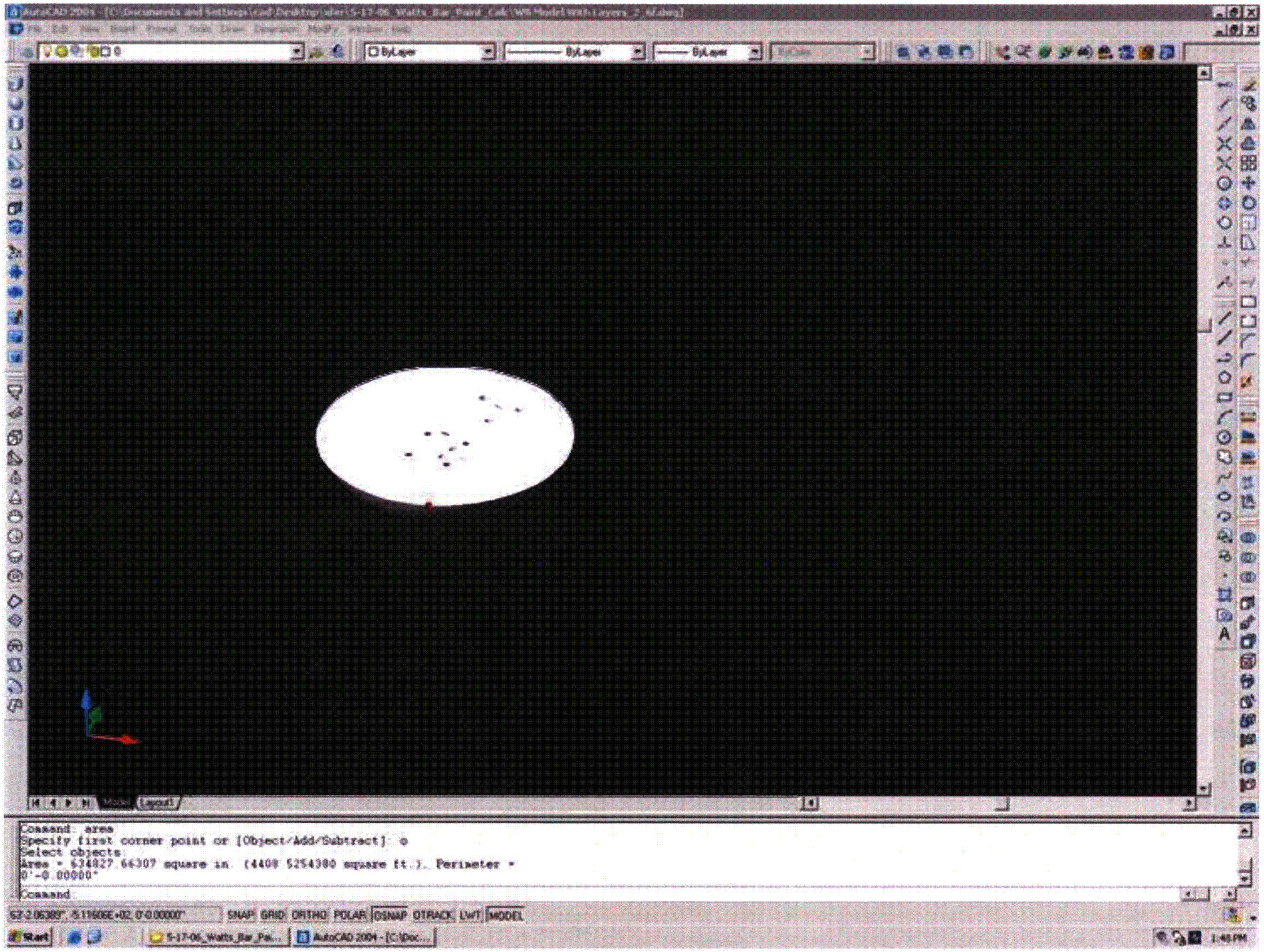


Figure 4.25 – Case 3 - Steel Subtracted from 10D ZOI Sphere Within 6' of Floor

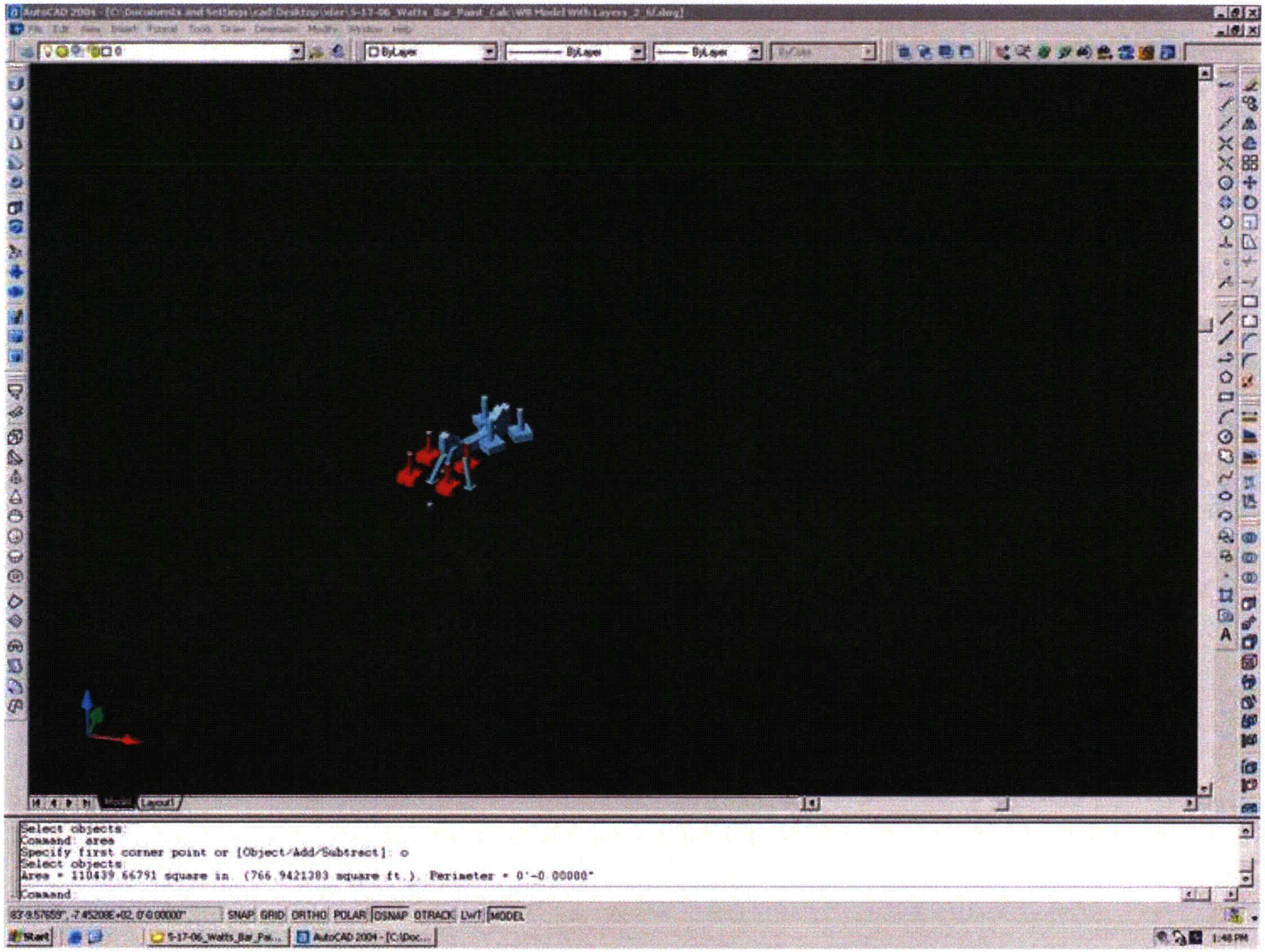


Figure 4.26 – Case 3 - Steel Intersected with 10D ZOI Sphere Within 6' of Floor

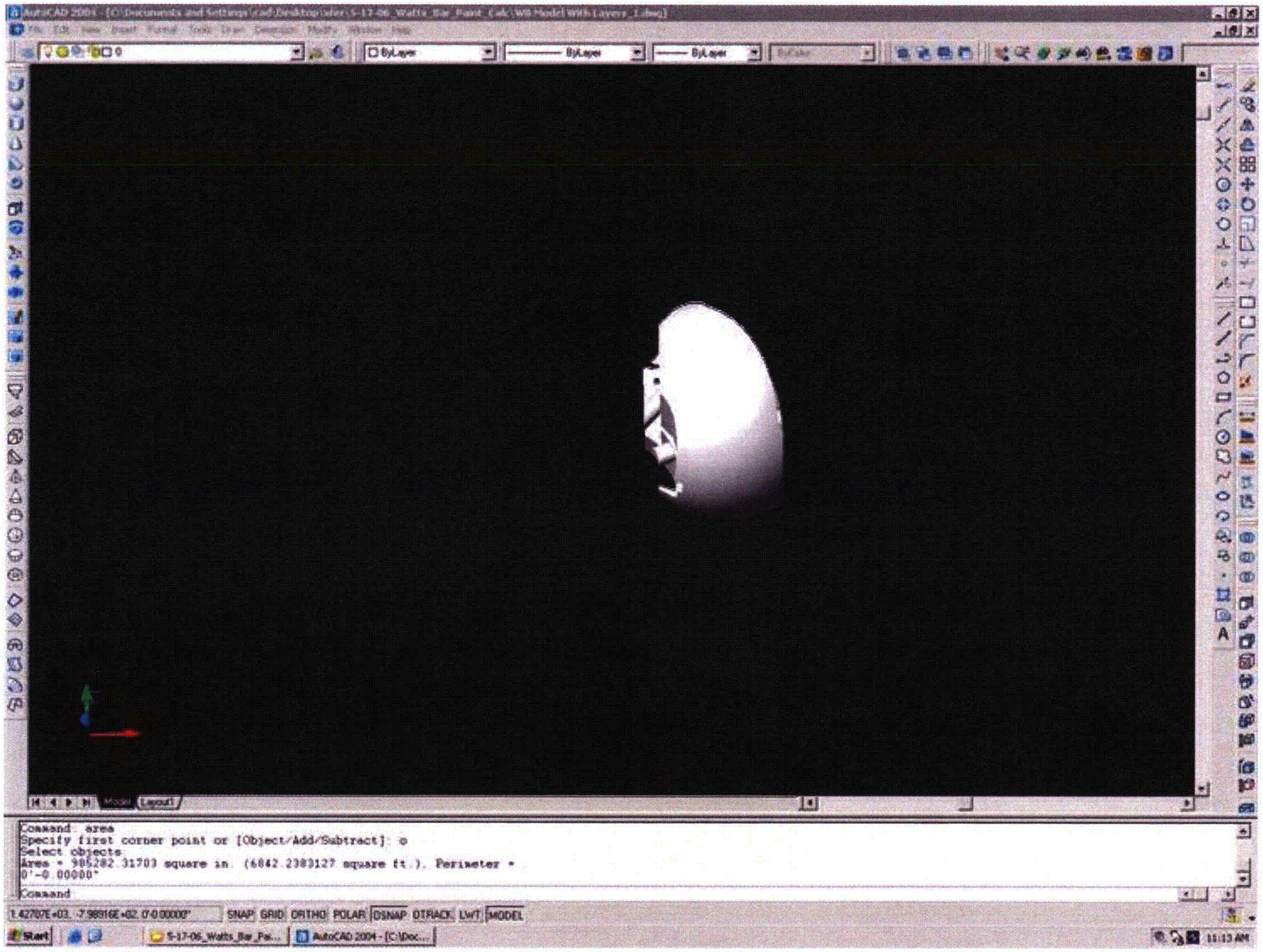


Figure 4.27 – Case 4 - Concrete Subtracted from 10D ZOI Sphere

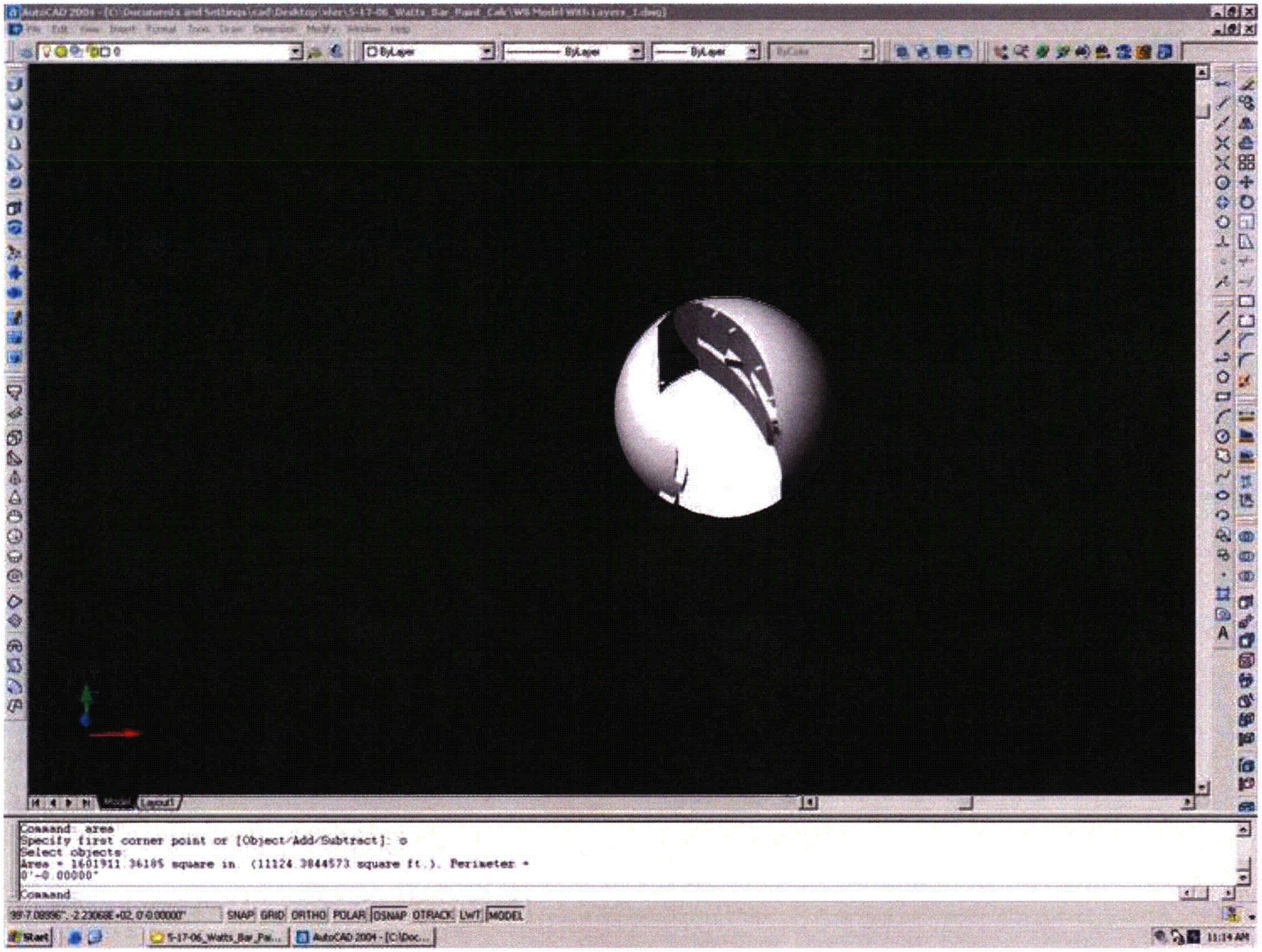


Figure 4.28 – Case 4 - Concrete Intersected with 10D ZOI Sphere

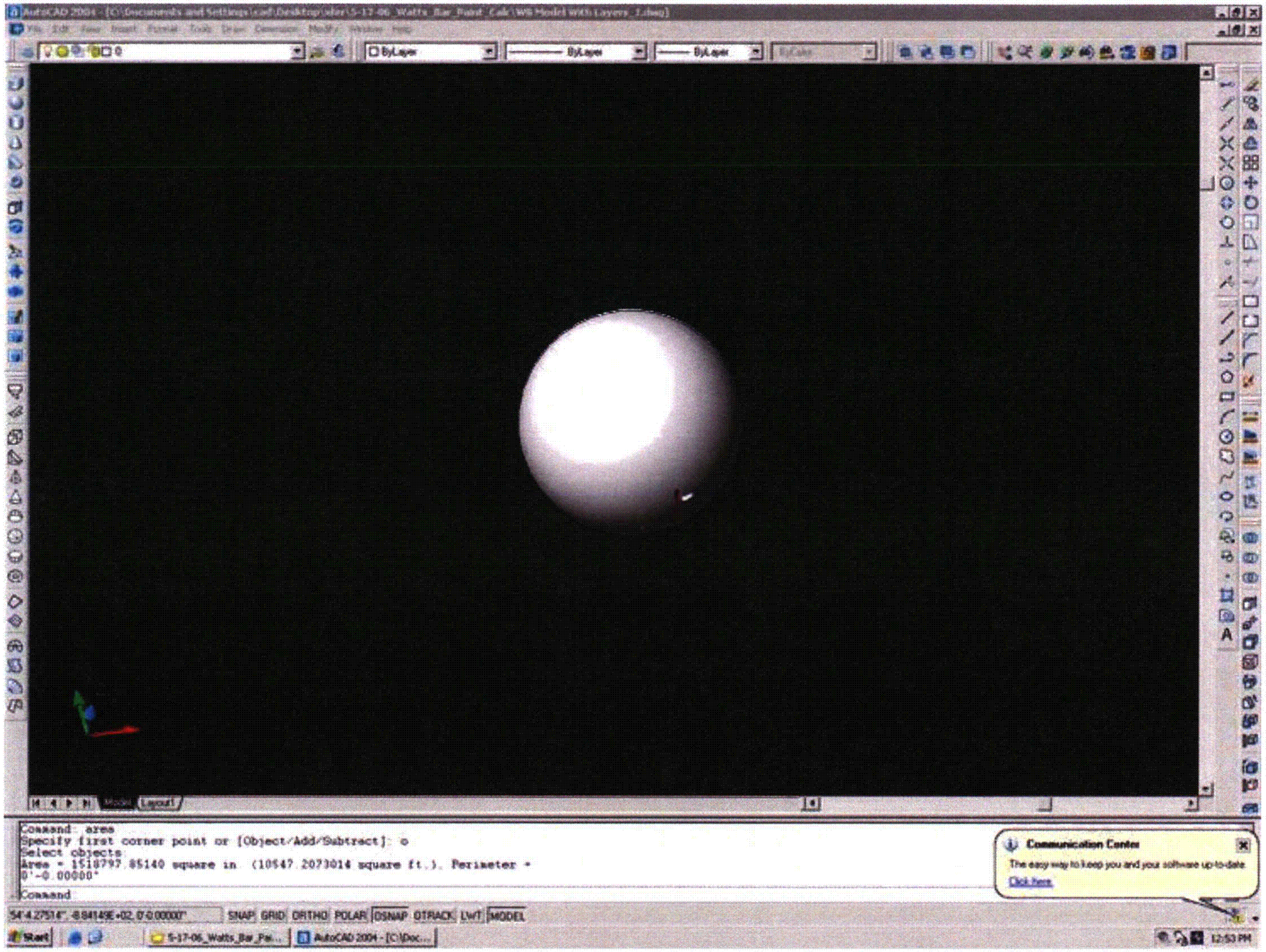


Figure 4.29 – Case 4 - Steel Subtracted from 10D ZOI Sphere

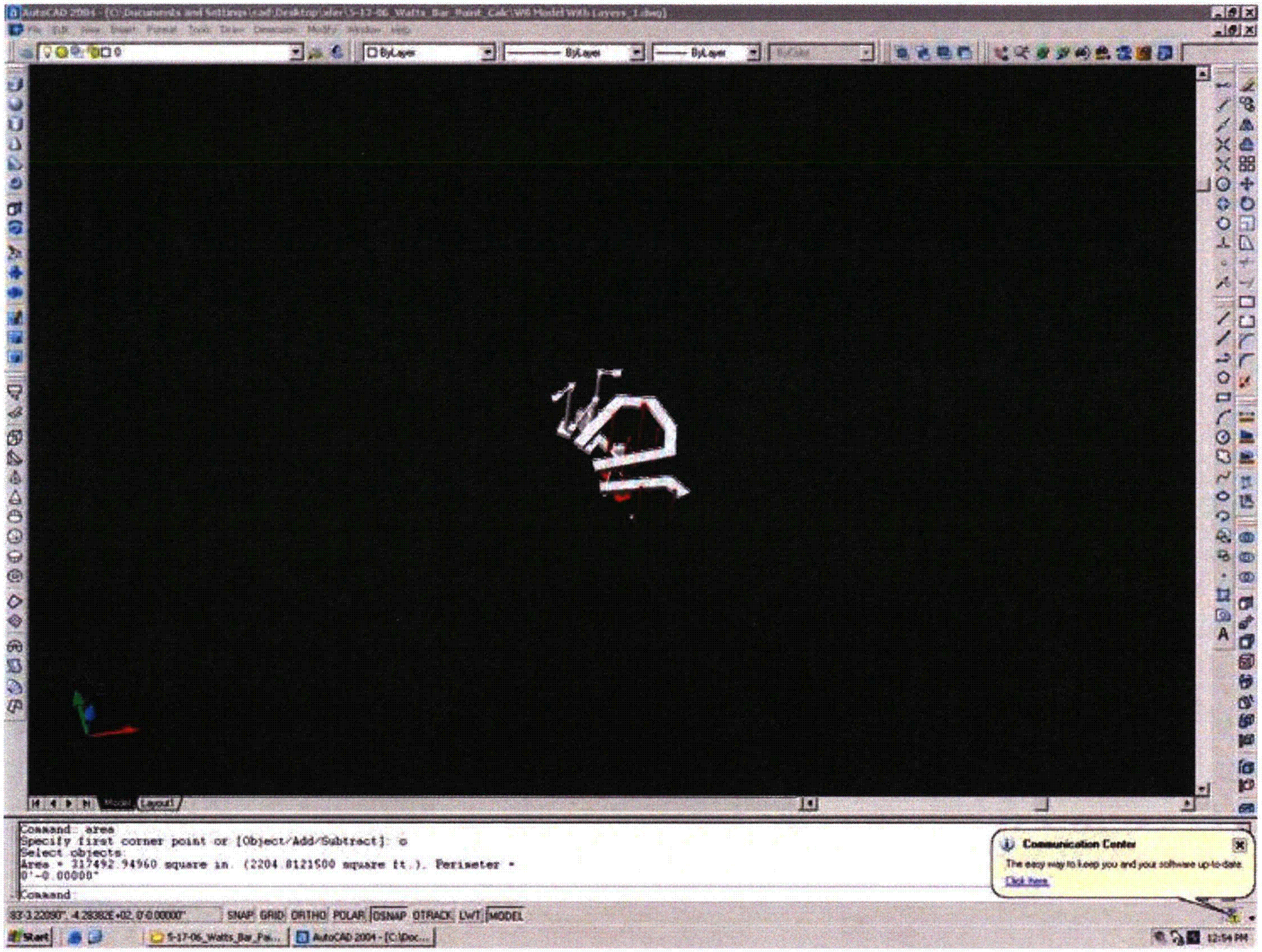


Figure 4.30 – Case 4 - Steel Intersected with 10D ZOI Sphere

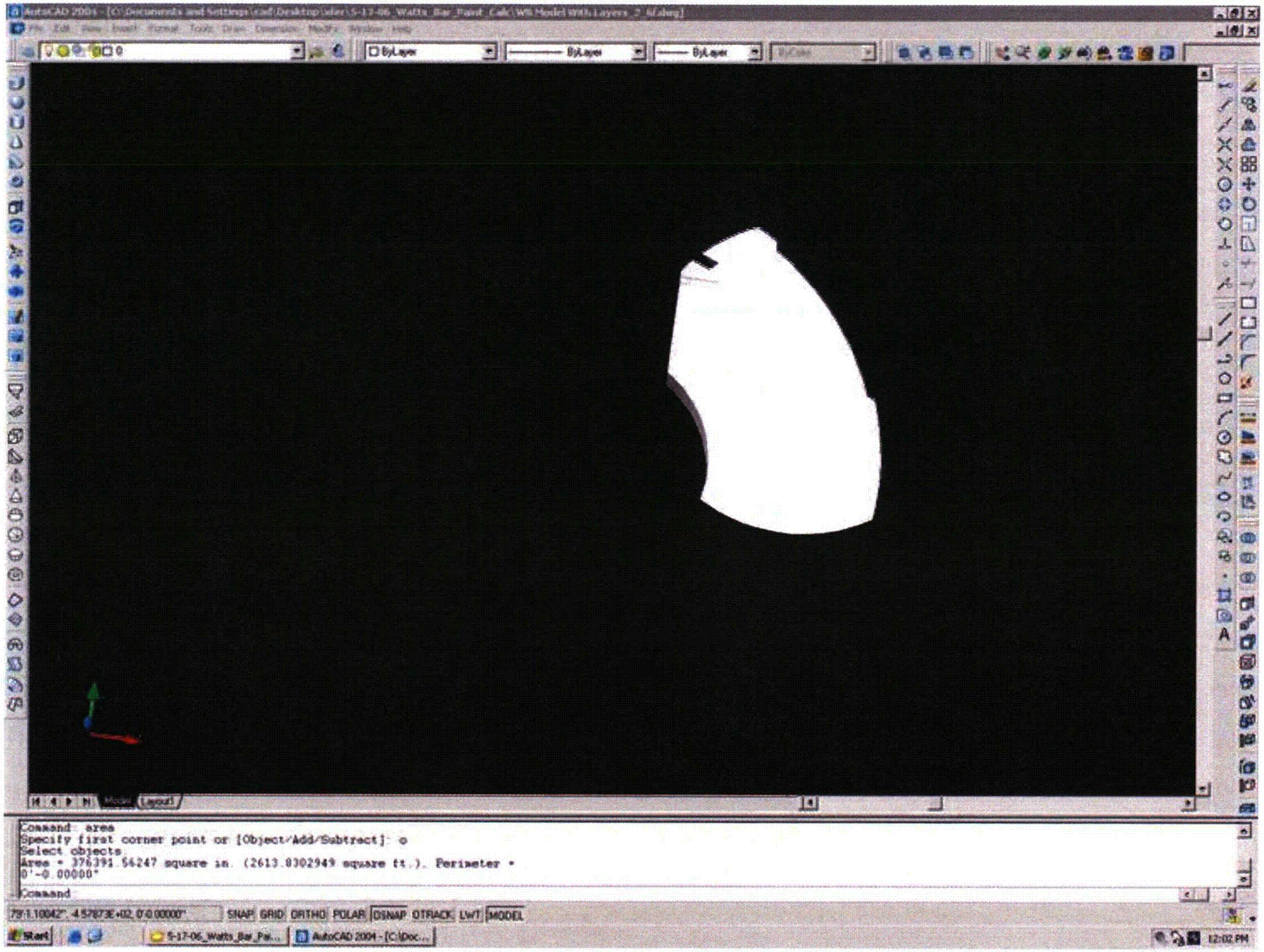


Figure 4.31 – Case 4 - Concrete Subtracted from 10D ZOI Sphere Within 6' of Floor

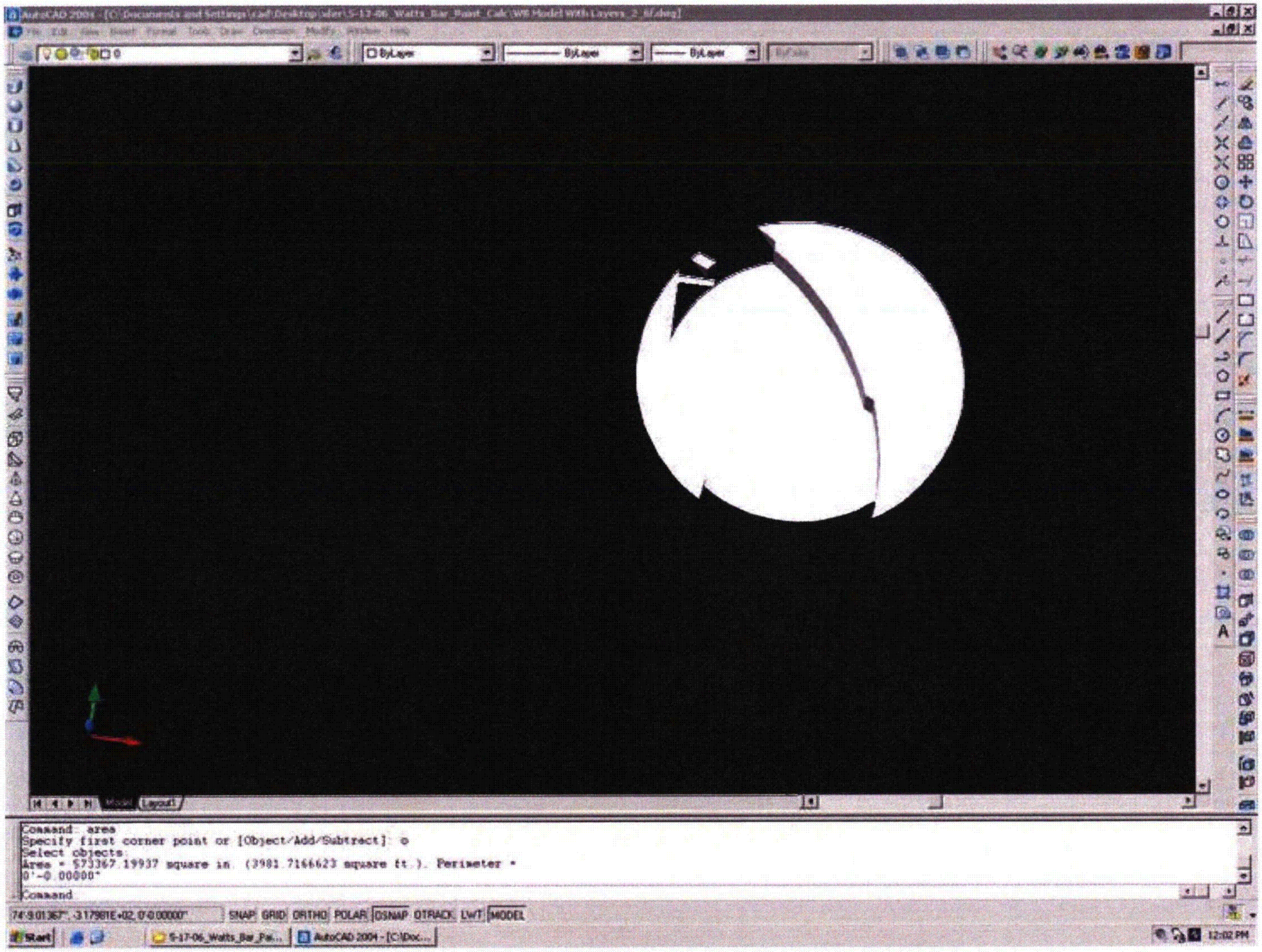


Figure 4.32 – Case 4 - Concrete Intersected with 10D ZOI Sphere Within 6' of Floor

