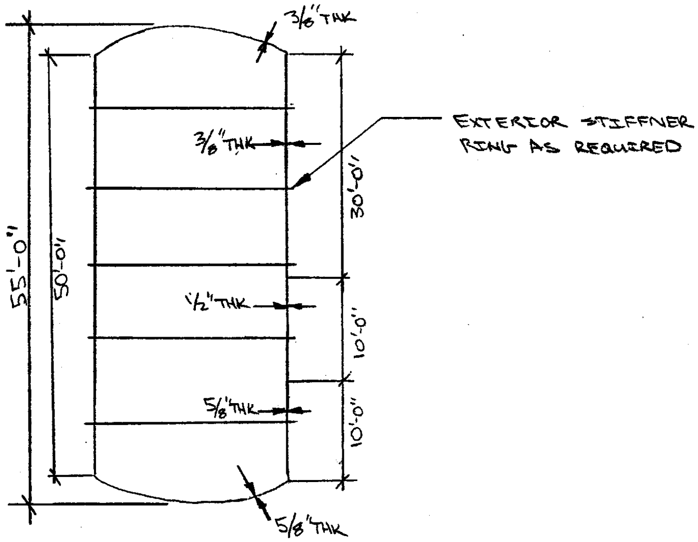
39(3)


I-DEAS 8 m4: My Team : domes : C:\BIN3STEELSZ2.mf1
C: \ BI N3STEELSZ2. mf 1
RESULTS: 3- B. C. 1, STRESS_3, LOAD SET 1
STRESS - VON MI SES MI N: 1. 26E+03 MAX: 3. 06E+05
DEFORMATI ON: 1- B. C. 1, DI SPLACEMENT_1, LOAD SET 1
DI SPLACEMENT - MAG MI N: 0. 00E+00 MAX: 8. 63E-03
FRAME OF REF: LOCAL 1
VALUE OPTI ON: ACTUAL
SHELL SURFACE: MI DDLE
3. 06D+05
2. 76D+05
2. 45D+05
2. 15D+05
1. 84D+05
1. 54D+05
1. 23D+05
9. 27D+04
6. 22D+04
3. 17D+04
1. 26D+03


I-DEAS 8 m4: My Team : domes : C:\BIN3STEELSZ2.mf1
C: \ BIN3STEELSZ2. mf1
RESULTS: 2- B.C. 1, REACTION FORCE_2, LOAD SET 1
REACTION FORCE - Z MIN: -1.10E+04 MAX: 1.10E+04
DEFORMATION: 1- B.C. 1, DISPLACEMENT_1, LOAD SET 1
DISPLACEMENT - MAG MIN: 0.00E+00 MAX: 8.63E-03
FRAME OF REF: LOCAL 1
VALUE OPTION: ACTUAL
1.10D+04
8.78D+03
6.58D+03
4.39D+03
2.19D+03
-9.73D-01
-2.20D+03
-4.39D+03
-6.59D+03
-8.78D+03
-1.10D+04

BIN # 4

144" ø BIN (3)



PROPERTIES

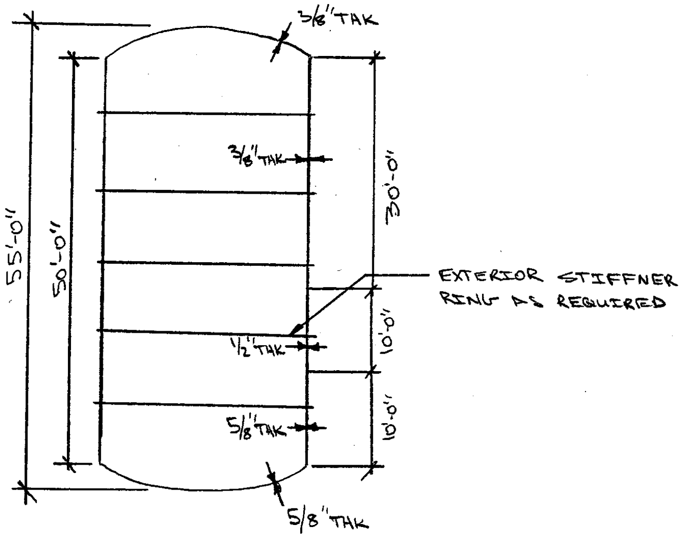
STEEL → A240-73 TYPE 304 (STAINLESS STEEL)

SIM TO BIN #3

Project Name:	Project #:	Initials:	Date:	Sheet: 42

BIN # 5

144" ⌀ BIN(7)



PROPERTIES

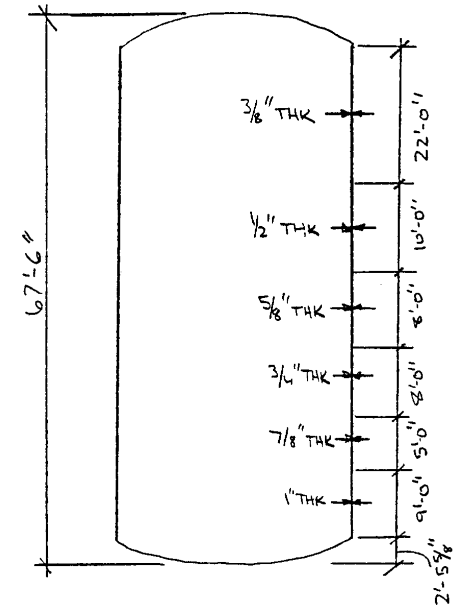
STEEL → TYPE 304L (STAINLESS STEEL)

SIM TO · BIN #3

Project Name:	Project #:	Initials:	Date:	Sheet: 43

BIN #6

162"ϕ BIN (7)



PROPERTIES

STEEL → TYPE 304L (STAINLESS STEEL)

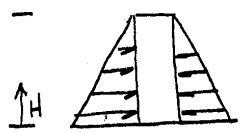
BIN #6 CONSIDERED FOR BIN #7

LOAD CASE #1 DL + PL

LOAD CASE #2 DL + PL + SZ

BIN #6

- LOAD CASE #1   DL + PL



SEE JANSON EQ

$\gamma q_c H = P$

VON MISES STRESS =

YEILD = 33 KSI

ASSUME ALLOWABLE STRESS

$= F_y$ = 0.6(33KSI) = 19.8KSI

3.13E5 PSF OR 2187 PSI

19.8 > 2.2 KSI OK

- LOAD CASE #2   SEE FOLLOWING PAGE FOR OVERTURNING FORCE

DL + PL + SZ W/ 1/3 STRESS INCREASE

V.M. = 1.5E5 PSF OR 1042 PSI

19.8 > 1.1 + 2.2 OK

* NOTE THIS ASSUMES V.M STRESS WORST CASE FOR (DL+PL) ALIGNS W/ V.M. STRESS WORST CASE FOR (SZ)

Project Name:	Project #:	Initials:	Date:	Sheet: 45

BIN #6

- SECOND ORDER EFFECTS

VERT BUCKLING OF BIN

ALLOWABLE STRESS PER KAMPS T. & J. LIEB
TECH PAPER No CB1 5460
1985 INT. J BULK SOLIDS
MAY 1986

$$F_{a_{all}} = 1750\ t/R\ \left[1 + 50{,}000\ (t/R)^2\right] + \frac{0.15}{t}\sqrt{\frac{\sigma_L \times R}{E}} \times E \cdot \frac{t}{R}$$

$$t/R = 1'/84'' = 0.0119$$

$$1750\ (0.0119)\ \left[1 + 50000\ (0.0119)^2\right] = 168\ ksi$$

2ND TERM NOT NEEDED 168 ksi >> YIELDING

OK

Project Name:	Project #:	Initials:	Date:	Sheet: 46

BIN #6 VOL & SEISMIC FORCE CALC.

- 13'-6" ⌀ x 60'-0" VAR. THK

$VOL = (13.5)^2 \pi/4 \; 60 = \underline{8588 \; ft^3}$

$MASS = \frac{120 (8588)}{1000} = \underline{1030.6 \; k}$

- SEISMIC

$80\% = (1030.6 + 64.5) \; 0.8 = 876 k$

- DETERMINATION OF ACC ON SIL TANK TO PROVIDE EQ. MASS

$\frac{32.2}{64.5} = \frac{X}{876} \qquad X = \underline{437.36 \; ft/s^2}$

SEISMIC ACC $= (0.087)(437)$

$= \underline{\underline{38.1 \; ft/s^2}}$

Project Name:	Project #:	Initials:	Date:	Sheet: 47

BFN #6

PG(1) FEA

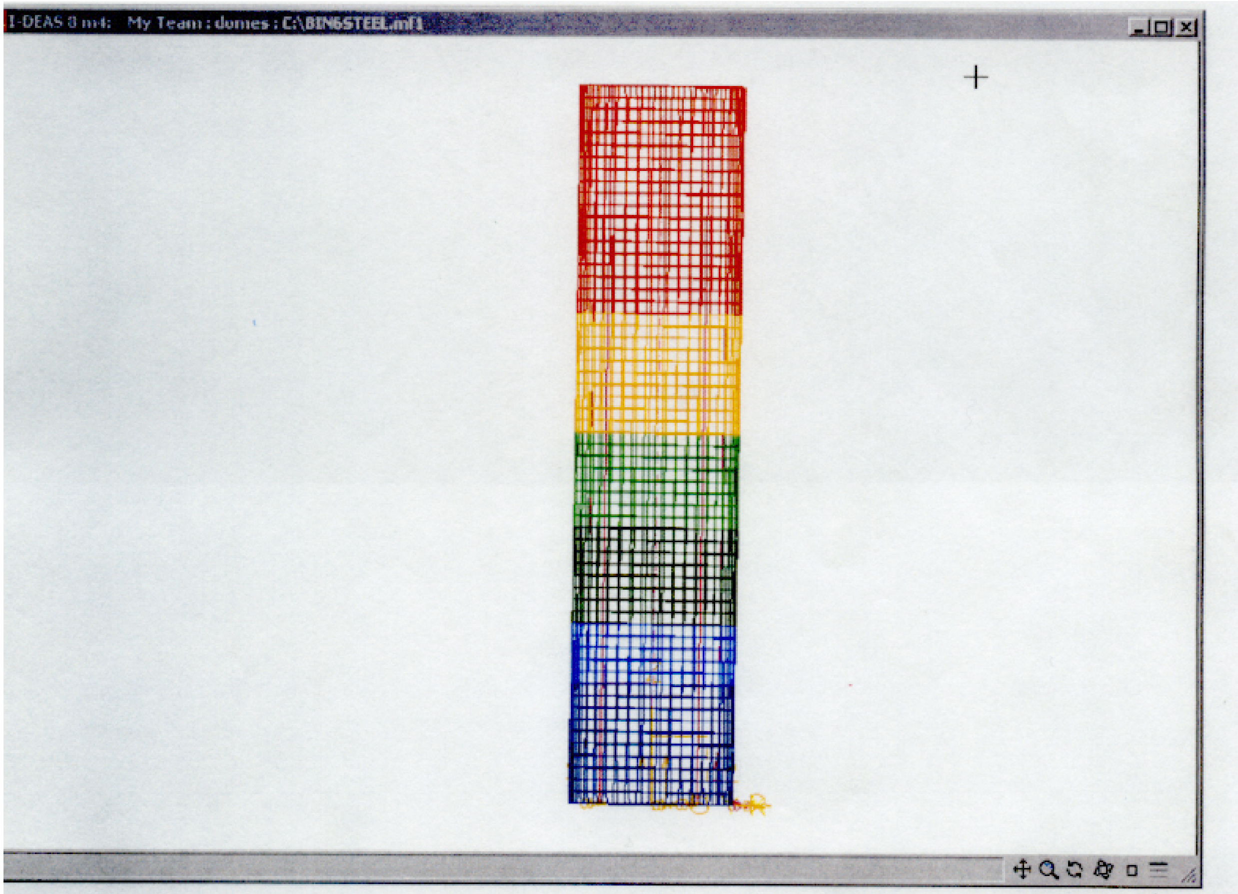
PG(2) GRANULAR LOADING & FEA (120pcF)(0.5) SEE JANSEN CALC PAGE 18

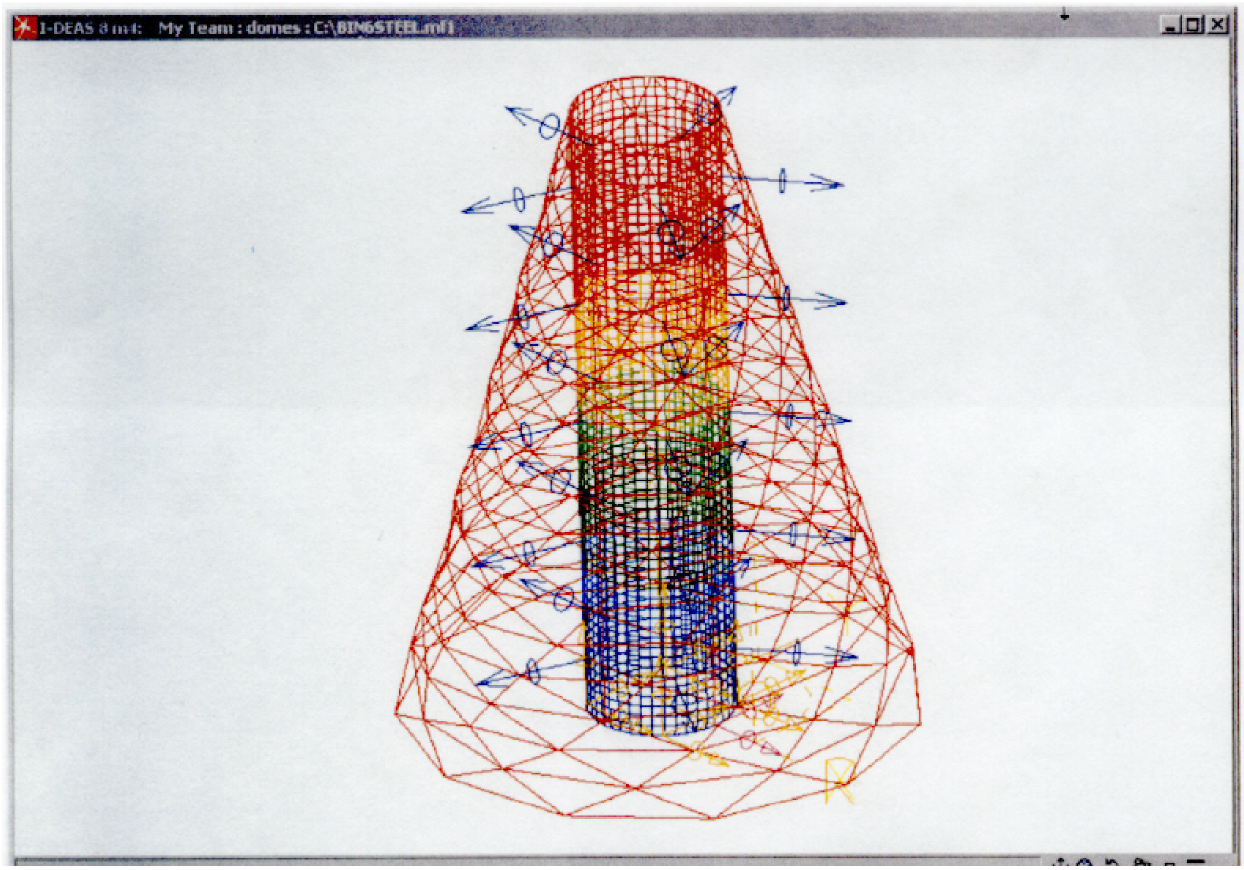
PG(3) VON MISES STRESS DL+PL (PSF)

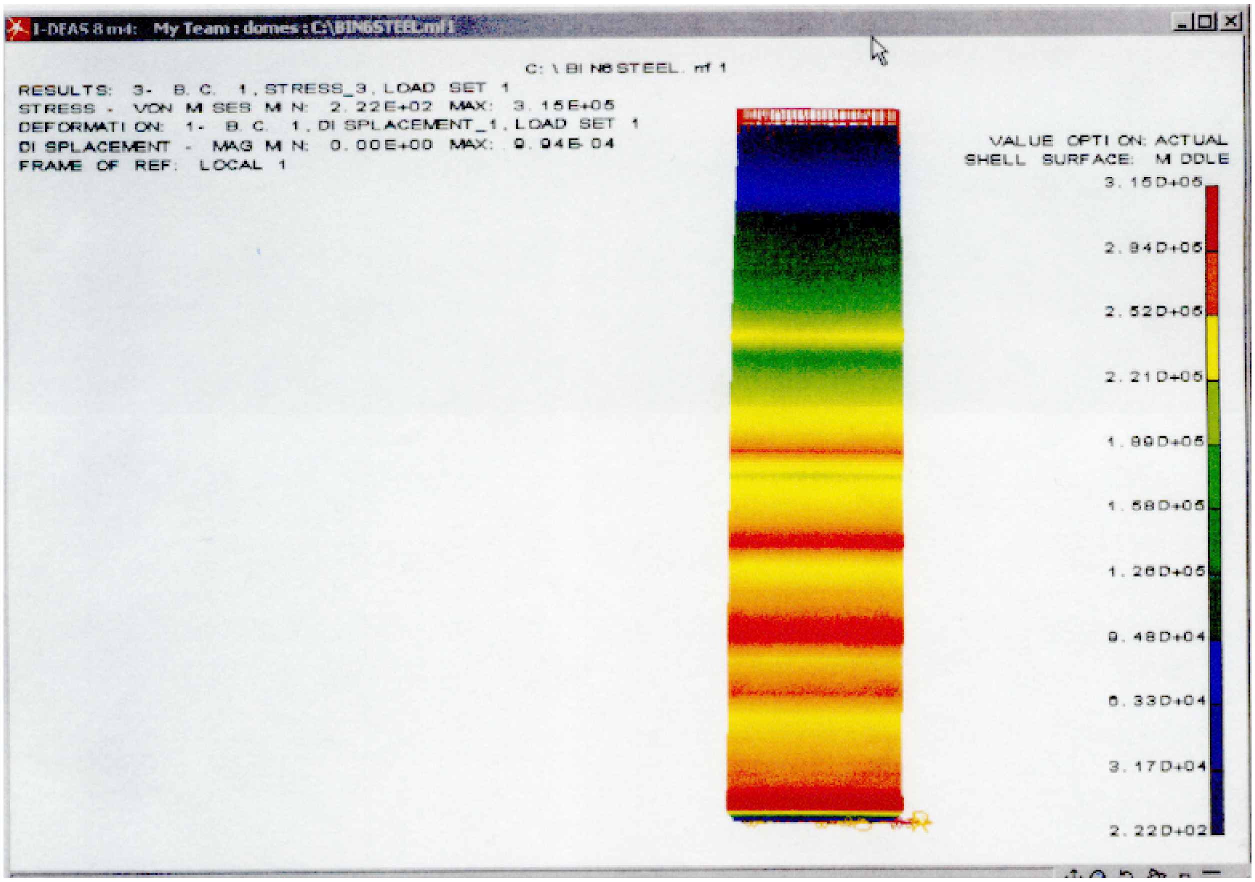
PG(4) VON MISES STRESS (S2)(PSF)

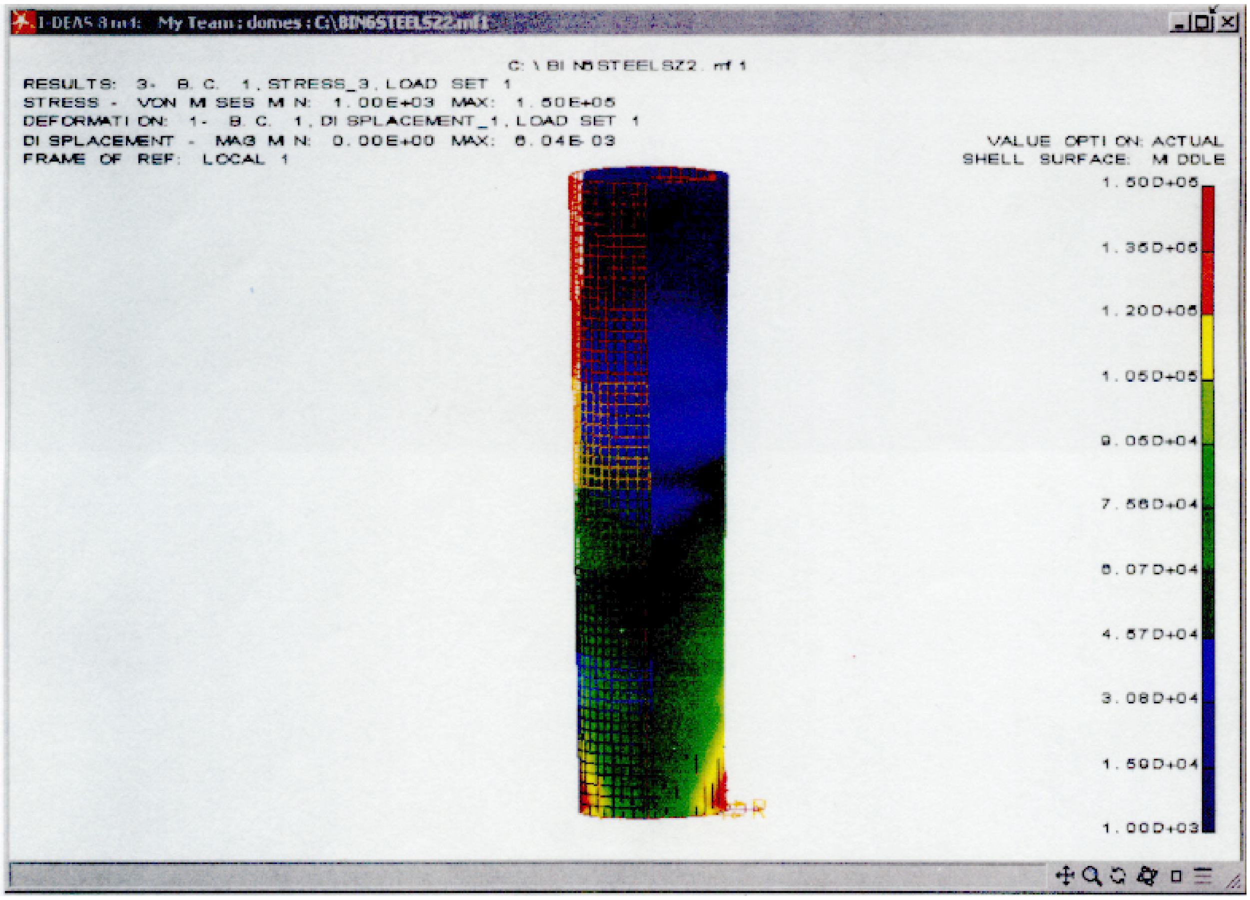
PG(5) REACTION FORCE (lb/ft)

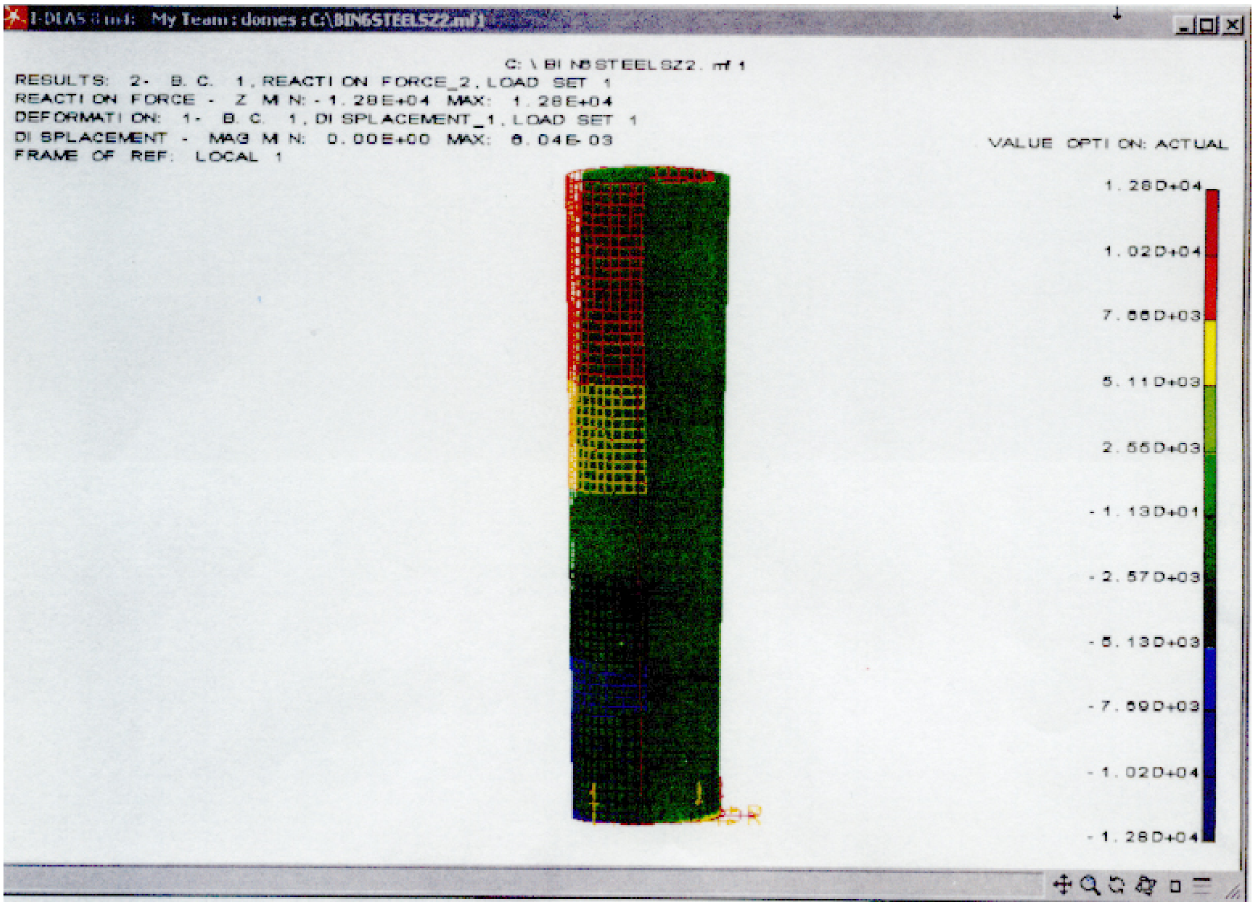
Project Name:	Project #:	Initials:	Date:	Sheet: 48


I-DEAS 8 m4: My Team : domes : C:\BIN6STEEL.mf1


I-DEAS 8 m4: My Team : domes : C:\BIN6STEEL.mf1

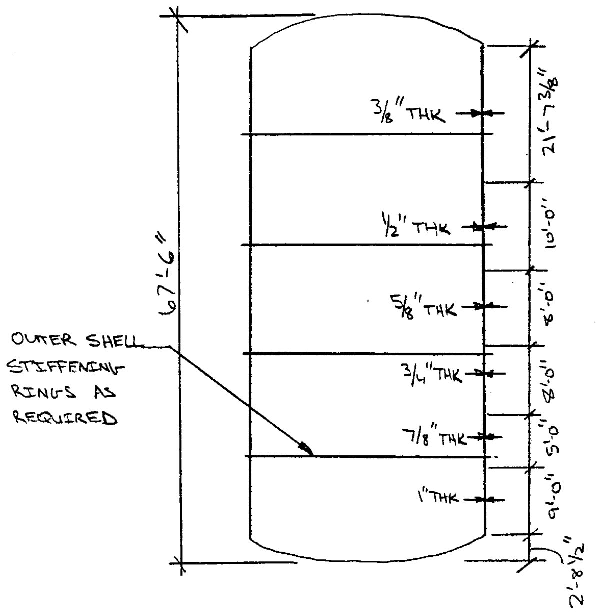

I-DEAS 8 m4: My Team : domes : C:\BIN6STEEL.mf1
C: \ BI N6STEEL. mf 1
RESULTS: 3- B. C. 1, STRESS_3, LOAD SET 1
STRESS - VON MI SES MI N: 2. 22E+02 MAX: 3. 15E+05
DEFORMATI ON: 1- B. C. 1, DI SPLACEMENT_1, LOAD SET 1
DI SPLACEMENT - MAG MI N: 0. 00E+00 MAX: 9. 94E-04
FRAME OF REF: LOCAL 1
VALUE OPTI ON: ACTUAL
SHELL SURFACE: MI DDLE
3. 15D+05
2. 84D+05
2. 52D+05
2. 21D+05
1. 89D+05
1. 58D+05
1. 26D+05
9. 48D+04
6. 33D+04
3. 17D+04
2. 22D+02


I-DEAS 8 m1: My Team : domes : C:\BIN6STEELSZ2.mf1
C:\BIN6STEELSZ2.mf1
RESULTS: 3- B.C. 1, STRESS_3, LOAD SET 1
STRESS - VON MISES MIN: 1.00E+03 MAX: 1.50E+05
DEFORMATION: 1- B.C. 1, DISPLACEMENT_1, LOAD SET 1
DISPLACEMENT - MAG MIN: 0.00E+00 MAX: 6.04E-03
FRAME OF REF: LOCAL 1
VALUE OPTION: ACTUAL
SHELL SURFACE: MIDDLE
1.50D+05
1.35D+05
1.20D+05
1.05D+05
9.05D+04
7.56D+04
6.07D+04
4.57D+04
3.08D+04
1.59D+04
1.00D+03


I-DEAS 8 m4: My Team : domes : C:\BIN6STEELSZ2.mf1
C:\BIN6STEELSZ2.mf1
RESULTS: 2- B.C. 1, REACTION FORCE_2, LOAD SET 1
REACTION FORCE - Z MIN: -1.28E+04 MAX: 1.28E+04
DEFORMATION: 1- B.C. 1, DISPLACEMENT_1, LOAD SET 1
DISPLACEMENT - MAG MIN: 0.00E+00 MAX: 6.04E-03
FRAME OF REF: LOCAL 1
VALUE OPTION: ACTUAL
1.28D+04
1.02D+04
7.66D+03
5.11D+03
2.55D+03
-1.13D+01
-2.57D+03
-5.13D+03
-7.69D+03
-1.02D+04
-1.28D+04

BIN #7

161 1/4" ø BIN (7)



PROPERTIES

STEEL → TYPE 304L (STAINLESS STEEL)

SIM. TO BIN 6.

Project Name:	Project #:	Initials:	Date:	Sheet: 54

CHECK A.B. BIN 1 (BIN #1 HALF THE SIZE OF BIN #2, USE HALF THE FORCE)

SHEAR FORCE ASSUME 1/2 BOLTS TAKE SHEAR

TENSION FORCE " " TENSION

BASE SHEAR 419k(0.087)/2 = 18.22K

TENSION FROM REACTION FEA = 3.1 k/ft
(USE HALF THE FORCE #2 FOR #1)

BOLT SHEAR 36.5/8 = 4.56 k/BOLT

BOLT TENS. 12π/16 2.35 ft/BOLT

2.35 (3.1 k/ft) = 7.3 k

CONCRETE DOES NOT CONTROL

BY INSPECTION

BOLTS IN TENSION N.G.

7.3 > 16.6 (.7) OK

SEE ATTACHED

BINS
AB 3,4,5

B.S = 569 (0.087) = 49.5 K

T = 11.0 K/ft

B.V. 49.5K/9 = 5.5k/BOLT ok

T 12.33π/18 = 23.67

× 11.0

66 > 33.8

23.67/.7

ok

Project Name:	Project #:	Initials:	Date:	Sheet: 55

ANCHOR BOLTS CON.

BRKN 6.7

B.S = 876 (0.087) = 76.2K

T = 12.8 K/FT

B.V 76.2/18 = 4.24 K/BOLT

T = 13.5 π/36 = 15.1

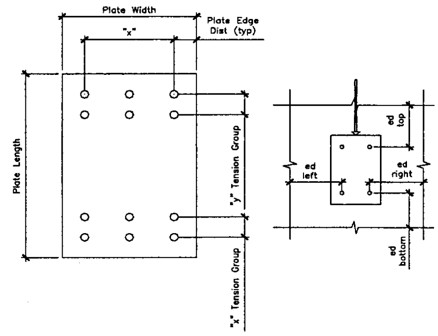
× 12.8

381K > 15.1K/.07 = 21.6K

ok

Project Name:	Project #:	Initials:	Date:	Sheet:
				56

CONCRETE EMBED PLATE DESIGN



DESCRIPTION: BIN 1

MATERIALS:
concrete f'c (psi): 2500
anchor tensile strength f_{ut} (ksi): 60
ϕ: 0.65
SPECIAL INSPECTION? (Y/N): N
located in tension zone ? (Y/N): Y
additional load multiplier, alm: 3.0
concrete type (1-3): 1
normal wt (1), lightwt. (2), sand ltwt (3)
λ: 1.00

GEOMETRY:

anchor diam. (in):	0.625	x (in):	4	concrete thickness (in):	24
anchor length, le (in):	12	y tens. group (in):	0	Ed left (in):	12
no. of anchors tens. group, a_t :	1	y compr. group (in):	0	Ed right (in):	12
# of rows in tens. group:	1	embed plate width (in):	12	Ed bottom (in):	12
no. of anchors compr. group, a_c:	0	embed plate length (in):	12	Ed top (in):	12
# of rows in comp. group:	0	embed plate thickness (in):	1		
Ab (in^2):	0.31	plate edge distance (in):	4		

LOADS: Applied factored loads ...

Vu (kips):	0.0	Vu tension group (kips):	0.0	Pu at tension group (kips):	0.0
Mu (k-ft):	0.0	Vu compression group (kips):	0.0	Pu at compression group (kips):	0.0
direct pullout Pu (kips):	0.0	a (in):	0.65		
e (in. from conc. face):	0.00				

TENSION STRENGTH:
STEEL CONTROLS

Thick slab projected failure surface...		Thin slab projected failure surface...		Steel control ...	
length (in):	24.0	length (in):	24.0	Pss (kips):	16.6
width (in):	28.0	width (in):	28.0		
Ap (in^2):	672.0	Ap (in^2):	672.0		
Pc (kips):	134.4	Pc (kips):	134.4		
		THIN SLAB GOVERNS			

SHEAR STRENGTH:
CONCRETE CONTROLS

	Vc tension group (kips) ...		Vc compression group (kips) ...		Steel control ...	
weakest anchor x no. of anchors	12.3	<<--- GOVERNS	0.0	<<--- GOVERNS	Vss (kips):	13.8
weakest row based on edge dist. x number of rows	12.3		0.0		Vc total (kips):	12.3
strongest row based on edge distance	12.3		0.0			

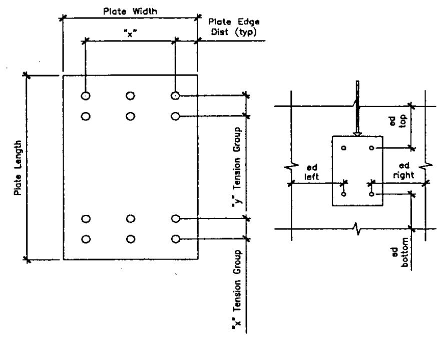
(Used only when edge distance is less than 10 diameters)

COMBINED STRESSES:

	Tension group ...		Compression group ...	
1 /f(Pu /Pc):	0.00	OK	...	
1 /f(Vu /Vc):	0.00	OK	#####	#DIV/0!
1 /f[(Pu /Pc)$^{5/3}$ + (Vu /Vc)$^{5/3}$]:	0.00	OK	#####	#DIV/0!
(Pu /Pss)^2 + (Vu /Vss)^2:	0.00	OK	0.00	OK

CONCRETE EMBED PLATE DESIGN

DESCRIPTION: BIN ~~1/2~~ 6, 7



MATERIALS:

concrete f'c (psi): 2500
anchor tensile strength f_{ut} (ksi): 60
ϕ: 0.65
SPECIAL INSPECTION? (Y/N): N
located in tension zone ? (Y/N): Y
additional load multiplier, alm: 3.0
concrete type (1-3): 1
normal wt (1), lightwt. (2), sand ltwt (3)
λ: 1.00

GEOMETRY:

anchor diam. (in): 3
anchor length l_e (in): 47
no. of anchors tens. group, a_t : 1
# of rows in tens. group: 1
no. of anchors compr. group, a_c: 0
# of rows in comp. group: 0
A_b (in^2): 7.07

x (in): 4
y tens. group (in): 0
y compr. group (in): 0
embed plate width (in): 12
embed plate length (in): 12
embed plate thickness (in): 1
plate edge distance (in): 4

concrete thickness (in): 24
$E_{d\ left}$ (in): 12
$E_{d\ right}$ (in): 12
$E_{d\ bottom}$ (in): 12
$E_{d\ top}$ (in): 12

LOADS:

Applied factored loads ...
V_u (kips): 0.0
M_u (k-ft): 0.0
direct pullout P_u (kips): 0.0
e (in. from conc. face): 0.00

V_u tension group (kips): 0.0
V_u compression group (kips): 0.0
a (in): 5.27

P_u at tension group (kips): 0.0
P_u at compression group (kips): 0.0

TENSION STRENGTH:
CONCRETE CONTROLS

Thick slab projected failure surface...
length (in): 24.0
width (in): 28.0
A_p (in^2): 672.0
P_c (kips): 134.4

Thin slab projected failure surface...
length (in): 24.0
width (in): 28.0
A_p (in^2): 672.0
P_c (kips): 134.4
THIN SLAB GOVERNS

Steel control ...
P_{ss} (kips): 381.7

SHEAR STRENGTH:
#DIV/0!

	Vc tension group (kips) ...		Vc compression group (kips) ...	
weakest anchor x no. of anchors	45.2	<<--- GOVERNS	0.0	#DIV/0!
weakest row based on edge dist. x number of rows	45.2		0.0	#DIV/0!
strongest row based on edge distance	45.2		#DIV/0!	

(Used only when edge distance is less than 10 diameters)

Steel control ...
V_{ss} (kips): 318.1
V_c total (kips): #DIV/0!

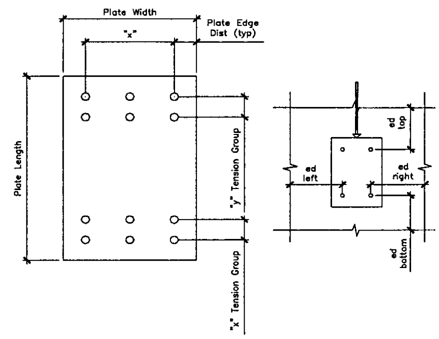
COMBINED STRESSES:

	Tension group ...		Compression group ...	
1 /f(Pu /Pc):	0.00	OK	...	
1 /f(Vu /Vc):	0.00	OK	#####	#DIV/0!
1 /f[(Pu /Pc)$^{5/3}$ + (Vu /Vc)$^{5/3}$]:	0.00	OK	#####	#DIV/0!
(Pu /Pss)^2 + (Vu /Vss)^2:	0.00	OK	0.00	OK

edited 6/3/02

CONCRETE EMBED PLATE DESIGN

DESCRIPTION: BIN ~~12~~ 2345



MATERIALS:

concrete f'c (psi): 2500
anchor tensile strength f_{ut} (ksi): 60
ϕ: 0.65
SPECIAL INSPECTION? (Y/N): N
located in tension zone ? (Y/N): Y
additional load multiplier, alm: 3.0
concrete type (1-3): 1
normal wt (1), lightwt. (2), sand ltwt (3)
λ: 1.00

GEOMETRY:

anchor diam. (in):	1.25	x (in):	4	concrete thickness (in):	24
anchor length l_e (in):	20	y tens. group (in):	0	Ed left (in):	12
no. of anchors tens. group, a_t:	1	y compr. group (in):	0	Ed right (in):	12
# of rows in tens. group:	1	embed plate width (in):	12	Ed bottom (in):	12
no. of anchors compr. group, a_c:	0	embed plate length (in):	12	Ed top (in):	12
# of rows in comp. group:	0	embed plate thickness (in):	1		
Ab (in^2):	1.23	plate edge distance (in):	4		

LOADS:

Applied factored loads ...

Vu (kips):	0.0	Vu tension group (kips):	0.0	Pu at tension group (kips):	0.0
Mu (k-ft):	0.0	Vu compression group (kips):	0.0	Pu at compression group (kips):	0.0
direct pullout Pu (kips):	0.0	a (in):	2.60		
e (in. from conc. face):	0.00				

TENSION STRENGTH:
STEEL CONTROLS

Thick slab projected failure surface...		Thin slab projected failure surface...		Steel control ...	
length (in):	24.0	length (in):	24.0	Pss (kips):	66.3
width (in):	28.0	width (in):	28.0		
Ap (in^2):	672.0	Ap (in^2):	672.0		
Pc (kips):	134.4	Pc (kips):	134.4		
		THIN SLAB GOVERNS			

SHEAR STRENGTH:

	Vc tension group (kips) ...		Vc compression group (kips) ...		Steel control ...	
#DIV/0! weakest anchor x no. of anchors	45.2	<<--- GOVERNS	0.0	#DIV/0!	Vss (kips):	55.2
weakest row based on edge dist. x number of rows	45.2		0.0	#DIV/0!	Vc total (kips):	#DIV/0!
strongest row based on edge distance	45.2		#DIV/0!			