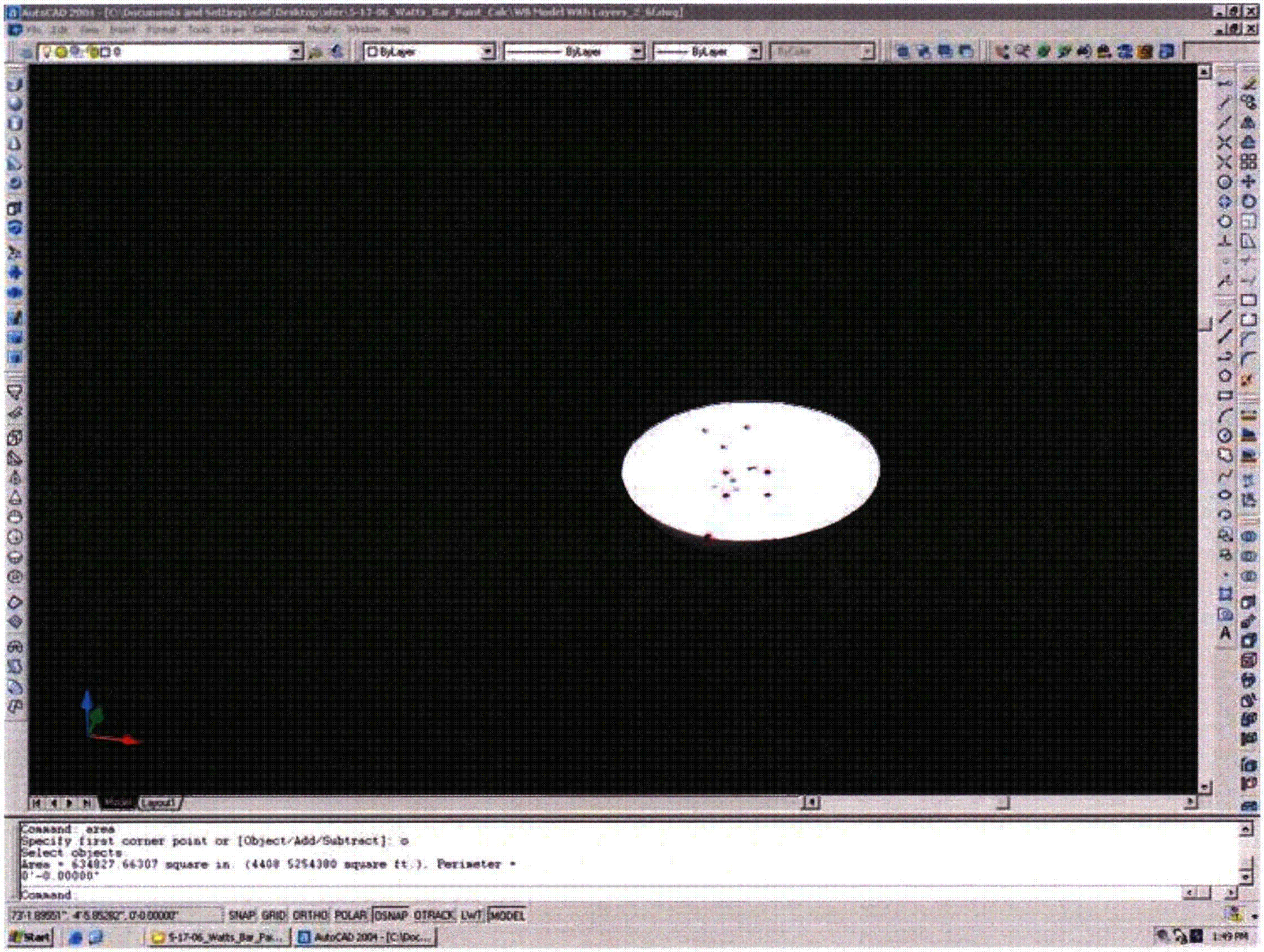


Figure 4.33 – Case 4 - Steel Subtracted from 10D ZOI Sphere Within 6’ of Floor

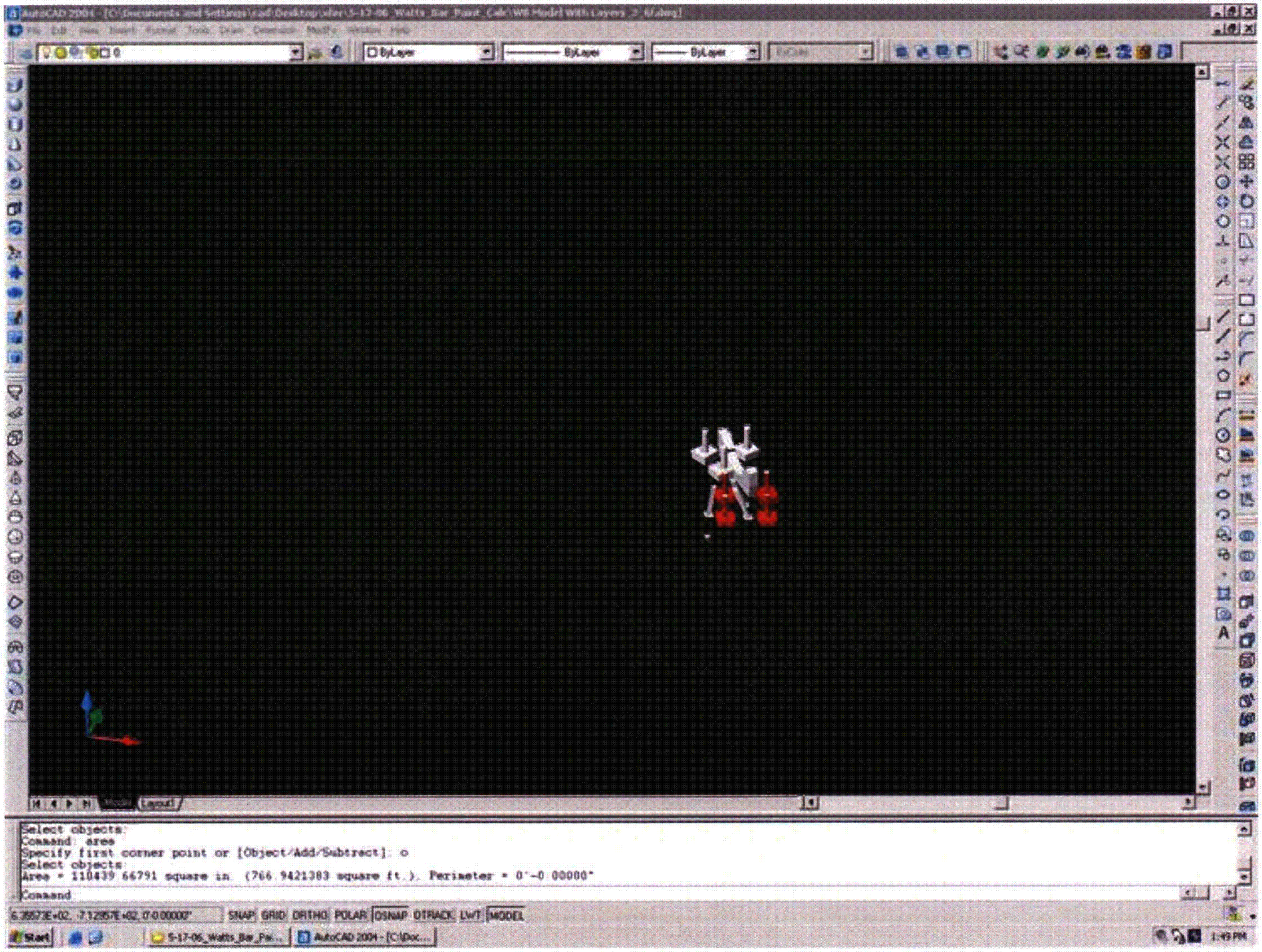


Figure 4.34 – Case 4 - Steel Intersected with 10D ZOI Sphere Within 6' of Floor

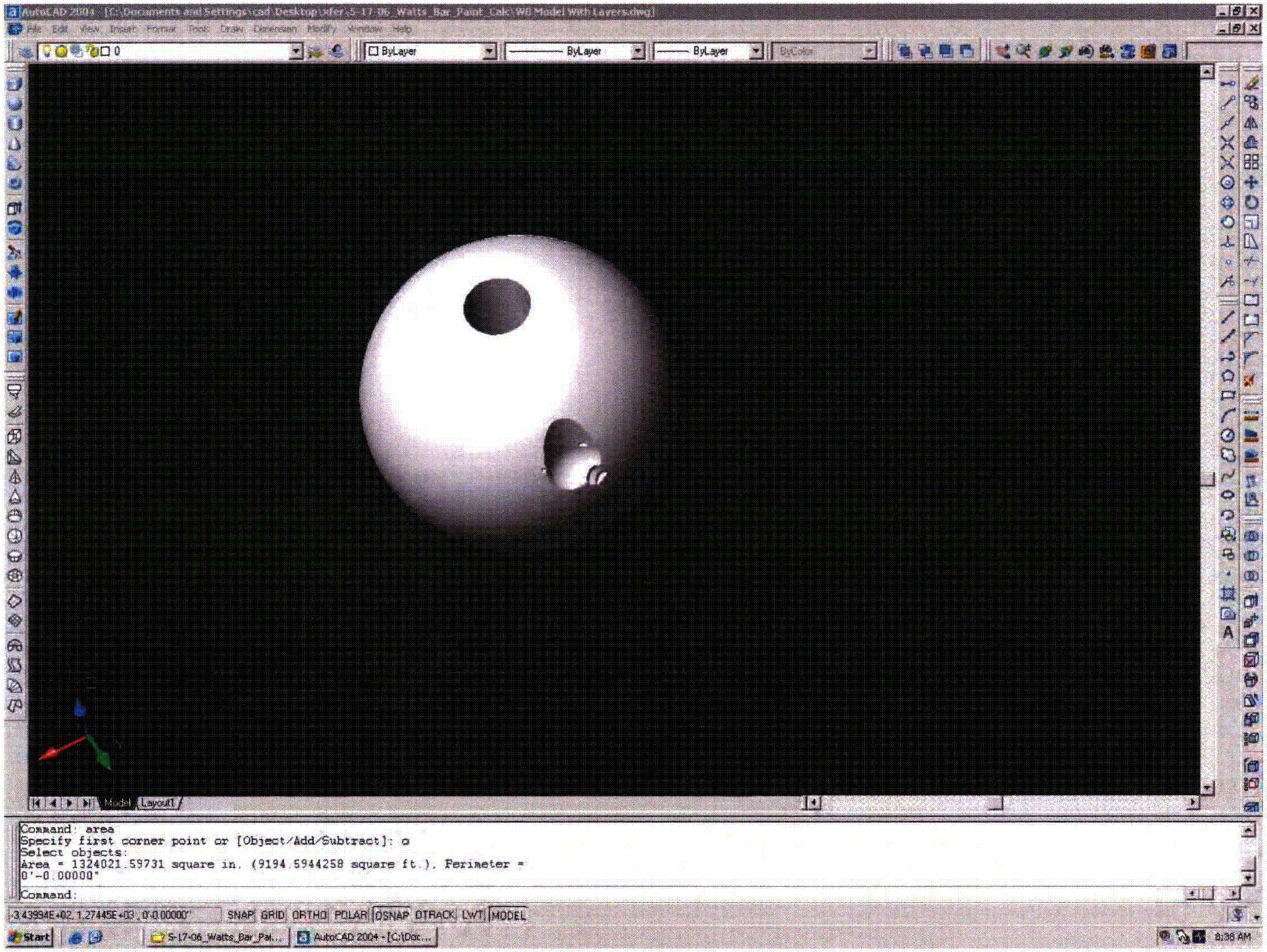


Figure 4.35 – Case 1 – Steam Generators Subtracted from 10D ZOI Sphere

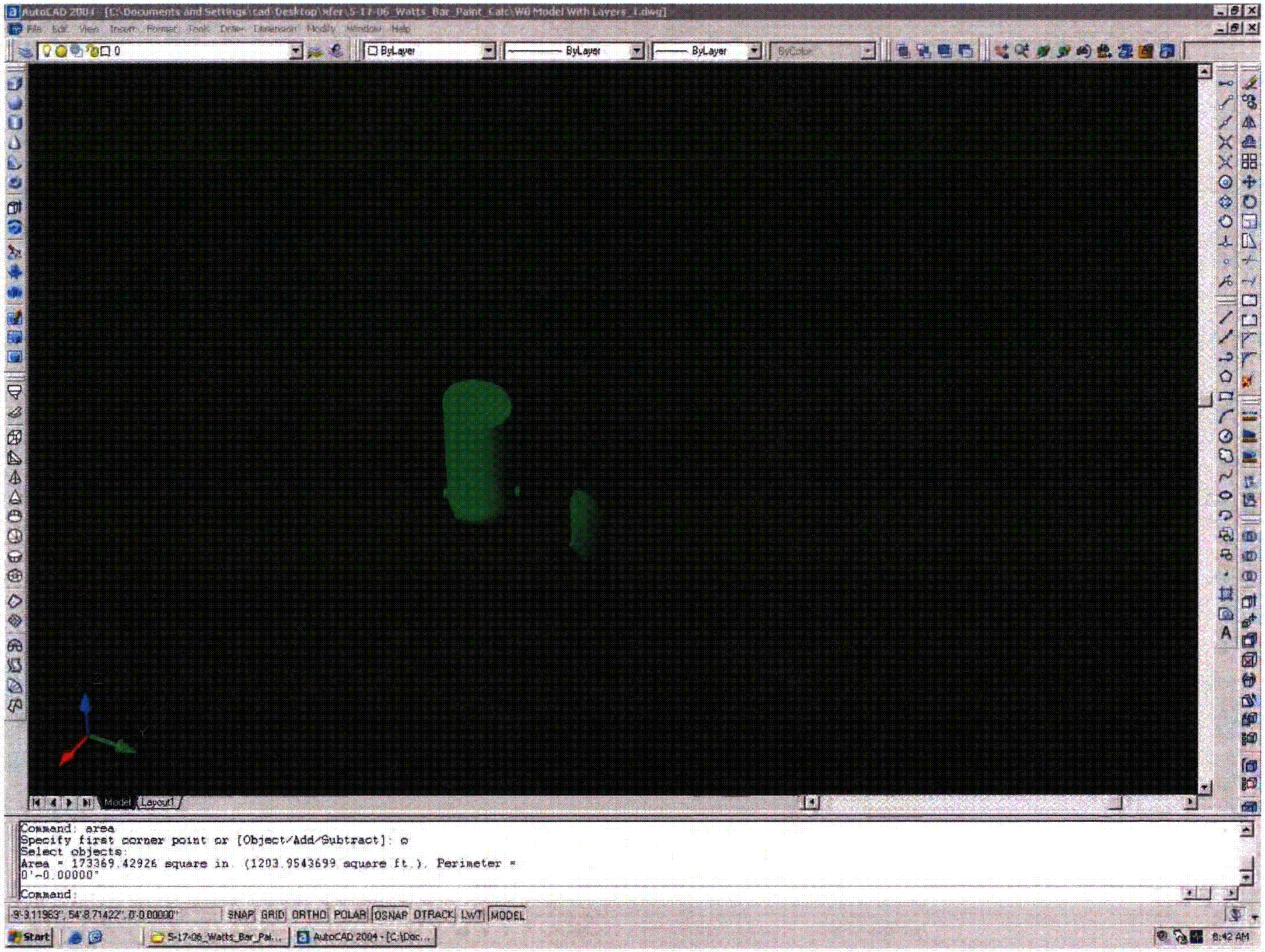


Figure 4.36 – Case 1 – Steam Generators Intersected with 10D ZOI Sphere

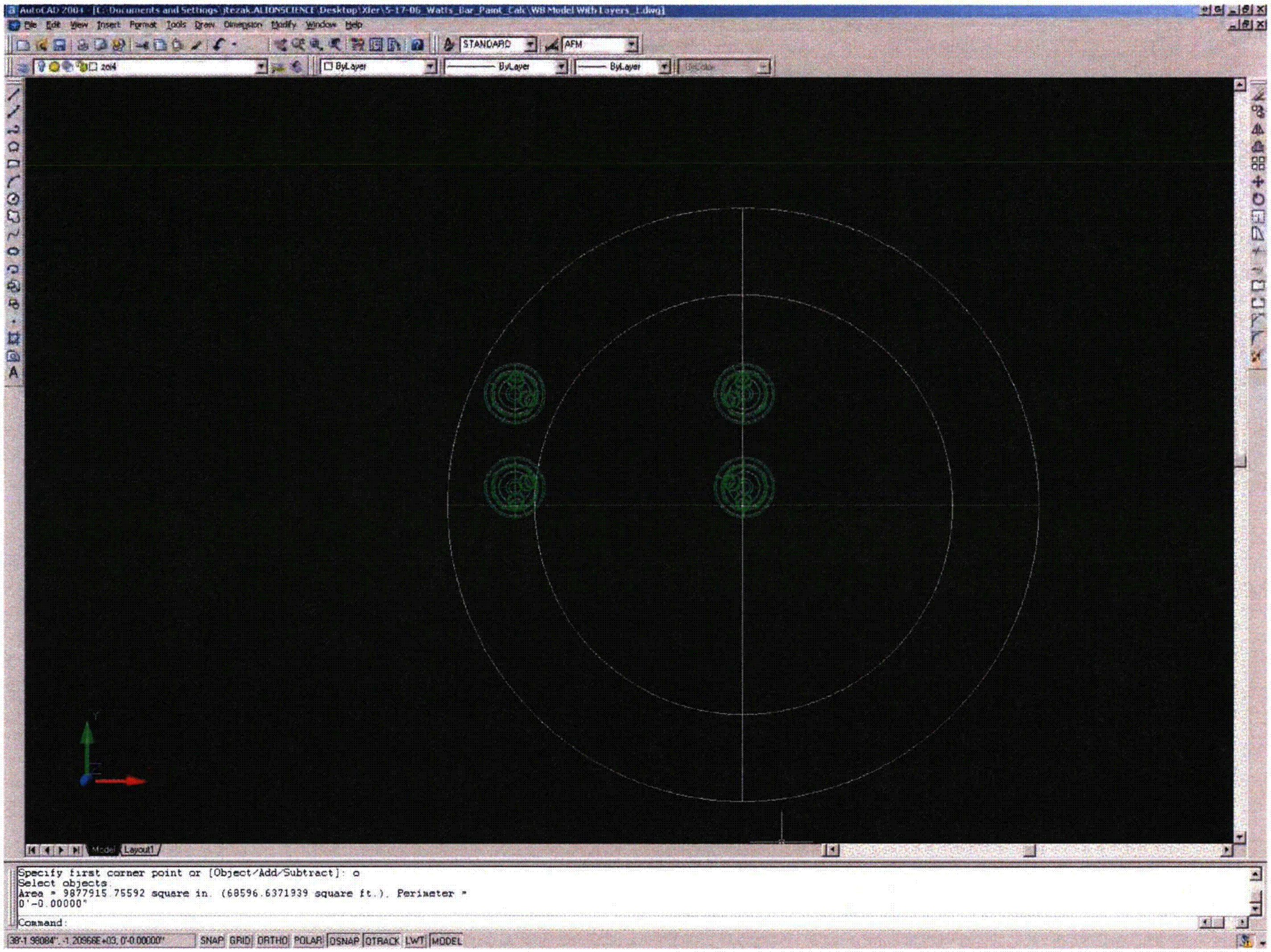


Figure 4.37 – 28.6D ZOI Sphere

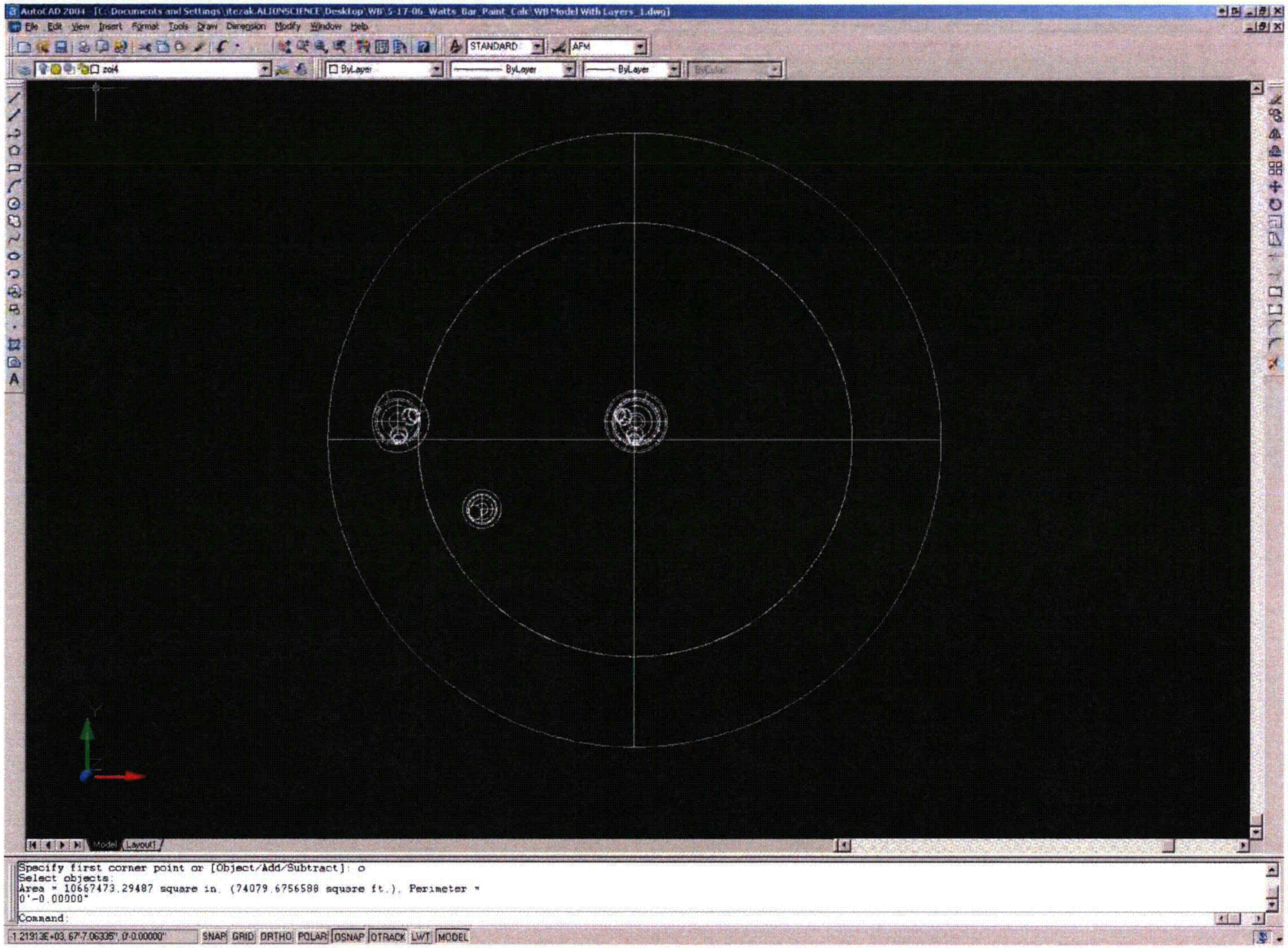


Figure 4.38 – Case 1 – Equipment Subtracted from 28.6D ZOI Sphere

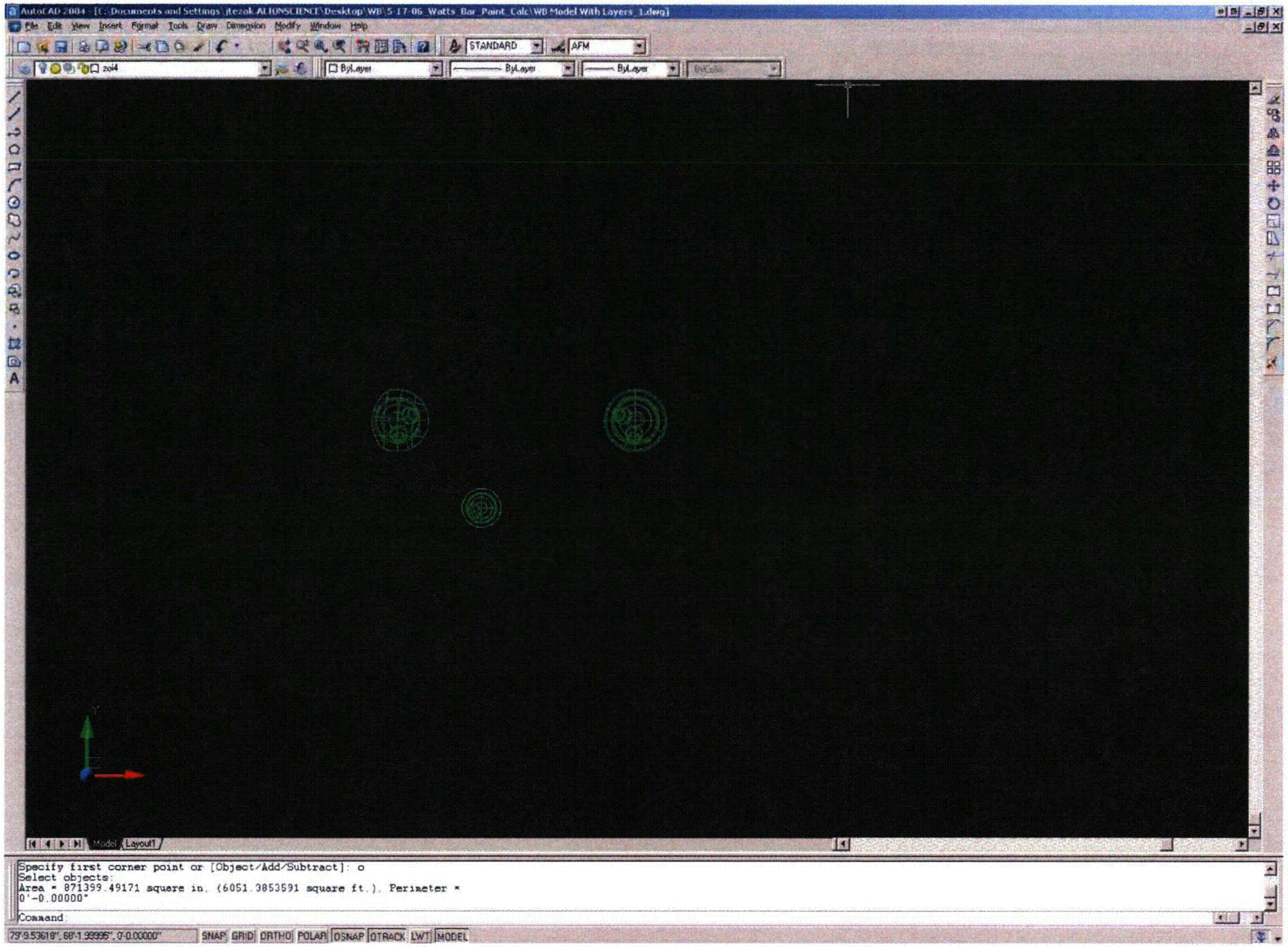


Figure 4.39 – Case 1 – Equipment Intersected with 28.6D ZOI Sphere

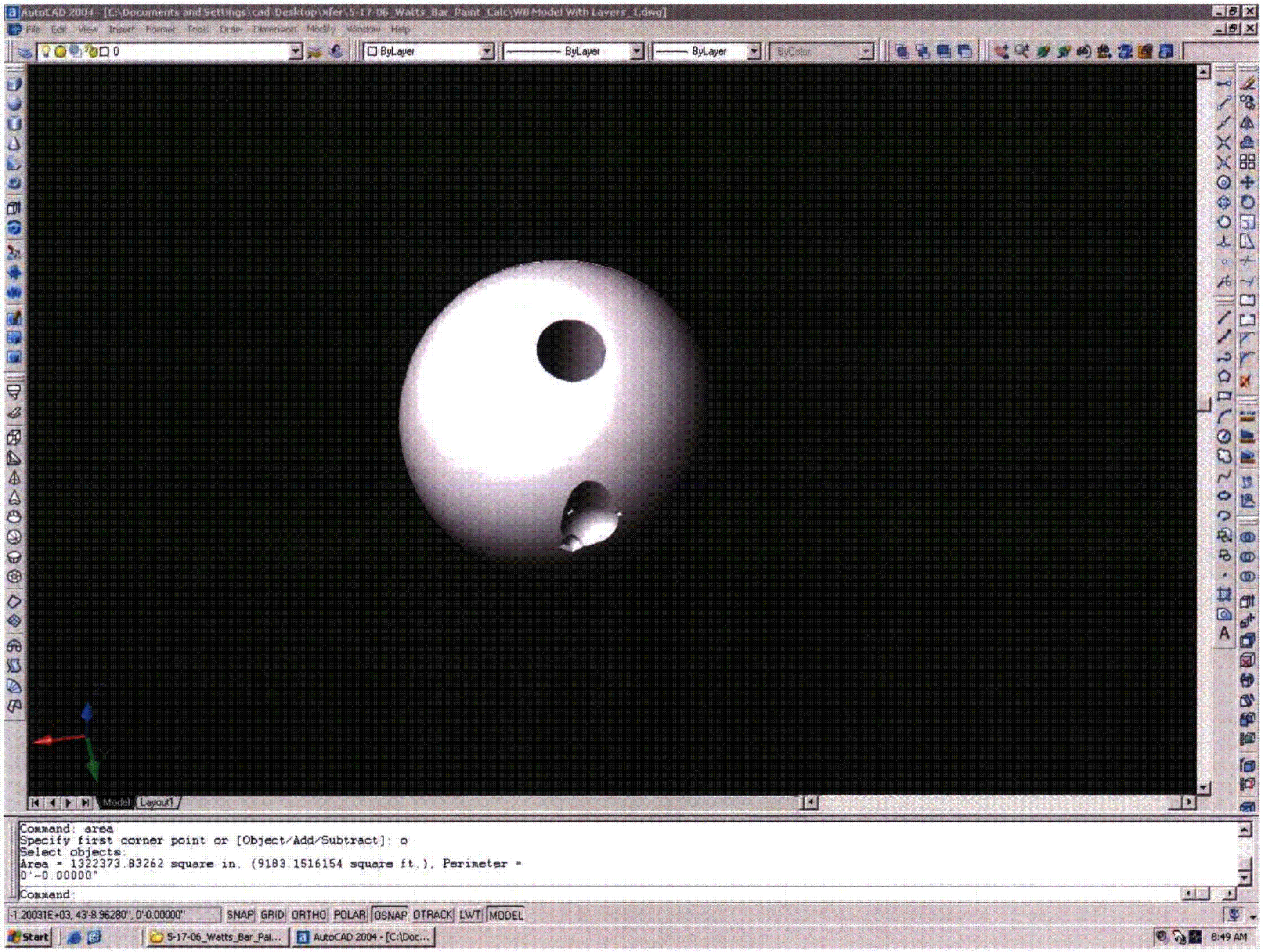


Figure 4.40 – Case 2 – Steam Generators Subtracted from 10D ZOI Sphere

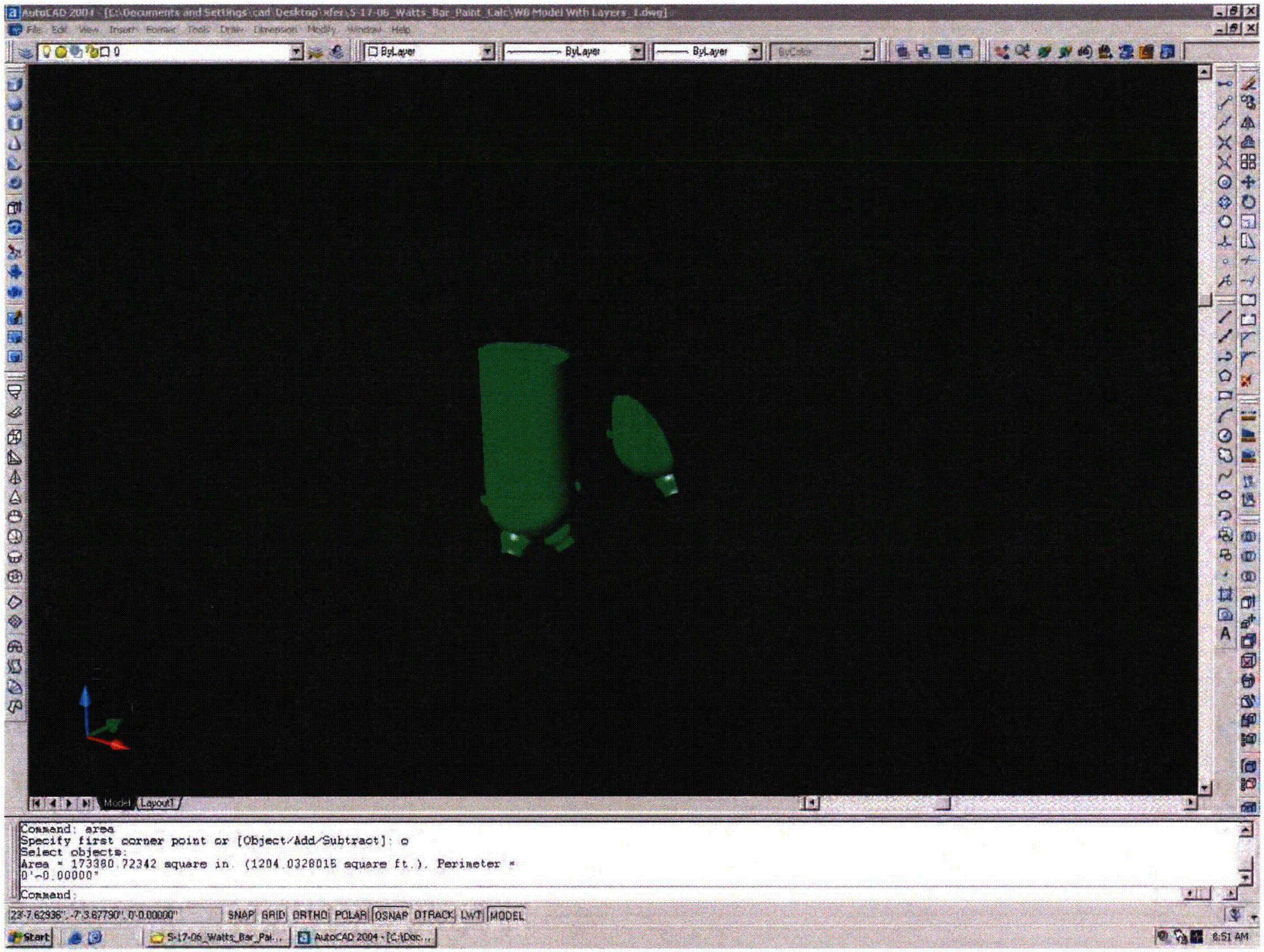


Figure 4.41 – Case 2 – Steam Generators Intersected with 10D ZOI Sphere

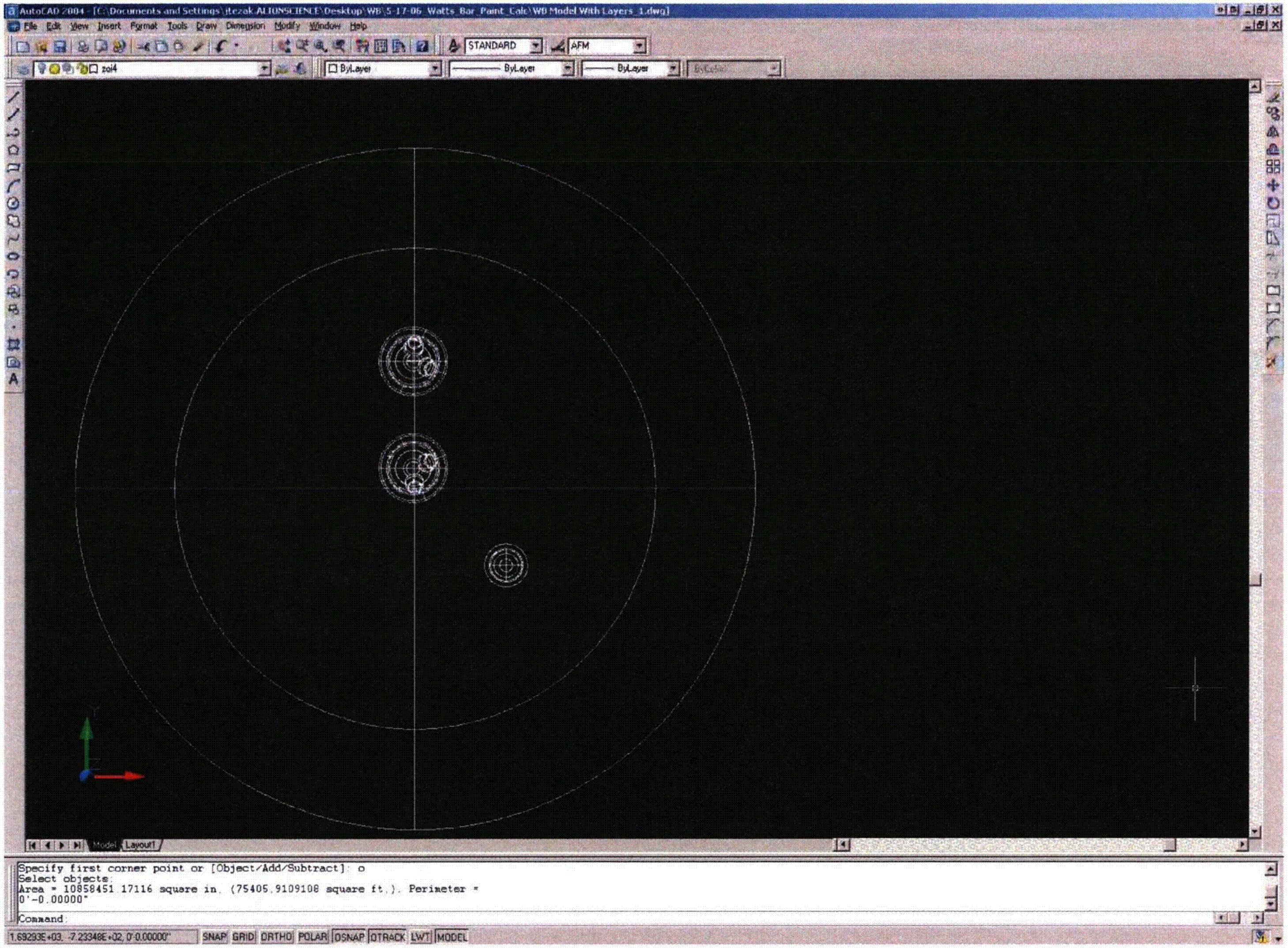


Figure 4.42 – Case 2 – Equipment Subtracted from 28.6D ZOI Sphere

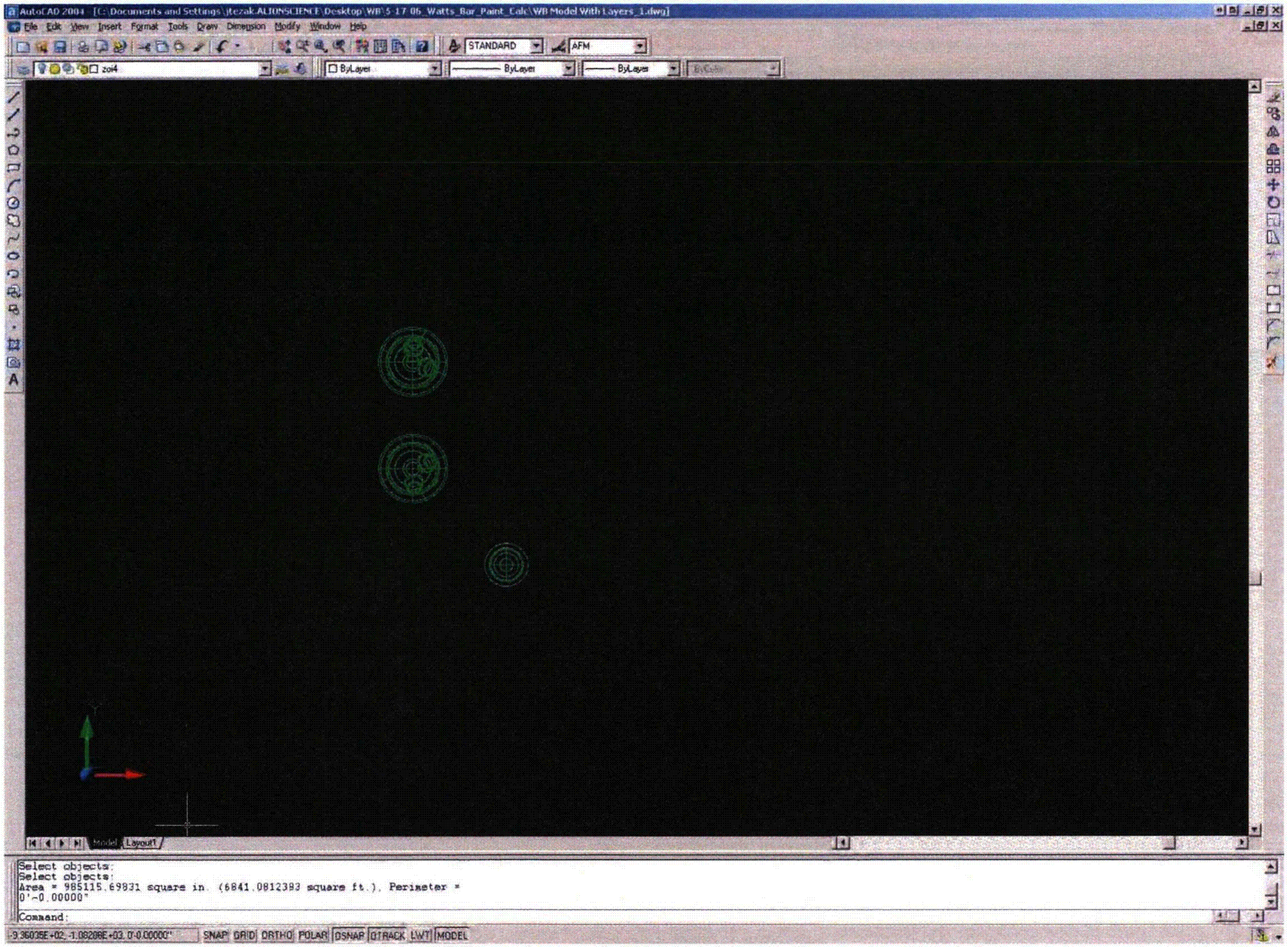


Figure 4.43 – Case 2 – Equipment Intersected with 28.6D ZOI Sphere

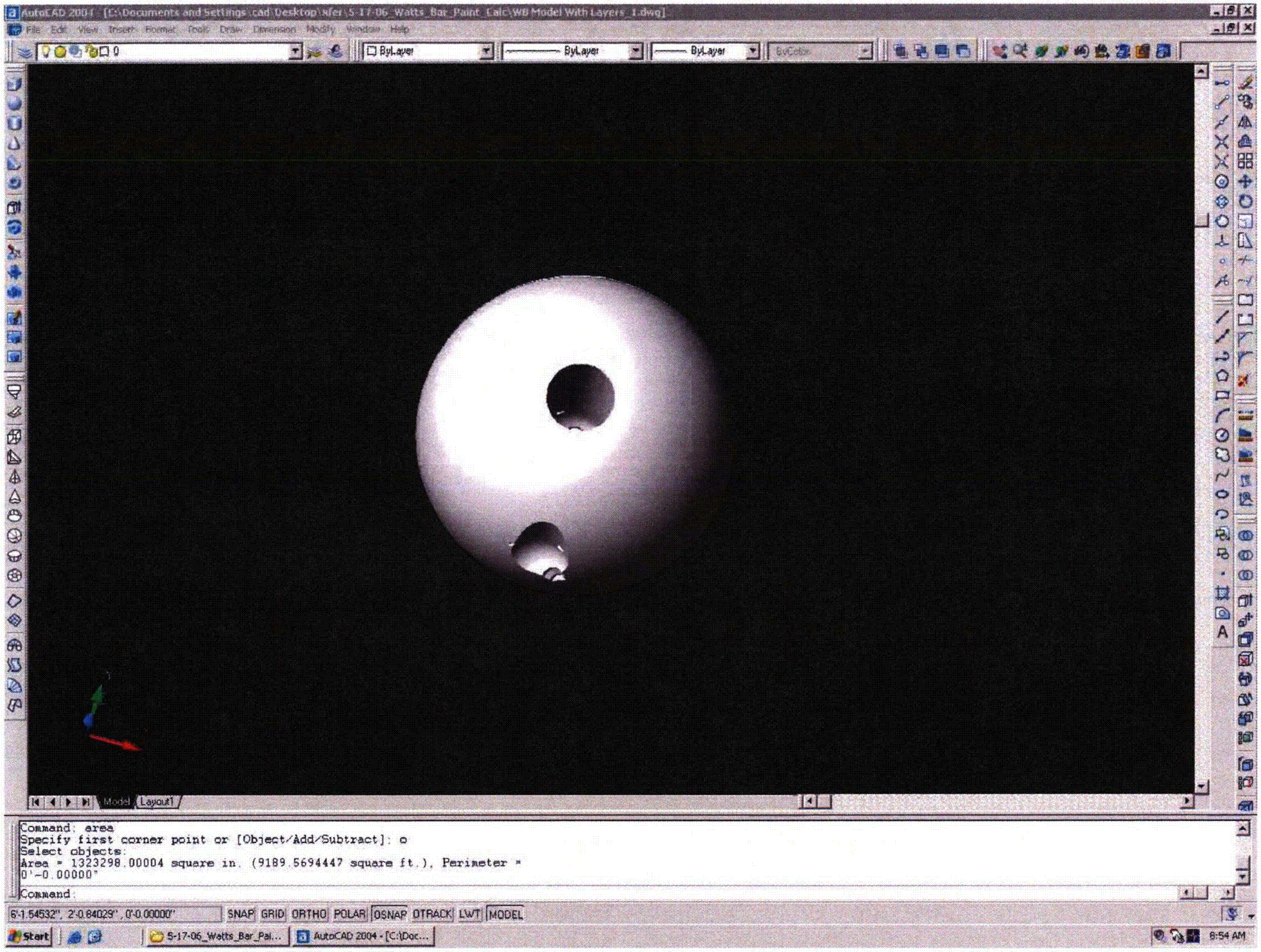


Figure 4.44 – Case 3 – Steam Generators Subtracted from 10D ZOI Sphere

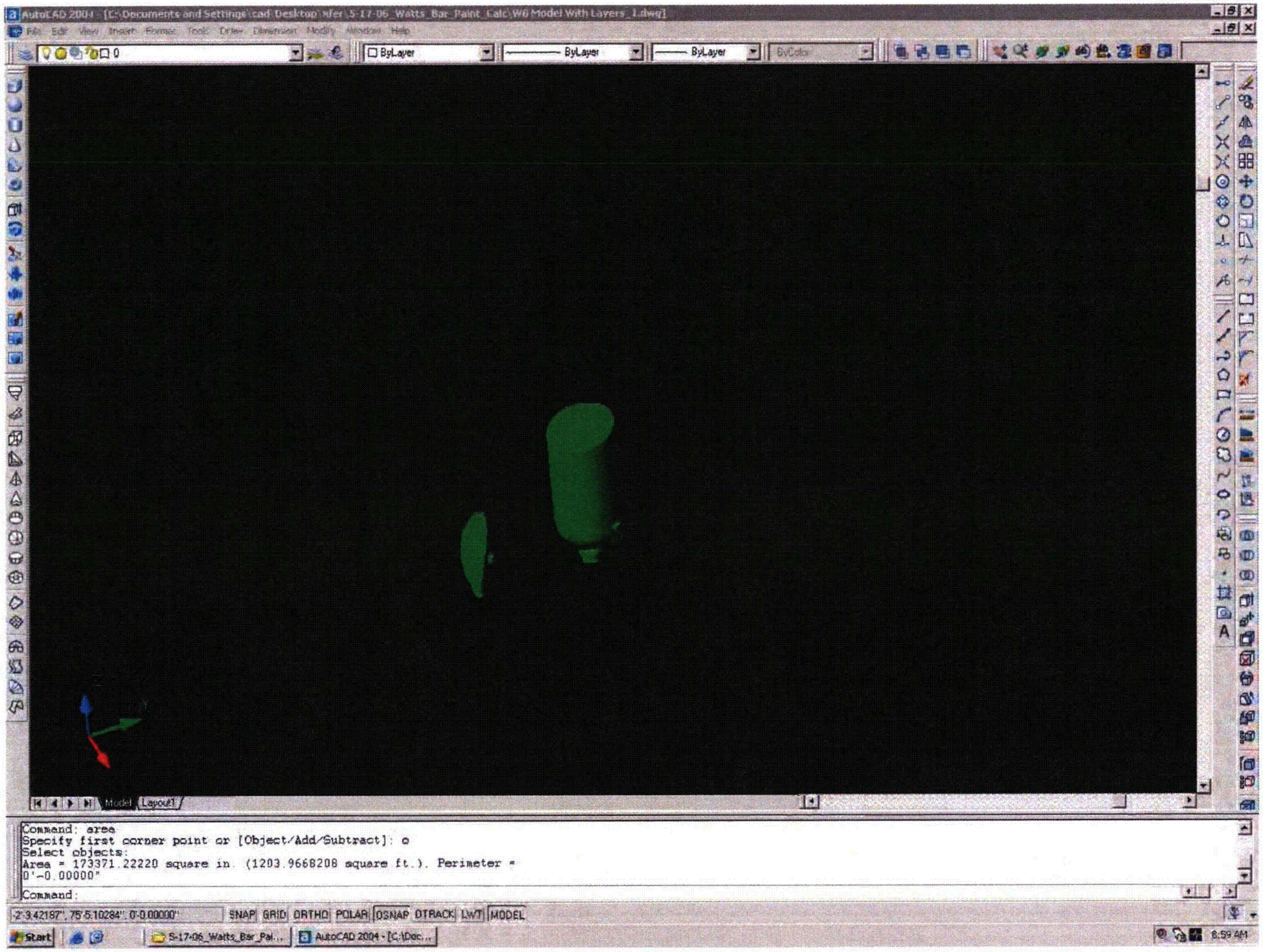


Figure 4.45 – Case 3 – Steam Generators Intersected with 10D ZOI Sphere

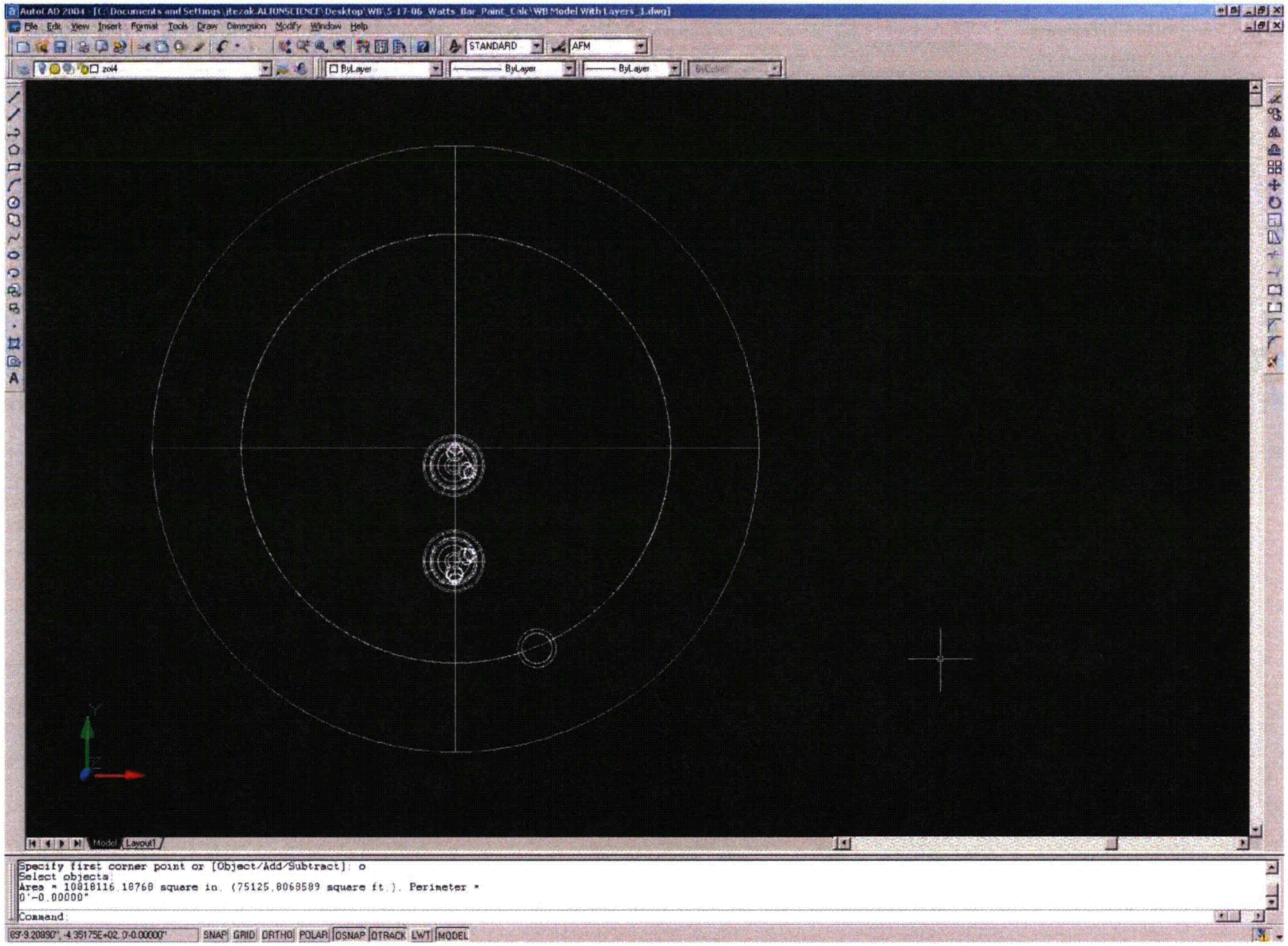


Figure 4.46 – Case 3 – Equipment Subtracted from 28.6D ZOI Sphere

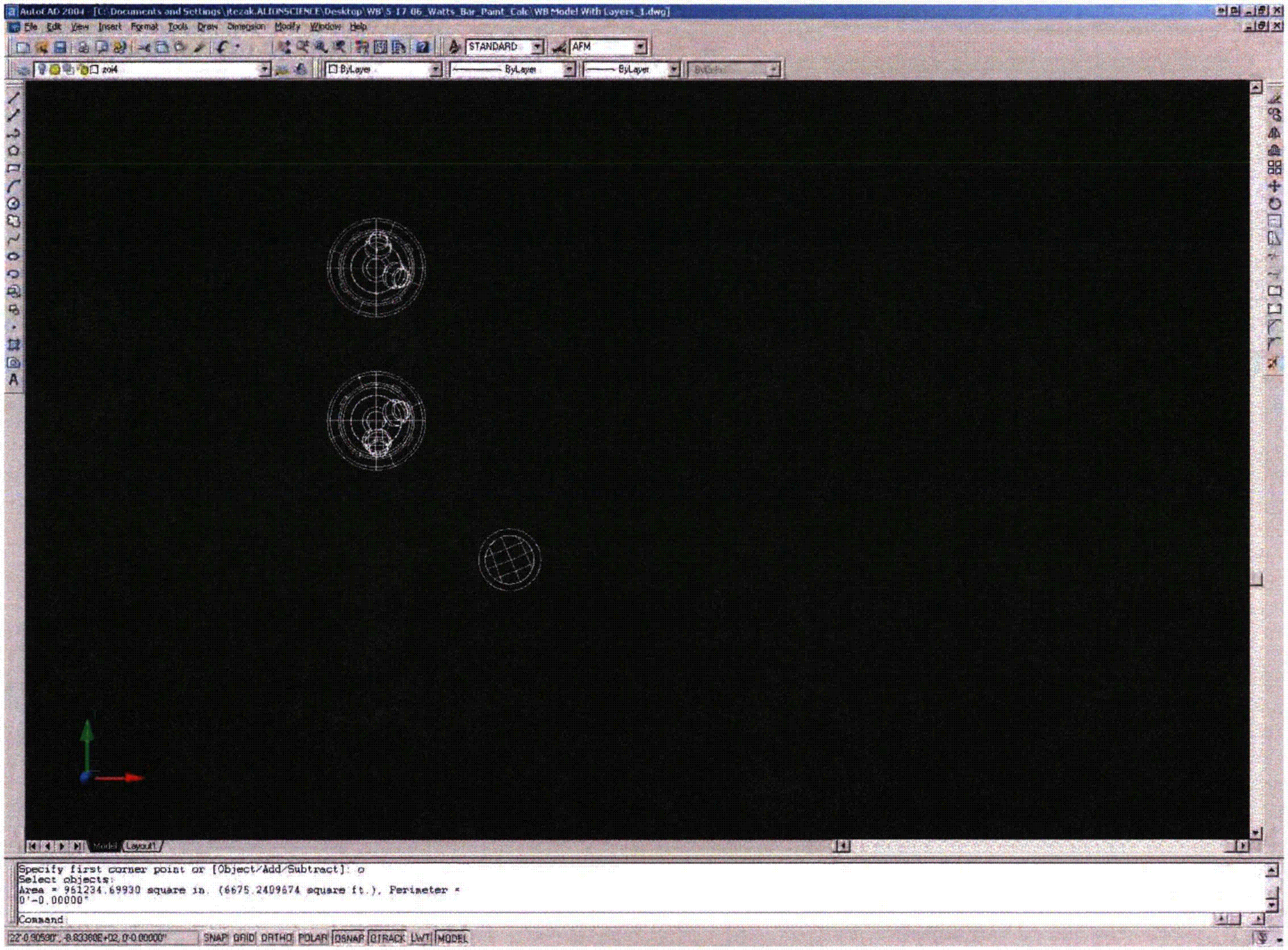


Figure 4.47 – Case 3 – Equipment Intersected with 28.6D ZOI Sphere

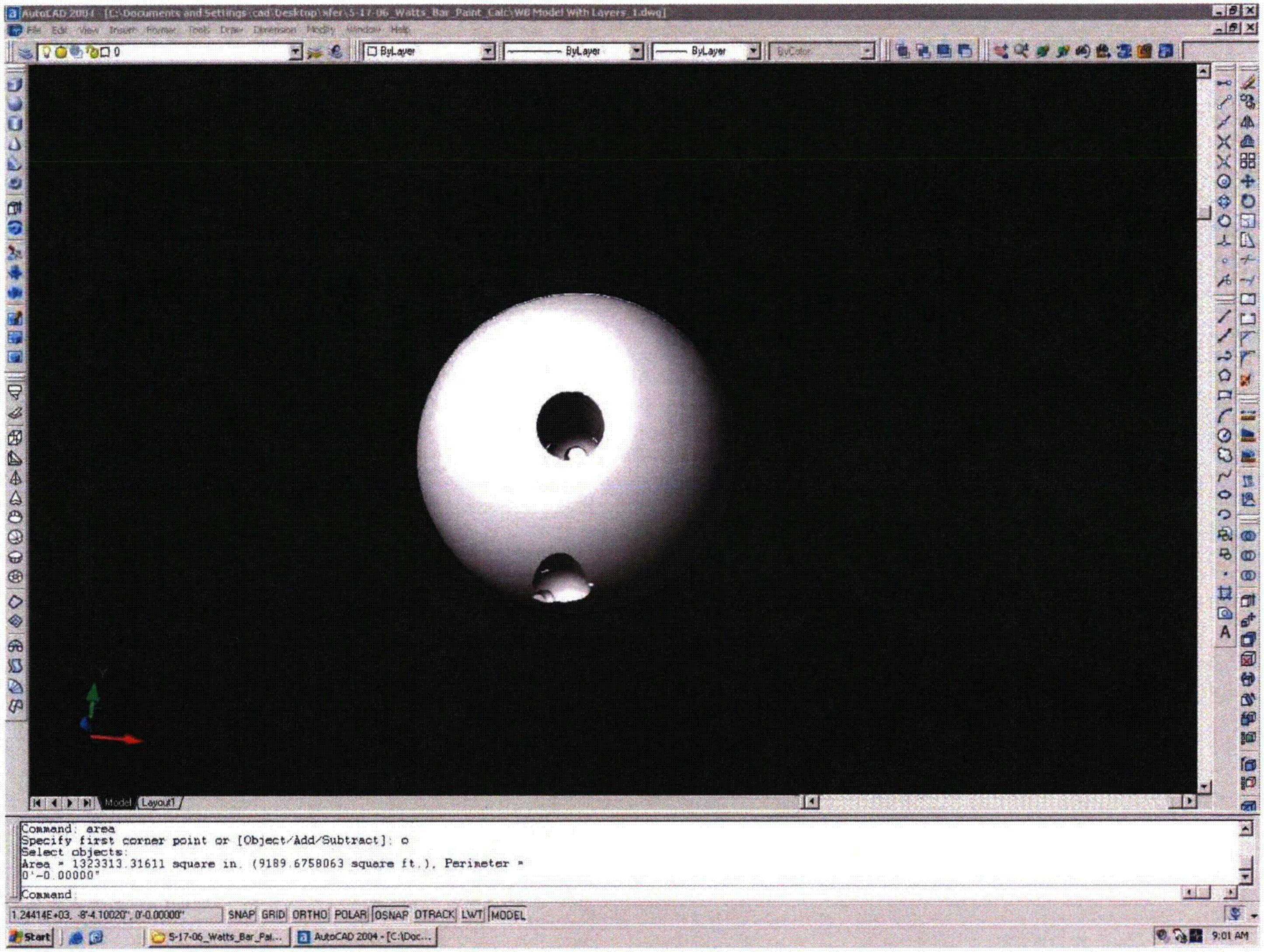


Figure 4.48 – Case 4 – Steam Generators Subtracted from 10D ZOI Sphere

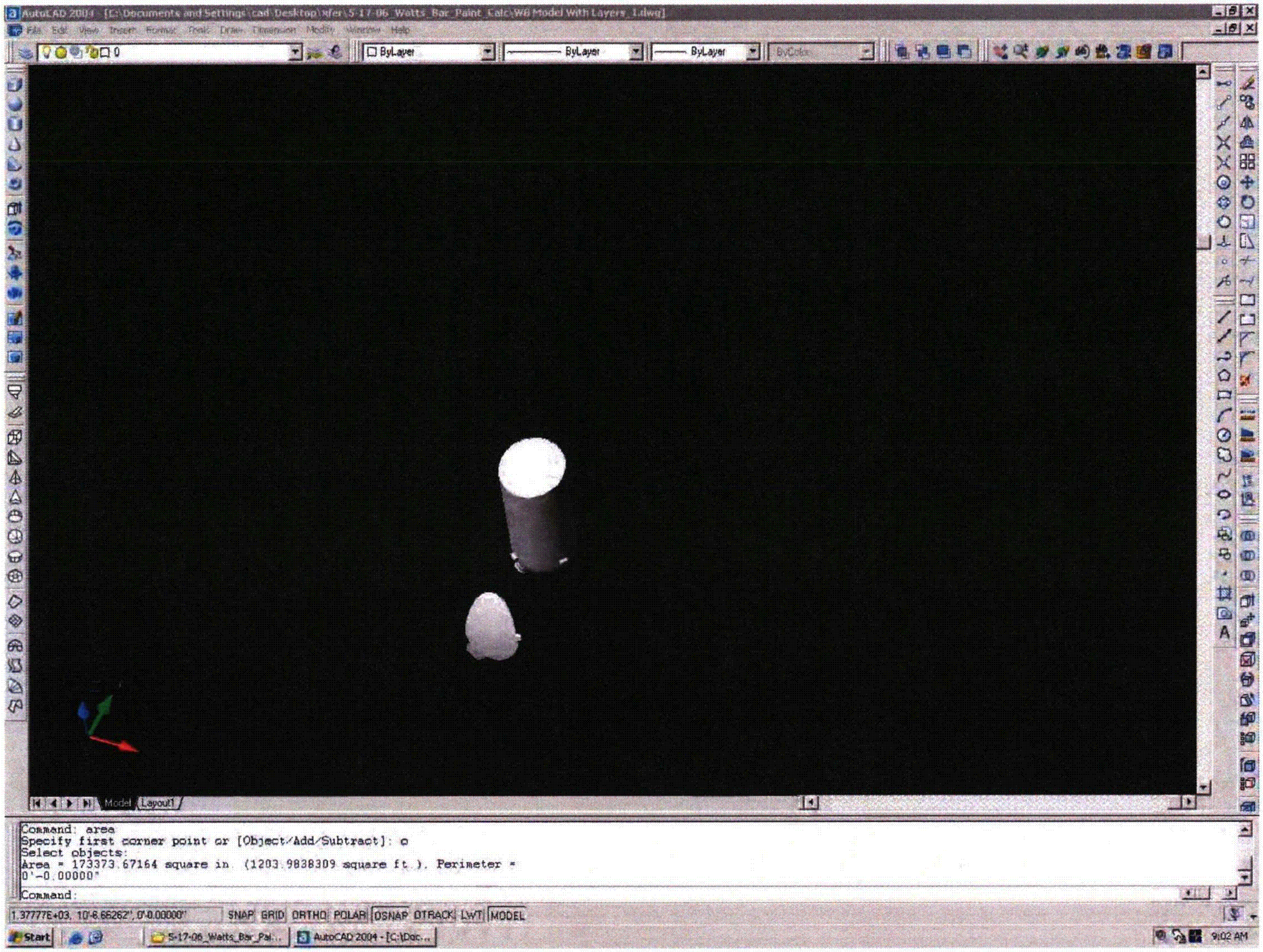


Figure 4.49 – Case 4 – Steam Generators Intersected with 10D ZOI Sphere

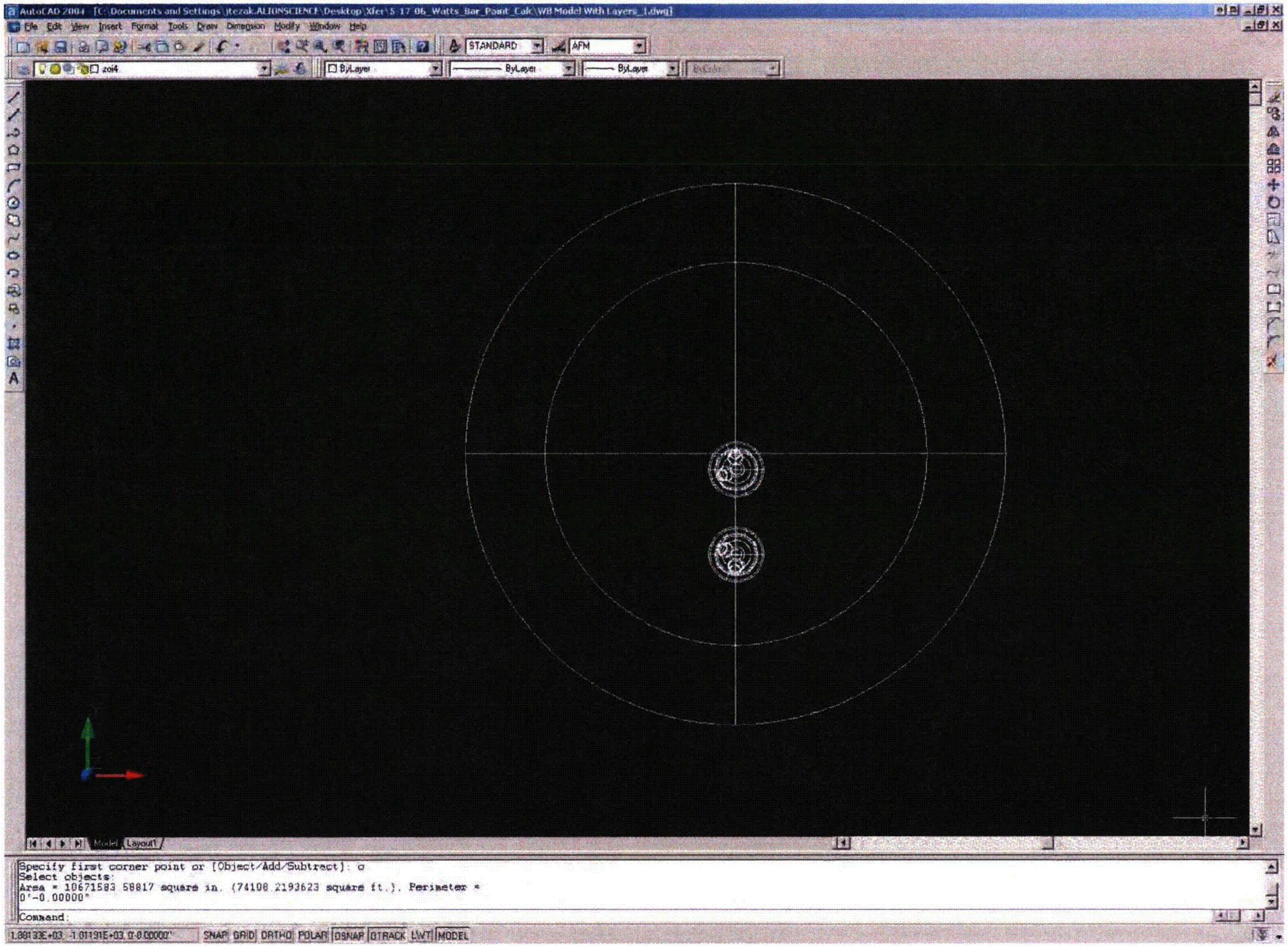


Figure 4.50 – Case 4 – Equipment Subtracted from 28.6D ZOI Sphere

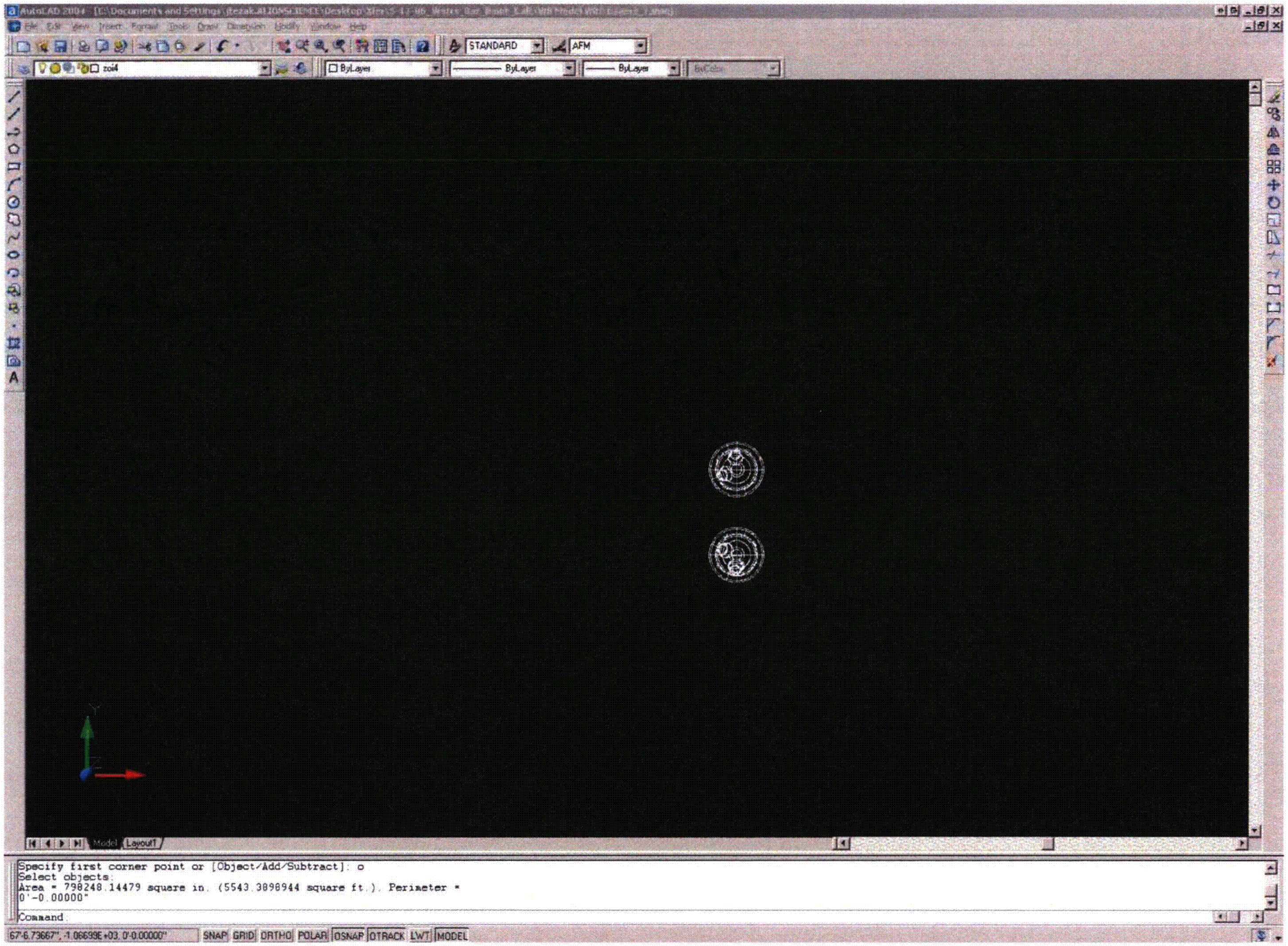


Figure 4.51 – Case 4 – Equipment Intersected with 28.6D ZOI Sphere

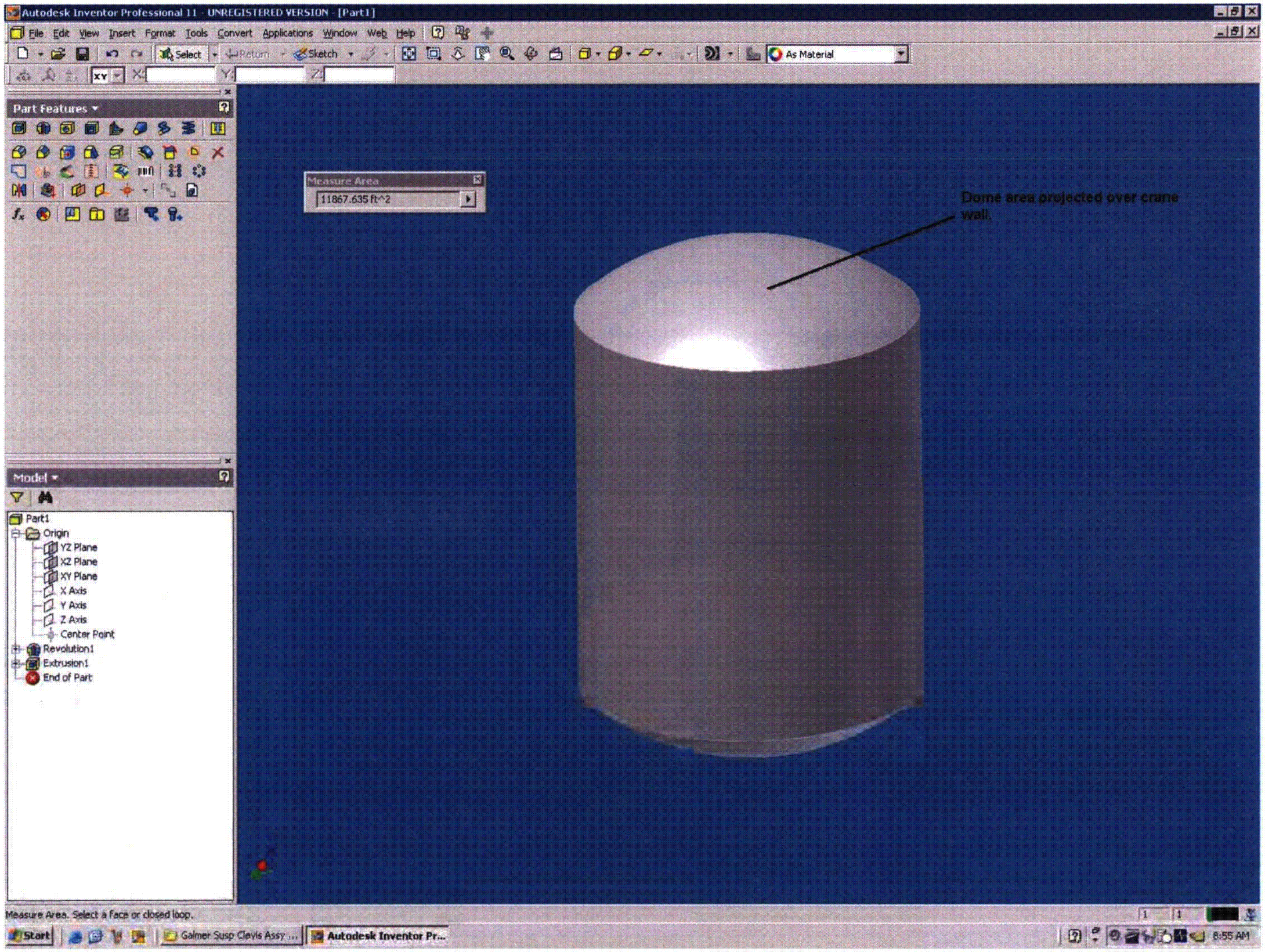


Figure 4.52 – Dome Area Projection Over Crane Wall

APPENDIX 5 – 3M WORKSHEETS

This Appendix contains the 3M calculation worksheets which were created to analyze shielding for the 3M insulation materials. Table 5-1 "TVA Walkdown Report / 1-47A243-6-0 Reconciliation" was used to identify and aid in mapping all conduits, raceways and junction boxes listed in "Watts Bar Nuclear Plant Unit No.1, 3M M20C Radiant Energy Shield – 1-47A243-6-0". This table displays line items from "'Report on Watts Bar Unit 1 Containment Building Walkdowns for Emergency Sump Strainer Issues', TVAW001-RPT-001, Rev 0." [Ref.9] and reconciles these items with the actual conduits from 1-47A243-6-0. The legend for Table 5-1 is as follows:

	From TVA Walkdown Report

This information is a line item as it is represented in the TVA walkdown report and is a "header" for the following items. For 3M insulation targets, these line items were found to summarize several different conduits, junction boxes or conduit supports into a single line item.

Identified	Mapped and analyzed for shielding

These items are individual conduits, junction boxes or conduit support entries as they are found in "Watts Bar Nuclear Plant Unit No.1, 3M M20C Radiant Energy Shield – 1-47A243-6-0". The individual items are reconciled with the TVA walkdown report and listed under the appropriate line items from that report.

Identified	Duplicate target, mapped under separate line item

These items are individual conduits, junction boxes or conduit support entries as they are found in "Watts Bar Nuclear Plant Unit No.1, 3M M20C Radiant Energy Shield – 1-47A243-6-0". Some items from this report were separated into multiple line items in the walkdown report. For the purposes of this analysis, the conduits were better left intact as a single entry. These items are identified as duplicates and the alternate item number is indicated. The individual items are reconciled with the TVA walkdown report and listed under the appropriate line items from that report.

Unidentified	Unidentified line item, conservative assumptions apply, no shielding will be credited

A small number of items could not be reconciled between the two reports. These are listed in the spreadsheet and no shielding is credited for these line items. This is a conservative approach as all unmapped items are considered to be destroyed.

Once the two input reports were reconciled, the items were mapped in the 3-D CAD model of the plant and each break was analyzed to determine shielding effects on the debris targets. Table 5-2 shows the results of this analysis. Per the SER, only 25% of the shielding effect is credited. An electronic copy (on CD) of the CAD model is included with this calculation as part of this Appendix.

Table 5-1 - TVA Walkdown Report / 1-47A243-6-0 Reconciliation

From TVA Walkdown Report	
Identified	Mapped and analyzed for shielding
Identified	Duplicate target, mapped under separate line item
Unidentified	Unidentified line item, conservative assumptions apply, no shielding will be credited

	DESCRIPTION	Line Item Number	INSUL. VOLUME (FT3)	Count	Insul Vol per Lin. Ft.	AREA	LOCATION	ELEV.	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	PACKET LETTER	Description
							Packet 6D							
	CONDUIT 3M-M20C INSULATION	Item 88	2.35			6	LOOP 1	716'	1.32	70.00	3M-M20C	0.1875	D	1" conduit (90/2 + 15 + 10)
	1PM8026E	Item 88A	3.02		0.0335					90				R-Z18/722 to 16' N of E-W line, Radius 17', FLR EL 702
	Unidentified	Item 88B	0.50		0.0335					15				**Unknown 1" Conduit, 15' in length**
	VC4432B	Item 88C	0.34		0.0335					10				From JB4557B R-Z73/732 TO R-Z64/734
	CONDUIT 3M-M20C INSULATION	Item 89	1.43			6	LOOP 1	716'	1.90	32.50	3M-M20C	0.1875	D	1.5" Conduit (5/2 + 15 + 30/2)
	1VC4062B	Item 89A	0.22		0.0438					5				R-Z68/754 From JB-6346-B to SPT #D12070109-10-F23981A
	1PM8022D	Item 89B	1.32		0.0438					30				R-Z138/722 Radius 39' to R-Z80/722 Radius 20 FLR EL 702
	1VC4064B	Item 89C	0.66		0.0438					15				R-Z68/754 From JB-6346-B to SPT #D12070111-4-47A056-210
	CONDUIT 3M-M20C INSULATION	Item 90	1.70			6	LOOP 1	716'	2.38	32.50	3M-M20C	0.1875	D	2" Conduit (65/2)
	1VC4431B	Item 90A	3.39		0.0522					65				R-Z144/741 TO JB-4557-B at R-Z73/732
	CONDUIT 3M-M20C INSULATION	Item 91	0.52			6	LOOP 1	716'	N/A	N/A	3M-M20C	N/A	D	Junction Boxes
	JB-293-4557-B	Item 91A	0.26											R-Z73/732 Mounted on Crane Wall
	JB-293-6347-A	Item 91B	0.26											R-Z125/725 Mounted on Crane Wall
	CONDUIT 3M-M20C INSULATION	Item 92	2.31			6	LOOP 1	716'	N/A	N/A	3M-M20C	N/A	D	Piping Supports
1"	1PM8026E	Item 92A								90				6D Supports
1"	Unidentified	Item 92B								15				6D Supports
1"	VC4432B	Item 92C								10				6D Supports
1"	**Total 1 inch**		1.66	13	0.1280					115				
1.5"	1VC4062B	Item 92D								5				6D Supports
1.5"	1PM8022D	Item 92E								30				6D Supports
1.5"	1VC4064B	Item 92F								15				6D Supports
1.5"	**Total 1.5 inch**		0.77	6	0.1280					50				
2"	1VC4431B	Item 92G								65				6D Supports
2"	**Total 2 inch**		1.02	8	0.1280					65				

DESCRIPTION	Line Item Number	INSUL. VOLUME (FT3)	Count	Insul Vol per Lin. Ft.	AREA	LOCATION	ELEV.	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	PACKET LETTER	Description
Packet 7B													
CONDUIT 3M-M20C INSULATION	Item 132	2.19			7	LOOP 2	716'	1.90	50.00	3M-M20C	0.1875	B	1.5" Conduit (15 + 30/2 + 20)
1PM8021D	Item 132A	0.66		0.0438					15	3M-M20C			R-Z138/722 Radius 39' to R-Z138/722 Radius 39, FLR EL 702
1PM8022D	Item 132B								30.00	3M-M20C			**Documented as Item 89B**
1VC4057A	Item 132C	0.88		0.0438					20	3M-M20C			R-Z125/725 Radius 40, FROM 1-JB-293-6347-A to R-Z150 FLR EL 702
CONDUIT 3M-M20C INSULATION	Item 133	3.65			7	LOOP 2	716'	2.38	70.00	3M-M20C	0.1875	B	2" Conduit (25 + 65/2 + 25/2)
1PM8020D	Item 133A	1.30		0.0522					25	3M-M20C			R-Z150/728 (HVAC opening to Fan Room 2) to R-Z138/722, Radius 39', Floor El 702
1VC4431B	Item 133B								65.00	3M-M20C			**Documented as Item 90A**
Unidentified	Item 133C	0.65		0.0522					12.50	3M-M20C			**Unknown 2" Conduit, 25' in length**
CONDUIT 3M-M20C INSULATION	Item 134	1.79			7	LOOP 2	716'	N/A	N/A	3M-M20C	N/A	B	Piping Supports
1.5" 1PM8021D	Item 134A								15	3M-M20C			7B Supports
1PM8022D	Item 134B									3M-M20C			**Documented under Item 92**
1VC4057A	Item 134C								20	3M-M20C			7B Supports
Total 1.5 inch		0.64	5	0.1280					35				
2" 1PM8020D	Item 134D								25	3M-M20C			7B Supports
1VC4431B	Item 134E									3M-M20C			**Documented under Item 92**
Unidentified	Item 134F								12.50	3M-M20C			7B Supports
Total 2 inch		0.64	5	0.1280					37.5				
Packet 7Q													
CONDUIT INSULATION 3M RADIANT	Item 178	1.51			7	LOOP 2	720-737	1.32	45.00	3M20C	SEE CALC	Q	1" Conduit (90/2)
1PM8026E	Item 178A								90.00	3M20C			**Documented as Item 88A**
CONDUIT 3M-M20C INSULATION	Item 179	0.77			7	LOOP 2	720-737	N/A	45.00	3M20C		Q	Piping Supports
1PM8026E	Item 179A												**Documented under Item 92**
Packet 10E													
CONDUIT INSULATION 3M RADIANT	Item 262	0.22			10	LOOP 1	745'	1.90	5.00	3M20C	SEE CALC	E	1.5" Conduit (5')
1VC4063B	Item 262A	0.22		0.0438					5				R-Z68/754 From JB-6346-B to Ceiling Penetration R-Z66/754
JUNCTION BOX	Item 263	0.26			10	LOOP 1	745'	N/A	N/A	3M20C	SEE CALC	E	
JB-293-6346-B	Item 263A	0.26											Inside Crane Wall at R-Z68/754
SUPPORT	Item 264	0.26			10	LOOP 1	745'	N/A	N/A	3M20C	SEE CALC	E	Piping Supports
1VC4063B	Item 264A	0.26	2	0.1280					5				10E Supports
Packet 13F													

DESCRIPTION	Line Item Number	INSUL. VOLUME (FT3)	Count	Insul Vol per Lin. Ft.	AREA	LOCATION	ELEV.	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	PACKET LETTER	Description
CONDUIT INSULATION 3M RADIANT	Item 311	0.08			13	LOOP 4	745'	1.90	2.50	3M20C	SEE CALC	F	1.5" Conduit (5/2)
1VC4062B	Item 311A								5.00				Documented as Item 89A
SUPPORT	Item 312	0.26			13	LOOP 4	745'	N/A	N/A	3M20C	SEE CALC	F	Piping Supports
1VC4062B	Item 312A												Documented under Item 92
Outside ZOI													
CONDUIT INSULATION 3M RADIANT	Item 326	1.34			14	FAN ROOM 1	716'	1.32	40.00	3M20C	SEE CALC	H	FAN ROOM 1
1PM8062E		1.34							40.00				
SUPPORT	Item 327	0.64			14	FAN ROOM 1	716'	N/A	N/A	3M20C	SEE CALC	H	
BOX	Item 328	2.08			14	FAN ROOM 1	716'	N/A	N/A	3M20C	SEE CALC	H	
CONDUIT INSULATION 3M RADIANT	Item 363	2.48			15	FAN ROOM 2	716'	2.38	47.50	3M20C	SEE CALC	C	FAN ROOM 2
1PM8020D		0.65							12.50				
Unidentified		1.83							35.00				
SUPPORT	Item 364	0.77			15	FAN ROOM 2	716'	N/A	N/A	3M20C	SEE CALC	C	
BOX	Item 365	2.08			15	FAN ROOM 2	716'	N/A	N/A	3M20C	SEE CALC	C	
CONDUIT 3M-M20C INSULATION	Item 543	2.19			24	INSTRUMENT ROOM	720-737	1.90	50.00	3M-M20C	0.1875	H	INSTRUMENT ROOM
1PM7580F		2.19							50.00				
CONDUIT 3M-M20C INSULATION	Item 544	1.00			24	INSTRUMENT ROOM	720-737	0.68	50.00	3M-M20C	0.1875	H	
1-SEN-68-442A		1.00							50.00				
CONDUIT 3M-M20C INSULATION	Item 545	1.54			24	INSTRUMENT ROOM	720-737	N/A	N/A	3M-M20C	0.1875	H	

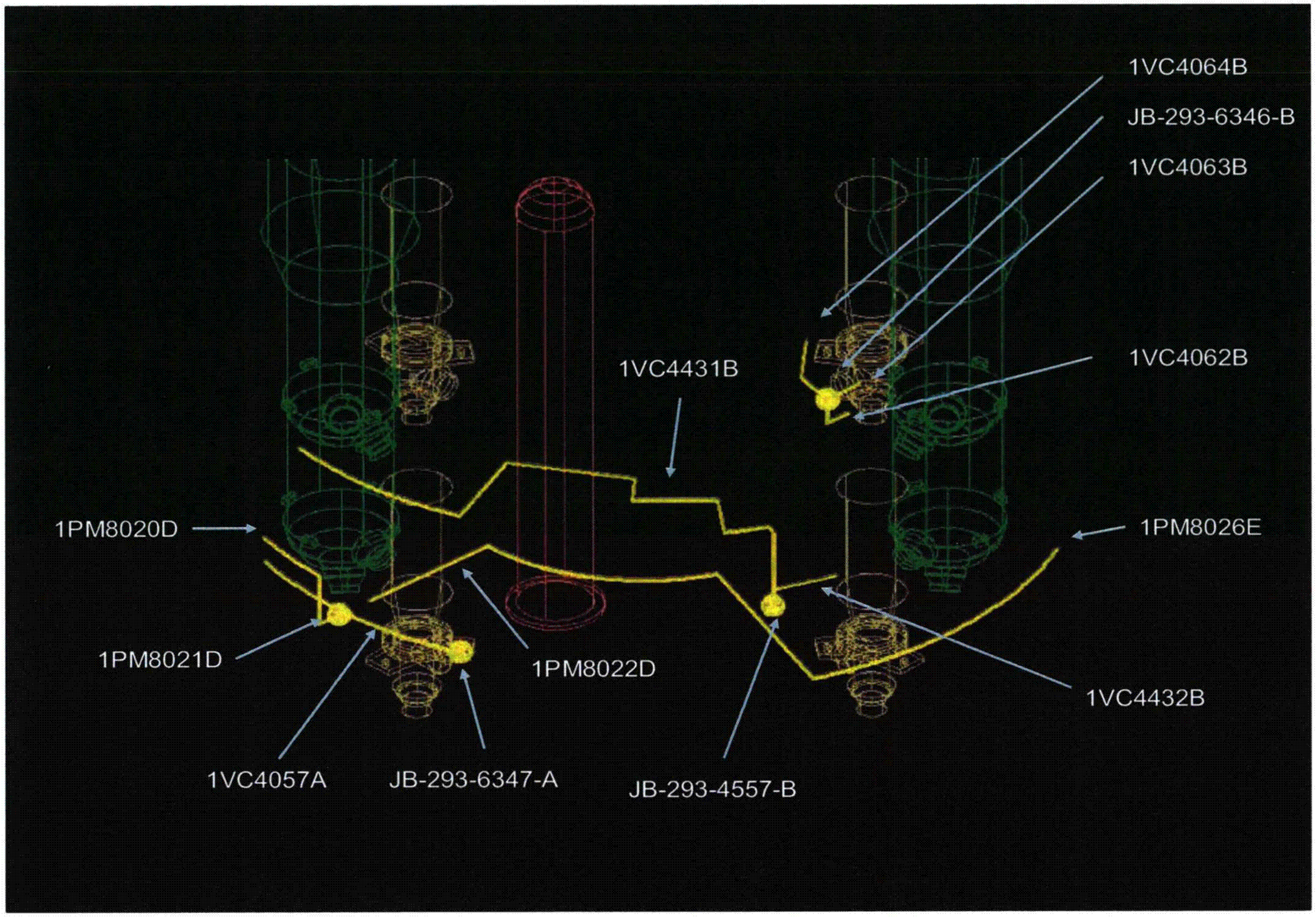
Table 5-2 - 3M Insulation Shielding Calculations

Shielding credited (-25% per SER)
Fully Shielded
Partially outside ZOI

DESCRIPTION	Line Item Number	INSUL. VOLUME (FT3)	LENGTH (FT)	Description	Break 1	Vol	Break 2	Vol	Break 3	Vol	Break 4	Vol
1PM8026E	Item 88A	3.02	90	R-Z18/722 to 16' N of E-W line, Radius 17', FLR EL 702	82' inside ZOI - 10' Shielded by RCP 1	2.74	7 ft. inside ZOI	0.23	Outside ZOI		Outside ZOI	
	Item 88B	0.50	15	**Unknown 1" Conduit, 15' in length**	0' Shielded	0.50	0' Shielded	0.50	0' Shielded	0.50	0' Shielded	0.50
1VC4432B	Item 88C	0.34	10	From JB4557B R-Z73/732 TO R-Z64/734	1.5' would be inside ZOI but entire length shielded by RCP1		Outside ZOI		Outside ZOI		Outside ZOI	
1VC4062B	Item 89A	0.22	5	R-Z68/754 From JB-6346-B to SPT #D12070109-10-F23981A	0' Shielded	0.22	Outside ZOI		Outside ZOI		Outside ZOI	
1PM8022D	Item 89B	1.32	30	R-Z138/722 Radius 35' to R-Z80/722 Radius 20 FLR EL 702	3.5' Inside ZOI	0.15	3.5' Outside ZOI	1.16	Outside ZOI		Outside ZOI	
1VC4064B	Item 89C	0.66	15	R-Z68/754 From JB-6346-B to SPT #D12070111-4-47A056-210	Outside ZOI		Outside ZOI		Outside ZOI		Outside ZOI	
1VC4431B	Item 90A	3.39	65	R-Z144/741 TO JB-4557-B at R-Z73/732	Outside ZOI		14.5' Inside ZOI	0.76	Outside ZOI		Outside ZOI	
JB-293-4557-B	Item 91A	0.26		R-Z73/732 Mounted on Crane Wall	Outside ZOI		Outside ZOI		Outside ZOI		Outside ZOI	
JB-293-6347-A	Item 91B	0.26		R-Z125/725 Mounted on Crane Wall	Outside ZOI		Shielded by RCP2		Outside ZOI		Outside ZOI	
1PM8026E	1 inch supports		90	6D Supports	82' inside ZOI - 10' Shielded by RCP 1		7 ft. inside ZOI		Outside ZOI		Outside ZOI	
	1 inch supports		15	6D Supports	15' Inside ZOI		0' Shielded		0' Shielded		0' Shielded	
VC4432B	1 inch supports		10	6D Supports	1.5' would be inside ZOI but entire length shielded by RCP1		Outside ZOI		Outside ZOI		Outside ZOI	
1 inch supports		**1.66**	**115**	**6D Supports**	**82' inside ZOI - 10' Shielded by RCP 1**	**1.216**	**22' inside ZOI 93' Outside ZOI**	**0.384**	**15' Inside ZOI**	**0.256**	**15' Inside ZOI**	**0.256**
1VC4062B	1.5 inch supports		5	6D Supports	0' Shielded		Outside ZOI		Outside ZOI		Outside ZOI	
1PM8022D	1.5 inch supports		30	6D Supports	3.5' Inside ZOI		3.5' Outside ZOI		Outside ZOI		Outside ZOI	
1VC4064B	1.5 inch supports		15	6D Supports	Outside ZOI		Outside ZOI		Outside ZOI		Outside ZOI	
1.5 inch supports		**0.77**	**50**	**6D Supports**	**0' Shielded 8.5' Inside ZOI**	**0.128**	**0' Shielded 23.5' Outside ZOI**	**0.384**	**Outside ZOI**		**Outside ZOI**	
1VC4431B	2 inch supports		65	6D Supports	Outside ZOI		14.5' Inside ZOI		Outside ZOI		Outside ZOI	
2 inch supports		**1.02**	**65**	**6D Supports**	**Outside ZOI**	**0**	14.5' Inside ZOI	**0.256**	Outside ZOI		Outside ZOI	
1PM8021D	Item 132A	0.66	15.00	R-Z138/722 Radius 39' to R-Z138/722 Radius 39, FLR EL 702	Outside ZOI		0' Shielded	0.66	Outside ZOI		Outside ZOI	
1VC4057A	Item 132C	0.88	20.00	R-Z125/725 Radius 40, FROM 1-JB-293-6347-A to R-Z150 FLR EL 702	Outside ZOI		0' Shielded	0.88	Outside ZOI		Outside ZOI	
1PM8020D	Item 133A	1.30	25.00	R-Z150/728 (HVAC opening to Fan Room 2) to R-Z138/722, Radius 39', Floor El 702	Outside ZOI		0' Shielded	1.30	Outside ZOI		Outside ZOI	
	Item 133C	0.65	25.00	**Unknown 2" Conduit, 25' in length.** It appears that 1/2 of item 363 is included because it is inside the penetration. If this is the case, this item should be included since item 133A wraps conduit to the opening in Fan Room 2. It is included here for the sake of conservativism.	0' Shielded	0.65	0' Shielded	0.65	0' Shielded	0.65	0' Shielded	0.65

DESCRIPTION	Line Item Number	INSUL. VOLUME (FT3)	LENGTH (FT)	Description	Break 1	Vol	Break 2	Vol	Break 3	Vol	Break 4	Vol
1PM8021D	1.5 inch supports		15.00	7B Supports	Outside ZOI		0' Shielded		Outside ZOI		Outside ZOI	
1VC4057A	1.5 inch supports		20.00	7B Supports	Outside ZOI		0' Shielded		Outside ZOI		Outside ZOI	
1.5 inch supports		**0.64**	**35**	**7B Supports**	**Outside ZOI**	**0**	**0' Shielded**	**0.64**	**Outside ZOI**		**Outside ZOI**	
1PM8020D	2 inch supports		25.00	7B Supports	Outside ZOI		0' Shielded		Outside ZOI		Outside ZOI	
	2 inch supports		12.50	7B Supports	0' Shielded		0' Shielded		0' Shielded		0' Shielded	
2 inch supports		**0.64**	**37.5**	**7B Supports**	**0' Shielded 25' Outside ZOI**	**0.26**	**0' Shielded**	**0.64**	**12.5' Inside ZOI**	**0.26**	**12.5' Inside ZOI**	**0.26**
1VC4063B	Item 262A	0.22	5.00	R-Z68/754 From JB-6346-B to Ceiling Penetration R-Z66/754	Outside ZOI		Outside ZOI		Outside ZOI		Outside ZOI	
JB-293-6346-B	Item 263A	0.26		Inside Crane Wall at R-Z68/754	Outside ZOI		Outside ZOI		Outside ZOI		Outside ZOI	
1VC4063B	Supports	0.26	5.00	10E Supports	Outside ZOI		Outside ZOI		Outside ZOI		Outside ZOI	
Totals		**18.93**			**Break 1 (ft^3)**	5.87	**Break 2 (ft^3)**	8.45	**Break 3 (ft^3)**	1.67	**Break 4 (ft^3)**	1.67

3M Insulation - 3D Model



ATTACHMENT A – ENERCON INSULATION SPREADSHEET

This Attachment contains the Enercon-provided Watts Bar insulation spreadsheet showing the type, quantity and location of insulation within containment. This spreadsheet was included with the walkdown report [9] and used to create Appendices 1 through 3.

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
N/A	RACEWAY	702'	1	SEALANT AROUND STAINLESS CONTAINMENT WALL	N/A	SEE CALC	SILICON/RTV	SEE CALC	0.327	N/A	N/A	N/A	SEALANT BET SHEET METAL AND STEEL CONTAINMENT	A
N/A	RACEWAY	702'	1	BEHIND PANEL	N/A	SEE CALC	FOAMGLASS	SEE CALC	260.73	N/A	N/A	N/A	N/A	A
N/A	RACEWAY	702'	1	SEALANT AROUND COVERS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	SEALANT APPLIED ALL AROUND COVER	B
N/A	RACEWAY	702'	1	MIRROR REFLECTIVE INSULATION	N/A	N/A	N/A	SEE CALC WB1-DWD-001G	N/A	N/A	N/A	N/A	MRI (LETDOWN LINES)	C
N/A	RACEWAY	702'	1	LABELS, SIGNS, & PENETRATION NO.	N/A	N/A	N/A	N/A	0.00	N/A	N/A	N/A	SEE REPORT FOR COMMENTS	D
N/A	RACEWAY	702'	1	TIE WRAPS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	SEE REPORT COMMENTS	E
N/A	RACEWAY	702'	1	CALCIUM SILICATE	SEE CALC	SEE CALC	CALCIUM SILICATE	SEE CALC	56.70	N/A	N/A	N/A	SEE CALCULATION	E
N/A	RACEWAY	702'	1	SEAL AROUND PENETRATION PIPE	N/A	N/A	RTV	SEE CALC	0.02	N/A	N/A	N/A	N/A	F
N/A	RACEWAY	702'	1	FOAM IN PENETRATION	N/A	N/A	FOAM	SEE CALC	3.18	N/A	N/A	N/A	N/A	F
0600200-08-09	RACEWAY	702'	1	LETDOWN LINE	3.50	64.75	RMI	1.75	12.98	S.S.	STD	N/A	7" OD INSULATION	G
0600200-08-09	RACEWAY	702'	1	LETDOWN LINE	2.38	130.34	RMI	1.81	21.57	S.S.	STD	N/A	6" OD INSULATION	G
0600200-08-09	RACEWAY	702'	1	LETDOWN LINE	2.28	5.34	RMI	4.31	3.31	S.S.	STD	N/A	11" OD INSULATION	G
0600200-08-09	RACEWAY	702'	1	LETDOWN LINE	2.38	4.36	RMI	0.81	0.25	S.S.	STD	N/A	4" OD INSULATION	G
0600200-08-09	RACEWAY	702'	1	LETDOWN LINE	2.38	2.70	RMI	1.31	0.28	S.S.	STD	N/A	5" OD INSULATION (2.38" OD PIPING)	G
0600200-08-09	RACEWAY	702'	1	LETDOWN LINE	1.06	0.80	RMI	1.97	0.10	S.S.	STD	N/A	5" OD INSULATION (1.06" OD PIPING)	G
N/A	RACEWAY	702'	1	CALCIUM SILICATE	SEE CALC	SEE CALC	CALCIUM SILICATE	SEE CALC	56.79	N/A	N/A	N/A	SEE CALCULATION	G
N/A	RACEWAY	702'	1	EXCESS LETDOWN	1.32	7.46	RMI	2.34	1.39	S.S.	STD	N/A	6" OD INSULATION	J
N/A	RACEWAY	702'	1	EXCESS LETDOWN	1.32	3.44	RMI	1.84	0.44	S.S.	STD	N/A	5" OD INSULATION	J
N/A	RACEWAY	702'	1	EXCESS LETDOWN	1.32	1.00	RMI	3.84	0.43	S.S.	STD	N/A	9" OD INSULATION	J
0600200-08-06, -07, -13	RACEWAY	702'	1	SEAL WATER RETURN LINE	4.50	160.00	RMI	1.75	38.18	S.S.	STD	N/A	8" OD INSULATION	K
0600200-08-06, -07, -13	RACEWAY	702'	1	SEAL WATER RETURN LINE	4.50	2.05	MIN-K	0.75	0.18	N/A	N/A	N/A	6" OD MIN-K INSULATION	K
0600200-08-06, -07, -13	RACEWAY	702'	1	SEAL WATER RETURN LINE	4.50	3.79	RMI	1.25	0.59	S.S.	STD	N/A	7" OD INSULATION	K
0600200-08-06, -07, -13	RACEWAY	702'	1	SEAL WATER RETURN LINE	4.50	1.58	MIN-K	0.5	0.09	N/A	N/A	N/A	5.5" OD MIN-K INSULATION	K
0600200-08-06, -07, -13	RACEWAY	702'	1	SEAL WATER RETURN LINE	4.50	1.52	MIN-K	0.5	0.08	N/A	N/A	N/A	6.12" OD MIN-K INSULATION	K
0600200-08-06, -07, -13	RACEWAY	702'	1	SEAL WATER RETURN LINE	4.50	0.94	RMI	1.625	0.20	S.S.	STD	N/A	7.75" OD INSULATION	K

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-08-06, -07, -13	RACEWAY	702'	1	SEAL WATER RETURN LINE	3.50	17.54	RMI	1.75	3.52	S.S.	STD	N/A	7" OD INSULATION	K
0600200-08-06, -07, -13	RACEWAY	702'	1	SEAL WATER RETURN LINE	3.50	1.00	MIN-K	0.56	0.05	N/A	N/A	N/A	4.62" OD MIN-K INSULATION	K
0600200-08-06, -07, -13	RACEWAY	702'	1	SEAL WATER RETURN LINE	3.50	2.74	RMI	1.25	0.35	S.S.	STD	N/A	6" OD INSULATION	K
0600200-08-06, -07, -13	RACEWAY	702'	1	SEAL WATER RETURN LINE	1.06	6.87	RMI	1.47	0.56	S.S.	STD	N/A	4" OD INSULATION	K
0600200-08-06, -07, -13	RACEWAY	702'	1	SEAL WATER RETURN LINE	1.06	1.37	MIN-K	1.47	0.11	S.S.	STD	N/A	4" OD MIN-K INSULATION	K
0600200-08-06, -07, -13	RACEWAY	702'	1	SEAL WATER RETURN LINE	1.06	0.92	RMI	3.97	0.40	S.S.	STD	N/A	9" OD INSULATION	K
0600200-08-06, -07, -13	RACEWAY	702'	1	SEAL WATER RETURN LINE	2.38	2.76	RMI	1.31	0.29	S.S.	STD	N/A	5" OD INSULATION	K
0600200-08-06, -07, -13	RACEWAY	702'	1	SEAL WATER RETURN LINE	2.38	0.65	RMI	1.81	0.11	S.S.	STD	N/A	6" OD INSULATION	K
0600200-08-06, -07, -13	RACEWAY	702'	1	SEAL WATER RETURN LINE	2.38	2.34	RMI	2.31	0.55	S.S.	STD	N/A	7" OD INSULATION	K
0600200-07-02	RACEWAY	702'	1	STEAM GENERATOR BLOWDOWN	4.50	149.59	RMI	2.25	49.57	S.S.	STD	N/A	9" OD INSULATION	L
0600200-07-02	RACEWAY	702'	1	STEAM GENERATOR BLOWDOWN	4.50	2.57	RMI	1.75	0.61	S.S.	STD	N/A	8" OD INSULATION	L
0600200-07-02	RACEWAY	702'	1	STEAM GENERATOR BLOWDOWN	4.50	1.52	MIN-K	1.375	0.27	S.S.	STD	N/A	7.25" OD INSULATION	L
0600200-07-02	RACEWAY	702'	1	STEAM GENERATOR BLOWDOWN	2.38	1.54	RMI	2.31	0.36	S.S.	STD	N/A	7" OD INSULATION	L
0600200-07-02	RACEWAY	702'	1	STEAM GENERATOR BLOWDOWN	2.38	1.72	RMI	2.81	0.55	S.S.	STD	N/A	8" OD INSULATION	L
0600200-07-03	RACEWAY	702'	1	STEAM GENERATOR BLOWDOWN	4.50	178.00	RMI	2.25	58.98	S.S.	STD	N/A	9" OD INSULATION	M
0600200-07-03	RACEWAY	702'	1	STEAM GENERATOR BLOWDOWN	4.50	1.27	RMI	1.75	0.30	S.S.	STD	N/A	8" OD INSULATION	M
0600200-07-03	RACEWAY	702'	1	STEAM GENERATOR BLOWDOWN	4.50	2.48	RMI	1.25	0.39	S.S.	STD	N/A	7" OD INSULATION	M
0600200-07-03	RACEWAY	702'	1	STEAM GENERATOR BLOWDOWN	2.38	1.48	RMI	2.31	0.35	S.S.	STD	N/A	7" OD INSULATION	M
0600200-07-03	RACEWAY	702'	1	STEAM GENERATOR BLOWDOWN	2.38	2.00	RMI	3.31	0.82	S.S.	STD	N/A	9" OD INSULATION	M
0600200-07-03	RACEWAY	702'	1	STEAM GENERATOR BLOWDOWN	8.62	0.73	RMI	2.19	0.38	S.S.	STD	N/A	13" OD INSULATION (FLANGE)	M
N/A	LOOP 1	702'	2	RC INTERIM LEG	SEE CALC	SEE CALC	RMI	SEE CALC	88.62	S.S.	STD	N/A	N/A	A
N/A	LOOP 1	702'	2	REACTOR COOLANT PUMP	SEE CALC	SEE CALC	RMI	SEE CALC	63.45	S.S.	STD	N/A	N/A	B
0600200-13-09	LOOP 1	702'	2	INTERIM LEG DRAIN	2.38	0.88	RMI	3.8125	0.45	S.S.	STD	N/A	10" OD INSULATION	C

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-13-09	LOOP 1	702'	2	INTERIM LEG DRAIN	2.38	14.00	RMI	2.8125	4.46	S.S.	STD	N/A	8" OD INSULATION	C
0600200-13-09	LOOP 1	702'	2	INTERIM LEG DRAIN	2.38	0.55	RMI	2.3125	0.13	S.S.	STD	N/A	7" OD INSULATION	C
0600200-13-09	LOOP 1	702'	2	INTERIM LEG DRAIN	2.38	0.50	RMI	1.3125	0.05	S.S.	STD	N/A	5" OD INSULATION	C
N/A	LOOP 1	702'	2	LABELS, SIGNS, & PENETRATION NO.	N/A	N/A	N/A	N/A	0.00	N/A	N/A	N/A	SEE REPORT FOR COMMENTS	D
N/A	LOOP 2	702'	3	RC INTERIM LEG	SEE CALC	SEE CALC	RMI	SEE CALC	86.81	S.S.	STD	N/A	N/A	A
N/A	LOOP 2	702'	3	REACTOR COOLANT PUMP	SEE CALC	SEE CALC	RMI	SEE CALC	63.45	S.S.	STD	N/A	N/A	B
0600200-13-10	LOOP 2	702'	3	INTERIM LEG DRAIN	2.38	0.88	RMI	3.8125	0.45	S.S.	STD	N/A	10" OD INSULATION	C
0600200-13-10	LOOP 2	702'	3	INTERIM LEG DRAIN	2.38	14.00	RMI	2.8125	4.46	S.S.	STD	N/A	8" OD INSULATION	C
N/A	LOOP 2	702'	3	CALCIUM SILICATE	SEE CALC	SEE CALC	CALCIUM SILICATE	SEE CALC	70.68	N/A	N/A	N/A	SEE CALCULATION	D
N/A	LOOP 3	702'	4	RC INTERIM LEG	SEE CALC	SEE CALC	RMI	SEE CALC	85.43	S.S.	STD	N/A	N/A	A
N/A	LOOP 3	702'	4	INTERIM LEG DRAIN	2.38	1.92	RMI	3.8125	0.99	S.S.	STD	N/A	10" OD INSULATION	B
N/A	LOOP 3	702'	4	INTERIM LEG DRAIN	2.38	9.50	RMI	2.8125	3.02	S.S.	STD	N/A	8" OD INSULATION	B
0600200-08-10	LOOP 3	702'	4	LETDOWN LINE	3.50	13.25	RMI	3.25	6.34	S.S.	STD	N/A	10" OD INSULATION	C
N/A	LOOP 3	702'	4	REACTOR COOLANT PUMP	SEE CALC	SEE CALC	RMI	SEE CALC	63.45	S.S.	STD	N/A	N/A	D
N/A	LOOP 3	702'	4	CALCIUM SILICATE	SEE CALC	SEE CALC	CALCIUM SILICATE	SEE CALC	42.24	N/A	N/A	N/A	SEE CALCULATION	E
N/A	LOOP 4	702'	5	RC INTERIM LEG	SEE CALC	SEE CALC	RMI	SEE CALC	85.05	S.S.	STD	N/A	N/A	A
N/A	LOOP 4	702'	5	REACTOR COOLANT PUMP	SEE CALC	SEE CALC	RMI	SEE CALC	63.45	S.S.	STD	N/A	N/A	B
0600200-13-12	LOOP 4	702'	5	INTERIM LEG DRAIN	2.38	1.92	RMI	3.8125	0.99	S.S.	STD	N/A	10" OD INSULATION	C
0600200-13-12	LOOP 4	702'	5	INTERIM LEG DRAIN	2.38	12.92	RMI	2.8125	4.11	S.S.	STD	N/A	8" OD INSULATION	C
N/A	LOOP 4	702'	5	MIN K TO WASTE DISP LINE	4.50	2.00	MIN-K	SEE CALC	0.05	N/A	N/A	N/A	WRAP AROUND 4" PIPE	D
N/A	LOOP 4	702'	5	TAGS, LABELS, & SIGNS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	SEE REPORT FOR COMMENTS	E
0600200-03-01	LOOP 4	702'	5	RESIDUAL HEAT REMOVAL	14.00	58.75	RMI	2	41.02	S.S.	STD	N/A	18" OD INSULATION	F
0600200-03-01	LOOP 4	702'	5	RESIDUAL HEAT REMOVAL	14.00	5.00	RMI	1	1.64	S.S.	STD	N/A	16" OD INSULATION	F
0600200-03-01	LOOP 4	702'	5	RESIDUAL HEAT REMOVAL	14.00	1.83	RMI	1.75	1.10	S.S.	STD	N/A	17.5" OD INSULATION	F

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS

PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-03-01	LOOP 4	702'	5	RESIDUAL HEAT REMOVAL	10.75	15.67	RMI	2.125	9.35	S.S.	STD	N/A	15" OD INSULATION	F
0600200-03-01	LOOP 4	702'	5	RESIDUAL HEAT REMOVAL	14.00	3.13	RMI	12	21.31	S.S.	STD	N/A	38" OD INSULATION (VALVE)	F
0600200-03-01	LOOP 4	702'	5	RESIDUAL HEAT REMOVAL	10.75	2.75	RMI	11.125	14.60	S.S.	STD	N/A	33" OD INSULATION (VALVE)	F
0600200-03-01	LOOP 4	702'	5	RESIDUAL HEAT REMOVAL	1.05	1.13	RMI	1.475	0.09	S.S.	STD	N/A	4" OD INSULATION	F
0600200-03-01	LOOP 4	702'	5	RESIDUAL HEAT REMOVAL	1.05	2.21	RMI	2.475	0.42	S.S.	STD	N/A	6" OD INSULATION	F
0600200-03-01	LOOP 4	702'	5	RESIDUAL HEAT REMOVAL	6.63	2.91	RMI	0.6875	0.32	S.S.	STD	N/A	8" OD INSULATION	F
0600200-03-01	LOOP 4	702'	5	RESIDUAL HEAT REMOVAL	6.63	2.05	RMI	8.6875	5.95	S.S.	STD	N/A	24" OD INSULATION	F
N/A	LOOP 1	716'	6	STEAM GENERATOR	SEE CALC	SEE CALC	RMI	SEE CALC	215.60	S.S.	STD	N/A	N/A	A
N/A	LOOP 1	716'	6	STEAM GENERATOR	SEE CALC	SEE CALC	RMI	SEE CALC	0.66	S.S.	STD	N/A	AT ROOT VALVES	A
0600200-02-01	LOOP 1	716'	6	FEEDWATER	16.00	24.10	RMI	2.5	24.32	S.S.	STD	N/A	21" OD INSULATION	B
0600200-02-01	LOOP 1	716'	6	FEEDWATER	16.00	10.59	RMI	0.5	1.91	S.S.	STD	N/A	17" OD INSULATION	B
0600200-02-01	LOOP 1	716'	6	FEEDWATER	SEE CALC	SEE CALC	RMI	SEE CALC	0.42	S.S.	STD	N/A	AT 1.88" OD LINE	B
0600200-02-01	LOOP 1	716'	6	FEEDWATER	SEE CALC	SEE CALC	RMI	SEE CALC	0.26	S.S.	STD	N/A	AT 1" LINE	B
0600200-02-01	LOOP 1	716'	6	FEEDWATER	30.25	0.50	MINERAL WOOL	2	0.70	N/A	STD	N/A	AT PENETRATION # X-12A	B
N/A	LOOP 1	716'	6	PAINT CHIP	N/A	N/A	N/A	N/A	0.00	N/A	N/A	N/A	SEE PAINT INSPECTION REPORT	C
N/A	LOOP 1	716'	6	CONDUIT 3M-M20C INSULATION	1.32	N/A	3M-M20C	0.1875	2.35	N/A	N/A	N/A	SEE CALCULATION	D
N/A	LOOP 1	716'	6	CONDUIT 3M-M20C INSULATION	1.90	N/A	3M-M20C	0.1875	1.43	N/A	N/A	N/A	SEE CALCULATION	D
N/A	LOOP 1	716'	6	CONDUIT 3M-M20C INSULATION	2.38	N/A	3M-M20C	0.1875	1.70	N/A	N/A	N/A	SEE CALCULATION	D
N/A	LOOP 1	716'	6	CONDUIT 3M-M20C INSULATION	N/A	N/A	N/A	N/A	0.52	N/A	N/A	N/A	JUNCTION BOXES SEE CALCULATION	D
N/A	LOOP 1	716'	6	CONDUIT 3M-M20C INSULATION	N/A	N/A	N/A	N/A	2.31	N/A	N/A	N/A	SUPPORT SEE CALCULATION	D
N/A	LOOP 1	710-720	6	LABELS, TAGS, AND TIE WRAPS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	SEE REPORT FOR COMMENTS	E
0600200-13-02	LOOP 1	716'	6	4" PRESSURIZER SPRAY LINE	4.50	43.40	RMI	2.75	18.88	S.S.	STD	N/A	10" OD INSULATION	F
0600200-13-02	LOOP 1	716'	6	4" PRESSURIZER SPRAY LINE	4.50	1.21	RMI	0.75	0.10	S.S.	STD	N/A	6" OD INSULATION	F

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-13-02	LOOP 1	716'	6	4" PRESSURIZER SPRAY LINE	4.50	0.67	MIN-K	1.5	0.13	S.S.	STD	N/A	7.5" OD INSULATION	F
0600200-13-02	LOOP 1	716'	6	4" PRESSURIZER SPRAY LINE	4.50	1.21	RMI	7.75	2.51	S.S.	STD	N/A	20" OD INSULATION	F
0600200-13-02	LOOP 1	716'	6	3/4" PRESSURIZER SPRAY BYPASS LINE	1.05	5.17	RMI	2.975	1.35	S.S.	STD	N/A	7" OD INSULATION	F
0600200-13-02	LOOP 1	716'	6	3/4" PRESSURIZER SPRAY BYPASS LINE	1.05	4.34	RMI	1.475	0.35	S.S.	STD	N/A	4" OD INSULATION	F
0600200-13-02	LOOP 1	716'	6	3/4" PRESSURIZER SPRAY BYPASS LINE	1.05	0.50	RMI	3.35	0.16	S.S.	STD	N/A	7.5" OD INSULATION	F
N/A	LOOP 1	716'	6	HOT LEG	SEE CALC	SEE CALC	RMI	SEE CALC	69.55	S.S.	STD	N/A	N/A	G
N/A	LOOP 1	716'	6	COLD LEG	SEE CALC	SEE CALC	RMI	SEE CALC	55.34	S.S.	STD	N/A	N/A	H
0600200-09-05	LOOP 1	716'	6	BORON INJECTION	1.90	5.65	RMI	2.55	1.40	S.S.	STD	N/A	7" OD INSULATION	J
0600200-09-05	LOOP 1	716'	6	BORON INJECTION	1.90	0.96	RMI	7.6	1.51	S.S.	STD	N/A	9.5" OD INSULATION	J
0600200-09-01	LOOP 1	716'	6	ACCUMULATOR INJECTION	10.75	2.36	RMI	0.795	0.47	S.S.	STD	N/A	12.34" OD INSULATION	K
0600200-09-01	LOOP 1	716'	6	ACCUMULATOR INJECTION	10.75	16.42	RMI	3.125	15.53	S.S.	STD	N/A	17" OD INSULATION	K
0600200-09-01	LOOP 1	716'	6	ACCUMULATOR INJECTION	10.75	2.65	MIN-K	1.25	0.87	S.S.	STD	N/A	13.25" OD INSULATION	K
0600200-09-01	LOOP 1	716'	6	ACCUMULATOR INJECTION	10.75	5.09	RMI	9.635	21.81	S.S.	STD	N/A	30" OD INSULATION	K
0600200-09-01	LOOP 1	716'	6	ACCUMULATOR INJECTION	10.75	0.57	RMI	6.126	1.29	S.S.	STD	N/A	23" OD INSULATION	K
0600200-09-01	LOOP 1	716'	6	LOWHEAD SAFETY INJECTION	6.63	7.94	RMI	2.6875	4.34	S.S.	STD	N/A	12" OD INSULATION	L
N/A	LOOP 1	716'	6	RESIDUAL HEAT REMOVAL	6.63	3.50	RMI	3.6875	2.90	S.S.	STD	N/A	14" OD INSULATION	M
N/A	LOOP 1	716'	6	RESIDUAL HEAT REMOVAL	6.63	2.09	RMI	0.6875	0.23	S.S.	STD	N/A	8" OD INSULATION	M
N/A	LOOP 1	716'	6	RESIDUAL HEAT REMOVAL	6.63	2.17	RMI	9.6875	7.48	S.S.	STD	N/A	26" OD INSULATION	M
N/A	LOOP 1	716'	6	RESIDUAL HEAT REMOVAL	8.63	26.50	RMI	9.6875	102.56	S.S.	STD	N/A	11" OD INSULATION	M
N/A	LOOP 1	716'	6	RESIDUAL HEAT REMOVAL	8.63	1.10	MIN-K	0.9375	0.22	S.S.	STD	N/A	10.5" OD INSULATION	M
0600200-08-11	LOOP 1	716'	6	NORMAL CHARGING	3.50	54.50	RMI	2.75	20.44	S.S.	STD	N/A	9" OD INSULATION	N
0600200-08-11	LOOP 1	716'	6	NORMAL CHARGING	3.50	0.89	RMI	1.5	0.15	S.S.	STD	N/A	6.5" OD INSULATION	N
0600200-08-11	LOOP 1	716'	6	NORMAL CHARGING	3.50	2.50	RMI	2	0.60	S.S.	STD	N/A	7.5" OD INSULATION	N

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-07-01	LOOP 1	716'	6	STEAM GENERATOR BLOWDOWN	3.50	41.67	RMI	2.25	11.76	S.S.	STD	N/A	8" OD INSULATION	P
0600200-07-01	LOOP 1	716'	6	STEAM GENERATOR BLOWDOWN	4.50	28.75	RMI	2.25	9.53	S.S.	STD	N/A	9" OD INSULATION	P
0600200-07-01	LOOP 1	716'	6	STEAM GENERATOR BLOWDOWN	4.50	3.01	RMI	0.75	0.26	S.S.	STD	N/A	6" OD INSULATION	P
0600200-07-01	LOOP 1	716'	6	STEAM GENERATOR BLOWDOWN	1.35	0.59	RMI	3.325	0.20	S.S.	STD	N/A	8" OD INSULATION	P
0600200-07-01	LOOP 1	716'	6	STEAM GENERATOR BLOWDOWN	1.33	1.22	RMI	3.335	0.41	S.S.	STD	N/A	8" OD INSULATION	P
0600200-07-01	LOOP 1	716'	6	STEAM GENERATOR BLOWDOWN	1.31	0.75	RMI	2.345	0.14	S.S.	STD	N/A	6" OD INSULATION	P
0600200-07-01	LOOP 1	716'	6	STEAM GENERATOR BLOWDOWN	1.30	1.13	RMI	3.35	0.38	S.S.	STD	N/A	8" OD INSULATION	P
0600200-07-01	LOOP 1	716'	6	STEAM GENERATOR BLOWDOWN	2.91	0.29	RMI	2.045	0.06	S.S.	STD	N/A	7" OD INSULATION	P
N/A	LOOP 1	716'	6	MIN-K	N/A	N/A	MIN-K	3.38	0.944	N/A	N/A	N/A	N/A	Q
0600200-08-11	LOOP 1	716'	6	3" ALTERNATE CHARGING	3.50	44.09	RMI	2.75	16.53	S.S.	STD	N/A	9" OD INSULATION	R
0600200-08-11	LOOP 1	716'	6	3" ALTERNATE CHARGING	3.50	1.83	MIN-K	1.25	0.24	S.S.	STD	N/A	6" OD INSULATION	R
N/A	LOOP 2	716'	7	STEAM GENERATOR	SEE CALC	SEE CALC	RMI	SEE CALC	215.60	S.S.	STD	N/A	N/A	A
N/A	LOOP 2	716'	7	STEAM GENERATOR	SEE CALC	SEE CALC	RMI	SEE CALC	0.67	S.S.	STD	N/A	AT ROOT VALVES	A
N/A	LOOP 2	716'	7	CONDUIT 3M-M20C INSULATION	1.90	50.00	3M-M20C	0.1875	2.19	N/A	N/A	N/A	SEE CALCULATION	B
N/A	LOOP 2	716'	7	CONDUIT 3M-M20C INSULATION	2.38	70.00	3M-M20C	0.1875	3.65	N/A	N/A	N/A	SEE CALCULATION	B
N/A	LOOP 2	716'	7	CONDUIT 3M-M20C INSULATION	N/A	N/A	3M-M20C	N/A	1.79	N/A	N/A	N/A	SUPPORT INSULATION SEE CALCULATION	B
0600200-13-01	LOOP 2	716'	7	PRESSURIZER SURGE LINE	14.00	34.40	RMI	4.5	62.48	S.S.	STD	N/A	23" OD INSULATIONS	C
0600200-13-01	LOOP 2	716'	7	PRESSURIZER SURGE LINE	14.00	7.67	RMI	0.5	1.21	S.S.	STD	N/A	15" OD INSULATIONS	C
0600200-13-01	LOOP 2	716'	7	PRESSURIZER SURGE LINE	14.00	3.34	RMI	1	1.09	S.S.	STD	N/A	16" OD INSULATIONS	C
0600200-13-01	LOOP 2	716'	7	PRESSURIZER SURGE LINE	14.00	3.01	RMI	2.5	2.71	S.S.	STD	N/A	19" OD INSULATIONS	C
0600200-13-01	LOOP 2	716'	7	PRESSURIZER SURGE LINE	14.00	8.67	RMI	1.5	4.40	S.S.	STD	N/A	17" OD INSULATIONS	C
0600200-02-02	LOOP 2	716'	7	FEEDWATER	16.00	18.50	RMI	2.5	18.67	S.S.	STD	N/A	21" OD INSULATION	D
0600200-02-02	LOOP 2	716'	7	FEEDWATER	16.00	0.80	RMI	2	0.63	S.S.	STD	N/A	20" OD INSULATION	D
0600200-02-02	LOOP 2	716'	7	FEEDWATER	16.00	1.59	MIN-K	1	0.59	S.S.	STD	N/A	18" OD INSULATION	D

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-02-02	LOOP 2	716'	7	FEEDWATER	16.00	10.84	RMI	0.5	1.95	S.S.	STD	N/A	17" OD INSULATION	D
0600200-02-02	LOOP 2	716'	7	FEEDWATER	SEE CALC	SEE CALC	RMI	SEE CALC	0.42	S.S.	STD	N/A	AT 1.88" OD LINE	D
0600200-02-02	LOOP 2	716'	7	FEEDWATER	SEE CALC	SEE CALC	RMI	SEE CALC	0.27	S.S.	STD	N/A	AT 1" LINE	D
0600200-02-02	LOOP 2	716'	7	FEEDWATER	30.25	0.50	MINERAL WOOL	2	0.70	N/A	STD	N/A	AT PENETRATION # X-12B	D
0600200-13-02	LOOP 2	716'	7	4" PRESSURIZER SPRAY LINE	4.50	32.67	RMI	2.75	14.21	S.S.	STD	N/A	10" OD INSULATION	E
0600200-13-02	LOOP 2	716'	7	4" PRESSURIZER SPRAY LINE	4.50	1.21	RMI	7.75	2.51	S.S.	STD	N/A	20" OD INSULATION	E
0600200-13-02	LOOP 2	716'	7	3/4" PRESSURIZER SPRAY BYPASS LINE	1.05	0.42	RMI	2.975	0.11	S.S.	STD	N/A	7" OD INSULATION	E
0600200-13-02	LOOP 2	716'	7	3/4" PRESSURIZER SPRAY BYPASS LINE	1.05	8.42	RMI	1.475	0.68	S.S.	STD	N/A	4" OD INSULATION	E
N/A	LOOP 2	716'	7	HOT LEG	SEE CALC	SEE CALC	RMI	SEE CALC	74.60	S.S.	STD	N/A	N/A	F
N/A	LOOP 2	716'	7	HOT LEG	SEE CALC	SEE CALC	RMI	SEE CALC	8.15	S.S.	STD	N/A	AT 6" SAFETY INJECTION	F
N/A	LOOP 2	716'	7	COLD LEG	SEE CALC	SEE CALC	RMI	SEE CALC	55.42	S.S.	STD	N/A	N/A	G
0600200-09-06	LOOP 2	716'	7	BORON INJECTION	1.90	3.94	RMI	2.55	0.98	S.S.	STD	N/A	7" OD INSULATION	H
0600200-09-06	LOOP 2	716'	7	BORON INJECTION	1.90	1.08	RMI	7.6	1.70	S.S.	STD	N/A	9.5" OD INSULATION	H
0600200-09-02	LOOP 2	716'	7	ACCUMULATOR INJECTION	10.75	17.75	RMI	3.125	16.79	S.S.	STD	N/A	17" OD INSULATION	J
0600200-09-02	LOOP 2	716'	7	ACCUMULATOR INJECTION	10.75	4.98	RMI	9.625	21.31	S.S.	STD	N/A	30" OD INSULATION	J
0600200-09-02	LOOP 2	716'	7	ACCUMULATOR INJECTION	10.75	0.96	RMI	0.625	0.15	S.S.	STD	N/A	12" OD INSULATION	J
0600200-09-02	LOOP 2	716'	7	ACCUMULATOR INJECTION	10.75	1.24	RMI	1.625	0.54	S.S.	STD	N/A	14" OD INSULATION	J
0600200-09-02	LOOP 2	716'	7	LOWHEAD SAFETY INJECTION	6.63	9.75	RMI	2.6875	5.32	S.S.	STD	N/A	12" OD INSULATION	K
N/A	LOOP 2	716'	7	RESIDUAL HEAT REMOVAL	8.63	31.25	RMI	1.1875	7.94	S.S.	STD	N/A	11" OD INSULATION	L
N/A	LOOP 2	716'	7	RESIDUAL HEAT REMOVAL	8.63	2.74	MIN-K	0.5625	0.31	S.S.	STD	N/A	9.75" OD MIN-K INSULATION	L
0600200-08-11	LOOP 2	716'	7	NORMAL CHARGING	3.50	26.92	RMI	2.75	10.09	S.S.	STD	N/A	9" OD INSULATION	M
0600200-08-11	LOOP 2	716'	7	NORMAL CHARGING	3.50	1.92	RMI	0.5	0.08	S.S.	STD	N/A	4.5" OD INSULATION	M
0600200-08-11	LOOP 2	716'	7	NORMAL CHARGING	3.50	0.84	RMI	1	0.08	S.S.	STD	N/A	5.5" OD MIN-K INSULATION	M

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-08-11	LOOP 2	716'	7	NORMAL CHARGING	3.50	3.17	RMI	0.75	0.22	S.S.	STD	N/A	5" OD INSULATION	M
0600200-08-12	LOOP 2	716'	7	EXCESS LETDOWN	1.32	39.67	RMI	2.34	7.41	S.S.	STD	N/A	6" OD INSULATION	N
0600200-08-12	LOOP 2	716'	7	EXCESS LETDOWN	1.32	3.87	MIN-K	2.34	0.72	S.S.	STD	N/A	6" OD INSULATION	N
0600200-08-12	LOOP 2	716'	7	EXCESS LETDOWN	1.32	6.75	RMI	1.84	0.86	S.S.	STD	N/A	5" OD INSULATION	N
0600200-08-12	LOOP 2	716'	7	EXCESS LETDOWN	1.32	0.59	RMI	0.84	0.02	S.S.	STD	N/A	3" OD INSULATION	N
0600200-07-02	LOOP 2	716'	7	STEAM GENERATOR BLOWDOWN	3.50	35.25	RMI	2.25	9.95	S.S.	STD	N/A	8" OD INSULATION	P
0600200-07-02	LOOP 2	716'	7	STEAM GENERATOR BLOWDOWN	4.50	28.59	RMI	2.25	9.47	S.S.	STD	N/A	9" OD INSULATION	P
0600200-07-02	LOOP 2	716'	7	STEAM GENERATOR BLOWDOWN	4.50	3.50	RMI	1.25	0.55	S.S.	STD	N/A	7" OD INSULATION	P
0600200-07-02	LOOP 2	716'	7	STEAM GENERATOR BLOWDOWN	1.31	1.67	RMI	2.845	0.43	S.S.	STD	N/A	7" OD INSULATION	P
0600200-07-02	LOOP 2	716'	7	STEAM GENERATOR BLOWDOWN	1.31	0.73	RMI	2.345	0.14	S.S.	STD	N/A	6" OD INSULATION	P
0600200-07-02	LOOP 2	716'	7	STEAM GENERATOR BLOWDOWN	1.31	0.59	RMI	3.345	0.20	S.S.	STD	N/A	8" OD INSULATION	P
0600200-07-02	LOOP 2	716'	7	STEAM GENERATOR BLOWDOWN	2.88	0.28	RMI	2.06	0.06	S.S.	STD	N/A	7" OD INSULATION	P
N/A	LOOP 2	720-737	7	CONDUIT INSULATION 3M RADIANT	1.32	45.00	3M20C	SEE CALC	1.51	N/A	N/A	N/A	SEE CALCULATION	Q
N/A	LOOP 2	720-737	7	SUPPORT	N/A	N/A	N/A	SEE CALC	0.77	N/A	N/A	N/A	SEE CALCULATION	Q
0600200-08-10	LOOP 2	716'	7	LETDOWN LINE	3.50	2.17	RMI	4.25	1.56	S.S.	STD	N/A	12" OD INSULATION	R
0600200-08-10	LOOP 2	716'	7	LETDOWN LINE	3.50	47.50	RMI	3.25	22.73	S.S.	STD	N/A	10" OD INSULATION	R
0600200-08-10	LOOP 2	716'	7	LETDOWN LINE	3.50	4.29	RMI	2.25	1.21	S.S.	STD	N/A	8" OD INSULATION	R
0600200-08-10	LOOP 2	716'	7	LETDOWN LINE	3.50	3.09	RMI	1.5	0.51	S.S.	STD	N/A	6.5" OD INSULATION	R
0600200-08-10	LOOP 2	716'	7	LETDOWN LINE	3.50	0.59	MIN-K	0.75	0.04	S.S.	STD	N/A	AT MIN-K INSULATION	R
0600200-08-11	LOOP 2	716'	7	3" ALTERNATE CHARGING	3.50	25.09	RMI	2.75	9.41	S.S.	STD	N/A	9" OD INSULATION	S
0600200-08-11	LOOP 2	716'	7	3" ALTERNATE CHARGING	3.50	1.25	RMI	0.5	0.05	S.S.	STD	N/A	4.5" OD INSULATION	S
0600200-08-11	LOOP 2	716'	7	3" ALTERNATE CHARGING	3.50	3.04	RMI	0.75	0.21	S.S.	STD	N/A	5" OD INSULATION	S
N/A	LOOP 3	716'	8	STEAM GENERATOR	SEE CALC	SEE CALC	RMI	SEE CALC	215.60	S.S.	STD	N/A	N/A	A
N/A	LOOP 3	716'	8	STEAM GENERATOR	SEE CALC	SEE CALC	RMI	SEE CALC	0.62	S.S.	STD	N/A	AT ROOT VALVES	A

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-02-03	LOOP 3	716'	8	FEEDWATER	16.00	19.42	RMI	2.5	19.60	S.S.	STD	N/A	21" OD INSULATION	B
0600200-02-03	LOOP 3	716'	8	FEEDWATER	16.00	1.09	RMI	2	0.86	S.S.	STD	N/A	19" OD INSULATION	B
0600200-02-03	LOOP 3	716'	8	FEEDWATER	16.00	6.34	RMI	0.5	1.14	S.S.	STD	N/A	17" OD INSULATION	B
0600200-02-03	LOOP 3	716'	8	FEEDWATER	SEE CALC	SEE CALC	RMI	SEE CALC	0.35	S.S.	STD	N/A	AT 1.88" OD LINE	B
0600200-02-03	LOOP 3	716'	8	FEEDWATER	SEE CALC	SEE CALC	RMI	SEE CALC	0.24	S.S.	STD	N/A	AT 1" LINE	B
0600200-02-03	LOOP 3	716'	8	FEEDWATER	30.25	0.50	MINERAL WOOL	2	0.70	N/A	STD	N/A	AT PENETRATION # X-12C	B
0600200-08-10	LOOP 3	716'	8	LETDOWN LINE	3.50	38.50	RMI	3.25	18.43	S.S.	STD	N/A	10" OD INSULATION	C
N/A	LOOP 3	716'	8	HOT LEG	SEE CALC	SEE CALC	RMI	SEE CALC	49.89	S.S.	STD	N/A	N/A	D
N/A	LOOP 3	716'	8	COLD LEG	SEE CALC	SEE CALC	RMI	SEE CALC	54.98	S.S.	STD	N/A	N/A	E
0600200-09-06	LOOP 3	716'	8	BORON INJECTION	1.90	5.20	RMI	2.55	1.29	S.S.	STD	N/A	7" OD INSULATION	F
0600200-09-06	LOOP 3	716'	8	BORON INJECTION	1.90	0.96	RMI	7.6	1.51	S.S.	STD	N/A	9.5" OD INSULATION	F
0600200-09-02	LOOP 3	716'	8	ACCUMULATOR INJECTION	10.75	17.25	RMI	3.125	16.32	S.S.	STD	N/A	17" OD INSULATION	G
0600200-09-02	LOOP 3	716'	8	ACCUMULATOR INJECTION	10.75	5.18	RMI	9.625	22.16	S.S.	STD	N/A	30" OD INSULATION	G
0600200-09-02	LOOP 3	716'	8	ACCUMULATOR INJECTION	10.75	1.07	RMI	0.625	0.17	S.S.	STD	N/A	12" OD INSULATION	G
0600200-09-02	LOOP 3	716'	8	ACCUMULATOR INJECTION	10.75	1.82	RMI	0.375	0.17	S.S.	STD	N/A	11.5" OD INSULATION	G
0600200-09-02	LOOP 3	716'	8	LOWHEAD SAFETY INJECTION	6.63	2.53	RMI	2.6875	1.38	S.S.	STD	N/A	12" OD INSULATION	H
0600200-09-02	LOOP 3	716'	8	LOWHEAD SAFETY INJECTION	6.63	4.26	RMI	0.6875	0.47	S.S.	STD	N/A	8" OD INSULATION	H
N/A	LOOP 3	716'	8	RESIDUAL HEAT REMOVAL	8.63	6.09	RMI	1.1875	1.55	S.S.	STD	N/A	11" OD INSULATION	J
N/A	LOOP 3	716'	8	RESIDUAL HEAT REMOVAL	6.63	2.17	RMI	9.6875	7.48	S.S.	STD	N/A	26" OD INSULATION (VALVE)	J
N/A	LOOP 3	716'	8	RESIDUAL HEAT REMOVAL	6.63	3.75	RMI	0.6875	0.41	S.S.	STD	N/A	8" OD INSULATION	J
N/A	LOOP 3	716'	8	RESIDUAL HEAT REMOVAL	6.63	2.67	RMI	3.6875	2.22	S.S.	STD	N/A	14" OD INSULATION	J
0600200-08-12	LOOP 3	716'	8	EXCESS LETDOWN	1.32	42.84	RMI	2.34	8.00	S.S.	STD	N/A	6" OD INSULATION	K
0600200-08-12	LOOP 3	716'	8	EXCESS LETDOWN	1.32	0.63	RMI	2.84	0.16	S.S.	STD	N/A	7" OD INSULATION (VALVE)	K

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS

PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-08-12	LOOP 3	716'	8	EXCESS LETDOWN	1.32	6.17	RMI	1.84	0.78	S.S.	STD	N/A	5" OD INSULATION	K
0600200-08-12	LOOP 3	716'	8	EXCESS LETDOWN	1.05	0.78	RMI	1.975	0.10	S.S.	STD	N/A	5" OD INSULATION	K
0600200-08-12	LOOP 3	716'	8	EXCESS LETDOWN	1.05	0.46	RMI	2.475	0.09	S.S.	STD	N/A	6" OD INSULATION (VALVE)	K
0600200-07-03	LOOP 3	716'	8	STEAM GENERATOR BLOWDOWN	3.50	44.92	RMI	2.25	12.68	S.S.	STD	N/A	8" OD INSULATION	L
0600200-07-03	LOOP 3	716'	8	STEAM GENERATOR BLOWDOWN	4.50	21.42	RMI	2.25	7.10	S.S.	STD	N/A	9" OD INSULATION	L
0600200-07-03	LOOP 3	716'	8	STEAM GENERATOR BLOWDOWN	4.50	3.17	RMI	1.25	0.50	S.S.	STD	N/A	7" OD INSULATION	L
0600200-07-03	LOOP 3	716'	8	STEAM GENERATOR BLOWDOWN	1.31	1.75	RMI	2.845	0.45	S.S.	STD	N/A	7" OD INSULATION	L
0600200-07-03	LOOP 3	716'	8	STEAM GENERATOR BLOWDOWN	1.31	0.75	RMI	2.345	0.14	S.S.	STD	N/A	6" OD INSULATION	L
0600200-07-03	LOOP 3	716'	8	STEAM GENERATOR BLOWDOWN	1.31	1.11	RMI	3.345	0.38	S.S.	STD	N/A	8" OD INSULATION	L
0600200-07-03	LOOP 3	716'	8	STEAM GENERATOR BLOWDOWN	2.88	0.28	RMI	2.06	0.06	S.S.	STD	N/A	7" OD INSULATION	L
N/A	LOOP 4	716'	9	STEAM GENERATOR	SEE CALC	SEE CALC	RMI	SEE CALC	215.60	S.S.	STD	N/A	N/A	A
N/A	LOOP 4	716'	9	STEAM GENERATOR	SEE CALC	SEE CALC	RMI	SEE CALC	0.58	S.S.	STD	N/A	AT ROOT VALVES	A
0600200-02-04	LOOP 4	716'	9	FEEDWATER	16.00	20.07	RMI	2.5	20.25	S.S.	STD	N/A	21" OD INSULATION	B
0600200-02-04	LOOP 4	716'	9	FEEDWATER	16.00	6.78	RMI	0.5	1.22	S.S.	STD	N/A	17" OD INSULATION	B
0600200-02-04	LOOP 4	716'	9	FEEDWATER	SEE CALC	SEE CALC	RMI	SEE CALC	0.35	S.S.	STD	N/A	AT 1.88" OD LINE	B
0600200-02-04	LOOP 4	716'	9	FEEDWATER	SEE CALC	SEE CALC	RMI	SEE CALC	0.14	S.S.	STD	N/A	AT 1" LINE	B
0600200-02-04	LOOP 4	716'	9	FEEDWATER	30.25	0.50	MINERAL WOOL	2	0.70	N/A	STD	N/A	AT PENETRATION # X-12D	B
N/A	LOOP 4	716'	9	HOT LEG	SEE CALC	SEE CALC	RMI	SEE CALC	72.51	S.S.	STD	N/A	N/A	C
N/A	LOOP 4	716'	9	COLD LEG	SEE CALC	SEE CALC	RMI	SEE CALC	54.86	S.S.	STD	N/A	N/A	D
0600200-09-05	LOOP 4	716'	9	BORON INJECTION	1.90	4.45	RMI	2.55	1.10	S.S.	STD	N/A	7" OD INSULATION	E
0600200-09-05	LOOP 4	716'	9	BORON INJECTION	1.90	0.90	RMI	7.6	1.42	S.S.	STD	N/A	9.5" OD INSULATION	E
0600200-09-01	LOOP 4	716'	9	ACCUMULATOR INJECTION	10.75	26.25	RMI	3.125	24.83	S.S.	STD	N/A	17" OD INSULATION	F
0600200-09-01	LOOP 4	716'	9	ACCUMULATOR INJECTION	10.75	5.42	RMI	9.625	23.19	S.S.	STD	N/A	30" OD INSULATION	F

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-09-01	LOOP 4	716'	9	LOWHEAD SAFETY INJECTION	6.63	7.04	RMI	1.1875	1.43	S.S.	STD	N/A	9" OD INSULATION	G
N/A	LOOP 4	720-737	9	LABELS AND TIE WRAPS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	SEE REPORT FOR COMMENTS	H
N/A	LOOP 4	720-737	9	RTV SEALANT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	J
0600200-07-04	LOOP 4	716'	9	STEAM GENERATOR BLOWDOWN	3.50	35.25	RMI	2.25	9.95	S.S.	STD	N/A	8" OD INSULATION	K
0600200-07-04	LOOP 4	716'	9	STEAM GENERATOR BLOWDOWN	4.50	36.84	RMI	2.25	12.21	S.S.	STD	N/A	9" OD INSULATION	K
0600200-07-04	LOOP 4	716'	9	STEAM GENERATOR BLOWDOWN	4.50	0.79	RMI	1.25	0.12	S.S.	STD	N/A	7" OD INSULATION	K
0600200-07-04	LOOP 4	716'	9	STEAM GENERATOR BLOWDOWN	1.32	1.63	RMI	2.84	0.42	S.S.	STD	N/A	7" OD INSULATION	K
0600200-07-04	LOOP 4	716'	9	STEAM GENERATOR BLOWDOWN	1.32	0.75	RMI	2.34	0.14	S.S.	STD	N/A	6" OD INSULATION	K
0600200-07-04	LOOP 4	716'	9	STEAM GENERATOR BLOWDOWN	1.32	0.59	RMI	3.34	0.20	S.S.	STD	N/A	8" OD INSULATION	K
0600200-07-03	LOOP 4	716'	9	STEAM GENERATOR BLOWDOWN	2.88	0.34	RMI	2.56	0.10	S.S.	STD	N/A	8" OD INSULATION	K
0600200-08-11	LOOP 4	716'	9	3" ALTERNATE CHARGING	3.50	65.75	RMI	2.75	24.65	S.S.	STD	N/A	9" OD INSULATION	L
0600200-08-11	LOOP 4	716'	9	3" ALTERNATE CHARGING	3.50	2.34	RMI	2.25	0.66	S.S.	STD	N/A	8" OD INSULATION	L
0600200-08-11	LOOP 4	716'	9	3" ALTERNATE CHARGING	3.50	2.91	RMI	6.75	4.39	S.S.	STD	N/A	17" OD INSULATION AT VALVES	L
0600200-06-01	LOOP 1	745'	10	MAIN STEAM	32.00	63.17	RMI	3.5	171.24	S.S.	STD	N/A	N/A	A
0600200-06-01	LOOP 1	745'	10	MAIN STEAM	32.00	3.55	MIN-K	6	17.66	S.S.	N/A	N/A	NEAR PENETRATION	A
0600200-06-01	LOOP 1	745'	10	MAIN STEAM	32.00	2.83	MIN-K	1.5	3.10	S.S.	N/A	N/A	NEAR TOP OF SG	A
0600200-06-01	LOOP 1	745'	10	MAIN STEAM	SEE CALC	SEE CALC	RMI	SEE CALC	1.48	S.S.	STD	N/A	AT 1" VENT LINE	A
0600200-06-01	LOOP 1	745'	10	MAIN STEAM	SEE CALC	SEE CALC	RMI	SEE CALC	0.34	S.S.	STD	N/A	AT 1" INSTRUMENT TEST LINE	A
0600200-06-01	LOOP 1	745'	10	MAIN STEAM	SEE CALC	SEE CALC	RMI	SEE CALC	1.34	S.S.	STD	N/A	AT 3/4" INSTRUMENT TEST LINES	A
N/A	LOOP 1	745'	10	STEAM GENERATOR	SEE CALC	SEE CALC	RMI	SEE CALC	451.03	S.S.	STD	N/A	N/A	B
0600200-02-05	LOOP 1	745'	10	AUXLILIARY FEEDWATER	6.63	3.17	RMI	5.1875	4.24	S.S.	STD	N/A	17" OD INSULATION	C
0600200-02-05	LOOP 1	745'	10	AUXLILIARY FEEDWATER	6.63	59.00	RMI	2.6875	32.21	S.S.	STD	N/A	12" OD INSULATION	C
0600200-02-05	LOOP 1	745'	10	AUXLILIARY FEEDWATER	6.63	3.01	MIN-K	2.8125	1.74	S.S.	STD	N/A	12.25" OD INSULATION	C
0600200-02-05	LOOP 1	745'	10	AUXLILIARY FEEDWATER	6.63	1.43	RMI	1.6875	0.44	S.S.	STD	N/A	10" OD INSULATION	C

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS

PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-02-05	LOOP 1	745'	10	AUXILIARY FEEDWATER	1.31	1.20	RMI	2.845	0.31	S.S.	STD	N/A	AT 1.31" OD LINE	C
N/A	LOOP 1	745'	10	SEAL AROUND HVAC DIFFUSER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	D
N/A	LOOP 1	745'	10	CONDUIT INSULATION 3M RADIANT	1.90	5.00	3M20C	SEE CALC	0.22	N/A	N/A	N/A	SEE CALCULATION	E
N/A	LOOP 1	745'	10	JUNCTION BOX	N/A	N/A	3M20C	SEE CALC	0.26	N/A	N/A	N/A	SEE CALCULATION	E
N/A	LOOP 1	745'	10	SUPPORT	N/A	N/A	3M20C	SEE CALC	0.26	N/A	N/A	N/A	SEE CALCULATION	E
0600200-06-02	LOOP 2	745'	11	MAIN STEAM	32.00	67.50	RMI	3.5	182.97	S.S.	STD	N/A	N/A	A
0600200-06-02	LOOP 2	745'	11	MAIN STEAM	32.00	2.75	MIN-K	1.5	3.01	S.S.	N/A	N/A	NEAR TOP OF SG	A
0600200-06-02	LOOP 2	745'	11	MAIN STEAM	SEE CALC	SEE CALC	RMI	SEE CALC	1.63	S.S.	STD	N/A	AT 1" VENT LINE	A
0600200-06-02	LOOP 2	745'	11	MAIN STEAM	SEE CALC	SEE CALC	RMI	SEE CALC	0.37	S.S.	STD	N/A	AT 1" INSTRUMENT TEST LINE	A
0600200-06-02	LOOP 2	745'	11	MAIN STEAM	SEE CALC	SEE CALC	RMI	SEE CALC	1.41	S.S.	STD	N/A	AT 3/4" INSTRUMENT TEST LINES	A
N/A	LOOP 2	745'	11	STEAM GENERATOR	SEE CALC	SEE CALC	RMI	SEE CALC	451.03	S.S.	STD	N/A	N/A	B
0600200-05-02	LOOP 2	745'	11	AUXILIARY FEEDWATER	6.63	3.50	RMI	5.1875	4.68	S.S.	STD	N/A	17" OD INSULATION	C
0600200-05-02	LOOP 2	745'	11	AUXILIARY FEEDWATER	6.63	2.28	RMI	3.6875	1.89	S.S.	STD	N/A	14" OD INSULATION	C
0600200-05-02	LOOP 2	745'	11	AUXILIARY FEEDWATER	6.63	50.72	RMI	2.6875	27.69	S.S.	STD	N/A	12" OD INSULATION	C
0600200-05-02	LOOP 2	745'	11	AUXILIARY FEEDWATER	6.63	2.10	RMI	1.6875	0.64	S.S.	STD	N/A	10" OD INSULATION	C
0600200-05-02	LOOP 2	745'	11	AUXILIARY FEEDWATER	6.63	2.44	MIN-K	0.3775	0.14	S.S.	STD	N/A	7.38" OD INSULATION	C
0600200-05-02	LOOP 2	745'	11	AUXILIARY FEEDWATER	6.63	15.09	RMI	2.6875	8.24	S.S.	STD	N/A	12" OD INSULATION	E
0600200-05-02	LOOP 2	745'	11	AUXILIARY FEEDWATER	4.50	26.09	RMI	2.75	11.35	S.S.	STD	N/A	10" OD INSULATION	E
0600200-05-02	LOOP 2	745'	11	AUXILIARY FEEDWATER	4.50	2.84	RMI	6.75	4.71	S.S.	STD	N/A	18" OD INSULATION	E
0600200-05-02	LOOP 2	745'	11	AUXILIARY FEEDWATER	1.31	0.45	RMI	2.345	0.08	S.S.	STD	N/A	6" OD INSULATION	E
0600200-05-02	LOOP 2	745'	11	AUXILIARY FEEDWATER	1.31	1.11	RMI	2.847	0.29	S.S.	STD	N/A	7" OD INSULATION	E
0600200-06-03	LOOP 3	745'	12	MAIN STEAM	32.00	66.70	RMI	3.5	180.80	S.S.	STD	N/A	N/A	A
0600200-06-03	LOOP 3	745'	12	MAIN STEAM	32.00	3.10	MIN-K	1.5	3.40	S.S.	N/A	N/A	NEAR TOP OF SG	A
0600200-06-03	LOOP 3	745'	12	MAIN STEAM	SEE CALC	SEE CALC	RMI	SEE CALC	1.42	S.S.	STD	N/A	AT 1" VENT LINE	A

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-06-03	LOOP 3	745'	12	MAIN STEAM	SEE CALC	SEE CALC	RMI	SEE CALC	0.38	S.S.	STD	N/A	AT 1" INSTRUMENT TEST LINE	A
0600200-06-03	LOOP 3	745'	12	MAIN STEAM	SEE CALC	SEE CALC	RMI	SEE CALC	1.35	S.S.	STD	N/A	AT 3/4" INSTRUMENT TEST LINES	A
N/A	LOOP 3	745'	12	STEAM GENERATOR	SEE CALC	SEE CALC	RMI	SEE CALC	451.03	S.S.	STD	N/A	N/A	B
0600200-05-01	LOOP 3	745'	12	AUXLILIARY FEEDWATER	6.63	3.50	RMI	5.1875	4.68	S.S.	STD	N/A	17" OD INSULATION	C
0600200-05-01	LOOP 3	745'	12	AUXLILIARY FEEDWATER	6.63	2.67	RMI	3.6875	2.22	S.S.	STD	N/A	14" OD INSULATION	C
0600200-05-01	LOOP 3	745'	12	AUXLILIARY FEEDWATER	6.63	48.70	RMI	2.6875	26.59	S.S.	STD	N/A	12" OD INSULATION	C
0600200-05-01	LOOP 3	745'	12	AUXLILIARY FEEDWATER	6.63	3.00	RMI	1.6875	0.92	S.S.	STD	N/A	10" OD INSULATION	C
0600200-05-01	LOOP 3	745'	12	AUXLILIARY FEEDWATER	6.63	1.92	RMI	0.6875	0.21	S.S.	STD	N/A	8" OD INSULATION	C
0600200-05-01	LOOP 3	745'	12	AUXLILIARY FEEDWATER	6.63	18.50	RMI	2.6875	10.10	S.S.	STD	N/A	12" OD INSULATION	D
0600200-05-01	LOOP 3	745'	12	AUXLILIARY FEEDWATER	4.50	20.50	RMI	2.75	8.92	S.S.	STD	N/A	10" OD INSULATION	D
0600200-05-01	LOOP 3	745'	12	AUXLILIARY FEEDWATER	4.50	1.72	RMI	1.75	0.41	S.S.	STD	N/A	8" OD INSULATION	D
0600200-05-01	LOOP 3	745'	12	AUXLILIARY FEEDWATER	4.50	3.32	RMI	7.25	6.17	S.S.	STD	N/A	19" OD INSULATION	D
0600200-05-01	LOOP 3	745'	12	AUXLILIARY FEEDWATER	1.31	2.18	RMI	2.345	0.41	S.S.	STD	N/A	6" OD INSULATION	D
N/A	LOOP 4	745'	13	DUST BETWEEN GRATING	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	A
0600200-06-04	LOOP 4	745'	13	MAIN STEAM	32.00	63.09	RMI	3.5	171.02	S.S.	STD	N/A	N/A	B
0600200-06-04	LOOP 4	745'	13	MAIN STEAM	32.00	3.51	MIN-K	6	17.46	S.S.	N/A	N/A	NEAR PENETRATION	B
0600200-06-04	LOOP 4	745'	13	MAIN STEAM	32.00	3.17	MIN-K	1.5	3.48	S.S.	N/A	N/A	NEAR TOP OF SG	B
0600200-06-04	LOOP 4	745'	13	MAIN STEAM	SEE CALC	SEE CALC	RMI	SEE CALC	1.45	S.S.	STD	N/A	AT 1" VENT LINE	B
0600200-06-04	LOOP 4	745'	13	MAIN STEAM	SEE CALC	SEE CALC	RMI	SEE CALC	0.35	S.S.	STD	N/A	AT 1" INSTRUMENT TEST LINE	B
0600200-06-04	LOOP 4	745'	13	MAIN STEAM	SEE CALC	SEE CALC	RMI	SEE CALC	1.13	S.S.	STD	N/A	AT 3/4" INSTRUMENT TEST LINES	B
N/A	LOOP 4	745'	13	STEAM GENERATOR	SEE CALC	SEE CALC	RMI	SEE CALC	451.03	S.S.	STD	N/A	N/A	C
0600200-02-08	LOOP 4	745'	13	AUXILIARY FEEDWATER	6.63	3.34	RMI	5.1875	4.47	S.S.	STD	N/A	17" OD INSULATION	D
0600200-02-08	LOOP 4	745'	13	AUXILIARY FEEDWATER	6.63	49.20	RMI	2.6875	26.86	S.S.	STD	N/A	12" OD INSULATION	D