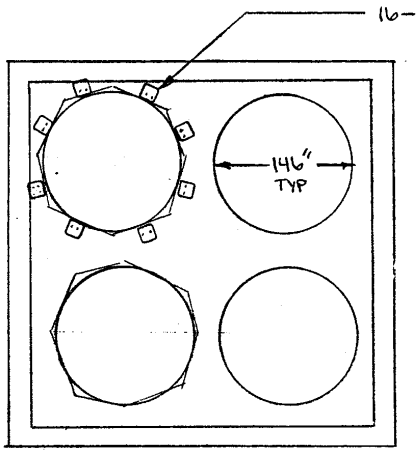
(Used only when edge distance is less than 10 diameters)

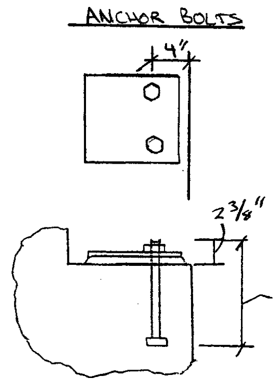
COMBINED STRESSES:

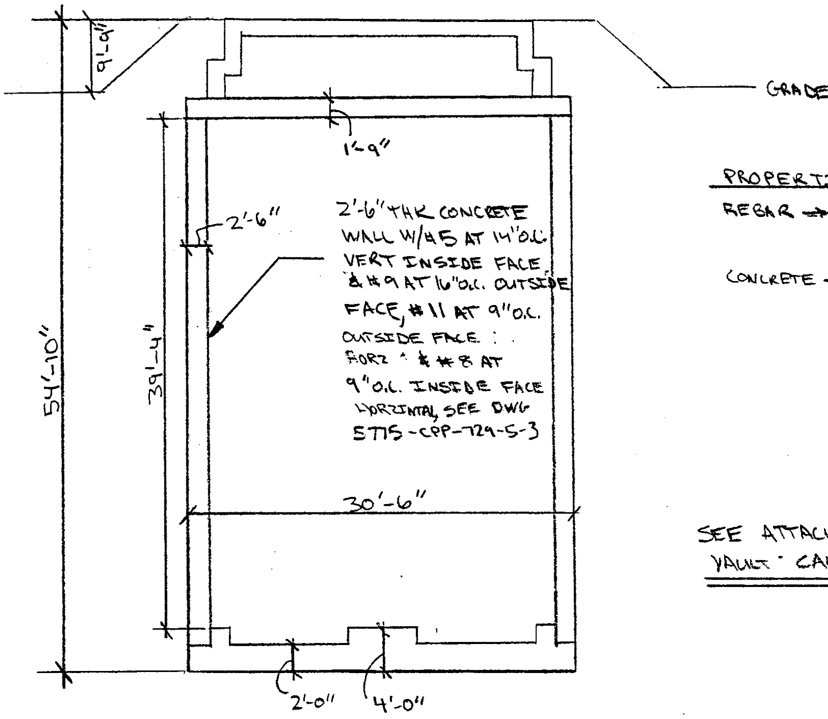
	Tension group ...		Compression group ...	
1 /f(Pu /Pc):	0.00	OK	...	
1 /f(Vu /Vc):	0.00	OK	#####	#DIV/0!
1 /f[(Pu /Pc)$^{5/3}$ + (Vu /Vc)$^{5/3}$]:	0.00	OK	#####	#DIV/0!
(Pu /Pss)^2 + (Vu /Vss)^2:	0.00	OK	0.00	OK

edited 6/3/02

BIN #1 (VAULT #1)







PROPERTIES

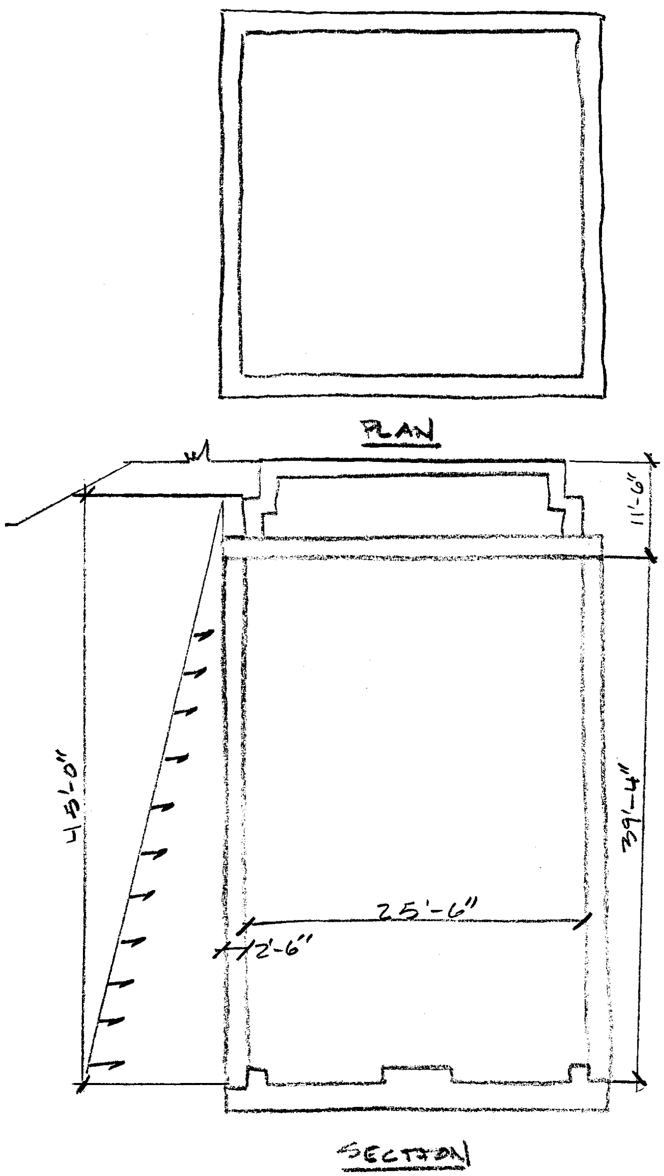
REBAR → NOT SPECIFIED
ASSUME $f_y = 60$ ksi

CONCRETE → $f_c' = 3000$ psi

SEE ATTACHED PAGES FOR CONCRETE VAULT CALCS

Project Name:	Project #:	Initials:	Date:	Sheet:
				60

LOADING VAULT #1

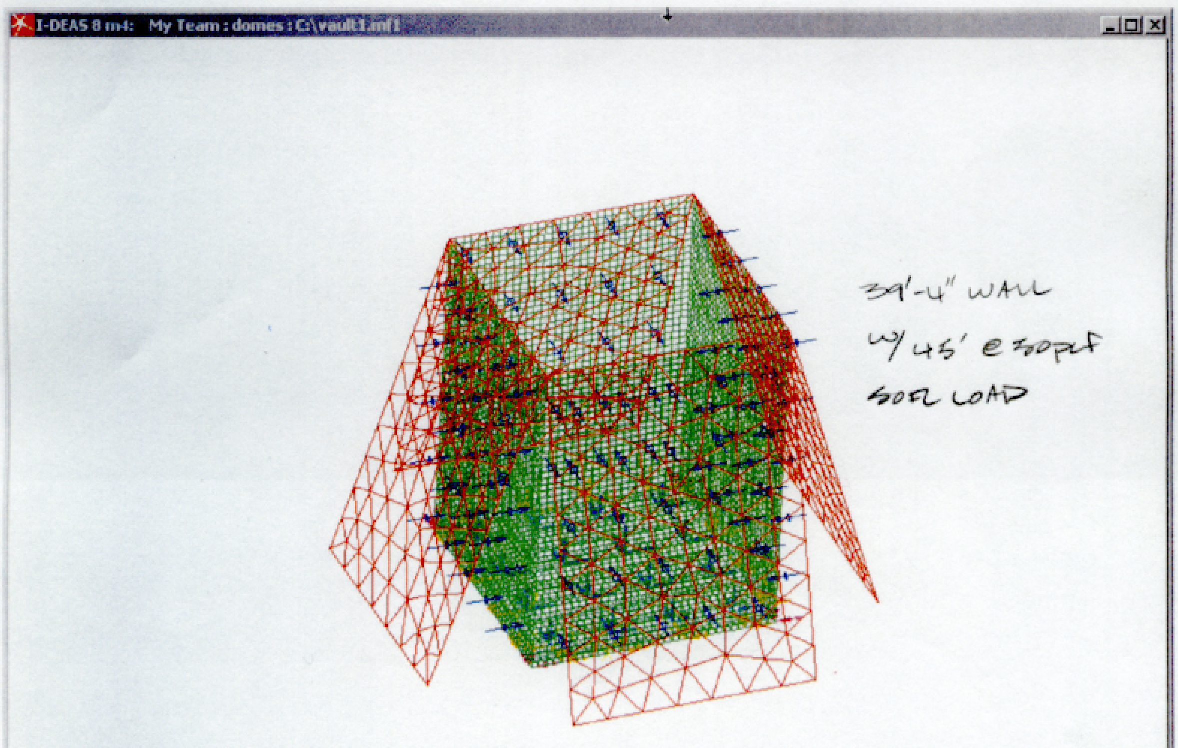


ASSUME 9'-9" SLOPED BERM IMPOSES 5'-0" SURCHARGE W/ SAME EFFECT AS ~~=~~ SOIL. USE 50 PCF FROM GOLDER & ASSOC. SOIL REPORT.

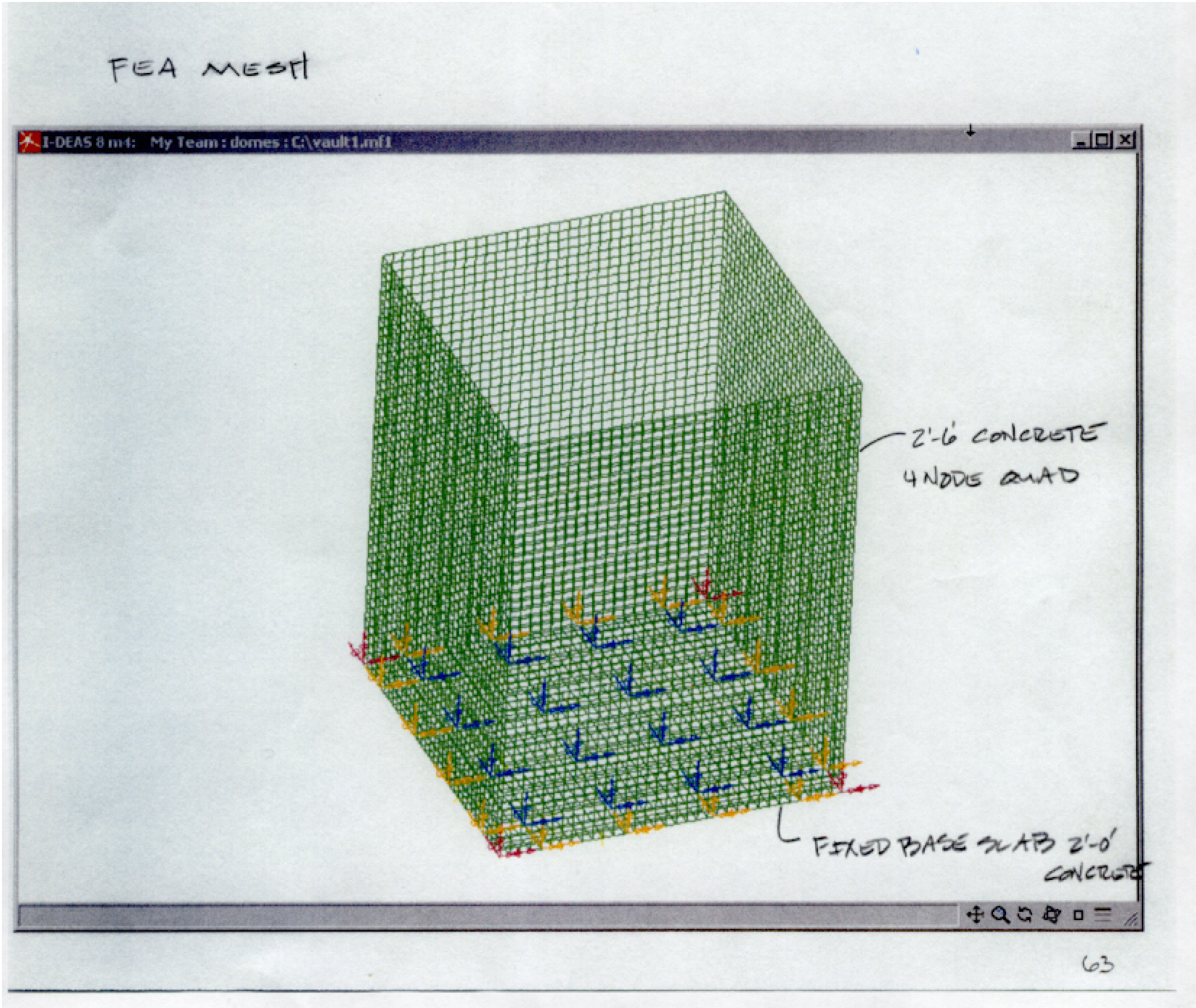
Project Name:	Project #:	Initials:	Date:	Sheet:
				61

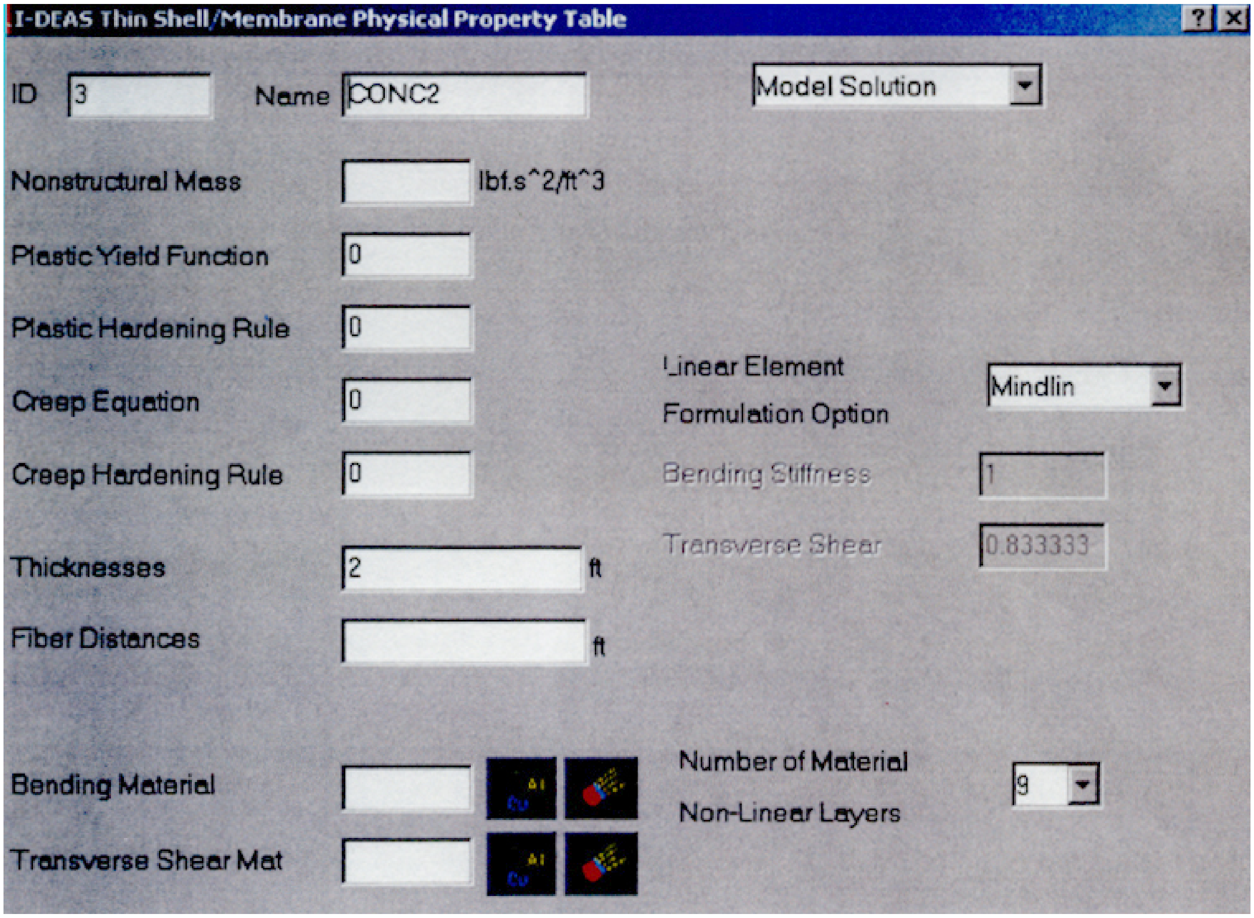
VAULT #1

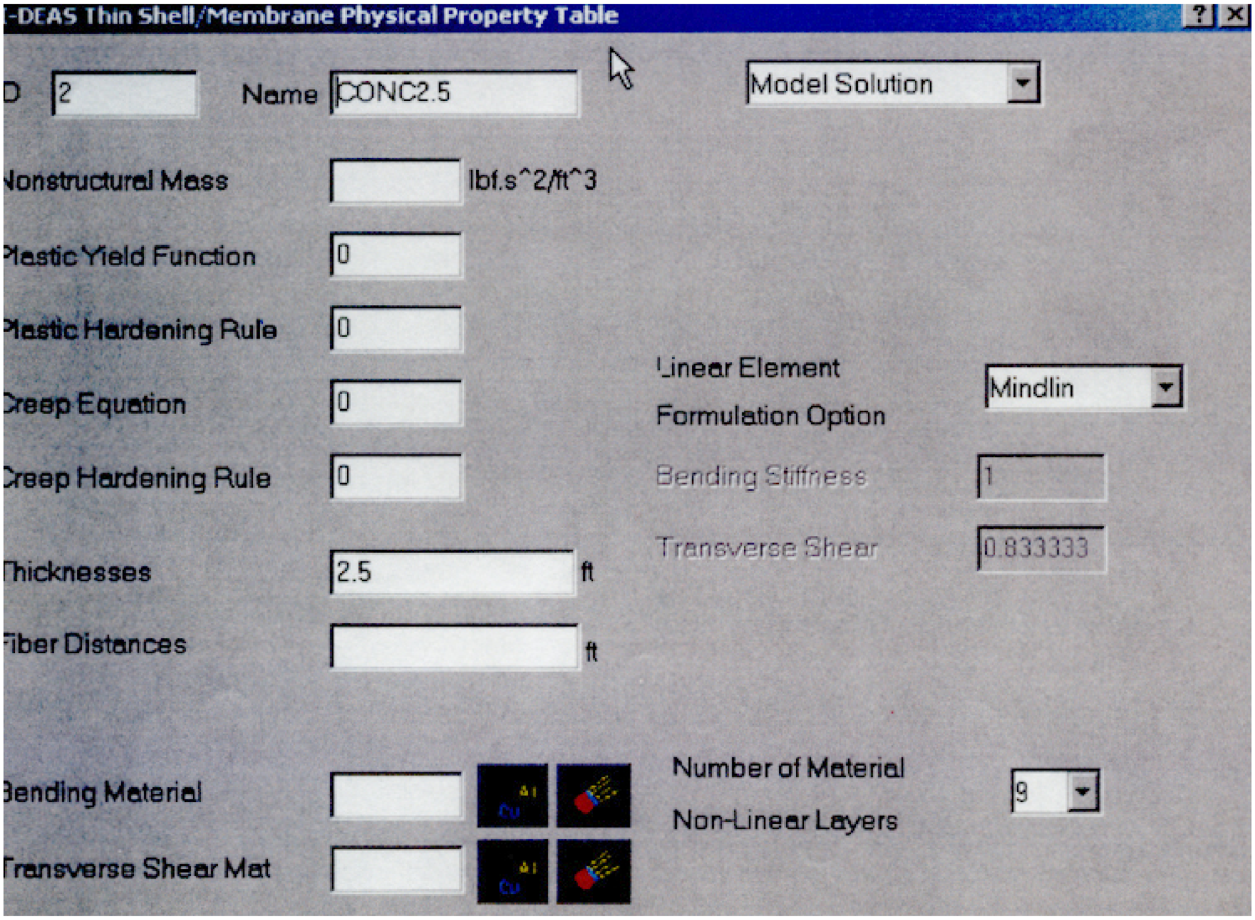
FEA LOADING



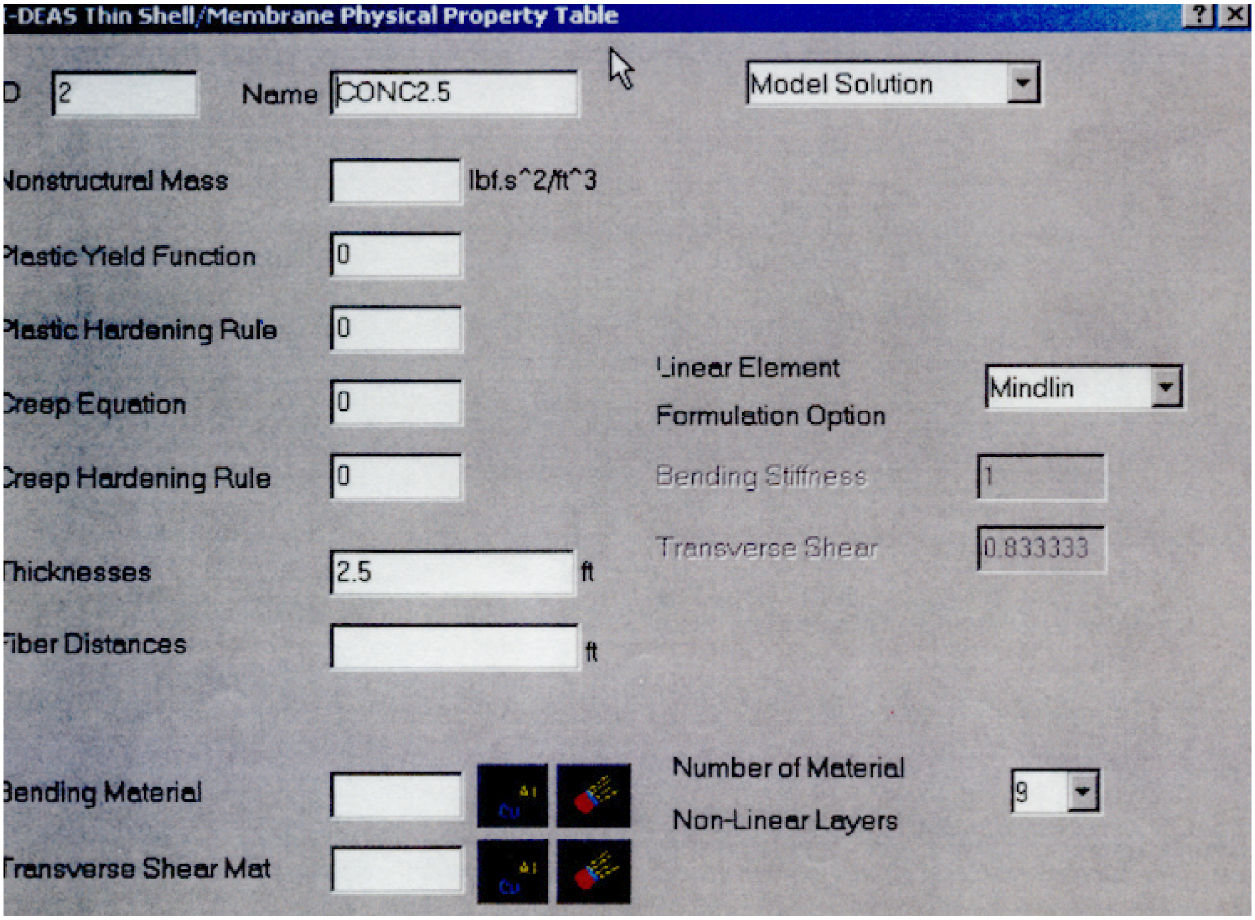
Vault #1


FEA MESH
I-DEAS 8 m4: My Team : domes : C:\vault1.mf1
2'-6 CONCRETE
4 NODE QUAD
FIXED BASE SLAB 2'-0'
CONCRETE
63


I-DEAS Thin Shell/Membrane Physical Property Table
ID
3
Name
CONC2
Model Solution
Nonstructural Mass
lbf.s^2/ft^3
Plastic Yield Function
0
Plastic Hardening Rule
0
Creep Equation
0
Creep Hardening Rule
0
Thicknesses
2
ft
Fiber Distances
ft
Linear Element Formulation Option
Mindlin
Bending Stiffness
1
Transverse Shear
0.833333
Bending Material
Transverse Shear Mat
Number of Material Non-Linear Layers
9



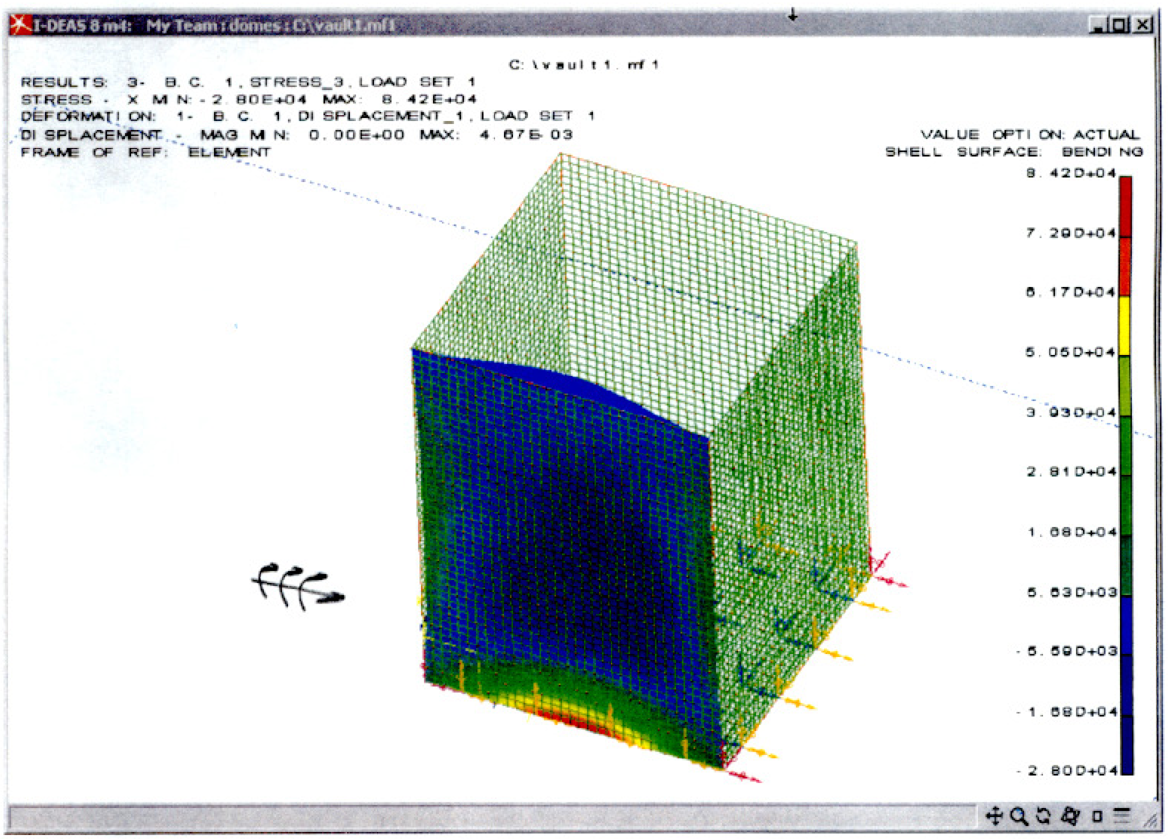
I-DEAS Thin Shell/Membrane Physical Property Table
D
2
Name
CONC2.5
Model Solution
Nonstructural Mass
lbf.s^2/ft^3
Plastic Yield Function
0
Plastic Hardening Rule
0
Creep Equation
0
Creep Hardening Rule
0
Thicknesses
2.5
ft
Fiber Distances
ft
Linear Element
Formulation Option
Mindlin
Bending Stiffness
1
Transverse Shear
0.833333
Bending Material
Transverse Shear Mat
Number of Material
Non-Linear Layers
9


I-DEAS Thin Shell/Membrane Physical Property Table
D 2
Name CONC2.5
Model Solution
Nonstructural Mass
lbf.s^2/ft^3
Plastic Yield Function 0
Plastic Hardening Rule 0
Creep Equation 0
Creep Hardening Rule 0
Thicknesses 2.5 ft
Fiber Distances ft
Linear Element Formulation Option
Mindlin
Bending Stiffness 1
Transverse Shear 0.833333
Bending Material
Transverse Shear Mat
Number of Material Non-Linear Layers
9

TOP TO BOTTOM
FLEX IN WALL

$M_u = 1.7\ (1.04)\ \frac{8.42E4 + 2.81E4}{2} = 99{,}273$ #-'/FT ← AVERAGE, LOAD DISTRIBUTED HORZ.
@ BASE WALL

M_u
@ MID WALL $= (1.7)(1.04)\ \frac{2.9E4 + 5.63E3}{2} = 29{,}730$ #-'/FT ← AVERAGE, LOAD DISTRIBUTED HORZ



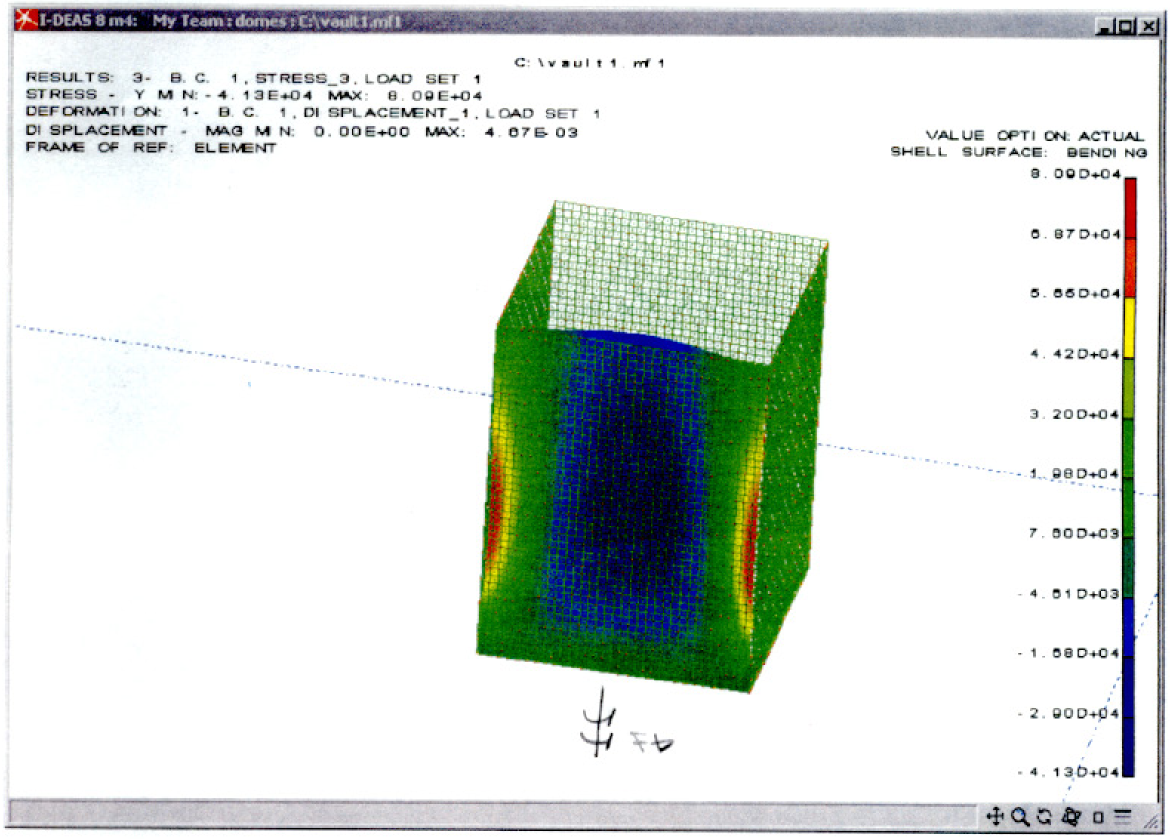
SIDE TO SIDE

FLEXURE IN WALL

$$Mu = (1.7)\,(S)Fb = \frac{(1)(2.6)^2}{6}(8.09E4)(1.7) = 143{,}260\#'/_{Ft}$$

@ WALL

$$Mu @ CENTER = 4.13E4\ \frac{(2.6)^2}{6}(1.7) = 73{,}133\ \#\text{-}'/_{Ft}$$



LB

SHEAR

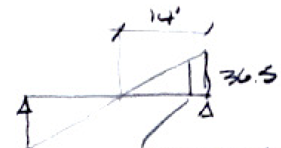
MAX SHEAR 5120 psf OR OVER 2.5 THK & 1.7 FACTOR

= 21,760 lbs

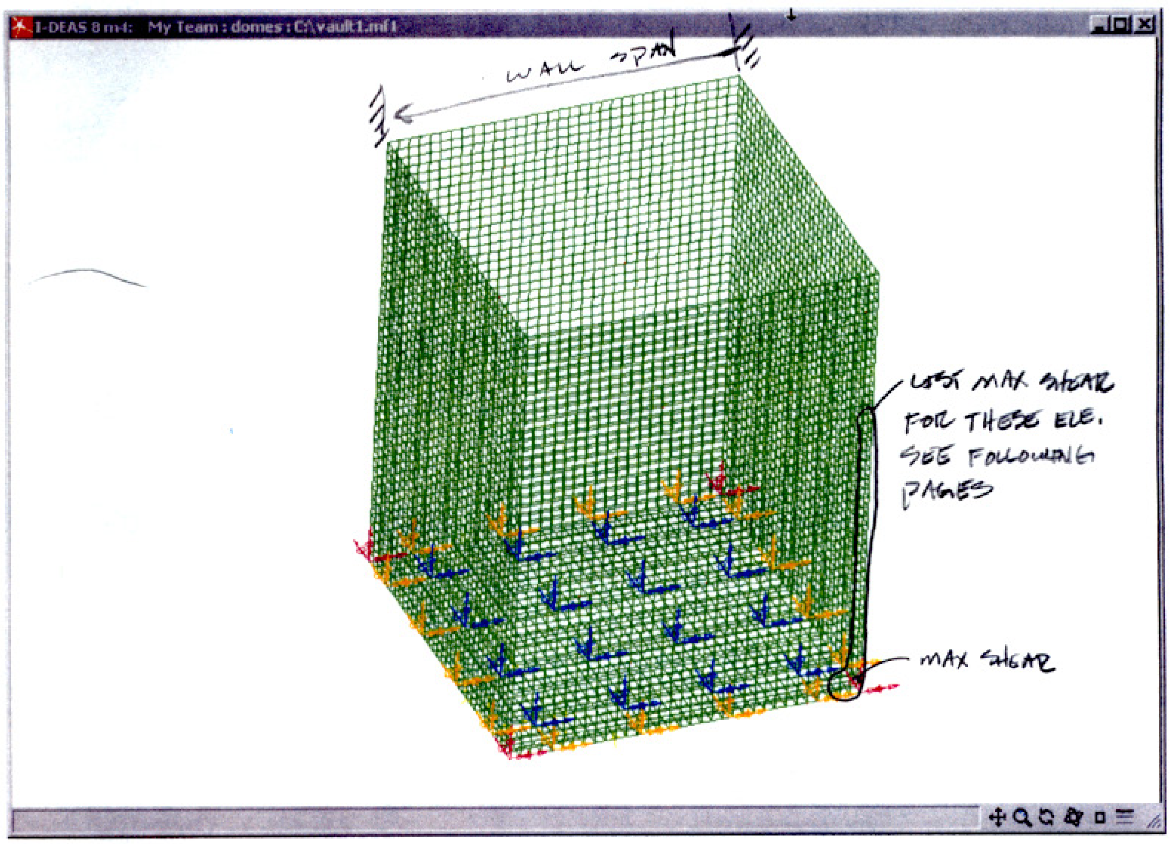
CONSIDER AXIAL FORCE & SHEAR @ D

AXIAL FORCE

36.5K SHEAR @ d



= 29.9K CLOSE TO 21.7K OK



I-DEAS List

I-DEAS 8 m4:   Simulation   30-Apr-03 08:00:20
C:\vault1.mf1

Group ID : None
Result Set : 3 - B.C. 1,STRESS_3,LOAD SET 1
Report Type : Contour   Units : BG
Result Type : STRESS
Frame of Reference: Element   Data Component: Max Shear
Surface Type : Middle

Node	Max Prin	Mid Prin	Min Prin	Max Shear	Von Mises
5	1.024E+04	-2.635E-36	1.163E+03	5.121E+03	9.714E+03
72	5.583E+03	-4.567E-36	6.117E+02	2.792E+03	5.304E+03
74	2.780E+03	-1.782E-36	-9.987E+02	1.889E+03	3.392E+03
75	3.780E+03	-2.642E-36	-2.911E+02	2.036E+03	3.934E+03
76	1.797E+03	7.864E-37	-1.922E+03	1.859E+03	3.221E+03
77	2.197E+03	5.865E-37	-1.543E+03	1.870E+03	3.255E+03
78	1.228E+03	-1.813E-35	-2.289E+03	1.759E+03	3.092E+03
79	1.489E+03	2.654E-36	-2.160E+03	1.824E+03	3.178E+03
80	7.798E+02	-9.494E-36	-2.318E+03	1.549E+03	2.791E+03
81	9.956E+02	-2.413E-36	-2.334E+03	1.665E+03	2.961E+03
82	3.832E+02	-4.664E-37	-2.167E+03	1.275E+03	2.381E+03
83	5.762E+02	-4.547E-36	-2.258E+03	1.417E+03	2.594E+03
84	3.598E+01	-1.812E-36	-1.941E+03	9.883E+02	1.959E+03
85	2.019E+02	1.638E-35	-2.057E+03	1.129E+03	2.165E+03
86	-2.170E+02	-4.554E-37	-1.740E+03	8.702E+02	1.643E+03
87	-1.075E+02	-4.348E-36	-1.830E+03	9.150E+02	1.779E+03
88	-2.777E+02	-8.064E-36	-1.689E+03	8.445E+02	1.569E+03
89	-2.777E+02	-8.064E-36	-1.689E+03	8.445E+02	1.569E+03
90	-1.075E+02	-4.348E-36	-1.830E+03	9.150E+02	1.779E+03
91	-2.170E+02	-4.554E-37	-1.740E+03	8.702E+02	1.643E+03
92	1.211E+02	1.459E-35	-1.982E+03	1.051E+03	2.045E+03
93	3.598E+01	-1.812E-36	-1.941E+03	9.883E+02	1.959E+03
158	-2.575E+03	-6.653E-35	-7.679E+03	3.839E+03	6.769E+03
160	-2.851E+03	1.002E-35	-8.118E+03	4.059E+03	7.134E+03
161	-2.669E+03	3.167E-37	-7.905E+03	3.952E+03	6.965E+03
162	-3.166E+03	-2.954E-36	-8.448E+03	4.224E+03	7.392E+03
163	-3.019E+03	5.943E-35	-8.301E+03	4.151E+03	7.278E+03
164	-3.368E+03	5.288E-34	-8.606E+03	4.303E+03	7.511E+03
165	-3.286E+03	3.473E-35	-8.552E+03	4.276E+03	7.472E+03
166	-3.381E+03	9.847E-35	-8.533E+03	4.266E+03	7.443E+03
167	-3.404E+03	8.842E-34	-8.602E+03	4.301E+03	7.504E+03
168	-3.108E+03	-7.207E-36	-8.159E+03	4.079E+03	7.132E+03
169	-3.287E+03	5.710E-35	-8.388E+03	4.194E+03	7.321E+03
170	-2.430E+03	2.409E-35	-7.404E+03	3.702E+03	6.537E+03
171	-2.828E+03	4.894E-35	-7.834E+03	3.917E+03	6.871E+03
172	-1.212E+03	-5.877E-35	-6.196E+03	3.098E+03	5.688E+03
173	-1.897E+03	-3.987E-35	-6.861E+03	3.430E+03	6.136E+03
174	6.719E+02	-4.171E-35	-4.496E+03	2.584E+03	4.867E+03
175	-3.592E+02	3.925E-35	-5.407E+03	2.703E+03	5.236E+03

I-DEAS List

3140	3.771E+03	-1.015E-34	-1.464E+03	2.617E+03	4.678E+03
3143	2.948E+03	-7.316E-37	-1.825E+03	2.386E+03	4.171E+03
3144	2.353E+03	-6.073E-36	-2.767E+03	2.560E+03	4.439E+03
3145	1.737E+03	-5.521E-34	-3.718E+03	2.727E+03	4.827E+03
3148	2.809E+03	1.858E-35	-2.513E+03	2.661E+03	4.611E+03
3149	1.884E+03	-8.948E-36	-3.556E+03	2.720E+03	4.784E+03
3150	3.636E+03	-2.700E-37	-1.074E+03	2.305E+03	4.178E+03
3151	3.795E+03	-3.535E-36	-3.962E+02	2.095E+03	4.008E+03
3152	5.398E+03	4.795E-36	2.237E+02	2.699E+03	5.290E+03
3153	4.739E+03	1.373E-36	-5.070E+02	2.623E+03	5.012E+03
3154	2.787E+03	-3.002E-37	-1.611E+03	2.199E+03	3.854E+03
3155	2.874E+03	1.552E-36	-1.124E+03	1.999E+03	3.571E+03
3158	1.446E+03	1.764E-36	-2.300E+03	1.873E+03	3.272E+03
3160	1.705E+03	5.749E-35	-2.368E+03	2.037E+03	3.543E+03
3161	1.318E+03	-3.720E-35	-2.555E+03	1.937E+03	3.411E+03
3162	1.132E+03	-5.099E-37	-2.420E+03	1.776E+03	3.144E+03
3163	1.812E+03	8.476E-37	-2.067E+03	1.939E+03	3.361E+03
3165	9.819E+02	-1.456E-36	-2.643E+03	1.813E+03	3.248E+03
3178	-3.456E+02	-1.030E-35	-2.235E+03	1.118E+03	2.084E+03
3179	-9.461E+01	1.631E-35	-2.107E+03	1.053E+03	2.061E+03
3188	1.420E+02	-1.316E-36	-2.513E+03	1.328E+03	2.587E+03
3189	3.530E+02	1.370E-34	-2.350E+03	1.351E+03	2.545E+03
3190	5.947E+02	-5.064E-36	-2.426E+03	1.510E+03	2.772E+03
3191	4.027E+02	2.816E-36	-2.606E+03	1.504E+03	2.829E+03
3192	-1.065E+02	-2.889E-36	-2.387E+03	1.193E+03	2.335E+03
3193	1.236E+02	-9.388E-36	-2.240E+03	1.182E+03	2.304E+03
3194	-8.019E+02	-1.053E-35	-1.881E+03	9.407E+02	1.635E+03
3195	-1.018E+03	7.532E-36	-1.691E+03	8.455E+02	1.475E+03
3196	-4.894E+02	-4.886E-36	-1.811E+03	9.053E+02	1.622E+03
3197	-5.773E+02	-2.572E-36	-2.065E+03	1.032E+03	1.845E+03
3198	-6.478E+02	-6.855E-37	-1.677E+03	8.383E+02	1.464E+03
3199	-3.006E+02	6.007E-36	-1.960E+03	9.799E+02	1.828E+03
3302	-5.773E+02	-2.572E-36	-2.065E+03	1.032E+03	1.845E+03
3303	-3.006E+02	6.007E-36	-1.960E+03	9.799E+02	1.828E+03
3316	-1.018E+03	7.532E-36	-1.691E+03	8.455E+02	1.475E+03
3317	-6.478E+02	-6.855E-37	-1.677E+03	8.383E+02	1.464E+03
3318	-7.467E+02	-7.244E-36	-1.589E+03	7.946E+02	1.377E+03
3319	-1.207E+03	-9.876E-37	-1.513E+03	7.567E+02	1.386E+03
3320	-8.019E+02	-1.053E-35	-1.881E+03	9.407E+02	1.635E+03
3321	-4.894E+02	-4.886E-36	-1.811E+03	9.053E+02	1.622E+03
3326	-4.544E+02	-4.812E-36	-2.143E+03	1.072E+03	1.956E+03
3329	-1.936E+02	1.301E-36	-2.021E+03	1.011E+03	1.932E+03
	5	167	5	5	5
Maximum	1.024E+04	8.842E-34	1.163E+03	5.121E+03	9.714E+03
	167	3145	164	2907	2904
Minimum	-3.404E+03	-5.521E-34	-8.606E+03	7.567E+02	1.377E+03

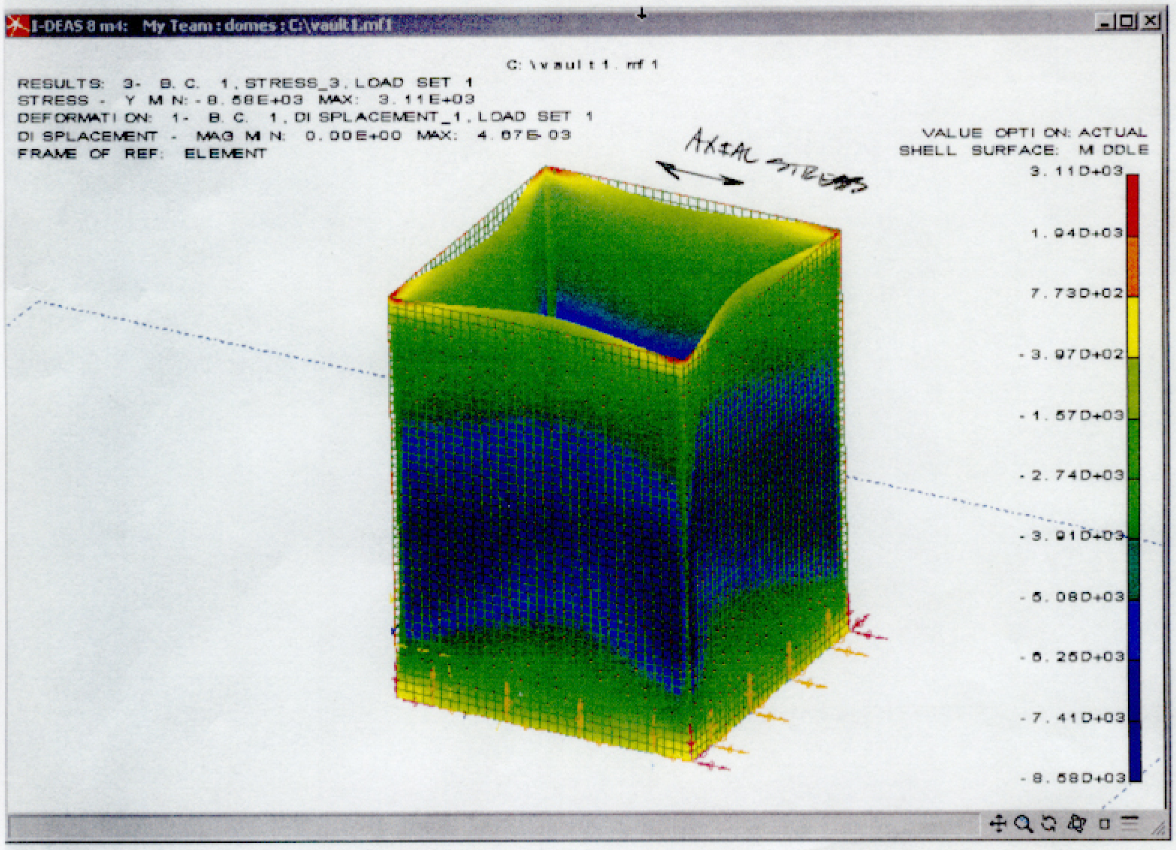
MAX

AXIAL FORCE MAX

-8.58E3 psf OR OVER 2.5' THK & 1.7 FACTOR

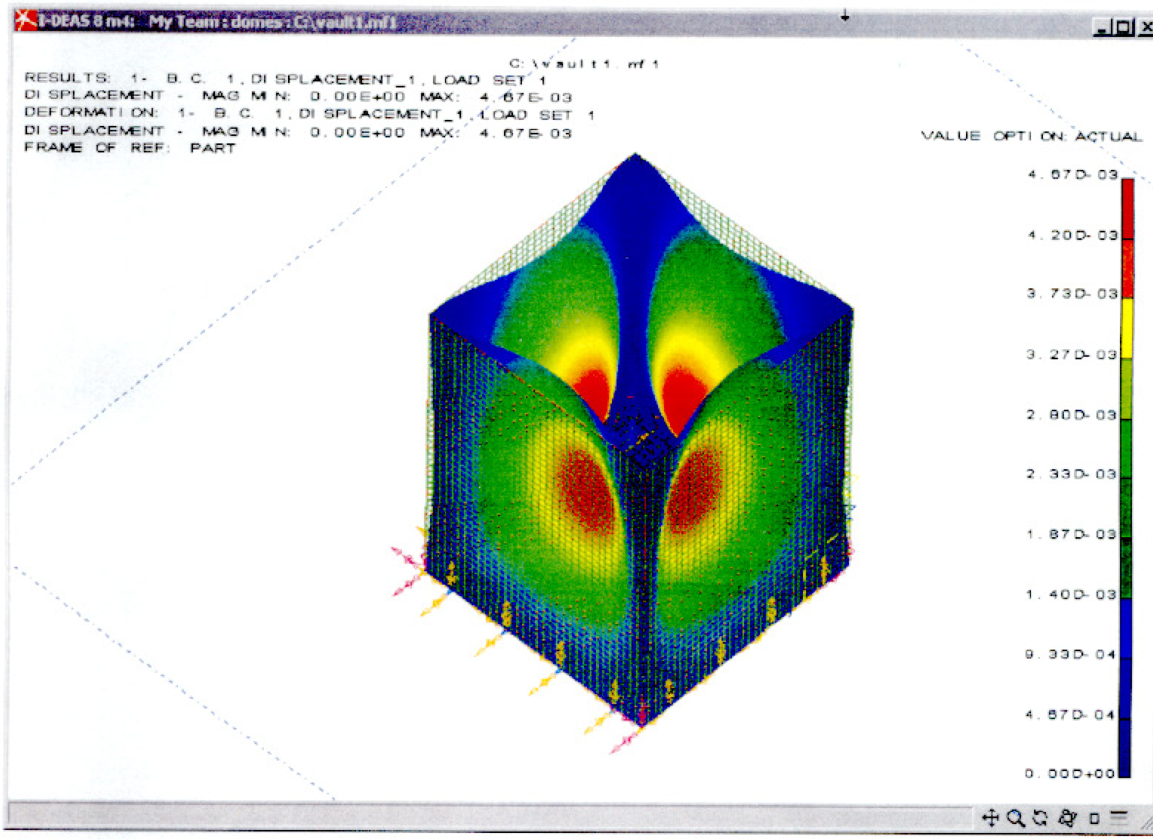
ok

P = 36,465#/1



MAX DISPLACEMENT

4.67E-3 ft
or 0.06 in



STEEL CHECK

$f_c' = 3\text{ ksi}$ $\quad d = 30in - 2in - \frac{1.5in}{2} = 27.25in$

$f_y = 40\text{ ksi}$ $\quad b = 12in$

HORIZONTAL

OUTSIDE FACE

WORST CASE @ MID HEIGHT → $M_u = 143.3\text{ k-ft}$ ← (FEA CALCS, SEE ATTACHED PAGES)

$A_{s_{REQ}} = 1.84 in^2/ft$

$A_{s_{ACTUAL}} = 2.08 in^2/ft$ ← OK #11 AT 9" O.C.