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-02-08	LOOP 4	745'	13	AUXLILIARY FEEDWATER	6.63	3.01	MIN-K	2.8125	1.74	S.S.	STD	N/A	12.25" OD INSULATION	D
0600200-02-08	LOOP 4	745'	13	AUXLILIARY FEEDWATER	6.63	1.18	RMI	1.6875	0.36	S.S.	STD	N/A	10" OD INSULATION	D
0600200-02-08	LOOP 4	745'	13	AUXLILIARY FEEDWATER	SEE CALC	SEE CALC	RMI	SEE CALC	0.43	S.S.	STD	N/A	AT 1" PIPE	D
N/A	LOOP 4	745'	13	LABELS AND TIE WRAPS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	SEE REPORT FOR COMMENTS	E
N/A	LOOP 4	745'	13	CONDUIT INSULATION 3M RADIANT	1.90	2.50	3M20C	SEE CALC	0.08	N/A	N/A	N/A	SEE CALCULATION	F
N/A	LOOP 4	745'	13	SUPPORT	N/A	N/A	3M20C	SEE CALC	0.26	N/A	N/A	N/A	SEE CALCULATION	F
N/A	FAN ROOM 1	716'	14	MIN-K-WR	N/A	SEE CALC	MIN-K-WR	0.25	0.02	N/A	N/A	N/A	ENCAPSULATED IN STAINLESS FOIL	A
N/A	FAN ROOM 1	716'	14	MIN-K-WR	N/A	SEE CALC	MIN-K-WR	0.375	0.02	N/A	N/A	N/A	ENCAPSULATED IN STAINLESS FOIL	B
N/A	FAN ROOM 1	716'	14	MIN-K-WR	N/A	SEE CALC	MIN-K-WR	0.375	0.04	N/A	N/A	N/A	ENCAPSULATED IN STAINLESS FOIL	C
N/A	FAN ROOM 1	716'	14	MIN-K-WR	N/A	SEE CALC	MIN-K-WR	0.5	0.03	N/A	N/A	N/A	ENCAPSULATED IN STAINLESS FOIL	D
N/A	FAN ROOM 1	716'	14	MIN-K-WR	N/A	SEE CALC	MIN-K-WR	SEE CALC	0.24	N/A	N/A	N/A	ENCAPSULATED IN STAINLESS	F
0600200-07-04	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	4.50	23.92	RMI	2.25	7.93	S.S.	STD	N/A	9" OD INSULATION	G
0600200-07-04	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	4.50	1.34	RMI	4.75	1.28	S.S.	STD	N/A	14" OD INSULATION (VALVE)	G
0600200-07-04	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	11.75	1.59	RMI	2.125	1.02	S.S.	STD	N/A	16" OD INSULATION (FLANGE)	G
0600200-07-04	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	4.50	1.55	RMI	4.25	1.26	S.S.	STD	N/A	13" OD INSULATION (VALVE)	G
0600200-07-04	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	2.38	1.96	RMI	3.31	0.81	S.S.	STD	N/A	9" OD INSULATION (VALVE)	G
0600200-07-04	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	2.38	0.40	RMI	12.5	1.62	S.S.	STD	N/A	7" OD INSULATION	G
0600200-07-04	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	8.62	0.64	RMI	2.19	0.33	S.S.	STD	N/A	13" OD INSULATION (FLANGE)	G
0600200-07-04	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	4.50	2.85	MIN-K	1.5	0.56	S.S.	STD	N/A	7.5" OD INSULATION	G
N/A	FAN ROOM 1	716'	14	CONDUIT INSULATION 3M RADIANT	1.32	40.00	3M20C	SEE CALC	1.34	N/A	N/A	N/A	SEE CALCULATION	H
N/A	FAN ROOM 1	716'	14	SUPPORT	N/A	N/A	3M20C	SEE CALC	0.64	N/A	N/A	N/A	SEE CALCULATION	H
N/A	FAN ROOM 1	716'	14	BOX	N/A	N/A	3M20C	SEE CALC	2.08	N/A	N/A	N/A	SEE CALCULATION	H
0600200-09-01	FAN ROOM 1	716'	14	LOWHEAD SAFETY INJECTION	6.63	54.00	RMI	2.6875	29.48	S.S.	STD	N/A	12" OD INSULATION	J
0600200-09-01	FAN ROOM 1	716'	14	LOWHEAD SAFETY INJECTION	1.05	0.43	RMI	0.975	0.02	S.S.	STD	N/A	3" OD INSULATION	J
0600200-09-01	FAN ROOM 1	716'	14	LOWHEAD SAFETY INJECTION	1.05	0.34	RMI	1.475	0.03	S.S.	STD	N/A	4" OD INSULATION	J

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-09-01	FAN ROOM 1	716'	14	LOWHEAD SAFETY INJECTION	2.38	0.63	RMI	0.81	0.04	S.S.	STD	N/A	4" OD INSULATION	J
N/A	FAN ROOM 1	716'	14	MIN-K-WR	N/A	SEE CALC	MIN-K-WR	0.5	0.02	N/A	N/A	N/A	ENCAPSULATED IN STAINLESS FOIL	K
N/A	FAN ROOM 1	716'	14	RESIDUAL HEAT REMOVAL	8.63	49.84	RMI	1.1875	12.67	S.S.	STD	N/A	11" OD INSULATION	L
N/A	FAN ROOM 1	716'	14	RESIDUAL HEAT REMOVAL	8.63	49.84	RMI	1.1875	12.67	S.S.	STD	N/A	11" OD INSULATION	M
N/A	FAN ROOM 1	716'	14	RESIDUAL HEAT REMOVAL	8.63	1.72	MIN-K	0.9375	0.34	S.S.	STD	N/A	10.5" OD MIN-K INSULATION	M
0600200-09-02	FAN ROOM 1	716'	14	LOWHEAD SAFETY INJECTION	8.63	44.60	RMI	1.1875	11.34	S.S.	STD	N/A	11" OD INSULATION	N
0600200-09-02	FAN ROOM 1	716'	14	LOWHEAD SAFETY INJECTION	8.63	1.98	MIN-K	0.56	0.22	S.S.	STD	N/A	9.75" OD INSULATION	N
0600200-09-02	FAN ROOM 1	716'	14	LOWHEAD SAFETY INJECTION	8.63	2.50	RMI	0.6875	0.35	S.S.	STD	N/A	10" OD INSULATION	N
0600200-07-01	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	4.50	30.09	RMI	2.25	9.97	S.S.	STD	N/A	9" OD INSULATION	P
0600200-07-01	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	4.50	1.04	RMI	1.75	0.25	S.S.	STD	N/A	8" OD INSULATION	P
0600200-07-01	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	4.50	1.81	MIN-K	1.25	0.28	S.S.	STD	N/A	7" OD INSULATION	P
0600200-07-01	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	4.50	1.28	RMI	4.75	1.23	S.S.	STD	N/A	14" OD INSULATION	P
0600200-07-01	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	11.50	1.50	RMI	2.25	1.01	S.S.	STD	N/A	16" OD INSULATION (FLANGES)	P
0600200-07-01	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	4.50	1.57	RMI	4.25	1.27	S.S.	STD	N/A	13" OD INSULATION	P
0600200-07-01	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	2.38	1.79	RMI	3.31	0.74	S.S.	STD	N/A	9" OD INSULATION	P
0600200-07-01	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	2.38	1.33	RMI	2.31	0.31	S.S.	STD	N/A	7" OD INSULATION	P
0600200-07-01	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	8.62	0.56	RMI	2.19	0.29	S.S.	STD	N/A	13" OD INSULATION (FLANGES)	P
0600200-07-01	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	2.00	0.59	RMI	2.81	0.17	S.S.	STD	N/A	8" OD INSULATION	P
0600200-07-01	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	4.50	1.13	MIN-K	0.56	0.07	S.S.	STD	N/A	5.62" OD INSULATION	P
0600200-07-02	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	4.50	28.42	RMI	2.25	9.42	S.S.	STD	N/A	9" OD INSULATION	Q
0600200-07-02	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	4.50	1.61	RMI	4.25	1.31	S.S.	STD	N/A	13" OD INSULATION	Q
0600200-07-02	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	4.50	1.37	RMI	4.75	1.31	S.S.	STD	N/A	14" OD INSULATION	Q
0600200-07-03	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	4.50	20.00	RMI	2.25	6.63	S.S.	STD	N/A	9" OD INSULATION	R

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-07-03	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	4.50	0.50	RMI	1.25	0.08	S.S.	STD	N/A	7" OD INSULATION	R
0600200-07-03	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	4.50	1.34	RMI	4.75	1.28	S.S.	STD	N/A	14" OD INSULATION (VALVE)	R
0600200-07-03	FAN ROOM 1	716'	14	STEAM GENERATOR BLOWDOWN	4.50	1.55	RMI	4.25	1.26	S.S.	STD	N/A	13" OD INSULATION (VALVE)	R
N/A	FAN ROOM 2	716'	15	MIN-K-WR	N/A	SEE CALC	MIN-K-WR	0.5	0.02	N/A	N/A	N/A	ENCAPSULATED IN STAINLESS FOIL	A
N/A	FAN ROOM 2	716	15	MARINITE BOARD	N/A	SEE CALC	MARINITE	1	0.03	N/A	N/A	N/A	N/A	A
0600200-09-02	FAN ROOM 2	716'	15	LOWHEAD SAFETY INJECTION	6.63	46.09	RMI	1.1875	9.33	S.S.	STD	N/A	9" OD INSULATION	B
0600200-09-02	FAN ROOM 2	716'	15	LOWHEAD SAFETY INJECTION	6.63	2.25	RMI	0.6875	0.25	S.S.	STD	N/A	8" OD INSULATION	B
0600200-09-02	FAN ROOM 2	716'	15	LOWHEAD SAFETY INJECTION	6.63	0.85	MIN-K	1.1875	0.17	S.S.	STD	N/A	9" OD MIN-K INSULATION	B
N/A	FAN ROOM 2	716'	15	CONDUIT INSULATION 3M RADIANT	2.38	47.50	3M20C	SEE CALC	2.48	N/A	N/A	N/A	SEE CALCULATION	C
N/A	FAN ROOM 2	716'	15	SUPPORT	N/A	N/A	3M20C	SEE CALC	0.77	N/A	N/A	N/A	SEE CALCULATION	C
N/A	FAN ROOM 2	716'	15	BOX	N/A	N/A	3M20C	SEE CALC	2.08	N/A	N/A	N/A	SEE CALCULATION	C
0600200-07-02	FAN ROOM 2	716'	15	STEAM GENERATOR BLOWDOWN	4.50	11.75	RMI	2.25	3.89	S.S.	STD	N/A	9" OD INSULATION	D
0600200-07-02	FAN ROOM 2	716'	15	STEAM GENERATOR BLOWDOWN	2.38	1.66	RMI	2.31	0.39	S.S.	STD	N/A	7" OD INSULATION	D
0600200-07-03	FAN ROOM 2	716'	15	STEAM GENERATOR BLOWDOWN	4.50	11.05	RMI	2.25	3.66	S.S.	STD	N/A	9" OD INSULATION	E
0600200-07-03	FAN ROOM 2	716'	15	STEAM GENERATOR BLOWDOWN	2.38	0.82	RMI	2.31	0.19	S.S.	STD	N/A	7" OD INSULATION	E
0600200-07-03	FAN ROOM 2	716'	15	STEAM GENERATOR BLOWDOWN	2.38	0.59	RMI	2.81	0.19	S.S.	STD	N/A	8" OD INSULATION	E
N/A	FAN ROOM 2	716'	15	MIN-K	N/A	N/A	MIN-K	0.505	0.03	N/A	N/A	N/A	N/A	F
N/A	ACCUMULATOR ROOM 1	716'	16	TAGS & LABELS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	SEE REPORT FOR COMMENTS	A
N/A	ACCUMULATOR ROOM 1	716'	16	POTENTIAL PAINT CHIPS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	SEE REPORT FOR PAINT ISSUE	B
N/A	ACCUMULATOR ROOM 1	716'	16	MIRROR INSULATIONS	SEE COMMENT	SEE COMMENT	SEE COMMENT	SEE CALC	SEE COMMENT	SEE COMMENT	N/A	N/A	SEE WB1-DWD-014D, -014E, -16F & -16G	C
0600200-09-01	ACCUMULATOR ROOM 1	716'	16	LOWHEAD SAFETY INJECTION	6.63	16.24	RMI	2.6875	8.87	S.S.	STD	N/A	12" OD INSULATION	D
0600200-09-01	ACCUMULATOR ROOM 1	716'	16	LOWHEAD SAFETY INJECTION	6.63	2.17	RMI	8.6875	6.30	S.S.	STD	N/A	24" OD INSULATION	D
0600200-09-01	ACCUMULATOR ROOM 1	716'	16	LOWHEAD SAFETY INJECTION	2.38	8.16	RMI	2.3125	1.93	S.S.	STD	N/A	7" OD INSULATION	D
0600200-09-01	ACCUMULATOR ROOM 1	716'	16	LOWHEAD SAFETY INJECTION	1.05	0.43	RMI	1.8125	0.05	S.S.	STD	N/A	6" OD INSULATION	D

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-09-01	ACCUMULATOR ROOM 1	716'	16	LOWHEAD SAFETY INJECTION	1.05	0.84	MIN-K	0.25	0.01	S.S.	STD	N/A	.25" THK. MIN-K INSULATION	D
0600200-09-01	ACCUMULATOR ROOM 1	716'	16	LOWHEAD SAFETY INJECTION	1.05	0.40	MIN-K	2.2	0.06	S.S.	STD	N/A	3.25" OD MIN-K INSULATION	D
N/A	ACCUMULATOR ROOM 1	716'	16	RESIDUAL HEAT REMOVAL	8.63	19.92	RMI	1.1875	5.06	S.S.	STD	N/A	11" OD INSULATION	E
N/A	ACCUMULATOR ROOM 1	716'	16	RESIDUAL HEAT REMOVAL	8.63	2.25	RMI	5.69	4.00	S.S.	STD	N/A	20" OD INSULATION	E
N/A	ACCUMULATOR ROOM 1	716'	16	RESIDUAL HEAT REMOVAL	8.63	2.64	RMI	1.6875	1.00	S.S.	STD	N/A	12" OD INSULATION	E
N/A	ACCUMULATOR ROOM 1	716'	16	RESIDUAL HEAT REMOVAL	2.38	4.50	RMI	1.31	0.47	S.S.	STD	N/A	5" OD INSULATION	E
N/A	ACCUMULATOR ROOM 1	716'	16	RESIDUAL HEAT REMOVAL	2.38	0.88	RMI	2.31	0.21	S.S.	STD	N/A	7" OD INSULATION	E
N/A	ACCUMULATOR ROOM 1	716'	16	RESIDUAL HEAT REMOVAL	1.06	0.71	RMI	2.47	0.14	S.S.	STD	N/A	6" OD INSULATION	E
N/A	ACCUMULATOR ROOM 1	716'	16	RESIDUAL HEAT REMOVAL	8.63	14.56	RMI	1.1875	3.70	S.S.	STD	N/A	11" OD INSULATION	F
0600200-09-02	ACCUMULATOR ROOM 1	716'	16	LOWHEAD SAFETY INJECTION	8.63	16.92	RMI	1.1875	4.30	S.S.	STD	N/A	11" OD INSULATION	G
0600200-13-02	ACCUMULATOR ROOM 2	716'	17	3" AUXILIARY SPRAY LINE	3.50	1.28	RMI	1.25	0.17	S.S.	STD	N/A	6" OD INSULATION	A
0600200-13-02	ACCUMULATOR ROOM 2	716'	17	3" AUXILIARY SPRAY LINE	3.50	22.91	RMI	2.75	8.59	S.S.	STD	N/A	9" OD INSULATION	A
0600200-13-02	ACCUMULATOR ROOM 2	716'	17	3" AUXILIARY SPRAY LINE	3.50	0.66	MIN-K	1.5	0.11	S.S.	STD	N/A	6.5" OD INSULATION	A
0600200-13-02	ACCUMULATOR ROOM 2	716'	17	3" AUXILIARY SPRAY LINE	3.50	1.09	RMI	4.25	0.78	S.S.	STD	N/A	12" OD INSULATION	A
0600200-09-02	ACCUMULATOR ROOM 2	716'	17	LOWHEAD SAFETY INJECTION	6.63	18.42	RMI	1.1875	3.73	S.S.	STD	N/A	9" OD INSULATION	B
0600200-09-02	ACCUMULATOR ROOM 2	716'	17	LOWHEAD SAFETY INJECTION	6.63	1.92	RMI	6.6875	3.73	S.S.	STD	N/A	20" OD INSULATION	B
0600200-09-02	ACCUMULATOR ROOM 2	716'	17	LOWHEAD SAFETY INJECTION	8.63	13.59	RMI	1.1875	3.45	S.S.	STD	N/A	11" OD INSULATION	B
0600200-09-02	ACCUMULATOR ROOM 2	716'	17	LOWHEAD SAFETY INJECTION	2.38	1.34	MIN-K	0.8125	0.08	S.S.	STD	N/A	4" OD MIN-K INSULATION	B
0600200-09-02	ACCUMULATOR ROOM 2	716'	17	LOWHEAD SAFETY INJECTION	2.38	0.78	RMI	0.5625	0.03	S.S.	STD	N/A	3.5" OD INSULATION	B
0600200-09-02	ACCUMULATOR ROOM 2	716'	17	LOWHEAD SAFETY INJECTION	2.38	0.92	MIN-K	0.5625	0.03	S.S.	STD	N/A	3.5" OD MIN-K INSULATION	B
0600200-09-02	ACCUMULATOR ROOM 2	716'	17	LOWHEAD SAFETY INJECTION	2.38	0.50	MIN-K	1.3125	0.05	S.S.	STD	N/A	5" OD MIN-K INSULATION	B
0600200-09-02	ACCUMULATOR ROOM 2	716'	17	LOWHEAD SAFETY INJECTION	2.38	4.29	RMI	1.3125	0.45	S.S.	STD	N/A	5" OD INSULATION	B
0600200-09-02	ACCUMULATOR ROOM 2	716'	17	LOWHEAD SAFETY INJECTION	2.38	10.00	RMI	2.3125	2.36	S.S.	STD	N/A	7" OD INSULATION	B

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-09-02	ACCUMULATOR ROOM 2	716'	17	LOWHEAD SAFETY INJECTION	2.38	1.15	RMI	3.8125	0.59	S.S.	STD	N/A	10" OD INSULATION	B
0600200-09-02	ACCUMULATOR ROOM 2	716'	17	LOWHEAD SAFETY INJECTION	2.38	1.45	RMI	3.8125	0.75	S.S.	STD	N/A	8" OD INSULATION	B
0600200-09-02	ACCUMULATOR ROOM 2	716'	17	LOWHEAD SAFETY INJECTION	1.05	0.51	RMI	1.475	0.04	S.S.	STD	N/A	4" OD INSULATION	B
0600200-09-02	ACCUMULATOR ROOM 2	716'	17	LOWHEAD SAFETY INJECTION	1.05	3.67	RMI	2.975	0.96	S.S.	STD	N/A	7" OD INSULATION	B
N/A	ACCUMULATOR ROOM 2	716'	17	RESIDUAL HEAT REMOVAL	8.63	27.84	RMI	1.1875	7.08	S.S.	STD	N/A	11" OD INSULATION	C
N/A	ACCUMULATOR ROOM 2	716'	17	RESIDUAL HEAT REMOVAL	8.63	2.17	RMI	8.6875	7.12	S.S.	STD	N/A	26" OD INSULATION	C
0600200-08-11	ACCUMULATOR ROOM 2	716'	17	NORMAL CHARGING	3.50	3.00	RMI	1.75	0.60	S.S.	STD	N/A	7" OD INSULATION	D
0600200-08-11	ACCUMULATOR ROOM 2	716'	17	NORMAL CHARGING	3.50	0.65	RMI	1.25	0.08	S.S.	STD	N/A	6" OD INSULATION	D
0600200-08-11	ACCUMULATOR ROOM 2	716'	17	NORMAL CHARGING	3.50	0.96	RMI	2.75	0.36	S.S.	STD	N/A	9" OD INSULATION	D
0600200-08-12	ACCUMULATOR ROOM 2	716'	17	EXCESS LETDOWN	1.32	11.09	RMI	2.34	2.07	S.S.	STD	N/A	6" OD INSULATION	E
0600200-08-12	ACCUMULATOR ROOM 2	716'	17	EXCESS LETDOWN	1.32	2.00	RMI	1.84	0.25	S.S.	STD	N/A	5" OD INSULATION	E
0600200-08-12	ACCUMULATOR ROOM 2	716'	17	EXCESS LETDOWN	1.05	1.07	RMI	1.975	0.14	S.S.	STD	N/A	5" OD INSULATION	E
0600200-08-12	ACCUMULATOR ROOM 2	716'	17	EXCESS LETDOWN	1.05	0.67	RMI	2.975	0.18	S.S.	STD	N/A	7" OD INSULATION (VALVE)	E
0600200-08-11	ACCUMULATOR ROOM 2	716'	17	3" ALTERNATE CHARGING	3.50	11.84	RMI	2.75	4.44	S.S.	STD	N/A	9" OD INSULATION	F
0600200-08-11	ACCUMULATOR ROOM 2	716'	17	3" ALTERNATE CHARGING	3.50	2.75	RMI	1.25	0.36	S.S.	STD	N/A	6" OD INSULATION	F
0600200-08-11	ACCUMULATOR ROOM 2	716'	17	3" ALTERNATE CHARGING	3.50	2.34	RMI	2.25	0.66	S.S.	STD	N/A	8" OD INSULATION	F
N/A	ACCUMULATOR ROOM 4	716'	19	TAGS & LABELS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	SEE REPORT FOR COMMENTS	A
N/A	ACCUMULATOR ROOM 4	716'	19	TAGS & LABELS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	SHOW RUBBER GASKETS	B
N/A	ACCUMULATOR ROOM 4	716'	19	TAGS & LABELS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	SEE REPORT FOR COMMENTS	C
N/A	ACCUMULATOR ROOM 4	716'	19	PENETRATIONS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NO POTENTIAL DEBRIS FROM THESE PENETRATIONS	D
0600200-08-09	ACCUMULATOR ROOM 4	716'	19	LETDOWN LINE	2.38	23.17	RMI	1.81	3.83	S.S.	STD	N/A	N/A	E
0600200-09-01	ACCUMULATOR ROOM 4	716'	19	LOWHEAD SAFETY INJECTION	6.63	15.67	RMI	1.1875	3.17	S.S.	STD	N/A	9" OD INSULATION	F
0600200-09-01	ACCUMULATOR ROOM 4	716'	19	LOWHEAD SAFETY INJECTION	6.63	2.17	RMI	9.6875	7.48	S.S.	STD	N/A	26" OD INSULATION	F

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-09-01	ACCUMULATOR ROOM 4	716'	19	LOWHEAD SAFETY INJECTION	8.63	35.09	RMI	1.1875	8.92	S.S.	STD	N/A	11" OD INSULATION	F
0600200-09-01	ACCUMULATOR ROOM 4	716'	19	LOWHEAD SAFETY INJECTION	8.63	0.53	RMI	2.8187	0.37	S.S.	STD	N/A	13" OD INSULATION	F
0600200-09-01	ACCUMULATOR ROOM 4	716'	19	LOWHEAD SAFETY INJECTION	1.05	8.92	RMI	2.475	1.70	S.S.	STD	N/A	6" OD INSULATION	F
0600200-09-01	ACCUMULATOR ROOM 4	716'	19	LOWHEAD SAFETY INJECTION	1.05	0.90	MIN-K	0.726	0.03	S.S.	STD	N/A	2.5" OD MIN-K INSULATION	F
0600200-09-01	ACCUMULATOR ROOM 4	716'	19	LOWHEAD SAFETY INJECTION	1.05	0.94	RMI	3.475	0.32	S.S.	STD	N/A	8" OD INSULATION	F
0600200-09-01	ACCUMULATOR ROOM 4	716'	19	LOWHEAD SAFETY INJECTION	2.38	6.25	RMI	2.31	1.48	S.S.	STD	N/A	7" OD INSULATION	F
0600200-09-01	ACCUMULATOR ROOM 4	716'	19	LOWHEAD SAFETY INJECTION	2.38	0.71	RMI	4.3125	0.45	S.S.	STD	N/A	11" OD INSULATION	F
0600200-09-01	ACCUMULATOR ROOM 4	716'	19	LOWHEAD SAFETY INJECTION	1.05	1.80	RMI	2.475	0.34	S.S.	STD	N/A	6" OD INSULATION	F
0600200-09-01	ACCUMULATOR ROOM 4	716'	19	LOWHEAD SAFETY INJECTION	1.05	3.42	RMI	1.975	0.45	S.S.	STD	N/A	5" OD INSULATION	F
0600200-09-01	ACCUMULATOR ROOM 4	716'	19	LOWHEAD SAFETY INJECTION	1.05	0.84	RMI	4.975	0.55	S.S.	STD	N/A	11" OD INSULATION	F
N/A	ACCUMULATOR ROOM 4	716'	19	RESIDUAL HEAT REMOVAL	8.63	51.59	RMI	1.1875	13.11	S.S.	STD	N/A	11" OD INSULATION	G
N/A	ACCUMULATOR ROOM 4	716'	19	RESIDUAL HEAT REMOVAL	8.63	1.00	MIN-K	0.935	0.20	S.S.	STD	N/A	10.5" OD INSULATION	G
N/A	ACCUMULATOR ROOM 4	716'	19	RESIDUAL HEAT REMOVAL	8.63	2.52	RMI	0.6875	0.35	S.S.	STD	N/A	10" OD INSULATION	G
N/A	ACCUMULATOR ROOM 4	716'	19	RESIDUAL HEAT REMOVAL	12.75	21.92	RMI	1.125	7.46	S.S.	STD	N/A	15" OD INSULATION	G
N/A	ACCUMULATOR ROOM 4	716'	19	RESIDUAL HEAT REMOVAL	12.75	1.50	RMI	2.625	1.32	S.S.	STD	N/A	18" OD INSULATION	G
N/A	ACCUMULATOR ROOM 4	716'	19	RESIDUAL HEAT REMOVAL	1.05	1.75	RMI	2.475	0.33	S.S.	STD	N/A	6" OD INSULATION	G
N/A	ACCUMULATOR ROOM 4	716'	19	RESIDUAL HEAT REMOVAL	1.05	0.80	RMI	1.475	0.07	S.S.	STD	N/A	4" OD INSULATION	G
N/A	ACCUMULATOR ROOM 4	716'	19	RESIDUAL HEAT REMOVAL	2.88	0.84	RMI	1.06	0.08	S.S.	STD	N/A	5" OD INSULATION (TIEBACK SUPPORT)	G
N/A	ACCUMULATOR ROOM 4	716'	19	RESIDUAL HEAT REMOVAL	1.05	0.46	RMI	1.975	0.06	S.S.	STD	N/A	5" OD INSULATION	G
N/A	ACCUMULATOR ROOM 4	716'	19	RESIDUAL HEAT REMOVAL	2.88	0.53	RMI	1.56	0.08	S.S.	STD	N/A	6" OD INSULATION (TIEBACK SUPPORT)	G
N/A	ACCUMULATOR ROOM 4	716'	19	RESIDUAL HEAT REMOVAL	1.05	11.09	RMI	1.475	0.90	S.S.	STD	N/A	4" OD INSULATION (DRAIN LINE)	G
N/A	ACCUMULATOR ROOM 4	716'	19	RESIDUAL HEAT REMOVAL	1.05	1.07	RMI	1.975	0.14	S.S.	STD	N/A	5" OD INSULATION (DRAIN VALVE)	G
0600200-03-01	ACCUMULATOR ROOM 4	716'	19	RESIDUAL HEAT REMOVAL	14.00	10.50	RMI	2	7.33	S.S.	STD	N/A	18" OD INSULATION	H

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-03-01	ACCUMULATOR ROOM 4	716'	19	RESIDUAL HEAT REMOVAL	10.75	6.00	RMI	2.125	3.58	S.S.	STD	N/A	15" OD INSULATION	H
0600200-03-01	ACCUMULATOR ROOM 4	716'	19	RESIDUAL HEAT REMOVAL	14.00	3.11	RMI	9.5	15.15	S.S.	STD	N/A	33" OD INSULATION (VALVE)	H
0600200-03-01	ACCUMULATOR ROOM 4	716'	19	RESIDUAL HEAT REMOVAL	10.75	2.72	RMI	8.625	9.92	S.S.	STD	N/A	28" OD INSULATION (VALVE)	H
0600200-03-01	ACCUMULATOR ROOM 4	716'	19	RESIDUAL HEAT REMOVAL	3.50	0.34	RMI	1.75	0.07	S.S.	STD	N/A	7" OD INSULATION	H
0600200-03-01	ACCUMULATOR ROOM 4	716'	19	RESIDUAL HEAT REMOVAL	1.05	0.82	RMI	0.975	0.04	S.S.	STD	N/A	3" OD INSULATION	H
0600200-09-02	ACCUMULATOR ROOM 4	716'	19	LOWHEAD SAFETY INJECTION	8.63	39.75	RMI	1.1875	10.11	S.S.	STD	N/A	11" OD INSULATION	J
0600200-09-02	ACCUMULATOR ROOM 4	716'	19	LOWHEAD SAFETY INJECTION	8.63	5.17	MIN-K	0.9375	1.01	S.S.	STD	N/A	10.5" OD MIN-K INSULATION	J
0600200-08-06	ACCUMULATOR ROOM 4	716'	19	SEAL WATER RETURN LINE	4.50	14.67	RMI	1.75	3.50	S.S.	STD	N/A	8" OD INSULATION	K
0600200-08-06	ACCUMULATOR ROOM 4	716'	19	SEAL WATER RETURN LINE	4.50	1.17	RMI	4.75	1.12	S.S.	STD	N/A	14" OD INSULATION	K
0600200-08-06	ACCUMULATOR ROOM 4	716'	19	SEAL WATER RETURN LINE	4.50	0.80	RMI	3.75	0.54	S.S.	STD	N/A	12" OD INSULATION	K
0600200-08-06	ACCUMULATOR ROOM 4	716'	19	SEAL WATER RETURN LINE	1.06	3.80	RMI	1.47	0.31	S.S.	STD	N/A	4" OD INSULATION	K
0600200-08-06	ACCUMULATOR ROOM 4	716'	19	SEAL WATER RETURN LINE	1.06	1.71	RMI	2.47	0.33	S.S.	STD	N/A	6" OD INSULATION	K
0600200-08-06	ACCUMULATOR ROOM 4	716'	19	SEAL WATER RETURN LINE	2.38	1.83	RMI	1.31	0.19	S.S.	STD	N/A	5" OD INSULATION	K
0600200-08-06	ACCUMULATOR ROOM 4	716'	19	SEAL WATER RETURN LINE	2.38	0.26	RMI	3.31	0.11	S.S.	STD	N/A	9" OD INSULATION	K
N/A	ACCUMULATOR ROOM 4	716'	19	MIN-K	N/A	N/A	MIN-K	0.72	0.04	N/A	N/A	N/A	N/A	L
N/A	UPPER CONTAINMENT	756'	20	GLYCOL RETURN/SUPPLY LINES	2.38	29.03	FOAMGLASS	3	10.22	S.S.	N/A	STD	EL. 756' TO EL. 769'-10 5/8"	A
N/A	UPPER CONTAINMENT	756'	20	GLYCOL RETURN/SUPPLY LINES	2.38	10.10	FOAMPLASTIC	3	3.56	N/A	N/A	N/A	EL. 771'-6"	A
N/A	UPPER CONTAINMENT	756'	20	GLYCOL RETURN/SUPPLY LINES	0.84	6.25	FOAMPLASTIC	3	1.57	N/A	N/A	N/A	EL. 771'-6"	A
N/A	UPPER CONTAINMENT	756'	20	GLYCOL RETURN/SUPPLY LINES	2.38	14.10	FOAMPLASTIC	3	4.96	N/A	N/A	N/A	EL. 775'-0"	A
N/A	UPPER CONTAINMENT	756'	20	GLYCOL RETURN/SUPPLY LINES	0.84	8.75	FOAMPLASTIC	3	2.20	N/A	N/A	N/A	EL. 775'-0"	A

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
N/A	UPPER CONTAINMENT	756'	20	GLYCOL RETURN/SUPPLY LINES	0.84	2.50	FOAMGLASS	3	0.63	S.S.	N/A	STD	CHECK VALVES	A
N/A	UPPER CONTAINMENT	756'	20	GLYCOL RETURN/SUPPLY LINES	SEE CALC	SEE CALC	FOAMPLASTIC	1	1.65	N/A	N/A	N/A	AT SUPPORTS	A
N/A	ICE CONDENSER	803'	21	VENT-CURTAINS	N/A	SEE CALC	SEE CALC	SEE CALC	2.20	N/A	N/A	N/A	N/A	A
N/A	ICE CONDENSER	803'	21	SEAL FRAME & VESSEL SHELL	N/A	SEE CALC	SEE CALC	SEE CALC	8.38	N/A	N/A	N/A	N/A	A
N/A	ICE CONDENSER	756'	21	GLYCOL RETURN/SUPPLY LINES	2.38	318.00	FOAMGLASS	3	111.97	S.S.	N/A	STD	N/A	B
N/A	ICE CONDENSER	756'	21	GLYCOL RETURN/SUPPLY LINES	1.05	264.00	FOAMGLASS	3	69.98	S.S.	N/A	STD	N/A	B
N/A	ICE CONDENSER	756'	21	DRAIN LINES	12.75	255.00	FOAMGLASS	3	262.86	S.S.	N/A	STD	N/A	B
N/A	ICE CONDENSER	819'-7 1/2"	21	TOP DECK BLANKET ASSEMBLY	SEE CALC	SEE CALC	SPONGE	0.75	444.00	S.S.	N/A	STITCHES	2 BLANKET LAYERS	C
N/A	ICE CONDENSER	803'	21	END WALLS/DOORS	SEE CALC	SEE CALC	FOAM RUBBER	1	40.20	N/A	N/A	N/A	N/A	D
N/A	ICE CONDENSER	803'	21	GLYCOL SUPPLY LINE	6.63	29.81	FOAMGLASS	3	18.78	N/A	N/A	N/A	S.S. JACKETING USED ON SOME PIPING OUTSIDE OF ICE CONDENSER BAY	E
N/A	ICE CONDENSER	803'	21	GLYCOL SUPPLY LINE	4.50	14.30	FOAMGLASS	3	7.02	N/A	N/A	N/A	S.S. JACKETING USED ON SOME PIPING OUTSIDE OF ICE CONDENSER BAY	E
N/A	ICE CONDENSER	803'	21	GLYCOL SUPPLY LINE	4.50	553.47	FOAMPLASTIC	2.5	211.31	N/A	N/A	N/A	S.S. JACKETING USED ON SOME PIPING OUTSIDE OF ICE CONDENSER BAY	E
N/A	ICE CONDENSER	803'	21	GLYCOL RETURN LINE	6.63	10.00	FOAMGLASS	3	6.30	N/A	N/A	N/A	S.S. JACKETING USED ON SOME PIPING OUTSIDE OF ICE CONDENSER BAY	E
N/A	ICE CONDENSER	803'	21	GLYCOL RETURN LINE	4.50	29.67	FOAMGLASS	3	14.56	N/A	N/A	N/A	S.S. JACKETING USED ON SOME PIPING OUTSIDE OF ICE CONDENSER BAY	E
N/A	ICE CONDENSER	803'	21	GLYCOL RETURN LINE	4.50	529.00	FOAMPLASTIC	2.5	201.97	N/A	N/A	N/A	S.S. JACKETING USED ON SOME PIPING OUTSIDE OF ICE CONDENSER BAY	E
N/A	ICE CONDENSER	803'	21	GLYCOL SUPPLY BY-PASS LINE	0.84	7.17	FOAMPLASTIC	2.5	1.31	N/A	N/A	N/A	N/A	E

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
N/A	ICE CONDENSER	803'	21	GLYCOL SUPPLY BY-PASS LINE	0.84	0.50	FOAMGLASS	3	0.13	N/A	N/A	N/A	VALVE	E
N/A	ICE CONDENSER	803'	21	GLYCOL RETURN BY-PASS LINE	0.84	8.27	FOAMPLASTIC	2.5	1.51	N/A	N/A	N/A	N/A	E
N/A	ICE CONDENSER	803'	21	GLYCOL RETURN BY-PASS LINE	0.84	0.50	FOAMGLASS	3	0.13	N/A	N/A	N/A	VALVE	E
N/A	ICE CONDENSER	803'	21	GLYCOL EXPANSION TANK LINES	3.50	0.59	FOAMPLASTIC	2.5	0.19	N/A	N/A	N/A	N/A	E
N/A	ICE CONDENSER	803'	21	GLYCOL EXPANSION TANK LINES	1.32	32.72	FOAMPLASTIC	2.5	6.82	N/A	N/A	N/A	N/A	E
N/A	ICE CONDENSER	803'	21	GLYCOL SUPPLY/RETURN LINES TO AHU'S	1.32	750.00	FOAMPLASTIC	2.5	156.26	N/A	N/A	N/A	N/A	E
N/A	ICE CONDENSER	803'	21	HEADER LINES	1.90	462.55	FOAMGLASS	3	148.34	S.S.	N/A	STD	N/A	E
N/A	ICE CONDENSER	803'	21	HEADER/AHU DRAINS/TRAPS	1.90	150.00	FOAMGLASS	3	48.11	S.S.	N/A	STD	N/A	E
N/A	ICE CONDENSER	803'	21	HEADER/AHU DRAINS/TRAPS	1.90	60.00	FOAMPLASTIC	2.5	14.40	S.S.	N/A	STD	N/A	E
N/A	ICE CONDENSER	803'	21	TOP DECK BEAMS	N/A	SEE CALC	FOAMPLASTIC	1	1376.00	N/A	N/A	N/A	N/A	F
N/A	ICE CONDENSER	803'	21	DUCT FLEX CONNECTIONS	N/A	SEE CALC	SEE CALC	SEE CALC	0.32	N/A	N/A	N/A	N/A	G
N/A	ICE CONDENSER	803'	21	DUCT FLEX CONNECTIONS	N/A	SEE CALC	SEE CALC	SEE CALC	4.59	N/A	N/A	N/A	N/A	G
N/A	ICE CONDENSER	803'	21	VENT-CURTAINS	N/A	SEE CALC	SEE CALC	SEE CALC	3.89	N/A	N/A	N/A	N/A	H
N/A	REACTOR VESSEL	713'	22	REACTOR VESSEL	SEE CALC	SEE CALC	RMI	SEE CALC	810.76	S.S.	STD	N/A	N/A	A
N/A	REACTOR VESSEL	713'	22	REACTOR VESSEL	1.06	SEE CALC	RMI	1.47	1.57	S.S.	STD	N/A	FILLED WITH MED. S.S. WOOL	A
N/A	PRESSURIZER	729'	23	PRESSURIZER	SEE CALC	SEE CALC	RMI	SEE CALC	449.41	S.S.	STD	N/A	N/A	A
0600200-13-02	PRESSURIZER	729'	23	6" PRESSURIZER SPRAY LINE	5.56	0.29	RMI	7.22	0.58	S.S.	STD	N/A	20" OD INSULATION	B
0600200-13-02	PRESSURIZER	729'	23	6" PRESSURIZER SPRAY LINE	5.56	0.38	RMI	2.22	0.14	S.S.	STD	N/A	10" OD INSULATION	B
0600200-13-02	PRESSURIZER	729'	23	6" PRESSURIZER SPRAY LINE	4.50	0.79	RMI	2.75	0.34	S.S.	STD	N/A	10" OD INSULATION	B
0600200-13-02	PRESSURIZER	729'	23	6" PRESSURIZER SPRAY LINE	6.62	49.34	RMI	2.69	26.96	S.S.	STD	N/A	12" OD INSULATION	B
0600200-13-02	PRESSURIZER	729'	23	6" PRESSURIZER SPRAY LINE	6.62	0.65	RMI	2	0.24	S.S.	STD	N/A	8.5" OD INSULATION	B
0600200-13-02	PRESSURIZER	729'	23	6" PRESSURIZER SPRAY LINE	1.05	1.05	RMI	2.975	0.27	S.S.	STD	N/A	7" OD INSULATION	B
0600200-13-02	PRESSURIZER	729'	23	3" AUXILIARY SPRAY LINE	3.50	16.75	RMI	2.75	6.28	S.S.	STD	N/A	9" OD INSULATION	B

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-13-02	PRESSURIZER	729'	23	3" AUXILIARY SPRAY LINE	3.50	1.34	MIN-K	0.56	0.07	S.S.	STD	N/A	4.62" OD INSULATION	B
0600200-13-02	PRESSURIZER	729'	23	3" AUXILIARY SPRAY LINE	3.50	1.30	RMI	0.75	0.09	S.S.	STD	N/A	5" OD INSULATION	B
0600200-13-02	PRESSURIZER	729'	23	3" AUXILIARY SPRAY LINE	3.50	1.46	RMI	6.25	1.94	S.S.	STD	N/A	16" OD INSULATION	B
0600200-13-02	PRESSURIZER	729'	23	3" AUXILIARY SPRAY LINE	3.50	0.70	MIN-K	1.5	0.11	S.S.	STD	N/A	6.5" OD INSULATION	B
N/A	PRESSURIZER	729'	23	3/4" INSTRUMENTATION	1.05	5.84	RMI	4.98	3.83	S.S.	STD	N/A	11" OD INSULATION	C
N/A	PRESSURIZER	729'	23	3/4" INSTRUMENTATION	1.05	1.46	RMI	3.98	0.64	S.S.	STD	N/A	9" OD INSULATION	C
N/A	PRESSURIZER	729'	23	PRESSURE RELIEF	6.63	9.84	RMI	2.6875	5.37	S.S.	STD	N/A	12" OD INSULATION	D
N/A	PRESSURIZER	729'	23	PRESSURE RELIEF	3.50	2.67	RMI	6.5	3.79	S.S.	STD	N/A	16.5" OD INSULATION	D
N/A	PRESSURIZER	729'	23	PRESSURE RELIEF	3.50	4.27	RMI	2.75	1.60	S.S.	STD	N/A	9" OD INSULATION	D
N/A	PRESSURIZER	729'	23	PRESSURE RELIEF	12.00	1.11	RMI	2	0.68	S.S.	STD	N/A	16" OD INSULATION (FLANGE)	D
N/A	PRESSURIZER	729'	23	PRESSURE RELIEF	3.50	1.67	RMI	3.75	0.99	S.S.	STD	N/A	11" OD INSULATION	D
N/A	PRESSURIZER	729'	23	PRESSURE RELIEF	3.50	0.64	RMI	2.25	0.18	S.S.	STD	N/A	8" OD INSULATION	D
N/A	PRESSURIZER	729'	23	PRESSURE RELIEF	12.00	1.11	RMI	2.25	0.78	S.S.	STD	N/A	13.5" OD INSULATION (FLANGE)	D
N/A	PRESSURIZER	729'	23	PRESSURE RELIEF	1.06	1.98	RMI	2.97	0.52	S.S.	STD	N/A	7" OD INSULATION	D
0600200-08-10	INSTRUMENT ROOM	716'	24	LETDOWN LINE	3.50	16.67	RMI	3.25	7.98	S.S.	STD	N/A	N/A	A
N/A	INSTRUMENT ROOM	716'	24	LETDOWN LINE	3.50	30.84	RMI	3.25	14.76	S.S.	STD	N/A	N/A	B
N/A	INSTRUMENT ROOM	716'	24	REGENERATIVE HEAT EXCHANGER	10.90	SEE CALC	RMI	3.05	45.63	S.S.	STD	N/A	N/A	B
0600200-08-09	INSTRUMENT ROOM	716'	24	LETDOWN LINE	3.50	15.34	RMI	1.74	3.05	S.S.	STD	N/A	N/A	C
0600200-08-11	INSTRUMENT ROOM	716'	24	NORMAL CHARGING LINE	3.50	23.67	RMI	2.75	8.88	S.S.	STD	N/A	AT 9" OD INSULATION	D
0600200-08-11	INSTRUMENT ROOM	716'	24	NORMAL CHARGING LINE	3.50	1.24	RMI	1.25	0.16	S.S.	STD	N/A	AT 6" OD INSULATION	D
0600200-08-11	INSTRUMENT ROOM	716'	24	NORMAL CHARGING LINE	3.50	2.82	RMI	1.75	0.57	S.S.	STD	N/A	AT 7" OD INSULATION	D
0600200-08-11	INSTRUMENT ROOM	716'	24	ALTERNATE CHARGING LINE	3.50	1.18	RMI	2.75	0.44	S.S.	STD	N/A	AT 9" OD INSULATION	D
0600200-08-11	INSTRUMENT ROOM	716'	24	ALTERNATE CHARGING LINE	3.50	1.69	RMI	2.25	0.48	S.S.	STD	N/A	AT 8" OD INSULATION	D

WATTS BAR NUCLEAR PLANT UNIT 1 WALK DOWN RESULTS														
PROBLEM NUMBER	LOCATION	ELEV.	AREA	DESCRIPTION	OD (IN)	LENGTH (FT)	INSUL. TYPE	INSULATION THICKNESS (IN)	INSUL. VOLUME (FT3)	JACKET MATERIAL	BUCKLE TYPE	STRAP TYPE	COMMENTS	PACKET LETTER
0600200-08-11	INSTRUMENT ROOM	716'	24	NORMAL CHARGING BYPASS LINE	1.05	3.34	RMI	1.975	0.44	S.S.	STD	N/A	AT 5" OD INSULATION	D
0600200-08-11	INSTRUMENT ROOM	716'	24	NORMAL CHARGING BYPASS LINE	1.05	1.80	RMI	0.975	0.08	S.S.	STD	N/A	AT 4" OD INSULATION	D
0600200-08-11	INSTRUMENT ROOM	716'	24	AUXILIARY SPRAY LINE	2.38	10.84	RMI	2.81	3.45	S.S.	STD	N/A	AT 8" OD INSULATION	D
0600200-13-02	INSTRUMENT ROOM	716'	24	AUXILIARY SPRAY LINE	3.50	1.05	RMI	2.75	0.39	S.S.	STD	N/A	AT 9" OD INSULATION	D
0600200-13-02	INSTRUMENT ROOM	716'	24	AUXILIARY SPRAY LINE	3.50	0.84	RMI	0.25	0.02	S.S.	STD	N/A	AT 4" OD INSULATION	D
0600200-13-02	INSTRUMENT ROOM	716'	24	AUXILIARY SPRAY LINE	3.50	0.59	RMI	0.75	0.04	S.S.	STD	N/A	AT 5" OD INSULATION	D
0600200-13-02	INSTRUMENT ROOM	716'	24	AUXILIARY SPRAY LINE	3.50	2.21	RMI	0.5	0.10	S.S.	N/A	STD	AT 4.5" OD INSULATION	D
N/A	INSTRUMENT ROOM	716'	24	RESIDUAL HEAT REMOVAL	8.63	55.34	RMI	1.1875	14.07	S.S.	STD	N/A	11" OD INSULATION	E
0600200-09-02	INSTRUMENT ROOM	716'	24	LOWHEAD SAFETY INJECTION	8.63	72.67	RMI	1.1875	18.47	S.S.	STD	N/A	11" OD INSULATION	F
0600200-08-12	INSTRUMENT ROOM	716'	24	EXCESS LETDOWN	1.32	16.67	RMI	2.34	3.11	S.S.	STD	N/A	6" OD INSULATION	G
0600200-08-12	INSTRUMENT ROOM	716'	24	EXCESS LETDOWN	1.32	1.17	MIN-K	1.34	0.09	S.S.	STD	N/A	4" OD INSULATION	G
0600200-08-12	INSTRUMENT ROOM	716'	24	EXCESS LETDOWN	1.32	0.72	RMI	1.84	0.09	S.S.	STD	N/A	5" OD INSULATION	G
0600200-08-12	INSTRUMENT ROOM	716'	24	EXCESS LETDOWN	1.05	0.93	RMI	2.84	0.22	S.S.	STD	N/A	7" OD INSULATION	G
N/A	INSTRUMENT ROOM	720-737	24	CONDUIT 3M-M20C INSULATION	1.90	50.00	3M-M20C	0.1875	2.19	N/A	N/A	N/A	SEE CALCULATION	H
N/A	INSTRUMENT ROOM	720-737	24	CONDUIT 3M-M20C INSULATION	0.68	50.00	3M-M20C	0.1875	1.00	N/A	N/A	N/A	SEE CALCULATION	H
N/A	INSTRUMENT ROOM	720-737	24	CONDUIT 3M-M20C INSULATION	N/A	N/A	3M-M20C	0.1875	1.54	N/A	N/A	N/A	SUPPORT INSULATION SEE CALCULATION	H
N/A	INSTRUMENT ROOM	720-737	24	MIN-K INSULATION	0.68	20.00	MIN-K	0.75	1.06	N/A	N/A	N/A	SEE CALCULATION	H
N/A	INSTRUMENT ROOM	716'	24	EXCESS LETDOWN HEAT EXCHANGER	18.75	SEE CALC	RMI	SEE CALC	4.00	S.S.	STD	N/A	25" OD INSULATION	J
N/A	INSTRUMENT ROOM	716'	24	EXCESS LETDOWN	1.32	6.00	RMI	2.34	1.12	S.S.	STD	N/A	6" OD INSULATION	K
N/A	INSTRUMENT ROOM	716'	24	EXCESS LETDOWN	1.32	1.32	RMI	2.84	0.34	S.S.	STD	N/A	7" OD INSULATION	K
N/A	INSTRUMENT ROOM	716'	24	EXCESS LETDOWN	1.32	0.84	RMI	4.34	0.45	S.S.	STD	N/A	10" OD INSULATION	K

ATTACHMENT B – CARBOZINC™ 11

This Attachment contains the data sheet for Carbozinc™ 11 taken off of the Carboline website (http://www.carboline.com/).

product data carboline®

Carbozinc 11 SG

Selection & Specification Data

Generic Type Self-curing, solvent based, inorganic zinc silicate

Description An inorganic zinc rich primer that protects steel galvanically, eliminating sub-film corrosion.

Features
- Excellent corrosion and weathering protection.
- High zinc loading per square foot.
- Meets Class "B" slip co-efficient and creep testing criteria for use on faying surfaces.
- Very good resistance to salting.
- Meets nuclear requirements for level one areas.
- Available in an ASTM D520, Type 2 zinc version.

Color Green (0300) and Gray (0700).

Finish Matte

Topcoats May be topcoated with epoxies, phenolics, acrylics, silicones, vinyls, chlorinated rubbers or others as recommended. Do not topcoat with alkyds.

Dry Film Thickness 2.0 – 3.0 mils (50 - 75 microns) per coat
Don't exceed 6 mils (150 microns) in a single coat. Excessive film thickness over inorganic zincs may increase damage during shipping or erection.

Solids Content By Weight:: 79% ± 2%
Total zinc in dry film: 85% minimum

Theoretical Coverage Rate 1000 mil ft^2 (24.5 m^2/l at 25 microns)
333 ft^2 at 3 mils (8.2 m^2/l at 75 microns)
Allow for loss in mixing and application.
As measured per NACE 6A181. Material losses during mixing and application will vary and must be taken into consideration when estimating job requirements.

VOC Values As supplied: 4.01 lbs./gal (481 g/l)
Thinned:
7oz/gal w/ Thinner #21: 4.15 lbs./gal (499 g/l)
5oz/gal w/ Thinner #26: 4.15 lbs./gal (499 g/l)
These are nominal values and may vary slightly with color.

Dry Temp. Resistance Continuous: 750°F (399°C)
Non-Continuous: 800°F (427°C)

With recommended silicone topcoats:
Continuous: 1000°F (538°C)
Non-Continuous: 1200°F (649°C)

Limitations Exposure to acids or alkalies without a suitable topcoat or for application over rust inhibitors.

Substrates & Surface Preparation

General Remove all oil or grease from the surface to be coated with Thinner 2 or Carboline Surface Cleaner 3 (refer to Surface Cleaner 3 instructions) in accordance with SSPC-SP1.

Steel **Non-Immersion Service:** Abrasive blast to a Commercial Finish in accordance with SSPC-SP6 and obtain a 1-3 mil (25-75 micron) blast profile.

Typical Chemical Resistance

Exposure	Splash & Spillage	Fumes
Acids	Very Good*	Excellent*
Alkalies	Very Good*	Excellent*
Solvents	Excellent	Excellent
Salt	Excellent	Excellent
Water	Excellent	Excellent

*With suitable topcoat.

Carbozinc 11 SG

Application Equipment

Listed below are general equipment guidelines for the application of this product. Job site conditions may require modifications to these guidelines to achieve the desired results.

General Guidelines:

Equipment Guidelines (General) The following spray equipment has been found suitable and is available from manufacturers such as Binks, DeVilbiss and Graco. Agitate the mixed material continuously during application. If spraying stops for more than 10 minutes, recirculate the material remaining in the spray line.

Conventional Spray Agitated pressure pot equipped with dual regulators, 3/8" I.D. minimum material hose, 50' maximum material hose .070" I.D. fluid tip and appropriate air cap.

Airless Spray

Pump Ratio:	30:1 (minimum)*
GPM Output:	3.0 (minimum)
Material Hose:	3/8" I.D. (minimum)
Tip Size:	.019-.023"
Output PSI:	1500-2000
Filter Size:	60 mesh

*Teflon packings are recommended and available from the pump manufacturer.

Brush For touch up of areas less than one square foot only. Use medium bristle brush. Avoid excessive rebrushing.

Roller Application by roller is not recommended.

Mixing & Thinning

Mixing Power mix base, then combine and power mix as follows:

Ratio	1 Gallon Kit	5 Gallon Kit
CZ 11 SG Base	**1 gallon (partially filled)**	**5 gallon (partially filled)**
Zinc Filler/Special Zinc Filler	14.6 lbs.	73 lbs.

Thinning May be thinned up to 5 oz/gal with Thinner #26. In cool weather, below 40°F (4°C), may be thinned up to 7 oz/gal with Thinner #21. Use of thinners other than those supplied or recommended by Carboline may adversely affect product performance and will void product warranty whether express or implied.

Pot Life Pot life ends when material becomes too thick to use.

Material Temperature	Time
60°F (16°C)	12 hours
75°F (24°C)	8 hours
90°F (32°C)	4 hours

Cleanup & Safety

Cleanup Use Thinner #21 or isopropyl alcohol. In case of spillage, absorb and dispose of in accordance with local applicable regulations.

Safety Read and follow all caution statements on this product data sheet and on the MSDS for this product. Employ normal workmanlike safety precautions. Hypersensitive persons should wear protective clothing, gloves and use protective cream on face, hands and all exposed areas.

Ventilation When used in enclosed areas, thorough air circulation must be used during and after application until the coating is cured. The ventilation system should be capable of preventing the solvent vapor concentration from reaching the lower explosion limit for the solvents used. User should test and monitor exposure levels to insure all personnel are below guidelines. If not sure or if not able to monitor levels, use MSHA/NIOSH approved respirator.

Caution This product contains flammable solvents. Keep away from sparks and open flames. All electrical equipment and installations should be made and grounded in accordance with the National Electric Code. In areas where explosion hazards exist, workmen should be required to use non-ferrous tools and wear conductive and non-sparking shoes.

Application Conditions

Condition	Material	Surface	Ambient	Humidity
Normal	40-95°F (4°-35°C)	40°-110°F (4°-43°C)	40-95°F (4°-35°C)	40-90%
Minimum	0°F (-18°C)	0°F (-18°C)	0°F (-18°C)	30%
Maximum	130°F (54°C)	200°F (93°C)	130°F (54°C)	95%

This product simply requires the substrate temperature to be above the dew point. Condensation due to substrate temperatures below the dew point can cause flash rusting on prepared steel and interfere with proper adhesion to the substrate. Special application techniques may be required above or below normal application conditions.

Curing Schedule

Surface Temp. & 50% Relative Humidity	Handle	Topcoat	Immersion Service
0°F (-18°C)	4 Hours	7 Days	N/R
40°F (4°C)	1 Hour	48 Hours	72 Hours
60°F (16°C)	45 Minutes	24 Hours	48 Hours
80°F (27°C)	45 Minutes	18 Hours	18 Hours
100°F (38°C)	15 Minutes	16 Hours	14 Hours

These times are based on a 2-3 mil (50-75 micron) dry film thickness and a 50% Relative Humidity or higher. Higher film thickness, insufficient ventilation or cooler temperatures will require longer cure times and could result in solvent entrapment and premature failure.

For shop applications or tank linings, if the relative humidity is low, the curing time can be reduced by raising the Relative Humidity by steam or a water spray on the coated surface after an initial dry time of 1 hour at 75°F (24°C).

Notes:

1. Any salting that appears on the zinc surface as a result of prolonged weathering exposure must be removed prior to the application of additional coatings.
2. Loose zinc dust must be removed from the cured film by rubbing with fiberglass screen wire if:
   a. The Carbozinc 11 SG is to be used without a topcoat in immersion service and "zinc pickup" could be detrimental, or
   b. When overspray is evident on the cured film and a topcoat will be applied.

Packaging, Handling & Storage

	1 Gallon Kit	5 Gallon Kit
Shipping Weight (Approximate)	23 Lbs. (10 kg)	113 Lbs. (51 kg)

Flash Point (Setaflash) 55°F (13°C) for Carbozinc 11 SG Base

Storage Temperature & Humidity 40° - 100°F (4°- 38°C) Store indoors. 0-90% Relative Humidity

Shelf Life Carbozinc 11 SG Base: 6 Months at 75°F (24°C)
Zinc Filler/Special Zinc Filler: 24 Months at 75°F (24°C)

***Shelf Life: (actual stated shelf life) when kept at recommended storage conditions and in original unopened containers.**

Note:
The Carbozinc 11SG base is unusable if the material is jelly-like, stringy or does not properly atomize with conventional spray equipment.

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April 2003 replaces January 2002

ATTACHMENT C – CARBOLINE™ 295

This Attachment contains the data sheet for Carboline™ 295 taken off of the Carboline website. (http://www.carboline.com/).

Carboline® 295 WB Surfacer

SELECTION DATA

GENERIC TYPE : Water-based epoxy-polyamide surfacer. Part A and Part B mixed prior to application.

GENERAL PROPERTIES : High build Water based epoxy coating for sealing and surfacing irregular cementitious surfaces. Particularly recommended for nuclear plants where concrete surfaces must be prepared for ease of decontamination. Approved by USDA for coating incidental food contact surfaces. Excellent application properties provide economical installation.

RECOMMENDED USES : As a primer-surfacer on concrete under recommended Carboline topcoats. As a water-based surfacer, it has low odor and no fire hazard during application. In many cases, this will enable application with minimal interruption of normal work and without interfering with other trades.

NOT RECOMMENDED FOR : Use without recommended topcoats.

CHEMICAL RESISTANCE GUIDE : See Product Data Sheet for selected topcoats.

TEMPERATURE RESISTANCE : (Non-immersion)
Continuous : 200°F (93°C)
Non-continuous : 275°F (135°C)

FLEXIBILITY : Poor　　WEATHERING : N.A.

ABRASION RESISTANCE : Good

SUBSTRATES : Poured concrete, concrete block or other surfaces as recommended.

TOPCOAT REQUIRED : Topcoat with catalyzed epoxies, epoxy-coal tar, modified phenolics, urethanes or others as recommended. Some suitable topcoats are Phenoline 305, Carboguard 890, Carboline 801 W and Carboline 801.

COMPATIBILITY WITH OTHER COATINGS : Should be applied directly to concrete. May be applied over catalyzed epoxies such as Carboline 1340 Clear.*

*Recommended concrete curing compound.

SELECTION DATA

THEORETICAL SOLIDS CONTENT OF MIXED MATERIAL :

	By Volume
Carboline 295 WB Surfacer	68% ± 2%

RECOMMENDED DRY FILM THICKNESS PER COAT : Normally 10-40 mils (250-1000μ), but as required to obtain smooth surface, up to 60 mils (1.5 mm) in a single coat. See Application Instructions for specifics.)

THEORETICAL COVERAGE PER MIXED GALLON *:
1091 mil sq. ft. (27.2 sq. m/ℓ @ 25μ)
55 sq. ft. at 20 mils (1.4 sq. m/ℓ @ 500μ)

*NOTE : Material losses during mixing and application will vary and must be taken into consideration when estimating job requirements.

SHELF LIFE : 12 months minimum

COLORS : Off-white only. Color may vary on batch bases.

GLOSS : Flat

ORDERING INFORMATION

APPROXIMATE SHIPPING WEIGHT :

	2's	10's
Carboline 295 WB Surfacer	32 lbs (14.5 kg)	155 lbs (70.4 kg)

FLASH POINT : (Pensky-Martens Closed Cup)

Carboline 295 WB Surfacer Part A	over 200°F (93°C)
Carboline 295 WB Surfacer Part B	110°F (43°C)
Carboline Thinner #15 *	77°F (25°C)

Prices may be obtained from Carboline Sales Representative or Main Office.

* For equipment clean-up

Note : Please refer to separate application instructions for more specific data if required.

APPLICATION INSTRUCTIONS

SURFACE PREPARATIONS : Remove any oil or grease from surface to be coated with clean rags soaked in Carboline Thinner # 2 or toluol in accordance with SSPC-SP 1-82.

Concrete must be cured at least 28 days at 70°F (21°C) and 50% R.H. or equivalent time before topcoating.

Note : Extremely dry concrete should be predampened with water prior to application of Carboline 295 WB Surfacer.

Carboline® 295 WB Surfacer

APPLICATION INSTRUCTIONS

Concrete :
Non-Immersion Service :

WALL AND CEILINGS : Remove fins and protrusions by stoning, sanding or grinding. Form oils, incompatible curing agents or hardeners must be removed by abrasive blasting to obtain a surface similar to medium grit sandpaper. Blow off with compressed air.

FLOORS : Smooth surfaces must be acid etched or abrasive blasted to remove laitance and to roughen surface. For broom finished floors, blow off with compressed air vacuum to remove dust.

Immersion Service :
Abrasive blast all surface to open voids and obtain a surface similar to medium grit sandpaper. Sweep or blow off with compressed air, and vacuum thoroughly to remove dust.

MIXING : Power mix separately, then combine and mix in the following proportions:

	2 Gal. Kit	10 Gal. Kit
Carboline 295 Surfacer WB Part A	1 Gallon	5 Gallon
Carboline 295 Surfacer WB Part B	1 Gallon	5 Gallon

Thin up to 12% by volume with clean, potable water.

POT LIFE : 2 Hours at 75°F (24°C) and less at higher temperatures. Pot life ends when coating loses body and begins to sag.

APPLICATION TEMPERATURES :

	Material	Surfaces
Normal	65-85°F(18-29°C)	65-85°F(18-29°C)
Minimum	55°F(13°C)	50°F(10°C)
Maximum	90°F(32°C)	130°F(54°C)

	Ambient	Humidity
Normal	65-85°F(18-29°C)	30-60%
Minimum	50°F(10°C)	0%
Maximum	130°F(54°C)	85%

Carboline 295 WB Surfacer may be applied to damp concrete; however, it should not be applied if concrete is "sweating" or over puddled water.

Special thinning and application techniques may be required above or below normal conditions.

SPRAY : Hold gun 12-14 inches from surface and at a right angle to the surface.

Use a 50% overlap with each pass of the gun. On irregular surfaces, coat the edges first, making an extra pass later.

WALLS AND CEILINGS : Spray 10-15 mils (250-375µ) coat, work into porosities with rubber squeegee, then spray on another 10-40mil (250-1000µ) coat to seal. Time between these coats may be as little as 5 minutes.

FLOORS :
Spray a 10-15 mils (250-375µ) coat, work into porosities with a rubber squeegee. Remove excess material from floor surface leaving surface in porosities and voids only. Do not apply an additional coat to seal surface. After surfacer has cured, lightly sand and vacuum surface prior to topcoating.

NOTE : The following equipment has been found suitable; however, equivalent equipment may be substituted.

Conventional : Not recommended.

Airless : Use 1/2" minimum I.D. material hose. A 30 mesh inline filter is recommended.

Mfr. & Gun	Pump*
Graco 207-300	Bulldog (30:1) or King(45:1)
Binks Model 620	88-36 (37:1)

*Teflon packings are recommended and available from pump manufacturer. Use a .031"-.035" tip with 2200-2400 psi. Revers-A-Clean tip is recommended.

BRUSH OR ROLLER : Brush only for touch-up with clean, bristled brush. May be rolled on, then squeegeed.

SQUEEGEE : Squeegee in an upward motion filling in all porosities. A second coat may be necessary if the surface is extremely rough. Thin up to 12% by volume with potable water.

DRYING TIMES : (At recommended thickness)

Temperature	To Topcoat
50°F(10°C)	14 days
60°F(16°C)	7 days
75°F(24°C)	3 days
90°F(32°C)	1.5 days

Final Cure : Dependent on topcoat used. See final cure for topcoat.

CLEAN UP : Use clean water followed by Carboline Thinner # 15 or glycol ether solvent.

STORAGE CONDITIONS :
Temperature : 45-110°F(7-43°C)
Humidity : 0-100%

FOR MORE DETAILED INFORMATION, PLEASE CONSULT SPECIFIC CARBOLINE APPLICATION INSTRUCTIONS.

CAUTION: CONTAINS FLAMMABLE SOLVENTS. KEEP AWAY FROM SPARKS AND OPEN FLAMES. IN CONFINED AREAS WORKMEN MUST WEAR FRESH AIRLINE RESPIRATORS. HYPERSENSITIVE PERSONS SHOULD WEAR GLOVES OR USE PROTECTIVE CREAM. ALL ELECTRIC EQUIPMENT AND INSTALLATIONS SHOULD BE MADE AND GROUNDED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE. IN AREAS WHERE EXPLOSION HAZARDS EXIST, WORKMEN SHOULD BE REQUIRED TO USE NONFERROUS TOOLS AND TO WEAR CONDUCTIVE AND NONSPARKING SHOES.

carboline

ATTACHMENT D – PHENOLINE™ 305

This Attachment contains the data sheet for Phenoline™ 305 faxed to Alion.

product data sheet

carboline®

PHENOLINE® 305 FINISH

VOC plus

SELECTION DATA

GENERIC TYPE: Modified phenolic. Part A and B mixed prior to application.

GENERAL PROPERTIES: PHENOLINE 305 Finish is a heavy duty topcoat which sets to a hard, tough, smooth finish having very good abrasion resistance. The surface is glossy and has excellent resistance to a wide range of solvents, caustics, cleaning solutions and acid entrained vapors of high concentration. Features include:

- Highly chemical resistant film
- Very good abrasion resistance
- Excellent resistance to hydraulic fluids
- Outstanding chemical and physical properties
- Meets most VOC (Volatile Organic Content) regulations

RECOMMENDED USES: PHENOLINE 305 Finish is an excellent coating for the protection of steel and concrete surfaces in nuclear power plants. Also used in chemical processing plants, and pulp and paper mills for the protection of structural steel and concrete against severe splash, spillage and fume conditions. The addition of 50 mesh silica provides a non-skid surface, making an excellent floor coating.

NOT RECOMMENDED FOR: Immersion service or continuous spillage of hot or concentrated acids.

TYPICAL CHEMICAL RESISTANCE:

Exposure	Splash & Spillage	Fumes
Acids	Very Good	Excellent
Alkalies	Excellent	Excellent
Solvents	Excellent	Excellent
Salt	Excellent	Excellent
Water	Excellent	Excellent

TEMPERATURE RESISTANCE: (Non-immersion)
Continuous: 200°F (93°C)
Non-Continuous: 250°F (121°C)

SUBSTRATES: Apply over properly primed metal or cementitious surfaces. Surfacer may be required for concrete surfaces, depending on roughness and texture.

COMPATIBLE COATINGS: May be applied over inorganic zincs, catalyzed epoxies, modified phenolics or others as recommended. A mist coat may be required when applied over inorganic zincs. A topcoat is normally not required. Consult Carboline Technical Service for specific recommendations.

SPECIFICATION DATA

THEORETICAL SOLIDS CONTENT OF MIXED MATERIAL:

	By Volume
PHENOLINE 305 Finish	64% ± 2%

VOLATILE ORGANIC CONTENT (VOC):* 607
The following are nominal values:
As Supplied: 2.43 lbs/gal (291 grams/liter)
Thinned: Utilizing Phenoline Thinner or Thinner #33

Thinner	% Thinned	Fluid Ozs./Gal.	Lbs/ Gal.	Gm./L
Phenoline Thinner	25	32	3.38	405
Thinner #33	25	32	3.42	410

*May vary slightly with color.

RECOMMENDED DRY FILM THICKNESS PER COAT*:
4-6 mils (100-150 microns)

THEORETICAL COVERAGE PER MIXED KIT:
1.25 Gallon Kit
1283 mil sq. ft. (25.6 sq. m/l at 25 microns)
256 sq. ft. at 5 mils (5.1 sq. m/l at 125 microns)
6.25 Gallon Kit
6416 mil sq. ft. (25.6 sq. m/l at 25 microns)
1283 sq. ft. at 5 mils (5.1 sq. m/l at 125 microns)

Mixing and application losses will vary and must be taken into consideration when estimating job requirements.

STORAGE CONDITIONS: Store Indoors
Temperature: 45-110°F (7-43°C)
Humidity: 0-100%

SHELF LIFE: 24 months when stored at 75°F (24°C)

COLORS: Available in a variety of colors. Consult your local Carboline Representative or Carboline Customer Service for availability.

GLOSS: High gloss

ORDERING INFORMATION

Prices may be obtained from your Carboline Sales Representative or Carboline Customer Service Department.

APPROXIMATE SHIPPING WEIGHT:

	1.25 Gal. Kit	6.25 Gal. Kit
PHENOLINE 305 Finish	17 lbs. (7.7 kg)	80 lbs. (36.3 kg)
PHENOLINE Thinner	9 lbs. (4.1 kg) (in ones)	45 lbs. (20.4 kg) (in fives)
Thinner #33	9 lbs. (4.1 kg) (in ones)	45 lbs (20.4 kg) (in fives)

FLASH POINT: (Setaflash)

PHENOLINE 305 Primer Part A	63°F (17°C)
PHENOLINE 305 Primer Part B	52°F (11°C)
PHENOLINE Thinner	74°F (23°C)
Thinner #33	89°F (32°C)

Jan 93 Replaces March 84

APPLICATION INSTRUCTIONS
Phenoline® 305 Finish

These instructions are not intended to show product recommendations for specific service. They are issued as an aid in determining correct surface preparation, mixing instructions and application procedure. It is assumed that the proper product recommendations have been made. These instructions should be followed closely to obtain the maximum service from the materials.

607

SURFACE PREPARATION: Remove any oil or grease from surface to be coated with clean rags soaked in Thinner #2 or Toluol in accordance with SSPC-SP1.

Steel/Concrete: Apply over clean, dry, recommended primer or surfacer. Application over inorganic zincs may require a mist coat.

MIXING: Mix separately, then combine and mix in the following proportions.:

	1.25 Gal. Kit	6.25 Gal. Kit
PHENOLINE 305 PART A	1 gallon can	5 gallon can
PHENOLINE 305 PART B	1 quart can	1.25 gallon can

INDUCTION TIMES: The following induction times are required to ensure uniform gloss and appearance.

Ambient or Material Temperature	Induction Time
65-80°F (18-27°C)	30 minutes
Above 80°F (27°C)	15 minutes

THINNING: For spray application, may be thinned up to 25% by volume with Phenoline Thinner. For brush or roller application, may be thinned up to 25% by volume with Thinner #33.

Refer to Specification Data for VOC information.

Use of thinners other than those supplied or approved by Carboline may adversely affect product performance and void product warranty, whether express or implied.

POT LIFE: One and one half hours at 75°F (24°C) and less at higher temperatures. Pot life ends when coating loses body and begins to sag.

APPLICATION TEMPERATURES:

	Material	Surfaces	Ambient	Humidity
Normal	65-85°F (18-29°C)	65-85°F (18-29°C)	65-85°F (18-29°C)	30-60%
Minimum	65°F (18°C)	65°F (18°C)	65°F (18°C)	0%
Maximum	90°F (32°C)	120°F (49°C)	110°F (43°C)	90%

Do not apply when surface temperature is less than 5°F (or 3°C) above the dew point.

Special thinning and application techniques may be required above or below normal conditions.

SPRAY: Use sufficient air volume for correct operation of equipment. Use a 50% overlap with each pass of the gun. On irregular surfaces, coat the edges first, making an extra pass later.

The following spray equipment has been found suitable and is available from manufacturers such as Binks, DeVilbiss and Graco.

Conventional: Pressure pot equipped with dual regulators, 3/8" I.D. minimum material hose, .070" I.D. fluid tip and appropriate air cap.

Airless:*

Pump Ratio:	30:1 (min)
GPM Output:	3.0 (min)
Material Hose:	3/8" I.D. (min)
Tip Size:	.015" - .019"
Output psi:	2200 -2400

*Teflon packings are recommended and are available from the pump manufacturer.

BRUSH OR ROLLER: Use a natural bristle brush, applying in full strokes. Avoid rebrushing. Use a medium nap lambswool roller with phenolic core. Avoid rerolling. Two coats may be required for proper hiding and film build.

APPLICATION FOR NON-SKID FINISH: For non-skid finishes, mix Part A and Part B as usual and add, under agitation, 2 and 1/2 pints (approximately 4.33 lbs.) of 50 mesh Ottawa Silica for each 1.25 gallon kit of PHENOLINE 305 Finish. Thin up to 25% by volume with Phenoline Thinner. Keep material under agitation during application.

Conventional: Use 1/2" I.D. minimum material hose and an agitated bottom outlet pressure pot with 1/2" minimum I.D. outlet. Pressure pot to be equipped with dual regulators. A .110" I.D. fluid tip and appropriate air cap are recommended for proper spray application.

Airless spray application is not recommended due to the abrasive action generated by the silica.

DRYING TIMES: These times are at the recommended dry film thickness of 4-6 mils. Higher film thicknesses will lengthen cure times.

Temperatures:	Between Coats	Final Cure
65°F (16°C)	36 hours	8 days
75°F (24°C)	18 hours	4 days
90°F (32°C)	12 hours	2 days

EXCESSIVE HUMIDITY OR CONDENSATION ON THE SURFACE DURING CURING MAY RESULT IN A SURFACE HAZE OR BLUSH; ANY HAZE OR BLUSH SHOULD BE REMOVED BY WASHING WITH WATER BEFORE RECOATING.

VENTILATION & SAFETY: WARNING: VAPORS MAY CUASE EXPLOSION. When used as a tank lining or in enclosed areas, thorough air circulation must be present during and after application until the coating is cured. The ventilation system should be capable of preventing the solvent vapor concentration from reaching the lower explosion limit for the solvents used. In addition, fresh air respirators or fresh air hoods must be used by all application personnel. Non-sparking shoes, non-conductive equipment and clothing must be used. Explosion-proof lighting equipment must be used. Hypersensitive persons should wear clean protective clothing, gloves and/or protective cream on face, hands and all exposed areas.

CLEANUP: Use Thinner #2 or Xylol.

CAUTION: READ AND FOLLOW ALL CAUTION STATEMENTS ON THIS PRODUCT DATA SHEET AND ON THE MATERIAL SAFETY DATA SHEET FOR THIS PRODUCT.

CAUTION: CONTAINS FLAMMABLE SOLVENTS. KEEP AWAY FROM SPARKS AND OPEN FLAMES. IN CONFINED AREAS, WORKMEN MUST WEAR FRESH AIRLINE RESPIRATORS. HYPERSENSITIVE PERSONS SHOULD WEAR GLOVES OR USE PROTECTIVE CREAM. ALL ELECTRIC EQUIPMENT AND INSTALLATIONS SHOULD BE MADE AND GROUNDED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE. IN AREAS WHERE EXPLOSION HAZARDS EXIST, WORKMEN SHOULD BE REQUIRED TO USE NONFERROUS TOOLS AND TO WEAR CONDUCTIVE AND NONSPARKING SHOES.

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ATTACHMENT E – CARBOLINE™ 4674

This Attachment contains the data sheet for Carboline™ 4674 taken off of the Carboline website. (http://www.carboline.com/).

Carboline® 4674

SELECTION DATA

GENERIC TYPE : Modified silicone

GENERAL PROPERTIES : A single package, medium to high temperature coating that withstands continuous temperatures of 750°F(399°C) and surges up to 1000°F(538°C).

- Resistant to thermal shock conditions from ambient to 750°F(399°C).
- Application over Carbozinc primers will provide superior performance by preventing rusting and rust streaking during a shutdown or when the equipment is exposed to moisture and/or salts at temperatures less than 200°F(93°C); otherwise, may be applied directly to properly prepared steel and stainless steel.
- Excellent weathering properties.
- Meets VOC (Volatile Organic Content) regulations of 5.42 lbs/gal (650 g/ℓ) for high temperature coatings.

RECOMMENDED USES : For the protection of the exterior of equipment such as stacks, incinerators, furnace exteriors, heat exchangers and other elevated temperature steel surfaces.

NOT RECOMMENDED FOR : Use as a lining or immersion service or exposure to splash and spillage of acids or alkalies.

CHEMICAL RESISTANCE GUIDE :

Exposure	Splash & Spillage	Fumes
Acids	Poor	Good
Alkalies	Poor	Good
Solvents	Poor	Good
Salt	Good	Very Good
water	Excellent	Excellent

TEMPERATURE RESISTANCE : (Dry)
Continuous : 750°F(399°C)
Non-Continuous : 1000°F(538°C)

SUBSTRATES : Properly prepared steel, stainless steel or other surfaces as recommended.

TOPCOAT REQUIRED : None

COMPATIBLE COATINGS : May be applied over inorganic zincs such as the Carbozinc series primers which will increase performance over steel. A mist coat may be required when applying over inorganic zincs to minimize bubbling.

SPECIFICATION DATA

THEORETICAL SOLIDS CONTENT OF MIXED MATERIAL :

	By Volume
Carboline 4674	40% ± 2%

VOLATILE ORGANIC CONTENT (VOC) : The following are nominal values :
As Supplied : 4.4 lbs/gal (525g/ℓ)

Thinned :

Thinner	oz/gal	lbs/gal	g/ℓ
10	8	4.5	543
10	16	4.7	560

RECOMMENDED DRY FILM THICKNESS PER COAT :
1 1/2 mils (40µ) — Two coats are recommended over bare steel and one or two coats over inorganic zincs.

Excessive film thickness over inorganic zincs may result in blistering and delamination when the temperature is increased.

THEORETICAL COVERAGE PER MIXED GALLON :
640 mil ft² (15.7 m²/ℓ at 25µ)
426 ft² at 1 1/2 mils (10.4 m²/ℓ at 40µ)

Material losses during mixing and application will vary and must be taken into consideration when estimating job requirements.

STORAGE CONDITIONS : Store indoors.
Temperature : 40-110°F(4-43°C)
Humidity : 0-100%

SHELF LIFE : 36 months when stored indoors at 75°F(24°C)

COLORS : Aluminum (C901), Black (C900) only.

FINISH : Flat

ORDERING INFORMATION

Prices may be obtained from Carboline Sales Representative or Carboline Customer Service.

APPROXIMATE SHIPPING WEIGHT :

	1's	5's
Carboline 4674	11 lbs (5 kg)	51 lbs (23 kg)
Carboline Thinner #10	8 lbs (4 kg)	40 lbs (18 kg)

FLASH POINT : (Setaflash)

Carboline 4674	68°F(20°C)
Carboline Thinner #10	83°F(28°C)

February 2003

Carboline® 4674

APPLICATION INSTRUCTIONS

SURFACE PREPARATION : Remove all oil or grease from the surface to be coated with Thinner #2 or Carboline Surface Cleaner 3 (refer to Surface Cleaner 3 instructions) in accordance with SSPC-SP 1.

Steel : Apply over properly prepared recommended primers. For application to unprimed steel, abrasive blast to a Near White Finish in accordance with SSPC-SP 10 and obtain a 1-1 1/2 mil (25-40µ) blast profile.

MIXING : Power mix to a uniform consistency before thinning.

THINNING : May be thinned up to 16 oz/gal (12%) with Thinner 10.

Use of thinner other than those supplied or approved by Carboline may adversely affect product performance and void product warranty, whether expressed or implied.

APPLICATION TEMPERATURES :

	Material	Surfaces
Normal	60~90°F(16~32°C)	60~90°F(16~32°C)
Minimum	40°F(4°C)	40°F(4°C)
Maximum	100°F(38°C)	130°F(54°C)

	Ambient	Humidity
Normal	60~90°F(16~32°C)	10~85%
Minimum	40°F(4°C)	0%
Maximum	130°F(54°C)	95%

Do not apply when the surface temperature is less than 5°F (3°C) above the dew point.

Special thinning and application techniques may be required above or below normal conditions.

SPRAY : The following spray equipment has been found suitable and is available from manufacturers such as Binks, DeVilbiss and Graco.

CONVENTIONAL : Pressure pot equipped with dual regulators, 3/8" I.D. minimum material hose, a 0.043" I.D. fluid tip and appropriate air cap.

Airless :

Pump Ratio	:	30 : 1 (min.)
GPM Output	:	3.0 (min.)
Material Hose	:	3/8" I.D.(min.)
Tip Size	:	0.013~0.015"
Output PSI	:	2200~2400
Filter Size	:	60 mesh

* Teflon packings are recommended and are available from the pump manufacturer.

BRUSH : For small touchup areas only. Use a natural bristle brush, applying with full strokes. Avoid rebrushing or reworking of material. Take care to avoid excessive film thickness.

ROLLER : Application by roller is not recommended.

DRYING TIMES : These times are based on a 1 1/2 mil (40 µ) dry film thickness. Excessive film thickness, insufficient ventilation or cooler temperatures will require longer cure times and could result in solvent entrapment and premature failure.

Surface Temperature	Between Coats
50°F(10°C)	8 Hours
60°F(16°C)	4 Hours
75°F(24°C)	2 Hour
90°F(32°C)	1 Hour

Note : Will air dry to touch, but will remain soft for handling purposes.

FINAL CURE : To obtain optimum properties, must be cured at temperatures in excess of 350~450°F(177~232°C). After a 2 hour flash off at 75°F(24°C), allow an increase in temperature to proceed slowly up to 350°F(177°C) over a 6 hour time period. Hold at 350~450°F(177~232°C) for 2 hours, the coating is then cured and may be put into service.

CLEAN UP : Use Thinner 2 or Toluol.

CAUTION : READ AND FOLLOW ALL CAUTION STATEMENTS ON THIS PRODUCT DATA SHEET AND ON THE MATERIAL SAFETY DATA SHEET FOR THIS PRODUCT.

CAUTION: CONTAINS FLAMMABLE SOLVENTS. KEEP AWAY FROM SPARKS AND OPEN FLAMES. IN CONFINED AREAS WORKMEN MUST WEAR FRESH AIRLINE RESPIRATORS. HYPERSENSITIVE PERSONS SHOULD WEAR GLOVES OR USE PROTECTIVE CREAM. ALL ELECTRIC EQUIPMENT AND INSTALLATIONS SHOULD BE MADE AND GROUNDED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE. IN AREAS WHERE EXPLOSION HAZARDS EXIST, WORKMEN SHOULD BE REQUIRED TO USE NONFERROUS TOOLS AND TO WEAR CONDUCTIVE AND NONSPARKING SHOES.

carboline

ATTACHMENT F – 3M-M20C (INTERAM)

This Attachment contains the information, including the data sheet, for 3M-M20C (Interam) insulation as provided by Watts Bar and letter of intent stating how to treat the constituents of 3M-M20C (Interam).

May 18, 2006

T 26 060428 188

Westinghouse Electric Corporation
Post Office Box 355
Pittsburgh, PA 15230

Attention: Krish M. Rajan

WATTS BAR NUCLEAR PLANT (WBN)
NUCLEAR STEAM SUPPLY SYSTEMS (NSSS)
CONTRACT-00026863
LETTER NUMBER W-7929

Subject: WATTS BAR NUCLEAR PLANT UNIT 1 - CONTRACT WORK AUTHORIZATION NO. WESTINGHOUSE-WBN-2005-008-GSI 191 - CONTAINMENT BUILDING SUMP MULTIDIMENSIONAL FLOW MODEL, NRC GENERIC SAFETY ISSUE GSI-191, "ASSESSMENT OF DEBRIS ACCUMULATION ON PWR SUMP PERFORMANCE"

1. Revision 1 of ALION-CAL-TVA-2739-03, Watts Bar Reactor Building GSI-191 Debris Generation Calculation, contains an assumption for 3M-M20C insulation that concluded the 3M-M20C was to be treated as High Density Fiberglass (HDFG) with a debris size distribution of 100 percent individual fibers. As stated in ALION-CAL-TVA-2739-03, the HDFG fines debris has been shown to be very similar to the Low Density Fiberglass (LDFG) fines debris and therefore the terms are used interchangeably. Since the issuance of revision 1, the Material Safety Data Sheet (MSDS) for Interam™ M-20A and M-20 and M-20C mat has been obtained (Enclosure 1). The MSDS for 3M-M20C shows that the composition of the insulation is made up of 40-60% vermiculite, 10-15% aluminum silicate, 5-10% organic binder, 5-10% metal foil, with the remaining 5-40% not being specified. Vermiculite and the metal foil are not fibrous materials and are treated as particulates. Using a conservative approach, the particulate components are minimized resulting in 45% of the 3M-M20C treated as particulates. The organic binder, aluminum silicate, and unknown material are assumed to be fibrous resulting in a maximum of 55% fibrous component of 3M-M20C. In addition, since the majority of the 3M-M20C is vermiculite, the density of the expanded 3M-M20C insulation for the particulate component is assumed to be the minimum expanded bulk density of vermiculite,

4 lb/cubic feet with a manufactured density of 156 lb/cubic feet (Enclosure 2). The particulate component of 3M-M20C can be conservatively assumed to fail as 10 micron particulate.

2. The bypass fractions for fibrous and particulate insulation are a maximum of 2.42% and 62% respectively (Enclosure 3). This input is being provided for use in the "Downstream Effects Calculations", CN-CSA-05-14 (Debris Ingestion) and CN-CSA-05-36 (Fuel Evaluation).
3. The Downstream Effects Debris Fuel Evaluation, CN-CSA-05-36, also assumes that the bottom fuel nozzles capture 95% of the available fibrous debris. However, based on the analysis of the sample of debris taken in the strainer test flume (sample 1A), the longest fiber is 3.8 mm or 0.1496 inches (Enclosure 4), which is shorter than the limiting hole size for one third of the fuel (bottom nozzles with alternate p-grid design Cycle 8 core load) but longer than the limiting hole size for the remaining two thirds of the fuel. The remaining two thirds of the fuel will incorporate the alternate p-grid design during the Unit 1 Cycle 8 (Cycle 9 core load) Refueling Outage and Unit 1 Cycle 9 Refueling Outage (Cycle 10 core load). Thus, cases should be performed to show the results of the fuel evaluation using the bypass fraction above with the additional assumption that a.) 67% of the available fibrous debris is captured on the bottom fuel nozzle and the nozzle on top of the fuel to represent the results after the Unit 1 Cycle 7 refueling outage and b.) 33% of available fibrous debris is captured on the bottom fuel nozzle and the nozzle on top of the fuel to represent the results after the Unit 1 Cycle 8 refueling outage.

Questions may be directed to F.A. Koontz at x1261.

Sincerely,

Frank A Koontz for

J. M. Frisco, Jr.
Site Engineering Manager
EQB 2A-WBN

Enclosures
cc: M. Gillman BR 3F-C
D. M. Lafever, OPS 3C-SQN
F. A. Koontz Jr., EQB 2A-WBN
L. L. McCormick, EQB 2N-WBN
K. A. Lovell, EQB 2N-WBN
R. H. Bryan, Jr., LP 4J-C

J. S. Robertson, EQB 2N-WBN
C. R. Allen, EQB 2N-WBN
C. M. Ledbetter, EQB 2N-WBN
EDMS, WT CA-K

Enclosure 1 pg 1 of 6

MATERIAL SAFETY DATA SHEET

3M
3M Center
St. Paul, Minnesota
55144-1000
1-800-364-3577 or (651) 737-6501 (24 hours)

DIVISION: SPECIFIED CONSTRUCTION PRODUCTS
TRADE NAME:
INTERAM(tm) M-20A AND M-20 AND M-20C MAT
ID NUMBER/U.P.C.:

80-6101-1874-9	- - -	80-6101-2301-2	00-51115-02061-2
98-0400-0171-5	- - -	98-0400-0254-9	- - -
98-0400-0255-6	00-51115-02438-2	98-0400-2676-1	00-51115-07590-2

ISSUED: April 12, 1999
SUPERSEDES: September 08, 1998
DOCUMENT: 10-8339-3

1. INGREDIENT

INGREDIENT	C.A.S. NO.	PERCENT
VERMICULITE	1318-00-9	40.0 - 60.0
ALUMINUM SILICATE	1327-36-2	10.0 - 15.0
ORGANIC BINDER	None	5.0 - 10.0
METAL FOIL LAMINATE	None	5.0 - 10.0

2. PHYSICAL DATA

BOILING POINT:................. N/A
VAPOR PRESSURE:................ N/A
VAPOR DENSITY:................. N/A
EVAPORATION RATE:.............. N/A
SOLUBILITY IN WATER:........... INSOLUBLE
SPECIFIC GRAVITY:.............. 0.625
PERCENT VOLATILE:.............. N/A
pH:............................ N/A
VISCOSITY:..................... N/A
MELTING POINT:................. N/D

APPEARANCE AND ODOR:
ODORLESS, GRAY MAT ALUM FOIL OR STAINLESS STEEL ON ONE SIDE

Abbreviations: N/D - Not Determined N/A - Not Applicable CA - Approximately

---

3. FIRE AND EXPLOSION HAZARD DATA

FLASH POINT:.................... N/A
FLAMMABLE LIMITS - LEL:........ N/A
FLAMMABLE LIMITS - UEL:........ N/A
AUTOIGNITION TEMPERATURE:...... N/D

EXTINGUISHING MEDIA:
Non-combustible. Choose material suitable for surrounding fire.

SPECIAL FIRE FIGHTING PROCEDURES:
Wear full protective clothing, including helmet, self-contained, positive pressure or pressure demand breathing apparatus, bunker coat and pants, bands around arms, waist and legs, face mask, and protective covering for exposed areas of the head.

UNUSUAL FIRE AND EXPLOSION HAZARDS:
Not applicable.

NFPA HAZARD CODES: HEALTH: 0 FIRE: 1 REACTIVITY: 0
UNUSUAL REACTION HAZARD: none

---

4. REACTIVITY DATA

STABILITY: Stable

INCOMPATIBILITY - MATERIALS/CONDITIONS TO AVOID:
None

HAZARDOUS POLYMERIZATION: Hazardous polymerization will not occur.

HAZARDOUS DECOMPOSITION PRODUCTS:
Carbon Monoxide and Carbon Dioxide.

---

5. ENVIRONMENTAL INFORMATION

SPILL RESPONSE:
Ventilate. Observe precautions from other sections. Use toxic dust mask if dust from fired (intensely heated) product is present. Collect spilled material. If waste dusts, place in a closed container.

RECOMMENDED DISPOSAL:
Reclaim if feasible. Dispose of unfired scrap in a sanitary landfill. Since regulations vary, consult applicable regulations or authorities before disposal of fired scrap. U.S. EPA Hazardous Waste No.: None.

Abbreviations: N/D - Not Determined N/A - Not Applicable CA - Approximately

Enclosure 1 pg 3 of 6

5. ENVIRONMENTAL INFORMATION (continued)

ENVIRONMENTAL DATA:
Not determined.

REGULATORY INFORMATION:
Volatile Organic Compounds: N/D.
VOC Less H2O & Exempt Solvents: N/D.

EPCRA HAZARD CLASS:
FIRE HAZARD: No PRESSURE: No REACTIVITY: No ACUTE: Yes CHRONIC: Yes

6. SUGGESTED FIRST AID

EYE CONTACT:
None normally required.

SKIN CONTACT:
None normally required.

INHALATION:
None normally required.

IF SWALLOWED:
None normally required.

OTHER FIRST AID INFORMATION:
None normally required.

7. PRECAUTIONARY INFORMATION

EYE PROTECTION:
Wear safety glasses with side shields.

SKIN PROTECTION:
Avoid prolonged or repeated skin contact.

RECOMMENDED VENTILATION:
Provide sufficient ventilation to maintain emissions below recommended exposure limits.

RESPIRATORY PROTECTION:
Avoid breathing of dust created by cutting, sanding or grinding. Not applicable.

7. PRECAUTIONARY INFORMATION (continued)

PREVENTION OF ACCIDENTAL INGESTION:
Wash hands after handling and before eating.

RECOMMENDED STORAGE:
Store under normal warehouse conditions.

FIRE AND EXPLOSION AVOIDANCE:
Not applicable.

OTHER PRECAUTIONARY INFORMATION:
Avoid eye contact. Avoid prolonged or frequent skin contact. Gloves or barrier creams may be useful if significant handling is necessary.

Avoid breathing dust and fibers released during processing. Provide ventilation sufficient to keep dust and fiber concentrations below recommended exposure limits. If concentrations exceed recommended exposure limits, wear a NIOSH-approved dust respirator.+

+NOTE: One manufacturer of ceramic fibers has recommended the use of respirators, regardless of fiber exposure levels.

EXPOSURE LIMITS

INGREDIENT	VALUE	UNIT	TYPE	AUTH	SKIN*
VERMICULITE..........................	NONE	NONE	NONE	NONE	
ALUMINUM SILICATE....................	1.0	FIBER/CC	TWA	OSHA	
	PROPOSED				
ALUMINUM SILICATE....................	1.0	FIBER/CC	TWA	CMRG	
ORGANIC BINDER.......................	NONE	NONE	NONE	NONE	
METAL FOIL LAMINATE..................	NONE	NONE	NONE	NONE	

* SKIN NOTATION: Listed substances indicated with 'Y' under SKIN refer to the potential contribution to the overall exposure by the cutaneous route including mucous membrane and eye, either by airborne or, more particularly, by direct contact with the substance. Vehicles can alter skin absorption.

SOURCE OF EXPOSURE LIMIT DATA:
- CMRG: Chemical Manufacturer Recommended Exposure Guidelines
- OSHA: Occupational Safety and Health Administration

- NONE: None Established

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8. HEALTH HAZARD DATA

EYE CONTACT:
See below

SKIN CONTACT:
EYE AND SKIN CONTACT: Fibers released during processing may cause mild irritation. Symptoms may include itching, redness and swelling. Based on 3M studies, normal processing and handling of this product should not result in significant irritation.

INHALATION:
This product contains ceramic fibers and vermiculite bound together with an organic binder. Fibers and dust released during processing may cause mild, transient respiratory irritation. Symptoms may include cough and itching of the nose and throat. Certain types of ceramic fibers have caused pulmonary fibrosis and cancer in laboratory animals (IARC-2B). However, because the fibers are bound in an organic substance, they are not likely to be inhaled during normal handling of the product in this form. Based on 3M studies, normal processing and handling of this product should not result in exposures exceeding the 3M exposure guideline for ceramic fibers. This guideline is based upon the OSHA PEL for asbestos and, thus, is believed to provide an adequate margin of safety for exposures to ceramic fibers. Total fiber concentrations in 3M operations involving cutting this product are less than 0.1 fibers per cc of air.

IF SWALLOWED:
Not determined

SECTION CHANGE DATES

INGREDIENTS	SECTION CHANGED SINCE September 08, 1998 ISSUE
REACTIVITY DATA	SECTION CHANGED SINCE September 08, 1998 ISSUE

Abbreviations: N/D - Not Determined N/A - Not Applicable CA - Approximately

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The information in this Material Safety Data Sheet (MSDS) is believed to be correct as of the date issued. 3M MAKES NO WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR COURSE OF PERFORMANCE OR USAGE OF TRADE. User is responsible for determining whether the 3M product is fit for a particular purpose and suitable for user's method of use or application. Given the variety of factors that can affect the use and application of a 3M product, some of which are uniquely within the user's knowledge and control, it is essential that the user evaluate the 3M product to determine whether it is fit for a particular purpose and suitable for user's method of use or application.

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Enclosure 2 pg 1 of 7

The Container Tree Nursery Manual

Enclosure 2 : Vermiculite Information

Volume Two
Containers and Growing Media

Chapter 2
Growing Media

Thomas D. Landis, Western Nursery Specialist, USDA Forest Service, State and Private Forestry, Portland, OR

Landis, T.D. 1990. Containers and growing media, Vol. 2. The Container Tree Nursery Manual. Agric. Handbk. 674. Washington, DC: U.S. Department of Agriculture, Forest Service. 41-85.

Enclosure 2 pg 2 of 7

Table 2.2.12—*Physical characteristics of various grades of vermiculite*

Grade	Bulk density (kg/m³)	U.S. sieve size	Range of particle sizes (mm)	Aeration porosity (%)	Water retention (% weight)	Water retention (% volume)
1	64.1–112.1	3/8–16	1.2–10.0	44.3	297	30.7
2*	64.1–128.2	4–30	0.6–4.7	40.4	412	39.0
3*	80.1–144.2	8–100	0.1–2.4	29.9	530	52.4
4	96.1–176.2	16–100	0.1–1.2	24.5	499	54.4

* Standard horticultural grades.
Source: adapted from Biamonte (1982).

Figure 2.2.12—*Because of its closed-cell structure that repels water, perlite is often added to growing media to increase the aeration porosity and drainage.*

According to the Container Nursery Survey, perlite is a minor component of growing media in forest tree nurseries, usually constituting from 10 to 30% of the mix. Perlite is usually added to organic components, such as peat moss, to increase aeration porosity, which is particularly important in the smaller volume containers used in container tree nurseries. Perlite grades are not standardized, but grades 6, 8, or "propagation grade" are normally used in growing media (table 2.2.13). Perlite grades are also not uniform and contain a range of particle sizes, depending on the sieve sizes used during manufacturing.

Table 2.2.13—*Elemental composition and horticultural grades of perlite*

Element	Average composition (%)
Oxygen	47.5
Silicon	33.8
Aluminum	7.2
Potassium	3.5
Sodium	3.4
Iron	0.6
Calcium	0.6
Magnesium	0.2
Trace elements	0.2
Bound water	3.0
Total	100.0

Grade*	Average particle size (mm)	Commercial labeling
No. 6	3.35	Horticultural grade—coarse
No. 8	1.70	Horticultural grade—fine
Propagation	3.20	Propagation grade

* There are no standard perlite grades, so each manufacturer has its own rating system.
Source: Perlite Institute (1983).

Perlite has a couple of operational drawbacks. Horticultural grades of perlite can contain considerable amounts (4% by weight) of very fine particle sizes (Maronek and others 1986) that cause eye and lung irritation during mixing if the perlite is not pre-moistened. Because of its closed-cell structure, perlite has a tendency to float to

Enclosure 2 pg 3 of 7

MATERIAL SAFETY DATA SHEET---VERMICULITE

----------------------I. PRODUCT IDENTIFICATION----------------------

TRADE NAME (as labeled)	Schundler Company Vermiculite (Expanded)
MANUFACTURERS NAME	THE SCHUNDLER COMPANY **www.schundler.com**
Address (complete mailing address):	150 Whitman Avenue Edison, N.J. 08817
Phone number:	(732) 287-2244 info@schundler.com
Date Prepared or Revised:	February 25, 2004

----------------------II. HAZARDOUS INGREDIENTS----------------------

Chemical Names	CAS Numbers	Exposure Limits in Air		
		ACGIH TLV (total)	ACGIH TLV (respirable)	OTHER)
Vermiculite	1318-00-9	10 mg/M^3	3 mg/M^3	30 mppcf

Vermiculite is the mineralogical name given to hydrated laminar mangesium-aluminum-iron silicates which resemble mica in appearance. When subjected to heat, crude vermiculite has the unusual property of exfoliating or expanded into worm-like particles (the name vermiculite is derived from the Latin 'vermiculare', meaning to breed worms.)

Vermiculite is considered a nuisance dust (also called "Particulates Not Otherwise Classified (PNOC) by ACGIH).

Alpha-Cristobalite & Tridymite:	Less than 0.1%
Alpha Quartz:	0.01 to 0.05%

----------------------III. PHYSICAL PROPERTIES----------------------

Vapor Density (air = 1)	N/A	**Melting point or range. C°**	1350+ (Collapse and coalescence of the individual flakes begin at this temperature.)

Enclosure 2 pg 4 of 7

Specific Gravity	2.5	**Boiling point or range. F°**	N/A
Solubility in Water	<1%	**Evaporation rate (butyl acetate = 1)**	N/A
Vapor Pressure, mmHg at 20° C	N/A		
Appearance and odor:	tan/brown with no odor		

HOW TO DETECT THIS SUBSTANCE (warning properties of substance as a gas, vapor, dust or mist)

Visual only (dust), No gas, vapors, or mist emitted.

----------------------IV. FIRE AND EXPLOSION----------------------

Flash Point, F° (give method)	Vermiculite is a fully oxidized non-flammable mineral. It is noncombustible and non-flammable.
Auto ignition temperature, F°	N/A
Flammable limits in air, Volume%:	N/A **lower (LEL)** N/A **upper(UEL)** N/A
Fire extinguishing materials:	N/A

______water spray **______carbon dioxide** **______other:**

______foam **______dry chemical**

Special fire fighting procedures: N/A

Unusual fire and explosion hazards: N/A

--------------------V. HEALTH HAZARD INFORMATION--------------------

SYMPTOMS OF OVEREXPOSURE for each potential route of exposure

Inhaled:	Coughing
Contact with skin or eyes:	Possible eye irritation from dust particles; wear eye protection
Absorbed through skin:	N/A
Swallowed:	N/A

HEALTH EFFECTS OR RISKS FROM EXPOSURE.

Enclosure 2 pg 5 of 7

Acute: None

Chronic: Excessive inhalation over long period may cause harmful irritation; use mask suitable for nuisance dust.

Target Organ: None

FIRST AID: EMERGENCY PROCEDURES

Eye Contact: Attempt to wash out with clear water; if unable have particle removed by doctor

Skin Contact: None

Inhaled: Remove affected individual from dusty area to area with clean air

Swallowed: None

SUSPECTED CANCER AGENT?

__X__ **NO: This product's ingredients are not found in the lists below.**

YES: ______ **Federal OSHA** ______**NTP** ______**IARC**

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE

Any Respiratory illnesses which a nuisance dust may aggravate

---------------------VI. REACTIVITY DATA--------------------

Stability: __X__ **Stable** _____ **Unstable**

Incompatibility (Materials to avoid): None

Hazardous decomposition products (including combustion products): None

Hazardous Polymerization: ______ **May Occur** __X__ **Will not occur**

Conditions to Avoid: None

-----------------VII. SPILL, LEAK, AND DISPOSAL PROCEDURES---------------

Spill response procedures (include employee protection measures):

Vacuum clean or sweep material; Use respirators suitable for nuisance dust and eye protection.

Preparing wastes for disposal (container types, neutralization, etc.):

Dispose in bulk or containers according to local dump requirements. No special treatment required.

Note: Dispose of all wastes in accordance with federal, state, and local regulations.

--------------------VIII. SPECIAL HANDLING INFORMATION--------------------

Ventilation and engineering controls:

Maintain dust level below TLV.

Respiratory protection (type)

Masks suitable for nuisance dust.

Eye Protection (type)

Protective goggles.

Gloves (specify material)

Not required.

Other Clothing and equipment

Not required.

Work practices, hygienic practices

Use good housekeeping to avoid transient dust.

Other handling and storage requirements

Use good housekeeping to avoid transient dust.

Protective measures during maintenance of contaminated equipment

None special other than respirators and goggles.

As of the date of preparation of this document, the foregoing information is believed to be accurate and is provided in good faith to comply with applicable federal and state laws. However, no warranty or representation with respect to such information is intended or given; and it is the responsibility of the user to comply with all applicable federal, state, and local laws and regulations.

Enclosure 2 pg 7 of 7

Back to ***Main***

Bypass Fraction Determination

Input

1. Representative Fiber Diameter of Long Fiber: 15 microns (ref. 1)
2. Representative Fiber Diameter of Medium Fiber: 10 microns (ref. 1)
3. Representative Fiber Diameter of Short Fiber: < 5 microns (ref. 1)
4. Number of fibers (ref. 1)
5. Long Fiber Length: 1100 microns (ref. 1)
6. Medium Fiber Length: 300 microns (ref. 1)
7. Short Fiber Length: 100 microns (ref. 1)
8. Fraction of fibers at varying lengths (ref. 1)
9. Flow rate: 68.2 gpm (ref. 2)
10. Density of Min-K:
    a. Bulk density = 16 lb/ft^3 (ref. 3)
    b. Particle density = 165 lb/ft^3 (ref. 3)
11. Density of Nukon (latent fiber)
    a. Bulk density = 2.4 lb/ft^3 (ref. 4)
    b. Particle density = 175 lb/ft^3 (ref. 4)
12. Density of 3M-M20C:
    a. Bulk density = 39 lb/ft^3 (ref. 3)
    b. Particle density = 175 lb/ft^3 (See assumption 5)
13. Mass quantities used from Table 3 of ref. 2
    a. 3M-M20C (total) = 1.3 lbm
    b. 3M-M20C (fiber) = 0.715 lbm (1.3 * 55%) - See assumption 6
    c. 3M-M20C (particulate) = 0.585 lbm (1.3 * 45%) - See assumption 6
    d. Nukon (latent fiber) = 0.15 lbm
    e. Min-K (total) = 0.20 lbm
    f. Min-K (fiber) = 0.04 lbm (0.20*20%)
    g. Min-K (particulate) = 0.16 lbm
    h. Silicone carbide = 4.60 lbm (used to simulate phenolics, alkyds and silicone coatings failed as 10 micron particulates)
    i. Tin powder = 2.20 lbm (used to simulate inorganic zinc failed as 10 micron particulates)
    j. Dirt/Dust = 0.60 lbm

Assumptions

1. Average diameters and lengths of fibers are representative.
   Technical Justification: This is a reasonable assumption and is based on data from NSL Labs. Further characterization of each individual fiber is very time intensive and would not be expected to produce a significant difference in the results.
2. Samples 4, 5 and 6 fiber lengths and diameters are assumed to be the same length and diameter as sample 3 fibers.

Bypass Fraction Determination

Technical Justification: This a reasonable assumption based on the data from samples 1, 2 and 3. Furthermore, one would expect that as fibers recirculated, the longer fibers would collect on the strainers and shorter fibers would bypass.

3. Sample 3 medium fiber diameter is assumed to be 10 microns.
   Technical Justification: The sample 3 medium fiber is 5 microns. However, for simplicity, it is assumed to be the same diameter as sample 1 and 2 medium fibers. This is conservative since the larger diameter will result in a greater quantity of fiber bypassing and does not significantly affect the particulate bypass quantity.
4. 20% of Min-K is fibrous while the remaining 80% is in particulate form (ref. 3).
5. Particle density of 3M-M20C is 175 lb/ft^3 (ref. 4 and 5).
   Technical Justification: Since 3M-M20C is assumed to behave as Low Density Fiberglass Insulation (LDFG) in the debris generation calculation (ref. 3), its particle density is assumed to be equivalent to Nukon.
6. 55% of 3M-M20C is fibrous while the remaining 45% is in particulate form.
   Technical Justification: The MSDS for 3M-M20C (ref. 6) shows that the composition of the insulation is made up of 40-60% vermiculite, 10-15% aluminum silicate, 5-10% organic binder, 5-10% metal foil, with the remaining 5-40% is not specified. Vermiculite and the metal foil are not fibrous materials and are treated as particulates. Using a conservative approach, the particulate components are minimized resulting in 45% of the 3M-M20C treated as particulates. The organic binder, aluminum silicate and unknown material are assumed to be 100% fibrous resulting in a maximum value of 55% fibrous component of 3M-M20C.

Methodology

Fibrous Debris Bypass Fraction

Bypass Fraction of Fibrous Debris was determined by calculating the total volume of fibers for each sample using the fiber lengths, diameters and total number of each fiber type (long, medium, short).

$$\text{Volume/25 ml } (ft^3/25\text{ ml}) = \text{Total Number Fibers/25 ml} * [(A_L * L_L * \%\text{ Long}) + (A_M * L_M * \%\text{ Medium}) + (A_S * L_S * \%\text{ Short})]$$

where
A_L = Cross Sectional Area Long Fiber (ft)
A_M = Cross Sectional Area Medium Fiber (ft)
A_S = Cross Sectional Area Short Fiber (ft)
L_L = Length of Long Fiber (ft)
L_M = Length of Medium Fiber (ft)
L_S = Length of Short Fiber (ft)

The total fiber volume was then converted to mass/25 ml by multiplying the volume (ft^3)/25 ml and the total material density (lb/ft^3). The material density was calculated

Bypass Fraction Determination

using the particle densities of each type of fibrous material weighted by percentage of total quantity in the test.

The total mass was calculated by determining the mass/min for each sample and then mass/10 min (time between samples).

The strainer test was performed for a minimum duration of approximately 50 minutes which is the calculated time for the water in the flume to recirculate 5 times. The data for fibrous debris was then plotted to determine the exponential trendline equation. Integration of the trendline equation y = 8.685E-4 exp (-3.963E-2 x) from 0 to infinity gives a total quantity of 0.0219 lbm.

Using an alternative method (Riemann sums), the mass/10 min values were summed for the total quantity of fibrous debris measured in the bypass sample. However, use of the exponential trendline resulted in a greater bypass fraction and thus is conservative.

The bypass fraction is the total mass of measured fibers that bypassed the screens divided by the total mass of fibrous debris introduced upstream of the strainers.

Particulate Debris Bypass Fraction

A similar methodology that was used to determine the fibrous debris bypass fraction, is employed to determine the particulate debris bypass fraction.

Since the samples are already given in weight, the total mass of all debris is calculated. The mass of the fibrous debris is subtracted from the total mass to give a total mass of particulate debris.

Three methods could be used to determine the total mass of particulate debris. Using a Riemann sums method, integrating a linear trendline from zero to a calculated depletion time of 69.2 min or integrating the exponential trendline from zero to infinity gives considerably different results. However, depending on the resulting application, the conservative value could be the minimum value of 39% using the Riemann sums method or 60% by integrating over the exponential trendline. The linear integrated value of 49% particulates bypassing the strainer is provided as well. Thus, these values are determined by this evaluation with the end user responsible for determining which is the appropriate value for the applicable application.

The bypass fraction is the total mass of particulate debris that bypassed the screens divided by the total mass of particulate debris introduces upstream of the strainers.

Enclosure 3 pg 4 of 7

Bypass Fraction Determination

Results

As shown on Worksheet A, the fraction of fibrous debris that bypasses the strainer was 2.42%.

As shown on Worksheet B, the fraction of particulate debris that bypasses the strainer was a minimum of 39% and maximum of 62% and a mid-range value of 49%. Depending on the application, the end user will determine the appropriate value to use.

References

1. FANP Document No. 38-9013790-000, NSL Analytical Test Report
2. FANP Document No. 51-90088451-002, Test Report for SURE-FLOW™ Strainer Performance Test for Watts Bar Nuclear
3. ALION-CAL-TVA2739-03, Rev. 1, Watts Bar Reaction Building GSI-191 Debris Generation Calculation
4. NRC Final Draft SER, Safety Evaluation by the Office of Nuclear Reactor Regulation Related to NRC Generic Letter 2004-02, Nuclear Energy Institute Guidance Report, "Pressurized Water Reactor Sump Performance Methodology", Appendix V, Section V.1.1
5. NRC Final Draft SER, Safety Evaluation by the Office of Nuclear Reactor Regulation Related to NRC Generic Letter 2004-02, Nuclear Energy Institute Guidance Report, "Pressurized Water Reactor Sump Performance Methodology", Section 3.5.2.3
6. Material Safety Data Sheet for INTERAM(tm) M-20A AND M-20 AND M-20C MAT. ISSUED: April 12, 1999. DOCUMENT: 10-8339-3

Prepared By: Cynthia M. Maples *Cynthia Maples* Date: 5-18-06
Tennessee Valley Authority

Reviewed By: Doug M. Pollock *Doug Pollock* Date: 5-18-06
Tennessee Valley Authority

WATTS BAR BYPASS FRACTION TESTING
WORKSHEET A - FIBROUS DEBRIS BYPASS

CASE	TIME	COUNT	LENGTH			VOLUME	MASS				
	min	per 25 ml	% long	% medium	% short	ft³	lb/25 ml	lb/ft^3	lb/min	lb/10 min	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Not used - Sample in flume and not taken via bypass sampling ports
Test 2A	10	290	6%	78%	16%	3.109E-10	5.427E-08	6.147E-05	5.604E-04	0.0056	
Test 3A	20	195	8%	75%	17%	2.311E-10	4.034E-08	4.569E-05	4.165E-04	0.0042	
Test 4A	30	290	8%	75%	17%	1.778E-10	3.103E-08	3.515E-05	3.204E-04	0.0032	
Test 5A	40	109	8%	75%	17%	6.681E-11	1.166E-08	1.321E-05	1.204E-04	0.0012	
Test 6A	50	130	8%	75%	17%	7.969E-11	1.391E-08	1.576E-05	1.436E-04	0.0014	

Total	lb	0.0156	0.0219
		Riemann sum	Integrated trendline
Integrated Bypass Total - Fibrous Debris		1.73%	2.42%

Representative Fiber Diameter (Long)
15 micron
4.9213E-05 ft
Cross Sectional Area
1.902E-09 ft²

Representative Fiber Diameter (Medium)
10 micron
3.2808E-05 ft
Cross Sectional Area
8.454E-10 ft²

Representative Fiber Diameter (Short)
5 micron
1.6404E-05 ft
Cross Sectional Area
2.113E-10 ft²

Flow Rate
68.2 gpm

Flow Rate
9.12 ft³/min

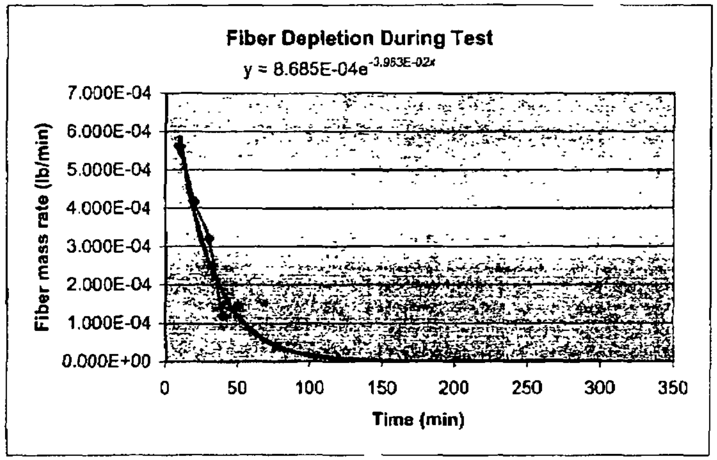
Material Density
174.56 lb/ft³

Total fiber 0.905 lbm

		Bulk Density lb/cu. ft.	Particle Density
% 3M	79.01%	39	175
% min-k	4.42%	16	165
% nukon	16.57%	2.4	175

Fiber Length

Long	1100 micron	3.609E-03 ft
Medium	300 micron	9.843E-04 ft
Short	100 micron	3.281E-04 ft



Enclosure 3 pg 5 of 7

WATTS BAR BYPASS FRACTION TESTING
WORKSHEET B - PARTICULATE DEBRIS BYPASS

CASE	TIME	Total Sample Weight	MASS				
	min	g/per 25 ml	lb/25 ml	lb/ft^3	lb/min	lb/10 min	
Test 1A	[illegible]	0.0072	1.6873E-05	1.798E-02	1.639E-01	1.6391	Not used
Test 2A	10	0.0045	9.9206E-06	1.124E-02	1.024E-01	1.0245	
Test 3A	20	0.0036	7.9365E-06	8.989E-03	8.196E-02	0.8196	
Test 4A	30	0.0027	5.9524E-06	6.742E-03	6.147E-02	0.6147	
Test 5A	40	0.0022	4.8501E-06	5.494E-03	5.009E-02	0.5009	
Test 6A	50	0.0014	3.0864E-06	3.496E-03	3.187E-02	0.3187	

Total 3.2783 lb
Total Minus Fiber 3.2564 lb

Fiber Mass
0.022 lb

Integrated Bypass Total - Particulate Debris 39.98%

Flow Rate
68.2 gpm

Using exponential trendline
Total 5.0106 lb
Total Minus Fiber 4.9887 lb

Flow Rate
9.12 ft³/min

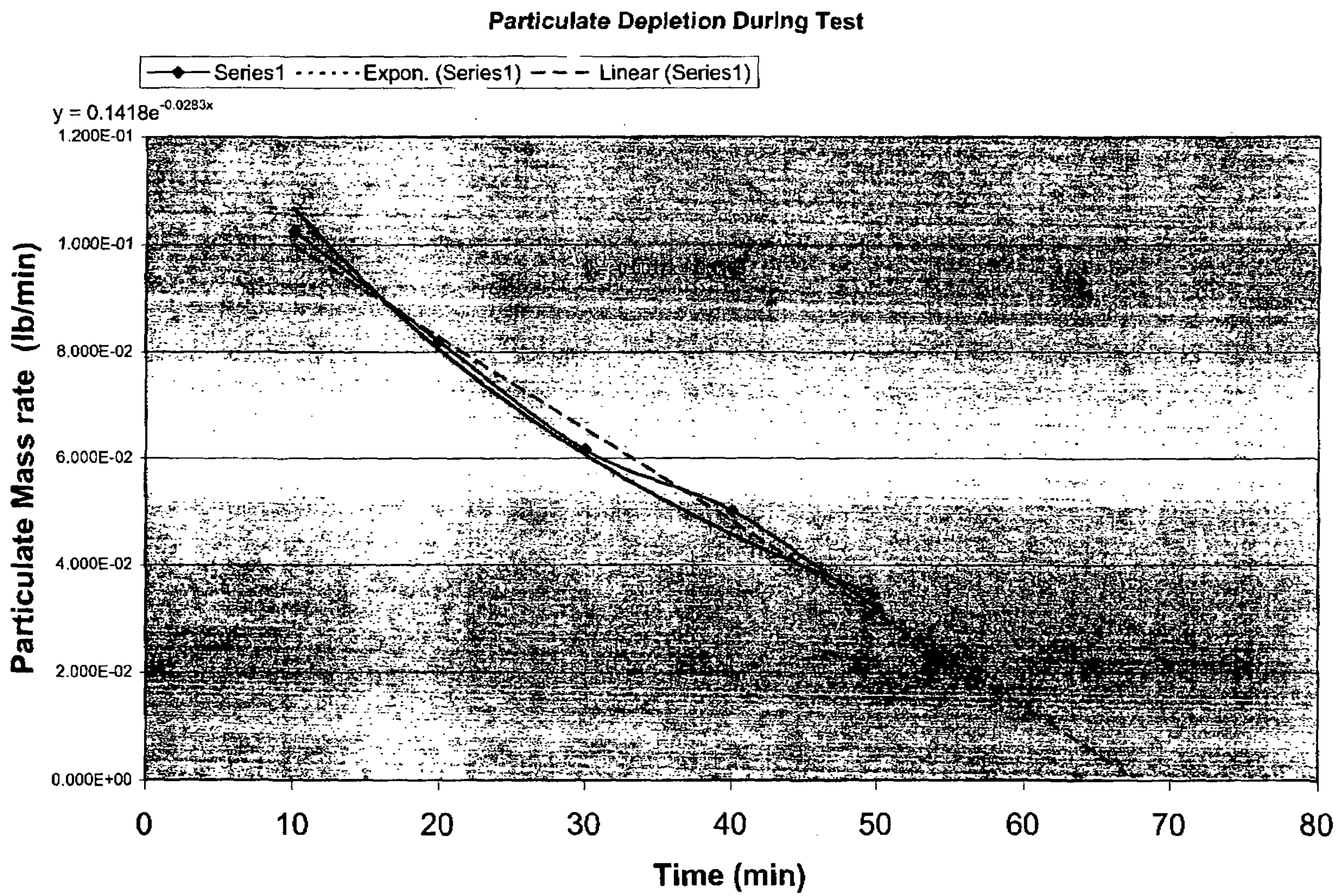
Integrated Bypass Total - Particulate Debris 61.25%

Total Mass
8.145 lb

Totally depleted in 69.12 min

Using linear trendline
Total 4.0607 lb
Total Minus Fiber 4.0387 lb

Integrated Bypass Total - Particulate Debris 49.59%



Enclosure 3 pg 7 of 7

Enclosure 4 Pg 1 of 16

AREVA

Document Number: 51-9008451-002

ATTACHMENT-3

FANP Document No. 38-9013790-000

WATTS BAR STRAINER PERFORMANCE TEST
DOWNSTREAM BYPASS RESULTS

Enclosure 4 pg 2 of 16

FROM (THU) DEC 15 2005 17:06/ST. 17:05/NO. 6309524074 P 1

51-9008451-002

NSL ANALYTICAL

Fariba Gartland, PMP
Project Manager II
FRAMATOME ANP, Inc.
An AREVA and Siemens Company
7207 IBM Drive, CLT-2A
Charlotte, NC 28262

Date: 12/15/05

Dear Fariba,

We have completed the analysis of the seven samples submitted on December 5th using methodology that was discussed and agreed upon between NSL and Framatone. Details of the method are listed below.

Insoluble Solids content

1. Three 25ml portions of the well-shaken sample were extracted and filtered through a weighed .45 micron nitrocellulose filter for each individual sample.

2. Sample filters were then dried at 105 degrees centigrade for approximately 20 minutes and weighed again after cooling.

3. Insoluble solid values were calculated from the weight difference for each filter and the average of the three analyses was reported.

Enclosure 4 pg 3 of 16

FROM (THU)DEC 15 2005 17:06/ST. 17:05/NO. 6309524074 P 2

51-9008451-002

NSL ANALYTICAL

Fiber count and length

1. Filters containing fibers and particles from previous test were used for the testing of fiber counts and length,
2. Preliminary light microscope observations were used to determine fiber location on the filter surface. Useful magnification is 100-200X
3. Collection of fibers was accomplished by using sticky carbon tape or other sticky conductive material. Tape was pressed against the filter and repeated as many times as needed to collect fibers fully from filter surface. Fix carbon tape on SEM stab.
4. A light microscopic observation of filter surface was performed to ensure complete fiber collection.
5. Tape containing fibers were examined by scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM/EDS) and PMS (Particle Measurement System) for count completion. Magnification varied depending on fibers size.
6. The longest and shortest fiber from each filter was measured and an average of each class of the three samplings was reported in millimeters.
7. Each individual filter was examined and all fibers were counted with the average of the three reported for the total fiber count.

Please let me know if you need any additional information regarding the analysis or the final results.