INSIDE FACE

$M_u = 73.2\text{ k-ft}$ ← (FEA CALCS, SEE ATTACHED PAGES)

WORST CASE @ MID HEIGHT & MID SPAN. → $A_{s_{REQ}} = .92 in^2/ft$

$A_{s_{ACTUAL}} = 1.05 in^2/ft$ ← OK #8 AT 9" O.C.

VERTICAL

OUTSIDE FACE

$M_u = 99.3\text{ k-ft}$ ← (FEA CALCS, SEE ATTACHED PAGES

$A_{s_{REQ}} = 1.25 in^2/ft$

$A_{s_{ACTUAL}} = .75 in^2/ft$ ← #9 AT 16" O.C. (OVER STRESSED) ← OK, SEE NOTE

NOTE: ADDITIONAL LOAD TAKEN IN HORIZONTAL STEEL
$\phi M_n = 160\text{ k-ft}$ AT BASE OF CONCRETE VAULT
& $M_u = 14\text{ k-ft}$ (ALSO SEE INTERACTION DIAGRAM) PAGE #76

INSIDE FACE

$M_u = 29.8\text{ k-ft}$ ← (FEA CALCS, SEE ATTACHED PAGES)

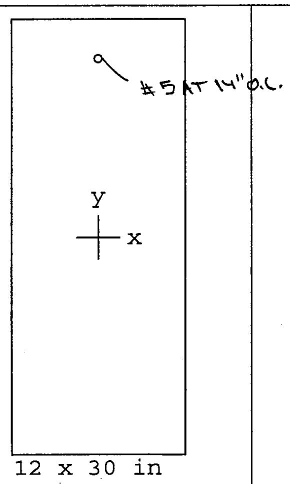
VERTICAL STEEL OK ← SEE INTERACTION DIAGRAM (PAGE #75)

SHEAR

$V_u = 29.9K$ ← (FEA CALCS, SEE ATTACHED PAGES)

$\phi V_c = \phi 2bd\sqrt{f_c} = .85(2)(12in)(27.25in)\sqrt{3000psi} = 30.45K$ ← OK

Project Name:	Project #:	Initials:	Date:	Sheet:
				74



Code: ACI 318-95

Units: English

Run axis: About X-axis

Run option: Investigation

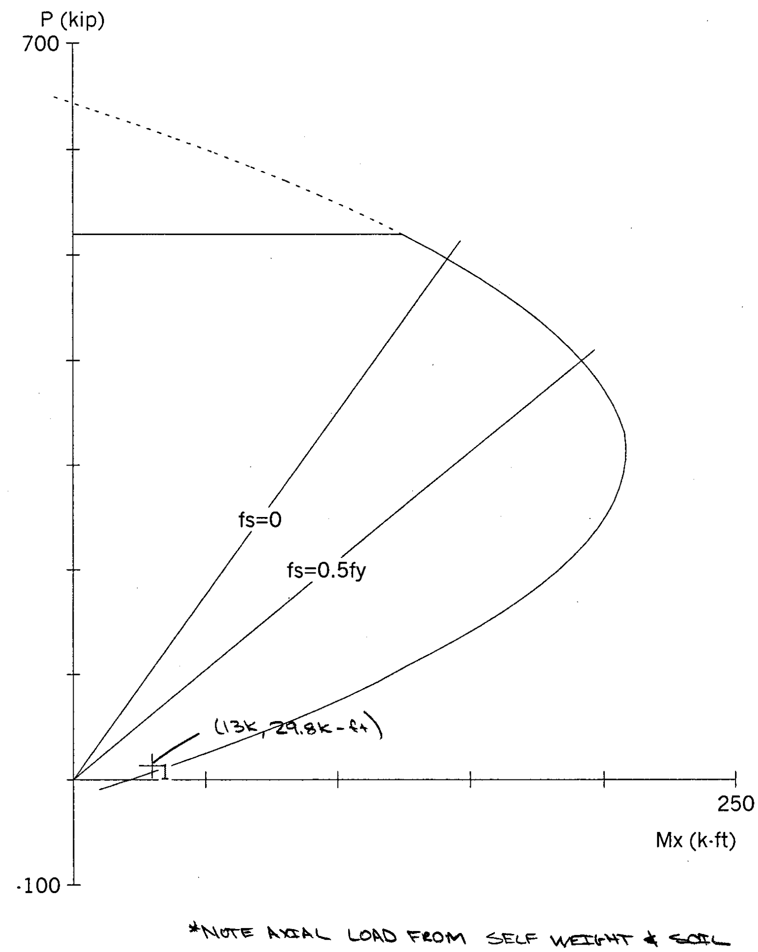
Slenderness: Not considered

Column type: Structural

Bars: ASTM A615

Date: 04/30/03

Time: 14:58:48

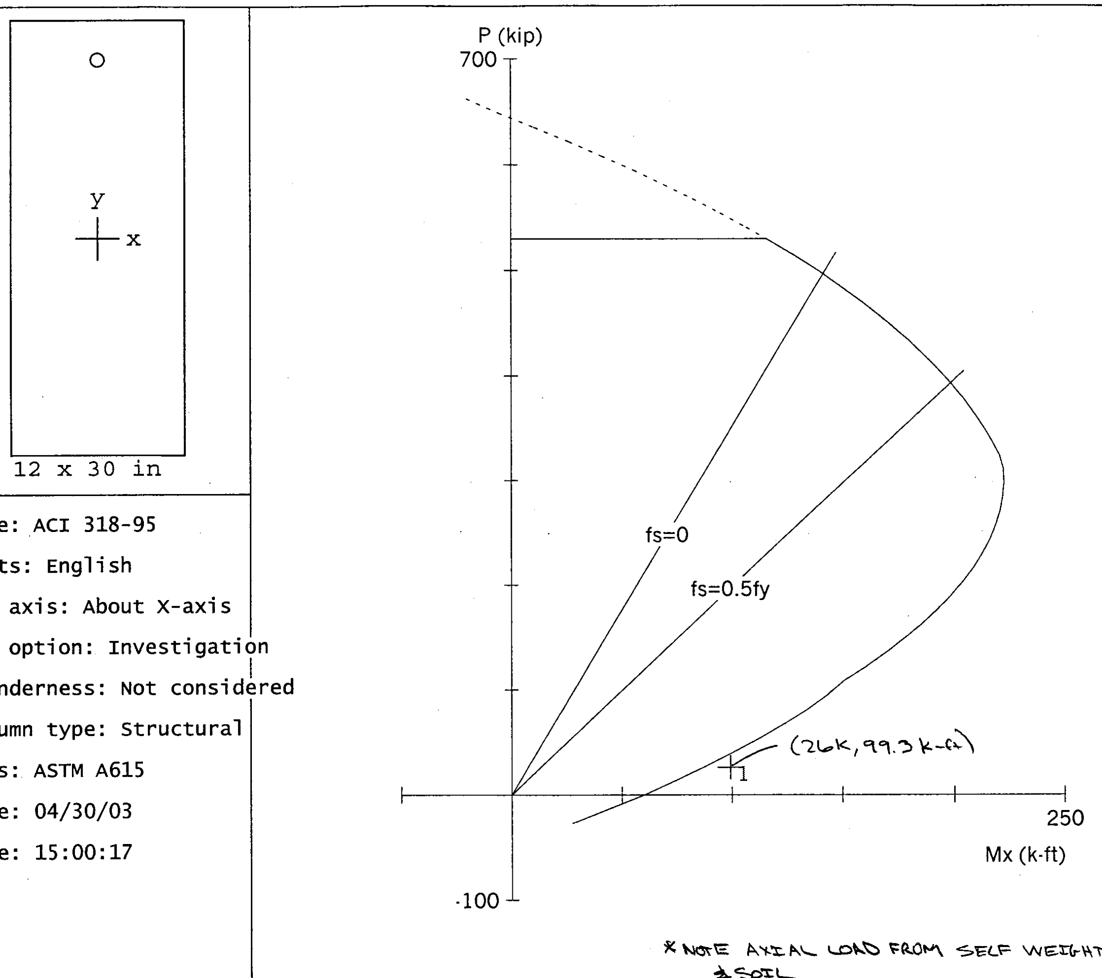


PCACOL V3.00 (PCA 1999) - Licensed to:

File: untitled.col

Project: Storage Vaults

Column: Vault#1		Engineer: MB	
f'c = 3 ksi	fy = 40 ksi	Ag = 360 in^2	1 bars
Ec = 3122 ksi	Es = 29000 ksi	As = 0.27 in^2	Rho = 0.07%
fc = 2.55 ksi	e_rup = Infinity	Xo = 0.00 in	Ix = 27000 in^4
e_u = 0.003 in/in		Yo = 0.00 in	Iy = 4320 in^4
Beta1 = 0.85		Clear spacing = 11.9	Clear cover = 2.46 in
Confinement: Tied	phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.7		



Code: ACI 318-95

Units: English

Run axis: About X-axis

Run option: Investigation

Slenderness: Not considered

Column type: Structural

Bars: ASTM A615

Date: 04/30/03

Time: 15:00:17

PCACOL V3.00 (PCA 1999) - Licensed to:

File: untitled.col

Project: Storage Vaults

Column: Vault#1		Engineer: MB	
f'c = 3 ksi	fy = 40 ksi	Ag = 360 in^2	1 bars
Ec = 3122 ksi	Es = 29000 ksi	As = 0.75 in^2	Rho = 0.21%
fc = 2.55 ksi	e_rup = Infinity	Xo = 0.00 in	Ix = 27000 in^4
e_u = 0.003 in/in		Yo = 0.00 in	Iy = 4320 in^4
Beta1 = 0.85		Clear spacing = 11.7	Clear cover = 2.26 in
Confinement: Tied	phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.7		

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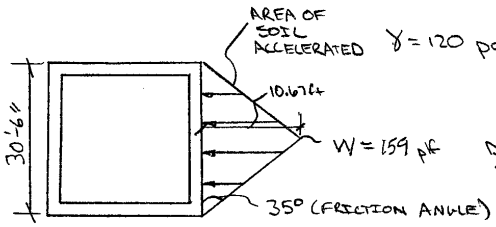
ACTIVE PRESSURE + SEISMIC ANALYSIS (1.7PL(.75)+1.0E)



γ = 120 pcf

SEISMIC ACCELERATION FACTOR (SEE SEISMIC LATERAL ANALYSIS, ULTIMATE STRENGTH) = .243

DUE TO SEISMIC → W = 10.67ft (120pcf)(.124) = 159plf

W_a = ~~1850~~ psf ← SEE PREVIOUS CALCS
= 50 pcf (41') .75 = 1538 psf @ 1/4 ht

LOAD COMBINATION

WORST CASE (ACTIVE + SEISMIC) → $W_{u\ TOTAL}$ = 1538 plf (.75)(1.7) + 159 plf = 2120 plf ← OK, LESS THAN ACTIVE PRESSURE

WORST CASE (ACTIVE PRESSURE ONLY) → W_u = 1538 plf (1.7) = 2615 plf

SUMMARY → ACTIVE PRESSURE + SEISMIC PRESSURE LESS THAN ACTIVE PRESSURE, SEE CALCS

Project Name:	Project #:	Initials:	Date:	Sheet: 78

CONCRETE SHEARWALL ANALYSIS

SIMPLIFIED DESIGN

WALL MARK : **Typical Wall (Vault #1)**

FLEXURAL ANALYSIS :

WALL GEOMETRY & PROPERTIES :

wall length, l_w :	30	ft	c / l_w :	0.24757
wall thickness, h :	30	in	β_1 :	0.85
wall height, ht:	0	ft		
fy :	60	ksi	ω :	0.35
f'c :	3	ksi	α :	0
ϕ :	0.9			
steel ea. face(Y/N):	n			

LOADS :

WALL LOADING = .1283 (~~2,460~~ 2050 psf)(15ft)$\frac{(40ft)^2}{2}$(1.7)

P_u :	0	k		
M_u :	6438	k*ft	ϕM_n :	12913.7 k*ft OK

REINFORCING :

A_{st} : 15.94 in^2

USE : # 5 @ 7 oc vert.

Vert. reinf. must not be less than the horz.

SHEAR ANALYSIS :

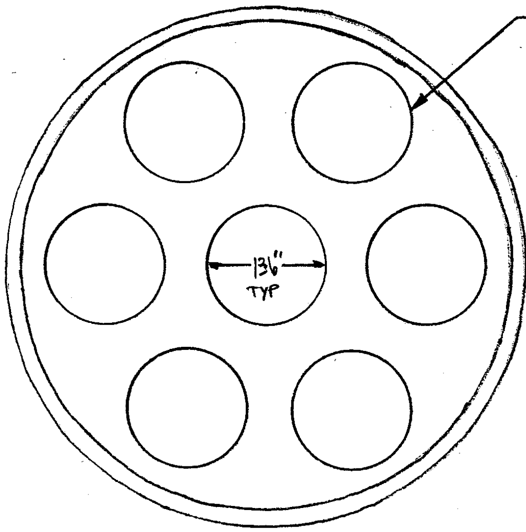
LOADS :			SHEAR STRENGTH :		
Siesmic Zone 3 or 4 (Y/N):	n		ϕ :	0.85	
ρ:	1.0		ϕV_c :	804.49 k	
V_u :	1286.0	k	ϕV_s :	1516.8 k	
ρ*V_u:	1286.0	k	ϕV_n :	2321.3 k	Ok
Hook edge reinforcement			Min steel:	0.72 in^2/ft	
Use two mats of reinforcing			**USE :**	# 8 @ 9 oc hor.	OK

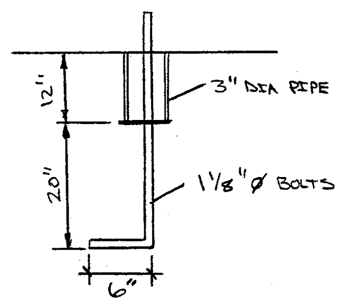
WALL LOADING = 1.7 (~~2,460~~ 2050 psf)(15ft)$\frac{(40ft)}{2}$

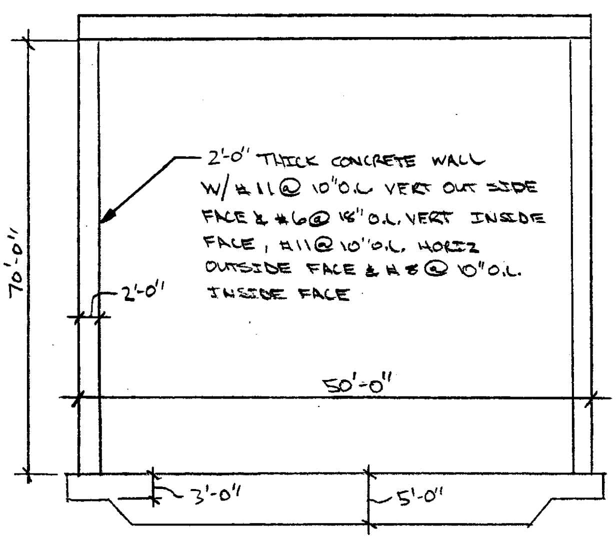
SUMMARY → WALLS PERPENDICULAR TO LOAD ARE OK FOR SHEAR TRANSFER

edited 6/3/02

BIN #2 (VAULT #2)







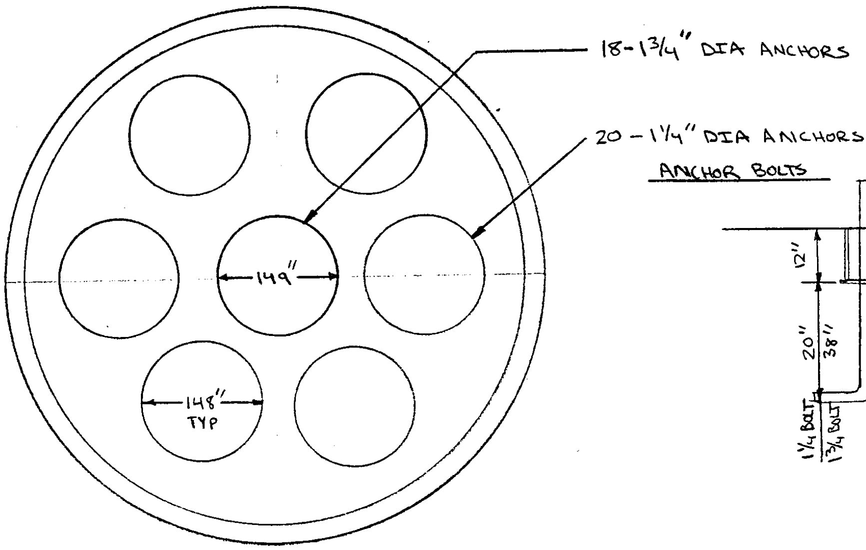
PROPERTIES

REBAR → INTERMEDIATE GRADE
CONCRETE → $f'_c = 4{,}000psi$

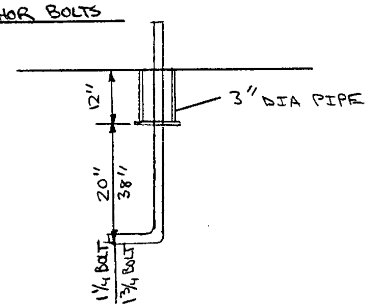
SAME AS VAULT #3

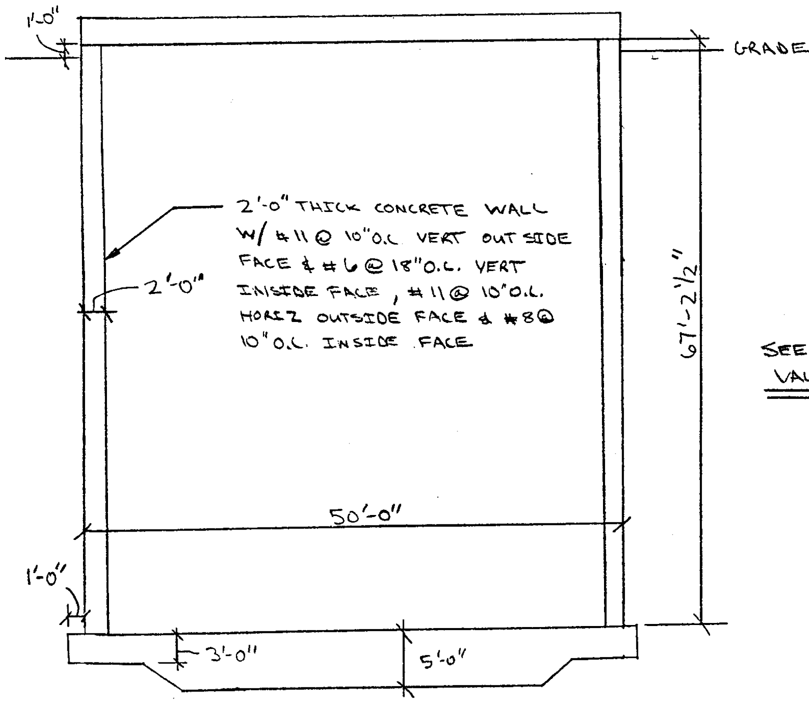
Project Name:	Project #:	Initials:	Date:	Sheet: 80

BIN #3 (VAULT #3)



ANCHOR BOLTS





PROPERTIES

REBAR → INTERMEDIATE GRADE

CONCRETE → NOT SPECIFIED

ASSUME f'_c = 3000 psi

SEE ATTACHED PAGES FOR CONCRETE VAULT CALCS

Project Name:	Project #:	Initials:	Date:	Sheet: 81

ANALYSIS OF CONCRETE VAULTS. (CYL. ONLY.)
SHAPE

- IN CONCRETE VAULTS 2-7. VAULT 3 IS CONSIDERED A WORST CASE CONDITION. VAULT 2 IS SIMILAR TO VAULT 3, DIFFERENCES ARE NEGLIGIBLE. VAULT 5 IS BIGGER THAN #3 BUT NOT BURIED AS DEEP & THE WALLS ARE 2X THICK. VAULT 4 IS SMALLER & NOT BURIED AS DEEP. THEREFORE VAULT #3 IS ANALYZED AS A WORST CASE CONDITION.

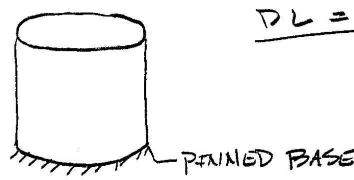
Project Name:	Project #:	Initials:	Date:	Sheet: 82

CONCRETE VAULT # 3

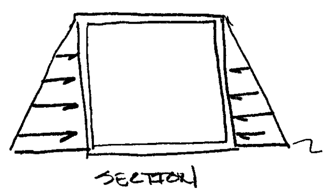
ANALYSIS OF CONCRETE BUNKERS IS CONSIDERED BY THE FOLLOWING:

ANALYSIS TYPE - CLOSED FORM MEMBRANE & FLEXURE ANALYSIS

- BOUNDARY CONDITIONS



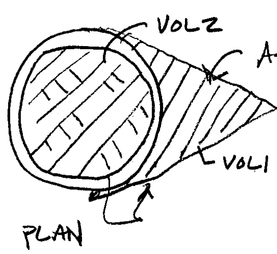
DL = SELF WT.



EXTERNAL P LOAD

$= \gamma g_c H$ COMPARE TO JANSSEN (EQ)
* CONSERVATIVE

EARTHQUAKE LOAD



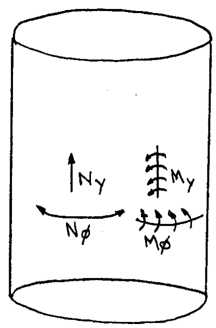
ASSUME PARTICIPATING MASS OF SOIL TO STRUCTURE EQ TO VOL · DENSITY.

ASSUME VOL1 = VOL2 · 40%

Project Name:	Project #:	Initials:	Date:	Sheet:
				83

CONCRETE VAULT #3

ANALYSIS (SEE ATTACHED SHEETS FOR VALUES)



$f_c = 3$ksi $d = 21.25$in
$f_y = 60$ksi $b = 12$in

LOAD CASE #1 (DL+PL)

VERTICAL STEEL CHECK

$M_u = M_\phi = 5.56$k-ft

$V_u = N_y = 26.8$K

(LOAD CASE #2 GOVERNS SEE BELOW)

HORIZONTAL STEEL CHECK

$M_u = M_y = 32.7$ k-ft

$V_u = N_\phi = 101.99$ K

(LOAD CASE #2 GOVERNS SEE BELOW

LOAD CASE #2 (.75DL+.75PL+E)

VERTICAL STEEL CHECK

$M_u = M_\phi + .75M_{\phi\,(\text{LOAD CASE \#1})} = 3.1$k-ft + .75(5.56 k-ft) = 7.27 k-ft

$V_u = N_y + .75N_{y\,(\text{LOAD CASE \#1})} = 26.88$K + .75(26.88K) = 47K

(SEE ATTACHED CALC FOR CAPACITY CHECK)

HORIZONTAL STEEL CHECK

$M_u = M_y + .75M_{y\,(\text{LOAD CASE \#1})} = 18.24$k-ft + .75(32.7k-ft) = 42.76k-ft

$V_u = N_\phi + .75N_{\phi\,(\text{LOAD CASE \#1})} = 96.78$K + .75(101.99K) = 173.3K

(SEE ATTACHED CALC FOR CAPACITY CHECK)

Project Name:	Project #:	Initials:	Date:	Sheet: 84

REAL #3 CONCRETE

VOL = $46^2 \pi/4$ 68' = 113009 ft^3

MASS = 120 pcf 13561156 lbs
ASSUME

MASS OF CON. CYL & TOP

TOP $50'^2 \pi/4$ (1)' 150pcf = 294525 lb

CYL 48'π 68' 150 pcf = 3076254.72 lb
x2'

- CONSIDER SEISMIC SOIL EFFECTS BY ASSUMING PARTICIPATING MASS OF CYL EXT. = TO CYL FULL OF FILL.

DETERMINE ACC FACTOR

$32.2 / 3.07$ MIL lbs $= X / (13.5)3.07$ X = 145.47 ft/s²

└CONSIDER 80% PER ACI 313

SEISMIC ACC (0.243) ULTIMATE (97 UBC) see note below

⇒ (0.243) 145.47 ft/s² = 35.34 ft/s²

NOTE ⇒ SEISMIC ACL. USED 0.243, WHICH IS CONSERVATIVE. ACTUAL ACCELERATION FACTOR FOR 2000 IBC IS .124 (SEE SEISMIC LATERAL ANALYSIS)

Project Name:	Project #:	Initials:	Date:	Sheet: 85

PROJECT DESCRIPTION : : INEEL BIN CHECK

TITLE : CONCRETE VAULT #3 (SHORT FORM) → LONG FORM IN BACK
DATE : 10/14/02

=

*** INPUT DATA AND CALCULATED PROPERTIES OF STRUCTURE ***

=

NOTE : THE BASE OF THE TANK WALL IS HINGED.

CYLINDER GEOMETRY :

WALL HEIGHT = 68.00 FT
CYLINDER RADIUS = 25.00 FT
WALL THICKNESS = 24.00 IN
FLOOR THICKNESS = .00 IN
VOLUME UNDER THE CYLINDERICAL TANK = .1335E+06 CU.FT

CONCRETE PROPERTIES :

UNIT WEIGHT OF CONCRETE = 210.00 PCF ← ULTIMATE LOAD 150pcf (1.7)
POISSONS RATIO = .1700
COMPRESSIVE STRENGTH OF CONCRETE = 3000.00 PSI
VOLUME OF CONCRETE SHELL = 791.22 CU.YD
VOLUME OF CONCRETE FLOOR = .00 CU.YD
YOUNGS MODULUS OF ELASTICITY = .5501E+07 PSI

PROPERITES OF GRANULAR :

DEPTH OF GRANULAR = 68.00 FT
VOLUME OF GRANULAR = 133517.60 CU-FT
SPECIFIC WEIGHT OF GRANULAR (GAMMA) = -102.00PCF ← ULTIMATE LOAD .5(120pcf)(1.7)

SEISMIC LOADING :

MAX. PRESSURE OF SEISMIC SHEAR ON SHELL = 460.96 PSF
HORIZONTAL SEISMIC ACCELERATION = 35.34 FT/SQ.SEC ← ULTIMATE LOAD (SEE ATTACHED CALC)
ACCELERATION OF GRAVITY = 32.20 FT/SQ.SEC
RELATIVE ACCELERATION (a/g) = 1.10

THERE IS NO EXTERNAL PRESTRESSING LOAD.

CONSTANT VALUE OF (BETA) = .18E+00 1/FT

***** TOTAL FORCES AT SHELL WALL WITHOUT PRESTRESS *****

LOAD CASE # 3 DL + EQL

HEIGHT(TOP-BOT)	N-THETA	MOM-THETA	N-Y	MOM-Y	SHEAR-Y
FEET	K/FT.	FT.K/FT	K/FT	FT.K/FT	K/FT
68.0	.00	.000	.00	.000	.0000
67.0	.00	.000	-.42	.000	-.0001
66.0	.00	.000	-.84	.000	-.0001
65.0	.00	.000	-1.26	.000	-.0001
64.0	.00	.000	-1.68	.000	-.0001
63.0	.00	.000	-2.10	.000	-.0001
62.0	.00	.000	-2.52	.001	-.0001
61.0	.00	.000	-2.94	.001	-.0002
60.0	.00	.000	-3.36	.001	-.0002
59.0	.00	.000	-3.78	.001	-.0002
58.0	.00	.000	-4.20	.001	-.0002
57.0	.00	.000	-4.62	.001	-.0001
56.0	.00	.000	-5.04	.001	-.0001
55.0	.00	.000	-5.46	.001	.0000
54.0	.00	.000	-5.88	.001	.0002
53.0	.01	.000	-6.30	.001	.0003
52.0	.01	.000	-6.72	.001	.0006
51.0	.01	.000	-7.14	.000	.0008
50.0	.01	.000	-7.56	-.001	.0012
49.0	.01	.000	-7.98	-.002	.0016
48.0	.01	-.001	-8.40	-.004	.0020
47.0	.01	-.001	-8.82	-.006	.0025
46.0	.01	-.002	-9.24	-.009	.0030
45.0	.01	-.002	-9.66	-.012	.0034
44.0	.01	-.003	-10.08	-.016	.0038
43.0	.00	-.003	-10.50	-.020	.0040
42.0	.00	-.004	-10.92	-.024	.0040
41.0	-.01	-.005	-11.34	-.028	.0037
40.0	-.03	-.005	-11.76	-.031	.0029
39.0	-.04	-.006	-12.18	-.034	.0015
38.0	-.06	-.006	-12.60	-.034	-.0006
37.0	-.09	-.005	-13.02	-.032	-.0037
36.0	-.12	-.004	-13.44	-.026	-.0078
35.0	-.15	-.003	-13.86	-.016	-.0130
34.0	-.18	.000	-14.28	.000	-.0196
33.0	-.21	.004	-14.70	.024	-.0275
32.0	-.24	.009	-15.12	.056	-.0367
31.0	-.27	.017	-15.54	.097	-.0470
30.0	-.28	.025	-15.96	.150	-.0580
29.0	-.27	.036	-16.38	.213	-.0691
28.0	-.24	.049	-16.80	.288	-.0796
27.0	-.18	.063	-17.22	.372	-.0882
26.0	-.07	.079	-17.64	.463	-.0934
25.0	.09	.095	-18.06	.557	-.0932
24.0	.32	.110	-18.48	.647	-.0854

23.0	.62	.123	-18.90	.724	-.0670
22.0	1.00	.132	-19.32	.776	-.0349
21.0	1.48	.134	-19.74	.788	.0144
20.0	2.05	.126	-20.16	.741	.0845
19.0	2.70	.104	-20.58	.611	.1791
18.0	3.42	.063	-21.00	.373	.3013
17.0	4.19	.000	-21.42	-.002	.4533
16.0	4.95	-.092	-21.84	-.544	.6361
15.0	5.65	-.218	-22.26	-1.284	.8483
14.0	6.19	-.382	-22.68	-2.249	1.0857
13.0	6.47	-.588	-23.10	-3.461	1.3401
12.0	6.35	-.838	-23.52	-4.930	1.5982
11.0	5.65	-1.131	-23.94	-6.652	1.8404
10.0	4.17	-1.461	-24.36	-8.597	2.0396
9.0	1.69	-1.820	-24.78	-10.705	2.1605
8.0	-2.04	-2.189	-25.20	-12.877	2.1579
7.0	-7.27	-2.543	-25.62	-14.962	1.9770
6.0	-14.24	-2.847	-26.04	-16.750	1.5529
5.0	-23.16	-3.054	-26.46	-17.962	.8115
4.0	-34.16	-3.101	-26.88	-18.240	-.3279
3.0	-47.28	-2.915	-27.30	-17.145	-1.9497
2.0	-62.37	-2.406	-27.72	-14.153	-4.1364
1.0	-79.09	-1.472	-28.14	-8.660	-6.9609
.0	-96.78	.000	-28.56	.000	-10.4765

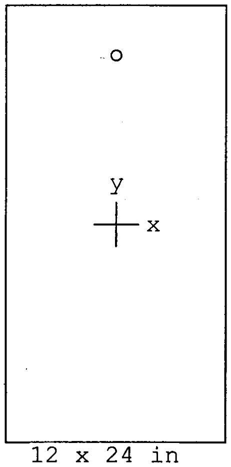
***** TOTAL FORCES AT SHELL WALL WITHOUT PRESTRESS *****

HEIGHT(TOP-BOT)	N-THETA	MOM-THETA	N-Y	MOM-Y	SHEAR-Y
FEET	K/FT.	FT.K/FT	K/FT	FT.K/FT	K/FT

LOAD CASE # 4 DL + FL/GR

68.0	.00	.000	.00	.000	.0001
67.0	-2.55	.000	-.42	.000	.0001
66.0	-5.10	.000	-.84	.000	.0001
65.0	-7.65	.000	-1.26	.000	.0002
64.0	-10.20	.000	-1.68	-.001	.0002
63.0	-12.75	.000	-2.10	-.001	.0002
62.0	-15.30	.000	-2.52	-.001	.0003
61.0	-17.85	.000	-2.94	-.001	.0003
60.0	-20.40	.000	-3.36	-.002	.0003
59.0	-22.95	.000	-3.78	-.002	.0003
58.0	-25.50	.000	-4.20	-.002	.0003
57.0	-28.05	.000	-4.62	-.002	.0002
56.0	-30.60	.000	-5.04	-.003	.0001
55.0	-33.15	.000	-5.46	-.003	.0000

54.0	-35.71	.000	-5.88	-.002	-.0003
53.0	-38.26	.000	-6.30	-.002	-.0006
52.0	-40.81	.000	-6.72	-.001	-.0010
51.0	-43.36	.000	-7.14	.000	-.0015
50.0	-45.92	.000	-7.56	.002	-.0021
49.0	-48.47	.001	-7.98	.004	-.0028
48.0	-51.02	.001	-8.40	.008	-.0036
47.0	-53.57	.002	-8.82	.012	-.0045
46.0	-56.12	.003	-9.24	.017	-.0054
45.0	-58.67	.004	-9.66	.022	-.0062
44.0	-61.21	.005	-10.08	.029	-.0068
43.0	-63.76	.006	-10.50	.036	-.0072
42.0	-66.29	.007	-10.92	.043	-.0072
41.0	-68.83	.009	-11.34	.050	-.0066
40.0	-71.35	.010	-11.76	.056	-.0052
39.0	-73.87	.010	-12.18	.060	-.0027
38.0	-76.39	.010	-12.60	.061	.0011
37.0	-78.89	.010	-13.02	.057	.0066
36.0	-81.39	.008	-13.44	.047	.0139
35.0	-83.88	.005	-13.86	.029	.0234
34.0	-86.38	.000	-14.28	.000	.0351
33.0	-88.87	-.007	-14.70	-.042	.0493
32.0	-91.36	-.017	-15.12	-.100	.0657
31.0	-93.87	-.030	-15.54	-.174	.0841
30.0	-96.40	-.046	-15.96	-.268	.1038
29.0	-98.96	-.065	-16.38	-.382	.1238
28.0	-101.56	-.088	-16.80	-.516	.1425
27.0	-104.23	-.113	-17.22	-.666	.1580
26.0	-106.97	-.141	-17.64	-.829	.1673
25.0	-109.81	-.170	-18.06	-.998	.1671
24.0	-112.76	-.197	-18.48	-1.159	.1530
23.0	-115.85	-.221	-18.90	-1.297	.1201
22.0	-119.10	-.236	-19.32	-1.391	.0626
21.0	-122.50	-.240	-19.74	-1.412	-.0258
20.0	-126.06	-.226	-20.16	-1.327	-.1515
19.0	-129.78	-.186	-20.58	-1.095	-.3209
18.0	-133.63	-.114	-21.00	-.669	-.5398
17.0	-137.55	.000	-21.42	.003	-.8122
16.0	-141.47	.166	-21.84	.974	-1.1396
15.0	-145.27	.391	-22.26	2.300	-1.5199
14.0	-148.79	.685	-22.68	4.029	-1.9452
13.0	-151.85	1.054	-23.10	6.200	-2.4010
12.0	-154.17	1.502	-23.52	8.833	-2.8634
11.0	-155.47	2.026	-23.94	11.918	-3.2973
10.0	-155.37	2.618	-24.36	15.403	-3.6543
9.0	-153.47	3.261	-24.78	19.180	-3.8708
8.0	-149.34	3.922	-25.20	23.071	-3.8663
7.0	-142.52	4.557	-25.62	26.806	-3.5421
6.0	-132.58	5.102	-26.04	30.010	-2.7822
5.0	-119.15	5.471	-26.46	32.181	-1.4540
4.0	-101.99	5.556	-26.88	32.680	.5874
3.0	-81.05	5.222	-27.30	30.718	3.4931
2.0	-56.56	4.311	-27.72	25.356	7.4109
1.0	-29.16	2.638	-28.14	15.515	12.4715
.0	.00	.000	-28.56	.000	18.7702



Code: ACI 318-95

Units: English

Run axis: About X-axis

Run option: Investigation

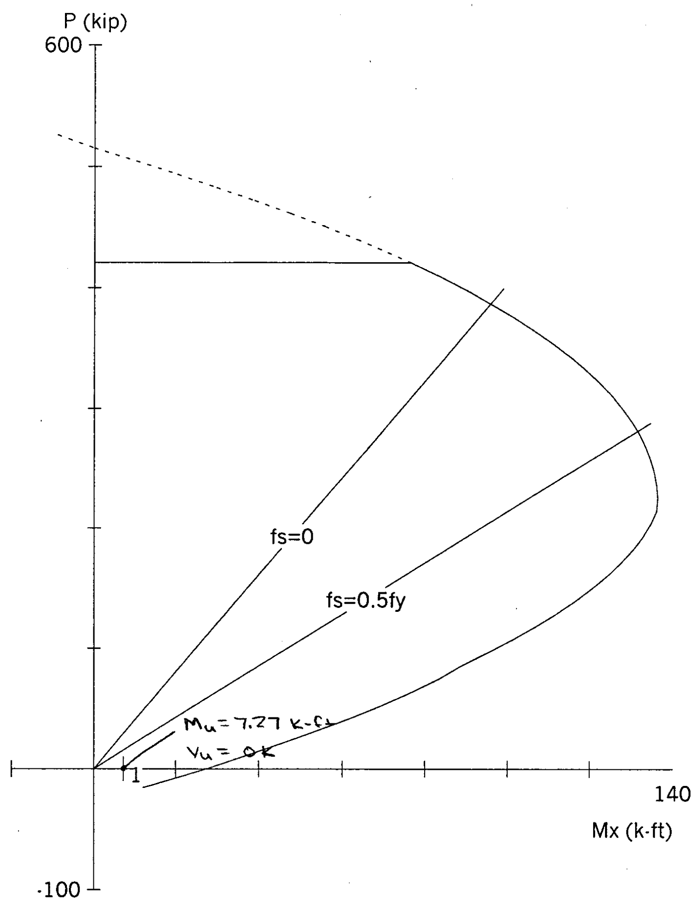
Slenderness: Not considered

Column type: Structural

Bars: ASTM A615

Date: 10/17/02

Time: 14:06:08



PCACOL V3.00 (PCA 1999) - Licensed to:

File: untitled.col

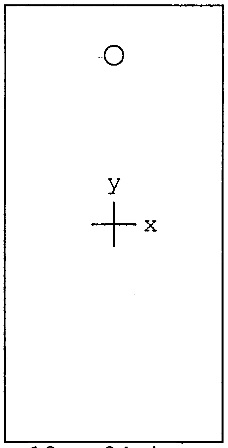
Project: INEEL BIN CHECK

Column: Vault #3 (VERTICAL STEEL) Engineer: MB

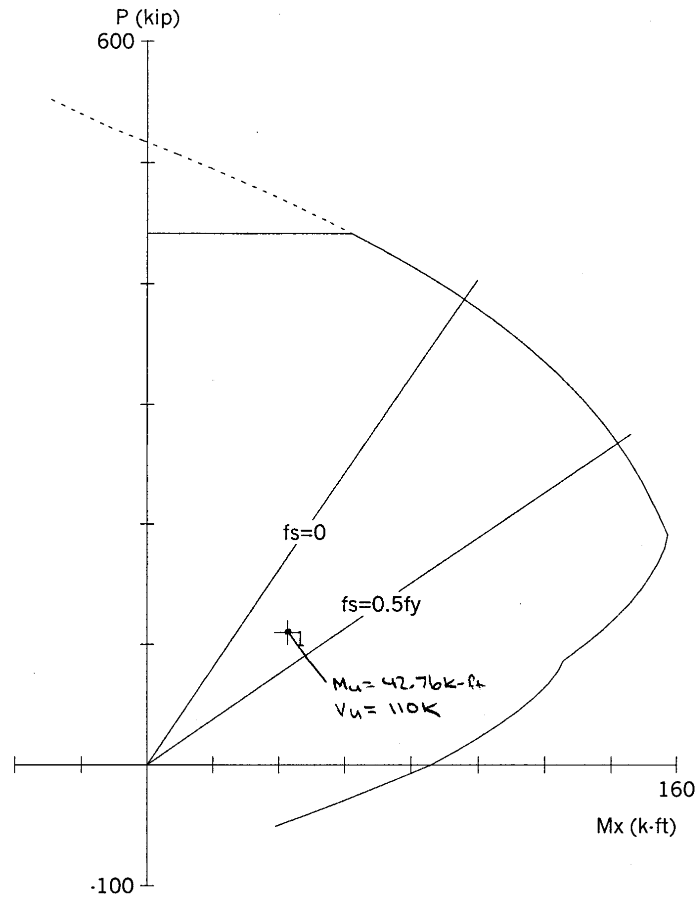
#6 AT 18" O.C.

f'c = 3 ksi	fy = 60 ksi	Ag = 288 in^2	1 bars
Ec = 3122 ksi	Es = 29000 ksi	As = 0.29 in^2	Rho = 0.10%
fc = 2.55 ksi	e_rup = Infinity	Xo = 0.00 in	Ix = 13824 in^4
e_u = 0.003 in/in		Yo = 0.00 in	Iy = 3456 in^4
Beta1 = 0.85		Clear spacing = 8.95	Clear cover = 2.45 in

Confinement: Tied phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.7



Code: ACI 318-95
Units: English
Run axis: About X-axis
Run option: Investigation
Slenderness: Not considered
Column type: Structural
Bars: ASTM A615
Date: 10/17/02
Time: 14:05:22



PCACOL V3.00 (PCA 1999) - Licensed to:

File: untitled.col
Project: INEEL BIN CHECK
Column: Vault #3 (HORIZONTAL STEEL) Engineer: MB

f'c = 3 ksi	fy = 60 ksi	Ag = 288 in^2	1 bars (#8 AT 10" O.C.)
Ec = 3122 ksi	Es = 29000 ksi	As = 0.94 in^2	Rho = 0.33%
fc = 2.55 ksi	e_rup = Infinity	Xo = 0.00 in	Ix = 13824 in^4
e_u = 0.003 in/in		Yo = 0.00 in	Iy = 3456 in^4
Beta1 = 0.85		Clear spacing = 8.70	Clear cover = 2.20 in

Confinement: Tied phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.7

91-a

CONCRETE VAULT #3 (CONTINUED)

STEEL CHECK

SEE ATTACHED CALCS

SHEAR CHECK

$V_u = 18.77(.75) + 10.47 = 24.55K$

$V_c = \phi 2bd\sqrt{f'c} = .85(2)(12in)(21.25in)\sqrt{3000} = 23.7K$ ← OK, SEISMIC ACCELERATION REDUCED BY 50%, BY INSPECTION OK. (see note pg 85)

SUMMARY → HORIZONTAL & VERTICAL REINFORCEMENT ARE OK & SHEAR IS OKAY

Project Name:	Project #:	Initials:	Date:	Sheet: 91-b

CONCRETE SHEARWALL ANALYSIS

SIMPLIFIED DESIGN

WALL MARK : **Typical Wall (Vault #3)**

FLEXURAL ANALYSIS :

WALL GEOMETRY & PROPERTIES :

wall length, l_w :	35	ft	c / l_w :	0.39834
wall thickness, h :	24	in	β_1 :	0.85
wall height, ht:	67	ft		
fy :	60	ksi	ω :	0.24
f'c :	3	ksi	α :	0.2381
ϕ :	0.9			
steel ea. face(Y/N):	Y			

LOADS : NEGLECT, TAKEN IN HOOP STRESS

P_u :	600	k		
M_u :	0	k*ft	ϕM_n : 15387.7 k*ft	OK

REINFORCING :

A_{st} : 10.27 in^2

USE : # 6 @ 18 oc vert.