Regards,

David Kluk

David Kluk
Technical Manager
NSL Analytical Services

7650 Hub Parkway • Cleveland, Ohio 44125 • Office: 216-447-1550 • 800-497-6752 • Fax: 216-447-0716 • Web Site: www.nslanalytical.com

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Enclosure 4 pg 4 of 16

51-9008451-002

NSL ANALYTICAL

TEST REPORT

THE REPORTED TEST RESULTS RELATE ONLY TO THE ITEM(S) TESTED

Accredited Nadcap ISO/IEC Guide 17025

Framatome ANP (Charlotte)
400 South Tyron St Suite 2100
Charlotte NC 28285

Attn: Fariba Gartland

Client Description: Water

Date: 12/12/2005

Report No.: 139090

Page: 1 of 1

NSL Lab No: 0524811

Sample ID: Sample# 1A Background sample from Flume 6" Town Water No Debris 11/29/05

Tests	Results/Units	Methods
Fiber Count	not detected	SEM
Longest Fiber Size	not detected	SEM
Shortest Fiber Size	not detected	SEM
Total Sample Weight	0.0003 gr./25 ml	Wet Chemistry

Reporting Officer: [signature]

FR 1

Carm D'Agostino , Wet Chem Supervisor

Enclosure 4 pg 5 of 14

51-9008451-002

NSL ANALYTICAL

TEST REPORT

THE REPORTED TEST RESULTS RELATE ONLY TO THE ITEM(S) TESTED

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Framatome ANP (Charlotte)
400 South Tyron St Suite 2100
Charlotte NC 28285

Attn: Fariba Gartland

Client Description: Water

Date: 12/12/2005

Report No.: 139080

Page: 1 of 1

NSL Lab No: 0524802 **Sample ID: Sample 1A 11:42 11/29/05**

Tests	Results/Units	Methods
Fiber Count	303/25 ml	SEM
Longest Fiber Size	3.8 mm	SEM
Shortest Fiber Size	0.15 mm	SEM
Total Sample Weight	0.0072g/25ml	Wet Chemistry

Reporting Officer: [signature]
Carm D'Agostino , Wet Chem Supervisor

FR 1

Enclosure 4 pg 6 of 16

51-9008451-062

FROM (MON)FEB 13 2006 13:18/ST. 13:18/NO. 6309524908 P 1

NSL ANALYTICAL

TEST REPORT

THE REPORTED TEST RESULTS RELATE ONLY TO THE ITEM(S) TESTED

Accredited Nadcap ISO/IEC Guide 17025

Framatome ANP (Charlotte)
400 South Tyron St Suite 2100
Charlotte NC 28285

Date: 2/9/2006

Report No.: 139080

Attn: Fariba Gartland

Revised Report: Sample Discription Corrected

Client Description: TVA/ Flume-Watts

Page: 1 of 2

NSL Lab No: 0524802 **Sample ID: Sample 1A 11:42 11/29/05**

Tests	Results/Units	Methods
Average Diameter of Long	15microns	SEM
Average Diameter of Medium	10microns	SEM
Average Diameter of Short	<5microns	SEM
Fiber Count	303/25 ml	SEM
% Long	13%	SEM
Long Fiber Length	1100microns	SEM
% Medium	77%	SEM
Medium Fiber Length	300microns	SEM
% Short	10%	SEM
Short Fiber Length	100microns	SEM

Reporting Officer: [signature]
Carm D'Agostino , Wet Chem Supervisor

FR 1

Enclosure 4 pg 7 of 16

81-9008451-002

FROM (MON)FEB 13 2006 13:18/ST. 13:18/NO. 6309524908 P 2

NSL ANALYTICAL

TEST REPORT

THE REPORTED TEST RESULTS RELATE ONLY TO THE ITEM(S) TESTED

Accredited Nadcap ISO/IEC Guide 17025

Framatome ANP (Charlotte)
400 South Tyron St Suite 2100
Charlotte NC 28285

Date: 2/9/2006

Report No.: 139080

Attn: Fariba Gartland

Revised Report: Sample Discription Corrected

Client Description: TVA/ Plume-Watts

Page: 2 of 2

NSL Lab No: 0524802 Sample ID: Sample 1A 11:42 11/29/05

Tests	Results/Units	Methods
Total Sample Weight	0.0072g/25ml	Wet Chemistry

Reporting Officer: [signature]

FR 1

Carm D'Agostino , Wet Chem Supervisor

Enclosure 4 pg 8 of 16

51-9008451-002

NSL ANALYTICAL

TEST REPORT

THE REPORTED TEST RESULTS RELATE ONLY TO THE ITEM(S) TESTED

Accredited Nadcap ISO/IEC Guide 17025

Framatome ANP (Charlotte)
400 South Tyron St Suite 2100
Charlotte NC 28285

Attn: Fariba Gartland

Client Description: Water

Date: 12/12/2005

Report No.: 139082

Page: 1 of 1

NSL Lab No: 0524803 **Sample ID: Sample 2A, Test 1A, Time 11:52**

Tests	Results/Units	Methods
Fiber Count	290/25ml	SEM
Longest Fiber Size	2.47 mm	SEM
Shortest Fiber Size	0.07 mm	SEM
Total Sample Weight	0.0045g/25ml	Wet Chemistry

Reporting Officer: [signature]
Carm D'Agostino , Wet Chem Supervisor

FR1

Enclosure 4 Pg 9 of 16

51-9008451-002

FROM (MON)FEB 13 2006 13:18/ST. 13:18/NO. 6309524908 P 3

NSL ANALYTICAL

TEST REPORT

THE REPORTED TEST RESULTS RELATE ONLY TO THE ITEM(S) TESTED

Accredited Nadcap ISO/IEC Guide 17025

Framatome ANP (Charlotte)
400 South Tyron St Suite 2100
Charlotte NC 28265

Date: 2/9/2006

Report No.: 139082

Attn: Fariba Gartland

Revised Report: Sample Discription and Units Corrected

Client Description: TVA/ Flume-Watts

NSL Lab No: 0524803 **Sample ID: Sample 2A, Test 1A, Time 11:52**

Tests	Results/Units	Methods
Average Diameter of Long	15microns	SEM
Average Diameter of Medium	10microns	SEM
Average Diameter of Short	<5microns	SEM
Fiber Count	290/25ml	SEM
% Long	6%	SEM
Long Fiber Length	1100microns	SEM
% Medium	78%	SEM
Medium Fiber Length	300microns	SEM
% Short	16%	SEM
Short Fiber Length	100microns	SEM

Reporting Officer: [signature]
Carm D'Agostino , Wet Chem Supervisor

FR1

Enclosure 4 pg 10 of 16

FROM 51-9008451-002 (MON) FEB 13 2006 13:18/ST. 13:18/NO. 6309524908 P 4

NSL ANALYTICAL

TEST REPORT

THE REPORTED TEST RESULTS RELATE ONLY TO THE ITEM(S) TESTED

Accredited Nadcap ISO/IEC Guide 17025

Framatome ANP (Charlotte)
400 South Tyron St Suite 2100
Charlotte NC 28285

Date: 2/9/2006

Report No.: 139082

Attn: Fariba Gartland

Revised Report: Sample Discription and Units Corrected

Client Description: TVA/ Flume-Watts

Page: 2 of 2

NSL Lab No: 0524803 Sample ID: Sample 2A, Test 1A, Time 11:52

Tests	Results/Units	Methods
Total Sample Weight	0.0045g/25ml	Wet Chemistry

Reporting Officer: [signature]

FR1

Carm D'Agostino , Wet Chem Supervisor

Enclosure 4 pg 11 of 16

51-9008451-002

NSL ANALYTICAL

TEST REPORT

THE REPORTED TEST RESULTS RELATE ONLY TO THE ITEM(S) TESTED

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Framatome ANP (Charlotte)
400 South Tyron St Suite 2100
Charlotte NC 28285

Attn: Fariba Gartland

Client Description: Water

Date: 12/12/2005

Report No.: 139085

Page: 1 of 1

NSL Lab No: 0524806 **Sample ID: Sample 3A, Test 1A, Time 12:02**

Tests	Results/Units	Methods
Fiber Count	195/25 ml	SEM
Longest Fiber Size	2.23 mm	SEM
Shortest Fiber Size	0.07 mm	SEM
Total Sample Weight	0.0036g/25ml	Wet Chemistry

Reporting Officer: [signature]

FR 1

Carm D'Agostino , Wet Chem Supervisor

Enclosure 4 pg 12 of 76

51-9008451-002

FROM (MON)FEB 13 2006 13:18/ST. 13:18/NO. 6309524908 P 5

NSL ANALYTICAL

TEST REPORT

THE REPORTED TEST RESULTS RELATE ONLY TO THE ITEM(S) TESTED

Accredited Nadcap ISO/IEC Guide 17025

Framatome ANP (Charlotte)
400 South Tyron St Suite 2100
Charlotte NC 28285

Date: 2/9/2006

Report No.: 139085

Attn: Fariba Gartland

Supplemental Report: Other Work Performed

Client Description: TVA/ Flume-Watts

Page: 1 of 2

NSL Lab No: 0524806 **Sample ID: Sample 3A, Test 1A, Time 12:02**

Tests	Results/Units	Methods
Average Diameter of Long	15microns	SEM
Average Diameter of Medium	5microns	SEM
Average Diameter of Short	<5microns	SEM
Fiber Count	195/25 ml	SEM
% Long	8%	SEM
Long Fiber Length	900microns	SEM
% Medium	75%	SEM
Medium Fiber Length	300microns	SEM
% Short	17%	SEM
Short Fiber Length	100microns	SEM

Reporting Officer: [signature]
Carm D'Agostino , Wet Chem Supervisor

FR 1

Enclosure 4 pg 13 of 16

FROM 51-9008451-002 (MON) FEB 13 2006 13:18/ST. 13:18/NO. 6309524908 P 6

NSL ANALYTICAL

TEST REPORT

THE REPORTED TEST RESULTS RELATE ONLY TO THE ITEM(S) TESTED

Accredited Nadcap ISO/IEC Guide 17025

Framatome ANP (Charlotte)
400 South Tyron St Suite 2100
Charlotte NC 28285

Date: 2/8/2006

Report No.: 139085

Attn: Fariba Gartland

Supplemental Report: Other Work Performed

Client Description: TVA/ Flume-Watts

Page: 2 of 2

NSL Lab No: 0524806 **Sample ID: Sample 3A, Test 1A, Time 12:02**

Tests	Results/Units	Methods
Total Sample Weight	0.0036g/25ml	Wet Chemistry

Reporting Officer: [signature]

FR1

Carm D'Agostino, Wet Chem Supervisor

Enclosure 4 pg 14 of 16 51-9008451-002

NSL ANALYTICAL

TEST REPORT

THE REPORTED TEST RESULTS RELATE ONLY TO THE ITEM(S) TESTED

Accredited Nadcap ISO/IEC Guide 17025

Framatome ANP (Charlotte)
400 South Tyron St Suite 2100
Charlotte NC 28285

Attn: Fariba Gartland

Client Description: Water

Date: 12/12/2005

Report No.: 139087

Page: 1 of 1

NSL Lab No: 0524808 **Sample ID: Sample 4A, Test 1A, Time 12:12**

Tests	Results/Units	Methods
Fiber Count	290/25 ml	SEM
Longest Fiber Size	1.27 mm	SEM
Shortest Fiber Size	0.06 mm	SEM
Total Sample Weight	0.0027g/25ml	Wet Chemistry

Reporting Officer: [signature]

FR 1

Carm D'Agostino , Wet Chem Supervisor

Enclosure 4 pg 15 of 16 51-9008451-002

NSL ANALYTICAL

TEST REPORT

THE REPORTED TEST RESULTS RELATE ONLY TO THE ITEM(S) TESTED

Accredited Nadcap ISO/IEC Guide 17025

Framatome ANP (Charlotte)
400 South Tyron St Suite 2100
Charlotte NC 28285

Attn: Fariba Gartland

Client Description: Water

Date: 12/12/2005

Report No.: 139089

Page: 1 of 1

NSL Lab No: 0524810 **Sample ID: Sample 5A, Test 1A, Time 12:22**

Tests	Results/Units	Methods
Fiber Count	109/25 ml	SEM
Longest Fiber Size	1.45 mm	SEM
Shortest Fiber Size	0.10 mm	SEM
Total Sample Weight	0.0022g/25ml	Wet Chemistry

Reporting Officer: [signature]
Carm D'Agostino , Wet Chem Supervisor

FR 1

Enclosure 4 pg 16 of 16

51-9008451-002

NSL ANALYTICAL

TEST REPORT

THE REPORTED TEST RESULTS RELATE ONLY TO THE ITEM(S) TESTED

Accredited Nadcap ISO/IEC Guide 17025

Framatome ANP (Charlotte)
400 South Tyron St Suite 2100
Charlotte NC 28285

Attn: Fariba Gartland

Client Description: Water

Date: 12/12/2005

Report No.: 139084

Page: 1 of 1

NSL Lab No: 0524805 **Sample ID: Sample# 6A Time: 12:32 11/29/05**

Tests	Results/Units	Methods
Fiber Count	130/25ml	SEM
Longest Fiber Size	1.33 mm	SEM
Shortest Fiber Size	0.05 mm	SEM
Total Sample Weight	0.0014g/25ml	Wet Chemistry

Reporting Officer: [signature]

FR 1

Carm D'Agostino , Wet Chem Supervisor

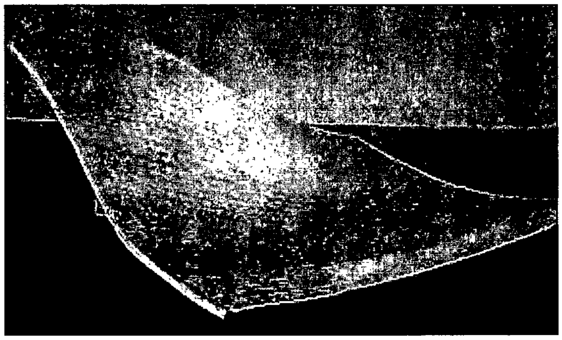
ATTACHMENT G – MIN-K

This Attachment contains emails from Thermal Ceramics and Microtherm International stating the composition of microporous insulation along with the Min-K data sheet as provided by Thermal Ceramics.

Thermal Ceramics

Flexible Min-K

Product Information



Flexible Min-K is a composite system consisting of a microporous core encapsulated between layers of high temperature cloth and quilted in 1" squares. The quilting maintains core distribution in high vibration environments and allows the insulation to be wrapped or bent to conform to unique geometric shapes during installation. Product thickness, core density and composition, and cloth selection vary with application.

Flexible Min-K Options

Core formulations .... F-150 (1200°F),F-182 (1832°F)
Cloth facings................ 2116 E-Glass (500°F), S-Glass (1200°F)
503 Quartz (1958°F), 593 Quartz (1958°F)
Nextel™(2200-2500°F)
Density, pcf* 8, 10, 16
Thickness, in. 1/8, 1/4, 3/16, 3/8, 1/2

*0.50" thick material available at a maximum of 14 pcf

Standard Tolerances

Thickness ....+ 0.060/- 0.030
Length and Width, Fabricated parts................................+/- 0.125
Length and Width, Standard sheets...........................+ 2.0/- 0.00

Standard Flexible Min-K Offerings

High temperature composition, rated at 1832°F
- 1801/8.................... Quartz 503 cloth, F182 core, 8 pcf density
- 1801/10................ Quartz 503 cloth, F182 core, 10 pcf density
- 1801/16................ Quartz 503 cloth, F182 core, 16 pcf density

Mid-range composition, rated at 1200°F
- 1201/8......................... S-Glass cloth, F150 core, 8 pcf density
- 1201/10..................... S-Glass cloth, F150 core, 10 pcf density
- 1201/16..................... S-Glass cloth, F150 core, 16 pcf density

Standard composition, rated at 500°F
- 501/8.................. 2116 E-Glass cloth, F150 core, 8 pcf density
- 501/10............. 2116 E-Glass cloth, F150 core, 10 pcf density
- 501/16............. 2116 E-Glass cloth, F150 core, 16 pcf density

*Variations of the cloth facing, hot or cold, core material, thread, and density are available.
Material is supplied in 3' x 3' or 4' x 3', square stitched (1"centers) sheets. Fabricated strips, referred to as tapes, are available in widths of 1", 1½" and 2½", in 6 ft lengths.Customized sheet sizes and fabricated shapes are available upon request.

Features
- Very low thermal conductivity
- Benefits weight and space constraints
- Durable
- Flexible and lightweight
- Composite temperature use limit ranges from 500 to 1832°F

Core and Textile Facing Selection

While thermal management requirements often dictate material thickness and core density, the maximum continuous use temperature seen in the application is the deciding factor for core and cloth selection. Because this is a composite material, the use limit is decided by the lowest use limit associated with the materials incorporated into the design.

Core: Maximum temperature use limit of the microporous core is a function of both shrinkage and degradation of thermal conductivity. At elevated temperatures, the cellular structure of the microporous insulation, which is responsible for the extremely low thermal conductivity, is compromised. The core components, including SiO_2, particles, metal oxides and re-enforcement fibers, may melt or sinter together at elevated temperatures increasing both the solid conduction due to material contact, and molecular conduction of air due to the degradation of the microporous structure.

Core Formulations
- **Mix F182** is utilized for temperatures up to 1832°F and where high vibration environments are seen.
- **Mix F150** is used for applications at 1200°F and lower.

Cloth: Cloth selection is based on the maximum temperature use limit required by the application, but may also be determined according to other physical characteristics such as rigidity, permeability or durability. Some cloths (Nextel) are also used due to their qualification as an industry approved fire barrier. The maximum temperature use limit is based on the degradation of the strength of the material. Some cloths are rated for higher temperature use in other industries, the use limits here reflect the survivability of the Min-K product in demanding aerospace environments.
- **2116 E-Glass** - Maximum use limit of 500°F (in harsh aerospace environments) used in 501 series of materials or Standard Flexible Min-K.
- **S-Glass** - Maximum use limit of 1200°F (in harsh aerospace environments) used in 1201 series of materials or Mid-Range Flexible Min-K.
- **Quartz 503** - Maximum use limit of 1958°F and used in 1801 (limited by core) series of materials.
- **Quartz 593** - Maximum use limit of 1958°F. Offers increased durability over Quartz 503 due to increased thickness.
- **Nextel** - Maximum use limit of 2200-2500°F. Excellent strength and durability at elevated temperatures.

Thread: Selection is based on maximum continuous use limit of the application and consistent with the cloth.
- **E-Glass** - Standard with 2116 E-Glass and S-Glass cloths.
- **Quartz** - Standard with higher temperature cloths.

Flexible Min-K

Product Information

Density Effects

Low thermal conductivity associated with Min-K is due to the microporous structure of the core. The particulate and fibrous material are sized to create pores which are <0.1um in diameter, less than the mean free path of air. By limiting quantity and motion of air particles in the pores, both conduction due to air and convection heat transfer is limited, thus reducing the thermal conductivity. This is the basis of microporous insulation.

At lower densities there may be insufficient material to create the very small pore structure, resulting in larger pores more capable of efficient transfer of heat and increased thermal conductivity. As the density of the microporous insulation decreases from 16 pcf, the thermal conductivity increases.

Min-K materials are engineered to provide the optimum thermal efficiency while maintaining product handling characteristics and cost.

Note 1. Density greatly affects the compression resistance of the material.
Note 2. Product density refers to core material and does not incorporate the cloth facings.

Thickness Considerations

	Flexible Min-K501[1]			Flexible Min-K 1201[2]			Flexible Min-K 1801[3]		
	8	10	16	8	10	16	8	10	16
Thermal Conductivity, BTU•in/hr•ft²•°F									
Thickness, 0.125"									
200	0.23	0.21	0.20	0.23	0.23	0.22	0.26	0.26	0.25
400	0.28	0.25	0.24	0.28	0.27	0.26	0.28	0.28	0.27
600	0.34	0.30	0.28	0.35	0.33	0.32	0.31	0.30	0.29
800	0.42	0.37	0.35	0.42	0.39	0.38	0.38	0.34	0.32
1000	0.49	0.45	0.41	0.50	0.47	0.44	0.44	0.39	0.36
1200	-	–	–	0.60	0.56	0.52	0.49	0.44	0.41
1400	–	–	–	0.72	0.66	0.63	0.58	0.52	0.47
1600	–	–	–	–	–	–	0.68	0.61	0.56
1800	–	–	–	–	–	–	0.79	0.71	0.65
Thickness, 0.250"									
200	0.20	0.19	0.18	0.21	0.21	0.20	0.23	0.23	0.22
400	0.25	0.23	0.22	0.26	0.24	0.23	0.25	0.25	0.24
600	0.31	0.27	0.26	0.32	0.29	0.28	0.27	0.27	0.26
800	0.38	0.34	0.32	0.39	0.35	0.34	0.34	0.30	0.28
1000	0.45	0.41	0.38	0.47	0.43	0.40	0.40	0.35	0.32
1200	–	–	–	0.56	0.52	0.48	0.45	0.40	0.37
1400	–	–	–	0.68	0.62	0.58	0.54	0.48	0.43
1600	–	–	–	–	–	–	0.65	0.57	0.51
1800	–	–	–	–	–	–	0.76	0.67	0.60
Thickness, 0.375"									
200	0.19	0.19	0.18	0.20	0.20	0.20	0.22	0.22	0.21
400	0.24	0.23	0.21	0.25	0.23	0.22	0.24	0.24	0.23
600	0.30	0.26	0.25	0.30	0.27	0.26	0.26	0.26	0.25
800	0.37	0.33	0.31	0.37	0.33	0.32	0.33	0.29	0.28
1000	0.44	0.40	0.37	0.45	0.40	0.37	0.39	0.34	0.31
1200	–	–	–	0.53	0.49	0.45	0.44	0.39	0.35
1400	–	–	–	0.65	0.59	0.55	0.53	0.47	0.41
1600	–	–	–	–	–	–	0.64	0.56	0.50
1800	–	–	–	–	–	–	0.75	0.66	0.59

1. F150 core, E-Glass facing, 8,10,16 pcf density
2. F150 core, S-Glass facing, 8,10,16 pcf density
3. F182 core, Quartz 503 facing, 8, 10, 16 pcf density

The values given herein are typical average values obtained in accordance with accepted test methods and are subject to normal manufacturing variations. They are supplied as a technical service and are subject to change without notice. Therefore, the data contained herein should not be used for specification purposes. Check with your Thermal Ceramics office to obtain current information.

The insulating capabilities of microporous insulation increases with increased thickness until a point of diminishing returns is eventually reached, above which added insulation provides only a marginal benefit.

Adding layers of insulation, in ⅛" increments can substantially reduce cold face temperatures. For a more accurate representation of your specific application, please contact your Thermal Ceramics Sales Representative.

Flexible Min-K is a composite of both a lower thermal conductivity microporous core and a higher thermal conductivity high temperature textile, as overall product thickness increases (while textile thickness is maintained) the composite thermal conductivity will decrease.

Flexible Min-K-16pcf* Thickness, in.	Cold Face (Hot Face=800°F)	Cold Face (Hot Face=1000°F)	Cold Face (Hot Face=1200°F)
0.125	341	410	477
0.250	268	317	367
0.375	229	269	309
0.500	204	238	273

This series of heat flow analysis were competed utilizing K-Flow 1.0 to provide a baseline for product thickness selection.

* 0.50" material is only available in densities up to 14 pcf.

Acoustic Characteristics

Sound absorption values range from 0 to 1.0 with 0 representing no absorption (perfect reflections) and 1.0 representing 100 percent absorption.

Specific Heat Parameters, Hz

Material, 0.25"	125	250	500	1000	2000	4000
8 pcf, F150 Core	0.025	0.032	0.066	0.272	0.331	0.253
16 pcf, F150 Core	0.027	0.025	0.060	0.157	0.355	0.306
16 pcf, F182 Core	0.028	0.028	0.052	0.132	0.322	0.258

Data for select Min-K Microporous insulation systems via ASTM 1050.

Temperature, °F	Specific Heat (BTU/lb°F)
100	0.18
400	0.23
800	0.26

Effects Of Moisture

Microporous insulation consists of a core which uses a standard grade, fumed silica as a key constituent. Due to the surface chemistry of the fumed silica, it absorbs moisture either through contact with water, fluids, or humidity in the air. When direct contact with fluids occurs an irreversible, catastrophic degradation of the microporous structure occurs, which degrades the low thermal conductivity of the material. Upon drying, it will not be restored.

Flexible Min-K submerging water tests (5 minutes) and then allowing it to dry results in approximately a 35% increase in thermal conductivity.Testing has shown that when exposed to an environment of 75% humidity for 8 hours Flexible Min-K experienced a weight gain of <5% and an increase in thermal conductivity of approximately 4%. The effects of moisture may become a concern where high humidity and heat for long duration exist.

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Attachment H – Min-K® Email Defining Characteristics of Min-K®

Daniel,
We have a wide range of formulations, but the material you are interested in is about 20% fiber, 65% fumed silica, and 15% TiO_2. This is by weight. The material will not break down entirely, but rather it will break into agglomerates if in a very high shear situation. I don't have the specific gravity data with me, but it is all the same as you would find for those materials in a CRC handbook. We don't have a lot of data on destructive testing, as our Flexible product, which I think is the material that interests you, doesn't really fail within the applications that it is often times used. The vibration tests are generally what are the most challenging (rather than MOR or something of that nature which tends not to apply), and the mode of failure on that test is associated with the breakage of the textile or threads, rather than the core. There is a theory that I have read on this material, though I don't know if it is of any use to you. However, the thought are that each time an aircraft takes off or lands (time during which vibration is the most extreme, the core essentially breaks apart a little. However, because the bonding mechanism is simply OH- bonds, the core re-bonds during times of low vibration. This was a considerable benefit our material has over fiber products which will simply break over time, and hence break down.
I am out of the office today, but can be reached at 574-596-3694 if you need anything immediately. Otherwise, I will give you a call next week to discuss any other issues.
Thanks,
Ken

-----Original Message-----
From: Wilkens, Daniel J [mailto:dwilkens@alionscience.com]
Sent: Wednesday, September 15, 2004 1:34 PM
To: kvannimwegen@thermalceramics.com
Subject: RE: Properties of Min-K

Ken:
My name is Daniel Wilkens, and I am a colleague of Tim's. Thank you for your original email, I was hoping that you could expand on a few points:
• • Can you tell me the percentages of SiO_2, TiO_2, and fiber? This would help us determine an average size for particulates. Please specify volume percent or mass percent.
• • Do you have information on how the insulation breaks down via destruction? Does it break down to elementary particles, does it break down in agglomerates, etc?
• • Do you have the specific gravity, or density, for the individual materials that comprise the Min-K?
Calculation No. SD-0023
Page G2
Revision 0
• • Finally, any information you can give on general destruction characteristics would be extremely helpful.
Thank you very much for the help

Daniel Wilkens
Alion Science and Technology, ITS Operations
6000 Uptown Blvd. NE, Suite 300
Albuquerque, NM 87110
(505) 872-1089 ext. 114 (voice)
(505) 872-0233 (fax)

-----Original Message-----
From: Sande, Timothy D
Sent: Monday, September 13, 2004 2:10 PM
To: Wilkens, Daniel J
Subject: FW: Properties of Min-K

-----Original Message-----
From: VanNimwegen, Ken [mailto:kvannimwegen@thermalceramics.com]
Sent: Wednesday, September 08, 2004 12:23 PM
To: Sande, Timothy D
Subject: RE: Properties of Min-K

Tim,
Please let me know if we can be of any additional help. We also work closely with some fabricators who are involved in nuclear work if you need any installed systems.
Ken

-----Original Message-----
From: Sande, Timothy D [mailto:tsande@alionscience.com]
Sent: Wednesday, September 08, 2004 1:15 PM
To: VanNimwegen, Ken
Subject: RE: Properties of Min-K

Ken,
That information will be helpful. Thank you very much.
Tim

-----Original Message-----
From: VanNimwegen, Ken
[mailto:kvannimwegen@thermalceramics.com]
Sent: Wednesday, September 08, 2004 12:00 PM
To: Sande, Timothy D

Cc: Duchon, Frank; Reisinger, Allen
Subject: RE: Properties of Min-K

Tim,
The as-fabricated density of our product varies with thickness and shape, which is why we tend to provide the core density rather than as-fabricated. With that said, I have attached a TechNote which provides you with the basis weight (mass/area) of our most commonly used flexible products.
Several materials are used in our core product including SiO_2 particles, which are sized from 0.01-0.015 microns, TiO_2 which is sized at less than 5 microns, and fiber products, most of which are between 2.5-10 microns in diameter.
You may also be interested to know that we have two specific formulations which contain an additive to allow us to pass NRC 1.36.
Regards,
Ken Van Nimwegen

-----Original Message-----
From: Sande, Timothy D
[mailto:tsande@alionscience.com]
Sent: Wednesday, September 01, 2004 3:45 PM
To: Min.K@thermalceramics.com
Subject: Properties of Min-K

I'm looking for information on Min-K in order to perform analyses on its use in nuclear power plants. Specifically, I need the as-fabricated density, and the material or particle density and size. Can you provide me with this information or let me know where I can go to get it?
Thank you,

Tim Sande
Assistant Engineer
Alion Science and Technology

Attachment F – Microtherm Email Defining Characteristics of Microtherm

-----Original Message-----
From: Mark Mortimer
Sent: Wednesday, September 15, 2004 9:28 AM
To: Mark Burton
Cc: Geoff Carr; Jeroen Goetschalckx
Subject: RE: Seeking technical support

Dear Mark,

It sounds as though Daniel is working on a calculation of settling rates for the material if completely dispersed in water.

If completely destroyed, Microtherm would revert to the particle sizes of the constituent materials.

Broadly speaking, Microtherm Super G is composed of filaments, fumed silica, and titanium dioxide in proportions of 3%, 58%, and 39%. We usually supply Super G into the nuclear industry but it is worth checking this in case it is Super G hydrophobic, which will float.

The filaments are 6 mm long and 6 microns in diameter. Specific gravity is approx 2.65 g/cc.

The titanium dioxide is irregular but broadly spherical, particle size centred around 2.5 micron, specific gravity 4.2 g/cc.

The fumed silica is a bit more complex, as it is formed of spherical primary particles fused together into irregular three dimensional branched chain aggregates which are further mechanically entangled into approximately spherical porous agglomerates. The agglomerates are centred very roughly around 20 microns diameter and have a specific gravity of around 0.06 g/cc (in air). I think for these purposes the agglomerates can be regarded as the fundamental particle, because it takes a great deal of dispersion energy in a high shear mixer and the use of dispersants to break the agglomerates down to aggregates.

Cabot or Degussa are the manufacturers of fumed silica and could probably offer more information if required. The behaviour of fumed silica in liquids is complex because it tends to form a cross linked gel in many circumstances.

If the Super G is supplied as naked block, it will have a packaged density of 350 kg per cubic meter (0.35 g/cc). If it is supplied as glass cloth covered panel it will have a packaged density of 240 kg per cubic meter (0.24 g/cc).

I hope this answers your questions. Please give me a call if you need any more info.

Best regards
-Mark

Dr Mark Mortimer
Manager, Materials Research Group

Direct Dial: +44 (0)151 6066211
Business Fax: +44 (0)151 606 6216
e-mail: mmortimer@microtherm.uk.com
MICROTHERM INTERNATIONAL LTD., 1 Arrowe Brook Road, Upton, Wirral CH49 1SX, UNITED KINGDOM

-----Original Message-----
From: Mark Burton
Sent: 15 September 2004 14:30
To: Mark Mortimer
Cc: Geoff Carr; Jeroen Goetschalckx
Subject: FW: Seeking technical support

Hello Mark
Mark can you provide me with the proper response for the questions below from Daniel Wilkens? Particle size of Microtherm if completely destroyed , Packed density, and Particle density. If more information is needed from Daniel let me know .Microtherm will be used in a Nuclear facility in New Mexico.

Thanks
Mark

-----Original Message-----
From: Wilkens, Daniel J [mailto:dwilkens@alionscience.com]
Sent: Tuesday, September 14, 2004 10:05 AM
To: Sales US
Subject: Seeking technical support

To Whom It May Concern:

My name is Daniel Wilkens. I am currently working on a calculation for Shearon Harris Nuclear Power Plant involving debris generation, specifically the destruction of insulation due to a high-energy line break. One of the insulation types at Shearon Harris is Microtherm, inserted as 'sheets' into RMI cassettes around the reactor.

I am searching for material properties for this product, specifically the following properties:

Packaged density
Particle size
Particle density

In regard to the above, I am using the following definitions:

Packaged density – the density of the product as shipped to customers
Particle – the fundamental size if Microtherm insulation is completely destroyed

I look forward to your response, thank you for the help.

Regards,

Daniel Wilkens
Alion Science and Technology, ITS Operations

6000 Uptown Blvd. NE, Suite 300
Albuquerque, NM 87110
(505) 872-1089 ext. 114 (voice)
(505) 872-0233 (fax)

-----Original Message-----
From: Mark Mortimer [mailto:mmortimer@microtherm.uk.com]
Sent: Wednesday, December 08, 2004 12:46 AM
To: Wilkens, Daniel J
Subject: RE: Seeking technical support

Dear Daniel,

The proportions are in wt.%.

Best regards
-Mark
-----Original Message-----
From: Wilkens, Daniel J [mailto:dwilkens@alionscience.com]
Sent: 06 December 2004 14:44
To: Mark Mortimer
Subject: RE: Seeking technical support

Mark:
I am writing to confirm a small detail regarding the specifications to microtherm you had provided three months ago. When you listed the proportions of filaments, fumed silica, and titanium dioxide (3%, 58%, and 39%), are these specified as wt% or vol%? This will be very helpful to me if it could be cleared up. Thanks again for all of your help.

Regards,

Daniel Wilkens
Alion Science and Technology, ITS Operations
6000 Uptown Blvd. NE, Suite 300
Albuquerque, NM 87110
(505) 872-1089 ext. 114 (voice)
(505) 872-0233 (fax)

ATTACHMENT H – FOAMGLASS/ARMAFLEX

This attachment contains the fax from Watts Bar containing the Armaflex and Foamglass design basis information used for this analysis.

Memorandum

TENNESSEE VALLEY AUTHORITY

MEB '82 1102 002

TO : J. A. Raulston, Chief, Nuclear Engineering Support Branch, W10C126 C-K

FROM : C. A. Chandley, Chief, Mechanical Engineering Support Branch, W7C126 C-K

DATE : OCT 29 1982

821112C0404 (8)

SUBJECT: WATTS BAR NUCLEAR PLANT UNITS 1 AND 2 - NRC QUESTIONS 212.113 - INSULATION SURVEY

We acknowledge receipt of your memorandum dated May 10, 1982 (NEB 820510 253) requesting additional information on NRC question 212.113. Attached is MEB's response to the request for a detailed insulation survey and questions concerning potential sump screen blockage by insulation.

C. A. Chandley

CLM:DYP
Attachments
cc (Attachments)
I. L. Beltz, W7C143 C-K
J. P. Little, W7C135 C-K
R. M. Pierce, 104 ESTA-K
J. C. Standifer, 204 GB-K
MEDS, W5B63 C-K

Principally Prepared By: C. L. Mills, Extension 2429

E62298.05

ATTACHMENT

Confirmatory Item - Information Request

Background

The response (FSAR Amendments 46 and 48 to RSB questions concerning sump debris (Q212.116) and the Letters referenced do not provide all the information (per Q212.116) necessary to perform a plant specific analytical assessment. Herein is the detailed insulation survey to complete this information.

Question 212.113 (212.116) (6.3)

4. With regard to the sump tests on Watts Bar, the responses to the following concerns pertaining to potential sump screen blockage are required:

a. Various types of insulation may be used in the containment. For each type provide the following information:

(1) The manufacturer, brand name, volume and area covered.

(2) A brief description of the material and an estimate of the tendency of this material either to form particles small enough to pass through the fine screen in the sump or to block the sump trash racks or sump screens.

(3) Location of the material (metal mirrored, foam glass, foam rubber, foam concrete, fiberglass, etc.) with respect to whether a mechanism exists for the material to be transported to the sump.

b. Provide an estimate of the amount of debris that the sump inlet screens may be subjected to during a loss-of-coolant accident. Describe the origin of the debris and design features of the containment sump and equipment which would preclude the screens becoming blocked or the sump plugged by debris. Your discussion should include consideration of at least the following sources of possible debris: equipment insulation, sand plug materials, reactor cavity annulus sand tanks or sand bags for biological shielding, containment loose insulation, and debris which could be generated by failure of non-safety realted equipment within the containment. Entry of sand plug materials into the containment sump and the possibility of sand covering the recirculation line inlets prior to the initiation of recirculation flow from the containment should be specifically addressed.

Please provide this information along with your conclusion regarding the percentage of the screens which would be expected to be blocked by particles of all sizes, including those greater than 250 mils.

c. With respect to the conclusion that debris with a specific gravity greater than unity will settle before reaching the sump cover, consider the potential for flow paths which may direct significant quantities of debris laden coolant into the lower containment in the vicinity of the sump and the availability or lack of sufficient horizontal surface areas or obstructions to promote settlings or holdup of debris prior to reaching the sump.

d. Does metal mirror insulation house other materials, fibrous or otherwise, which could become debris if the insulation were blown off as a result of a LOCA?

e. If the Watts Bar containment contains loose insulation, include examples of how the insulation will be precluded from reaching the sump.

Responses

4(a)(1)

Manufacturer	Brand Name	Volume and Area Covered
Mirror Insulation Division Diamond Power Specialty Corporation	Mirror Insulation	Reactor Vessel, Steam Generators Pressurizer, Reactor Coolant Pumps and Piping, RHR Piping, SIS Piping, Main Steam, and Feedwater Piping
Pittsburgh Corning Corporation	Foamglass	Refrigerant lines and ducts to Instrument Room, 4-foot high band around Containment Vessel, 80 percent of Ice Condenser piping

WATTS BAR NUCLEAR PLANTS UNITS 1 AND 2 - NRC QUESTIONS 212.113 - INSULATION SURVEY

Rubatex Corporation	Rubatex	20 percent of Ice Condenser piping
Owens/Corning Fiberglass	Fiberglass	Piping inside air handling units located in upper plenum area of Ice Condenser (approximately 1 foot of pipe per air handling unit. Also used for crane wall insulation, and wall insulation, and sealing joints of wall panels of Ice Condenser
Christiansen Foam Corporation	Polyurethane Foam	Wall panel insulation between steel air cooling ducts and the concentric steel containment shell
E. R. Carpenter	Polyurethane Foam	Top deck insulation of Ice Condenser
(Furnished by Westinghouse)	Urethane Foam	Insulating inside Ice Condenser doors
Forty-Eight Insulators Incorporated	Mineral Wool	Main pipe penetrations of Containment Vessel

4(a)(2) and 4(a)(3)

Mirror Insulatio is a all-metal reflective insulation constructed of austenetic stainless steel. The metallic reflective insulation is strong mechanically and composed of sections which are latched together when in place. The sections will not segment or breakup into small particles. The sections will sink to the bottom and will remain stationary. Insulation in the vicinity of the pipe break will be blown or stripped off. It is not considered that the sections would be torn apart due to their strong mechanical construction.

Foamglass Insulation is a rigid insulation composed of sealed glass cells. Each cell is an insulating air space. Foamglass is all-glass and is completely inorganic. The insulation on refrigerant lines, ducts, and piping is covered and banded by stainless steel jacketing to minimize or eliminate the conditions whereby the insulation could crumble. The insulation on the containment vessel is covered by a stainless steel sheath. This insulation is also located in areas least affected by postulated pipe breaks (i.e. in upper regions of the containment and outside the crane wall). In addition to it being completely encased as well as being located in areas protected from the effects of pipe breaks, this insulation will float and cannot enter the sump because of a 8.0 foot minimum water level which exists over the sump coverplate before recirculation begins.

Rubatex Insulation is a flexible closed cell rubber type insulation. This insulation is located on portions of the ice condenser system where it is least affected by postulated pipe breaks (i.e. upper plenum area of the ice condenser). This insulation is not expected to suffer damage from any primary system pipe break; however, it should be noted that the insulation will float and could not enter the sump because of a 8.0 foot minimum water level which exists over the sump coverplate before recirculation begins.

J. A. Raulston

WATTS BAR NUCLEAR PLANT UNITS 1 AND 2 - NRC QUESTIONS 212.113 - INSULATION SURVEY

Fiberglass Insulation is a glass fiber preformed pipe insulation encased in a vapor barrier jacket for the air handling units. For the Ice Condenser c… ne wall insulation, end wall insulation, and for sealing the joints in the ice condenser wall, the glass fiber is in blanket form enclosed in polyethylene bags and covered by metal panels. The insulation in all cases is behind metal (i.e. inside housing of air handling unit or under metal wall panels) to protect and assure it does not have a pathway to the sump.

Polyurethane and Urethane Foam Insulation is closed cell urethane resin foam. The polyurethane foam between the air ducts and the containment vessel does not have a pathway to the sump. The polyurethane form insulating the top deck of the Ice Condenser is a blanket between stainless steel sheaths. The assembly rests on floor grating and is hinged at the crane wall to form doors that open upon a LOCA. This assembly maintained its integrity when tested under blowdown conditions that exceeded the worst LOCA. The urethane foam insulating the Ice Condenser inlet doors is completely enclosed. Refer to FSAR Figure 6.7-17 and 6.7-20. These doors have been tested rigorously.

Mineral Wool Insulation is a refactory fiber block insulation laminated and bonded by high temperature binders. The insulation is between the process piping and the penetration sleeve and would not be subject to direct sprays and water from pipe breaks.

4(b)

Restraints will prevent pipe whip thereby limiting the …ount of insulation that could be blown off to that around th… pipe at the break location. The worst case would be a break locate… immediately under the point at which two sections of mirror insulati… abut in the longitudinal direction of the pipe. No more than half … the abutted insulation section could be blown toward the sump.

J. A. Raulston

WATTS BAR NUCLEAR PLANTS UNITS 1 AND 2 - NRC QUESTIONS 212.113 - INSULATION SURVEY

The mirror insualtion is cylindrical on the straight portions of the primary system p'ping. Over elbows, the outside surface is composed of flat sections in the shape of rectangles of the outside and inside bends of the elbow, and in the shape of trapezoids on the elbow sides. The largest single flat outside surface area of the insulation covering an elbow is 6.88 square feet. In cross section, a section end has a parting surface area of 1.79 square feet and the longest straight length has a parting surface area in the longitudinal direction of 2.0 square feet.

The sump is located beneath the refueling canal to provide protection from high energy piping failures. Additionally the area around the sump is enclosed on two sides by concrete walls and on two sides by walls consisting of structural steel and 1/4-inch mesh backed by 1 1/2-inch grating. Considering the curvature of the insulation over straight portions of the primary system piping and the angularity of the insulation over elbows, and the quantity of equipment and supports anchored to the containment floor that would prevent movement of settled insulation sections, the maximum possible screened area that could be blocked is very small. Any contact between an insulation section and the screen wall would most probably be along a line or at a point in the unlikely event that some of the mirror insulation were to fall against the screen wall. Since the insulation covering one elbow together with the insulation covering one straight length of piping is all that could be affected by a given break, there is only one outer flat surface of insulation available to contact the screen wall. The only other flat surfaces either are along longitudinal or transverse parting surfaces.

In the most conservative hypothetical case, the largest flat surfaces area of insulation covering an elbow together with the largest parting surface of the longest straight section could be assumed to be against the screen wall. The total area blocked by these two sections of mirror insulation would be 8.88 square feet of the [illegible] screen area of 265.9 square feet. Therefore, this small blockage would have a negligible effect on sump operation.

4(d)

Mirror insul· ion is made entirely of stainless steel sheet material and does not contain any other materials.

4(e)

Mirror Insulation will not segment or break up into small particles. The sections will sink to the bottom and remain stationary.

Foamglass and Rubatex are installed in a manner and/or in locations that will preclude damage from primary system pipe breaks; however it should be noted that the insulation will float and could not enter the sump because of a 8.0 foot minimum water level which exists over the sump cover plate. This insulation is located outside the crane wall.

Fiberglass is located within the housing of the air handling units used to cool the ice condenser or is covered by metal panels or sheaths. This protection assures that the insulation will not enter the sump.

Polyurethane and Urethane is sandwiched between the steel cooling ducts and the containment vessel or is covered by metal panels or sheaths. This will assure the insulation will not enter the sump.

Mineral Wool is located between the sleeves aend the process pipe for the penetrations. The spider construction of the penetration will prevent the insulation from being pushed from within the penetration. There should be no turbulence or direct sprays directed into the penetration cavities. The penetrations are located outside the crane wall. This should prevent any passageway of the insulation to the sump.

SER Supplement No. 2

NUREG-0847
Supplement No. 2

SAFETY EVALUATION REPORT

related to the operation of
Watts Bar Nuclear Plant
Units 1 and 2
Docket Nos. 50-390 and 50-391

Tennessee Valley Authority

U.S Nuclear Regulatory Commission

6 ENGINEERED SAFETY FEATURES, Supplement 2

6.3 Emergency Core Cooling System - Page 6-1, Supplement 2

6.3.3 Testing - Page 6-1, Supplement 2

To ensure that debris following a loss-of-coolant accident will not compromise the performance of the emergency core cooling system by clogging the sump, the staff asked the applicant to perform a detailed survey of insulation materials used within the containment. The applicant provided this information in a letter dated November 23, 1982. This survey confirms the staff's initial conclusion that the Watts Bar design to provide protection against sump debris is acceptable. The reactor system and main steam piping and components are encased in metal reflective insulation that, if dislocated by a major pipe rupture, would not form small debris particles that would clog the sump screens. Other materials (foam glass, Rubatex, fiberglass, polyurethane foam, urethane foam, and mineral wool) are either encapsulated in steel or located in areas of the containment where they would be unaffected by pipe rupture forces. The staff concludes that the Watts Bar design regarding protection against sump debris is acceptable and this issue, therefore, is closed.

ATTACHMENT I – ICE CONDENSER DEBRIS

This attachment contains the Ice Condenser Loose Debris Listing as provided by Watts Bar.

FOREIGN OBJECTS VS BAYS

Some Item No.s may fall in more than one category.

ICE CONDENSER DEBRIS INDEX

Ice Condenser Debris Index

BAY	BASKET	FLOW	OTHER	LOCATION	DESCRIPTION	EVALUATION #	NOTES
1	A6			Bottom of basket A6	Gray duct tape, 2 to 3 inches in length	105	NEW U1C3
1	C5			Bottom of basket C5	Unidentified debris appearing to be metallic.	98	REMOVED U1C4
1	D8			Bottom of basket D8	Cellophane tape	97	REMOVED U1C4
1	F6	103		2nd lattice from bottom in flow passage	Clear plastic sheet 1' x 2'	100	NEW U1C3
1	G2			Bottom of basket G2	Blue tie	2	REMOVED U1C4
1	I2			Basket I2	Thermal drill head is larger than the openings on the side of the basket	3	
1		42		Flow passage 42, 6-feet from bottom of baskets	Undetermined length of grass tie-off rope	92	
1		138		Flow passage 138, 12-ft up from bottom of baskets	12 inch long, black tie-wrap found	93	
1		151		Outside wall flow passage 151 to 162	Whisk broom dropped to the bottom of the flow area	5	REMOVED U1C3
1			X	End wall and turning vanes - Floor	Window Weight	1	
1			X	Either baskets or floor	Seven (7) screws lost	4	
1	A6			Near baskets A6 and A7	Artic gear glove	111	NEW U1C4
1	NEAR A6	95/96 113/114		24' down from top near A6	Red shackle pin	127	NEW U1C5
1		2		12' down from top	10 # hammer with long handle	128	NEW U1C5
1		145		12' down from top	Electrical tape, 1" x 12"	129	NEW U1C5
1				Near end wall, vertical location unknown	Sheetmetal, 11 ga, formed, 3 pieces approx 1-in x 32-in ea, ASTM A526 or A527	130	NEW U1C5

Ice Condenser Debris Index

BAY	BASKET	FLOW	OTHER	LOCATION	DESCRIPTION	EVALUATION #	NOTES
2	G9	153		Flow passage 153 next to basket G9	Broom trapped in lattice frame	7	
2		46		Flow passage 46, 6 feet up	Stainless steel intermediate deck door ID tag	91	
2		153		6 or 12 foot down from top of lattice frame	Intermediate Brass Deck shim	96	
2	F/G		X	Some where in Bay 2	Ratchet with 1/4-inch socket lossed	6	
2			X	Lower ice	Whisk broom lost	8	
3	G6			Bottom of basket G6	Two drop weights	9	
3	H4			Bottom of basket H4	Wood splinters	99	
4	D3			20' up from bottom	6' of metal banding material	10	
4	D4			Basket D4	C-Zone gloves	11	
4	E8			Basket E8	C-Zone gloves	12	
4			X	Row 9	C-Zone gloves	13	
4	D4			Near baskets D4 and E4	Ink pen	112	NEW U1C4
5	A2			Flow passage near Basket A2 - 6' up from bottom	Plastic hook (small piece of plastic) from tube light found	90	
5	C9	X		Flow passage next to basket C9; 18-feet down in flow passage	Weight and rope,	14	
5	H3			Basket H3 -3' up from bottom	Orange plastic (most likely from the bags used to maintain the ice) found - 2" sq	89	
5		48/49		Bottom of flow passage 48-49, 12 ft. up	Piece of air bag (unknown length) found	88	

Ice Condenser Debris Index

BAY	BASKET	FLOW	OTHER	LOCATION	DESCRIPTION	EVALUATION #	NOTES
6	I/H			Bottom of basket H/I	Yellow plastic found	15	
6			X	Upper area	Putty knife	101	NEW U1C3
7	B7			Outside basket B7, 12 ft. from bottom	Orange tie-wrap found	60	
7	C9			Bottom of basket C9	Small piece of black insulation	16	
8	B8	148		20' down from top	Flashlight in flow passage	102	NEW U1C3
8	B8	X		Flow passage next to basket B8	Safety glasses lodged on a structural member inside of the flow passage	17	
8	E3	X		In upper plenum near E3	1-1/16 inch nut	106	NEW U1C3
8		141		Flow passage 141-6' up from bottom	Metal vacuum nozzle found	87	
8			X	Upper ice baskets; in ice baskets or on the floor	Screw(s) lost	18	
8		141		12' up from bottom	Rubber shoe cover, yellow	131	NEW U1C5
9	A6			Bottom of basket A6	Metal box cutter	122	NEW U1C4
9	B8			Bottom of basket B8	Wrench is is wedged against the side and bottom	19	
9	B8			Bottom of basket B8	Yellow/Black tape is balled up configuration about the size of a golf ball	20	
9	B8			Bottom of basket B8	Plastic safety glasses found	45	
9	C1	X		Outside of basket C1	Thin cable, 1/4"x6" long	86	REMOVED U1C3
9	F6			Bottom of basket F6	Gray tape is balled up configuration about the size of a golf ball	21	REMOVED U1C4

Ice Condenser Debris Index

BAY	BASKET	FLOW	OTHER	LOCATION	DESCRIPTION	EVALUATION #	NOTES
9	F6			Bottom of basket F6	Yellow plastic most likely from bags used to maintain the ice in baskets	22	
9	G6			Basket G6	End of stick light in basket	23	
9	H1			Near baskets H1 and H2	Open end wrench	113	NEW U1C4
9	H7			bottom of basket H7	1" diameter plug of silicone-like caulk	123	NEW U1C4
10	F3			Basket F3 - 45' down from top	Drill head is larger than the basket openings	24	
10	F5/F6	X		Upper plenum in flowpassage near F5/F6	3/8 inch nut	107	NEW U1C3
10	I5			bottom of basket I5	plywood spliter	124	NEW U1C4
10	I7			Bottom of basket I7	Brass coupling found	80	
10	I8			Basket I8 - bottom	Duct tape approximately 6 to 8-inches long found balled up	81	
11	B1			Bottom of basket B1	Piece of electrical wire, 1/4"x2" found inside basket	85	
11	I5			Bottom of basket I5	2 inch square piece of duct tape found wadded	84	
11		141		Flow passage 141	Light cover from tube light	25	
12	D7	125		2nd lattice from bottom	Shiny object - unknown	103	NEW U1C3
12	H3			Bottom of basket H3	Red plastic found	26	REMOVED U1C3
13	B1			Bottom of basket B1	Black metal possibly from banding strap found	27	
13	B4			Basket B4- bottom	Brass shim found	28	

Ice Condenser Debris Index

BAY	BASKET	FLOW	OTHER	LOCATION	DESCRIPTION	EVALUATION #	NOTES
13	C1			bottom of basket C1	rubber like material	125	NEW U1C4
13	H7	118		Flow passage 118, next to basket H7 - 6' down from top	FME tieoff (approximately 6-feet long) fell into the flow passage.	29	REMOVED U1C3
13		135		Flow passage 135, 6 feet up	2'-0" piece of air bag found	83	
13			X	Lost in bay	1/4 - 20 x 1" cap screw	114	NEW U1C4
13	I9			Near basket I9	9/16" open-end wrench	115	NEW U1C4
13			X	Lost in bay	Small nut	116	NEW U1C4
14	A7			Bottom of basket A7	Brass shim found	82	
14	B3			Basket B3	Yellow plastic (most likely from the bags that are used to maintain the ice) found.	30	REMOVED U1C4
14	H7	116		Flow passages 116/118, next to basket H7, 12 feet up from bottom of basket	Strip of red plastic found - 1/2" x 4'	31	
14	H8	137		Flow passage 137, next to basket H8; 6 feet down in flow passage	Brass door shim found	32	
15	F8/F9	138/141		12' down from top.	Thermal drill head with approximately 10' of cable	132	NEW U1C5
16	A9			Basket A9; 8 feet down	Banding material (carbon steel) found	33	
16	F2			Bottom of basket F2	Cellulose based, orange paper found	34	REMOVED U1C4
16	F8			Bottom of basket	1 - inch square plastic UNID name plate	108	REMOVED U1C4
16	I4			Bottom of basket I4	1 inch piece of wood found	79	
16		2		Flow passage 2 - between 6' and 12' up from bottom	Two air bags found, assumed to be part of larger air bag	35	

Ice Condenser Debris Index

BAY	BASKET	FLOW	OTHER	LOCATION	DESCRIPTION	EVALUATION #	NOTES
16		146		Bottom of flow passage 146, 6' up	6 ft. of electrical wire causes a small percentage of blockage	78	
17	D8			Bottom of basket D8	1 inch square plastic sheeting	77	
17	E1			Bottom of basket E1	red duct tape (in a balled up configuration the size of a golf ball) found	36	REMOVED U1C4
17	E6			Bottom of basket E6	Brass shim found	38	
17	F2			Bottom of basket F2	Red tape (balled up in configuration the size of a golf ball) found	39	REMOVED U1C4
17	H1		X	Between basket H1 and wall	Orange plastic (most likely from the bags used to maintain the ice) found	40	
17	I3			Bottom of basket I3	Red duct tape found in a balled up configuration the size of a golf ball	41	
17			X	Either baskets or floor	4-screw heads from top ring are lost	42	
18	A3			Bottom of basket A3	Brass shim found	43	
18	A4			Bottom of basket A4	Brass IDD shim found	37	
18	B3			Bottom of basket B3	3 in. black plastic strip	76	
18	C3			Bottom of basket C3	Black duct tape found in a balled up configuration the size of a golf ball	44	
18	E1			bottom of basket E1	duct tape	126	NEW U1C4
18	F4			Bottom of basket F4	12 in. wadded duct tape found	75	
18	F4			Bottom of basket F4	Brass IDD shim in basket	109	NEW U1C3
18		84		Bottom of flow passage 84, 6 ft up	Brass shim used in lattice frames found	74	

Ice Condenser Debris Index

BAY	BASKET	FLOW	OTHER	LOCATION	DESCRIPTION	EVALUATION #	NOTES
18		139		Bottom of flow passage 139, 9 ft up	5 in. piece of air bag found	73	
18		160		12' up from bottom	Duct tape, red	133	NEW U1C5
19	D5			Bottom of basket D5	Brass shim found	46	
19	D6			Basket D6	Electronic Dosimeter entrained in the ice with the vertical location unknown	94	
20	A5			Bottom of basket A5	Brass shim found	47	
20	C5			Bottom of basket C5	Brass shim found	48	
20	F1			Bottom of basket F1	Brass shim found	72	
20	I5			Bottom of basket I5	Brass shim found	49	
20		33		Flow passage 33, 6 ft from bottom	Cable tie wrap lost	71	
20			X	Currently entrained in the ice, may be in a basket or a flow passage	Lanyard, key ring, keys, TLD,badge and pens may remain as a unit or get separated during a Design Basis event	95	
21	A5			Bottom of basket A5	Brass shim found	70	
21	A8	149		2nd lattice down from top	Brown plastic sheet - shredded - 2" x 2'	104	NEW U1C3
21	D1			Bottom of basket D1	Brass shim found	50	
21	F9			By blast wall in basket F9	Cord used to lower the thermal drill down ice basket found	51	
21		4		20 feet down from top	Drop weight with 20' of white (cotton?) rope attached	110	NEW U1C3

Ice Condenser Debris Index

BAY	BASKET	FLOW	OTHER	LOCATION	DESCRIPTION	EVALUATION #	NOTES
21	I9			Near basket I9	9/16" open-end wrench	117	NEW U1C4
23	A3			Bottom of Basket A3	Plywood, nut and brass shim found	52	
23	A4			Bottom of basket A4	Brass shim found	69	
23	H7			Bottom of basket H7	Duct tape found in a balled up configuration the size of a golf ball	53	REMOVED U1C4
23	I5			Bottom of basket I5	2 in. square piece of white plastic film	68	REMOVED U1C4
23		148		12 ft. up from bottom of flow passage 148	4 in. X 4 in. towel found	67	
23			X	Under the turning vane	Putty knife found	54	
23			X	Lost in bay	Two 9/16" nuts	118	NEW U1C4
24	H3			Bottom of basket H3	Orange paper from a bag that contained tie wraps	59	
24	D7			Bottom of basket D7	Duct tape found in a balled up configuration the size of a golf ball	56	REMOVED U1C4
24	F6			Bottom of basket F6	Stainless Steel banding strip found	57	
24	G6			Basket G6	Dark green plywood (2" x 2" x 1/4") and orange plastic bag material (1" x 3")	58	
24	H8			Bottom of bsket H8	Clear Plastic from bags used to maintain the ice	61	
24	I3			Bottom of basket I3	Brass shim found	62	
24	I5			Bottom of basket I5	3" spare piece of brass shim found	63	
24		97		Flow passage 97	C-Zone Glove found	55	

Ice Condenser Debris Index

BAY	BASKET	FLOW	OTHER	LOCATION	DESCRIPTION	EVALUATION #	NOTES
24		118		6' up from bottom in flow passage 118 and 119 on the outside of the ice baskets	Black banding strip found	66	REMOVED U1C4
24		156		Flow passages 156 and 157, 12 feet from bottom	Air bag found	65	
24			X	Upper ice area, between Crane wall and Row 1	Pry bar lost	64	
24	E1			Near baskets E1 and E2	One 1 1/8" nut	119	NEW U1C4
24	I8			Near baskets and I9	Pencil	120	NEW U1C4
24	Near I6			12' down from top in flow passage	Insulated glove, orange	134	NEW U1C5
??			X	Location unknown	Pencil	121	NEW U1C4

ATTACHMENT J – DIAMOND POWER RMI

This attachment contains the formal letter from Transco stating that from the drawings they sampled, the foil spacing for the Diamond Power RMI is 3 foils per inch.

QA Record   BS8 050524 800

TRANSCO® PRODUCTS INC.
EXECUTIVE OFFICES
Fifty Five East Jackson Blvd.
Suite 2100
Chicago, Illinois 60604-4166
312-427-2818
Facsimile 312-427-4975

BRUCE J. ALPHA
Vice President

Building Excellence in Service · Delivering Energetic Solutions

May 23, 2005

Contract No.
72C61-92750

Mr. Heyward R. Rogers
Engineering Manager
Tennessee Valley Authority
Sequoyah Nuclear Plant
Post Office Box 2000
Soddy Daisy, Tennessee 37384

Dear Mr. Rogers:

In response to your Letter No. 30M518 dated May13, 2005, we have conducted a preliminary review of the Diamond Power design and manufacturing drawings for the reflective metal insulation provided under the Purchase Orders referenced in the letter. While the requested information was not included on the insulation design/assembly drawings, a review of the manufacturing drawings for the following sample component insulation panels established the following information.

Sequoyah Unit 1

Reactor Coolant Pump	2.66" actual insulation thickness with 3 foil liners/inch
Pressurizer	4.00" actual insulation thickness with 3 foil liners/inch

Based on this sample information, it is expected that the number of liners per inch would not change throughout the four (4) projects listed in your letter.

However, confirmation of this expectation will require a concerted effort to retrieve and review all of the insulation manufacturing drawings for the primary components (i.e., reactor vessel, reactor coolant pumps, steam generators and pressurizer) and all piping greater than 3" in diameter (i.e., main steam, main feedwater, pressurizer surge, residual heat removal letdown, cold leg accumulator, safety injection, primary system hot/cold legs and crossover legs) for all four plants.

If TVA requires confirmation of the manufacturing information for all the insulation provided for the four plants, please advise us accordingly and we will provide a resource and schedule estimate for the data retrieval and review.

A CORPORATION OF THE TRANSCO® GROUP

ISO 9001 VERSION 2000

Please contact me at 312-427-2818 (x140) if you have any questions or comments concerning this response.

Very truly yours,
TRANSCO PRODUCTS INC.

Bruce J. Alpha
Vice President

RIMS, WTC-K, w/Attachment

TVA

Tennessee Valley Authority, Post Office Box 2000, Soddy-Daisy, Tennessee 37384-2000

MAY 1 3 2005

Transco Products Incorporated
55 E. Jackson Boulevard, Suite 2100
Chicago, Illinois 60604

Attention: Mr. Edward Wolbert

Gentlemen:

SEQUOYAH AND WATTS BAR NUCLEAR PLANT UNITS 1 AND 2 - THERMAL INSULATION FOR PIPING AND EQUIPMENT - CONTRACT NO. 72C61-92750 - LETTER NO. 30M518

REFLECTIVE METAL INSULATION DESIGN INFORMATION REQUIRED TO SUPPORT NRC GENERIC LETTER 2004-02 CONTAINMENT SUMP ANALYSIS - N2M-150

In response to NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors", TVA is currently conducting an analysis of emergency equipment operation in the reactor containment building for the Sequoyah and Watts Bar Nuclear Plants. The analysis involves quantifying the amount of debris generated during certain postulated piping system breaks inside the reactor containment buildings and evaluating the effect of the debris on the ability to recirculate fluid collected in the containment building sump for post event reactor core cooling.

In quantifying the amount of debris generated under accident conditions for this analysis, we have reviewed the reflective metal insulation originally supplied by the Diamond Power Specialty Company under the subject contract for primary system equipment and piping systems located inside the reactor containment building. To support completion of the debris generation calculation, the following information is required to characterize the type and quantity of debris generated by the impact of a high energy pipe break on insulation supplied by Diamond power.

1. The number of reflective metal foils per inch of insulation thickness.

2. The average thickness of the reflective metal foil.

We have reviewed the documentation file for the subject contract and have not been able to locate this information. To support the TVA analysis, please provide the information outlined in Items 1 and 2 above for the Diamond Power reflective metal insulation provided for Sequoyah and Watts Bar under the subject contract.

The insulation involved in this request was provided under the following Diamond Power Purchase Orders.

Purchase Order	Plant
590008-R	Sequoyah Unit 1
590009-R	Watts Bar Unit 1
590026-R	Sequoyah Unit 2
590027-R	Watts Bar Unit 2

Please review the above request and provide a written response. To support TVA analysis schedules for responding to NRC Generic Letter 2004-02, please provide a response on or before May 20, 2005.

Please contact D. M. Lafever at Sequoyah (423-843-8377) if you have any questions or comments regarding this request.

Sincerely,

for H. R. Rogers, Engineering Manager
Sequoyah Engineering and Materials

ATTACHMENT K – MAIN STEAM AND FEEDWATER BREAKS

This attachment contains the formal letter from Watts Bar discussing Main Steam and Feedwater breaks and the plant licensing basis.

T25 050526 050

May 26, 2005

Westinghouse Electric Corporation
Post Office Box 355
Pittsburgh, PA 15230

Attention: Krish M. Rajan

WATTS BAR NUCLEAR PLANT (WBN)
NUCLEAR STEAM SUPPLY SYSTEMS (NSSS)
CONTRACT- 00026863
LETTER NUMBER W-7850

Subject: WATTS BAR NUCLEAR PLANT UNIT 1 - CONTRACT WORK AUTHORIZATION NO. WESTINGHOUSE-WBN-2005-008-GSI 191 - CONTAINMENT BUILDING SUMP MULTIDIMENSIONAL FLOW MODEL , NRC GENERIC SAFETY ISSUE GSI-191, "ASSESSMENT OF DEBRIS ACCUMULATION ON PWR SUMP PERFORMANCE"

Watts Bar Nuclear Plant's licensing basis is such that a break is not postulated to occur in Main Steam System or Feedwater System lines at the locations where guardpipes are provided when penetrating the crane wall, containment vessel and shield wall. Section 3.6 of the FSAR discusses the analysis methodology and postulated break locations and is analyzed in accordance with NUREG-0800 Section 3.6, Branch Technical Position MEB 3-1. Therefore, a break inside the guardpipe for the Main Steam System piping and Feedwater System piping should not be used to characterize the event for which potential sump blockage could occur. Watts Bar Nuclear Plant feels it prudent to consider a sensitivity analysis for a Main Steam Line Break outside of the guardpipe.

TVA will provide to the NRC the justification for taking an exception to a break in the Main Steam System and Feedwater System lines where protected by guardpipes between the crane wall and shield wall.

Questions may be directed to F.A. Koontz at x1261.

Sincerely,

Frank A Koontz Jr for

W. M. Justice
Acting Site Engineering Manager
EQB 2A-WBN

cc: D. M. Lafever, OPS 3C-SQN
F. A. Koontz Jr., EQB 2A-WBN
C. M. Ledbetter, EQB 2N-WBN
L. L. McCormick, EQB 2N-WBN
R. H. Bryan, Jr., LP 4J-C
J. S. Robertson, EQB 2N-WBN
C. R. Allen, EQB 2N-WBN
EDMS, WT CA-K

ATTACHMENT L – COATINGS

This attachment contains a clarification email from Jon Cavallo, the individual who performed the Enercon Coatings walkdown for Watts Bar.

Tezak, Joe

From: JRCPE@aol.com
Sent: Monday, February 07, 2005 8:11 AM
To: Tezak, Joe
Subject: Re: Watts Bar Coatings...

Joe:

Here's what I've got. The info below is based on TVA Drawing 46W466-1 Rev. 23 and TVA General Construction Specification G-55 (various revisions).

1. The coatings on the steel support structures

All steel was shop or field primed with Carboline Carbo Zinc 11, 2.5 - 5.0 mils DFT. The entire liner plate, and all steel to a dado height of 6' from the lower containment floor were topcoated with Carboline Phenoline 305 4.0-6.0 mils DFT. The Upper Containment Dome was left untopcoated (primer only).

2. The coatings on the concrete inside the crane wall

Concrete floors:

Carboline 295 Surfacer 40-60 mils DFT
Carboline 305 intermediate coat 4.0-6.0 mils DFT
Carboline 305 topcoat 4.0-6.0 mils DFT

Concrete Walls up 6' dado height from the floor:

Same system as floors

3. The coatings under the insulation on the crossover leg and main steam lines (if any)

I can't find any indication that any coating was applied to these surfaces.

4. The coatings on the RCPs

According to TVA Nonconformance Report 8633 dated 7/1/87, the RCP motors were coated by Westinghouse with and unqualified system:

Ameron Dimetcoat 2 Inorganic Zinc Primer
Ameron Amercoat 66 Epoxy Phenolic Topcoat

No DFT's were given, but you can assume the primer at 2.5-5.0 mils and the topcoat at 4-6 mils.

5. Specifications for the 3M-M20C insulation that they say runs on conduit in loops 1, 2, and 4

Not in my rice bowl - ask Enercon

Hope this helps.

Jon

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ATTACHMENT M – COMMENT RESOLUTION

Comment Resolution
Rev.3

Comment	Calc. Section	Comment	Proposed Resolution
1.	Appendix 1 - Item 258	The Post Installation Design Package has progressed to the point since letter W-8078 that the actual volume of Item 258 will be 0.64 ft^3 rather than 0.87. I will send a follow up W-letter to back up this change. This change will probably ripple throughout the calc. So I don't have a problem with the calc stating that the 0.87 ft^3 value will be retained for conservatism (or something like that). - Steve Robertson	EG - Revised per TVA LetterW-8081
2.	Appendix 1 - Item 307	In the Comments Column, insert "W-8078" between the words "Letter" and "dated"- Steve Robertson	EG - Complied
3.	Page 12	Watts Bar survey was completed on 09/06. Ref W Letter LTR-CSA-06-74. total latent debris load was 69.2 lb - Cindy Maples	EG - Complied
4.	Page 23	Watts Bar survey was completed on 09/06. Ref W Letter LTR-CSA-06-74. total latent debris load was 69.2 lb- Cindy Maples	EG - Complied
5.	Page 57, 6th bullet	Revise to the following: The destruction pressure of 2.4 psi and the corresponding ZOI of 28.6D are likely overly conservative for the Min-K with no additional banding in Watts Bar. These ZOI values are for unjacketed Min-K and the installed Min-K at Watts Bar is jacketed in the same jacketing as the RMI. However, the SER instructs to use this value if no test data is available for the plant-specific jacketing. Jet impingement testing has been conducted on the Watts Bar Min-K configuration with additional banding which shows no insulation destruction at distances beyond 10.0D. - Cindy Maples	EG - Complied
6.	Page 57, 7th bullet	Delete. - Cindy Maples	EG - Complied
7.	Page 60:	Reference Westinghouse letter LTR-CSA-06-74.	EG - Complied

ATTACHMENT N – REVIEW CHECKLIST

This attachment contains Alion QA Form 3.4.2 – Design Calculations and Analysis Review Checklist.