Vert. reinf. must not be less than the horz.

Minimum requirements not met

SHEAR ANALYSIS :

LOADS :

Siesmic Zone 3 or 4 (Y/N):	n		
ρ:	1.0	.243 (8,300 k)	
V_u :	2048.0	k	
ρ^*V_u:	2048.0	k	

Hook edge reinforcement

Use two mats of reinforcing

SHEAR STRENGTH :

ϕ :	0.85		
ϕV_c :	750.86	k	
ϕV_s :	1592.6	k	
ϕV_n :	2343.5	k	Ok
Min steel:	0.576 in^2/ft		

USE : # 8 @ 10 oc hor. OK

SUMMARY → WALLS PERPENDICULAR TO LOAD ARE OK FOR SHEAR TRANSFER

edited 6/3/02

PROJECT DESCRIPTION : INEEL BIN CHECK

TITLE : CONCRETE VAULT #3 (LONG FORM)
DATE : 10/14/02

=
*** INPUT DATA AND CALCULATED PROPERTIES OF STRUCTURE ***
=

NOTE : THE BASE OF THE TANK WALL IS HINGED.

CYLINDER GEOMETRY :

WALL HEIGHT = 68.00 FT
CYLINDER RADIUS = 25.00 FT
WALL THICKNESS = 24.00 IN
FLOOR THICKNESS = .00 IN
VOLUME UNDER THE CYLINDERICAL TANK = .1335E+06 CU.FT

CONCRETE PROPERTIES :

UNIT WEIGHT OF CONCRETE = 210.00 PCF ← ULTIMATE LOAD 150pcf (1.7)
POISSONS RATIO = .1700
COMPRESSIVE STRENGTH OF CONCRETE = 3000.00 PSI
VOLUME OF CONCRETE SHELL = 791.22 CU.YD
VOLUME OF CONCRETE FLOOR = .00 CU.YD
YOUNGS MODULUS OF ELASTICITY = .5501E+07 PSI

PROPERITES OF GRANULAR :

DEPTH OF GRANULAR = 68.00 FT
VOLUME OF GRANULAR = 133517.60 CU-FT
SPECIFIC WEIGHT OF GRANULAR (GAMMA) = -102.00PCF ← ULTIMATE LOAD .5(120pcf)(1.7)

SEISMIC LOADING :

MAX. PRESSURE OF SEISMIC SHEAR ON SHELL = 460.96 PSF
HORIZONTAL SEISMIC ACCELERATION = 35.34 FT/SQ.SEC ← ULTIMATE LOAD (SEE ATTACHED CALC)
ACCELERATION OF GRAVITY = 32.20 FT/SQ.SEC
RELATIVE ACCELERATION (a/g) = 1.10

THERE IS NO EXTERNAL PRESTRESSING LOAD.

CONSTANT VALUE OF (BETA) = .18E+00 1/FT

LOAD CASE # 3 DL + EQL

SOLUTIONS FOR CYLIDERICAL TANK :

ERROR >>>

TRANSLATION FORCE ERROR DUE TO MEMBRANE
FORCES (MATERIAL LOADS)(E*D10) = -1209.78 KIPS/FT
ROTATIONAL FORCE ERROR DUE TO MEMBRANE
FORCES (MATERIAL LOADS)(E*D20) = .00 KIPS/FT

CORRECTION >>>

TRANSITIONAL DISPLACEMENT AT THE BASE
FROM UNIT FORCES (HORIZONTAL (E*D11) = 115.48
ROTATIONAL DISPLACEMENT AT THE BASE
FROM UNIT FORCES (HORIZONTAL (E*D12=E*D21) = -21.34
ROTATIONAL DISPLACEMENT AT THE BASE
FROM UNIT FORCES (MOMENT) (E*D22) = 7.88
CORRECTIONAL FORCE (FROM DL AND LL ONLY)(X1)= -10.48 KIPS/FT
CORRECTIONAL FORCE (FROM DL AND LL ONLY)(X2)= .00 FT-KIPS/FT

LOAD CASE # 4 DL + FL/GR

SOLUTIONS FOR CYLIDERICAL TANK :

ERROR >>>

TRANSLATION FORCE ERROR DUE TO MEMBRANE
FORCES (MATERIAL LOADS)(E*D10) = 2167.50 KIPS/FT
ROTATIONAL FORCE ERROR DUE TO MEMBRANE
FORCES (MATERIAL LOADS)(E*D20) = .00 KIPS/FT

CORRECTION >>>

TRANSITIONAL DISPLACEMENT AT THE BASE
FROM UNIT FORCES (HORIZONTAL (E*D11) = 115.48
ROTATIONAL DISPLACEMENT AT THE BASE
FROM UNIT FORCES (HORIZONTAL (E*D12=E*D21) = -21.34
ROTATIONAL DISPLACEMENT AT THE BASE
FROM UNIT FORCES (MOMENT) (E*D22) = 7.88
CORRECTIONAL FORCE (FROM DL AND LL ONLY)(X1)= 18.77 KIPS/FT
CORRECTIONAL FORCE (FROM DL AND LL ONLY)(X2)= .00 FT-KIPS/FT

DL = Forces from dead load
LL = ... live load (Int/Ext fluid,granular)
WL = ... Wind load.
EQL= .... Seismic load.

N-THETA FOR WL .. is taken at thetha = 75 degree
N-THETA FOR EQL .. is taken at thetha = 180 degree
N-Y FOR WL .. is taken at thetha = 0 degree
N-Y FOR EQL .. is taken at thetha = 0 degree
N-Y,THETA FOR WL .. is taken at thetha = 45 degree
N-Y,THETA FOR EQL.. is taken at thetha = 90 degree

MEMBRANE SOLUTION FOR ALL LOAD CONDITIONS

HEIGHT (FT) FROM TOP-BOT.	N-THETA (KIPS/FT) HOOP			N-Y (KIPS/FT) VERTICAL			N-Y,THETA (KIPS/FT) SHEAR	
	LL	WL	EQL	DL	WL	EQL	WL	EQL
68.0	.000	.000	.000	.000	.000	.000	.000	.000
67.0	-2.550	.000	.000	-.420	.000	.000	.000	.000
66.0	-5.100	.000	.000	-.840	.000	.000	.000	.000
65.0	-7.650	.000	.000	-1.260	.000	.000	.000	.000
64.0	-10.200	.000	.000	-1.680	.000	.000	.000	.000
63.0	-12.750	.000	.000	-2.100	.000	.000	.000	.000
62.0	-15.300	.000	.000	-2.520	.000	.000	.000	.000
61.0	-17.850	.000	.000	-2.940	.000	.000	.000	.000
60.0	-20.400	.000	.000	-3.360	.000	.000	.000	.000
59.0	-22.950	.000	.000	-3.780	.000	.000	.000	.000
58.0	-25.500	.000	.000	-4.200	.000	.000	.000	.000
57.0	-28.050	.000	.000	-4.620	.000	.000	.000	.000
56.0	-30.600	.000	.000	-5.040	.000	.000	.000	.000
55.0	-33.150	.000	.000	-5.460	.000	.000	.000	.000
54.0	-35.700	.000	.000	-5.880	.000	.000	.000	.000
53.0	-38.250	.000	.000	-6.300	.000	.000	.000	.000
52.0	-40.800	.000	.000	-6.720	.000	.000	.000	.000
51.0	-43.350	.000	.000	-7.140	.000	.000	.000	.000
50.0	-45.900	.000	.000	-7.560	.000	.000	.000	.000
49.0	-48.450	.000	.000	-7.980	.000	.000	.000	.000
48.0	-51.000	.000	.000	-8.400	.000	.000	.000	.000
47.0	-53.550	.000	.000	-8.820	.000	.000	.000	.000
46.0	-56.100	.000	.000	-9.240	.000	.000	.000	.000
45.0	-58.650	.000	.000	-9.660	.000	.000	.000	.000
44.0	-61.200	.000	.000	-10.080	.000	.000	.000	.000
43.0	-63.750	.000	.000	-10.500	.000	.000	.000	.000
42.0	-66.300	.000	.000	-10.920	.000	.000	.000	.000
41.0	-68.850	.000	.000	-11.340	.000	.000	.000	.000
40.0	-71.400	.000	.000	-11.760	.000	.000	.000	.000
39.0	-73.950	.000	.000	-12.180	.000	.000	.000	.000
38.0	-76.500	.000	.000	-12.600	.000	.000	.000	.000
37.0	-79.050	.000	.000	-13.020	.000	.000	.000	.000

36.0	-81.600	.000	.000	-13.440	.000	.000	.000	.000
35.0	-84.150	.000	.000	-13.860	.000	.000	.000	.000
34.0	-86.700	.000	.000	-14.280	.000	.000	.000	.000
33.0	-89.250	.000	.000	-14.700	.000	.000	.000	.000
32.0	-91.800	.000	.000	-15.120	.000	.000	.000	.000
31.0	-94.350	.000	.000	-15.540	.000	.000	.000	.000
30.0	-96.900	.000	.000	-15.960	.000	.000	.000	.000
29.0	-99.450	.000	.000	-16.380	.000	.000	.000	.000
28.0	-102.000	.000	.000	-16.800	.000	.000	.000	.000
27.0	-104.550	.000	.000	-17.220	.000	.000	.000	.000
26.0	-107.100	.000	.000	-17.640	.000	.000	.000	.000
25.0	-109.650	.000	.000	-18.060	.000	.000	.000	.000
24.0	-112.200	.000	.000	-18.480	.000	.000	.000	.000
23.0	-114.750	.000	.000	-18.900	.000	.000	.000	.000
22.0	-117.300	.000	.000	-19.320	.000	.000	.000	.000
21.0	-119.850	.000	.000	-19.740	.000	.000	.000	.000
20.0	-122.400	.000	.000	-20.160	.000	.000	.000	.000
19.0	-124.950	.000	.000	-20.580	.000	.000	.000	.000
18.0	-127.500	.000	.000	-21.000	.000	.000	.000	.000
17.0	-130.050	.000	.000	-21.420	.000	.000	.000	.000
16.0	-132.600	.000	.000	-21.840	.000	.000	.000	.000
15.0	-135.150	.000	.000	-22.260	.000	.000	.000	.000
14.0	-137.700	.000	.000	-22.680	.000	.000	.000	.000
13.0	-140.250	.000	.000	-23.100	.000	.000	.000	.000
12.0	-142.800	.000	.000	-23.520	.000	.000	.000	.000
11.0	-145.350	.000	.000	-23.940	.000	.000	.000	.000
10.0	-147.900	.000	.000	-24.360	.000	.000	.000	.000
9.0	-150.450	.000	.000	-24.780	.000	.000	.000	.000
8.0	-153.000	.000	.000	-25.200	.000	.000	.000	.000
7.0	-155.550	.000	.000	-25.620	.000	.000	.000	.000
6.0	-158.100	.000	.000	-26.040	.000	.000	.000	.000
5.0	-160.650	.000	.000	-26.460	.000	.000	.000	.000
4.0	-163.200	.000	.000	-26.880	.000	.000	.000	.000
3.0	-165.750	.000	.000	-27.300	.000	.000	.000	.000
2.0	-168.300	.000	.000	-27.720	.000	.000	.000	.000
1.0	-170.850	.000	.000	-28.140	.000	.000	.000	.000
.0	-173.400	.000	.000	-28.560	.000	.000	.000	.000

SOLUTION OF WALL TANK FOR HOOP FORCES

HEIGHT(TOP-BOT) FEET	MEMBRANE KIPS/FT	CORR.(X1,X2) KIPS/FT	TOTAL FORCE KIPS/FT
LOAD CASE # 3 DL + EQL			
68.0	.00	.00	.00
67.0	.00	.00	.00
66.0	.00	.00	.00

65.0	.00	.00	.00
64.0	.00	.00	.00
63.0	.00	.00	.00
62.0	.00	.00	.00
61.0	.00	.00	.00
60.0	.00	.00	.00
59.0	.00	.00	.00
58.0	.00	.00	.00
57.0	.00	.00	.00
56.0	.00	.00	.00
55.0	.00	.00	.00
54.0	.00	.00	.00
53.0	.00	.01	.01
52.0	.00	.01	.01
51.0	.00	.01	.01
50.0	.00	.01	.01
49.0	.00	.01	.01
48.0	.00	.01	.01
47.0	.00	.01	.01
46.0	.00	.01	.01
45.0	.00	.01	.01
44.0	.00	.01	.01
43.0	.00	.00	.00
42.0	.00	.00	.00
41.0	.00	-.01	-.01
40.0	.00	-.03	-.03
39.0	.00	-.04	-.04
38.0	.00	-.06	-.06
37.0	.00	-.09	-.09
36.0	.00	-.12	-.12
35.0	.00	-.15	-.15
34.0	.00	-.18	-.18
33.0	.00	-.21	-.21
32.0	.00	-.24	-.24
31.0	.00	-.27	-.27
30.0	.00	-.28	-.28
29.0	.00	-.27	-.27
28.0	.00	-.24	-.24
27.0	.00	-.18	-.18
26.0	.00	-.07	-.07
25.0	.00	.09	.09
24.0	.00	.32	.32
23.0	.00	.62	.62
22.0	.00	1.00	1.00
21.0	.00	1.48	1.48
20.0	.00	2.05	2.05
19.0	.00	2.70	2.70
18.0	.00	3.42	3.42
17.0	.00	4.19	4.19
16.0	.00	4.95	4.95
15.0	.00	5.65	5.65
14.0	.00	6.19	6.19
13.0	.00	6.47	6.47
12.0	.00	6.35	6.35
11.0	.00	5.65	5.65
10.0	.00	4.17	4.17

9.0	.00	1.69	1.69
8.0	.00	-2.04	-2.04
7.0	.00	-7.27	-7.27
6.0	.00	-14.24	-14.24
5.0	.00	-23.16	-23.16
4.0	.00	-34.16	-34.16
3.0	.00	-47.28	-47.28
2.0	.00	-62.37	-62.37
1.0	.00	-79.09	-79.09
.0	.00	-96.78	-96.78

SOLUTION OF WALL TANK FOR HOOP FORCES

HEIGHT(TOP-BOT) FEET	MEMBRANE KIPS/FT	CORR.(X1,X2) KIPS/FT	TOTAL FORCE KIPS/FT
LOAD CASE # 4	DL + FL/GR		
68.0	.00	.00	.00
67.0	-2.55	.00	-2.55
66.0	-5.10	.00	-5.10
65.0	-7.65	.00	-7.65
64.0	-10.20	.00	-10.20
63.0	-12.75	.00	-12.75
62.0	-15.30	.00	-15.30
61.0	-17.85	.00	-17.85
60.0	-20.40	.00	-20.40
59.0	-22.95	.00	-22.95
58.0	-25.50	.00	-25.50
57.0	-28.05	.00	-28.05
56.0	-30.60	.00	-30.60
55.0	-33.15	.00	-33.15
54.0	-35.70	-.01	-35.71
53.0	-38.25	-.01	-38.26
52.0	-40.80	-.01	-40.81
51.0	-43.35	-.01	-43.36
50.0	-45.90	-.02	-45.92
49.0	-48.45	-.02	-48.47
48.0	-51.00	-.02	-51.02
47.0	-53.55	-.02	-53.57
46.0	-56.10	-.02	-56.12
45.0	-58.65	-.02	-58.67
44.0	-61.20	-.01	-61.21
43.0	-63.75	-.01	-63.76
42.0	-66.30	.01	-66.29
41.0	-68.85	.02	-68.83
40.0	-71.40	.05	-71.35
39.0	-73.95	.08	-73.87

38.0	-76.50	.11	-76.39
37.0	-79.05	.16	-78.89
36.0	-81.60	.21	-81.39
35.0	-84.15	.27	-83.88
34.0	-86.70	.32	-86.38
33.0	-89.25	.38	-88.87
32.0	-91.80	.44	-91.36
31.0	-94.35	.48	-93.87
30.0	-96.90	.50	-96.40
29.0	-99.45	.49	-98.96
28.0	-102.00	.44	-101.56
27.0	-104.55	.32	-104.23
26.0	-107.10	.13	-106.97
25.0	-109.65	-.16	-109.81
24.0	-112.20	-.56	-112.76
23.0	-114.75	-1.10	-115.85
22.0	-117.30	-1.80	-119.10
21.0	-119.85	-2.65	-122.50
20.0	-122.40	-3.66	-126.06
19.0	-124.95	-4.83	-129.78
18.0	-127.50	-6.13	-133.63
17.0	-130.05	-7.50	-137.55
16.0	-132.60	-8.87	-141.47
15.0	-135.15	-10.12	-145.27
14.0	-137.70	-11.09	-148.79
13.0	-140.25	-11.60	-151.85
12.0	-142.80	-11.37	-154.17
11.0	-145.35	-10.12	-155.47
10.0	-147.90	-7.47	-155.37
9.0	-150.45	-3.02	-153.47
8.0	-153.00	3.66	-149.34
7.0	-155.55	13.03	-142.52
6.0	-158.10	25.52	-132.58
5.0	-160.65	41.50	-119.15
4.0	-163.20	61.21	-101.99
3.0	-165.75	84.70	-81.05
2.0	-168.30	111.74	-56.56
1.0	-170.85	141.69	-29.16
.0	-173.40	173.40	.00

BENDING SOLUTION FOR THE WALL TANK

VARIABLE HEIGHT (TOP-BOT) FEET	MEMBRANE VERTICAL KIPS/FT	CORR.(X1,X2) MOM - Y KIPS/FT	CORR.(X1,X2) MOM-THETA,Y KIPS/FT	CORR.(X1,X2) SHEAR KIPS/FT

LOAD CASE # 3 DL + EQL

68.0	.00	.00	.00	.00
67.0	-.42	.00	.00	.00
66.0	-.84	.00	.00	.00
65.0	-1.26	.00	.00	.00
64.0	-1.68	.00	.00	.00
63.0	-2.10	.00	.00	.00
62.0	-2.52	.00	.00	.00
61.0	-2.94	.00	.00	.00
60.0	-3.36	.00	.00	.00
59.0	-3.78	.00	.00	.00
58.0	-4.20	.00	.00	.00
57.0	-4.62	.00	.00	.00
56.0	-5.04	.00	.00	.00
55.0	-5.46	.00	.00	.00
54.0	-5.88	.00	.00	.00
53.0	-6.30	.00	.00	.00
52.0	-6.72	.00	.00	.00
51.0	-7.14	.00	.00	.00
50.0	-7.56	.00	.00	.00
49.0	-7.98	.00	.00	.00
48.0	-8.40	.00	.00	.00
47.0	-8.82	-.01	.00	.00
46.0	-9.24	-.01	.00	.00
45.0	-9.66	-.01	.00	.00
44.0	-10.08	-.02	.00	.00
43.0	-10.50	-.02	.00	.00
42.0	-10.92	-.02	.00	.00
41.0	-11.34	-.03	.00	.00
40.0	-11.76	-.03	-.01	.00
39.0	-12.18	-.03	-.01	.00
38.0	-12.60	-.03	-.01	.00
37.0	-13.02	-.03	-.01	.00
36.0	-13.44	-.03	.00	-.01
35.0	-13.86	-.02	.00	-.01
34.0	-14.28	.00	.00	-.02
33.0	-14.70	.02	.00	-.03
32.0	-15.12	.06	.01	-.04
31.0	-15.54	.10	.02	-.05
30.0	-15.96	.15	.03	-.06
29.0	-16.38	.21	.04	-.07
28.0	-16.80	.29	.05	-.08
27.0	-17.22	.37	.06	-.09
26.0	-17.64	.46	.08	-.09
25.0	-18.06	.56	.09	-.09
24.0	-18.48	.65	.11	-.09
23.0	-18.90	.72	.12	-.07
22.0	-19.32	.78	.13	-.03
21.0	-19.74	.79	.13	.01
20.0	-20.16	.74	.13	.08
19.0	-20.58	.61	.10	.18
18.0	-21.00	.37	.06	.30
17.0	-21.42	.00	.00	.45
16.0	-21.84	-.54	-.09	.64

15.0	-22.26	-1.28	-.22	.85
14.0	-22.68	-2.25	-.38	1.09
13.0	-23.10	-3.46	-.59	1.34
12.0	-23.52	-4.93	-.84	1.60
11.0	-23.94	-6.65	-1.13	1.84
10.0	-24.36	-8.60	-1.46	2.04
9.0	-24.78	-10.71	-1.82	2.16
8.0	-25.20	-12.88	-2.19	2.16
7.0	-25.62	-14.96	-2.54	1.98
6.0	-26.04	-16.75	-2.85	1.55
5.0	-26.46	-17.96	-3.05	.81
4.0	-26.88	-18.24	-3.10	-.33
3.0	-27.30	-17.15	-2.91	-1.95
2.0	-27.72	-14.15	-2.41	-4.14
1.0	-28.14	-8.66	-1.47	-6.96
.0	-28.56	.00	.00	-10.48

BENDING SOLUTION FOR THE WALL TANK

VARIABLE HEIGHT (TOP-BOT) FEET	MEMBRANE VERTICAL KIPS/FT	CORR.(X1,X2) MOM - Y KIPS/FT	CORR.(X1,X2) MOM-THETA,Y KIPS/FT	CORR.(X1,X2) SHEAR KIPS/FT

LOAD CASE # 4 DL + FL/GR

68.0	.00	.00	.00	.00
67.0	-.42	.00	.00	.00
66.0	-.84	.00	.00	.00
65.0	-1.26	.00	.00	.00
64.0	-1.68	.00	.00	.00
63.0	-2.10	.00	.00	.00
62.0	-2.52	.00	.00	.00
61.0	-2.94	.00	.00	.00
60.0	-3.36	.00	.00	.00
59.0	-3.78	.00	.00	.00
58.0	-4.20	.00	.00	.00
57.0	-4.62	.00	.00	.00
56.0	-5.04	.00	.00	.00
55.0	-5.46	.00	.00	.00
54.0	-5.88	.00	.00	.00
53.0	-6.30	.00	.00	.00
52.0	-6.72	.00	.00	.00
51.0	-7.14	.00	.00	.00
50.0	-7.56	.00	.00	.00
49.0	-7.98	.00	.00	.00

48.0	-8.40	.01	.00	.00
47.0	-8.82	.01	.00	.00
46.0	-9.24	.02	.00	-.01
45.0	-9.66	.02	.00	-.01
44.0	-10.08	.03	.00	-.01
43.0	-10.50	.04	.01	-.01
42.0	-10.92	.04	.01	-.01
41.0	-11.34	.05	.01	-.01
40.0	-11.76	.06	.01	-.01
39.0	-12.18	.06	.01	.00
38.0	-12.60	.06	.01	.00
37.0	-13.02	.06	.01	.01
36.0	-13.44	.05	.01	.01
35.0	-13.86	.03	.00	.02
34.0	-14.28	.00	.00	.04
33.0	-14.70	-.04	-.01	.05
32.0	-15.12	-.10	-.02	.07
31.0	-15.54	-.17	-.03	.08
30.0	-15.96	-.27	-.05	.10
29.0	-16.38	-.38	-.06	.12
28.0	-16.80	-.52	-.09	.14
27.0	-17.22	-.67	-.11	.16
26.0	-17.64	-.83	-.14	.17
25.0	-18.06	-1.00	-.17	.17
24.0	-18.48	-1.16	-.20	.15
23.0	-18.90	-1.30	-.22	.12
22.0	-19.32	-1.39	-.24	.06
21.0	-19.74	-1.41	-.24	-.03
20.0	-20.16	-1.33	-.23	-.15
19.0	-20.58	-1.09	-.19	-.32
18.0	-21.00	-.67	-.11	-.54
17.0	-21.42	.00	.00	-.81
16.0	-21.84	.97	.17	-1.14
15.0	-22.26	2.30	.39	-1.52
14.0	-22.68	4.03	.68	-1.95
13.0	-23.10	6.20	1.05	-2.40
12.0	-23.52	8.83	1.50	-2.86
11.0	-23.94	11.92	2.03	-3.30
10.0	-24.36	15.40	2.62	-3.65
9.0	-24.78	19.18	3.26	-3.87
8.0	-25.20	23.07	3.92	-3.87
7.0	-25.62	26.81	4.56	-3.54
6.0	-26.04	30.01	5.10	-2.78
5.0	-26.46	32.18	5.47	-1.45
4.0	-26.88	32.68	5.56	.59
3.0	-27.30	30.72	5.22	3.49
2.0	-27.72	25.36	4.31	7.41
1.0	-28.14	15.52	2.64	12.47
.0	-28.56	.00	.00	18.77

***** TOTAL FORCES AT SHELL WALL WITHOUT PRESTRESS *****

LOAD CASE # 3 DL + EQL

HEIGHT(TOP-BOT) FEET	N-THETA K/FT.	MOM-THETA FT.K/FT	N-Y K/FT	MOM-Y FT.K/FT	SHEAR-Y K/FT
68.0	.00	.000	.00	.000	.0000
67.0	.00	.000	-.42	.000	-.0001
66.0	.00	.000	-.84	.000	-.0001
65.0	.00	.000	-1.26	.000	-.0001
64.0	.00	.000	-1.68	.000	-.0001
63.0	.00	.000	-2.10	.000	-.0001
62.0	.00	.000	-2.52	.001	-.0001
61.0	.00	.000	-2.94	.001	-.0002
60.0	.00	.000	-3.36	.001	-.0002
59.0	.00	.000	-3.78	.001	-.0002
58.0	.00	.000	-4.20	.001	-.0002
57.0	.00	.000	-4.62	.001	-.0001
56.0	.00	.000	-5.04	.001	-.0001
55.0	.00	.000	-5.46	.001	.0000
54.0	.00	.000	-5.88	.001	.0002
53.0	.01	.000	-6.30	.001	.0003
52.0	.01	.000	-6.72	.001	.0006
51.0	.01	.000	-7.14	.000	.0008
50.0	.01	.000	-7.56	-.001	.0012
49.0	.01	.000	-7.98	-.002	.0016
48.0	.01	-.001	-8.40	-.004	.0020
47.0	.01	-.001	-8.82	-.006	.0025
46.0	.01	-.002	-9.24	-.009	.0030
45.0	.01	-.002	-9.66	-.012	.0034
44.0	.01	-.003	-10.08	-.016	.0038
43.0	.00	-.003	-10.50	-.020	.0040
42.0	.00	-.004	-10.92	-.024	.0040
41.0	-.01	-.005	-11.34	-.028	.0037
40.0	-.03	-.005	-11.76	-.031	.0029
39.0	-.04	-.006	-12.18	-.034	.0015
38.0	-.06	-.006	-12.60	-.034	-.0006
37.0	-.09	-.005	-13.02	-.032	-.0037
36.0	-.12	-.004	-13.44	-.026	-.0078
35.0	-.15	-.003	-13.86	-.016	-.0130
34.0	-.18	.000	-14.28	.000	-.0196
33.0	-.21	.004	-14.70	.024	-.0275
32.0	-.24	.009	-15.12	.056	-.0367
31.0	-.27	.017	-15.54	.097	-.0470
30.0	-.28	.025	-15.96	.150	-.0580
29.0	-.27	.036	-16.38	.213	-.0691
28.0	-.24	.049	-16.80	.288	-.0796
27.0	-.18	.063	-17.22	.372	-.0882
26.0	-.07	.079	-17.64	.463	-.0934
25.0	.09	.095	-18.06	.557	-.0932
24.0	.32	.110	-18.48	.647	-.0854

23.0	.62	.123	-18.90	.724	-.0670
22.0	1.00	.132	-19.32	.776	-.0349
21.0	1.48	.134	-19.74	.788	.0144
20.0	2.05	.126	-20.16	.741	.0845
19.0	2.70	.104	-20.58	.611	.1791
18.0	3.42	.063	-21.00	.373	.3013
17.0	4.19	.000	-21.42	-.002	.4533
16.0	4.95	-.092	-21.84	-.544	.6361
15.0	5.65	-.218	-22.26	-1.284	.8483
14.0	6.19	-.382	-22.68	-2.249	1.0857
13.0	6.47	-.588	-23.10	-3.461	1.3401
12.0	6.35	-.838	-23.52	-4.930	1.5982
11.0	5.65	-1.131	-23.94	-6.652	1.8404
10.0	4.17	-1.461	-24.36	-8.597	2.0396
9.0	1.69	-1.820	-24.78	-10.705	2.1605
8.0	-2.04	-2.189	-25.20	-12.877	2.1579
7.0	-7.27	-2.543	-25.62	-14.962	1.9770
6.0	-14.24	-2.847	-26.04	-16.750	1.5529
5.0	-23.16	-3.054	-26.46	-17.962	.8115
4.0	-34.16	-3.101	-26.88	-18.240	-.3279
3.0	-47.28	-2.915	-27.30	-17.145	-1.9497
2.0	-62.37	-2.406	-27.72	-14.153	-4.1364
1.0	-79.09	-1.472	-28.14	-8.660	-6.9609
.0	-96.78	.000	-28.56	.000	-10.4765

***** TOTAL FORCES AT SHELL WALL WITHOUT PRESTRESS *****

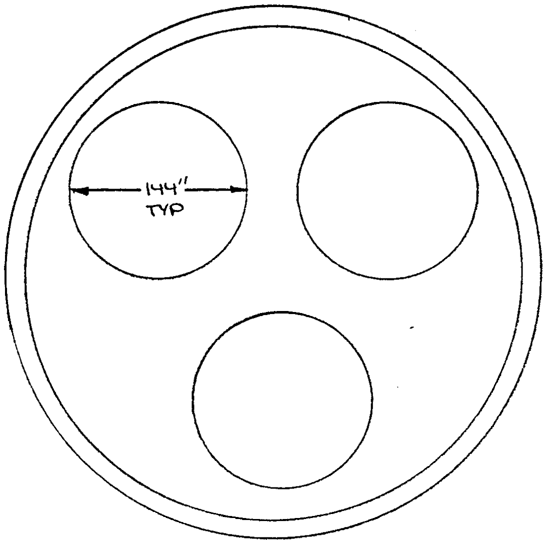
HEIGHT(TOP-BOT)	N-THETA	MOM-THETA	N-Y	MOM-Y	SHEAR-Y
FEET	K/FT.	FT.K/FT	K/FT	FT.K/FT	K/FT

LOAD CASE # 4 DL + FL/GR

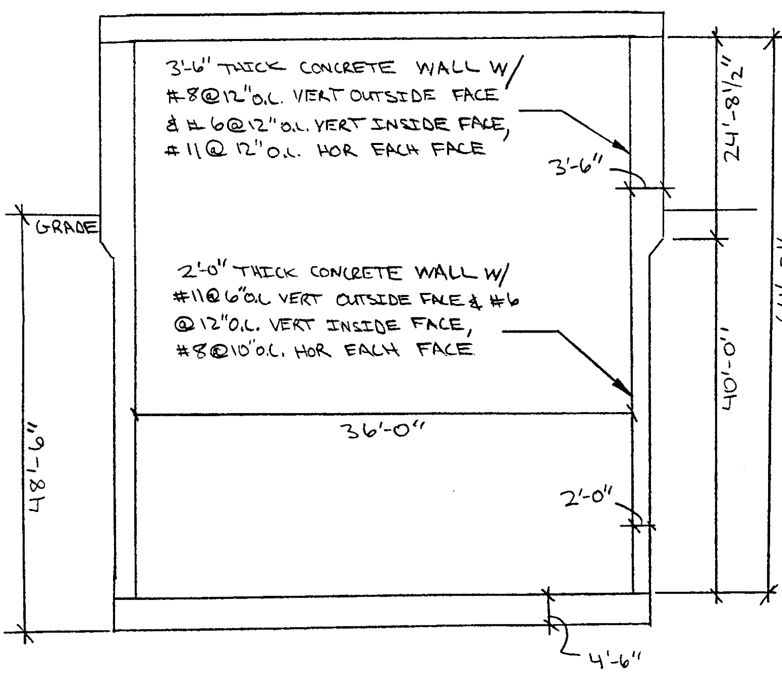
68.0	.00	.000	.00	.000	.0001
67.0	-2.55	.000	-.42	.000	.0001
66.0	-5.10	.000	-.84	.000	.0001
65.0	-7.65	.000	-1.26	.000	.0002
64.0	-10.20	.000	-1.68	-.001	.0002
63.0	-12.75	.000	-2.10	-.001	.0002
62.0	-15.30	.000	-2.52	-.001	.0003
61.0	-17.85	.000	-2.94	-.001	.0003
60.0	-20.40	.000	-3.36	-.002	.0003
59.0	-22.95	.000	-3.78	-.002	.0003
58.0	-25.50	.000	-4.20	-.002	.0003
57.0	-28.05	.000	-4.62	-.002	.0002
56.0	-30.60	.000	-5.04	-.003	.0001
55.0	-33.15	.000	-5.46	-.003	.0000

54.0	-35.71	.000	-5.88	-.002	-.0003
53.0	-38.26	.000	-6.30	-.002	-.0006
52.0	-40.81	.000	-6.72	-.001	-.0010
51.0	-43.36	.000	-7.14	.000	-.0015
50.0	-45.92	.000	-7.56	.002	-.0021
49.0	-48.47	.001	-7.98	.004	-.0028
48.0	-51.02	.001	-8.40	.008	-.0036
47.0	-53.57	.002	-8.82	.012	-.0045
46.0	-56.12	.003	-9.24	.017	-.0054
45.0	-58.67	.004	-9.66	.022	-.0062
44.0	-61.21	.005	-10.08	.029	-.0068
43.0	-63.76	.006	-10.50	.036	-.0072
42.0	-66.29	.007	-10.92	.043	-.0072
41.0	-68.83	.009	-11.34	.050	-.0066
40.0	-71.35	.010	-11.76	.056	-.0052
39.0	-73.87	.010	-12.18	.060	-.0027
38.0	-76.39	.010	-12.60	.061	.0011
37.0	-78.89	.010	-13.02	.057	.0066
36.0	-81.39	.008	-13.44	.047	.0139
35.0	-83.88	.005	-13.86	.029	.0234
34.0	-86.38	.000	-14.28	.000	.0351
33.0	-88.87	-.007	-14.70	-.042	.0493
32.0	-91.36	-.017	-15.12	-.100	.0657
31.0	-93.87	-.030	-15.54	-.174	.0841
30.0	-96.40	-.046	-15.96	-.268	.1038
29.0	-98.96	-.065	-16.38	-.382	.1238
28.0	-101.56	-.088	-16.80	-.516	.1425
27.0	-104.23	-.113	-17.22	-.666	.1580
26.0	-106.97	-.141	-17.64	-.829	.1673
25.0	-109.81	-.170	-18.06	-.998	.1671
24.0	-112.76	-.197	-18.48	-1.159	.1530
23.0	-115.85	-.221	-18.90	-1.297	.1201
22.0	-119.10	-.236	-19.32	-1.391	.0626
21.0	-122.50	-.240	-19.74	-1.412	-.0258
20.0	-126.06	-.226	-20.16	-1.327	-.1515
19.0	-129.78	-.186	-20.58	-1.095	-.3209
18.0	-133.63	-.114	-21.00	-.669	-.5398
17.0	-137.55	.000	-21.42	.003	-.8122
16.0	-141.47	.166	-21.84	.974	-1.1396
15.0	-145.27	.391	-22.26	2.300	-1.5199
14.0	-148.79	.685	-22.68	4.029	-1.9452
13.0	-151.85	1.054	-23.10	6.200	-2.4010
12.0	-154.17	1.502	-23.52	8.833	-2.8634
11.0	-155.47	2.026	-23.94	11.918	-3.2973
10.0	-155.37	2.618	-24.36	15.403	-3.6543
9.0	-153.47	3.261	-24.78	19.180	-3.8708
8.0	-149.34	3.922	-25.20	23.071	-3.8663
7.0	-142.52	4.557	-25.62	26.806	-3.5421
6.0	-132.58	5.102	-26.04	30.010	-2.7822
5.0	-119.15	5.471	-26.46	32.181	-1.4540
4.0	-101.99	5.556	-26.88	32.680	.5874
3.0	-81.05	5.222	-27.30	30.718	3.4931
2.0	-56.56	4.311	-27.72	25.356	7.4109
1.0	-29.16	2.638	-28.14	15.515	12.4715
.0	.00	.000	-28.56	.000	18.7702