ALION
SCIENCE AND TECHNOLOGY

DESIGN CALCULATION & ANALYSIS REVIEW CHECKLIST

Calculation Number: ALION-CAL-TVA-2739-03 Revision: 3

Calculation Title: Watts Bar Reactor Building 631-191 Debris Generation Calculation

CRITERIA	RESPONSE	COMMENTS
Document prepared, formatted & fully legible consistent with the following:		
Applicable Alion Project Plan has been reviewed to determine that the appropriate governing procedure(s) & quality requirements have been correctly implemented?	☑ Yes ☐ No	
Appropriate Revisions of Forms were used (Design Calculation & Analysis Cover Page & Design Calculation & Analysis Review Checklist)	☑ Yes ☐ No	
All required sections are included	☑ Yes ☐ No	
Revision History clearly & accurately documents original or revision(s) made	☑ Yes ☐ No	
Correct header (title & page count)	☑ Yes ☐ No	
Correct Appendix titles & page count	☑ Yes ☐ No ☐ N/A	
Correct Attachment titles & page count	☑ Yes ☐ No ☐ N/A	
Alion Intellectual Property (proprietary &/or confidential) identified on cover & each page?	☐ Yes ☑ No ☐ N/A	Not necessary
The document title is consistent with contents?	☑ Yes ☐ No	
The objective(s) are clearly described?	☑ Yes ☐ No	
Acceptance criteria clearly identified, reasonable & met?	☑ Yes ☐ No ☐ N/A	
Is the technical approach & basis used appropriate, clearly defined & referenced for the stated objectives?	☑ Yes ☐ No	
Have the appropriate initial boundary conditions and plant operating modes been considered?	☑ Yes ☐ No ☐ N/A	
Technical inputs are clearly defined, identified, & appropriately referenced?	☑ Yes ☐ No	
Codes, standards, &/or regulatory requirements are clearly defined, identified & appropriately referenced?	☑ Yes ☐ No ☐ N/A	
Assumptions are clearly defined & adequately justified, or flagged for further verification, (e.g. Open Item)?	☑ Yes ☐ No ☐ N/A	
Mathematical derivations specify all mathematical steps necessary for the Reviewer to clearly understand the conclusions?	☑ Yes ☐ No ☐ N/A	
Empirical correlations used have been correctly applied?	☑ Yes ☐ No ☐ N/A	
Analytical steps verified without recourse to originator?	☑ Yes ☐ No	
Calculations/analyses are clearly presented & consistent with the stated technical approach, design inputs & assumptions?	☑ Yes ☐ No	
Results are clearly presented & reasonable (based on inputs)?	☑ Yes ☐ No	
Uncertainty in calculated results has been considered?	☑ Yes ☐ No	
The conclusions are clearly presented & reasonable?	☑ Yes ☐ No	
If a spreadsheet is used, have the values or formulas been manually verified?	☑ Yes ☐ No ☐ N/A	
If uncontrolled software is used, is it clearly identified & results used only for supplemental insights?	☐ Yes ☐ No ☑ N/A	
Software:		
Was a controlled computer program used? If No, reviewer may skip the next five (5) questions.	☑ Yes ☐ No	
Are computer programs clearly identified as to name & version #?	☑ Yes ☐ No	

ALION SCIENCE AND TECHNOLOGY

DESIGN CALCULATION & ANALYSIS REVIEW CHECKLIST

Calculation Number: Alion-CAL-TVA-2739-03 Revision: 3

Calculation Title: [illegible]

CRITERIA	RESPONSE	COMMENTS
Are computer programs appropriate for intended use?	☑ Yes ☐ No	
Where results rely on computer calculations, the work clearly references the supporting computer runs, & the input & output listings are provided?	☑ Yes ☐ No	
Where computer calculations are used, appropriate analysis parameters are used.	☑ Yes ☐ No	
If client provided software, are terms of use clearly delineated?	☐ Yes ☐ No ☑ N/A	
Additional Criteria:		
Does this analysis support a modification? If No, reviewer may skip the next seven (7) questions.	☐ Yes ☑ No	
Have impacts on plant design/licensing basis been considered and addressed?	☐ Yes ☐ No ☐ N/A	
Have appropriate system interface impacts been considered and addressed?	☐ Yes ☐ No ☐ N/A	
Applicable construction & operating experience has been considered?	☐ Yes ☐ No ☐ N/A	
The specified parts, equipment & processes are suitable for the required application?	☐ Yes ☐ No ☐ N/A	
Specified materials are compatible with each other & the design environmental conditions to which they will be exposed?	☐ Yes ☐ No ☐ N/A	
Adequate maintenance, repair and design features, provisions & requirements are addressed, (including maintenance & in-service inspection accessibility)?	☐ Yes ☐ No ☐ N/A	
Design considered radiation exposure to the public & plant personnel?	☐ Yes ☐ No ☐ N/A	
Is this a specialized or unique analysis that requires specific review items? If yes, list below or attach additional items.	☐ Yes ☑ No	

Add additional line items below (i.e. as many as needed): or, See attached ☐ Yes ☐ No

CRITERIA	APPLICABLE	COMMENTS
	☐ Yes ☐ No ☐ N/A	
	☐ Yes ☐ No ☐ N/A	
	☐ Yes ☐ No ☐ N/A	

Notes:

1. If items above indicate "NO", the calculation is not acceptable unless an explanation is provided in the "Comments" block (exceptions are shaded above).
2. Additional line items may be included (or attached) as necessary in the blank boxes provided above.

Reviewed By	Joseph E. Tezak	[signature]	2/1/[illegible]
	Printed/Typed Name	Signature	Date

ATTACHMENT 2

Calculation Number:	PCI-5464-S01
Calculation Title:	Structural Evaluation of Advanced Design Containment Building Sump Strainers
Client: Performance Contracting Inc.	**Station:** Watts Bar
Project Number: PCI-5464	**Unit(s):** 1
Project Title:	Watts Bar Strainer Qualification

Safety Related Yes ☒ No ☐

Revision	Affected Pages	Revision Description	Approval Signature / Date	Signature / Initials of Preparers & Reviewers
0	All	Initial Issue	Curtis J. Warchol 05/18/2006	Curtis J. Warchol (CJW) Scott T. Nelson (STN)
1	1-5, 10, 13, 17, 19, 21, 17-29, 37, 38, 50, 53, 57, 76, 83, 87-94, 97, 100-107	Revised to incorporate as-built drawings and to incorporate additional client comments	Curtis J. Warchol 08/08/2006	Curtis J. Warchol (CJW) Scott T. Nelson (STN)
2	1-4, 17, 22, 28, 29, 33, 35, 39, 49, 63-64, 94, 100 – 105 Attach. A & B	Revised to incorporate unbalanced pressure loads on the top of the modules. This revision resolves AES CAR 06-006	Curtis J. Warchol Curtis J. Warchol 08/25/2006	Curtis J. Warchol Curtis J. Warchol (CJW) Kishore D. Patel Kishore D. Patel (KDP)

REVIEWER'S CHECKLIST FOR DESIGN CALCULATIONS SHEET 1 of 2

STATION: Watts Bar **NUCLEAR SAFETY RELATED: YES** ☒ **NO** ☐

PROJECT NO: PCI-5464 **CLIENT:** Performance Contracting Inc.

CALCULATION TITLE: Structural Evaluation of Advanced Design Containment Building Sump Strainers

CALC. NO: PCI-5464-S01 **CALC. REV. NO:** 2

INDICATE THE DESIGN INPUT DOCUMENTS USED:

TYPE OF DOCUMENT	DOCUMENT ID, REV AND/OR DATE	YES	N/A	COMMENT
1. General Design Basis	3,4,5,9,21,22,24,25,31,33,34	X		
2. System Description			X	
3. Design information package from related equipment vendor	18, 27, 28	X		
4. Electrical Discipline Input			X	
5. Mechanical Discipline Input			X	
6. Control Systems Discipline Input			X	
7. Structural Discipline Input	7,8,12,13,15,16,17,19,20,26,32,35	X		
8. Specifications	1, 2, 29, 30	X		
9. Vendor Drawings	6	X		
10. Design Standards			X	
11. Client Standards			X	
12. Checked Calculations	14, 23	X		
13. Other (specify)	10, 11 (AES QA Files)	X		

PREPARER'S SIGNATURE: Curtis J. Warchol DATE: 08/25/2006
Curtis J. Warchol

REVIEWER'S SIGNATURE: [signature] DATE: 08/25/2006
Kishore D. Patel

APPROVER'S SIGNATURE: Curtis J. Warchol DATE: 08/25/2006
Curtis J. Warchol

REVIEWER'S CHECKLIST FOR DESIGN CALCULATIONS SHEET 2 of 2

PROJECT NO: PCI-5464

CALC. NO: PCI-5464-S01, Revision 2

REVIEWER TO COMPLETE THE FOLLOWING ITEMS:	YES	NO	N/A	COMMENT
1. Has the purpose of the calculation been clearly stated?	X			
2.. Have the applicable codes, standards and regulatory requirements been:				
A. Properly Identified?	X			
B. Properly Applied?	X			
3. Were the inputs correctly selected and used?	X			
4. A. Was Design Input Log used?		X		
B. If 4A is No, provide Manager's signature in Comment column to signify approval of Design Input Documents used in the calculation.				Curtis J. Warchol
5. Are necessary assumptions adequately stated?	X			
6. Are the assumptions reasonable?	X			
7. Was the calculation methodology appropriate?	X			
8. Are symbols and abbreviations adequately identified?	X			
9. Are the calculations:				
A. Neat?	X			
B. Legible?	X			
C. Easy to follow?	X			
D. Presented in logical order?	X			
E. Prepared in proper format?	X			
10. Is the output reasonable compared to the inputs?	X			
11. If a computer program was used:				
A. Is the program listed on the ASL and has the SRN been reviewed for any program use limitations?	X			
B. Have existing user notices and/or error reports for the production version been reviewed as appropriate?	X			
C. Were codes properly verified?	X			
D. Were they appropriate for the application?	X			
E. Were they correctly used:	X			
F. Was data input correct?	X			
G. Is the computer program and revision identified?	X			

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1.0 PURPOSE/OBJECTIVE

The purpose of this calculation is to qualify the Performance Contracting Inc. (PCI) Suction Strainers to be installed in Tennessee Valley Authority Watts Bar Nuclear Plant Unit 1. This calculation evaluates, by analysis, the strainer modules. The supporting structures (i.e., plenum) associated with the new strainers are evaluated in a separate calculation.

2.0 METHODOLOGY

The evaluations are performed using a combination of manual calculations and finite element analyses using the GTSTRUDL Computer Program, and the ANSYS Computer Program. The evaluations follow the requirements of the TVA Design Specification for Sequoyah Nuclear Plant Unit 1 & 2 and Watts Bar Nuclear Plant Unit 1 for Advance Design Containment Building Sump Strainers, Specification No. SQN/WBN-DS-2005-063-001, Revision 00 (Reference [1]) as supplemented by References [2] and [29].

Seismic Loads

The strainers will be located in the space directly above and surrounding the existing sump pit at floor Elevation 702' - 9 3/8" of the Containment Building. The response spectrum required per Reference [1] is for the 703' elevation of the Reactor Building Interior Concrete.

According to the Design Specification (Reference [1]), the strainers and their supporting elements are required to meet the seismic analysis criteria contained in Appendix D to the Design Specification. The strainer modules are analyzed using the response spectra method using GTSTRUDL Version 25 software. The strainers are considered "passive equipment" and per Reference [2], the design should be based on seismic response spectra generated with 2% damping for the Operating Basis Earthquake (OBE) and 3% damping for the Safe Shutdown Earthquake (SSE). These are conservative damping values for bolted steel structures.

The strainer assemblies are excited in one horizontal and one vertical direction. Since the strainer design is symmetrical, only one horizontal worst case excitation is required. The worst case response would be identical in the other horizontal direction. The enveloped response spectra from the E-W or N-S direction is used, and is applied in the worst case direction for the strainer, which is considered to be parallel with the edges of the strainer disks. The results from the horizontal and vertical seismic cases are combined by absolute summation.

The modal combination is performed by the statistical method (SRSS combination) as per Appendix D of the TVA Design Specification (Reference [1]). The seismic stresses of closely spaced modes (within 10%) are combined by SRSS. Therefore, the TPM (Ten Percent Method) of GTSTRUDL is used for the modal combination. The cutoff frequency is taken at approximately 33 Hz. Zero Period Acceleration (ZPA) residual mass effects for frequencies above 33 hz are considered and combined with the response spectra modal results by ABS.

Operating Loads

Operating loads are comprised of weight and pressure loads. The weight of the strainer includes the weight of the strainer self weight and the weight of the debris which accumulates on the strainer. The debris weight is taken from Reference [23].

The pressure load acting on the strainer is the differential pressure across the strainer perforated plates in the operating condition. Conservatively, this is taken as the hydrostatic pressure associated with the maximum allowed head loss through the debris covered strainers as defined in Section 6.2.1.

Thermal expansion loads are considered negligible. The strainers themselves are free to expand in the vertical direction without constraint. In the lateral direction, the only constraint is at the bottom of the bottom module. Since the modules are attached to a stainless steel plenum, the thermal expansion of the plenum and the strainers should be about equal resulting in negligible thermal stresses on the strainer modules. The design and operating temperatures for the strainers are defined in Section 5.1.

Software

MathCad software is used to generate the calculations. All MathCad calculations are independently verified for accuracy and correctness as if they were manually generated. ANSYS is used for the analysis of the inner gap plate. ANSYS Version 5.7.1 is fully verified with no restrictions or limitations (Reference [11]). GTSTRUDL Version 25 is used in the seismic response spectra analysis of the strainer modules. GTSTRUDL Version 25.0 is verified and validated under the AES QA program as documents in the AES validation and maintenance file (Reference [10]). The validation of GTSTRUDL was a partial validation and only validated certain commands. These commands are listed in the validation report. The GTSTRUDL runs utilize several commands outside the scope of this validation. A list of these commands, and their alternate validation method used for this particular application, is provided below:

Command	Validation Method
GENERATE REPEAT	The GENERATE and REPEAT commands are used to automatically generate member nodes and incidences. These generated items for these models are verified manually.
JOINT TIES SLAVE RELEASES	The JOINT TIES and SLAVE RELEASES commands are used in conjunction with MEMBER TEMPERATURE LOADS to account for the preload on the tension rods. The commands also constrain the pipe spacers and tension rods to move together in certain degrees of freedom. Their use is acceptable because the nodal displacements are manually compared for these nodes to confirm the command is working as planned.
CHANGES DELETIONS ADDITIONS ACTIVE	These commands simply control how the program reads and processes upcoming commands. It is easily verifiable by reviewing the computer output to ensure the results are as expected.

Command	Validation Method
MEMBER TEMPERATURE LOADS	This command applies a specified temperature increase/decrease to a given member. This command is used as a simple way to generate preload in the rods. Its use is acceptable because the preloads produced by this load are verified manually.
DEFINE GROUP	This command groups members and/or joints together for easier specification of member properties and load placements. This command is verified by checking manually that the cross sections and loads are applied properly to each member.
MEMBER ADDED INERTIA	This command is used to apply the mass of the certain strainer components not directly included in the model on to members that would carry their mass for a certain direction of seismic response. This command was verified manually by listing the dynamic mass summary and comparing the total dynamic mass in each direction to the calculated total mass.
PIPE	PIPE is a command used to specify the cross section of the core tube. It is necessary to use this command rather than referencing a pipe cross section from a table because the diameter and thickness are unique to the strainer and are not available in the provided tables. Because GTSTRUDL uses only the section properties when code checking, the properties are printed out for selected members defined by this command and those properties are verified manually.
TABLE 'RBAR' TABLE 'BARS' TABLE 'ROUND' TABLE 'MYCHAN'	These are predefined GTSTRUDL tables that contain steel cross sections for rectangular and round shapes. The members that are defined by these tables are subjected to loadings and then code checked in GTSTRUDL. These tables are verified in the same fashion as for the PIPE command listed above. In addition any code checks performed by GTSTRUDL for these sections are manually verified.

The limitations and program error reports for GTSTRUDL Version 25 (Reference [10]) were reviewed for applicability to the GTSTRUDL runs made for this calculation. The limitations for the 78AISC Code check were found not to be applicable for this calculation (none of the components are subjected to significant torsion, therefore warping torsion stresses would be negligible, and the other limitations deal primarily with structural angle shapes which are not included in this model). Also, steel cross sections that are not available in the GTSTRUDL cross section libraries are created for the face disk edge channels, the external stiffeners, the stiffener collar, the cross braces, and the ends of the external stiffeners where the stiffeners are welded to the cross braces. These cross sections were verified by outputting the computed properties of the cross sections and checking these values manually.

3.0 ACCEPTANCE CRITERIA

The strainer components shall meet the requirements of the codes, standards and regulations listed in Section 3.1 of TVA Design Specification SQN/WBN-DS-2005-063-001, (Reference [1]). Section 3.1 of the Design Specification states that the equipment shall be designed in accordance with the AISC 7th Edition (Reference [9]), therefore the acceptance criteria will primarily be in accordance with this code. In circumstances where the AISC Code does not provide adequate guidance for a particular component, other codes or standards are used for guidance. These alternate codes are discussed briefly below.

The AISC Code does not provide any design guidelines for perforated plate. Therefore, the equations from Appendix A, Article A-8000 of the ASME B&PV Code, Section III, 1977 Edition (Reference [3]) are used to calculate the perforated plate stresses. The acceptance criteria is also based on this code. In addition, the AISC Code does not specifically cover stainless steel materials. Since the strainers are fabricated entirely from stainless steel, the ANSI/AISC N690-1994, "Specification for the Design, Fabrication, and Erection of Steel Safety Related Structures for Nuclear Facilities", Reference [21] is used to supplement the AISC in any areas related specifically to the structural qualification of stainless steel. Note that only the basic acceptance criteria (allowable stresses) are used from the ASME Code and load combinations and allowable stress factors for higher service level loads are not used.

The strainer also has several components made from thin gage sheet steel, and cold formed stainless sheet steel. Therefore, SEI/ASCE 8-02, "Specification for the Design of Cold-Formed Stainless Steel Structural Members", (Reference [22]) is used for certain components where rules specific to thin gage and cold form stainless steel should be applicable. The rules for Allowable Stress Design (ASD) as specified in Appendix D of this code are used. This is further supplemented by the AISI Code (Reference [5]) where the ASCE Code is lacking specific guidance. Finally guidance is also taken from AWS D1.6, "Structural Welding Code - Stainless Steel", (Reference [25]) as it relates to the qualification of stainless steel welds. Detailed acceptance criteria for each type of strainer component is provided in the sections below.

Load Combinations

The applicable load combinations are taken from the Appendix E of the Design Specification (Reference [1]) as supplemented by Reference [30]. The primary governing code for the strainers is AISC 7th Edition. As per Appendix E of the Design Specification (Reference [1]) the structural analysis of the strainers, supports and associated equipment shall considered the following design basis loads.

1. DW - Dead Weight Loads and forces .
2. TOL - Thermal Effect Loads during normal operation (loads imposed by normal operating temperatures, conservatively taken at 140 degrees F per Reference [30]).
3. OBE - Seismic Loads generated by the operating basis earthquake.
4. SSE - Seismic Loads generated by the safe shutdown earthquake.
5. TAL - Thermal Effect Loads during accident operation (loads imposed by accident operating temperatures, taken as the maximum water temperature of 190 degrees F).
6. JIL - Jet Impingement equivalent static load (if applicable) (JIL = 0 for WBN).
7. DIL - Debris Impact equivalent static load (if applicable) (DIL = 0 for WBN).
8. DP - Differential pressure across perforated plates and other pressure boundaries.
9. DEB - Debris weight.

The required load combinations are defined in Reference [30] as:

	Load Condition	Combination	Allowable	
*	Load Combination 1	DW + DEB + DP	1.0 S	Notes 1, 4, 5, 7
*	Load Combination 2	DW + OBE	1.0 S	Notes 1, 6, 7
	Load Combination 3	DW + TOL + OBE	1.5 S	Notes 1, 6, 7
	Load Combination 4	DW + TOL + SSE	1.6 S	Notes 1, 6, 7
	Load Combination 5	DW + DP + DEB + TAL	1.6 S	Notes 1, 4, 5, 6, 7
*	Load Combination 6	DW + JIL + DIL + SSE	1.6 S	Notes 1, 2, 3, 6, 7

* Per Note 3, JIL and DIL are not applicable. Thermal loads, TOL and TAL, are negligible for the strainers as described in Section 2.0. Therefore, only Load Combinations 1, 2, and 6 require detailed evaluation, and Load Combination 6 reduces simply to DW + SSE.

Notes

1. For structural steel, the "S" value is the required section strength based on the elastic design methods and allowable stresses defined in Part 1 of the AISC specification, Seventh Edition, referenced in Section 3.0 of the Design Specification (Reference [1]). The 33 percent increase in the allowable stresses for steel due to seismic or wind loadings permitted by the AISC standard shall not be applied to this evaluation. When alternate codes are used for guidance, the "S" value is defined consistently as described above, except that the standard allowable stresses are taken from these other codes. Additional detail for each type of component is provided below.

   For perforated plates, the "S" value is the allowable stress from the ASME Section III Boiler and Pressure Vessel Code, Section III, 1989 Edition including Appendix A, Article A-8000 provisions for calculating perforated plate stresses.

   For concrete anchor bolt, the tensile and shear forces shall not exceed the allowable loads for the selected anchor bolts in TVA DS-C1.7.1 (Reference [5]). TVA concurrence with anchor bolt selection is required. Thermal stresses on anchor bolts shall be considered and minimized by the design.

2. The AISC allowable stresses for Load Combination 6 shall not exceed the following limits (excluding perforated plate)

$0.9x\ S_y$	for Tension or Bending Stress
$(0.9x\ S_y) / (3.0)^{0.5}$	for Shear Stress
$0.9x\ S_{cb}$	for Compression Stress

   where S_y = minimum specified yield strength of the material, and
   S_{cb} = the critical buckling compressive stress calculated by the AISC equations without the appropriate factor of safety.

3. The Jet impingement load (JIL) and debris impact load (DIL) are negligible for the final strainer design.

4. The differential pressure (DP) shall be the larger of 3.5 feet of water or the design basis head loss as determined by the evaluation performed in response to Section 7.4 of the Specification (Reference [1]).

5. Debris weight shall be considered for Load Combination 1 and 5. The debris weight on the strainer shall be the larger of 25 pounds per square foot applied to the total stariner/flow plenum horizontal footprint, or the maximum calculated debris weight transported to the strainer under design basis conditions.

6. Per Reference [2] and [30], the design and licensing basis of the Watts Bar containment sump intake structures does not require the consideration of a seismic event during recovery from a design basis accident. As the containment sump strainers will only be underwater during the recovery from a design basis event, seismic / structural qualification of the advanced strainers in the flooded condition is beyond the current design and licensing basis of the plant. As such, the hydrodynamic effects of a seismic event which occurs when the strainers are underwater need not be included in the structural evaluation.

7. Per Reference [21], because stainless steel does not display a single, well defined modulus of elasticity, the allowable compression stress equations from the AISC are not applicable for stainless steels. Therefore, the allowable compression stress will be based on the lower allowables from Reference [21] as opposed to those provided in the AISC Code (Reference [9]). Per Q1.5.9.2 of Reference [21], the allowable stresses for tension, shear, bending and bearing for stainless steel can be taken as the same allowables provided for carbon steel, therefore the AISC 7th Edition will be used for allowables for these types of stresses.

GTSTRUDL Code Check

Most support components are qualified using the GTSTRUDL code check features. The GTSTRUDL AISC 7th Edition Code check is not QA verified in AES's QA program, therefore the AISC 8th Edition Code check is used (78AISC). A code reconciliation was performed between the 7th and 8th editions to identify any differences that could affect the results. Although there are differences between the two codes, by reviewing the code provisions checked with regards to the types of members in the model (channels, rods, and bars), there are no significant differences between the AISC 7th Edition requirements and the evaluation performed by GTSTRUDL using the AISC 8th Edition. Therefore, the use of the 8th Edition Code check feature of GTSTRUDL is acceptable for this application with the exception of the allowable compression stress as described above. The effective buckling length factor, K, will be manually adjusted to account for the lower compression stress allowable. See Section 6.5.8 for additional discussion.

The parameter "Code Tolerance" is used in GTSTRUDL to allow for the higher stresses associated with Load Combination # 6. This parameter is used to only flag members with an interaction ratio higher than a certain threshold as a failing member. In this way, if a particular member is only 10% overstressed from standard AISC allowables, it is not flagged as a failing member if the Code Tolerance is higher the 0.10. Based on the allowable stressed defined above for Load Combination # 6, the Code Tolerance is calculated as follows:

$$CT := \min\left(1.6, \frac{0.9S_y}{0.66 \cdot S_y}, \frac{0.9S_y}{\sqrt{3} \cdot 0.4 \cdot S_y}, \frac{0.9}{\frac{12}{23}}\right) - 1 \qquad CT = 0.30$$

where 0.66 Sy is taken as the worst case bending stress allowable for the non-rectangluar members, and 12/23 is taken as the standard code factor of safety against buckling. For rectangular members, the code tolerance for weak axis bending is taken as:

$$CT_{rect} := \frac{0.9}{0.75} - 1 \qquad CT_{rect} = 0.20$$

Edge Channels

The edge channel and the attached perforated plate work as a combined section to resist bending loads. The effective width of the perforated plate that acts in combination with the edge channel is based on Section 2.3 of the ASCE Standard for Cold-Formed Stainless Steel Structural Members (Reference [22]), which provides design guidelines for very thin members such as the perforated plate. The effective width of the plate is limited by the width to thickness ratios such that local buckling of the plate will not occur for the compression face. The minimum spacing and edge distance required for the rivets is based on the AISI (Reference [5]) requirements for screw spacing.

Strainer Perforated Plates

For the perforated plates, the AISC Code does not provide any design guidelines. Therefore, the equations from Appendix A, Article A-8000 of the ASME B&PV Code, Section III, 1977 Edition (Reference [3]) are used to calculate the perforated plate stresses. Note that Article A-8000 refers to Subsection NB for allowable stresses, which are defined in terms of stress intensity limits, S_m. Conservatively, stress limits are based on the standard allowable stress, S, as opposed to S_m. NB-3220 provides stress limits for the primary membrane, and primary membrane plus bending. Based on this section, and as allowed by Reference [29], the allowable stresses for the perforated plate are as follows:

Load Condition	Stress Type	Allowable Stress
Normal/Upset	Primary Membrane Stress Intensity	1.0 S
Normal/Upset	Primary Local Membrane + Bending Stress Intensity	1.5 S

Welds

Welds for strainer components, are qualified per the AISC 7th Edition (Reference [9]). AWS D1.6 (Reference [25]) was reviewed to ensure that any special qualification requirements associated with stainless steel welding were considered. Since the weld allowables provided in AWS D1.6 are essentially the same as allowed for carbon steel welds under AWS D1.1 (Reference [24]), no special adjustments are required to account for stainless steel.

Rivets

There are three areas in the strainer module where rivets are used as fasteners. The disk faces are riveted to the perforated edge channels, the gap disk is fashioned into a ring using two rivets, and the end cover perforated plate is riveted to the end cover stiffener. The rivets' capacities are based on testing. From Reference [18], the capacities of the rivets are taken as the average value from six tests (six tests for shear and six tests for tension). A factor of safety is then calculated according to the ASCE Standard (Reference [22]) as supplemented by the AISI Code (Reference [5]) accounting for the capacities being found experimentally via a small sample group (n = 6). The factor of safety used accounts for the load capacity variation in the test sample. This factor of safety will be used on these ultimate capacities for OBE. An increase of (1 + CT) is allowed for SSE, resulting in a FS / (1 + CT) for SSE.

4.0 ASSUMPTIONS

None

5.0 DEFINITIONS AND DESIGN INPUT

Define, $ksi \equiv 10^3 \cdot psi$ $kips \equiv 10^3 \cdot lbf$ $kPa := 1000 \cdot Pa$ $ORIGIN \equiv 1$

5.1 Material Properties

Material Types per Reference [6g]:

Perforated Plate:	Stainless Steel ASTM A-240, Type 304
Core Tube:	Stainless Steel ASTM A-240, Type 304
Radial Stiffeners:	Stainless Steel ASTM A-240, Type 304
Wire Stiffeners:	Stainless Steel ASTM A-493, Type 302 (Drafted to a higher tensile strength)
Rivets:	Stainless Steel ASTM A-240, Type 304
Tension Rods:	Stainless Steel ASTM A-276, Type 304, Condition B
Bolts:	Stainless Steel ASTM 193 Grade B8, Class 2
Nuts:	Stainless Steel ASTM A-194, Grade 8
Washers:	Stainless Steel ASTM A-240 or A-666 Type 304
Spacer Sleeves:	Stainless Steel ASTM A-312, Type 304
Cable Bracing:	Stainless Steel Type 304
Filler Metal:	Stainless Steel Electrodes ER308 or ER308L

Design Temperature (Reference [30]) $T_{AL} := 190 \cdot F$

Max Operating Temperature (Reference [30]) $T_{OL} := 140 \cdot F$

Since AISC (Reference [9]) does not provide material properties at elevated temperatures, the ASME Code (Reference [3]) is used to determine material properties at elevated temperatures. Properties are defined for three temperatures as shown below.

All Type 302/304 Steels	100 degrees F	140 degrees F	190 degrees F
Modulus of Elasticity (Table I-6.0, Ref. [3]),	$E_{sc} := 28300 \cdot ksi$	$E_{so} := 27925 \cdot ksi$	$E_{sa} := 27650 \cdot ksi$
Yield strength (Table I-2.2, Ref. [3])	$S_{yc} := 30.00 \cdot ksi$	$S_{yo} := 28.00 \cdot ksi$	$S_{ya} := 25.50 \cdot ksi$
Ultimate Strength (Table I-3.2, Ref. [3])	$S_{uc} := 75.0 \cdot ksi$	$S_{uo} := 73.4 \cdot ksi$	$S_{ua} := 71.4 \cdot ksi$
ASME Allowable Stress (Table I-7.2, Ref. [3])			$S := 17.9 \cdot ksi$

Note these properties are conservative for the Type 302 wire stiffeners which are drafted to a higher tensile strength than standard Type 302 stainless steels. Per Reference [33], A-240 Type 302 steel has the same properties as A-240 Type 304, therefore use the properties for Type 304 from Reference [3].

ASTM A-276, Type 304, Condition B (Tension Rods)

S_{ytr} - Yield strength (Ref. [31]), $S_{ytr} := 100 \cdot ksi$

S_{utr} - Ultimate Strength (Ref. [31]) $S_{utr} := 125 \cdot ksi$

Adjusting these values for temperature, using the same reductions as applied for the Condition A material

$S_{ytr} := S_{ytr} \cdot \frac{S_{yo}}{S_{yc}}$ $S_{ytr} = 93.3\ ksi$

$S_{utr} := S_{utr} \cdot \frac{S_{uo}}{S_{uc}}$ $S_{utr} = 122.3\ ksi$

ASTM ASTM 193 Grade B8, Class 2 (Bolting)

S_{yb} - Yield strength (Ref. [34]), $S_{yb} := 100 \cdot ksi$

S_{ub} - Ultimate Strength (Ref. [34]) $S_{ub} := 125 \cdot ksi$

Allowable stresses for bolting materials are taken from Reference [22] and are similarly scaled down for elevated temperature effects in Section 6.13.

Other Miscellaneous Properties

E_c - Modulus of Elasticity of Cable (Reference [27]) $E_c := 12180 \cdot ksi$

Density of stainless steel from Reference [20], $\rho_{steel} := 501 \cdot \frac{lbf}{ft^3}$

Poisson's Ratio of stainless steel from Reference [20], $\nu := 0.305$

Shear Modulus of stainless steel at 190 °F $G_s := \frac{E_{sa}}{2 \cdot (1 + \nu)}$ $G_s = 10594\ ksi$

Density of water at temperature of 20°C (Ref. [12]), $\gamma_{H20} := 62.4 \cdot \frac{lbf}{ft^3}$

Coefficient of Thermal Expansion (CTE) of stainless steel, (going from 70°F to 190°F (Ref. [3], Table I-5.0) $CTE := 8.77 \cdot 10^{-6}$

5.2 Strainer Geometry and Dimensions

All data are per Ref. [6] unless otherwise noted.

Perforated Plate Dimensions

Mean thickness of 16 gage perforated plate as per Reference [28] $t_{perf} := 0.0595 \cdot in$

Hole diameter of perforated disk plate, $D_{disk.holes} := 0.085 \cdot in$

Pitch distance between holes in disk plate (Center-to-center distance) $P_{disk.holes} := 0.1406 \cdot in$

Disk Dimensions (Ref. [6a] & [6b])

Strainer disk size

$L1_{disk} := 28.0 \cdot in$

$L2_{disk} := 28.0 \cdot in$

Number of disks per strainer module

$N_{disk} := \begin{pmatrix} 6 \\ 7 \end{pmatrix}$ (Ref. [6d])

Strainer disk edge channel dimensions

$d_{chan} := 0.5 \cdot in$

$b_{chan} := 0.5 \cdot in$ (Ref. [6h])

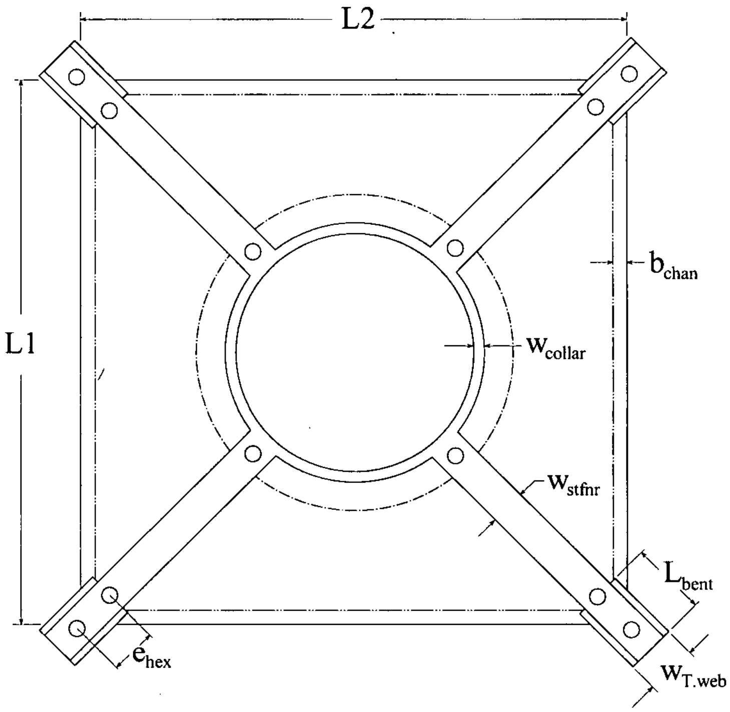


Figure 5.2-1 - Top view of Strainer Module

Width of each middle disk assembly (Ref. [6h])

$W_{disk} := d_{chan} + 2 \cdot t_{perf}$ $W_{disk} = 0.619 \, in$

Width of gap spacing between consecutive disks (Ref. [6h])

$W_{gap} := 1.0 \cdot in$

Welded Radial Stiffener Dimensions (All data per Ref. [6a & 6b] unless otherwise noted)

The disks are supported by radial stiffeners which are welded to the core tube.

Thickness of welded radial stiffeners $t_{stfnr} := 0.25 \cdot in$

Width of welded radial stiffeners $w_{stfnr} := 2.25 \cdot in$

Width of radial stiffener collar $w_{collar} := 0.96875 \cdot in$

Width of top stiffener (bent-up) channel web $w_{T.web} := 3.25 \cdot in$

Width of bottom stiffener (bent-down) channel web $w_{B.web} := 3.75 \cdot in$

Width of top and bottom stiffener (bent) channel flanges $w_{bent} := 1.75 \cdot in$

Length of the channel portion of the radial stiffener $L_{bent} := 2.875 \cdot in$

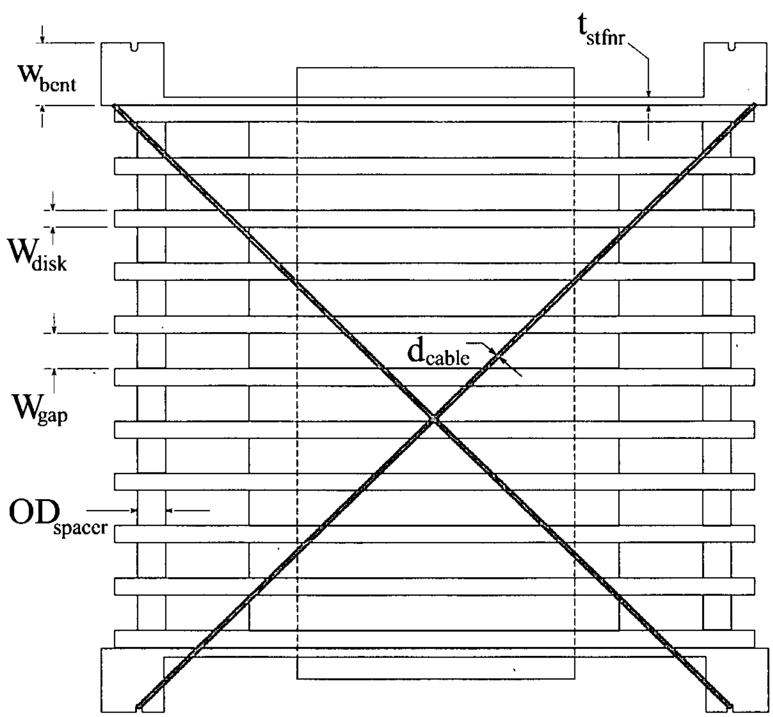


Figure 5.2-2 - Side view of Strainer Module

Tension Rod Dimensions (All data per Ref. [6a & 6b] unless otherwise noted)

Number of tension rods $N_{rod} := 8$

Tension rod diameter $OD_{rod} := 0.5 \cdot in$

Tension rod tensile diameter $OD_{tens} := OD_{rod} - \frac{0.9743 \cdot in}{13}$ $OD_{tens} = 0.425\, in$ (Ref. [9])

Outside diameter of pipe spacers (1/2" dia pipe, sch. 80) $OD_{spacer} := 0.84 \cdot in$

Thickness of pipe spacers $t_{spacer} := 0.147 \cdot in$

Eccentricity between edge of disk and outer tension rod $e_{rod} := 0.9375 \cdot in$

Nominal tension rod tightening torque $T_{rod} := 35 \cdot ft \cdot lbf$

Core Tube Dimensions (All data per Ref. [6a & 6b] unless otherwise noted)

Outer diameter of core tube $OD_{tube} := 13.25 \cdot in$

Corrosion Allowance / Fabrication Tolerance $t_{ca} := 0.0 \cdot in$

Core tube wall thickness (16 ga.) $t_{16ga} := 0.0598 \cdot in$ (Ref. [9])

Core tube wall thickness after allowance $t_{tube} := t_{16ga} - 2 \cdot t_{ca}$ $t_{tube} = 0.0598\, in$ (Ref. [9])

Outer diameter of disk gap $OD_{gap} := 15.75 \cdot in$ (Ref. [6h])

Number of rows of core tube holes $N_{hole} := \begin{pmatrix} 6 \\ 7 \end{pmatrix}$ (Ref. [6j])

Number of core tube holes per row $N_{hole.circ} := 4$ (Ref. [6j])

Radial stiffener to core tube weld thickness $t_{w.ct} := 0.0625 \cdot in$

Radial stiffener to core tube weld length (per individual weld) $w_{w.ct} := 1.5 \cdot in$

Outer diameter of the debris stop $OD_{debris} := 15.25 \cdot in$

Inside diameter of core tube sleeve (at base) $D_{sleeve} := 13.375 \cdot in$ (Ref. [6i])

Width of Core Tube Sleeve $W_{sleeve} := 2.5 \cdot in$ (Ref. [6i])

Core tube sleeve wall thickness (16 ga.) $t_{sleeve} := 0.0598 \cdot in$ (Ref. [6i])

The orientation of the hole along the circumference $\phi := \begin{pmatrix} 0 \\ 90 \\ 180 \\ 270 \end{pmatrix} deg$

Rivet Dimensions (All data per Ref. [6h] unless otherwise noted)

Number of edge channel rivets per disk side $N1_{rivet} := 8$ $N2_{rivet} := 8$

Rivet head radius $c_{rivet} := .1875in$ (Ref. [6g])

Number of intermediate disk face rivets $N_{rivet.face} := 0$

Number of inner gap rivets holding the hoop together $N_{rivet.hoop} := 2$

Number of end cover rivets $N_{rivet.end} := 16$ (Ref. [6i])

Eccentricity between the edge channel rivets and the adjacent edge of disk $e_{rivet} := 0.3125 \cdot in$

Approximate offset from line from center of core tube and center of outer rod $e_{off} := 1.75 \cdot in$ (not shown on dwg.)

Internal Wire Stiffener Dimensions (All data per Ref. [6h] unless otherwise noted)

Number of intermediate circumferential stiffeners $N_{circ} := 1$

Diameter of radial wire stiffeners (7 ga) $d_{wire.rad} := 0.177 \cdot in$ (Ref. [6a/b])

Maximum diameter of circumferential wire spacers (8 ga) $d_{wire.circ} := 0.162 \cdot in$ (Ref. [6a/b])

Inner circumferential stiffener width $L_{circ.in} := OD_{tube} + 1.5 \cdot in$ $L_{circ.in} = 14.75\,in$

Outer circumferential stiffener width (Side 1) $L1_{circ.out} := L1_{disk} - 1.875 \cdot in$ $L1_{circ.out} = 26.125\,in$

Outer circumferential stiffener width (Side 2) $L2_{circ.out} := L2_{disk} - 1.875 \cdot in$ $L2_{circ.out} = 26.125\,in$

Corner distance for outer circumferential $L_{circ.cor} := 1.5 \cdot in$

Other Miscellaneous Dimensions (All data per Ref. [6a & 6b] unless otherwise noted)

Length of hex coupling $L_{hex} := 2.5 \cdot in$

Outer dimensions of 1 1/6" Hex Coupling (C is point-to-point, F is flat-to-flat) * $C_{hex} := 1.25 \cdot in$ $F_{hex} := 1.0625 \cdot in$

Effective outside diameter of hex couple $OD_{hex} := 0.5 \cdot (C_{hex} + F_{hex})$ $OD_{hex} = 1.15625\,in$

Inside diameter of hex coupling $ID_{hex} := 0.50 \cdot in$

* 1 1/6" hex bar is 1 1/6" flat-to-flat. Per AISC (Ref. [9]), this is equivalent to a 5/8" heavy hex nut which has a 1.25" C dimension (corner-to-corner)

Eccentricity between outer tie rod and hex coupling $e_{hex} := 1.875 \cdot in$

Nominal diameter of connecting bolts $OD_{bolt} := 0.5 \cdot in$

Cross Section Metal Area of Bracing Cable $A_{cable} := 0.029 \cdot in^2$ (Ref. [27])

Effective Diameter of cross bracing cables $d_{cable} := \sqrt{\frac{4}{\pi} \cdot A_{cable}}$ $d_{cable} = 0.192\ in$

End Cover Stiffener Dimensions (All data per Ref. [6i] unless otherwise noted)

Number of radial spokes $N_{spoke} := 8$

Number of circumferential rings $N_{circ.end} := 1$

Thickness of spokes and rings $t_{end} := 0.375 \cdot in$

Width of radial spokes $w_{spoke} := 0.25 \cdot in$

Width of circumferential rings $w_{circ} := 0.25 \cdot in$

Radius of circumferential rings $R_{circ.end} := \begin{pmatrix} 0.5 \\ 4.125 \end{pmatrix} \cdot in$

Mean thickness of end cover mounting tabs (11 ga.) $t_{11ga} := 0.1196 \cdot in$ (Ref. [9])

Width of end cover mounting tabs $w_{end.tab} := 1.25 \cdot in$

End cover tab all around weld thickness $t_{w.tab} := 0.125 \cdot in$

Cap plate width $w_{cap} := 2.1875 \cdot in - 0.125 \cdot in$

Mean cap plate thickness (11 ga.) $t_{cap} := 0.1196 \cdot in$ (Ref. [9])

Cap plate diameter $D_{cap} := 13.5 \cdot in$

Leg size for end cover stiffener weld $t_{w.spdr} := 0.125 \cdot in$

Core Tube Hole Pattern (All data per Ref. [6j] unless otherwise noted)

The hole/slot distributions along the length the core tube are given in terms of dimensions H (the width of the slot (W on the PCI drawing)) and L2, the length of the slot (H on the PCI drawing). The length of the slot (L2) is orientated along the axis of the core tube. There are four holes around the circumference of each row. There are N_{hole}, number of rows. H is provided in array format, where the rows are the hole locations, the first row being the lowest hole, and the last being the highest hole. The first column represents the holes associated with the 0 and 180 degree locations of a module, and the second column represents the holes associated with the 90 and 270 degree locations of a module. The hole size are based on an average 6 disk strainer module. Use the middle 6 disk module of the 4 module stack.

$k := 1 .. N_{hole_1}$ $\quad j := 1 .. 2$

0 90 deg

$$H := \begin{pmatrix} 2.70 & 2.70 \\ 2.89 & 2.89 \\ 3.09 & 3.09 \\ 3.33 & 3.33 \\ 3.61 & 3.61 \\ 3.98 & 3.98 \end{pmatrix} \cdot in$$

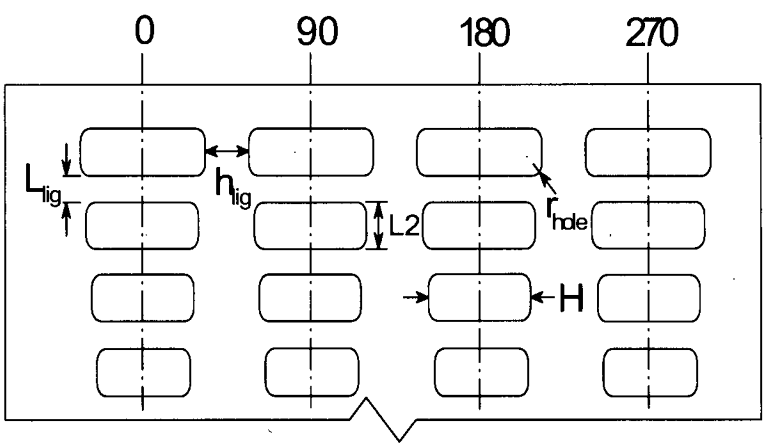


Figure 5.2-3 - Partial View of Core Tube Layout

(Figure is a partial view of complete layout, see Ref. [6j])

$L2 := 0.958 \cdot in$

$L_{lig} := 0.5 \cdot in$

$r_{hole} := \min\left(\frac{H}{2}, 0.25 \cdot in\right)$

Note the holes at 0 degrees and 180 degrees are the same size, and the holes at 90 degrees and 270 degrees are also the same size. The maximum hole sizes for any module are given below.

0 90 deg

$H_{max} := (8.88 \quad 8.88) \cdot in$

$L2_{max} := 0.958 \cdot in$

6.0 CALCULATIONS

6.1 Weight Calculations

The weights of the strainer components are calculated piece by piece

Core Tube

Length of core suction tube (stacked-disk length only),

$L_{strnr} := N_{disk} \cdot (W_{disk}) + (N_{disk} - 1) \cdot W_{gap}$ $\qquad L_{strnr} = \begin{pmatrix} 8.71 \\ 10.33 \end{pmatrix} in$

Length of core tube extension (beyond active strainer length, including gap)

$L_{stub} := \frac{1}{2} \cdot (L_{hex} + 2 \cdot t_{stfnr})$ $\qquad L_{stub} = 1.50\, in$

Overall effective length of core tube (includes gap between core tube)

$L_{tube} := L_{strnr} + 2 \cdot L_{stub}$ $\qquad L_{tube} = \begin{pmatrix} 11.71 \\ 13.33 \end{pmatrix} in$

Inner diameter of perforated core tube,

$ID_{tube} := OD_{tube} - 2 \cdot t_{tube}$ $\qquad ID_{tube} = 13.1\, in$

Weight of the core tube not considering the holes (not including stub pieces)

$Wt_{tube} := \rho_{steel} \cdot \frac{\pi}{4} \cdot \left(OD_{tube}^2 - ID_{tube}^2\right) \cdot L_{strnr}$ $\qquad Wt_{tube} = \begin{pmatrix} 6.3 \\ 7.4 \end{pmatrix} lbf$

Surface Area of the holes

$A_{hole} := \overrightarrow{(H \cdot L2)} - \left(4 \cdot r_{hole}^2 - \pi \cdot r_{hole}^2\right)$ $\qquad A_{hole} = \begin{pmatrix} 2.53 & 2.53 \\ 2.71 & 2.71 \\ 2.91 & 2.91 \\ 3.14 & 3.14 \\ 3.4 & 3.4 \\ 3.76 & 3.76 \end{pmatrix} in^2$

The total volume of holes per module (averaged between the upper and lower modules), is

$Vol_{holes} := \frac{N_{hole.circ} \cdot t_{tube}}{2} \cdot \sum_{j=1}^{2} \sum_{i=1}^{N_{hole_1}} A_{hole_{i,j}}$ $\qquad Vol_{holes} = 4.41\, in^3$

$Wt_{perf.tube} := Wt_{tube} - \begin{pmatrix} Vol_{holes} \\ 0.5 \cdot Vol_{holes} \end{pmatrix} \cdot \rho_{steel}$ $\qquad Wt_{perf.tube} = \begin{pmatrix} 5.0 \\ 6.8 \end{pmatrix} lbf$

Core Tube Sleeve

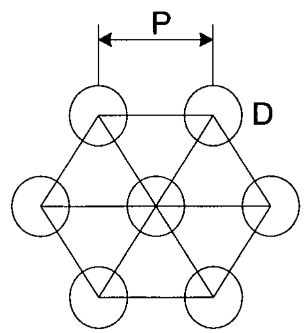
Number of sleeve $\qquad N_{sleeve} := 4$

$Wt_{sleeve} := N_{sleeve} \cdot \frac{\pi}{4} \cdot \left[(D_{sleeve} + 2 \cdot t_{sleeve})^2 - D_{sleeve}^2 \right] \cdot W_{sleeve} \cdot \rho_{steel}$ $\qquad Wt_{sleeve} = 7.3\ lbf$

Perforated Plate

The disks, outer rims, and inner gaps are made from perforated plate. Calculate the percentage of open area for the perforate plate (perf plate).

Perforation ratio (open area) of perforated disk plates,



Disk plate area $\qquad A_{dp} := \frac{P_{disk.holes}^2 \cdot \sin(60 \cdot deg)}{2}$ $\qquad A_{dp} = 0.0086\ in^2$

Open area $\qquad A_{op} := \frac{\pi \cdot D_{disk.holes}^2}{4} \cdot \frac{3}{6}$ $\qquad A_{op} = 0.0028\ in^2$

Perforation ratio $\qquad PR_{disk} := \frac{A_{op}}{A_{dp}}$ $\qquad PR_{disk} = 33.1\ \%$

The perforated plate stresses are calculated based on an equivalent solid plate. Equivalent solid plate stresses are multiplied by the ratio of the hole spacing (pitch) divided by the ligament width (see Reference [4]). Therefore, the perforated plate stress multiplier is:

Ligament width between holes in perf plate,

$h_{disk.holes} := P_{disk.holes} - D_{disk.holes}$ $\qquad h_{disk.holes} = 0.0556\ in$

The stress increase ratio for perf plate is therefore

$K_{pp} := \frac{P_{disk.holes}}{h_{disk.holes}}$ $\qquad K_{pp} = 2.53$

The weights of the perf plate are broken down into three parts. The disk face plates, the disk outer channels, and the disk inner gaps.

$$Wt_{face} := \left(L1_{disk} \cdot L2_{disk} - \frac{\pi}{4} \cdot OD_{gap}^{\ 2}\right) \cdot 2 \cdot t_{perf} \cdot (N_{disk}) \cdot (1 - PR_{disk}) \cdot \rho_{steel} \qquad Wt_{face} = \begin{pmatrix} 81.5 \\ 95.1 \end{pmatrix} lbf$$

$$Wt_{edge} := (d_{chan} + 2 \cdot b_{chan}) \cdot t_{perf} \cdot 2 \cdot (L1_{disk} + L2_{disk} - 2 \cdot b_{chan}) \cdot N_{disk} \cdot (1 - PR_{disk}) \cdot \rho_{steel}$$

$$Wt_{edge} = \begin{pmatrix} 11.4 \\ 13.3 \end{pmatrix} lbf$$

$$Wt_{gap} := \pi \cdot OD_{gap} \cdot t_{perf} \cdot (1 - PR_{disk}) \cdot \rho_{steel} \cdot (N_{disk} - 1) \cdot (W_{gap}) \qquad Wt_{gap} = \begin{pmatrix} 2.9 \\ 3.4 \end{pmatrix} lbf$$

<u>Welded Radial Stiffeners</u>

The weight of the corner welded radials is calculated below

The length of the stiffener from the outside of the collar to the outer tie rod (beginning of bent up channel) is

$$L_{stfnr} := \sqrt{\left(\frac{L1_{circ.out}}{2}\right)^2 + \left(\frac{L2_{circ.out}}{2}\right)^2} - \left(\frac{OD_{tube}}{2} + w_{collar} + \frac{1}{16} \cdot in\right) \qquad L_{stfnr} = 10.82\ in$$

Therefore, the weight of the radial stiffeners (including collars and bent up channels) is

$$Wt_{stfnr} := \left[4 \cdot \left[(4 \cdot w_{bent} + w_{T.web} + w_{B.web} - 4 \cdot t_{stfnr}) \cdot L_{bent} + 2 \cdot w_{stfnr} \cdot L_{stfnr}\right] \cdot t_{stfnr} \cdot \rho_{steel}\right] \ldots$$
$$+ 2 \cdot \left[\pi \cdot \left(OD_{tube} + \frac{1}{8} \cdot in + w_{collar}\right) \cdot w_{collar} \cdot t_{stfnr} \cdot \rho_{steel}\right]$$

$$Wt_{stfnr} = 31.28\ lbf$$

(Note the steel removed for holes is not subtracted, rather it takes the place of the weight of the nuts)

Intermediate Wire Stiffeners

The intermediate wire stiffeners are made up of two layers of radially orientated stiffener wires supporting the perforated plate, separated by a single layer of stiffener wire orientated in the circumferential direction. The radially orientated stiffeners are arranged in a zig-zag pattern. Additionally, there are corner radial stiffeners that are curved around the tension rods which hold the stiffener wires in place. The radial wires support the perforated plate for suction pressure. They are not physically attached to the perforated plate; they only support the plate through bearing. The circumferentially orientated stiffeners are there to support the radial stiffeners. Welds connect the radial wires to the circumferential wires, but these welds are considered non-structural as the load is transferred in bearing. The circumferential stiffeners are simply in compression through their thickness and serve to maintain the spacing between the radial wires for the suction pressure load case.

The wire pattern is designed such that the outer bends are aligned with the edge rivets. The rivets are spaced equally along each edge, with the first and last rivets offset from the edge a certain distance. Therefore, in order to determine the spacing of the wire stiffeners, this offset must first be calculated. The distance from the edge of the disk to the first edge channel rivet is found by drawing a line from the center of the core tube to the center of the outside rod. Offsetting that line by 1.25" in both directions and finding the points where these lines intersect with lines drawn parallel with the disk edges that are offset 0.25" inward, the locations of the first edge channel rivets for side 1 and side 2 are found.

$$\alpha_{disk.1} := \text{atan}\left(\frac{L2_{disk} - 2\cdot e_{rod}}{L1_{disk} - 2\cdot e_{rod}}\right) \qquad \alpha_{disk.1} = 45.00\ \text{deg}$$

$$\alpha_{disk.2} := \text{atan}\left(\frac{L1_{disk} - 2\cdot e_{rod}}{L2_{disk} - 2\cdot e_{rod}}\right) \qquad \alpha_{disk.2} = 45.00\ \text{deg}$$

$$d_{rivet.edge.1} := e_{off}\cdot\sin(\alpha_{disk.1}) \ldots + e_{rod} - \left(\frac{e_{rod} - e_{off}\cdot\cos(\alpha_{disk.1}) - e_{rivet}}{\tan(\alpha_{disk.1})}\right) \qquad d_{rivet.edge.1} = 2.787\ \text{in}$$

$$d_{rivet.edge.2} := e_{off}\cdot\sin(\alpha_{disk.2}) \ldots + e_{rod} - \left(\frac{e_{rod} - e_{off}\cdot\cos(\alpha_{disk.2}) - e_{rivet}}{\tan(\alpha_{disk.2})}\right) \qquad d_{rivet.edge.2} = 2.787\ \text{in}$$

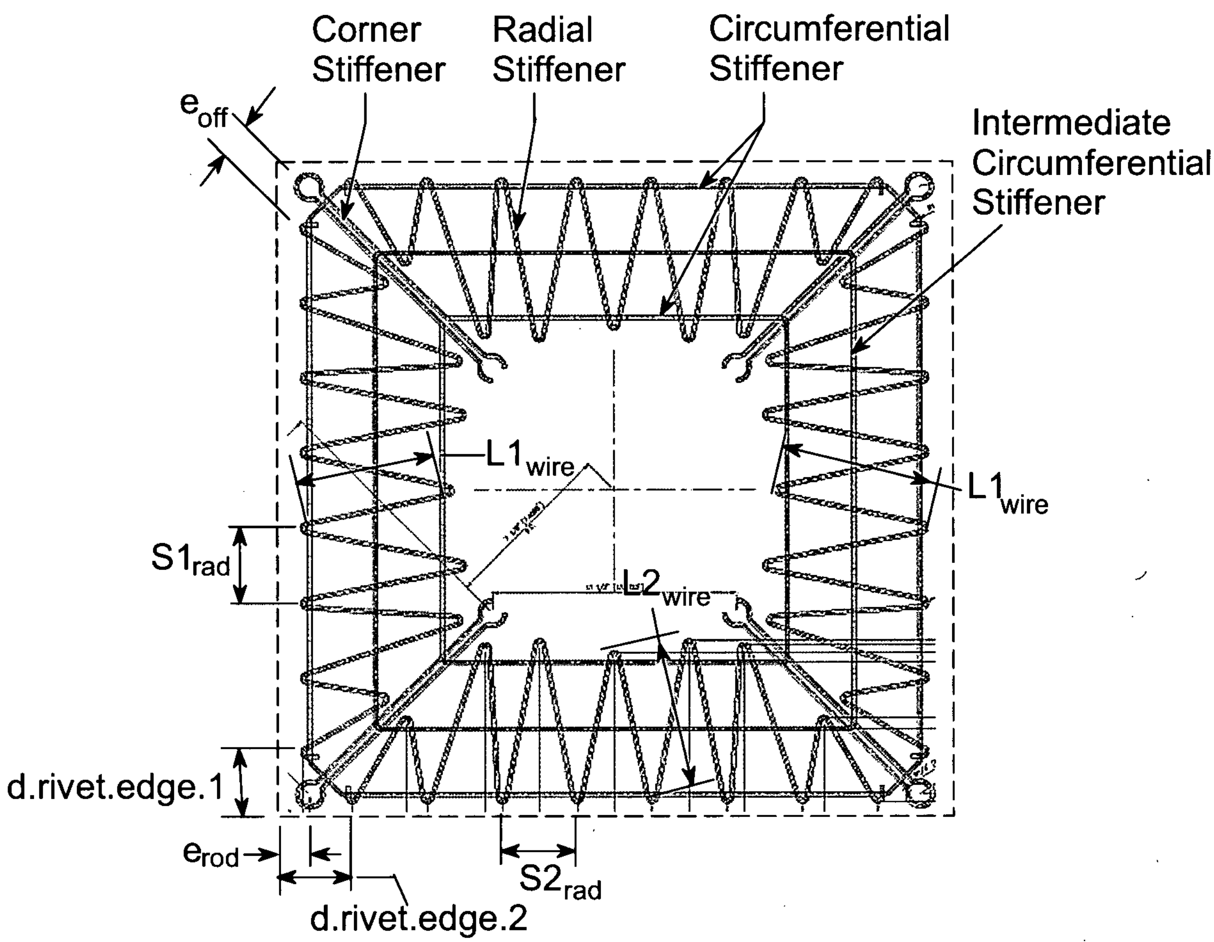


Figure 6.1-1 Internal Wire Stiffeners

(actual configuration may differ)

Therefore, the spacing of the wire stiffeners is

$$S1_{rad} := \frac{L1_{disk} - 2 \cdot d_{rivet.edge.1}}{N1_{rivet} - 1} \qquad S1_{rad} = 3.20\,in$$

$$S2_{rad} := \frac{L2_{disk} - 2 \cdot d_{rivet.edge.2}}{N2_{rivet} - 1} \qquad S2_{rad} = 3.20\,in$$

The length of each radial wire (not including corners) is calculated below,

$$L1_{wire} := \sqrt{\left(\frac{S1_{rad}}{2}\right)^2 + \left(\frac{L1_{circ.out} - L_{circ.in}}{2}\right)^2} \qquad L1_{wire} = 5.91\,in$$

$$L2_{wire} := \sqrt{\left(\frac{S2_{rad}}{2}\right)^2 + \left(\frac{L2_{circ.out} - L_{circ.in}}{2}\right)^2} \qquad L2_{wire} = 5.91\,in$$

The total length of the zig-zag radial wires is calculated below. 3/4" is added to each spoke to account for the extra material overhanging the circumferential support wires. A 1/2 length segment is considered on each end.

$$L_{radial} := (L1_{wire} + 0.75 \cdot in) \cdot (N1_{rivet} + 4) + (L2_{wire} + 0.75 \cdot in) \cdot (N2_{rivet} + 4) \qquad L_{radial} = 159.81\,in$$

The corner radials wrap around the corner tension rod spacers to hold them in place, therefore their length is calculated as follows

$$L_{corner} := 2 \cdot \left[\sqrt{\left(\frac{L1_{circ.out}}{2}\right)^2 + \left(\frac{L2_{circ.out}}{2}\right)^2} - \frac{OD_{gap}}{2} - \frac{OD_{spacer}}{2}\right] + \frac{3}{2} \cdot (2 \cdot \pi) \cdot \left(OD_{spacer} + d_{wire.rad} + \frac{1}{32} \cdot in\right)$$

$$L_{corner} = 30.24\,in$$

$$Wt_{radial} := 2 \cdot N_{disk} \cdot \left(\frac{\pi}{4}\right) \cdot d_{wire.rad}^{\;2} \cdot (4 \cdot L_{corner} + 2 \cdot L_{radial}) \cdot \rho_{steel} \qquad Wt_{radial} = \begin{pmatrix} 37.7 \\ 44.0 \end{pmatrix} lbf$$

The circumferential stiffener wires consist of a square shaped inner wire, and rectangular shaped outer wire offset slightly in from the edge of the edge channel with the corners trimmed to clear the outer tension rods. Additional circumferential wires (if used) are approximately equally spaced and their length is considered equal to the average length between the inner and outer wires.

$$L_{inner} := 4 \cdot L_{circ.in} \qquad L_{inner} = 59.00\,in$$

$$L_{outer} := 2 \cdot (L1_{circ.out}) + 2 \cdot (L2_{circ.out}) - 4 \cdot (2 - \sqrt{2}) \cdot L_{circ.cor} \qquad L_{outer} = 100.99\,in$$

$$Wt_{circ} := N_{disk} \cdot \frac{\pi}{4} \cdot d_{wire.circ}^{\,2} \cdot \left[L_{inner} + L_{outer} + N_{circ} \cdot \left(\frac{L_{inner} + L_{outer}}{2}\right)\right] \cdot \rho_{steel} \qquad Wt_{circ} = \begin{pmatrix} 8.6 \\ 10.0 \end{pmatrix} lbf$$

Tension Rods

$$L_{rod} := L_{strnr} + 2 \cdot in \qquad L_{rod} = \begin{pmatrix} 10.71 \\ 12.33 \end{pmatrix} in$$

The total weight of the tension rods is

$$Wt_{rod} := 8 \cdot L_{rod} \cdot \frac{\pi}{4} \cdot \left(OD_{rod}^{\,2}\right) \cdot \rho_{steel} \qquad Wt_{rod} = \begin{pmatrix} 4.9 \\ 5.6 \end{pmatrix} lbf$$

Cross Bracing Cables

$$L_{cable} := 4 \cdot \left(\sqrt{L1_{disk}^{\,2} + L_{strnr}^{\,2}} + \sqrt{L2_{disk}^{\,2} + L_{strnr}^{\,2}}\right) \qquad L_{cable} = \begin{pmatrix} 234.60 \\ 238.77 \end{pmatrix} in$$

$$Wt_{cable} := \frac{\pi}{4} \cdot d_{cable}^{\,2} \cdot L_{cable} \cdot \rho_{steel} \qquad Wt_{cable} = \begin{pmatrix} 2.0 \\ 2.0 \end{pmatrix} lbf$$

Spacers

$$L_{spacer} := N_{disk} \cdot d_{chan} + \left(N_{disk} - 1\right) \cdot W_{gap} \qquad L_{spacer} = \begin{pmatrix} 8.00 \\ 9.50 \end{pmatrix} in$$

$$ID_{spacer} := OD_{spacer} - 2 \cdot t_{spacer} \qquad ID_{spacer} = 0.55\,in$$

$$Wt_{spacer} := 8 \cdot \frac{\pi}{4} \cdot \left(OD_{spacer}^{\,2} - ID_{spacer}^{\,2}\right) \cdot L_{spacer} \cdot \rho_{steel} \qquad Wt_{spacer} = \begin{pmatrix} 5.9 \\ 7.1 \end{pmatrix} lbf$$

Module-to-module connectivity

$$Wt_{hex} := 2 \cdot 4 \cdot \frac{\pi}{4} \cdot \left(OD_{hex}^{\,2}\right) \cdot L_{hex} \cdot \rho_{steel} \qquad Wt_{hex} = 6.1\,lbf$$

(Use outside diameter to account for both hex nuts and connecting bolts. Multiply by two to account for bolt heads and cross bracing cable connection hardware)

End Cover

$$Wt_{ec} := \left[\frac{\pi}{4}\left(D_{cap}^{\,2}\right) \cdot t_{perf} \cdot \left(1 - PR_{disk}\right) + \pi D_{cap} \cdot w_{cap} \cdot t_{cap} \cdots + \left[\frac{D_{cap}}{2} \cdot N_{spoke} + \pi\left[D_{cap} + \sum_{n=1}^{N_{circ.end}+1} \left(2 \cdot R_{circ.end_n}\right)\right]\right] \cdot \left(t_{end} \cdot w_{spoke}\right)\right] \cdot \rho_{steel} \qquad Wt_{ec} = 8.1\,lbf$$

Total Weight and CG of Strainer

Component	Weight	
Core Tube	$Wt_{perf.tube} = \begin{pmatrix} 5.0 \\ 6.8 \end{pmatrix} lbf$	(6 disk module) (7 disk module)
Disk Faces	$Wt_{face} = \begin{pmatrix} 81.5 \\ 95.1 \end{pmatrix} lbf$	
Disk Edge Channels	$Wt_{edge} = \begin{pmatrix} 11.4 \\ 13.3 \end{pmatrix} lbf$	
Disk Inner Gaps	$Wt_{gap} = \begin{pmatrix} 2.9 \\ 3.4 \end{pmatrix} lbf$	
Welded Radial Stiffeners	$Wt_{stfnr} = 31.3\,lbf$	
Radial Wire Stiffeners	$Wt_{radial} = \begin{pmatrix} 37.7 \\ 44.0 \end{pmatrix} lbf$	
Circumferential Wire Stiffeners	$Wt_{circ} = \begin{pmatrix} 8.6 \\ 10.0 \end{pmatrix} lbf$	
Tension Rods	$Wt_{rod} = \begin{pmatrix} 4.9 \\ 5.6 \end{pmatrix} lbf$	
Rod Spacers	$Wt_{spacer} = \begin{pmatrix} 5.9 \\ 7.1 \end{pmatrix} lbf$	
Cross Bracing Cables	$Wt_{cable} = \begin{pmatrix} 2.0 \\ 2.0 \end{pmatrix} lbf$	
Hex Couplings	$Wt_{hex} = 6.1\,lbf$	
End Cover	$Wt_{ec} = 8.1\,lbf$	
Sleeve	$Wt_{sleeve} = 7.3\,lbf$	

Total weight of one strainer module

$$Wt_{strnr} := Wt_{perf.tube} + Wt_{face} + Wt_{edge} + Wt_{gap} + Wt_{stfnr} \ldots + Wt_{radial} + Wt_{circ} + Wt_{rod} + Wt_{spacer} + Wt_{cable} + Wt_{hex}$$

$$Wt_{strnr} = \begin{pmatrix} 197 \\ 225 \end{pmatrix} lbf$$

(not including end cover or sleeve)

(Note that the weight of the sleeves that connect module to module were not included in the GTSTRUDL model. This weight is small and can be neglected)

6.2 Strainer Loads

The loads on the strainer are comprised of weight, pressure, and dynamic loads. The applicable loads and load combinations are described in Section 3.0.