BIN #4



SAME AS BIN #3



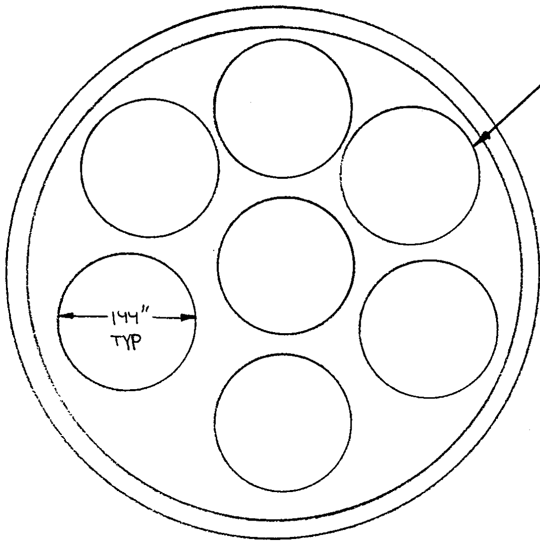
PROPERTIES

REBAR → NOT SPECIFIED
ASSUME f_y = 60ksi

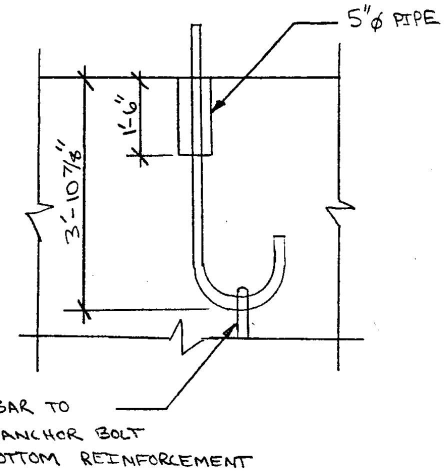
CONCRETE → f_c' = 4000psi

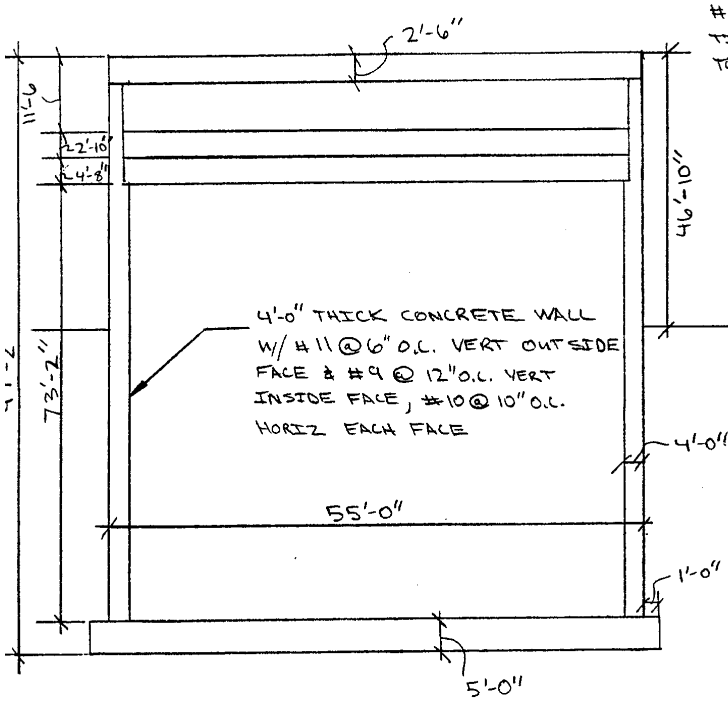
Project Name:	Project #:	Initials:	Date:	Sheet: 106

BIN # 5



ANCHOR BOLTS





PROPERTIES

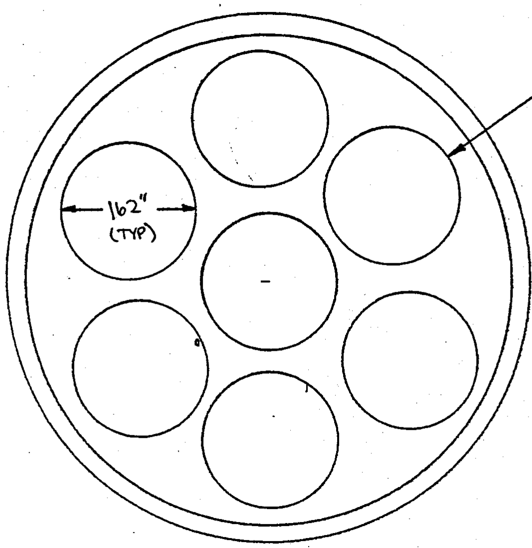
REBAR → NOT SPECIFIED
ASSUME f_y = 60 KSI

CONCRETE → f_c' = 4,000 psi

SAME AS BIN #3

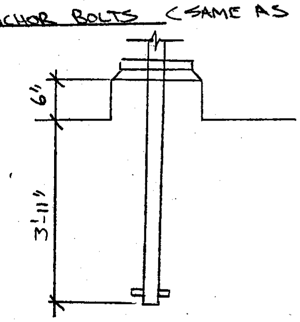
Project Name:	Project #:	Initials:	Date:	Sheet: 107

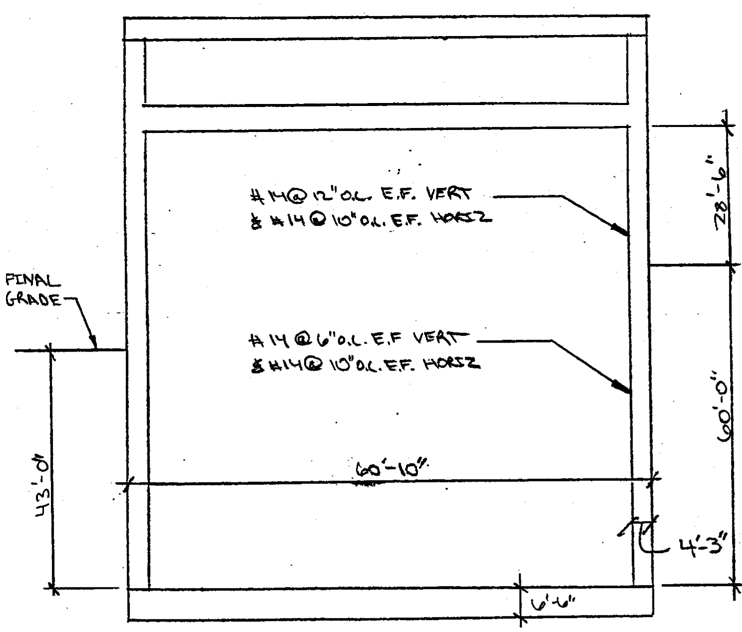
BIN #6 (VAULT #6)



36-3" DIA ANCHOR

ANCHOR BOLTS (SAME AS BIN #7)





PROPERTIES

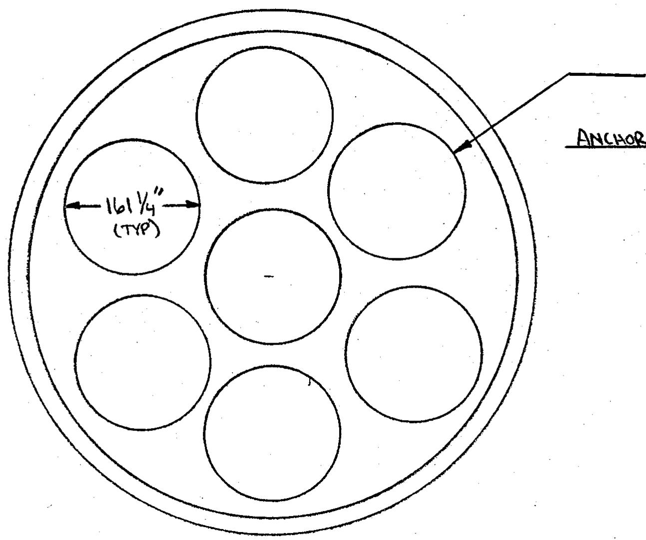
REBAR → NOT SPECIFIED
ASSUME $f_y = 60$ ksi

CONCRETE → NOT SPECIFIED
ASSUME $f_c = 3{,}000$ psi

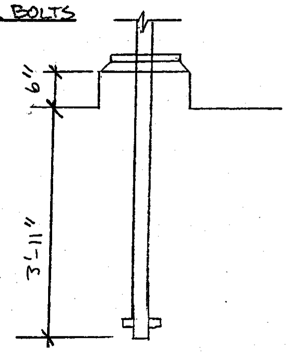
SAME AS BIN #3

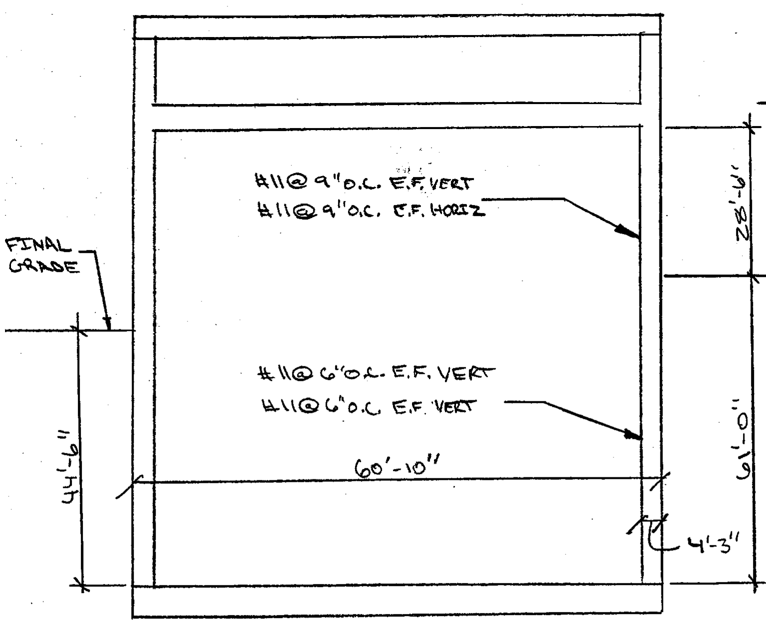
Project Name:	Project #:	Initials:	Date:	Sheet: 108

BIN #7 (VAULT #7)



ANCHOR BOLTS





PROPERTIES

REBAR → NOT SPECIFIED
ASSUME f_y = 60ksi

CONCRETE → NOT SPECIFIED
ASSUME f_c = 3,000psi

SAME AS BIN #3

Project Name:	Project #:	Initials:	Date:	Sheet: 109

ATTACHMENT B

BIN SET INTEGRITY ASSESSMENT - CORROSION

BY

CORROSION CONTROL SPECIALIST INC.

INEEL

BIN SET INTEGRITY ASSESSMENT - CORROSION

PREPARED BY:

CORROSION CONTROL SPECIALIST INC.

JORAM LICHTENSTEIN, Ph.D., P.E.
REGISTERED PROFESSIONAL ENGINEER
N.A.C.E. CERTIFIED CORROSION SPECIALIST

CORROSION SPECIALIST
NACE INTERNATIONAL
JORAM LICHTENSTEIN
507

JULY 2002

JORAM LICHTENSTEIN
No. 102
Corrosion

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INEEL CALCINE BIN SET - CORROSION EVALUATION

JULY 2002

CORROSION CONTROL SPECIALIST INC. was asked to conduct an evaluation of the corrosion propensity of the bin materials. The work was done under Contract with Jason Associates Corporation, Consultant Agreement No. 02-005-2336 Dated July 2002.

The Scope of Services was described as:

> Existing corrosion protection measures will be evaluated as will the tank (bin) systems compatibility with the waste being stored. The effort will also consider possible (as it is assumed any close inspection is not feasible) tank system conditions as a result of corrosion or potential corrosion and, if there is potential for corrosion, what effect it might have on the structural integrity of the system. That is, the analysis should determine if there are suspected or potential corrosion concerns associated with any of the seven (7) bin sets that could cause them to collapse, rupture, or otherwise fail under their current use. The corrosion engineer will make determinations based primarily on the bin set designs (including the materials of construction) and the characteristics of the materials stored. This information will be provided to the corrosion engineer.

Per discussions with the client, it is assumed that this effort will include consideration of moisture entering the vaults in which the bin sets are located. That is, what effect such moisture might have on the bin sets and would the effect be worsened were any of the stored calcine material to reach the moisture. The deliverable for this element will be a short report, signed and stamped (PE) by the corrosion engineer, summarizing the results of the corrosion analysis. The report should summarize the results of the corrosion engineer's analysis and provide a basis for the findings.

The report should identify existing corrosion protection measures incorporated into the bin sets 1 through 7 (based on their designs) and provide a conclusion on the adequacy of those measures. The corrosion engineer will not perform any evaluation as to the structural integrity of the bins or tanks, nor conduct any leak tests, nor determine the structural strength of the tanks. The corrosion engineer will only carry out a corrosion evaluation based on the materials of construction and content of the tanks, based on information received from the Client.

In accordance with the above Scope of Work, the corrosion propensity of the bins have been reviewed based on the information, reference documents, and drawings that were submitted by Jason Associates Corporation. These references are listed at the end of this report. This report was written based on the information received.

As far as could be determined, the only corrosion control measures taken was the metallurgy, or selection of materials, used for the construction of the bins.

From the data submitted, as well as the bin drawings and several of the referenced reports, the primary material of construction is Stainless Steel, type 304, 304L and 405. One report also mentions coupons made of Type 1025 Carbon Steel, but no reference to a bin manufactured of this type of material was found.

The report stated the following materials of construction:

Bin 1 - Type 405 Stainless Steel

Bin 2-4 - Type 304 Stainless Steel

Bin 5-7 - Type 304L Stainless Steel

The following material of construction paragraph was submitted:

"This information is based on document (referenced in the HLW EIS), Calcine Waste Storage at the Idaho Nuclear Technology and Engineering Center (M. D. Staiger, INEEL/EXT-98-00455, June 1999)(Ref. 5) that provides a summary of construction materials and thicknesses for the bin sets. The construction materials identified in this document are as follows:

Bin Set #1: Type 405 stainless steel

Bin Sets 2, 3, and 4: Type 304 stainless steel

Bin Sets 5 and 6: Type 304L stainless steel

(Bin Set 7 is shown in the drawings as Type 304L stainless steel.)"

The materials stored in these bins are of a dry calcine nature, reportedly containing the following elements:

1. Volume: 3,809 m3 Density: 1.48 g/cm3 (weighted average), which includes:

Zr-based calcine:2,291 m3 at 1.65 g/cm3; and

Al-based calcine: 918 m3 at 1.09 g/cm3

2. Sodium Based Waste (SBW) Calcine and Newly Generated Waste Calcine:

Volume: 577 m3 ; Density: 1.2 g/cm3

(Note: The volume of this type calcine was obtained from the total volume of calcine as of May 2000 per the preliminary HLW FEIS - 4,386 m3 - less the HLW Calcine - 3,809 m3)

From a copy of a document of the HWMA/RCRA Partial Closure of the New Waste Calcine Facility (Calciner System) at the INEEL (DOE/ID-10801, April 2002), which has the following (in its Table 1) as the typical constituents of calcine produced in the last Calciner campaign (March through May 2000):

Aluminum (Al) - 33.4% by weight
Oxygen (O) - 33.2%
Sodium (Na) - 17.0%
Calcium (Ca) - 3.7%
Nitrate (NO3) - 3.6%
Potassium (K) - 3.2%
Sulfate (SO4) - 1.5%
Iron (Fe) - 0.6%
Chloride (Cl) - 0.5%
Zirconium (Zr) - 0.3%
Boron (B) - 0.1%
Cadmium (Cd) - 0.1%
Other - 1.9% (includes radio nuclides and trace components such as Hg, Cr, Ni, etc.)

Some of the referenced documents, (such as Ref.3, Table 4-3, Pg.4-4) have similar lists of calcine composition, most without the Chlorides, but since the Chlorides are the most troublesome element, it was considered in this report. The concentration of Chlorides was also stated in Ref.3 and Ref.5. The 0.5% cited above is the "worse-case" condition. From the corrosion evaluation standpoint, the older and newer calcines are similar in their chemical compositions and their effects on the materials of construction.

None of these materials should effect the integrity of the bin materials as long as they are kept dry.

A question was asked about the corrosion propensity of the materials of construction in the postulated event that moisture enters the vaults in which the bins are located. It is assumed that the question relates to calcined material that has spilled over the side of the bins or otherwise has reached the bins exterior surfaces, and adhered to the exterior surfaces, and combines with moisture in the vault.

The main problem that would be of concern is the presence of wet Chlorides (Cl) which might cause pitting type corrosion of the Stainless Steel, primarily the 405 and to some extent the 304, and to a lesser degree the 304L, and might even cause Stress Corrosion Cracking if stresses are involved.

This is a remote postulation, but should be considered. To prevent such occurrence, the wet contaminated surfaces should immediately be washed with clean water to remove all wet calcine deposits. This issue is a hypothetical one, and although cited by Staiger (Ref. 5) it is a highly unlikely event that the contaminated water levels will be high enough to reach the bins, but it must be considered.

Since the type of corrosion expected under such a circumstances is Pitting, there is no accurate way to predict the time to failure, and "Corrosion Allowance" can not be considered as a reliable line of defense in such a case, even though an allowance was designed into the wall thickness of the bins. Although the pitting resistance of Stainless Steels can be calculated, the formula and the index used were developed for aerated (oxidizing) chloride solutions and the pitting factor is applicable primarily to duplex stainless steel. The pitting factor refers to environments containing chloride solutions, which might only be the case if the chloride containing calcine is wet. It is not possible to properly postulate the pitting propensity of the bins materials under such circumstances.

Several coupon sets were installed in the bins for future corrosion evaluation. One of the referenced reports (Ref.1) cited a test conducted on some of the coupons after about 6 years of service.

The coupons were installed in 1966, and some of them were tested in 1973. The average annual corrosion rate for the type 405 Stainless Steel was 0.014 mils and for the type 304 and 304L Stainless Steel it was 0.003 mils. Based on this corrosion rate, and if the rate remains constant, the projected uniform corrosion rate of the bins in 500 years is 7 mils for type 405 and 2 mils for types 304 and 304L. A later report, dated June 1994, (Ref. 7) reached basically the same conclusion that for uniform corrosion, the corrosion rate is minimal for the next 500 years.

The information and conclusions reached in these referenced documents confirms the theoretical conclusion reached in this report. It must be remembered that this corrosion rate refers to uniform corrosion, and is not applicable in the case of pitting corrosion. Coupon corrosion rate is a tool for predicting uniform corrosion and metal loss, but is not applicable to pitting corrosion.

The corrosion rate of the coupons is a good indication that at present time, there is no general corrosion activity effecting the bin materials of construction.

It can be concluded that the integrity of the bins from the uniform corrosion standpoint is sound, and the rate of material losses is negligible. It is recommended, however, that the coupon testing program continues as originally planned, supplemented by visual inspections whenever possible.

Reference Documents:

1. "Corrosion Monitoring of Storage Bins for Radioactive Calcine", Allied Chemical Corp. Oct. 1975 (ICP-1071)
2. "Properties of Radioactive Calcine Retrieved From the Second Calcined Solid Storage Facility at ICPP", Allied Chemicals, March 1979 (ICP-1189)
3. "Inventories and Properties of ICPP Calcined High Level Waste" Westinghouse Idaho Nuclear Co. Feb 1988 (WINCO-1050)
4. "Waste Disposal Options Report" Vol2, INEEL, Feb. 1998 (INEEL/EXT-97-01145)
5. "Calcined Waste Storage at the Idaho Nuclear Technology and Engineering Center" M.D. Staiger, Lockheed Martin, June 1999 (INEEL/EXT-98-00455)
6. "Solids Waste Bins, Specification No. 5775-cpf-p10", Rev. 11-30-60 (AEC Contract AT(10-1)-890
7. "Long Term Laboratory Corrosion Monitoring of Calcine Bin Set Materials Exposed to Zirconia Calcine", WINCO-1219, June1994
8. "Solid Storage Bins Specification No. P-7, CPP-Additional Calcined Waste Storage Facilities", Norman Engineering Co., Dec.11, 1964, AEC Contract AT (10-1) - 1180

CORROSION SPECIALIST NACE INTERNATIONAL JORAM LICHTENSTEIN 507

Respectfully Submitted,

JORAM LICHTENSTEIN No. 102 Corrosion

Joram Lichtenstein, Ph.D. P.E. 7/31/02

CORROSION CONTROL SPECIALIST INC.

ATTACHMENT C

TELEPHONE LOG

Jason Associates Corporation

TELEPHONE LOG,

Date of Telephone Conversation: September 26, 2002
Time of Telephone Conversation: Afternoon
Topic of Discussion: Date of Fabrication for Bins in Bin Sets #6 and #7
Related Action Tracking Number (if any):

Jason Representative for Telephone Call: Keith D. Davis, P.E.

Personnel Involved in Telephone Conversation	Company/Organization Representing
Mr. Mike Swenson (208-526-3576)	INEEL

Summary of Conversation: Mr. Swenson was contacted earlier with regard to the dates of fabrication for the bins in Bin Sets #6 and #7. These fabrication dates were not contained in the reference (Staiger 1999) from which fabrication dates for the other bins were obtained. When asked if he could obtain the needed dates, Mr. Swenson said he would try and would get back to me. On September 26, 2002, he called me to provide information.

Mr. Swenson indicated he located a drawing from the Mason Steel company of the bins in Bin Set #6. The drawing was labeled Revision 3 and shown as "as-built" on the latest date on the drawing, which was March 21, 1983. Based on the drawing information, Mr. Swenson said it appears that 1983 would be the appropriate date of fabrication for the bins in Bin Set #6.

Mr. Swenson indicated he was unable to locate similar information for Bin Set #7, but he was able to locate design drawings for the Bin Set that were dated April 1985. His guess is that the bins would have been fabricated sometime (maybe 6 to 18 months) afterward. Accordingly, he would assume a fabrication date of 1985 or 1986. Mr. Swenson also said I could probably get a better answer for Bin Set #7 by contacting Mr. Roben Aeschbacher (208-526-9693) who manages engineering design drawings at INTEC. He thought Mr. Aeschbacher would be able to easily call up electronic records based on the vessel numbers that would provide fabrication dates.

Actions Items Stemming from Telephone Conversation	Responsibility
Call Mr. Aeschbacher for fabrication date of the bins in Bin Set #7	Keith Davis, Jason Associates

RCRA PART B PERMIT REAPPLICATION

FOR THE
IDAHO NATIONAL LABORATORY

VOLUME 22
IDAHO NUCLEAR TECHNOLOGY & ENGINEERING CENTER

CALCINED SOLIDS STORAGE FACILITY

APPENDIX 3

REPRESENTATIVE CALCINE SAMPLE ANALYTICAL DATA

MAY 2016

Al Calcine VOC Representative Analytical Data

Field Sample ID	Lab Sample ID	Type	Analysis	CAS Number	Compound	Result	Units	Lab Flag	Validator Flag
CAL0011301TV	3AZ44	ORG	(TCLP VOC)	71-43-2	Benzene	10	UG/L	UHZ	R
CAL0011301TV	3AZ44	ORG	(TCLP VOC)	78-93-3	2-Butanone	10	UG/L	UH	R
CAL0011301TV	3AZ44	ORG	(TCLP VOC)	56-23-5	Carbon tetrachloride	10	UG/L	UH	R
CAL0011301TV	3AZ44	ORG	(TCLP VOC)	108-90-7	Chlorobenzene	10	UG/L	UH	R
CAL0011301TV	3AZ44	ORG	(TCLP VOC)	67-66-3	Chloroform	10	UG/L	UH	R
CAL0011301TV	3AZ44	ORG	(TCLP VOC)	75-35-4	1,1-Dichloroethene	10	UG/L	UHZ	R
CAL0011301TV	3AZ44	ORG	(TCLP VOC)	107-06-2	1,2-Dichloroethane	10	UG/L	UH	R
CAL0011301TV	3AZ44	ORG	(TCLP VOC)	127-18-4	Tetrachloroethene	10	UG/L	UH	R
CAL0011301TV	3AZ44	ORG	(TCLP VOC)	79-01-6	Trichloroethene	10	UG/L	UHZ	R
CAL0011301TV	3AZ44	ORG	(TCLP VOC)	75-01-4	Vinyl Chloride	10	UG/L	UH	R

Al Calcine Total VOC Representative Analytical Data

Field Sample ID	Lab Sample ID	Type	ANALYSIS	CAS Number	Compound	Result	Units	Lab Flag	Validator Flag
CAL0012001VG	3AZ51	ORG	(VOC)	71-55-6	1,1,1-Trichloroethane	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	79-34-5	1,1,2,2-Tetrachloroethane	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	79-00-5	1,1,2-Trichloroethane	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	75-34-3	1,1-Dichloroethane	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	75-35-4	1,1-Dichloroethene	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	107-06-2	1,2-Dichloroethane	10	UG/KG	UMH	R
CAL0012001VG	3AZ51	ORG	(VOC)	78-87-5	1,2-Dichloropropane	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	78-93-3	2-Butanone	10	UG/KG	UMH	R
CAL0012001VG	3AZ51	ORG	(VOC)	591-78-6	2-Hexanone	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	108-10-1	4-Methyl-2-pentanone	27	UG/KG	H	J
CAL0012001VG	3AZ51	ORG	(VOC)	67-64-1	Acetone	10	UG/KG	UHZ	R
CAL0012001VG	3AZ51	ORG	(VOC)	71-43-2	Benzene	20	UG/KG	UHZ	R
CAL0012001VG	3AZ51	ORG	(VOC)	75-27-4	Bromodichloromethane	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	75-25-2	Bromoform	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	74-83-9	Bromomethane	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	75-15-0	Carbon disulfide	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	56-23-5	Carbon tetrachloride	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	108-90-7	Chlorobenzene	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	75-00-3	Chloroethane	10	UG/KG	UMH	R
CAL0012001VG	3AZ51	ORG	(VOC)	67-66-3	Chloroform	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	74-87-3	Chloromethane	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	156-59-2	cis-1,2-Dichloroethene	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	10061-01-5	cis-1,3-Dichloropropene	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	124-48-1	Dibromochloromethane	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	100-41-4	Ethylbenzene	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	75-09-2	Methylene Chloride	20	UG/KG	UHZ	R
CAL0012001VG	3AZ51	ORG	(VOC)	95-47-6	o-Xylene	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	100-42-5	Styrene	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	127-18-4	Tetrachloroethene	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	108-88-3	Toluene	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	156-60-5	trans-1,2-Dichloroethene	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	10061-02-6	trans-1,3-Dichloropropene	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	79-01-6	Trichloroethene	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	75-69-4	Trichlorofluoromethane	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	75-01-4	Vinyl Chloride	10	UG/KG	UH	R
CAL0012001VG	3AZ51	ORG	(VOC)	1330-20-7	Xylene, Isomers m&p	20	UG/KG	UH	R

Al Calcine SVOC Representative Analytical Data

Field Sample ID	Lab Sample ID	Type	Analysis	CAS Number	Compound	Result	Units	Lab Flag	Validator Flag
CAL0011301TA	3AZ44	ORG	(TCLP SVOC)	106-46-7	1,4-Dichlorobenzene	10	UG/L	UHZ	R
CAL0011301TA	3AZ44	ORG	(TCLP SVOC)	121-14-2	2,4-Dinitrotoluene	10	UG/L	UHZ	R
CAL0011301TA	3AZ44	ORG	(TCLP SVOC)	118-74-1	Hexachlorobenzene	10	UG/L	UH	R
CAL0011301TA	3AZ44	ORG	(TCLP SVOC)	87-68-3	Hexachlorobutadiene	10	UG/L	UH	R
CAL0011301TA	3AZ44	ORG	(TCLP SVOC)	67-72-1	Hexachloroethane	10	UG/L	UH	R
CAL0011301TA	3AZ44	ORG	(TCLP SVOC)	95-48-7	2-Methylphenol (o-Cresol)	10	UG/L	UH	R
CAL0011301TA	3AZ44	ORG	(TCLP SVOC)	*3&4-METHYLPHENOL	3&4-methylphenol	20	UG/L	UH	R
CAL0011301TA	3AZ44	ORG	(TCLP SVOC)	98-95-3	Nitrobenzene	10	UG/L	UH	R
CAL0011301TA	3AZ44	ORG	(TCLP SVOC)	87-86-5	Pentachlorophenol	10	UG/L	UHZ	R
CAL0011301TA	3AZ44	ORG	(TCLP SVOC)	95-95-4	2,4,5-Trichlorophenol	10	UG/L	UH	R
CAL0011301TA	3AZ44	ORG	(TCLP SVOC)	88-06-2	2,4,6-Trichlorophenol	10	UG/L	UH	R

Al Calcine Total SVOC Representative Analytical Data

Field Sample ID	Lab Sample ID	Type	Analysis	CAS Number	Compound	Result	Units	Lab Flag	Validator Flag
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	83-32-9	Acenaphthene	200	UG/KG	UHZ	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	208-96-8	Acenaphthylene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	120-12-7	Anthracene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	103-33-3	Azobenzene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	56-55-3	Benzo(a)anthracene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	205-99-2	Benzo(b)fluoranthene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	207-08-9	Benzo(k)fluoranthene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	191-24-2	Benzo(g,h,i)perylene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	50-32-8	Benzo(a)pyrene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	111-91-1	Bis-(2-chloroethoxy)methane	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	111-44-4	bis-(2-Chloroethyl)ether	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	108-60-1	bis(2-Chloroisopropyl)ether	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	117-81-7	bis-(2-ethylhexyl)phthalate	1000	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	101-55-3	4-Bromophenyl phenyl ether	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	85-68-7	Benzyl butyl phthalate	600	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	86-74-8	Carbazole	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	106-47-8	4-Chloroaniline	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	59-50-7	4-Chloro-3-methylphenol	200	UG/KG	UHZ	R
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	91-58-7	2-Chloronaphthalene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	95-57-8	2-Chlorophenol	200	UG/KG	UHZ	R
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	7005-72-3	4-Chlorophenyl phenyl ether	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	218-01-9	Chrysene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	53-70-3	Dibenzo(a,h)anthracene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	132-64-9	Dibenzofuran	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	84-74-2	Di-n-butyl phthalate	800	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	95-50-1	1,2-Dichlorobenzene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	541-73-1	1,3-Dichlorobenzene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	106-46-7	1,4-Dichlorobenzene	200	UG/KG	UHZ	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	91-94-1	3,3'-Dichlorobenzidine	600	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	120-83-2	2,4-Dichlorophenol	200	UG/KG	UH	R
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	84-66-2	Diethyl Phthalate	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	105-67-9	2,4-Dimethylphenol	400	UG/KG	UH	R
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	131-11-3	Dimethyl phthalate	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	534-52-1	4,6-Dinitro-2-methylphenol	400	UG/KG	UH	R
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	51-28-5	2,4-Dinitrophenol	400	UG/KG	UH	R
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	121-14-2	2,4-Dinitrotoluene	200	UG/KG	UHZ	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	606-20-2	2,6-Dinitrotoluene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	117-84-0	Di-n-octyl phthalate	400	UG/KG	UH	UJ

CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	206-44-0	Fluoranthene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	86-73-7	Fluorene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	118-74-1	Hexachlorobenzene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	87-68-3	Hexachlorobutadiene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	77-47-4	Hexachlorocyclopentadiene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	67-72-1	Hexachloroethane	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	193-39-5	Indeno(1,2,3-cd)pyrene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	78-59-1	Isophorone	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	91-57-6	2-Methylnaphthalene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	95-48-7	2-Methylphenol (o-Cresol)	200	UG/KG	UH	R
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	*3&4-METHYLPHENOL	3&4-methylphenol	400	UG/KG	UH	R
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	91-20-3	Naphthalene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	88-74-4	2-Nitroaniline	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	99-09-2	3-Nitroaniline	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	100-01-6	4-Nitroaniline	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	98-95-3	Nitrobenzene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	88-75-5	2-Nitrophenol	200	UG/KG	UH	R
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	100-02-7	4-Nitrophenol	400	UG/KG	UH	R
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	62-75-9	n-Nitrosodimethylamine	400	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	86-30-6	n-Nitrosodiphenylamine	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	621-64-7	n-Nitrosodi-n-propylamine	200	UG/KG	UHZ	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	87-86-5	Pentachlorophenol	200	UG/KG	UHZ	R
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	85-01-8	Phenanthrene	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	108-95-2	Phenol	200	UG/KG	UHZ	R
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	129-00-0	Pyrene	400	UG/KG	UHZ	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	110-86-1	Pyridine	400	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	126-73-8	tri-n-butyl phosphate	200	UG/KG	UH	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	120-82-1	1,2,4-Trichlorobenzene	200	UG/KG	UHZ	UJ
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	95-95-4	2,4,5-Trichlorophenol	200	UG/KG	UH	R
CAL0011301SV	3AZ44RA	ORG	(SEMIVOLATILE)	88-06-2	2,4,6-Trichlorophenol	200	UG/KG	UH	R

H3 Calcine Metals Representative Analytical Data

Field Sample ID	Lab Sample ID	Type	Analysis	CAS Number	Analyte	Result	Units	Concentration Qualifier	Lab Flag	Validation Flag
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7429-90-5	Aluminum	4.13E+04	UG/L			
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7440-36-0	Antimony	4.20E+02	UG/L	U		
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7440-38-2	Arsenic	5.30E+02	UG/L	U		
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7440-39-3	Barium	5.30E+02	UG/L	B		
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7440-41-7	Beryllium	1.00E+01	UG/L	U		
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7440-43-9	Cadmium	5.00E+04	UG/L			
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7440-70-2	Calcium	6.28E+05	UG/L	B	D	
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7440-47-3	Chromium	9.33E+03	UG/L			
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7440-48-4	Cobalt	1.00E+02	UG/L	U		
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7440-50-8	Copper	1.60E+02	UG/L	U		
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7439-89-6	Iron	5.70E+02	UG/L	B		U
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7439-92-1	Lead	3.70E+02	UG/L	U		
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7439-95-4	Magnesium	5.78E+03	UG/L	B		
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7439-96-5	Manganese	6.00E+01	UG/L	B		U
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7439-97-6	Mercury	2.70E+01	UG/L	B	N	J
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7439-98-7	Molybdenum	4.20E+02	UG/L	B		
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7440-02-0	Nickel	2.20E+02	UG/L	B		U
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7440-09-7	Potassium	3.04E+05	UG/L	B		
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7782-49-2	Selenium	3.50E+02	UG/L	U		
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7440-22-4	Silver	3.20E+02	UG/L	U	N	R
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7440-23-5	Sodium	1.23E+06	UG/L	B	D	
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7440-28-0	Thallium	4.90E+02	UG/L	U		
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7440-62-2	Vanadium	1.60E+02	UG/L	B		
CAL0011201TI	3AY20	INORG	(TCLP METALS)	7440-66-6	Zinc	1.90E+02	UG/L	B		U

H3 Calcine Total Metals Representative Analytical Data

Field Sample ID	Lab Sample ID	Type	Analysis	CAS Number	Analyte	Result	Units	Concentration Qualifier	Lab Flag	Validation Flag
CAL0011201XM	3AY20	INORG	(METALS)	7429-90-5	Aluminum	1.35E+05	MG/KG			
CAL0011201XM	3AY20	INORG	(METALS)	7440-36-0	Antimony	3.93E+01	MG/KG	U		
CAL0011201XM	3AY20	INORG	(METALS)	7440-38-2	Arsenic	4.95E+01	MG/KG	U		
CAL0011201XM	3AY20	INORG	(METALS)	7440-39-3	Barium	1.15E+02	MG/KG	B		
CAL0011201XM	3AY20	INORG	(METALS)	7440-41-7	Beryllium	9.30E-01	MG/KG	B		U
CAL0011201XM	3AY20	INORG	(METALS)	7440-43-9	Cadmium	2.93E+04	MG/KG			
CAL0011201XM	3AY20	INORG	(METALS)	7440-70-2	Calcium	2.19E+05	MG/KG			
CAL0011201XM	3AY20	INORG	(METALS)	7440-47-3	Chromium	9.94E+02	MG/KG			
CAL0011201XM	3AY20	INORG	(METALS)	7440-48-4	Cobalt	9.30E-00	MG/KG	U		
CAL0011201XM	3AY20	INORG	(METALS)	7440-50-8	Copper	1.24E+02	MG/KG	B		U
CAL0011201XM	3AY20	INORG	(METALS)	7439-89-6	Iron	2.08E+03	MG/KG			
CAL0011201XM	3AY20	INORG	(METALS)	7439-92-1	Lead	2.18E+02	MG/KG			
CAL0011201XM	3AY20	INORG	(METALS)	7439-95-4	Magnesium	4.67E+03	MG/KG	B		
CAL0011201XM	3AY20	INORG	(METALS)	7439-96-5	Manganese	8.14E+02	MG/KG			
CAL0011201XM	3AY20	INORG	(METALS)	7439-97-6	Mercury	2.30E-00	MG/KG	U	D	UJ
CAL0011201XM	3AY20	INORG	(METALS)	7439-98-7	Molybdenum	3.08E+02	MG/KG			
CAL0011201XM	3AY20	INORG	(METALS)	7440-02-0	Nickel	4.66E+02	MG/KG			
CAL0011201XM	3AY20	INORG	(METALS)	7440-09-7	Potassium	4.93E+03	MG/KG	B	N	J
CAL0011201XM	3AY20	INORG	(METALS)	7782-49-2	Selenium	3.37E+01	MG/KG	U		
CAL0011201XM	3AY20	INORG	(METALS)	7440-22-4	Silver	3.08E+01	MG/KG	U	N	UJ
CAL0011201XM	3AY20	INORG	(METALS)	7440-23-5	Sodium	2.12E+04	MG/KG	B		
CAL0011201XM	3AY20	INORG	(METALS)	7440-28-0	Thallium	4.71E+01	MG/KG	U		
CAL0011201XM	3AY20	INORG	(METALS)	7440-62-2	Vanadium	1.40E+01	MG/KG	U		
CAL0011201XM	3AY20	INORG	(METALS)	7440-66-6	Zinc	6.06E+01	MG/KG	B		U

H3 Calcine VOC Representative Analytical Data

Field Sample ID	Lab Sample ID	Type	Analysis	CAS Number	Compound	Result	Units	Lab Flag	Validator Flag
CAL0010501TV	3AY21	ORG	(TCLP VOC)	75-35-4	1,1-Dichloroethene	50	UG/L	UD	
CAL0010501TV	3AY21	ORG	(TCLP VOC)	107-06-2	1,2-Dichloroethane	50	UG/L	UMD	
CAL0010501TV	3AY21	ORG	(TCLP VOC)	78-93-3	2-Butanone	50	UG/L	UD	
CAL0010501TV	3AY21	ORG	(TCLP VOC)	71-43-2	Benzene	50	UG/L	UD	
CAL0010501TV	3AY21	ORG	(TCLP VOC)	56-23-5	Carbon tetrachloride	50	UG/L	UD	
CAL0010501TV	3AY21	ORG	(TCLP VOC)	108-90-7	Chlorobenzene	50	UG/L	UD	
CAL0010501TV	3AY21	ORG	(TCLP VOC)	67-66-3	Chloroform	50	UG/L	UD	
CAL0010501TV	3AY21	ORG	(TCLP VOC)	127-18-4	Tetrachloroethene	50	UG/L	UD	
CAL0010501TV	3AY21	ORG	(TCLP VOC)	79-01-6	Trichloroethene	50	UG/L	UD	
CAL0010501TV	3AY21	ORG	(TCLP VOC)	75-01-4	Vinyl Chloride	50	UG/L	UD	

H3 Calcine Total VOC Representative Analytical Data

Field Sample ID	Lab Sample ID	Type	Analysis	CAS Number	Compound	Result	Units	Lab Flag	Validator Flag
CAL0010801VG	3AY24RERE	ORG	(VOC)	71-55-6	1,1,1-Trichloroethane	10	UG/KG	UH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	79-34-5	1,1,2,2-Tetrachloroethane	10	UG/KG	UMH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	10	UG/KG	UHZ	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	79-00-5	1,1,2-Trichloroethane	10	UG/KG	UH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	75-34-3	1,1-Dichloroethane	10	UG/KG	UH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	75-35-4	1,1-Dichloroethene	10	UG/KG	UH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	107-06-2	1,2-Dichloroethane	10	UG/KG	UMH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	78-87-5	1,2-Dichloropropane	10	UG/KG	UH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	78-93-3	2-Butanone	10	UG/KG	UMH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	591-78-6	2-Hexanone	10	UG/KG	UMH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	108-10-1	4-Methyl-2-pentanone	260	UG/KG	JMHE	J
CAL0010801VG	3AY24RERE	ORG	(VOC)	67-64-1	Acetone	66	UG/KG	JBHZ	U
CAL0010801VG	3AY24RERE	ORG	(VOC)	71-43-2	Benzene	20	UG/KG	UHZ	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	75-27-4	Bromodichloromethane	10	UG/KG	UH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	75-25-2	Bromoform	10	UG/KG	UMH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	74-83-9	Bromomethane	10	UG/KG	UMH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	75-15-0	Carbon disulfide	10	UG/KG	UH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	56-23-5	Carbon tetrachloride	10	UG/KG	UMH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	108-90-7	Chlorobenzene	10	UG/KG	UMH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	75-00-3	Chloroethane	10	UG/KG	UH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	67-66-3	Chloroform	10	UG/KG	UH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	74-87-3	Chloromethane	10	UG/KG	JBH	U
CAL0010801VG	3AY24RERE	ORG	(VOC)	156-59-2	cis-1,2-Dichloroethene	10	UG/KG	UH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	10061-01-5	cis-1,3-Dichloropropene	10	UG/KG	UH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	124-48-1	Dibromochloromethane	10	UG/KG	UH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	100-41-4	Ethylbenzene	10	UG/KG	UMH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	75-09-2	Methylene Chloride	20	UG/KG	UHZ	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	95-47-6	o-Xylene	10	UG/KG	UMH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	100-42-5	Styrene	10	UG/KG	UMH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	127-18-4	Tetrachloroethene	10	UG/KG	UH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	108-88-3	Toluene	10	UG/KG	UH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	156-60-5	trans-1,2-Dichloroethene	10	UG/KG	UH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	10061-02-6	trans-1,3-Dichloropropene	10	UG/KG	UH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	79-01-6	Trichloroethene	10	UG/KG	UH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	75-69-4	Trichlorofluoromethane	10	UG/KG	UH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	75-01-4	Vinyl Chloride	10	UG/KG	UH	R
CAL0010801VG	3AY24RERE	ORG	(VOC)	1330-20-7	Xylene, Isomers m&p	20	UG/KG	UH	R

H3 Calcine SVOC Representative Analytical Data

Field Sample ID	Lab Sample ID	Type	Analysis	CAS Number	Compound	Result	Units	Lab Flag	Validator Flag
CAL0010501TA	3AY21	ORG	(TCLP SVOC)	106-46-7	1,4-Dichlorobenzene	10	UG/L	U	
CAL0010501TA	3AY21	ORG	(TCLP SVOC)	95-95-4	2,4,5-Trichlorophenol	10	UG/L	U	
CAL0010501TA	3AY21	ORG	(TCLP SVOC)	88-06-2	2,4,6-Trichlorophenol	10	UG/L	U	
CAL0010501TA	3AY21	ORG	(TCLP SVOC)	121-14-2	2,4-Dinitrotoluene	10	UG/L	U	
CAL0010501TA	3AY21	ORG	(TCLP SVOC)	95-48-7	2-Methylphenol (o-Cresol)	10	UG/L	U	
CAL0010501TA	3AY21	ORG	(TCLP SVOC)	*3&4-METHYLPHENOL	3&4-methylphenol	20	UG/L	U	
CAL0010501TA	3AY21	ORG	(TCLP SVOC)	118-74-1	Hexachlorobenzene	20	UG/L	U	
CAL0010501TA	3AY21	ORG	(TCLP SVOC)	87-68-3	Hexachlorobutadiene	10	UG/L	U	
CAL0010501TA	3AY21	ORG	(TCLP SVOC)	67-72-1	Hexachloroethane	10	UG/L	U	
CAL0010501TA	3AY21	ORG	(TCLP SVOC)	98-95-3	Nitrobenzene	10	UG/L	U	
CAL0010501TA	3AY21	ORG	(TCLP SVOC)	87-86-5	Pentachlorophenol	10	UG/L	U	

H3 Calcine Total SVOC Representative Analytical Data

Field Sample ID	Lab Sample ID	Type	Analysis	CAS Number	Compound	Result	Units	Lab Flag	Validator Flag
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	120-82-1	1,2,4-Trichlorobenzene	200	UG/KG	UZ	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	95-50-1	1,2-Dichlorobenzene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	541-73-1	1,3-Dichlorobenzene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	106-46-7	1,4-Dichlorobenzene	200	UG/KG	UZ	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	95-95-4	2,4,5-Trichlorophenol	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	88-06-2	2,4,6-Trichlorophenol	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	120-83-2	2,4-Dichlorophenol	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	105-67-9	2,4-Dimethylphenol	400	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	51-28-5	2,4-Dinitrophenol	400	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	121-14-2	2,4-Dinitrotoluene	200	UG/KG	UZ	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	606-20-2	2,6-Dinitrotoluene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	91-58-7	2-Chloronaphthalene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	95-57-8	2-Chlorophenol	200	UG/KG	UZ	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	91-57-6	2-Methylnaphthalene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	95-48-7	2-Methylphenol (o-Cresol)	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	88-74-4	2-Nitroaniline	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	88-75-5	2-Nitrophenol	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	*3&4-METHYLPHENOL	3&4-methylphenol	400	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	91-94-1	3,3'-Dichlorobenzidine	600	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	99-09-2	3-Nitroaniline	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	534-52-1	4,6-Dinitro-2-methylphenol	400	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	101-55-3	4-Bromophenyl phenyl ether	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	59-50-7	4-Chloro-3-methylphenol	200	UG/KG	UZ	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	106-47-8	4-Chloroaniline	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	7005-72-3	4-Chlorophenyl phenyl ether	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	100-01-6	4-Nitroaniline	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	100-02-7	4-Nitrophenol	400	UG/KG	UZ	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	83-32-9	Acenaphthene	200	UG/KG	UZ	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	208-96-8	Acenaphthylene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	120-12-7	Anthracene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	103-33-3	Azobenzene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	56-55-3	Benzo(a)anthracene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	50-32-8	Benzo(a)pyrene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	205-99-2	Benzo(b)fluoranthene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	191-24-2	Benzo(g,h,i)perylene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	207-08-9	Benzo(k)fluoranthene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	85-68-7	Benzyl butyl phthalate	600	UG/KG	U	R

CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	111-91-1	bis-(2-chloroethoxy)methane	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	111-44-4	Bis-(2-Chloroethyl)ether	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	108-60-1	bis(2-Chloroisopropyl)ether	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	117-81-7	bis-(2-ethylhexyl)phthalate	1000	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	86-74-8	Carbazole	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	218-01-9	Chrysene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	53-70-3	Dibenzo(a,h)anthracene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	132-64-9	Dibenzofuran	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	84-66-2	Diethyl Phthalate	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	131-11-3	Dimethyl phthalate	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	84-74-2	Di-n-butyl phthalate	800	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	117-84-0	Di-n-octyl phthalate	400	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	206-44-0	Fluoranthene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	86-73-7	Fluorene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	118-74-1	Hexachlorobenzene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	87-68-3	Hexachlorobutadiene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	77-47-4	Hexachlorocyclopentadiene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	67-72-1	Hexachloroethane	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	193-39-5	Indeno(1,2,3-cd)pyrene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	78-59-1	Isophorone	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	91-20-3	Naphthalene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	98-95-3	Nitrobenzene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	62-75-9	n-Nitrosodimethylamine	400	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	621-64-7	n-Nitrosodi-n-propylamine	200	UG/KG	UZ	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	86-30-6	n-Nitrosodiphenylamine	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	87-86-5	Pentachlorophenol	200	UG/KG	UZ	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	85-01-8	Phenanthrene	200	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	108-95-2	Phenol	200	UG/KG	UZ	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	129-00-0	Pyrene	400	UG/KG	UZ	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	110-86-1	Pyridine	400	UG/KG	U	R
CAL0010501SV	3AY21	ORG	(SEMIVOLATILE)	126-73-8	tri-n-butyl phosphate	200	UG/KG	U	R

Zr Calcine Metals Representative Analytical Data

Field Sample ID	Lab Sample ID	Type	Analysis	CAS Number	Analyte	Result	Units	Concentration Qualifier	Lab Flag	Validation Flag
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7429-90-5	Aluminum	6.24E+04	UG/L			
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7440-36-0	Antimony	6.56E+02	UG/L	U		
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7440-38-2	Arsenic	4.75E+02	UG/L	U		
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7440-39-3	Barium	9.60E+02	UG/L	B		
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7440-41-7	Beryllium	2.02E+01	UG/L	U		UJ
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7440-43-9	Cadmium	7.07E+01	UG/L	B		
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7440-70-2	Calcium	9.00E+05	UG/L			
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7440-47-3	Chromium	6.93E+03	UG/L			
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7440-48-4	Cobalt	1.01E+02	UG/L	U		
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7440-50-8	Copper	1.52E+02	UG/L	U		
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7439-89-6	Iron	3.84E+02	UG/L	B		U
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7439-92-1	Lead	3.74E+02	UG/L	U		
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7439-95-4	Magnesium	7.30E+04	UG/L	B		
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7439-96-5	Manganese	2.52E+02	UG/L	B		
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7439-97-6	Mercury	4.52E+02	UG/L			R
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7439-98-7	Molybdenum	4.04E+02	UG/L	U		
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7440-02-0	Nickel	2.42E+02	UG/L	B		
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7440-09-7	Potassium	2.03E+04	UG/L	B		
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7782-49-2	Selenium	4.95E+02	UG/L	U		
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7440-22-4	Silver	1.62E+02	UG/L	U		
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7440-23-5	Sodium	1.30E+05	UG/L	B		
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7440-28-0	Thallium	4.95E+02	UG/L	U		UJ
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7440-62-2	Vanadium	2.83E+02	UG/L	U		
CAL0012101TI	3AZ65	INORG	(TCLP METALS)	7440-66-6	Zinc	1.01E+03	UG/L	B		
CAL0012501TI	3AZ69	INORG	(TCLP METALS)	7429-90-5	Aluminum	4.11E+04	UG/L			
CAL0012501TI	3AZ69	INORG	(TCLP METALS)	7440-36-0	Antimony	6.56E+02	UG/L	U		
CAL0012501TI	3AZ69	INORG	(TCLP METALS)	7440-38-2	Arsenic	4.75E+02	UG/L	U		

Zr Calcine VOC Representative Analytical Data

Field Sample ID	Lab Sample ID	Type	Analysis	CAS Number	Compound	Result	Units	Lab Flag	Validator Flag
CAL0012101TV	3AZ65	ORG	(TCLP VOC)	71-43-2	Benzene	10	UG/L	UHZ	R
CAL0012101TV	3AZ65	ORG	(TCLP VOC)	78-93-3	2-Butanone	10	UG/L	UH	R
CAL0012101TV	3AZ65	ORG	(TCLP VOC)	56-23-5	Carbon tetrachloride	10	UG/L	UH	R
CAL0012101TV	3AZ65	ORG	(TCLP VOC)	108-90-7	Chlorobenzene	10	UG/L	UH	R
CAL0012101TV	3AZ65	ORG	(TCLP VOC)	67-66-3	Chloroform	10	UG/L	UH	R
CAL0012101TV	3AZ65	ORG	(TCLP VOC)	75-35-4	1,1-Dichloroethene	10	UG/L	UHZ	R
CAL0012101TV	3AZ65	ORG	(TCLP VOC)	107-06-2	1,2-Dichloroethane	10	UG/L	UH	R
CAL0012101TV	3AZ65	ORG	(TCLP VOC)	127-18-4	Tetrachloroethene	10	UG/L	UH	R
CAL0012101TV	3AZ65	ORG	(TCLP VOC)	79-01-6	Trichloroethene	10	UG/L	UHZ	R
CAL0012101TV	3AZ65	ORG	(TCLP VOC)	75-01-4	Vinyl Chloride	10	UG/L	UH	R

Zr Calcine Total VOC Representative Analytical Data

Field Sample ID	Lab Sample ID	Type	Analysis	CAS Number	Compound	Result	Units	Lab Flag	Validator Flag
CAL0012201VG	3AZ66	ORG	(VOC)	71-55-6	1,1,1-Trichloroethane	10	UG/KG	UH	R
CAL0012201VG	3AZ66	ORG	(VOC)	79-34-5	1,1,2,2-Tetrachloroethane	10	UG/KG	UMH	R
CAL0012201VG	3AZ66	ORG	(VOC)	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	10	UG/KG	UHZ	R
CAL0012201VG	3AZ66	ORG	(VOC)	79-00-5	1,1,2-Trichloroethane	10	UG/KG	UH	R
CAL0012201VG	3AZ66	ORG	(VOC)	75-34-3	1,1-Dichloroethane	10	UG/KG	UH	R
CAL0012201VG	3AZ66	ORG	(VOC)	75-35-4	1,1-Dichloroethene	10	UG/KG	UH	R
CAL0012201VG	3AZ66	ORG	(VOC)	107-06-2	1,2-Dichloroethane	10	UG/KG	UMH	R
CAL0012201VG	3AZ66	ORG	(VOC)	78-87-5	1,2-Dichloropropane	10	UG/KG	UH	R
CAL0012201VG	3AZ66	ORG	(VOC)	78-93-3	2-Butanone	10	UG/KG	UMH	R
CAL0012201VG	3AZ66	ORG	(VOC)	591-78-6	2-Hexanone	10	UG/KG	UMH	R
CAL0012201VG	3AZ66	ORG	(VOC)	108-10-1	4-Methyl-2-pentanone	10	UG/KG	UMH	R
CAL0012201VG	3AZ66	ORG	(VOC)	67-64-1	Acetone	100	UG/KG	JBHEZ	U
CAL0012201VG	3AZ66	ORG	(VOC)	71-43-2	Benzene	20	UG/KG	UHZ	R
CAL0012201VG	3AZ66	ORG	(VOC)	75-27-4	Bromodichloromethane	10	UG/KG	UH	R
CAL0012201VG	3AZ66	ORG	(VOC)	75-25-2	Bromoform	10	UG/KG	UMH	R
CAL0012201VG	3AZ66	ORG	(VOC)	74-83-9	Bromomethane	10	UG/KG	UMH	R
CAL0012201VG	3AZ66	ORG	(VOC)	75-15-0	Carbon disulfide	10	UG/KG	UH	R
CAL0012201VG	3AZ66	ORG	(VOC)	56-23-5	Carbon tetrachloride	10	UG/KG	UMH	R
CAL0012201VG	3AZ66	ORG	(VOC)	108-90-7	Chlorobenzene	10	UG/KG	UMH	R
CAL0012201VG	3AZ66	ORG	(VOC)	75-00-3	Chloroethane	10	UG/KG	UH	R
CAL0012201VG	3AZ66	ORG	(VOC)	67-66-3	Chloroform	10	UG/KG	UH	R
CAL0012201VG	3AZ66	ORG	(VOC)	74-87-3	Chloromethane	10	UG/KG	JBH	U
CAL0012201VG	3AZ66	ORG	(VOC)	156-59-2	cis-1,2-Dichloroethene	10	UG/KG	UH	R
CAL0012201VG	3AZ66	ORG	(VOC)	10061-01-5	cis-1,3-Dichloropropene	10	UG/KG	UH	R
CAL0012201VG	3AZ66	ORG	(VOC)	124-48-1	Dibromochloromethane	10	UG/KG	UH	R
CAL0012201VG	3AZ66	ORG	(VOC)	100-41-4	Ethylbenzene	10	UG/KG	UMH	R
CAL0012201VG	3AZ66	ORG	(VOC)	75-09-2	Methylene Chloride	20	UG/KG	UHZ	R
CAL0012201VG	3AZ66	ORG	(VOC)	95-47-6	o-Xylene	10	UG/KG	UMH	R
CAL0012201VG	3AZ66	ORG	(VOC)	100-42-5	Styrene	10	UG/KG	UMH	R
CAL0012201VG	3AZ66	ORG	(VOC)	127-18-4	Tetrachloroethene	10	UG/KG	UH	R
CAL0012201VG	3AZ66	ORG	(VOC)	108-88-3	Toluene	10	UG/KG	UH	R
CAL0012201VG	3AZ66	ORG	(VOC)	156-60-5	trans-1,2-Dichloroethene	10	UG/KG	UH	R
CAL0012201VG	3AZ66	ORG	(VOC)	10061-02-6	trans-1,3-Dichloropropene	10	UG/KG	UH	R
CAL0012201VG	3AZ66	ORG	(VOC)	79-01-6	Trichloroethene	10	UG/KG	UH	R
CAL0012201VG	3AZ66	ORG	(VOC)	75-69-4	Trichlorofluoromethane	10	UG/KG	UH	R
CAL0012201VG	3AZ66	ORG	(VOC)	75-01-4	Vinyl Chloride	10	UG/KG	UH	R
CAL0012201VG	3AZ66	ORG	(VOC)	1330-20-7	Xylene, Isomers m&p	20	UG/KG	UH	R

Zr Calcine SVOC Representative Analytical Data

Field Sample ID	Lab Sample ID	Type	Analysis	CAS Number	Compound	Result	Units	Lab Flag	Validator Flag
CAL0012101TA	3AZ65	ORG	(TCLP SVOC)	106-46-7	1,4-Dichlorobenzene	10	UG/L	UHZ	R
CAL0012101TA	3AZ65	ORG	(TCLP SVOC)	121-14-2	2,4-Dinitrotoluene	10	UG/L	UHZ	R
CAL0012101TA	3AZ65	ORG	(TCLP SVOC)	118-74-1	Hexachlorobenzene	10	UG/L	UH	R
CAL0012101TA	3AZ65	ORG	(TCLP SVOC)	87-68-3	Hexachlorobutadiene	10	UG/L	UH	R
CAL0012101TA	3AZ65	ORG	(TCLP SVOC)	67-72-1	Hexachloroethane	10	UG/L	UH	R
CAL0012101TA	3AZ65	ORG	(TCLP SVOC)	95-48-7	2-Methylphenol (o-Cresol)	10	UG/L	UH	R
CAL0012101TA	3AZ65	ORG	(TCLP SVOC)	*3&4-METHYLPHENOL	3&4-methylphenol	20	UG/L	UH	R
CAL0012101TA	3AZ65	ORG	(TCLP SVOC)	98-95-3	Nitrobenzene	10	UG/L	UH	R
CAL0012101TA	3AZ65	ORG	(TCLP SVOC)	87-86-5	Pentachlorophenol	10	UG/L	UHZ	R
CAL0012101TA	3AZ65	ORG	(TCLP SVOC)	95-95-4	2,4,5-Trichlorophenol	10	UG/L	UH	R
CAL0012101TA	3AZ65	ORG	(TCLP SVOC)	88-06-2	2,4,6-Trichlorophenol	10	UG/L	UH	R

Zr Calcine Total SVOC Representative Analytical Data

Field Sample ID	Lab Sample ID	Type	Analysis	CAS Number	Compound	Result	Units	Lab Flag	Validator Flag
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	83-32-9	Acenaphthene	200	UG/KG	UHZ	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	208-96-8	Acenaphthylene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	120-12-7	Anthracene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	103-33-3	Azobenzene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	56-55-3	Benzo(a)anthracene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	205-99-2	Benzo(b)fluoranthene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	207-08-9	Benzo(k)fluoranthene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	191-24-2	Benzo(g,h,i)perylene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	50-32-8	Benzo(a)pyrene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	111-91-1	bis-(2-chloroethoxy)methane	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	111-44-4	bis-(2-Chloroethyl)ether	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	108-60-1	bis(2-Chloroisopropyl)ether	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	117-81-7	bis-(2-ethylhexyl)phthalate	1000	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	101-55-3	4-Bromophenyl phenyl ether	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	85-68-7	Benzyl butyl phthalate	600	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	86-74-8	Carbazole	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	106-47-8	4-Chloroaniline	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	59-50-7	4-Chloro-3-methylphenol	200	UG/KG	UHZ	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	91-58-7	2-Chloronaphthalene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	95-57-8	2-Chlorophenol	200	UG/KG	UHZ	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	7005-72-3	4-Chlorophenyl phenyl ether	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	218-01-9	Chrysene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	53-70-3	Dibenzo(a,h)anthracene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	132-64-9	Dibenzofuran	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	84-74-2	Di-n-butyl phthalate	800	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	95-50-1	1,2-Dichlorobenzene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	541-73-1	1,3-Dichlorobenzene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	106-46-7	1,4-Dichlorobenzene	200	UG/KG	UHZ	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	91-94-1	3,3'-Dichlorobenzidine	600	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	120-83-2	2,4-Dichlorophenol	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	84-66-2	Diethyl Phthalate	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	105-67-9	2,4-Dimethylphenol	400	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	131-11-3	Dimethyl phthalate	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	534-52-1	4,6-Dinitro-2-methylphenol	400	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	51-28-5	2,4-Dinitrophenol	400	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	121-14-2	2,4-Dinitrotoluene	200	UG/KG	UHZ	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	606-20-2	2,6-Dinitrotoluene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	117-84-0	Di-n-octyl phthalate	400	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	206-44-0	Fluoranthene	200	UG/KG	UH	UJ

CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	86-73-7	Fluorene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	118-74-1	Hexachlorobenzene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	87-68-3	Hexachlorobutadiene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	77-47-4	Hexachlorocyclopentadiene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	67-72-1	Hexachloroethane	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	193-39-5	Indeno(1,2,3-cd)pyrene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	78-59-1	Isophorone	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	91-57-6	2-Methylnaphthalene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	95-48-7	2-Methylphenol (o-Cresol)	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	*3&4-METHYLPHENOL	3&4-methylphenol	400	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	91-20-3	Naphthalene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	88-74-4	2-Nitroaniline	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	99-09-2	3-Nitroaniline	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	100-01-6	4-Nitroaniline	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	98-95-3	Nitrobenzene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	88-75-5	2-Nitrophenol	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	100-02-7	4-Nitrophenol	400	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	62-75-9	n-Nitrosodimethylamine	400	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	86-30-6	n-Nitrosodiphenylamine	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	621-64-7	n-Nitrosodi-n-propylamine	200	UG/KG	UHZ	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	87-86-5	Pentachlorophenol	200	UG/KG	UHZ	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	85-01-8	Phenanthrene	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	108-95-2	Phenol	200	UG/KG	UHZ	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	129-00-0	Pyrene	400	UG/KG	UHZ	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	110-86-1	Pyridine	400	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	126-73-8	tri-n-butyl phosphate	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	120-82-1	1,2,4-Trichlorobenzene	200	UG/KG	UHZ	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	95-95-4	2,4,5-Trichlorophenol	200	UG/KG	UH	UJ
CAL0012101SV	3AZ65RA	ORG	(SEMIVOLATILE)	88-06-2	2,4,6-Trichlorophenol	200	UG/KG	UH	UJ

Flags found in the analytical data tables for organics.

Flags	Represent	VOC	Total VOC	SVOC	Total SVOC
B	Analyte detected in blank		X		
D	Identified in an analysis at a secondary dilution factor	X			
E	Analyte exceeds the calibration curve		X		
H	Holding time exceeded	X	X	X	X
J	Estimated value		X		X
M	Indicates that the analyte was quantified using a calibration curve constructed using a first or higher order regression fit	X	X		
R	The data are unusable (may or may not be present). Resampling and reanalysis is necessary for verification	X	X	X	X
U	Analyte was not detected (report sample-specific MDL)	X	X	X	X
Z	One or more QC samples do not meet acceptance criteria	X	X	X	X

Flags found in the analytical data tables for metals.

Flags	Represent	Metals	Total Metals
B	Reported value is less than contract required detection limit, but greater than or equal to IDL	X	X
D	Identified in an analysis at a secondary dilution factor	X	X
J	Estimated value	X	X
N	Spiked sample recovery was not within control limits	X	X
R	The data are unusable (may or may not be present). Resampling and reanalysis is necessary for verification	X	
U	Analyte was not detected (report sample-specific IDL)	X	X

RCRA PART B PERMIT REAPPLICATION

FOR THE

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IDAHO NUCLEAR TECHNOLOGY & ENGINEERING CENTER

CALCINED SOLIDS STORAGE FACILITY

APPENDIX 4

CSSF ENGINEERING DESIGN FILE

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Engineering Design File

Hydrostatic and Hydrodynamic Forces on the INTEC CSSF During a 100-Year Flood

Prepared for:
U.S. Department of Energy
Idaho Operations Office
Idaho Falls, Idaho

INEEL
Idaho National Engineering and Environmental Laboratory

Form 412.14
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PEER REVIEW OF EDF-3996

The peer review of revision 0 of EDF-3996, "Hydrostatic and Hydrodynamic Forces on the INTEC CSSF During a 100-Year Flood," indicates that the analysis performed in this EDF meets the appropriate criteria for evaluating partially underground structures. Soil pressures based on an actual geotechnical investigation and well established soil mechanics theory were used. Also, appropriate hydrostatic pressures were applied based on an actual flooding evaluation. Load Factors of 1.00 were used, which are appropriate for evaluations to meet RCRA requirements. The analyses in EDF-3996 indicate that the imposed moments, the critical reactions, are within the ACI 318 code allowable values. The EDF therefore provides adequate assurance that the reinforced vault structures will not fail during the 100-year flood referenced in the EDF.

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ENGINEERING DESIGN FILE

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1. Title: Hydrostatic and Hydrodynamic Forces on the INTEC CSSF During a 100-Year Flood

2. Index Codes:
   Building/Type Various SSC ID Calcined Solids Storage Facility (Bin Sets) Site Area 200

3. NPH Performance Category: ______ or ☒ N/A

4. EDF Safety Category: SS or ☐ N/A SCC Safety Category: SS or ☐ N/A

5. Summary:

The purpose of this analysis is to evaluate the INTEC Calcined Solids Storage Facility (Bin Sets) to determine if the facility can withstand floodwater forces during a 100-year flood at the INEEL site. This analysis is performed to ensure compliance with RCRA regulations that require an engineering analysis to determine the various hydrodynamic and hydrostatic forces expected to result at the site as a consequence of a 100-year flood. The design basis flood event is a 100-year flood coincident with a Mackay Dam failure. The floodwater elevation for the postulated flood is 4916 ft and the floodwater depth at INTEC is approximately 4 ft.

The Calcined Solids Storage Facility includes seven bin sets, with each set consisting of 3 to 7 stainless steel storage bins located in concrete vaults that are partially or completely underground. A structural evaluation of the vaults was used to check whether the vault walls have enough strength to withstand hydrodynamic and hydrostatic forces resulting from the postulated 100-year flood. The concrete walls of bin sets 1 to 7 meet the structural requirements given in ACI-318. The structural capacity of the walls ensures that washout of hazardous waste from these bin sets will be prevented.

6. Review (R) and Approval (A) and Acceptance (Ac) Signatures:

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Purpose

The purpose of this analysis is to evaluate the INTEC Calcined Solids Storage Facility (Bin Sets) to determine if the facility can withstand floodwater forces during a 100-year flood at the INEEL site. This analysis is performed to ensure compliance with RCRA regulations [1] that require an engineering analysis to determine the various hydrodynamic and hydrostatic forces expected to result at the site as a consequence of a 100-year flood, and structural or other engineering studies showing the design of operational units and flood protection devices at the facility and how these will prevent washout. In the RCRA regulations, washout is defined as the movement of hazardous waste from the active portion of a facility as a result of flooding.

Scope

The Calcined Solids Storage Facility includes seven bin sets, with each set consisting of 3 to 7 stainless steel storage bins located in concrete vaults that are partially or completely underground. A structural evaluation of the concrete vaults is needed to check whether the walls have enough strength to resist damage as a result of hydrodynamic and hydrostatic forces that may occur during a 100-year flood coincident with a Mackay Dam failure.

Safety Category

Safety categories are used for systems, structures, and components (SSC) to establish a graded approach to design and analysis based on the safety function performed by the SSC. The bin sets have been identified as Safety Significant per SAR-104 [8] and SAR-106 [9].

Natural Phenomena Hazards Performance Category

Performance categories are used for an SSC exposed to natural phenomena hazards to establish a graded approach to design and analysis based on the importance of the SSC. The bin sets have been identified as PC-2 per SAR-104 [8] and SAR-106 [9]. However, the performance category is not used in this analysis since the design basis flood event and scope of the analysis are governed by RCRA regulations.

Subject Specific Data

Koslow and Van Haaften [2] examined the consequences of a failure of Mackay Dam and performed a hydraulic analysis to determine the extent of the flood plain for several scenarios. Their analysis included a 100-year flood and simultaneous piping failure at Mackay Dam, which leads to a breach of the dam, overtopping of the INEEL diversion dam, and flooding of the INEEL site. This scenario results in a peak flow released from the dam equal to 57,740 ft^3/s. The flow between Mackay Dam and the INEEL is attenuated by storage, agricultural diversion, and channel infiltration. The calculated flow at the INEEL diversion dam is 28,500 ft^3/s. Since the diversion dam is unable to retain the high flow, most of the floodwater will flow onto the site.

The peak flow calculated by Koslow and Van Haaften [2] was used in a flow routing analysis to determine the extent of the flood plain at the INEEL site. A hydraulic analysis of open channel flow was used to compute the peak flow and water elevation at each cross-section of the Big Lost River channel. The leading edge of the flood wave arrives at INTEC approximately 17.1 hours after breach of the dam. The peak flow is attenuated to 24,870 ft^3/s, and the peak water velocity is 2.2 ft/s. Since the area surrounding INTEC is very flat, floodwater will spread easily and so the flood plain is wide and shallow. The elevation of the streambed in the vicinity of INTEC is 4911 ft. and the calculated water elevation is 4916 ft.

Koslow and Van Haaften [2] also performed an analysis to examine the potential for overland flooding due to localized heavy rain and snowmelt. It was found that localized flooding due to a 25-year peak rainfall and simultaneous snowmelt lead to a peak flow of 32 ft^3/s. Although this runoff can be accommodated by the drainage basin at INTEC and flood control devices such as culverts, dikes, and ditches, floodwater may collect in low-elevation areas.

With the exception of bin set 1, the structural design of the bin sets is similar. Stainless steel bins are arranged inside a cylindrical vault constructed of reinforced concrete. Bin set 1 is contained inside a rectangular concrete vault. The vault for bin set 1 is completely underground and the vaults for bin sets 2 through 7 are partially underground. A soil embankment surrounds the vaults for bin sets 2 and 3. Regarding the 100-year flood, the main concern is whether the external structure is strong enough to withstand hydrostatic and hydrodynamic forces, or whether the structure will be damaged and allow hazardous waste to escape. It is sufficient to show that the concrete walls can withstand floodwater forces, which include soil pressure, static water pressure, and dynamic wave pressure.

The elevations of the concrete base slabs of each bin set, as shown on the construction drawings, are listed in Table 1. Elevations are currently measured in reference to the National Geodetic Vertical Datum of 1929 (NGVD29). However, the bin sets were constructed during the years 1959 to 1985, when the datum was not NGVD29. Elevations in reference to NGVD29 are approximately 1 ft. less than those shown on the construction drawings. This correction is included in Table 1.

Table 1. Base slab elevations in feet above sea level.

Bin Set	Elevation at top of base slab (shown on as-built drawing)	Elevation at top of base slab (in reference to NGVD29)	INEEL Drawing Number
1 (CPP-729)	4869.0	4868.0	106583
2 (CPP-742)	4872.0	4871.0	118876
3 (CPP-746)	4866.5	4865.5	153241
4 (CPP-760)	4868.0	4867.0	157778
5 (CPP-765)	4868.0	4867.0	158457
6 (CPP-791)	4868.5	4867.5	161360
7 (CPP-795)	4868.5	4867.5	168109

1. WCF Bin Sets 1 – 3 were built from 1959 to 1969 and NWCF Bin Sets 4 – 7 were built from 1976 to 1985.

Assumptions

1. The only pathway for floodwater infiltration into a bin set vault is at pipe penetrations, which are sealed and watertight.
2. The floodwater elevation for the postulated 100-year flood coincident with a Mackay Dam failure is 4916 ft. in reference to NGVD29 (Koslow and Van Haaften, [2]). Since the elevation at grade level is approximately 4912 ft., the floodwater depth is 4 ft.
3. The wave height of shallow water waves generated by a 60 mph wind with a water depth equal to 4 ft is approximately 2 ft from crest to trough (Fig. 10-16 in Brater and King [3]). The maximum water level during the postulated 100-year flood is 4917 ft. (still water level + ½ wave height).

Acceptance Criteria

The concrete walls of the bin sets shall meet the structural requirements given in ACI-318 [4].

Software

All calculations use equations for stress given in Roark and Young [5] and Szilard [11]. MathCAD was used to evaluate the mathematical equations, which were independently verified by hand calculation.

Calculations

The data used in the calculations is given in Tables 2 - 4. This data includes vault height, vault diameter, wall thickness, depth of surrounding soil (elevation at grade – elevation of base slab), details of the vertical reinforcing bar, and details of the dowels joining the wall and base slab.

Table 2. Structural details of bin set vaults – dimensions.

Bin Set	Vault Inside Diameter (ft)	Vault Wall Height (ft)	Vault Wall Thickness (ft)	Soil Depth at Base Slab (ft)	INEEL Drawing Number
1 (CPP-729)	25.5$^{(1)}$	41.3	2.5	52.8	106583, 106585
2 (CPP-742)	46	61.8	2	67.3	118877, 118879
3 (CPP-746)	46	67.2	2	72.8	153242, 154148
4 (CPP-760)	36	64.7	2$^{(2)}$	45.5	157774, 157778
5 (CPP-765)	47	73.2	4	45.3	158457, 158462
6 (CPP-791)	52.3	88.5	4.25	44.5	161360, 161373
7 (CPP-795)	52.3	88.5	4.25	44.5	168109, 168110, 168116

1. Vault is rectangular; dimension indicates width of inside wall.
2. Wall thickness varies from 2 ft. at bottom to 3.5 ft. at top.

Table 3. Structural details of bin set vaults – vertical reinforcing bar.

Bin Set	Vertical reinforcing bar (outside face)	Vertical reinforcing bar (inside face)	INEEL Drawing Number
1 (CPP-729)	#5@ 14 in.	#5@ 14 in.	106583, 106585, 106588
2 (CPP-742)	#10@ 8 in. or #11@ 10 in.	#6@ 18 in.	118877
3 (CPP-746)	#11@ 10 in.	#6@ 18 in.	153242
4 (CPP-760)	#11@ 6 in.	#6@ 12 in.	157778
5 (CPP-765)	#11@ 6 in.	#9@ 12 in.	158468
6 (CPP-791)	#14@ 6 in.	#14@ 6 in.	161377
7 (CPP-795)	#11@ 6 in.	#11@ 6 in.	168120

1. Rebar strength varies; 40,000 psi for Bin Sets 1 – 3 is assumed and 60,000 psi for Bin Sets 4 – 7 per ASTM A432.
2. Concrete compressive strength varies; 3000 psi for Bin Set 1 and 4000 psi for Bin Sets 2 –7 is assumed.
3. Concrete cover varies; 2 in. for wall thickness of 2 ft. and 5 in. for wall thickness of 4 ft. is assumed.

Table 4. Structural details of bin set vaults – dowels joining wall and base slab.

Bin Set	Dowels (outside face)	Dowels (inside face)	INEEL Drawing Number
1 (CPP-729)	#9@ 14 in.	#9@ 14 in.	106583, 106585, 106588
2 (CPP-742)	#9@ 2°	#9@ 2°	118876
3 (CPP-746)	#9@ 2°	#9@ 2°	153241
4 (CPP-760)	#11@ 6 in.	#6@ 12 in.	157777
5 (CPP-765)	#11@ 6 in.	#9@ 12 in.	158467
6 (CPP-791)	#14@ 6 in.	#14@ 6 in.	161377
7 (CPP-795)	#11@ 6 in.	#11@ 6 in.	168120

1. Rebar strength varies; 40,000 psi for Bin Sets 1 – 3 is assumed and 60,000 psi for Bin Sets 4 – 7 per ASTM A432.

The data given in the tables above was used to calculate the bending moment and shear in the wall of each bin set vault. In the case of bin sets 2 – 7, the wall was modeled as a hollow cylinder with the bottom end fixed to the base slab and the top end free to move. In the case of bin set 1, the wall was modeled as a plate with the bottom and sides fixed to the base slab and adjoining walls and the top pinned to the roof slab. External pressure boundary conditions were applied to the outer surface of the cylinder and plate, which represent hydrostatic and hydrodynamic forces. Soil properties were obtained from references [6] and [7]. The bending moment and shear were compared to the moment and shear capacity of the concrete wall. Since a 100-year flood with a Mackay Dam failure is the maximum credible flood associated with a 100-year peak flow in the Big Lost River (exceeding RCRA requirements for a design basis flood event), load factors for floodwater forces and soil pressure were set equal to one. The calculations for each bin set are given in Appendices A – G.

Conclusions

A structural evaluation of the bin set vaults was used to check whether the vault walls are able to withstand hydrostatic and hydrodynamic forces resulting from the postulated 100-year flood. The concrete walls of bin sets 1 to 7 meet the structural requirements given in ACI-318 [4]. The structural capacity of the walls ensures that washout of hazardous waste from these bin sets will be prevented.

References

1. *Code of Federal Regulations*, 40 CFR Sect. 270.14(b) Para. 11(iv), August 1, 2000.
2. K. N. Koslow and D. H. Van Haaften, *Flood Routing Analysis for a Failure of Mackay Dam*, EGG-EP-7184, June, 1986.
3. E. F. Brater and H. W. King, *Handbook of Hydraulics*, 6th Edition, McGraw-Hill, NY, 1976.
4. *Building Code Requirements for Structural Concrete*, ACI 318-99, American Concrete Institute, 1999.
5. R. J. Roark and W. C. Young, *Formulas for Stress and Strain*, 5th Edition, McGraw-Hill, NY, 1975.
6. *Soil and Foundation Investigation for the Proposed New Waste Calcining Facility*, Prepared for The Energy Research and Development Administration, Fluor Contract No. 453504, Dames and Moore, 1976.
7. R. B. Peck, W. E. Hanson, and T. H. Thornburn, *Foundation Engineering*, 2nd Edition, John Wiley & Sons, NY, 1974.
8. *Safety Analysis Report – First Calcined Solids Storage Facility*, SAR-104, July 2001.
9. *Safety Analysis Report – Sixth Calcined Solids Storage Facility*, SAR-106, January 2002.
10. *Deformed Billet Steel Bars for Concrete Reinforcement With 60,000 PSI Minimum Yield Strength*, ASTM A432-64, American Society for Testing and Materials, 1964.
11. R. Szilard, *Theory and Analysis of Plates*, Prentice-Hall, Englewood Cliffs, NJ, 1974.

Appendices

A. Concrete Stress Calculations for Bin Set 1.

B. Concrete Stress Calculations for Bin Set 2.

C. Concrete Stress Calculations for Bin Set 3.

D. Concrete Stress Calculations for Bin Set 4.

E. Concrete Stress Calculations for Bin Set 5.

F. Concrete Stress Calculations for Bin Set 6.

G. Concrete Stress Calculations for Bin Set 7.

Calculate bending moment and shear in the vault wall. Wall is modeled as a rectangular plate loaded by external pressure. Plate is fixed at the base, fixed at the sides and simply supported at the top. Load is hydrostatic pressure due to soil and water. Neglect weight of vault wall and loads due to weight of roof and equipment room since these loads cause compression rather than shear and bending.

$D := 25.5 \cdot ft$ Width of plate.

$H := 41.3 \cdot ft$ Height of plate.

$t := 2.5 \cdot ft$ Wall thickness.

$d_{soil} := 52.8 \cdot ft$ Depth of soil at base of plate.

$d_{water} := 48.0 \cdot ft$ Depth of water at base of plate.

$\gamma_{dry} := 118 \cdot \frac{lbf}{ft^3}$ Weight of dry soil, from Table I in "Soil and Foundation Investigation for the Proposed New Waste Calcining Facility."

$\gamma_{wet} := 135 \cdot \frac{lbf}{ft^3}$ Weight of saturated soil, from Table 1.4 in Peck, Hanson, and Thornburn, "Foundation Engineering."

$\gamma_w := 62.4 \cdot \frac{lbf}{ft^3}$ Weight of water.

$\phi := 43 \cdot \frac{\pi}{180}$ Angle of internal friction, from Table I in "Soil and Foundation Investigation for the Proposed New Waste Calcining Facility."

$\phi = 0.75$

$K_0 := 1 - \sin(\phi)$ Earth pressure coefficient.

$K_0 = 0.318$

$f_c := 3000 \cdot psi$ Compressive strength of concrete.

$\gamma_c := 150 \cdot \frac{lbf}{ft^3}$ Weight of concrete.

$E_c := \gamma_c^{1.5} \cdot 33 \cdot \sqrt{f_c} \cdot \frac{ft^{4.5}}{lbf \cdot in}$ Modulus of elasticity of concrete.

$E_c = 3.321 \times 10^6 psi$

$\nu_c := 0.2$ Poisson's ratio of concrete.

Elasticity solution from Roark and Young, Table 26, Case 9a.

Total load is superposition of loads due to soil pressure and water pressure.
Use a uniformly distributed load as a conservative approximation to a hydrostatic load.

Load 1: Uniformly distributed load due to soil pressure.

$w := K_0 \cdot (\gamma_{wet} - \gamma_w) \cdot d_{soil}$ Load. $w = 1.219 \times 10^3 \frac{lbf}{ft^2}$

$r := \frac{D}{H}$ $r = 0.617$ Ratio of width to height.

Interpolate to get required solution parameters.

$\beta_{11} := 0.081$ $\beta_{21} := 0.018$ $\gamma_{11} := 0.230$ Solution parameters for r=0.50.

$\beta_{12} := 0.173$ $\beta_{22} := 0.062$ $\gamma_{12} := 0.343$ Solution parameters for r=0.75.

$\beta_1 := \beta_{11} + (\beta_{12} - \beta_{11}) \cdot \frac{r - 0.5}{0.25}$ $\beta_1 = 0.124$

$\gamma_1 := \gamma_{11} + (\gamma_{12} - \gamma_{11}) \cdot \frac{r - 0.5}{0.25}$ $\gamma_1 = 0.283$

$\beta_2 := \beta_{21} + (\beta_{22} - \beta_{21}) \cdot \frac{r - 0.5}{0.25}$ $\beta_2 = 0.039$

$R_1 := \gamma_1 \cdot w \cdot H$ Reaction at center of fixed base. $R_1 = 1.425 \times 10^4 \frac{lbf}{ft}$

$M_1 := \frac{-\beta_1 \cdot w \cdot H^2}{6}$ Moment at center of fixed base. $M_1 = -4.305 \times 10^4 \frac{lbf \cdot ft}{ft}$

Solution from Roark and Young is given in terms of bending stress. Bending moment is obtained from relation between moment and bending stress for a rectangular section: $\sigma = 6\ M / t^2$.

Note: R and M are given per unit width of wall. M>0 when producing compression at outside face.

Maximum negative moment and shear at center of fixed base.

$V_{soil} := R_1$ $M_{neg\_soil} := M_1$ $V_{soil} = 1.425 \times 10^4 \frac{lbf}{ft}$ $M_{neg\_soil} = -4.305 \times 10^4 \frac{lbf \cdot ft}{ft}$

Positive moment at a distance of 0.6 H from center of fixed base

$M_1 := \frac{\beta_2 \cdot w \cdot H^2}{6}$ Moment at a distance of 0.6 H from center of fixed base. $M_1 = 1.34 \times 10^4 \frac{lbf \cdot ft}{ft}$

$M_{pos\_soil} := M_1$ Positive moment. $M_{pos\_soil} = 1.34 \times 10^4 \frac{lbf \cdot ft}{ft}$

Load 2: Uniformly distributed load due to water pressure.

$w := \gamma_w \cdot d_{water}$ Load. $w = 2.995 \times 10^3 \frac{lbf}{ft^2}$

Note: "w" redefined for this load case.

$R_1 := \gamma_1 \cdot w \cdot H$ Reaction at center of fixed base. $R_1 = 3.502 \times 10^4 \frac{lbf}{ft}$

$M_1 := \frac{-\beta_1 \cdot w \cdot H^2}{6}$ Moment at center of fixed base. $M_1 = -1.058 \times 10^5 \frac{lbf \cdot ft}{ft}$

Solution from Roark and Young is given in terms of bending stress. Bending moment is obtained from relation between moment and bending stress for a rectangular section: $\sigma = 6\ M / t^2$.

Note: R and M are given per unit width of wall. M>0 when producing compression at outside face.

Maximum negative moment and shear at center of fixed base.

$V_{water} := R_1$ $M_{neg\_water} := M_1$ $V_{water} = 3.502 \times 10^4 \frac{lbf}{ft}$ $M_{neg\_water} = -1.058 \times 10^5 \frac{lbf \cdot ft}{ft}$

Positive moment at a distance of 0.6 H from center of fixed base.

$M_1 := \frac{\beta_2 \cdot w \cdot H^2}{6}$ Moment at a distance of 0.6 H from center of fixed base. $M_1 = 3.293 \times 10^4 \frac{lbf \cdot ft}{ft}$

$M_{pos\_water} := M_1$ Positive moment. $M_{pos\_water} = 3.293 \times 10^4 \frac{lbf \cdot ft}{ft}$

Superpose solutions using load factors of 1.0 for lateral earth pressure and 1.0 for hydrostatic floodwater pressure. Hydrodynamic wave pressure is neglected since it is small in comparison to hydrostatic pressure.

$V := 1.0 \cdot V_{soil} + V_{water}$ $\quad V = 4.927 \times 10^{4} \frac{lbf}{ft}$

$M_{neg} := 1.0 \cdot M_{neg\_soil} + M_{neg\_water}$ $\quad M_{neg} = -1.488 \times 10^{5} \frac{lbf \cdot ft}{ft}$

$M_{pos} := 1.0 \cdot M_{pos\_soil} + M_{pos\_water}$ $\quad M_{pos} = 4.633 \times 10^{4} \frac{lbf \cdot ft}{ft}$

Calculate shear capacity of concrete wall per ACI 318, Section 11.3.1.
Assume dowels carry entire load.

$f_y := 40000 \cdot psi$ — Yield strength of reinforcement.

$d_s := 1.128 \cdot in$ — Diameter of #9 rebar.

$A_s := 1.0 \cdot in^2$ — Cross-sectional area of #9 rebar.

$s := 14 \cdot in$ — Spacing of dowels at inside and outside faces.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $\quad A_s = 0.857\, in^2$ — Area of shear reinforcement.

$V_c := 0.85 \cdot 2 \cdot A_s \cdot f_y$ — Shear capacity per one foot width of wall.

$V_c = 5.829 \times 10^{4}\, lbf$

Compare factored shear to shear capacity.

$V_u := V$ — Factored shear. $\quad V_u = 4.927 \times 10^{4} \frac{lbf}{ft}$

$ratio := \frac{V_u \cdot 1 \cdot ft}{V_c}$ $\quad ratio = 0.845$ — OK.

Calculate moment capacity of concrete wall per ACI 318, Section 10.2.7.
Assume vertical rebar carries entire load.

$c := 2 \cdot in$ — Concrete cover.

$b := 12 \cdot in$ — Width of wall.

Check rebar at outside face.

$d_s := 0.625 \cdot in$ — Diameter of #5 rebar.

$d := t - c - 0.5 \cdot d_s$ — Distance from extreme compression fiber to center of mass of tension reinforcement.

$A_s := 0.31 \cdot in^2$ — Cross-sectional area of #5 rebar.

$s := 14 \cdot in$ — Spacing of vertical rebar at outside face.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $\quad A_s = 0.266\, in^2$ — Area of tension reinforcement.

$a := \frac{A_s \cdot f_y}{0.85 \cdot f_c \cdot b}$ — Depth of concrete compression block.

$M_c := 0.90 \cdot A_s \cdot f_y \cdot (d - 0.5 \cdot a)$ — Moment capacity per one foot width of wall.

$M_c = 2.193 \times 10^4\, lbf \cdot ft$

Compare factored moment to moment capacity.

$M_u := -M_{neg}$ — Factored moment. $\quad M_u = 1.488 \times 10^5\, \frac{lbf \cdot ft}{ft}$

$ratio := \frac{M_u \cdot 1 \cdot ft}{M_c}$ $\quad ratio = 6.785$ — Not OK.

Check rebar at inside face.

$d_s := 0.625 \cdot in$ — Diameter of #5 rebar.

$d := t - c - 0.5 \cdot d_s$ — Distance from extreme compression fiber to center of mass of tension reinforcement.

$A_s := 0.31 \cdot in^2$ — Cross-sectional area of #5 rebar.

$s := 14 \cdot in$ — Spacing of vertical rebar at inside face.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $\quad A_s = 0.266\, in^2$ — Area of tension reinforcement.

$a := \frac{A_s \cdot f_y}{0.85 \cdot f_c \cdot b}$ — Depth of concrete compression block.

$M_c := 0.90 \cdot A_s \cdot f_y \cdot (d - 0.5 \cdot a)$ — Moment capacity per one foot width of wall.

$M_c = 2.193 \times 10^4\, lbf \cdot ft$

Compare factored moment to moment capacity.

$M_u := M_{pos}$ — Factored moment. $\quad M_u = 4.633 \times 10^4\, \frac{lbf \cdot ft}{ft}$

$ratio := \frac{M_u \cdot 1 \cdot ft}{M_c}$ $\quad ratio = 2.112$ — Not OK.

Vertical bar is unable to resist bending moment. Redo calculations with base simply supported instead of fixed and assuming horizontal bar carries entire load.

Use solution given in Szilard, "Theory and Analysis of Plates," Case 90, p. 661. Bending moment with hydrostatic loading is C_i w b^2, with w = load, b = width of plate, and C_i a coefficient given below for moment about vertical axis and height to width ratio of plate equal to 2.

$C_1 := -0.0572$ For maximum negative moment near base and edge of plate.

$C_2 := -0.0424$ For negative moment at midpoint of edge of plate.

$C_5 := 0.0247$ For maximum positive moment near base and center of plate.

$C_6 := 0.0207$ For positive moment at center of plate.

$h := 52.8 \cdot ft$ Plate height (from top of base slab to top of roof).

$b := 25.5 \cdot ft$ Plate width.

$r := \frac{h}{b}$ $r = 2.071$ Ratio of height to width.

Load 1: Hydrostatic load due to soil pressure.

$w := K_0 \cdot (\gamma_{wet} - \gamma_w) \cdot d_{soil}$ $w = 1.219 \times 10^3 \frac{lbf}{ft^2}$

Note: "w" redefined for new load cases.

Bending moments:

$M_{1\_soil} := C_1 \cdot w \cdot D^2$ $M_{1\_soil} = -4.534 \times 10^4 \frac{lbf \cdot ft}{ft}$

$M_{2\_soil} := C_2 \cdot w \cdot D^2$ $M_{2\_soil} = -3.361 \times 10^4 \frac{lbf \cdot ft}{ft}$

$M_{5\_soil} := C_5 \cdot w \cdot D^2$ $M_{5\_soil} = 1.958 \times 10^4 \frac{lbf \cdot ft}{ft}$

$M_{6\_soil} := C_6 \cdot w \cdot D^2$ $M_{6\_soil} = 1.641 \times 10^4 \frac{lbf \cdot ft}{ft}$

Reaction at boundary supports:

$R_{soil} := 0.5 \cdot w \cdot b$ $R_{soil} = 1.554 \times 10^4 \frac{lbf}{ft}$

Note: R and M are given per unit height of wall. M>0 when producing compression at outside face.

Load 2: Hydrostatic load due to water pressure.

$w := \gamma_w \cdot d_{water}$ $\quad$ $w = 2.995 \times 10^3 \frac{lbf}{ft^2}$

Bending moments:

$M_{1\_water} := C_1 \cdot w \cdot D^2$ $\quad$ $M_{1\_water} = -1.114 \times 10^5 \frac{lbf \cdot ft}{ft}$

$M_{2\_water} := C_2 \cdot w \cdot D^2$ $\quad$ $M_{2\_water} = -8.258 \times 10^4 \frac{lbf \cdot ft}{ft}$

$M_{5\_water} := C_5 \cdot w \cdot D^2$ $\quad$ $M_{5\_water} = 4.811 \times 10^4 \frac{lbf \cdot ft}{ft}$

$M_{6\_water} := C_6 \cdot w \cdot D^2$ $\quad$ $M_{6\_water} = 4.032 \times 10^4 \frac{lbf \cdot ft}{ft}$

Reaction at boundary supports:

$R_{water} := 0.5 \cdot w \cdot b$ $\quad$ $R_{water} = 3.819 \times 10^4 \frac{lbf}{ft}$

Note: R and M are given per unit height of wall. M>0 when producing compression at outside face.

Superpose solutions using load factors of 1.0 for lateral earth pressure and 1.0 for hydrostatic floodwater pressure. Hydrodynamic wave pressure is neglected since it is small in comparison to hydrostatic pressure.

$V := 1.0 \cdot R_{soil} + R_{water}$ $\quad$ $V = 5.373 \times 10^4 \frac{lbf}{ft}$

$M_1 := 1.0 \cdot M_{1\_soil} + M_{1\_water}$ $\quad$ $M_1 = -1.567 \times 10^5 \frac{lbf \cdot ft}{ft}$

$M_2 := 1.0 \cdot M_{2\_soil} + M_{2\_water}$ $\quad$ $M_2 = -1.162 \times 10^5 \frac{lbf \cdot ft}{ft}$

$M_5 := 1.0 \cdot M_{5\_soil} + M_{5\_water}$ $\quad$ $M_5 = 6.768 \times 10^4 \frac{lbf \cdot ft}{ft}$

$M_6 := 1.0 \cdot M_{6\_soil} + M_{6\_water}$ $\quad$ $M_6 = 5.672 \times 10^4 \frac{lbf \cdot ft}{ft}$

Calculate shear capacity of concrete wall per ACI 318, Section 11.3.1. Assume corner dowels carry entire load. Horizontal rebar specifications obtained from Drawing 106585

$f_y := 40000 \cdot psi$ — Yield strength of reinforcement.

$d_s := 1.000 \cdot in$ — Diameter of #8 rebar (dowels at top of wall).

$A_s := 0.79 \cdot in^2$ — Cross-sectional area of #8 rebar.

$s := 9 \cdot in$ — Spacing of dowels at both corners.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $\quad A_s = 1.053\, in^2$ — Area of shear reinforcement.

$V_c := 0.85 \cdot 2 \cdot A_s \cdot f_y$ — Shear capacity per one foot height of wall.

$V_c = 7.163 \times 10^4\, lbf$

Compare factored shear to shear capacity.

$V_u := V$ — Factored shear. $\quad V_u = 5.373 \times 10^4 \frac{lbf}{ft}$

$ratio := \frac{V_u \cdot 1 \cdot ft}{V_c}$ $\quad ratio = 0.75$ — OK.

Calculate moment capacity of concrete wall per ACI 318, Section 10.2.7.
Assume horizontal rebar carries entire load.

$c := 2 \cdot in$ — Concrete cover.

$b := 12 \cdot in$ — Width of section of wall.

Check 1: Rebar at outside face at midpoint of wall.

$d_s := 1.270 \cdot in$ — Diameter of #10 rebar (corner strip rebar).

$d := t - c - 0.5 \cdot d_s$ — Distance from extreme compression fiber to center of mass of tension reinforcement.

$A_s := 1.27 \cdot in^2$ — Cross-sectional area of #10 rebar.

$s := 9 \cdot in$ — Spacing of horizontal rebar at outside face.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $\quad A_s = 1.693\, in^2$ — Area of tension reinforcement.

$a := \frac{A_s \cdot f_y}{0.85 \cdot f_c \cdot b}$ — Depth of concrete compression block.

$M_c := 0.90 \cdot A_s \cdot f_y \cdot (d - 0.5 \cdot a)$ — Moment capacity per one foot height of wall.

$M_c = 1.334 \times 10^5\, lbf \cdot ft$

Compare factored moment to moment capacity.

$M_u := -M_2$ Factored moment. $M_u = 1.162 \times 10^5 \dfrac{lbf \cdot ft}{ft}$

$ratio := \dfrac{M_u \cdot 1 \cdot ft}{M_c}$ $ratio = 0.871$ OK.

Check 2: Rebar at outside face at base of wall.

$d_s := 1.410 \cdot in$ Diameter of #11 rebar (corner strip rebar).

$d := t - c - 0.5 \cdot d_s$ Distance from extreme compression fiber to center of mass of tension reinforcement.

$A_s := 1.56 \cdot in^2$ Cross-sectional area of #11 rebar.

$s := 9 \cdot in$ Spacing of horizontal rebar at outside face.

$A_s := A_s \cdot \dfrac{12 \cdot in}{s}$ $A_s = 2.08\, in^2$ Area of tension reinforcement.

$a := \dfrac{A_s \cdot f_y}{0.85 \cdot f_c \cdot b}$ Depth of concrete compression block.

$M_c := 0.90 \cdot A_s \cdot f_y \cdot (d - 0.5 \cdot a)$ Moment capacity per one foot height of wall.

$M_c = 1.618 \times 10^5\, lbf \cdot ft$

Compare factored moment to moment capacity.

$M_u := -M_1$ Factored moment. $M_u = 1.567 \times 10^5 \dfrac{lbf \cdot ft}{ft}$

$ratio := \dfrac{M_u \cdot 1 \cdot ft}{M_c}$ $ratio = 0.969$ OK.

Check 3: Rebar at inside face at midpoint of wall.

$d_s := 0.875 \cdot in$ Diameter of #7 rebar.

$d := t - c - 0.5 \cdot d_s$ Distance from extreme compression fiber to center of mass of tension reinforcement.

$A_s := 0.60 \cdot in^2$ Cross-sectional area of #7 rebar.

$s := 9 \cdot in$ Spacing of horizontal rebar at inside face.

$A_s := A_s \cdot \dfrac{12 \cdot in}{s}$ $A_s = 0.8\, in^2$ Area of tension reinforcement.

$a := \frac{A_s \cdot f_y}{0.85 \cdot f_c \cdot b}$ Depth of concrete compression block.

$M_c := 0.90 \cdot A_s \cdot f_y \cdot (d - 0.5 \cdot a)$ Moment capacity per one foot height of wall.

$M_c = 6.49 \times 10^4 \, lbf \cdot ft$

Compare factored moment to moment capacity.

$M_u := M_6$ Factored moment. $M_u = 5.672 \times 10^4 \, \frac{lbf \cdot ft}{ft}$

$ratio := \frac{M_u \cdot 1 \cdot ft}{M_c}$ $ratio = 0.874$ OK.

Check 4: Rebar at inside face at base of wall.

$d_s := 1.000 \cdot in$ Diameter of #8 rebar.

$d := t - c - 0.5 \cdot d_s$ Distance from extreme compression fiber to center of mass of tension reinforcement.

$A_s := 0.79 \cdot in^2$ Cross-sectional area of #8 rebar.

$s := 9 \cdot in$ Spacing of horizontal rebar at inside face.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $A_s = 1.053 \, in^2$ Area of tension reinforcement.

$a := \frac{A_s \cdot f_y}{0.85 \cdot f_c \cdot b}$ Depth of concrete compression block.

$M_c := 0.90 \cdot A_s \cdot f_y \cdot (d - 0.5 \cdot a)$ Moment capacity per one foot height of wall.

$M_c = 8.472 \times 10^4 \, lbf \cdot ft$

Compare factored moment to moment capacity.

$M_u := M_5$ Factored moment. $M_u = 6.768 \times 10^4 \, \frac{lbf \cdot ft}{ft}$

$ratio := \frac{M_u \cdot 1 \cdot ft}{M_c}$ $ratio = 0.799$ OK.

Calculate bending moment and shear in the vault wall. Wall is modeled as a hollow cylinder loaded by external radial pressure. Cylinder is fixed at the base and free at the top. Load is hydrostatic pressure due to soil and water. Neglect weight of vault wall and loads due to weight of roof and equipment room since these loads cause compression rather than shear and

$D_i := 46 \cdot ft$ Inside diameter of cylinder.

$H := 61.8 \cdot ft$ Height of cylinder.

$t := 2 \cdot ft$ Wall thickness.

$d_{soil} := 67.3 \cdot ft$ Depth of soil at base of cylinder.

$d_{water} := 45.0 \cdot ft$ Depth of water at base of cylinder.

$\gamma_{dry} := 118 \cdot \frac{lbf}{ft^3}$ Weight of dry soil.

$\gamma_{wet} := 135 \cdot \frac{lbf}{ft^3}$ Weight of saturated soil.

$\gamma_w := 62.4 \cdot \frac{lbf}{ft^3}$ Weight of water.

$\phi := 43 \cdot \frac{\pi}{180}$ Angle of internal friction.

$K_0 := 1 - \sin(\phi)$ Earth pressure coefficient.

$f_c := 4000 \cdot psi$ Compressive strength of concrete.

$\gamma_c := 150 \cdot \frac{lbf}{ft^3}$ Weight of concrete.

$E_c := \gamma_c^{1.5} \cdot 33 \cdot \sqrt{f_c} \cdot \frac{ft^{4.5}}{lbf \cdot in}$ Modulus of elasticity of concrete.

$E_c = 3.834 \times 10^6 psi$

$\nu_c := 0.2$ Poisson's ratio of concrete.

Elasticity solution from Roark and Young, Table 8, Case 2, left end fixed.

$R := \frac{D_i + t}{2}$ Mean radius of cylinder.

$C := \pi \cdot (D_i + 2 \cdot t)$ Circumference of cylinder.

$\lambda := \left[\frac{3 \cdot \left(1 - \nu_c^2\right)}{R^2 \cdot t^2}\right]^{0.25}$ $D := \frac{E_c \cdot t^3}{12\left(1 - \nu_c^2\right)}$ Shell parameters, see Roark and Young, Table 30, and discussion on p. 456.

$L := \lambda \cdot H$ $L = 11.62$ L>6 and resultant load closer to left end; use semi-infinite beam.

Total load is superposition of loads due to soil pressure and water pressure.
Use a uniformly distributed load as a conservative approximation to a hydrostatic load.

Load 1: Uniformly distributed load due to soil pressure.

$w := K_0 \cdot (\gamma_{wet} - \gamma_w) \cdot d_{soil}$ Load. $w = 1.554 \times 10^3 \frac{lbf}{ft^2}$

$a := 0 \cdot ft$

$b := H$

Load applied from "a" to "b."

$A_1 := 0.5 \cdot e^{-\lambda \cdot a} \cdot \cos(\lambda \cdot a)$ $B_1 := 0.5 \cdot e^{-\lambda \cdot b} \cdot \cos(\lambda \cdot b)$

$A_2 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) - \cos(\lambda \cdot a))$ $B_2 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) - \cos(\lambda \cdot b))$

$A_3 := -0.5 \cdot e^{-\lambda \cdot a} \cdot \sin(\lambda \cdot a)$ $B_3 := -0.5 \cdot e^{-\lambda \cdot b} \cdot \sin(\lambda \cdot b)$

$A_4 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) + \cos(\lambda \cdot a))$ $B_4 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) + \cos(\lambda \cdot b))$

$R_1 := \frac{-2 \cdot w}{\lambda} \cdot (B_1 - A_1)$ Reaction at end. $R_1 = 8.263 \times 10^3 \frac{lbf}{ft}$

$M_1 := \frac{w}{\lambda^2} \cdot (B_4 - A_4)$ Moment at end. $M_1 = -2.197 \times 10^4 \frac{lbf \cdot ft}{ft}$

Note: R and M are given per unit width of wall. M>0 when producing compression at outside face.

Maximum negative moment and maximum shear occur at fixed end.

$V_{soil} := R_1$ $M_{neg\_soil} := M_1$ $V_{soil} = 8.263 \times 10^3 \frac{lbf}{ft}$ $M_{neg\_soil} = -2.197 \times 10^4 \frac{lbf \cdot ft}{ft}$

Maximum positive moment occurs at intermediate location near fixed end.

$x := 8.4 \cdot ft$ Location between "a" and "b."

$F_1 := \cosh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_2 := \cosh(\lambda \cdot x) \cdot \sin(\lambda \cdot x) + \sinh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_{a3} := \sinh[\lambda \cdot (x - a)] \cdot \sin[\lambda \cdot (x - a)]$ $F_{b3} := 0$ $x < b$.

$LT_M := \frac{-w}{2 \cdot \lambda^2} \cdot (F_{a3} - F_{b3})$

$M_{1A} := M_1 \cdot F_1 + \frac{R_1}{2 \cdot \lambda} \cdot F_2 + LT_M$ $M_{1A} = 4.567 \times 10^3 \frac{lbf \cdot ft}{ft}$

$M_{pos\_soil} := M_{1A}$ Maximum positive moment. $M_{pos\_soil} = 4.567 \times 10^3 \frac{lbf \cdot ft}{ft}$

Load 2: Uniformly distributed load due to water pressure.

$w := \gamma_w \cdot d_{water}$ Load. $w = 2.808 \times 10^3 \frac{lbf}{ft^2}$

$a := 0 \cdot ft$ Load applied from "a" to "b."

$b := d_{water}$

$A_1 := 0.5 \cdot e^{-\lambda \cdot a} \cdot \cos(\lambda \cdot a)$ $B_1 := 0.5 \cdot e^{-\lambda \cdot b} \cdot \cos(\lambda \cdot b)$

$A_2 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) - \cos(\lambda \cdot a))$ $B_2 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) - \cos(\lambda \cdot b))$

$A_3 := -0.5 \cdot e^{-\lambda \cdot a} \cdot \sin(\lambda \cdot a)$ $B_3 := -0.5 \cdot e^{-\lambda \cdot b} \cdot \sin(\lambda \cdot b)$

$A_4 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) + \cos(\lambda \cdot a))$ $B_4 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) + \cos(\lambda \cdot b))$

$R_1 := \frac{-2 \cdot w}{\lambda} \cdot (B_1 - A_1)$ Reaction at end. $R_1 = 1.494 \times 10^4 \frac{lbf}{ft}$

$M_1 := \frac{w}{\lambda^2} \cdot (B_4 - A_4)$ Moment at end. $M_1 = -3.971 \times 10^4 \frac{lbf \cdot ft}{ft}$

Note: R and M are given per unit width of wall. M>0 when producing compression at outside face.

Maximum negative moment and maximum shear occur at fixed end.

$V_{water} := R_1$ $M_{neg\_water} := M_1$ $V_{water} = 1.494 \times 10^4 \frac{lbf}{ft}$ $M_{neg\_water} = -3.971 \times 10^4 \frac{lbf \cdot ft}{ft}$

Maximum positive moment occurs at intermediate location near fixed end.

$x := 8.4 \cdot ft$ Location between "a" and "b."

$F_1 := \cosh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_2 := \cosh(\lambda \cdot x) \cdot \sin(\lambda \cdot x) + \sinh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_{a3} := \sinh[\lambda \cdot (x - a)] \cdot \sin[\lambda \cdot (x - a)]$ $F_{b3} := 0$ $x < b$.

$LT_M := \frac{-w}{2 \cdot \lambda^2} \cdot (F_{a3} - F_{b3})$

$M_{1A} := M_1 \cdot F_1 + \frac{R_1}{2 \cdot \lambda} \cdot F_2 + LT_M$ $M_{1A} = 8.266 \times 10^3 \frac{lbf \cdot ft}{ft}$

$M_{pos\_water} := M_{1A}$ Maximum positive moment. $M_{pos\_water} = 8.266 \times 10^3 \frac{lbf \cdot ft}{ft}$

Superpose solutions using load factors of 1.0 for lateral earth pressure and 1.0 for hydrostatic floodwater pressure. Hydrodynamic wave pressure is neglected since it is small in comparison to hydrostatic pressure.

$V := 1.0 \cdot V_{soil} + V_{water}$ $\quad V = 2.32 \times 10^4 \frac{lbf}{ft}$

$M_{neg} := 1.0 \cdot M_{neg\_soil} + M_{neg\_water}$ $\quad M_{neg} = -6.168 \times 10^4 \frac{lbf \cdot ft}{ft}$

$M_{pos} := 1.0 \cdot M_{pos\_soil} + M_{pos\_water}$ $\quad M_{pos} = 1.283 \times 10^4 \frac{lbf \cdot ft}{ft}$

Calculate shear capacity of concrete wall per ACI 318, Section 11.3.1.
Assume dowels carry entire load.

$f_y := 40000 \cdot psi$ — Yield strength of reinforcement.

$d_s := 1.128 \cdot in$ — Diameter of #9 rebar.

$A_s := 1.0 \cdot in^2$ — Cross-sectional area of #9 rebar.

$s := \frac{C}{180}$ — Spacing of dowels at inside and outside faces.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $\quad A_s = 1.146\, in^2$ — Area of shear reinforcement.

$V_c := 0.85 \cdot 2 \cdot A_s \cdot f_y$ — Shear capacity per one foot width of wall.

$V_c = 7.792 \times 10^4\, lbf$

Compare factored shear to shear capacity.

$V_u := V$ — Factored shear. $\quad V_u = 2.32 \times 10^4 \frac{lbf}{ft}$

$ratio := \frac{V_u \cdot 1 \cdot ft}{V_c}$ $\quad ratio = 0.298$ — OK.

Calculate moment capacity of concrete wall per ACI 318, Section 10.2.7.
Assume vertical rebar carries entire load.

$c := 2 \cdot in$ — Concrete cover.

$b := 12 \cdot in$ — Width of wall.

Check rebar at outside face.

$d_s := 1.41 \cdot in$ — Diameter of #11 rebar.

$d := t - c - 0.5 \cdot d_s$ — Distance from extreme compression fiber to center of mass of tension reinforcement.

$A_s := 1.56 \cdot in^2$ — Cross-sectional area of #11 rebar.

$s := 10 \cdot in$ — Spacing of vertical rebar at outside face.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $A_s = 1.872\, in^2$ — Area of tension reinforcement.

$a := \frac{A_s \cdot f_y}{0.85 \cdot f_c \cdot b}$ — Depth of concrete compression block.

$M_c := 0.90 \cdot A_s \cdot f_y \cdot (d - 0.5 \cdot a)$ — Moment capacity per one foot width of wall.

$M_c = 1.144 \times 10^5\, lbf \cdot ft$

Compare factored moment to moment capacity.

$M_u := -M_{neg}$ — Factored moment. $M_u = 6.168 \times 10^4 \frac{lbf \cdot ft}{ft}$

$ratio := \frac{M_u \cdot 1 \cdot ft}{M_c}$ $ratio = 0.539$ — OK.

Check rebar at inside face.

$d_s := 0.75 \cdot in$ — Diameter of #6 rebar.

$d := t - c - 0.5 \cdot d_s$ — Distance from extreme compression fiber to center of mass of tension reinforcement.

$A_s := 0.44 \cdot in^2$ — Cross-sectional area of #6 rebar.

$s := 18 \cdot in$ — Spacing of vertical rebar at inside face.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $A_s = 0.293\, in^2$ — Area of tension reinforcement.

$a := \frac{A_s \cdot f_y}{0.85 \cdot f_c \cdot b}$ — Depth of concrete compression block.

$M_c := 0.90 \cdot A_s \cdot f_y \cdot (d - 0.5 \cdot a)$ — Moment capacity per one foot width of wall.

$M_c = 1.89 \times 10^4\, lbf \cdot ft$

Compare factored moment to moment capacity.

$M_u := M_{pos}$ — Factored moment. $M_u = 1.283 \times 10^4 \frac{lbf \cdot ft}{ft}$

$ratio := \frac{M_u \cdot 1 \cdot ft}{M_c}$ $ratio = 0.679$ — OK.

Calculate bending moment and shear in the vault wall. Wall is modeled as a hollow cylinder loaded by external radial pressure. Cylinder is fixed at the base and free at the top. Load is hydrostatic pressure due to soil and water. Neglect weight of vault wall and loads due to weight of roof and equipment room since these loads cause compression rather than shear and

$D_i := 46 \cdot ft$ Inside diameter of cylinder.

$H := 67.2 \cdot ft$ Height of cylinder.

$t := 2 \cdot ft$ Wall thickness.

$d_{soil} := 72.8 \cdot ft$ Depth of soil at base of cylinder.

$d_{water} := 50.5 \cdot ft$ Depth of water at base of cylinder.

$\gamma_{dry} := 118 \cdot \frac{lbf}{ft^3}$ Weight of dry soil.

$\gamma_{wet} := 135 \cdot \frac{lbf}{ft^3}$ Weight of saturated soil.

$\gamma_w := 62.4 \cdot \frac{lbf}{ft^3}$ Weight of water.

$\phi := 43 \cdot \frac{\pi}{180}$ Angle of internal friction.

$K_0 := 1 - \sin(\phi)$ Earth pressure coefficient.

$f_c := 4000 \cdot psi$ Compressive strength of concrete.

$\gamma_c := 150 \cdot \frac{lbf}{ft^3}$ Weight of concrete.

$E_c := \gamma_c^{1.5} \cdot 33 \cdot \sqrt{f_c} \cdot \frac{ft^{4.5}}{lbf \cdot in}$ Modulus of elasticity of concrete.

$E_c = 3.834 \times 10^6 psi$

$\nu_c := 0.2$ Poisson's ratio of concrete.

Elasticity solution from Roark and Young, Table 8, Case 2, left end fixed.

$R := \frac{D_i + t}{2}$ Mean radius of cylinder.

$C := \pi \cdot (D_i + 2 \cdot t)$ Circumference of cylinder.

$\lambda := \left[\frac{3 \cdot \left(1 - \nu_c^2\right)}{R^2 \cdot t^2}\right]^{0.25}$ $D := \frac{E_c \cdot t^3}{12\left(1 - \nu_c^2\right)}$ Shell parameters.

$L := \lambda \cdot H$ $L = 12.636$ L>6 and resultant load closer to left end; use semi-infinite beam.

Total load is superposition of loads due to soil pressure and water pressure.
Use a uniformly distributed load as a conservative approximation to a hydrostatic load.

Load 1: Uniformly distributed load due to soil pressure.

$w := K_0 \cdot (\gamma_{wet} - \gamma_w) \cdot d_{soil}$ Load. $w = 1.681 \times 10^3 \frac{lbf}{ft^2}$

$a := 0 \cdot ft$

$b := H$

Load applied from "a" to "b."

$A_1 := 0.5 \cdot e^{-\lambda \cdot a} \cdot \cos(\lambda \cdot a)$ $B_1 := 0.5 \cdot e^{-\lambda \cdot b} \cdot \cos(\lambda \cdot b)$

$A_2 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) - \cos(\lambda \cdot a))$ $B_2 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) - \cos(\lambda \cdot b))$

$A_3 := -0.5 \cdot e^{-\lambda \cdot a} \cdot \sin(\lambda \cdot a)$ $B_3 := -0.5 \cdot e^{-\lambda \cdot b} \cdot \sin(\lambda \cdot b)$

$A_4 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) + \cos(\lambda \cdot a))$ $B_4 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) + \cos(\lambda \cdot b))$

$R_1 := \frac{-2 \cdot w}{\lambda} \cdot (B_1 - A_1)$ Reaction at end. $R_1 = 8.939 \times 10^3 \frac{lbf}{ft}$

$M_1 := \frac{w}{\lambda^2} \cdot (B_4 - A_4)$ Moment at end. $M_1 = -2.377 \times 10^4 \frac{lbf \cdot ft}{ft}$

Note: R and M are given per unit width of wall. M>0 when producing compression at outside face.

Maximum negative moment and maximum shear occur at fixed end.

$V_{soil} := R_1$ $M_{neg\_soil} := M_1$ $V_{soil} = 8.939 \times 10^3 \frac{lbf}{ft}$ $M_{neg\_soil} = -2.377 \times 10^4 \frac{lbf \cdot ft}{ft}$

Maximum positive moment occurs at intermediate location near fixed end.

$x := 8.4 \cdot ft$ Location between "a" and "b."

$F_1 := \cosh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_2 := \cosh(\lambda \cdot x) \cdot \sin(\lambda \cdot x) + \sinh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_{a3} := \sinh[\lambda \cdot (x - a)] \cdot \sin[\lambda \cdot (x - a)]$ $F_{b3} := 0$ $x < b$.

$LT_M := \frac{-w}{2 \cdot \lambda^2} \cdot (F_{a3} - F_{b3})$

$M_{1A} := M_1 \cdot F_1 + \frac{R_1}{2 \cdot \lambda} \cdot F_2 + LT_M$ $M_{1A} = 4.941 \times 10^3 \frac{lbf \cdot ft}{ft}$

$M_{pos\_soil} := M_{1A}$ Maximum positive moment. $M_{pos\_soil} = 4.941 \times 10^3 \frac{lbf \cdot ft}{ft}$

Load 2: Uniformly distributed load due to water pressure.

$w := \gamma_w \cdot d_{water}$ Load. $w = 3.151 \times 10^3 \frac{lbf}{ft^2}$

$a := 0 \cdot ft$ Load applied from "a" to "b."

$b := d_{water}$

$A_1 := 0.5 \cdot e^{-\lambda \cdot a} \cdot \cos(\lambda \cdot a)$ $B_1 := 0.5 \cdot e^{-\lambda \cdot b} \cdot \cos(\lambda \cdot b)$

$A_2 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) - \cos(\lambda \cdot a))$ $B_2 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) - \cos(\lambda \cdot b))$

$A_3 := -0.5 \cdot e^{-\lambda \cdot a} \cdot \sin(\lambda \cdot a)$ $B_3 := -0.5 \cdot e^{-\lambda \cdot b} \cdot \sin(\lambda \cdot b)$

$A_4 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) + \cos(\lambda \cdot a))$ $B_4 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) + \cos(\lambda \cdot b))$

$R_1 := \frac{-2 \cdot w}{\lambda} \cdot (B_1 - A_1)$ Reaction at end. $R_1 = 1.676 \times 10^4 \frac{lbf}{ft}$

$M_1 := \frac{w}{\lambda^2} \cdot (B_4 - A_4)$ Moment at end. $M_1 = -4.457 \times 10^4 \frac{lbf \cdot ft}{ft}$

Note: R and M are given per unit width of wall. M>0 when producing compression at outside face.
Maximum negative moment and maximum shear occur at fixed end.

$V_{water} := R_1$ $M_{neg\_water} := M_1$ $V_{water} = 1.676 \times 10^4 \frac{lbf}{ft}$ $M_{neg\_water} = -4.457 \times 10^4 \frac{lbf \cdot ft}{ft}$

Maximum positive moment occurs at intermediate location near fixed end.

$x := 8.4 \cdot ft$ Location between "a" and "b."

$F_1 := \cosh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_2 := \cosh(\lambda \cdot x) \cdot \sin(\lambda \cdot x) + \sinh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_{a3} := \sinh[\lambda \cdot (x - a)] \cdot \sin[\lambda \cdot (x - a)]$ $F_{b3} := 0$ $x < b$.

$LT_M := \frac{-w}{2 \cdot \lambda^2} \cdot (F_{a3} - F_{b3})$

$M_{1A} := M_1 \cdot F_1 + \frac{R_1}{2 \cdot \lambda} \cdot F_2 + LT_M$ $M_{1A} = 9.272 \times 10^3 \frac{lbf \cdot ft}{ft}$

$M_{pos\_water} := M_{1A}$ Maximum positive moment. $M_{pos\_water} = 9.272 \times 10^3 \frac{lbf \cdot ft}{ft}$

Superpose solutions using load factors of 1.0 for lateral earth pressure and 1.0 for hydrostatic floodwater pressure. Hydrodynamic wave pressure is neglected since it is small in comparison to hydrostatic pressure.

$V := 1.0 \cdot V_{soil} + V_{water}$ $\quad V = 2.57 \times 10^4 \frac{lbf}{ft}$

$M_{neg} := 1.0 \cdot M_{neg\_soil} + M_{neg\_water}$ $\quad M_{neg} = -6.834 \times 10^4 \frac{lbf \cdot ft}{ft}$

$M_{pos} := 1.0 \cdot M_{pos\_soil} + M_{pos\_water}$ $\quad M_{pos} = 1.421 \times 10^4 \frac{lbf \cdot ft}{ft}$

Calculate shear capacity of concrete wall per ACI 318, Section 11.3.1.
Assume dowels carry entire load.

$f_y := 40000 \cdot psi$ — Yield strength of reinforcement.

$d_s := 1.128 \cdot in$ — Diameter of #9 rebar.

$A_s := 1.0 \cdot in^2$ — Cross-sectional area of #9 rebar.

$s := \frac{C}{180}$ — Spacing of dowels at inside and outside faces.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $\quad A_s = 1.146 \, in^2$ — Area of shear reinforcement.

$V_c := 0.85 \cdot 2 \cdot A_s \cdot f_y$ — Shear capacity per one foot width of wall.

$V_c = 7.792 \times 10^4 \, lbf$

Compare factored shear to shear capacity.

$V_u := V$ — Factored shear. $\quad V_u = 2.57 \times 10^4 \frac{lbf}{ft}$

$ratio := \frac{V_u \cdot 1 \cdot ft}{V_c}$ $\quad ratio = 0.33$ — OK.

Calculate moment capacity of concrete wall per ACI 318, Section 10.2.7.
Assume vertical rebar carries entire load.

$c := 2 \cdot in$ — Concrete cover.

$b := 12 \cdot in$ — Width of wall.

Check rebar at outside face.

$d_s := 1.41 \cdot in$ — Diameter of #11 rebar.

$d := t - c - 0.5 \cdot d_s$ — Distance from extreme compression fiber to center of mass of tension reinforcement.

$A_s := 1.56 \cdot in^2$ — Cross-sectional area of #11 rebar.

$s := 10 \cdot in$ Spacing of vertical rebar at outside face.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $A_s = 1.872\, in^2$ Area of tension reinforcement.

$a := \frac{A_s \cdot f_y}{0.85 \cdot f_c \cdot b}$ Depth of concrete compression block.

$M_c := 0.90 \cdot A_s \cdot f_y \cdot (d - 0.5 \cdot a)$ Moment capacity per one foot width of wall.

$M_c = 1.144 \times 10^5\, lbf \cdot ft$

Compare factored moment to moment capacity.

$M_u := -M_{neg}$ Factored moment. $M_u = 6.834 \times 10^4\, \frac{lbf \cdot ft}{ft}$

$ratio := \frac{M_u \cdot 1 \cdot ft}{M_c}$ $ratio = 0.597$ OK.

Check rebar at inside face.

$d_s := 0.75 \cdot in$ Diameter of #6 rebar.

$d := t - c - 0.5 \cdot d_s$ Distance from extreme compression fiber to center of mass of tension reinforcement.

$A_s := 0.44 \cdot in^2$ Cross-sectional area of #6 rebar.

$s := 18 \cdot in$ Spacing of vertical rebar at inside face.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $A_s = 0.293\, in^2$ Area of tension reinforcement.

$a := \frac{A_s \cdot f_y}{0.85 \cdot f_c \cdot b}$ Depth of concrete compression block.

$M_c := 0.90 \cdot A_s \cdot f_y \cdot (d - 0.5 \cdot a)$ Moment capacity per one foot width of wall.

$M_c = 1.89 \times 10^4\, lbf \cdot ft$

Compare factored moment to moment capacity.

$M_u := M_{pos}$ Factored moment. $M_u = 1.421 \times 10^4\, \frac{lbf \cdot ft}{ft}$

$ratio := \frac{M_u \cdot 1 \cdot ft}{M_c}$ $ratio = 0.752$ OK.

Calculate bending moment and shear in the vault wall. Wall is modeled as a hollow cylinder loaded by external radial pressure. Cylinder is fixed at the base and free at the top. Load is hydrostatic pressure due to soil and water. Neglect weight of vault wall and loads due to weight of roof and equipment room since these loads cause compression rather than shear and

$D_i := 36 \cdot ft$ Inside diameter of cylinder.

$H := 64.7 \cdot ft$ Height of cylinder.

$t := 2 \cdot ft$ Wall thickness.

$d_{soil} := 45.5 \cdot ft$ Depth of soil at base of cylinder.

$d_{water} := 49 \cdot ft$ Depth of water at base of cylinder.

$\gamma_{dry} := 118 \cdot \frac{lbf}{ft^3}$ Weight of dry soil.

$\gamma_{wet} := 135 \cdot \frac{lbf}{ft^3}$ Weight of saturated soil.

$\gamma_w := 62.4 \cdot \frac{lbf}{ft^3}$ Weight of water.

$\phi := 43 \cdot \frac{\pi}{180}$ Angle of internal friction.

$K_0 := 1 - \sin(\phi)$ Earth pressure coefficient.

$f_c := 4000 \cdot psi$ Compressive strength of concrete.

$\gamma_c := 150 \cdot \frac{lbf}{ft^3}$ Weight of concrete.

$E_c := \gamma_c^{1.5} \cdot 33 \cdot \sqrt{f_c} \cdot \frac{ft^{4.5}}{lbf \cdot in}$ Modulus of elasticity of concrete.

$E_c = 3.834 \times 10^6 psi$

$\nu_c := 0.2$ Poisson's ratio of concrete.

Elasticity solution from Roark and Young, Table 8, Case 2, left end fixed.

$R := \frac{D_i + t}{2}$ Mean radius of cylinder.

$C := \pi \cdot (D_i + 2 \cdot t)$ Circumference of cylinder.

$\lambda := \left[\frac{3 \cdot (1 - \nu_c^2)}{R^2 \cdot t^2} \right]^{0.25}$ $D := \frac{E_c \cdot t^3}{12(1 - \nu_c^2)}$ Shell parameters.

$L := \lambda \cdot H$ $L = 13.673$ L>6 and resultant load closer to left end; use semi-infinite beam.

Total load is superposition of loads due to soil pressure and water pressure.
Use a uniformly distributed load as a conservative approximation to a hydrostatic load.

Load 1: Uniformly distributed load due to soil pressure.

$w := K_0 \cdot (\gamma_{wet} - \gamma_w) \cdot d_{soil}$ Load. $w = 1.05 \times 10^3 \frac{lbf}{ft^2}$

$a := 0 \cdot ft$

$b := d_{soil}$ Load applied from "a" to "b."

$A_1 := 0.5 \cdot e^{-\lambda \cdot a} \cdot \cos(\lambda \cdot a)$ $B_1 := 0.5 \cdot e^{-\lambda \cdot b} \cdot \cos(\lambda \cdot b)$

$A_2 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) - \cos(\lambda \cdot a))$ $B_2 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) - \cos(\lambda \cdot b))$

$A_3 := -0.5 \cdot e^{-\lambda \cdot a} \cdot \sin(\lambda \cdot a)$ $B_3 := -0.5 \cdot e^{-\lambda \cdot b} \cdot \sin(\lambda \cdot b)$

$A_4 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) + \cos(\lambda \cdot a))$ $B_4 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) + \cos(\lambda \cdot b))$

$R_1 := \frac{-2 \cdot w}{\lambda} \cdot (B_1 - A_1)$ Reaction at end. $R_1 = 4.971 \times 10^3 \frac{lbf}{ft}$

$M_1 := \frac{w}{\lambda^2} \cdot (B_4 - A_4)$ Moment at end. $M_1 = -1.176 \times 10^4 \frac{lbf \cdot ft}{ft}$

Note: R and M are given per unit width of wall. M>0 when producing compression at outside face.

Maximum negative moment and maximum shear occur at fixed end.

$V_{soil} := R_1$ $M_{neg\_soil} := M_1$ $V_{soil} = 4.971 \times 10^3 \frac{lbf}{ft}$ $M_{neg\_soil} = -1.176 \times 10^4 \frac{lbf \cdot ft}{ft}$

Maximum positive moment occurs at intermediate location near fixed end.

$x := 8.4 \cdot ft$ Location between "a" and "b."

$F_1 := \cosh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_2 := \cosh(\lambda \cdot x) \cdot \sin(\lambda \cdot x) + \sinh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_{a3} := \sinh[\lambda \cdot (x - a)] \cdot \sin[\lambda \cdot (x - a)]$ $F_{b3} := 0$ $x < b$.

$LT_M := \frac{-w}{2 \cdot \lambda^2} \cdot (F_{a3} - F_{b3})$

$M_{1A} := M_1 \cdot F_1 + \frac{R_1}{2 \cdot \lambda} \cdot F_2 + LT_M$ $M_{1A} = 2.358 \times 10^3 \frac{lbf \cdot ft}{ft}$

$M_{pos\_soil} := M_{1A}$ Maximum positive moment. $M_{pos\_soil} = 2.358 \times 10^3 \frac{lbf \cdot ft}{ft}$

Load 2: Uniformly distributed load due to water pressure.

$w := \gamma_w \cdot d_{water}$ Load. $w = 3.058 \times 10^3 \frac{lbf}{ft^2}$

$a := 0 \cdot ft$ Load applied from "a" to "b."

$b := d_{water}$

$A_1 := 0.5 \cdot e^{-\lambda \cdot a} \cdot \cos(\lambda \cdot a)$ $B_1 := 0.5 \cdot e^{-\lambda \cdot b} \cdot \cos(\lambda \cdot b)$

$A_2 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) - \cos(\lambda \cdot a))$ $B_2 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) - \cos(\lambda \cdot b))$

$A_3 := -0.5 \cdot e^{-\lambda \cdot a} \cdot \sin(\lambda \cdot a)$ $B_3 := -0.5 \cdot e^{-\lambda \cdot b} \cdot \sin(\lambda \cdot b)$

$A_4 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) + \cos(\lambda \cdot a))$ $B_4 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) + \cos(\lambda \cdot b))$

$R_1 := \frac{-2 \cdot w}{\lambda} \cdot (B_1 - A_1)$ Reaction at end. $R_1 = 1.447 \times 10^4 \frac{lbf}{ft}$

$M_1 := \frac{w}{\lambda^2} \cdot (B_4 - A_4)$ Moment at end. $M_1 = -3.423 \times 10^4 \frac{lbf \cdot ft}{ft}$

Note: R and M are given per unit width of wall. M>0 when producing compression at outside face.

Maximum negative moment and maximum shear occur at fixed end.

$V_{water} := R_1$ $M_{neg\_water} := M_1$ $V_{water} = 1.447 \times 10^4 \frac{lbf}{ft}$ $M_{neg\_water} = -3.423 \times 10^4 \frac{lbf \cdot ft}{ft}$

Maximum positive moment occurs at intermediate location near fixed end.

$x := 8.4 \cdot ft$ Location between "a" and "b."

$F_1 := \cosh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_2 := \cosh(\lambda \cdot x) \cdot \sin(\lambda \cdot x) + \sinh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_{a3} := \sinh[\lambda \cdot (x - a)] \cdot \sin[\lambda \cdot (x - a)]$ $F_{b3} := 0$ $x < b$.

$LT_M := \frac{-w}{2 \cdot \lambda^2} \cdot (F_{a3} - F_{b3})$

$M_{1A} := M_1 \cdot F_1 + \frac{R_1}{2 \cdot \lambda} \cdot F_2 + LT_M$ $M_{1A} = 6.86 \times 10^3 \frac{lbf \cdot ft}{ft}$

$M_{pos\_water} := M_{1A}$ Maximum positive moment. $M_{pos\_water} = 6.86 \times 10^3 \frac{lbf \cdot ft}{ft}$

Superpose solutions using load factors of 1.0 for lateral earth pressure and 1.0 for hydrostatic floodwater pressure. Hydrodynamic wave pressure is neglected since it is small in comparison to hydrostatic pressure.

$V := 1.0 \cdot V_{soil} + V_{water}$ $\quad V = 1.944 \times 10^{4} \frac{lbf}{ft}$

$M_{neg} := 1.0 \cdot M_{neg\_soil} + M_{neg\_water}$ $\quad M_{neg} = -4.6 \times 10^{4} \frac{lbf \cdot ft}{ft}$

$M_{pos} := 1.0 \cdot M_{pos\_soil} + M_{pos\_water}$ $\quad M_{pos} = 9.218 \times 10^{3} \frac{lbf \cdot ft}{ft}$

Calculate shear capacity of concrete wall per ACI 318, Section 11.3.1.
Assume dowels carry entire load.

$f_y := 60000 \cdot psi$ Yield strength of reinforcement.

$d_s := 1.41 \cdot in$ Diameter of #11 rebar.

$A_s := 1.56 \cdot in^2$ Cross-sectional area of #11 rebar.

$s := 6 \cdot in$ Spacing of dowels at outside face (#6 bar at inside face neglected).

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $\quad A_s = 3.12\, in^2$ Area of shear reinforcement.

$V_c := 0.85 \cdot A_s \cdot f_y$ Shear capacity per one foot width of wall.

$V_c = 1.591 \times 10^{5}\, lbf$

Compare factored shear to shear capacity.

$V_u := V$ Factored shear. $\quad V_u = 1.944 \times 10^{4} \frac{lbf}{ft}$

$ratio := \frac{V_u \cdot 1 \cdot ft}{V_c}$ $\quad ratio = 0.122$ OK.

Calculate moment capacity of concrete wall per ACI 318, Section 10.2.7.
Assume vertical rebar carries entire load.

$c := 2 \cdot in$ Concrete cover.

$b := 12 \cdot in$ Width of wall.

Check rebar at outside face.

$d_s := 1.41 \cdot in$ Diameter of #11 rebar.

$d := t - c - 0.5 \cdot d_s$ Distance from extreme compression fiber to center of mass of tension reinforcement.

$A_s := 1.56 \cdot in^2$ Cross-sectional area of #11 rebar.

$s := 6 \cdot in$ — Spacing of vertical rebar at outside face.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $\quad A_s = 3.12\,in^2$ — Area of tension reinforcement.

$a := \frac{A_s \cdot f_y}{0.85 \cdot f_c \cdot b}$ — Depth of concrete compression block.

$M_c := 0.90 \cdot A_s \cdot f_y \cdot (d - 0.5 \cdot a)$ — Moment capacity per one foot width of wall.

$M_c = 2.668 \times 10^5\,lbf \cdot ft$

Compare factored moment to moment capacity.

$M_u := -M_{neg}$ — Factored moment. $\quad M_u = 4.6 \times 10^4 \frac{lbf \cdot ft}{ft}$

$ratio := \frac{M_u \cdot 1 \cdot ft}{M_c}$ $\quad ratio = 0.172$ — OK.

Check rebar at inside face.

$d_s := 0.75 \cdot in$ — Diameter of #6 rebar.

$d := t - c - 0.5 \cdot d_s$ — Distance from extreme compression fiber to center of mass of tension reinforcement.

$A_s := 0.44 \cdot in^2$ — Cross-sectional area of #6 rebar.

$s := 12 \cdot in$ — Spacing of vertical rebar at inside face.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $\quad A_s = 0.44\,in^2$ — Area of tension reinforcement.

$a := \frac{A_s \cdot f_y}{0.85 \cdot f_c \cdot b}$ — Depth of concrete compression block.

$M_c := 0.90 \cdot A_s \cdot f_y \cdot (d - 0.5 \cdot a)$ — Moment capacity per one foot width of wall.

$M_c = 4.218 \times 10^4\,lbf \cdot ft$

Compare factored moment to moment capacity.

$M_u := M_{pos}$ — Factored moment. $\quad M_u = 9.218 \times 10^3 \frac{lbf \cdot ft}{ft}$

$ratio := \frac{M_u \cdot 1 \cdot ft}{M_c}$ $\quad ratio = 0.219$ — OK.

Calculate bending moment and shear in the vault wall. Wall is modeled as a hollow cylinder loaded by external radial pressure. Cylinder is fixed at the base and free at the top. Load is hydrostatic pressure due to soil and water. Neglect weight of vault wall and loads due to weight of roof and equipment room since these loads cause compression rather than shear and

$D_i := 47 \cdot ft$ Inside diameter of cylinder.

$H := 73.2 \cdot ft$ Height of cylinder.

$t := 4 \cdot ft$ Wall thickness.

$d_{soil} := 45.3 \cdot ft$ Depth of soil at base of cylinder.

$d_{water} := 49 \cdot ft$ Depth of water at base of cylinder.

$\gamma_{dry} := 118 \cdot \frac{lbf}{ft^3}$ Weight of dry soil.

$\gamma_{wet} := 135 \cdot \frac{lbf}{ft^3}$ Weight of saturated soil.

$\gamma_w := 62.4 \cdot \frac{lbf}{ft^3}$ Weight of water.

$\phi := 43 \cdot \frac{\pi}{180}$ Angle of internal friction.

$K_0 := 1 - \sin(\phi)$ Earth pressure coefficient.

$f_c := 4000 \cdot psi$ Compressive strength of concrete.

$\gamma_c := 150 \cdot \frac{lbf}{ft^3}$ Weight of concrete.

$E_c := \gamma_c^{1.5} \cdot 33 \cdot \sqrt{f_c} \cdot \frac{ft^{4.5}}{lbf \cdot in}$ Modulus of elasticity of concrete.

$E_c = 3.834 \times 10^6 \, psi$

$\nu_c := 0.2$ Poisson's ratio of concrete.

Elasticity solution from Roark and Young, Table 8, Case 2, left end fixed.

$R := \frac{D_i + t}{2}$ Mean radius of cylinder.

$C := \pi \cdot (D_i + 2 \cdot t)$ Circumference of cylinder.

$\lambda := \left[\frac{3 \cdot \left(1 - \nu_c^2\right)}{R^2 \cdot t^2} \right]^{0.25}$ $D := \frac{E_c \cdot t^3}{12\left(1 - \nu_c^2\right)}$ Shell parameters.

$L := \lambda \cdot H$ $L = 9.442$ L>6 and resultant load closer to left end; use semi-infinite beam.

Total load is superposition of loads due to soil pressure and water pressure.
Use a uniformly distributed load as a conservative approximation to a hydrostatic load.

Load 1: Uniformly distributed load due to soil pressure.

$w := K_0 \cdot (\gamma_{wet} - \gamma_w) \cdot d_{soil}$ Load. $w = 1.046 \times 10^3 \frac{lbf}{ft^2}$

$a := 0 \cdot ft$

$b := d_{soil}$ Load applied from "a" to "b."

$A_1 := 0.5 \cdot e^{-\lambda \cdot a} \cdot \cos(\lambda \cdot a)$ $B_1 := 0.5 \cdot e^{-\lambda \cdot b} \cdot \cos(\lambda \cdot b)$

$A_2 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) - \cos(\lambda \cdot a))$ $B_2 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) - \cos(\lambda \cdot b))$

$A_3 := -0.5 \cdot e^{-\lambda \cdot a} \cdot \sin(\lambda \cdot a)$ $B_3 := -0.5 \cdot e^{-\lambda \cdot b} \cdot \sin(\lambda \cdot b)$

$A_4 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) + \cos(\lambda \cdot a))$ $B_4 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) + \cos(\lambda \cdot b))$

$R_1 := \frac{-2 \cdot w}{\lambda} \cdot (B_1 - A_1)$ Reaction at end. $R_1 = 8.087 \times 10^3 \frac{lbf}{ft}$

$M_1 := \frac{w}{\lambda^2} \cdot (B_4 - A_4)$ Moment at end. $M_1 = -3.139 \times 10^4 \frac{lbf \cdot ft}{ft}$

Note: R and M are given per unit width of wall. M>0 when producing compression at outside face.

Maximum negative moment and maximum shear occur at fixed end.

$V_{soil} := R_1$ $M_{neg\_soil} := M_1$ $V_{soil} = 8.087 \times 10^3 \frac{lbf}{ft}$ $M_{neg\_soil} = -3.139 \times 10^4 \frac{lbf \cdot ft}{ft}$

Maximum positive moment occurs at intermediate location near fixed end.

$x := 8.4 \cdot ft$ Location between "a" and "b."

$F_1 := \cosh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_2 := \cosh(\lambda \cdot x) \cdot \sin(\lambda \cdot x) + \sinh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_{a3} := \sinh[\lambda \cdot (x - a)] \cdot \sin[\lambda \cdot (x - a)]$ $F_{b3} := 0$ $x < b$.

$LT_M := \frac{-w}{2 \cdot \lambda^2} \cdot (F_{a3} - F_{b3})$

$M_{1A} := M_1 \cdot F_1 + \frac{R_1}{2 \cdot \lambda} \cdot F_2 + LT_M$ $M_{1A} = 4.281 \times 10^3 \frac{lbf \cdot ft}{ft}$

$M_{pos\_soil} := M_{1A}$ Maximum positive moment. $M_{pos\_soil} = 4.281 \times 10^3 \frac{lbf \cdot ft}{ft}$

Load 2: Uniformly distributed load due to water pressure.

$w := \gamma_w \cdot d_{water}$ Load. $w = 3.058 \times 10^3 \frac{lbf}{ft^2}$

$a := 0 \cdot ft$ Load applied from "a" to "b."

$b := d_{water}$

$A_1 := 0.5 \cdot e^{-\lambda \cdot a} \cdot \cos(\lambda \cdot a)$ $B_1 := 0.5 \cdot e^{-\lambda \cdot b} \cdot \cos(\lambda \cdot b)$

$A_2 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) - \cos(\lambda \cdot a))$ $B_2 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) - \cos(\lambda \cdot b))$

$A_3 := -0.5 \cdot e^{-\lambda \cdot a} \cdot \sin(\lambda \cdot a)$ $B_3 := -0.5 \cdot e^{-\lambda \cdot b} \cdot \sin(\lambda \cdot b)$

$A_4 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) + \cos(\lambda \cdot a))$ $B_4 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) + \cos(\lambda \cdot b))$

$R_1 := \frac{-2 \cdot w}{\lambda} \cdot (B_1 - A_1)$ Reaction at end. $R_1 = 2.366 \times 10^4 \frac{lbf}{ft}$

$M_1 := \frac{w}{\lambda^2} \cdot (B_4 - A_4)$ Moment at end. $M_1 = -9.172 \times 10^4 \frac{lbf \cdot ft}{ft}$

Note: R and M are given per unit width of wall. M>0 when producing compression at outside face.

Maximum negative moment and maximum shear occur at fixed end.

$V_{water} := R_1$ $M_{neg\_water} := M_1$ $V_{water} = 2.366 \times 10^4 \frac{lbf}{ft}$ $M_{neg\_water} = -9.172 \times 10^4 \frac{lbf \cdot ft}{ft}$

Maximum positive moment occurs at intermediate location near fixed end.

$x := 8.4 \cdot ft$ Location between "a" and "b."

$F_1 := \cosh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_2 := \cosh(\lambda \cdot x) \cdot \sin(\lambda \cdot x) + \sinh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_{a3} := \sinh[\lambda \cdot (x - a)] \cdot \sin[\lambda \cdot (x - a)]$ $F_{b3} := 0$ $x < b$.

$LT_M := \frac{-w}{2 \cdot \lambda^2} \cdot (F_{a3} - F_{b3})$

$M_{1A} := M_1 \cdot F_1 + \frac{R_1}{2 \cdot \lambda} \cdot F_2 + LT_M$ $M_{1A} = 1.271 \times 10^4 \frac{lbf \cdot ft}{ft}$

$M_{pos\_water} := M_{1A}$ Maximum positive moment. $M_{pos\_water} = 1.271 \times 10^4 \frac{lbf \cdot ft}{ft}$

Superpose solutions using load factors of 1.0 for lateral earth pressure and 1.0 for hydrostatic floodwater pressure. Hydrodynamic wave pressure is neglected since it is small in comparison to hydrostatic pressure.

$V := 1.0 \cdot V_{soil} + V_{water}$ $\quad V = 3.175 \times 10^4 \frac{lbf}{ft}$

$M_{neg} := 1.0 \cdot M_{neg\_soil} + M_{neg\_water}$ $\quad M_{neg} = -1.231 \times 10^5 \frac{lbf \cdot ft}{ft}$

$M_{pos} := 1.0 \cdot M_{pos\_soil} + M_{pos\_water}$ $\quad M_{pos} = 1.699 \times 10^4 \frac{lbf \cdot ft}{ft}$

Calculate shear capacity of concrete wall per ACI 318, Section 11.3.1.
Assume dowels carry entire load.

$f_y := 60000 \cdot psi$ — Yield strength of reinforcement.

$d_s := 1.41 \cdot in$ — Diameter of #11 rebar.

$A_s := 1.56 \cdot in^2$ — Cross-sectional area of #11 rebar.

$s := 6 \cdot in$ — Spacing of dowels at outside face (#9 bar at inside face neglected).

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $\quad A_s = 3.12\, in^2$ — Area of shear reinforcement.

$V_c := 0.85 \cdot A_s \cdot f_y$ — Shear capacity per one foot width of wall.

$V_c = 1.591 \times 10^5\, lbf$

Compare factored shear to shear capacity.

$V_u := V$ — Factored shear. $\quad V_u = 3.175 \times 10^4 \frac{lbf}{ft}$

$ratio := \frac{V_u \cdot 1 \cdot ft}{V_c}$ $\quad ratio = 0.2$ — OK.

Calculate moment capacity of concrete wall per ACI 318, Section 10.2.7.
Assume vertical rebar carries entire load.

$c := 5 \cdot in$ — Concrete cover.

$b := 12 \cdot in$ — Width of wall.

Check rebar at outside face.

$d_s := 1.41 \cdot in$ — Diameter of #11 rebar.

$d := t - c - 0.5 \cdot d_s$ — Distance from extreme compression fiber to center of mass of tension reinforcement.

$A_s := 1.56 \cdot in^2$ — Cross-sectional area of #11 rebar.

$s := 6 \cdot in$ Spacing of vertical rebar at outside face.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $A_s = 3.12\, in^2$ Area of tension reinforcement.

$a := \frac{A_s \cdot f_y}{0.85 \cdot f_c \cdot b}$ Depth of concrete compression block.

$M_c := 0.90 \cdot A_s \cdot f_y \cdot (d - 0.5 \cdot a)$ Moment capacity per one foot width of wall.

$M_c = 5.616 \times 10^5\, lbf \cdot ft$

Compare factored moment to moment capacity.

$M_u := -M_{neg}$ Factored moment. $M_u = 1.231 \times 10^5 \frac{lbf \cdot ft}{ft}$

$ratio := \frac{M_u \cdot 1 \cdot ft}{M_c}$ $ratio = 0.219$ OK.

Check rebar at inside face.

$d_s := 1.128 \cdot in$ Diameter of #9 rebar.

$d := t - c - 0.5 \cdot d_s$ Distance from extreme compression fiber to center of mass of tension reinforcement.

$A_s := 1.0 \cdot in^2$ Cross-sectional area of #9 rebar.

$s := 12 \cdot in$ Spacing of vertical rebar at inside face.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $A_s = 1\, in^2$ Area of tension reinforcement.

$a := \frac{A_s \cdot f_y}{0.85 \cdot f_c \cdot b}$ Depth of concrete compression block.

$M_c := 0.90 \cdot A_s \cdot f_y \cdot (d - 0.5 \cdot a)$ Moment capacity per one foot width of wall.

$M_c = 1.877 \times 10^5\, lbf \cdot ft$

Compare factored moment to moment capacity.

$M_u := M_{pos}$ Factored moment. $M_u = 1.699 \times 10^4 \frac{lbf \cdot ft}{ft}$

$ratio := \frac{M_u \cdot 1 \cdot ft}{M_c}$ $ratio = 0.091$ OK.

Calculate bending moment and shear in the vault wall. Wall is modeled as a hollow cylinder loaded by external radial pressure. Cylinder is fixed at the base and free at the top. Load is hydrostatic pressure due to soil and water. Neglect weight of vault wall and loads due to weight of roof and equipment room since these loads cause compression rather than shear and

$D_i := 52.3 \cdot ft$ Inside diameter of cylinder.

$H := 88.5 \cdot ft$ Height of cylinder.

$t := 4.25 \cdot ft$ Wall thickness.

$d_{soil} := 44.5 \cdot ft$ Depth of soil at base of cylinder.

$d_{water} := 48.5 \cdot ft$ Depth of water at base of cylinder.

$\gamma_{dry} := 118 \cdot \frac{lbf}{ft^3}$ Weight of dry soil.

$\gamma_{wet} := 135 \cdot \frac{lbf}{ft^3}$ Weight of saturated soil.

$\gamma_w := 62.4 \cdot \frac{lbf}{ft^3}$ Weight of water.

$\phi := 43 \cdot \frac{\pi}{180}$ Angle of internal friction.

$K_0 := 1 - \sin(\phi)$ Earth pressure coefficient.

$f_c := 4000 \cdot psi$ Compressive strength of concrete.

$\gamma_c := 150 \cdot \frac{lbf}{ft^3}$ Weight of concrete.

$E_c := \gamma_c^{1.5} \cdot 33 \cdot \sqrt{f_c} \cdot \frac{ft^{4.5}}{lbf \cdot in}$ Modulus of elasticity of concrete.

$E_c = 3.834 \times 10^6 psi$

$\nu_c := 0.2$ Poisson's ratio of concrete.

Elasticity solution from Roark and Young, Table 8, Case 2, left end fixed.

$R := \frac{D_i + t}{2}$ Mean radius of cylinder.

$C := \pi \cdot (D_i + 2 \cdot t)$ Circumference of cylinder.

$\lambda := \left[\frac{3 \cdot \left(1 - \nu_c^2\right)}{R^2 \cdot t^2}\right]^{0.25}$ $D := \frac{E_c \cdot t^3}{12\left(1 - \nu_c^2\right)}$ Shell parameters.

$L := \lambda \cdot H$ $L = 10.517$ L>6 and resultant load closer to left end; use semi-infinite beam.

Total load is superposition of loads due to soil pressure and water pressure. Use a uniformly distributed load as a conservative approximation to a hydrostatic load.

Load 1: Uniformly distributed load due to soil pressure.

$w := K_0 \cdot (\gamma_{wet} - \gamma_w) \cdot d_{soil}$ Load. $w = 1.027 \times 10^3 \frac{lbf}{ft^2}$

$a := 0 \cdot ft$

$b := d_{soil}$ Load applied from "a" to "b."

$A_1 := 0.5 \cdot e^{-\lambda \cdot a} \cdot \cos(\lambda \cdot a)$ $B_1 := 0.5 \cdot e^{-\lambda \cdot b} \cdot \cos(\lambda \cdot b)$

$A_2 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) - \cos(\lambda \cdot a))$ $B_2 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) - \cos(\lambda \cdot b))$

$A_3 := -0.5 \cdot e^{-\lambda \cdot a} \cdot \sin(\lambda \cdot a)$ $B_3 := -0.5 \cdot e^{-\lambda \cdot b} \cdot \sin(\lambda \cdot b)$

$A_4 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) + \cos(\lambda \cdot a))$ $B_4 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) + \cos(\lambda \cdot b))$

$R_1 := \frac{-2 \cdot w}{\lambda} \cdot (B_1 - A_1)$ Reaction at end. $R_1 = 8.621 \times 10^3 \frac{lbf}{ft}$

$M_1 := \frac{w}{\lambda^2} \cdot (B_4 - A_4)$ Moment at end. $M_1 = -3.643 \times 10^4 \frac{lbf \cdot ft}{ft}$

Note: R and M are given per unit width of wall. M>0 when producing compression at outside face.

Maximum negative moment and maximum shear occur at fixed end.

$V_{soil} := R_1$ $M_{neg\_soil} := M_1$ $V_{soil} = 8.621 \times 10^3 \frac{lbf}{ft}$ $M_{neg\_soil} = -3.643 \times 10^4 \frac{lbf \cdot ft}{ft}$

Maximum positive moment occurs at intermediate location near fixed end.

$x := 8.4 \cdot ft$ Location between "a" and "b."

$F_1 := \cosh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_2 := \cosh(\lambda \cdot x) \cdot \sin(\lambda \cdot x) + \sinh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_{a3} := \sinh[\lambda \cdot (x - a)] \cdot \sin[\lambda \cdot (x - a)]$ $F_{b3} := 0$ x < b.

$LT_M := \frac{-w}{2 \cdot \lambda^2} \cdot (F_{a3} - F_{b3})$

$M_{1A} := M_1 \cdot F_1 + \frac{R_1}{2 \cdot \lambda} \cdot F_2 + LT_M$ $M_{1A} = 3.766 \times 10^3 \frac{lbf \cdot ft}{ft}$

$M_{pos\_soil} := M_{1A}$ Maximum positive moment. $M_{pos\_soil} = 3.766 \times 10^3 \frac{lbf \cdot ft}{ft}$

Load 2: Uniformly distributed load due to water pressure.

$w := \gamma_w \cdot d_{water}$ Load. $w = 3.026 \times 10^3 \frac{lbf}{ft^2}$

$a := 0 \cdot ft$ Load applied from "a" to "b."

$b := d_{water}$

$A_1 := 0.5 \cdot e^{-\lambda \cdot a} \cdot \cos(\lambda \cdot a)$ $B_1 := 0.5 \cdot e^{-\lambda \cdot b} \cdot \cos(\lambda \cdot b)$

$A_2 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) - \cos(\lambda \cdot a))$ $B_2 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) - \cos(\lambda \cdot b))$

$A_3 := -0.5 \cdot e^{-\lambda \cdot a} \cdot \sin(\lambda \cdot a)$ $B_3 := -0.5 \cdot e^{-\lambda \cdot b} \cdot \sin(\lambda \cdot b)$

$A_4 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) + \cos(\lambda \cdot a))$ $B_4 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) + \cos(\lambda \cdot b))$

$R_1 := \frac{-2 \cdot w}{\lambda} \cdot (B_1 - A_1)$ Reaction at end. $R_1 = 2.54 \times 10^4 \frac{lbf}{ft}$

$M_1 := \frac{w}{\lambda^2} \cdot (B_4 - A_4)$ Moment at end. $M_1 = -1.07 \times 10^5 \frac{lbf \cdot ft}{ft}$

Note: R and M are given per unit width of wall. M>0 when producing compression at outside face.

Maximum negative moment and maximum shear occur at fixed end.

$V_{water} := R_1$ $M_{neg\_water} := M_1$ $V_{water} = 2.54 \times 10^4 \frac{lbf}{ft}$ $M_{neg\_water} = -1.07 \times 10^5 \frac{lbf \cdot ft}{ft}$

Maximum positive moment occurs at intermediate location near fixed end.

$x := 8.4 \cdot ft$ Location between "a" and "b."

$F_1 := \cosh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_2 := \cosh(\lambda \cdot x) \cdot \sin(\lambda \cdot x) + \sinh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_{a3} := \sinh[\lambda \cdot (x - a)] \cdot \sin[\lambda \cdot (x - a)]$ $F_{b3} := 0$ $x < b$.

$LT_M := \frac{-w}{2 \cdot \lambda^2} \cdot (F_{a3} - F_{b3})$

$M_{1A} := M_1 \cdot F_1 + \frac{R_1}{2 \cdot \lambda} \cdot F_2 + LT_M$ $M_{1A} = 1.134 \times 10^4 \frac{lbf \cdot ft}{ft}$

$M_{pos\_water} := M_{1A}$ Maximum positive moment. $M_{pos\_water} = 1.134 \times 10^4 \frac{lbf \cdot ft}{ft}$

Superpose solutions using load factors of 1.0 for lateral earth pressure and 1.0 for hydrostatic floodwater pressure. Hydrodynamic wave pressure is neglected since it is small in comparison to hydrostatic pressure.

$V := 1.0 \cdot V_{soil} + V_{water}$ $\quad V = 3.402 \times 10^{4} \dfrac{lbf}{ft}$

$M_{neg} := 1.0 \cdot M_{neg\_soil} + M_{neg\_water}$ $\quad M_{neg} = -1.435 \times 10^{5} \dfrac{lbf \cdot ft}{ft}$

$M_{pos} := 1.0 \cdot M_{pos\_soil} + M_{pos\_water}$ $\quad M_{pos} = 1.51 \times 10^{4} \dfrac{lbf \cdot ft}{ft}$

Calculate shear capacity of concrete wall per ACI 318, Section 11.3.1.
Assume dowels carry entire load.

$f_y := 60000 \cdot psi$ — Yield strength of reinforcement.

$d_s := 1.693 \cdot in$ — Diameter of #14 rebar.

$A_s := 2.25 \cdot in^2$ — Cross-sectional area of #14 rebar.

$s := 6 \cdot in$ — Spacing of dowels at inside and outside faces.

$A_s := A_s \cdot \dfrac{12 \cdot in}{s}$ $\quad A_s = 4.5\, in^2$ — Area of shear reinforcement.

$V_c := 0.85 \cdot 2 \cdot A_s \cdot f_y$ — Shear capacity per one foot width of wall.

$V_c = 4.59 \times 10^{5}\, lbf$

Compare factored shear to shear capacity.

$V_u := V$ — Factored shear. $\quad V_u = 3.402 \times 10^{4} \dfrac{lbf}{ft}$

$ratio := \dfrac{V_u \cdot 1 \cdot ft}{V_c}$ $\quad ratio = 0.074$ — OK.

Calculate moment capacity of concrete wall per ACI 318, Section 10.2.7.
Assume vertical rebar carries entire load.

$c := 5 \cdot in$ — Concrete cover.

$b := 12 \cdot in$ — Width of wall.

Check rebar at outside face.

$d_s := 1.693 \cdot in$ — Diameter of #14 rebar.

$d := t - c - 0.5 \cdot d_s$ — Distance from extreme compression fiber to center of mass of tension reinforcement.

$A_s := 2.25 \cdot in^2$ — Cross-sectional area of #14 rebar.

$s := 6 \cdot in$ — Spacing of vertical rebar at outside face.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $\quad A_s = 4.5\, in^2$ — Area of tension reinforcement.

$a := \frac{A_s \cdot f_y}{0.85 \cdot f_c \cdot b}$ — Depth of concrete compression block.

$M_c := 0.90 \cdot A_s \cdot f_y \cdot (d - 0.5 \cdot a)$ — Moment capacity per one foot width of wall.

$M_c = 8.474 \times 10^5\, lbf \cdot ft$

Compare factored moment to moment capacity.

$M_u := -M_{neg}$ — Factored moment. $\quad M_u = 1.435 \times 10^5 \frac{lbf \cdot ft}{ft}$

$ratio := \frac{M_u \cdot 1 \cdot ft}{M_c}$ $\quad ratio = 0.169$ — OK.

Check rebar at inside face.

$d_s := 1.693 \cdot in$ — Diameter of #14 rebar.

$d := t - c - 0.5 \cdot d_s$ — Distance from extreme compression fiber to center of mass of tension reinforcement.

$A_s := 2.25 \cdot in^2$ — Cross-sectional area of #14 rebar.

$s := 6 \cdot in$ — Spacing of vertical rebar at inside face.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $\quad A_s = 4.5\, in^2$ — Area of tension reinforcement.

$a := \frac{A_s \cdot f_y}{0.85 \cdot f_c \cdot b}$ — Depth of concrete compression block.

$M_c := 0.90 \cdot A_s \cdot f_y \cdot (d - 0.5 \cdot a)$ — Moment capacity per one foot width of wall.

$M_c = 8.474 \times 10^5\, lbf \cdot ft$

Compare factored moment to moment capacity.

$M_u := M_{pos}$ — Factored moment. $\quad M_u = 1.51 \times 10^4 \frac{lbf \cdot ft}{ft}$

$ratio := \frac{M_u \cdot 1 \cdot ft}{M_c}$ $\quad ratio = 0.018$ — OK.

Calculate bending moment and shear in the vault wall. Wall is modeled as a hollow cylinder loaded by external radial pressure. Cylinder is fixed at the base and free at the top. Load is hydrostatic pressure due to soil and water. Neglect weight of vault wall and loads due to weight of roof and equipment room since these loads cause compression rather than shear and

$D_i := 52.3 \cdot ft$ Inside diameter of cylinder.

$H := 88.5 \cdot ft$ Height of cylinder.

$t := 4.25 \cdot ft$ Wall thickness.

$d_{soil} := 44.5 \cdot ft$ Depth of soil at base of cylinder.

$d_{water} := 48.5 \cdot ft$ Depth of water at base of cylinder.

$\gamma_{dry} := 118 \cdot \frac{lbf}{ft^3}$ Weight of dry soil.

$\gamma_{wet} := 135 \cdot \frac{lbf}{ft^3}$ Weight of saturated soil.

$\gamma_w := 62.4 \cdot \frac{lbf}{ft^3}$ Weight of water.

$\phi := 43 \cdot \frac{\pi}{180}$ Angle of internal friction.

$K_0 := 1 - \sin(\phi)$ Earth pressure coefficient.

$f_c := 4000 \cdot psi$ Compressive strength of concrete.

$\gamma_c := 150 \cdot \frac{lbf}{ft^3}$ Weight of concrete.

$E_c := \gamma_c^{1.5} \cdot 33 \cdot \sqrt{f_c} \cdot \frac{ft^{4.5}}{lbf \cdot in}$ Modulus of elasticity of concrete.

$E_c = 3.834 \times 10^6 psi$

$\nu_c := 0.2$ Poisson's ratio of concrete.

Elasticity solution from Roark and Young, Table 8, Case 2, left end fixed.

$R := \frac{D_i + t}{2}$ Mean radius of cylinder.

$C := \pi \cdot (D_i + 2 \cdot t)$ Circumference of cylinder.

$\lambda := \left[\frac{3 \cdot \left(1 - \nu_c^2\right)}{R^2 \cdot t^2} \right]^{0.25}$ $D := \frac{E_c \cdot t^3}{12\left(1 - \nu_c^2\right)}$ Shell parameters.

$L := \lambda \cdot H$ $L = 10.517$ L>6 and resultant load closer to left end; use semi-infinite beam.

Total load is superposition of loads due to soil pressure and water pressure.
Use a uniformly distributed load as a conservative approximation to a hydrostatic load.

Load 1: Uniformly distributed load due to soil pressure.

$w := K_0 \cdot (\gamma_{wet} - \gamma_w) \cdot d_{soil}$ Load. $w = 1.027 \times 10^3 \frac{lbf}{ft^2}$

$a := 0 \cdot ft$ Load applied from "a" to "b."

$b := d_{soil}$

$A_1 := 0.5 \cdot e^{-\lambda \cdot a} \cdot \cos(\lambda \cdot a)$ $B_1 := 0.5 \cdot e^{-\lambda \cdot b} \cdot \cos(\lambda \cdot b)$

$A_2 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) - \cos(\lambda \cdot a))$ $B_2 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) - \cos(\lambda \cdot b))$

$A_3 := -0.5 \cdot e^{-\lambda \cdot a} \cdot \sin(\lambda \cdot a)$ $B_3 := -0.5 \cdot e^{-\lambda \cdot b} \cdot \sin(\lambda \cdot b)$

$A_4 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) + \cos(\lambda \cdot a))$ $B_4 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) + \cos(\lambda \cdot b))$

$R_1 := \frac{-2 \cdot w}{\lambda} \cdot (B_1 - A_1)$ Reaction at end. $R_1 = 8.621 \times 10^3 \frac{lbf}{ft}$

$M_1 := \frac{w}{\lambda^2} \cdot (B_4 - A_4)$ Moment at end. $M_1 = -3.643 \times 10^4 \frac{lbf \cdot ft}{ft}$

Note: R and M are given per unit width of wall. M>0 when producing compression at outside face.

Maximum negative moment and maximum shear occur at fixed end.

$V_{soil} := R_1$ $M_{neg\_soil} := M_1$ $V_{soil} = 8.621 \times 10^3 \frac{lbf}{ft}$ $M_{neg\_soil} = -3.643 \times 10^4 \frac{lbf \cdot ft}{ft}$

Maximum positive moment occurs at intermediate location near fixed end.

$x := 8.4 \cdot ft$ Location between "a" and "b."

$F_1 := \cosh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_2 := \cosh(\lambda \cdot x) \cdot \sin(\lambda \cdot x) + \sinh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_{a3} := \sinh[\lambda \cdot (x - a)] \cdot \sin[\lambda \cdot (x - a)]$ $F_{b3} := 0$ $x < b$.

$LT_M := \frac{-w}{2 \cdot \lambda^2} \cdot (F_{a3} - F_{b3})$

$M_{1A} := M_1 \cdot F_1 + \frac{R_1}{2 \cdot \lambda} \cdot F_2 + LT_M$ $M_{1A} = 3.766 \times 10^3 \frac{lbf \cdot ft}{ft}$

$M_{pos\_soil} := M_{1A}$ Maximum positive moment. $M_{pos\_soil} = 3.766 \times 10^3 \frac{lbf \cdot ft}{ft}$

Load 2: Uniformly distributed load due to water pressure.

$w := \gamma_w \cdot d_{water}$ Load. $w = 3.026 \times 10^3 \frac{lbf}{ft^2}$

$a := 0 \cdot ft$ Load applied from "a" to "b."

$b := d_{water}$

$A_1 := 0.5 \cdot e^{-\lambda \cdot a} \cdot \cos(\lambda \cdot a)$ $B_1 := 0.5 \cdot e^{-\lambda \cdot b} \cdot \cos(\lambda \cdot b)$

$A_2 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) - \cos(\lambda \cdot a))$ $B_2 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) - \cos(\lambda \cdot b))$

$A_3 := -0.5 \cdot e^{-\lambda \cdot a} \cdot \sin(\lambda \cdot a)$ $B_3 := -0.5 \cdot e^{-\lambda \cdot b} \cdot \sin(\lambda \cdot b)$

$A_4 := 0.5 \cdot e^{-\lambda \cdot a} \cdot (\sin(\lambda \cdot a) + \cos(\lambda \cdot a))$ $B_4 := 0.5 \cdot e^{-\lambda \cdot b} \cdot (\sin(\lambda \cdot b) + \cos(\lambda \cdot b))$

$R_1 := \frac{-2 \cdot w}{\lambda} \cdot (B_1 - A_1)$ Reaction at end. $R_1 = 2.54 \times 10^4 \frac{lbf}{ft}$

$M_1 := \frac{w}{\lambda^2} \cdot (B_4 - A_4)$ Moment at end. $M_1 = -1.07 \times 10^5 \frac{lbf \cdot ft}{ft}$

Note: R and M are given per unit width of wall. M>0 when producing compression at outside face.
Maximum negative moment and maximum shear occur at fixed end.

$V_{water} := R_1$ $M_{neg\_water} := M_1$ $V_{water} = 2.54 \times 10^4 \frac{lbf}{ft}$ $M_{neg\_water} = -1.07 \times 10^5 \frac{lbf \cdot ft}{ft}$

Maximum positive moment occurs at intermediate location near fixed end.

$x := 8.4 \cdot ft$ Location between "a" and "b."

$F_1 := \cosh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_2 := \cosh(\lambda \cdot x) \cdot \sin(\lambda \cdot x) + \sinh(\lambda \cdot x) \cdot \cos(\lambda \cdot x)$

$F_{a3} := \sinh[\lambda \cdot (x - a)] \cdot \sin[\lambda \cdot (x - a)]$ $F_{b3} := 0$ $x < b$.

$LT_M := \frac{-w}{2 \cdot \lambda^2} \cdot (F_{a3} - F_{b3})$

$M_{1A} := M_1 \cdot F_1 + \frac{R_1}{2 \cdot \lambda} \cdot F_2 + LT_M$ $M_{1A} = 1.134 \times 10^4 \frac{lbf \cdot ft}{ft}$

$M_{pos\_water} := M_{1A}$ Maximum positive moment. $M_{pos\_water} = 1.134 \times 10^4 \frac{lbf \cdot ft}{ft}$

Superpose solutions using load factors of 1.0 for lateral earth pressure and 1.0 for hydrostatic floodwater pressure. Hydrodynamic wave pressure is neglected since it is small in comparison to hydrostatic pressure.

$V := 1.0 \cdot V_{soil} + V_{water}$ $\quad V = 3.402 \times 10^4 \frac{lbf}{ft}$

$M_{neg} := 1.0 \cdot M_{neg\_soil} + M_{neg\_water}$ $\quad M_{neg} = -1.435 \times 10^5 \frac{lbf \cdot ft}{ft}$

$M_{pos} := 1.0 \cdot M_{pos\_soil} + M_{pos\_water}$ $\quad M_{pos} = 1.51 \times 10^4 \frac{lbf \cdot ft}{ft}$

Calculate shear capacity of concrete wall per ACI 318, Section 11.3.1.
Assume dowels carry entire load.

$f_y := 60000 \cdot psi$ Yield strength of reinforcement.

$d_s := 1.41 \cdot in$ Diameter of #11 rebar.

$A_s := 1.56 \cdot in^2$ Cross-sectional area of #11 rebar.

$s := 6 \cdot in$ Spacing of dowels at inside and outside faces.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $\quad A_s = 3.12\, in^2$ Area of shear reinforcement.

$V_c := 0.85 \cdot 2 \cdot A_s \cdot f_y$ Shear capacity per one foot width of wall.

$V_c = 3.182 \times 10^5\, lbf$

Compare factored shear to shear capacity.

$V_u := V$ Factored shear. $\quad V_u = 3.402 \times 10^4 \frac{lbf}{ft}$

$ratio := \frac{V_u \cdot 1 \cdot ft}{V_c}$ $\quad ratio = 0.107$ OK.

Calculate moment capacity of concrete wall per ACI 318, Section 10.2.7.
Assume vertical rebar carries entire load.

$c := 5 \cdot in$ Concrete cover.

$b := 12 \cdot in$ Width of wall.

Check rebar at outside face.

$d_s := 1.41 \cdot in$ Diameter of #11 rebar.

$d := t - c - 0.5 \cdot d_s$ Distance from extreme compression fiber to center of mass of tension reinforcement.

$A_s := 1.56 \cdot in^2$ Cross-sectional area of #11 rebar.

$s := 6 \cdot in$ — Spacing of vertical rebar at outside face.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $\quad A_s = 3.12\, in^2$ — Area of tension reinforcement.

$a := \frac{A_s \cdot f_y}{0.85 \cdot f_c \cdot b}$ — Depth of concrete compression block.

$M_c := 0.90 \cdot A_s \cdot f_y \cdot (d - 0.5 \cdot a)$ — Moment capacity per one foot width of wall.

$M_c = 6.037 \times 10^5\, lbf \cdot ft$

Compare factored moment to moment capacity.

$M_u := -M_{neg}$ — Factored moment. $\quad M_u = 1.435 \times 10^5\, \frac{lbf \cdot ft}{ft}$

$ratio := \frac{M_u \cdot 1 \cdot ft}{M_c}$ $\quad ratio = 0.238$ — OK.

Check rebar at inside face.

$d_s := 1.41 \cdot in$ — Diameter of #11 rebar.

$d := t - c - 0.5 \cdot d_s$ — Distance from extreme compression fiber to center of mass of tension reinforcement.

$A_s := 1.56 \cdot in^2$ — Cross-sectional area of #11 rebar.

$s := 6 \cdot in$ — Spacing of vertical rebar at inside face.

$A_s := A_s \cdot \frac{12 \cdot in}{s}$ $\quad A_s = 3.12\, in^2$ — Area of tension reinforcement.

$a := \frac{A_s \cdot f_y}{0.85 \cdot f_c \cdot b}$ — Depth of concrete compression block.

$M_c := 0.90 \cdot A_s \cdot f_y \cdot (d - 0.5 \cdot a)$ — Moment capacity per one foot width of wall.

$M_c = 6.037 \times 10^5\, lbf \cdot ft$

Compare factored moment to moment capacity.

$M_u := M_{pos}$ — Factored moment. $\quad M_u = 1.51 \times 10^4\, \frac{lbf \cdot ft}{ft}$

$ratio := \frac{M_u \cdot 1 \cdot ft}{M_c}$ $\quad ratio = 0.025$ — OK.

RCRA PART B PERMIT REAPPLICATION

FOR THE

IDAHO NATIONAL LABORATORY

VOLUME 22

IDAHO NUCLEAR TECHNOLOGY & ENGINEERING CENTER

CALCINED SOLIDS STORAGE FACILITY

APPENDIX 5

SECTION E - GROUNDWATER MONITORING

MAY 2016

E. Groundwater Monitoring [IDAPA 58.01.05.008; 40 CFR 264.90 through 264.101]

In accordance with 40 CFR 264.90(a)(2), all solid waste management units must comply with the requirements in 40 CFR 264.101, corrective action for solid waste management units.

The corrective action requirements for the units covered by this permit application are addressed in the previously issued Volume 18 Idaho National Laboratory (INL) Idaho Nuclear Technology and Engineering Center (INTEC) Partial Permit Module VIII.

The groundwater monitoring requirements of 40 CFR 270.14(c), including IDAPA 58.01.05.008; 40 CFR 264.91 through 264.100, are not applicable to the Idaho Nuclear Technology and Engineering Center Calcined Solids Storage Facility buildings as these buildings are not landfills, surface impoundments, waste piles, or land treatment facilities.

Hydrogeologic information required by 40 CFR 270.14(b)(11) is addressed in Volume 3 of the INL HWMA/RCRA Part B Permit Application.

RCRA PART B PERMIT REAPPLICATION

FOR THE

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APPENDIX 6

SECTION J - CORRECTIVE ACTION FOR SOLID WASTE MANAGEMENT UNITS

MAY 2016

J. Corrective Action For Solid Waste Management Units [IDAPA 58.01.05.008; 40 CFR 264.101]

Any RCRA corrective action required at Idaho Nuclear Technology and Engineering Center (INTEC) will be addressed under the Federal Facilities Agreement and Consent Order (FFA/CO) or Module VIII of the previously issued Volume 18 INTEC Partial Permit.

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APPENDIX 7

SECTION K - OTHER FEDERAL LAWS

MAY 2016

K. Other Federal Laws [IDAPA 58.01.05.012; 40 CFR 270.14(b)(20), 40 CFR 270.3]

The subject for other federal laws applicable to waste management units at the Idaho National Laboratory (INL) is addressed in Section K in Volume 3 of the INL Resource Conservation and Recovery Act Part B Permit Application.

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APPENDIX 8

SECTION L - CERTIFICATION

MAY 2016

REGULATORY CERTIFICATION

[IDAPA 58.01.05.012; 40 CFR 270.11(d) and 270.30(k)]

RCRA PART B PERMIT REAPPLICATION
FOR THE CSSF VOLUME 22 –MAY 2016

The undersigned certifies as required per IDAPA 58.01.05.012 [40 CFR 270.11(d) and 270.30(k)] as follows:

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Operator Signature

______________________________ Date: 5-5-16

David P. Hutchison, Vice President ESH&QA
CH2M WG-Idaho, LLC.

REGULATORY CERTIFICATION

[IDAPA 58.01.05.012; 40 CFR 270.11(d) and 270.30(k)]

RCRA PART B PERMIT REAPPLICATION
FOR THE CSSF Volume 22 – May 2016

The undersigned certifies as required per IDAPA 58.01.05.012 [40 CFR 270.11(d) and 270.30(k)] as follows:

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Operator Signature

Frederick P. Hughes _________________________ Date: 5/9/16

Frederick P. Hughes, Program Manager
Fluor Idaho, LLC

REGULATORY CERTIFICATION

[IDAPA 58.01.05.012; 40 CFR 270.11(d) and 270.30(k)]

RCRA PART B PERMIT REAPPLICATION
FOR THE CSSF VOLUME 22 – MAY 2016

The undersigned certifies as required per IDAPA 58.01.05.012 [40 CFR 270.11(d) and 270.30(k)] as follows:

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Owner Signature

for

_______________________________________ Date: 5/10/2016

Richard B. Provencher, Manager
Department of Energy Idaho Operations Office