6.2.1 Pressure, Weight, and Thermal Loads

Two weight loads are applicable. This includes the weight of the strainer components themselves (WT), and the weight of the debris which accumulates on the strainer (WD). The weight of the strainer modules is calculated in Section 6.1 and is summarized below.

$WT := Wt_{strnr}$ $\quad WT = \begin{pmatrix} 197 \\ 225 \end{pmatrix} lbf$ (6 disk module) (7 disk module) (not including end cover)

The weight of the debris per strainer module used in the analysis is shown below. These values are slightly higher than the actual debris weights calculated in Reference [23]. This weight is included in the GTSTRUDL model and is spread out over the surface area of the perforated plate. These values far exceed the 25 pounds per square foot minimum weight specified in Reference [30].

$WD := \begin{pmatrix} 259 \\ 303 \end{pmatrix} \cdot lbf$ (6 disk module) (7 disk module) (Reference [23]) (actual values from Reference [23] are 239 lbf for the 6-disk module, and 280 lbf for the 7-disk module. Use of these higher weights is conservative)

Thermal expansion loads are zero because the strainers are essentially free standing structures and for the most part free to expand without restraint. In the lateral direction, both the strainers and the top of the plenum expand about equally since both are made from stainless steel. Therefore thermal loads are considered negligible and are taken equal to zero.

The differential pressure load (DP), is pressure load across the perforated plate during accident conditions when the strainers are covered with debris. This is conservatively based on the maximum allowable hydrostatic pressure drop across the debris covered strainers provided in Reference [1] and [29].

$DP := 3.5 \cdot ft \cdot \gamma_{H20}$ (Reference [1] and [29]) $\quad DP = 1.52\, psi$

Pressure is for the most part equalized on all strainer surfaces, except that the pressure force on the strainer end cap of the top strainer modules is not balanced. This is applied in GTSTRUDL as a pressure force to the four joints at the intersection of the core tube and the top radial stiffener of the top module (Joints 4161 to 4164). The magnitude of the pressure force per joint is:

$P_{ec} := \frac{1}{4} \cdot DP \cdot \frac{\pi}{4} \cdot D_{sleeve}^{2}$ $\quad P_{ec} = 53.3\ lbf$

6.2.2 Seismic Inertia Loads

A response spectra analysis is performed to analyze the seismic inertia loads. The seismic analysis methodology is detailed in Section 2.0. The response spectra are taken from Reference [2]. The 2% damping spectra at Elevation 703' is used for the OBE load case, and the 3% damping spectra is used for the SSE case. The response spectra in the horizontal direction are enveloped at each frequency for the E/W and N/S directions. These enveloped spectra are shown in the figures below:

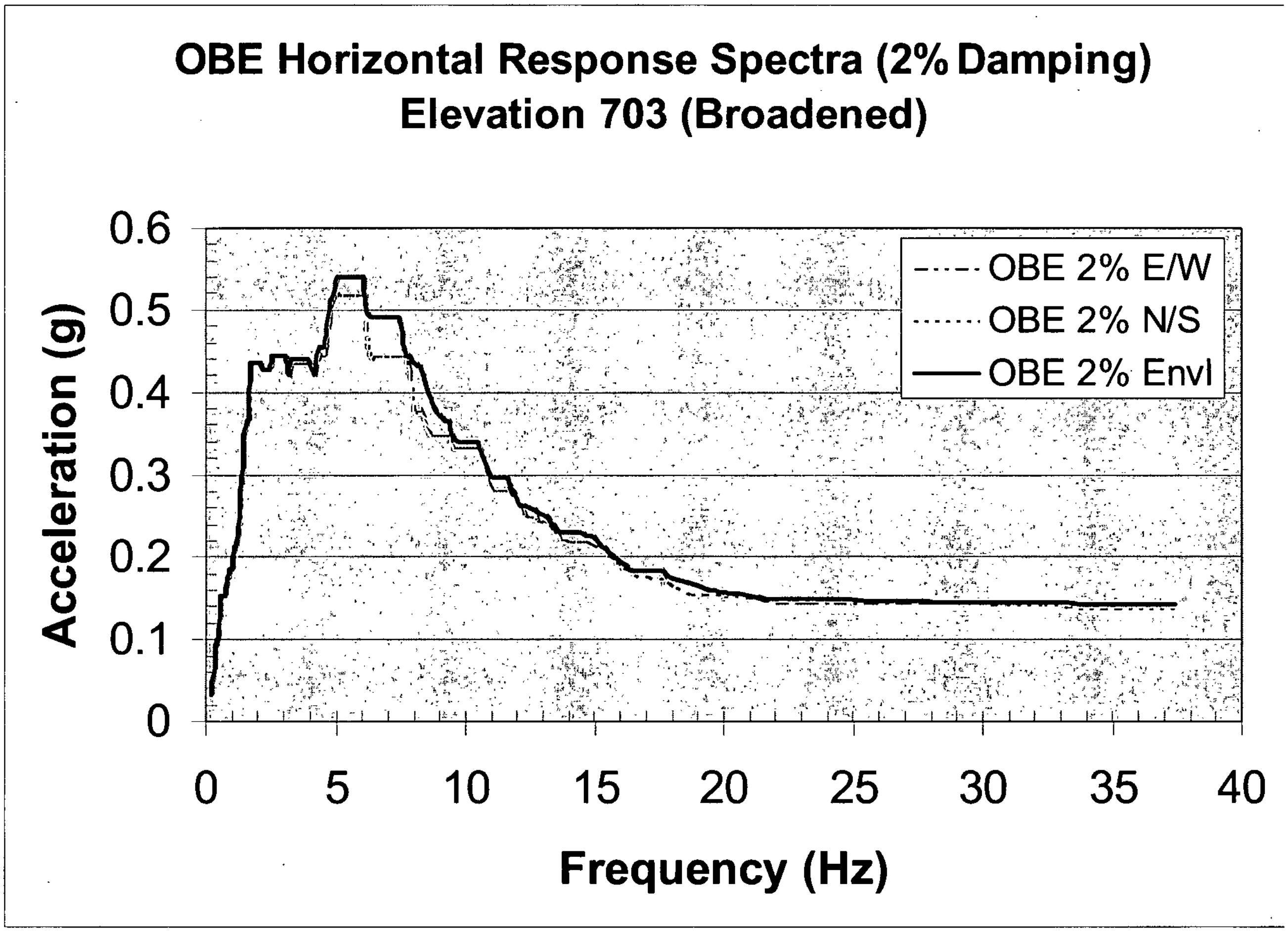


Figure 6.2-1 OBE Horizontal Response Spectra

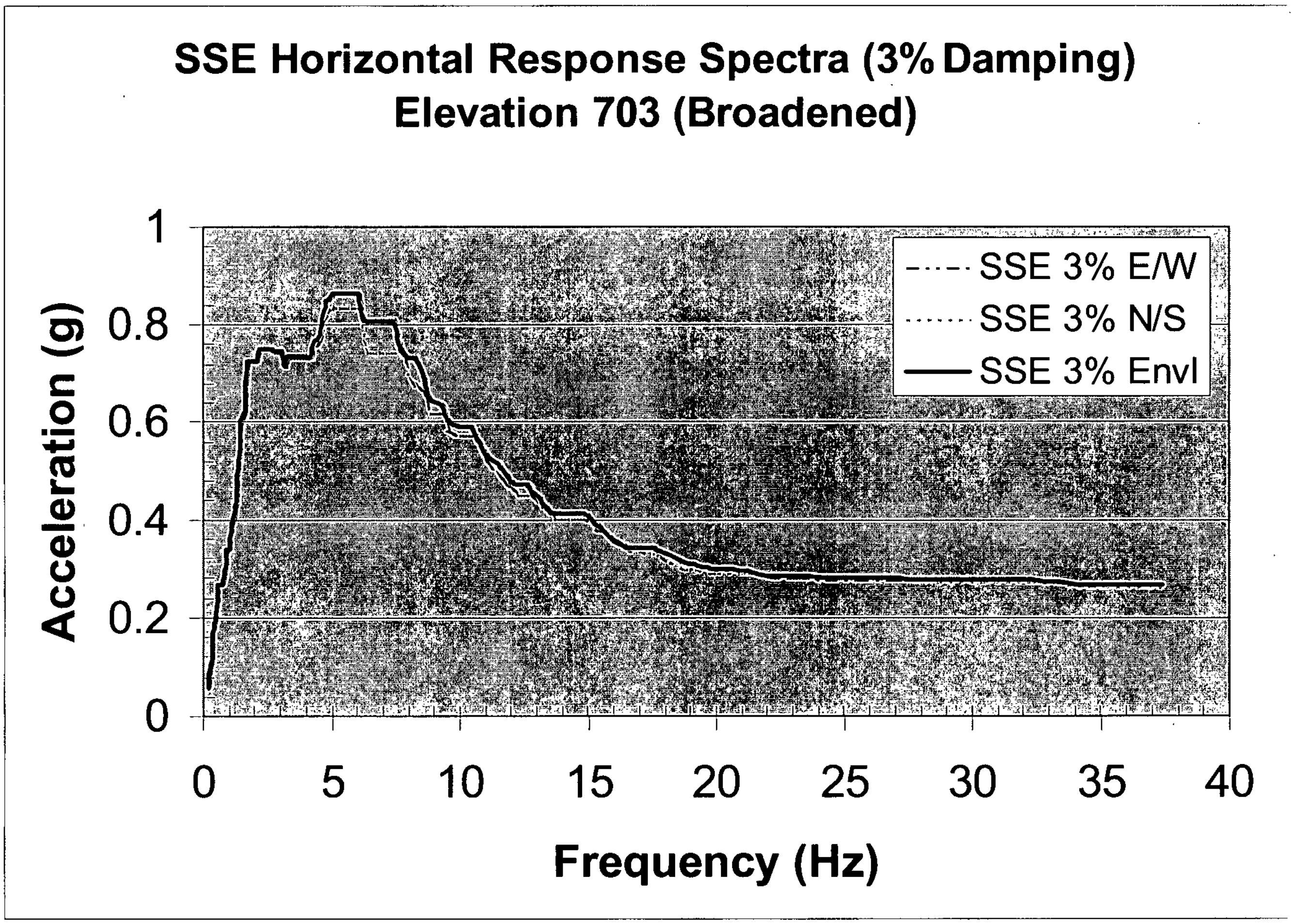


Figure 6.2-1 SSE Horizontal Response Spectra

The actual digitized data points can be seen in the GTSTRUDL input file included as Attachment A. The peak of the response spectra are shown below:

$h := 1 .. 2$ (h = 1 corresponds to OBE, and h = 2 corresponds to SSE)

$a_h := \begin{pmatrix} 0.541 \\ 0.864 \end{pmatrix}$ OBE / SSE $a_v := \begin{pmatrix} 0.335 \\ 0.562 \end{pmatrix}$ OBE / SSE

6.3 Calculation of Strainer Surface Area

The enclosed volume of one strainer module (including 1/2 the core tube volume between modules) is,

$L_{disk} := W_{disk} \cdot N_{disk}$ (total length of all disks) $L_{disk} = \begin{pmatrix} 3.71 \\ 4.33 \end{pmatrix} in$

$L_{gap} := W_{gap} \cdot (N_{disk} - 1)$ (total length of all gaps) $L_{gap} = \begin{pmatrix} 5.00 \\ 6.00 \end{pmatrix} in$

The projected area of the strainer modules in each of the three directions

$A_{proj.x} := L_{disk} \cdot L2_{disk} + L_{gap} \cdot OD_{gap} + L_{stub} \cdot OD_{tube}$ $A_{proj.x} = \begin{pmatrix} 1.41 \\ 1.64 \end{pmatrix} ft^2$

$A_{proj.y} := L1_{disk} \cdot L2_{disk}$ $A_{proj.y} = 5.44\ ft^2$

$A_{proj.z} := L_{disk} \cdot L1_{disk} + L_{gap} \cdot OD_{gap} + L_{stub} \cdot OD_{tube}$ $A_{proj.z} = \begin{pmatrix} 1.41 \\ 1.64 \end{pmatrix} ft^2$

The approximate strainer surface area is calculated below (note this is for structural purposes only, this value may somewhat differ from that used in the head loss calculations which is calculated more accurately)

$A_{s.gap} := \pi \cdot OD_{gap} \cdot W_{gap} \cdot (N_{disk} - 1)$ $A_{s.gap} = \begin{pmatrix} 1.72 \\ 2.06 \end{pmatrix} ft^2$

$A_{s.edge} := 2 \cdot (L1_{disk} + L2_{disk}) \cdot W_{disk} \cdot N_{disk}$ $A_{s.edge} = \begin{pmatrix} 2.89 \\ 3.37 \end{pmatrix} ft^2$

$A_{s.end} := \left(L1_{disk} \cdot L2_{disk} - \frac{\pi}{4} \cdot OD_{tube}^2\right)$ $A_{s.end} = 4.49\ ft^2$

$A_{s.mid} := \left(L1_{disk} \cdot L2_{disk} - \frac{\pi}{4} \cdot OD_{gap}^2\right)$ $A_{s.mid} = 4.09\ ft^2$

$A_s := A_{s.gap} + A_{s.edge} + A_{s.end} \cdot 2 + A_{s.mid} \cdot (2 \cdot N_{disk} - 2)$ $A_s = \begin{pmatrix} 54.50 \\ 63.50 \end{pmatrix} ft^2$

6.4 GTSTRUDL Model

6.4.1 General Description

The analysis of the strainer modules is performed using GTSTRUDL. Due to the similarity between modules, only one stack of strainer modules is analyzed. The modules are essentially identical with the only difference being the hole sizes in the core tube. The critical stack is the taller one, composed of one 7 disk module, and three 6 disk modules stacked on top of each other. The modules are connected with hex couplings at the four corners and the core tubes are connected with sheet metal sleeves. These sleeves can take shear loads and axial compression loads (through bearing) but not tension. The sleeves are considered as axial supports for the downward vertical loads (Pressure, Dead Weight, and Debris) but are released for seismic load combinations (since they do not resist tension). Conservatively, the sleeves are also released for shear therefore all shear loads are transferred through the hex couples. Note, the bands have a fairly large capacity in shear so there is not a concern that the bands will fail in shear due to relative lateral motion between the core tubes. The GTSTRUDL model contains the main structural elements of the module. The perforated plate and internal wire stiffeners are not included in the model (except for their mass). The following member types are included in the model:

Member Type	Member Numbers
Welded Radial Stiffener Arms	'RADS1' to 'RADS64'
Collar (Debris Stop)	'COL1' to 'COL64'
Bent Up Portions of Stiffeners	'BENT1' to 'BENT32' and 'PA1 to 'PA32' 'PC9' to 'PC40' 'PAB1 to 'PAB32' and 'PBC9' to 'PBC40'
Hex Couplings	'HEX1 to 'HEX32'
Outer Tension Rods	'OROD501' to 'OROD529' (increment range by 100 for each additional strainer)
Outer Rod Spacers	'SPCR501' to 'SPCR529' (increment range by 100 for each additional strainer)
Inner Tension Rods	'IROD101' to 'IROD129' (increment range by 100 for each additional strainer)
Inner Rod Spacers	'SPCR101' to 'SPCR129' (increment range by 100 for each additional strainer)
Core Tube	'CT1' to 'CT29'
Core Tube to Core Tube Sleeve	'CTS1' to 'CTS3'
Edge Channels	'EC1001' to 'EC1112' 'EC2001' TO 'EC2096' 'EC3001' TO 'EC3096' 'EC4001' TO 'EC4096'
Cross Bracing Cables	'CABLE1' to 'CABLE32' and 'PB1' to 'PB16'
Core Tube Rigid Links	'RIGID1' to 'RIGID32'
Links Between Modules	'ELMNT1' TO 'ELMNT16' and 'ELMNT17' to 'ELMNT20'

A solid plot of the GTSTRUDL model is provided below. Additional single line plots are included in Attachment C which show the specific member numbers. The model is displayed group by group in these plots such that the numbers are readable without overlapping one another.

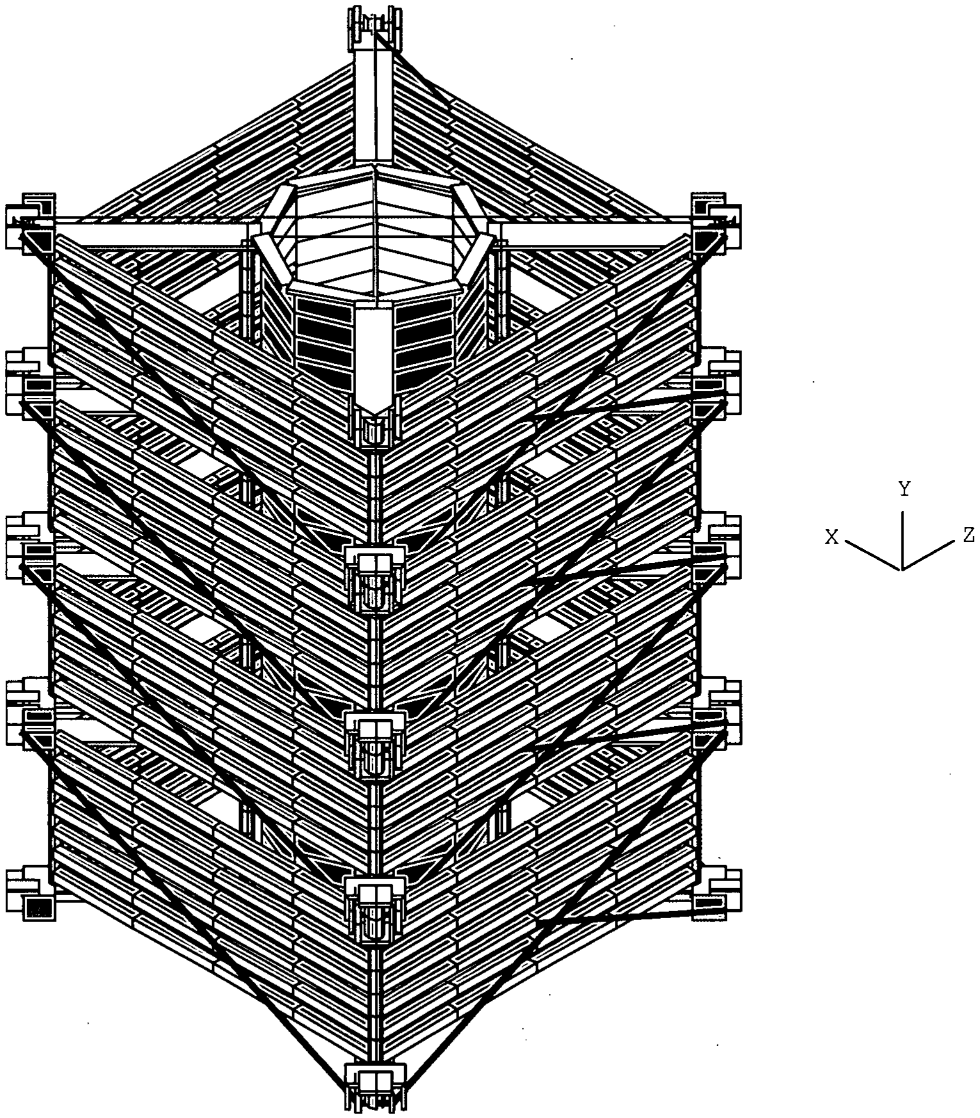


Figure 6.4-1 GTSTRUDL Model (Solid Model)

A couple stick model representations are shown below with the overall dimensions given

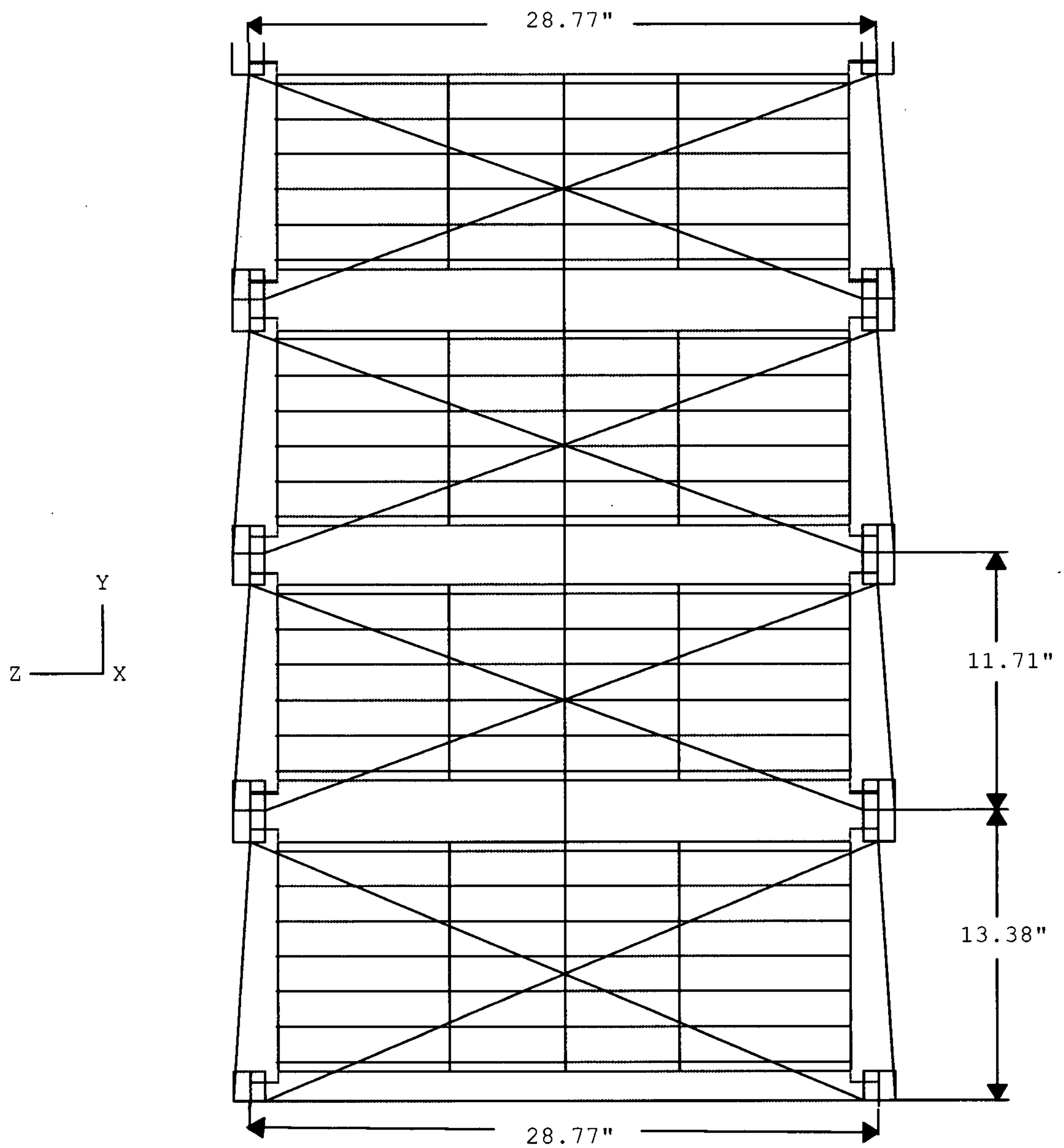


Figure 6.4-2 GTSTRUDL Model (Stick Model Side View)

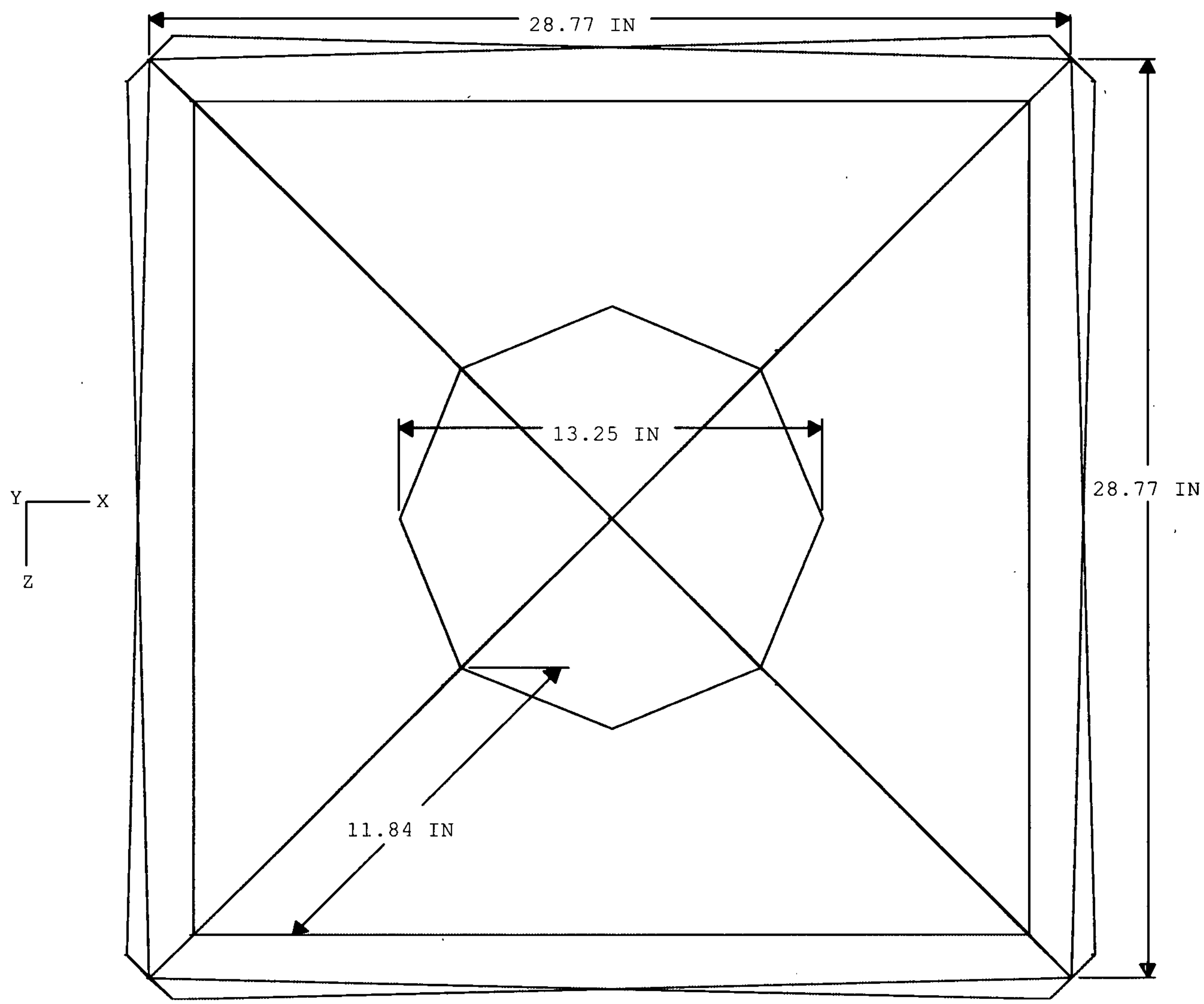


Figure 6.4-3 GTSTRUDL Model (Stick Model Plan View)

Tension Rod / Spacer Modeling

The tension rods and spacers are modeled on top of one another using a second set of nodes with identical coordinates. The rods are not connected to the spacers, rather the JOINT TIES and SLAVE RELEASES commands in GTSTRUDL are used to constrain the relative motion between these coincident nodes. The nodes are allowed to move relative to one another along the axis of the rods, but are constrained to move together in the lateral directions. The spacers have the capacity to carry a certain amount of lateral loads because they are pre-compressed. As long as the bending moments in the spacers do not result in a tension stress in excess of the preload, these spacers can carry lateral loads. Once the bending moment reaches this point (a net tension in the extreme fiber of the spacer), the spacers can take no additional lateral loads and any further lateral loads are carried solely by the tension rods. This is discussed in more detail in Section 6.5.

Radial Stiffeners

The external radial stiffeners are cut from one plate in a "cross and collar" pattern, where all four stiffener legs are continuous with a collar that goes around the core tube. This collar is then welded to the core tube and provides the structural backbone and the primary torsional resistance capacity for the modules. The radial arms are connected to the collar which is modeled as an octagon to represent the curved shape. A 4 1/2" wide section is modeled from the collar/arm intersection to the outside of the core tube. This piece represents the portion of the collar that is welded to the core tube by two 1 1/2" long welds with a 1 1/2" gap between welds (4 1/2" wide total) for each radial rib.

Rigid Link Modeling

In GTSTRUDL, the core tube is supported at its ends by rigid links (Group "RIGID") that extend from the centroidal axis of the core tube to the external radial stiffeners (essentially between the weld pairs of the debris stop to the core tube). The properties of these rigid links are inputted manually such that they absorb no axial load or torsional moment but do transfer shear loads. The reasoning is that the debris stop creates the load path from one side of the strainer module to the other as it is much stiffer than the flexible 16 gauge thick core tube. Bending in the axial direction of the core tube is released for the rigid links at the external radial stiffener connection as this bending will be resisted by the debris stop, and the inner tie rods and spacers.

Additional flexible links connect the four hex couplings at the module intersections. These links are used to easily find the displacements and rotations at the intersection between each module. This data is used in a separate calculation for the plenum such that the strainer modules can be represented by simple stiffness matrices. The links are modeled with very small properties so they do not effect the response of the model. They are also pinned at the connection to the modules. This ensures these members do not pick up any load, yet remain straight such that a single node at the center of these links can be used to determine the rotations at the ends of the modules. The links at the very bottom connect the four elastic support points and are used to represent the mass and stiffness of the plenum. They are modeled as 16" wide 1/2" plates to represent the top cover plate of the plenum, and are given mass to represent the mass of the plenum acting on the elastic supports (see Section 6.4.6 for additional information).

Cross Bracing Cable Modeling

The cross bracing cables are modeled as solid circular rods with a cross sectional area equal to the actual metal area of the cable. There are four cables per module that run from one upper corner, diagonally down to the adjacent corner at the bottom, and then back up to the opposite corner at the top. The cables are free to slide through tube guides at the bottom corners. This sliding action is allowed in the GTSTRUDL model. This is accomplished by the use of the JOINT TIES command.

Each cable is composed of three sections, the two main diagonals, and a short section at the bottom corners. The cables have their own nodes at this lower corner and there are releases at the ends of the short section allowing the cable to bend. The nodes at the ends are connected to different nodes that share the same coordinates that are attached to the radial stiffeners. The JOINT TIES command forces these nodes to displace together except that, in the direction parallel to the short section, the cable can slide relative to the radial stiffener. This represents the actual behavior of this cable connection.

The cables are only allowed to take tension loads. A static horizontal acceleration run is used to determined which cables experience tension, and which cables experience compression. Any cables that experience compression are removed from the model for the seismic runs using an INACTIVE command.

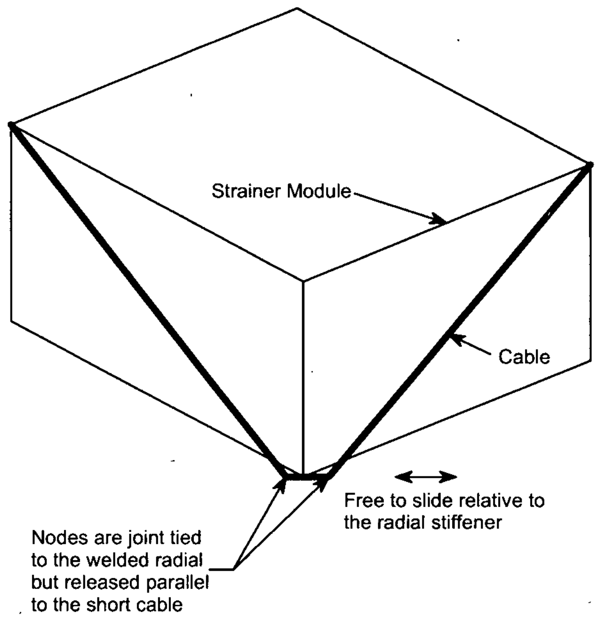


Figure 6.4-4 Modeling of Cables

For deadweight, and the vertical seismic case, conservatively, all cables are inactive. For the horizontal seismic case, one half of the cables are removed (the ones showing compression in the static case). Figure 6.4-5 on the next page shows which cables are active for the horizontal seismic case. Note the eigenvalue analysis which determines the frequencies and mode shapes are run for the same cable configuration as is used in the analysis of that load combination (i.e. no cables for vertical seismic, and only the X-tension cables for lateral seismic. Note that the cables are not preloaded, however the cables are tightened to the point where all the slack is removed such that they will be active for the lateral seismic cases.

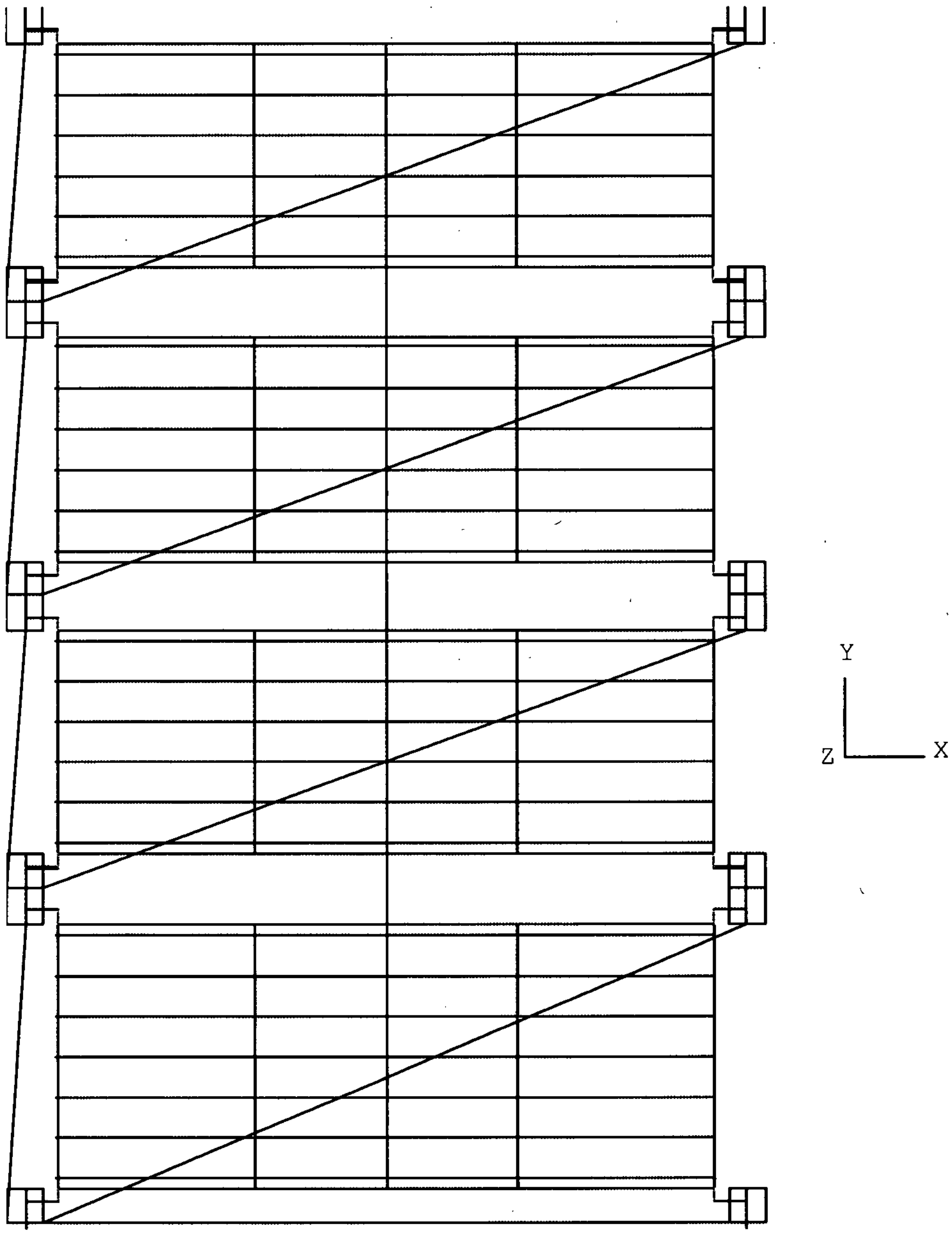


Figure 6.4-5 GTSTRUDL Model (Active Cables for Horizontal Seismic)

6.4.2 Member Properties

Most of the member properties are defined using standard shapes available in GTSTRUDL. However, for some of the members equivalent sections are defined to account for the holes in the members (i.e. core tube, and edge channels).

Welded Radial Stiffener Properties

The welded radial stiffeners members are made up of two separate cross sections. The first is a simple flat plate with a rectangular cross section, representing the portion between the collar and the bent-up channels. The second is a channel cross section used to replicate the bent-up channels at the ends of the radial stiffeners. The properties are input into GTSTRUDL using a user defined table. Only the width and thickness are required for the rectangular cross section while the channel cross section requires the flange and web widths and thicknesses. GTSTRUDL then internally calculates all of the cross sectional properties for that shape. Since this is a user defined table which is not included in the verification of GTSTRUDL, these properties are printed out in the output and manually verified to be correct for each size. The applicable sizes are:

Welded radials	1/4" thick x 2 1/4" wide	
Top bent-up channels	Flange: 1/4" thick x 1.75" wide	Web: 1/4" thick x 3.25" wide
Bottom bent-up channels	Flange: 1/4" thick x 1.75" wide	Web: 1/4" thick x 3.75" wide

Tension Rods and Spacer Properties

The tension rods are solid round bars with a circular cross section. The spacers, are hollow round bars with a pipe like cross section. The properties are input into GTSTRUDL using a user defined table. Only the outer diameter and thickness (for the spacers) of the members are required and then GTSTRUDL internally calculates all of the cross sectional properties for that shape. Since this is a user defined table which is not included in the verification of GTSTRUDL, these properties are printed out in the output and manually verified to be correct for each size. The applicable sizes are:

Outer Tension Rods	1/2" diameter solid round bar (see note below)
Inner Tension Rods	1/2" diameter solid round bar (see note below)
Outer Rod Spacers	0.84" outer diameter, with 0.147" thickness
Inner Rod Spacers	0.84" outer diameter, with 0.147" thickness

Note the tensile diameter of 0.425" (Reference [9]) is used for the elements at the end of the rods to account for the threads in these locations.

Core Tube Properties

This section calculates the core tube properties (i.e. effective cross-sectional properties) including the effect of holes. These properties are used as input in the GTSTRUDL model.

Calculate the reduction in metal area of the cross section due to holes. The last row of the array is used to calculate the effect of the largest holes in any module.

$$Area_{red_k} := 2 \cdot t_{tube} \cdot \left(H_{k,1} + H_{k,2}\right)$$

$$Area_{red_{Nhole_1+1}} := 2 \cdot t_{tube} \cdot \left(H_{max_{1,1}} + H_{max_{1,2}}\right)$$

$$k2 := 1 .. N_{hole_1} + 1$$

$$Area_{red} = \begin{pmatrix} 0.65 \\ 0.69 \\ 0.74 \\ 0.80 \\ 0.86 \\ 0.95 \\ 2.12 \end{pmatrix} in^2$$

The reduced area due to the holes is,

$$A_{tube} := \frac{\pi}{4} \cdot \left(OD_{tube}^2 - ID_{tube}^2\right) \qquad A_{tube} = 2.48\,in^2$$

$$A_{red} := A_{tube} - Area_{red} \qquad A_{red} = \begin{pmatrix} 1.83 \\ 1.79 \\ 1.74 \\ 1.68 \\ 1.61 \\ 1.53 \\ 0.35 \end{pmatrix} in^2$$

Moment of inertia of the core tube without holes,

$$I_{tube} := \frac{\pi}{64} \cdot \left(OD_{tube}^4 - ID_{tube}^4\right) \qquad I_{tube} = 53.89\,in^4$$

Mean Radius of Core Tube,

$$R_{mean} := \frac{OD_{tube} + ID_{tube}}{4} \qquad R_{mean} = 6.60\,in$$

Moment arm of hole around x-axis
(from Core Tube center to Core Tube slots),

$$x := \left(R_{mean} \cdot \sin\left(\phi + \frac{\pi}{4}\right)\right) \qquad x2 := \overrightarrow{x^2} \qquad x = \begin{pmatrix} 4.66 \\ 4.66 \\ -4.66 \\ -4.66 \end{pmatrix} in \qquad x2 = \begin{pmatrix} 21.75 \\ 21.75 \\ 21.75 \\ 21.75 \end{pmatrix} in^2$$

$$y := R_{mean} \cdot \cos\left(\phi + \frac{\pi}{4}\right) \qquad y2 := \overrightarrow{y^2} \qquad y = \begin{pmatrix} 4.66 \\ -4.66 \\ -4.66 \\ 4.66 \end{pmatrix} in \qquad y2 = \begin{pmatrix} 21.75 \\ 21.75 \\ 21.75 \\ 21.75 \end{pmatrix} in^2$$

Moment of Inertia of Core Tube Holes
(neglecting I about their own centroids),

$$I_{hole.x} := \left(\frac{Area_{red}}{N_{hole.circ}}\right) \cdot x2^T \qquad I_{hole.x} = \begin{pmatrix} 3.51 & 3.51 & 3.51 & 3.51 \\ 3.76 & 3.76 & 3.76 & 3.76 \\ 4.02 & 4.02 & 4.02 & 4.02 \\ 4.33 & 4.33 & 4.33 & 4.33 \\ 4.69 & 4.69 & 4.69 & 4.69 \\ 5.18 & 5.18 & 5.18 & 5.18 \\ 11.55 & 11.55 & 11.55 & 11.55 \end{pmatrix} in^4$$

$$I_{holes.x_{k2}} := \sum_{j=1}^{4} I_{hole.x_{k2,j}} \qquad I_{holes.x} = \begin{pmatrix} 14.05 \\ 15.03 \\ 16.07 \\ 17.32 \\ 18.78 \\ 20.7 \\ 46.19 \end{pmatrix} in^4$$

$$I_{hole.y} := \left(\frac{Area_{red}}{N_{hole.circ}}\right) \cdot y2^T \qquad I_{hole.y} = \begin{pmatrix} 3.51 & 3.51 & 3.51 & 3.51 \\ 3.76 & 3.76 & 3.76 & 3.76 \\ 4.02 & 4.02 & 4.02 & 4.02 \\ 4.33 & 4.33 & 4.33 & 4.33 \\ 4.69 & 4.69 & 4.69 & 4.69 \\ 5.18 & 5.18 & 5.18 & 5.18 \\ 11.55 & 11.55 & 11.55 & 11.55 \end{pmatrix} in^4$$

$$I_{holes.y_{k2}} := \sum_{j=1}^{4} I_{hole.y_{k2,j}}$$

$$I_{holes.y} = \begin{pmatrix} 14.05 \\ 15.03 \\ 16.07 \\ 17.32 \\ 18.78 \\ 20.7 \\ 46.19 \end{pmatrix} in^4$$

Reduced moment of inertia due to holes,

$$I_{red} := I_{tube} - \left(\frac{I_{holes.x} + I_{holes.y}}{2}\right)$$

$$I_{red} = \begin{pmatrix} 39.85 \\ 38.86 \\ 37.82 \\ 36.57 \\ 35.11 \\ 33.19 \\ 7.70 \end{pmatrix} in^4$$

An equivalent moment of inertia for the core tube is determined by averaging the moment of inertia of the various full and reduced sections over their length. Once the equivalent moment of inertia is determined, an equivalent thickness can be determined.

$$I_{avg} := \frac{\displaystyle\sum_{i=1}^{N_{hole_1}} \left(I_{red_i} \cdot L2\right) + I_{tube} \cdot \left(L_{strnr_1} - L2 \cdot N_{hole_1}\right)}{L_{strnr_1}}$$

$$I_{avg} = 42.68\ in^4$$

$$EQ_{ID.I} := \left(OD_{tube}^{\ 4} - \frac{64}{\pi} \cdot I_{avg}\right)^{\frac{1}{4}}$$

$$EQ_{ID.I} = 13.16\ in$$

$$t_{eq} := \frac{OD_{tube} - EQ_{ID.I}}{2}$$

$t_{eq} = 0.047\ in$ vs. $t_{tube} = 0.060\ in$

Therefore, this equivalent thickness is used in the GTSTRUDL model to account for the holes in the core tube.

The area and section modulus of the equivalent core tube is calculated as follows,

$$A_{eq} := \frac{\pi}{4}\cdot\left[OD_{tube}^{2} - \left(OD_{tube} - 2\cdot t_{eq}\right)^{2}\right] \qquad A_{eq} = 1.96\,in^{2}$$

$$S_{eq} := \frac{\pi}{32\cdot OD_{tube}}\cdot\left[OD_{tube}^{4} - \left(OD_{tube} - 2\cdot t_{eq}\right)^{4}\right] \qquad S_{eq} = 6.44\,in^{3}$$

$$S_{red_{k2}} := \left(\left(I_{red_{k2}}\right)\right)\cdot\frac{2}{OD_{tube}} \qquad S_{red} = \begin{pmatrix} 6.01 \\ 5.87 \\ 5.71 \\ 5.52 \\ 5.30 \\ 5.01 \\ 1.16 \end{pmatrix} in^{3}$$

$$S_{min} := \min\left(S_{red}\right) \qquad S_{min} = 1.16\,in^{3}$$

A stress multiplier is used for the core tube. This stress multiplier is applied to the GTSTRUDL results (which is based on the equivalent thickness) to account for the largest core tube holes. This multiplier is,

$$K_{ct} := \frac{S_{eq}}{S_{min}} \qquad K_{ct} = 5.54$$

Edge Channel Properties

This section calculates the edge channel properties (i.e. effective cross-sectional properties) including the combined effect of the perforated plate disks that are riveted to the channels (also made from perforated plate). The channel and the attached perforated plate work as a combined section to resist bending loads. The effective width of the perforated plate that acts in combination with the radial stiffener is based on Section 2.3 of the ASCE Standard (Reference [22]) which provides design guidelines for very thin members such as the perforated plate. The effective width of the plate is limited by the width to thickness ratios such that local buckling of the plate will not occur for the compression face. The combined properties are used to solve for an effective channel shape that has the same properties, and this effective channel shape is used in the GTSTRUDL model.

The width of the disk face that is effective in the combined section is based on the ASCE Standard (Reference [22]). The slenderness factor, λ, is determined from Equation 2.2.1-4 of Reference [22]. Conservatively consider the face disks to be unstiffened elements with a total width equal to the distance from the edge of the disk to the edge of the hole for the core tube. Note that this conservatism more than offsets any impact resulting from the connection of the perf plate to the channel not being continuous

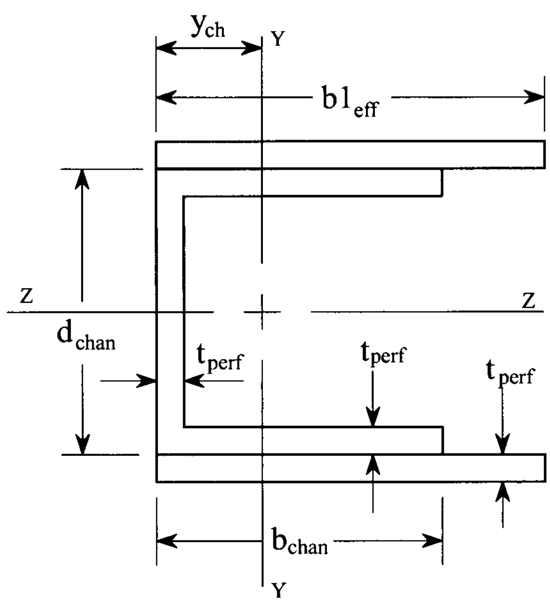


Figure 6.4-6 - Combined Channel and Plate Section

The ligament efficiency (h/p) for the perforated plate is

$$hp := \frac{h_{disk.holes}}{P_{disk.holes}} \qquad hp = 0.40$$

From Fig.A-8131-1 of Reference [4],

Effective Poisson's ratio, $\nu_{eff} := 0.325$

Effective Modulus of Elasticity, $E_{eff} := 0.39 \cdot E_{sa}$ $\qquad E_{eff} = 10784\ \text{ksi}$

$$\lambda := \frac{1.052}{\sqrt{0.50}} \cdot \frac{\frac{\min(L1_{disk}, L2_{disk}) - L_{circ.in}}{2}}{t_{perf}} \cdot \sqrt{\frac{S_{ya}}{E_{eff}}} \qquad \lambda = 8.06$$

The effective width is determined from Equation 2.2.1-5 or 2.2.1-6 of Reference [22]

$$b_{eff} := \text{if}\left[\lambda \le 0.673, \left(\frac{\min(L1_{disk}, L2_{disk}) - L_{circ.in}}{2}\right), \left[\frac{1 - \frac{0.22}{\lambda}}{\lambda} \cdot \left(\frac{\min(L1_{disk}, L2_{disk}) - L_{circ.in}}{2}\right)\right]\right]$$

$b_{eff} = 0.80\,in$

Using this effective width, the properties for the combined section are determined. Note the properties are based on solid sections (no perforations). The equivalent modulus is used in the GTSTRUDL model to account for stiffness, and the Kpp factor is applied later to calculate the stresses considering the holes.

$$A_{ch.x} := \left[2 \cdot b_{eff} + 2 \cdot b_{chan} + (d_{chan} - 2 \cdot t_{perf})\right] \cdot t_{perf}$$

$A_{ch.x} = 0.17737\,in^2$

$$y_{ch} := \frac{b_{eff}^2 + b_{chan}^2 + (d_{chan} - 2 \cdot t_{perf}) \cdot \left(\frac{t_{perf}}{2}\right)}{2 \cdot b_{eff} + 2 \cdot b_{chan} + (d_{chan} - 2 \cdot t_{perf})}$$

$y_{ch} = 0.302\,in$

$$I_{ch.z} := \frac{(b_{eff}) \cdot (d_{chan} + 2 \cdot t_{perf})^3}{12} - \frac{(b_{eff} - b_{chan}) \cdot (d_{chan}^3)}{12} - \frac{(b_{chan} - t_{perf}) \cdot (d_{chan} - 2 \cdot t_{perf})^3}{12}$$

$I_{ch.z} = 0.0107\,in^4$

$$I_{y1} := \frac{(d_{chan} - 2 \cdot t_{perf}) \cdot (t_{perf}^3)}{12} + (d_{chan} - 2 \cdot t_{perf}) \cdot (t_{perf}) \cdot \left(y_{ch} - \frac{t_{perf}}{2}\right)^2$$

$I_{y1} = 0.0017\,in^4$

$$I_{y2} := 2 \cdot \left[\left(\frac{t_{perf} \cdot b_{chan}^3}{12}\right) + t_{perf} \cdot b_{chan} \cdot \left(y_{ch} - \frac{b_{chan}}{2}\right)^2\right]$$

$I_{y2} = 0.0014\,in^4$

$$I_{y3} := 2 \cdot \left[\left(\frac{t_{perf} \cdot b_{eff}^3}{12}\right) + t_{perf} \cdot b_{eff} \cdot \left(y_{ch} - \frac{b_{eff}}{2}\right)^2\right]$$

$I_{y3} = 0.0060\,in^4$

$$I_{ch.y} := (I_{y1} + I_{y2} + I_{y3})$$

$I_{ch.y} = 0.0091\,in^4$

$R_{ch.z} := \sqrt{\dfrac{I_{ch.z}}{A_{ch.x}}}$ $\quad$ $R_{ch.y} := \sqrt{\dfrac{I_{ch.y}}{A_{ch.x}}}$ $\quad$ $R_{ch.z} = 0.245\,in$

$R_{ch.y} = 0.226\,in$

$S_{ch.y} := \dfrac{I_{ch.y}}{b_{eff} - y_{ch}}$ $\quad$ $S_{ch.z} := \dfrac{I_{ch.z}}{\dfrac{d_{chan}}{2} + t_{perf}}$ $\quad$ $S_{ch.y} = 0.0182\,in^3$

$S_{ch.z} = 0.0344\,in^3$

A solve block is used to calculate a channel cross section that has section properties equivalent to those calculated above. Before entering the solve block, initial guesses must be made for all variables and the units must be removed.

Initial Guesses:

$L_{flange} := \dfrac{b_{eff} + b_{chan}}{2 \cdot in}$ $\quad$ $L_{web} := \dfrac{d_{chan} + t_{perf}}{in}$

$t_{web} := \dfrac{t_{perf}}{in}$ $\quad$ $t_{flange} := \dfrac{t_{perf}}{in}$

$A_{ch} := \dfrac{A_{ch.x}}{in^2}$ $\quad$ $y_{ch.eff} := \dfrac{y_{ch}}{in}$

$I_{ch.z} := \dfrac{I_{ch.z}}{in^4}$ $\quad$ $I_{ch.y} := \dfrac{I_{ch.y}}{in^4}$

$S_{ch.y} := \dfrac{S_{ch.y}}{in^3}$

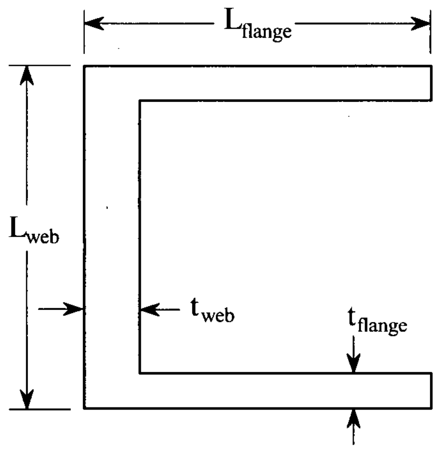


Figure 6.5-7 - Effective Channel used in STRUDL

Given

$$A_{ch} = 2 \cdot L_{flange} \cdot t_{flange} + \left(L_{web} - 2 \cdot t_{flange}\right) \cdot t_{web}$$

$$I_{ch.z} = \left[2 \cdot \left[\left(\frac{L_{flange} \cdot t_{flange}^{3}}{12}\right) + \left[L_{flange} \cdot t_{flange} \cdot \left(\frac{L_{web} - t_{flange}}{2}\right)^{2}\right]\right] + \frac{\left(L_{web} - 2 \cdot t_{flange}\right)^{3} \cdot t_{web}}{12}\right]$$

$$y_{ch.eff} = \frac{\left(L_{flange}^{2} \cdot t_{flange}\right) + \left(L_{web} - 2 \cdot t_{flange}\right) \cdot \frac{t_{web}^{2}}{2}}{2 \cdot L_{flange} \cdot t_{flange} + \left(L_{web} - 2 \cdot t_{flange}\right) \cdot t_{web}}$$

$$I_{ch.y} = \left[2 \cdot \left[\frac{L_{flange}^{3} \cdot t_{flange}}{12} + L_{flange} \cdot t_{flange} \cdot \left(\frac{L_{flange}}{2} - y_{ch.eff}\right)^{2}\right] \cdots + \frac{\left(L_{web} - 2 \cdot t_{flange}\right) \cdot t_{web}^{3}}{12} + \left(L_{web} - 2 \cdot t_{flange}\right) \cdot t_{web} \cdot \left(\frac{t_{web}}{2} - y_{ch.eff}\right)^{2}\right]$$

$$S_{ch.y} = \frac{I_{ch.y}}{L_{flange} - y_{ch.eff}}$$

$$\mathrm{Find}\left(L_{web}, t_{web}, L_{flange}, t_{flange}, y_{ch.eff}\right) = \begin{pmatrix} 0.655 \\ 0.139 \\ 0.750 \\ 0.071 \\ 0.252 \end{pmatrix}$$

Back checking against the section properties calculated above with those calculated by GTSTRUDL using the flange and web lengths and thicknesses from the solve block, the effective channel is verified and acceptable for use in the GTSTRUDL model.

" MEMBER/SEG	TYPE		SEG.L	AX	AY	AZ	IX	IY	IZ	SY	SZ"
"				YD	ZD	YC	ZC	EY	EZ"		
" EC1001	TABLE	MYCHAN	WBCHANEF	0.178	0.091	0.071	0.001	0.009	0.011	0.018	0.033"
"				0.655	0.750	0.327	0.252	0.000 "			

6.4.3 Member End Releases

The actual configuration of the connections is modeled by adding member end releases to the model. The following releases are used in the model:

The moments for tension rods are released at their ends where they attach to the welded radial stiffeners. The moments on the edge channels are released where they connect to the tension rods.

The spacers are released at the ends where they attach to the welded radial stiffeners. They are attached to the rest of the model only at these locations, as the joints in between are created through the use of the JOINT TIES and SLAVE RELEASES commands. The coincident nodes for the spacers and the tension rods are initially tied together for all degrees of freedom, then slave releases are used to release the relative axial displacement, and the relative torsional rotation, and the relative lateral rotations at all of the intermediate nodes (Fx, Mx, My, and Mz). For the end nodes, where the spacers attach to the radial stiffeners, all of the moments are released (Mx, My and Mz). These nodal relationships are verified by examining the nodal displacements at these locations and confirming the command is working as intended.

The cables are released at their ends at the top corners where they connect to the radial stiffeners, and also at the bottom corners. A detailed discussion on the cable end releases is provided in Section 6.4.1.

The core tube rigid links are released for Mz at the connection with the collar as this weld cannot transfer moments. Also the rigid links used to connect the hex couplings between modules are released for all three moments. Note these are fictitious members and do not take any loads.

For downward vertical load cases (DW, DEB and PRES), the core tube to core tube sleeves are released at one end for force Fy & Fz, and moments Mx, My, & Mz. For other load cases, the Fx force is also released (sleeve can not take tension).

6.4.4 Support Joints and Joint Releases

The 4 strainer module stack (one 7 disk module and three 6 disk modules) is supported at the corner support joints. All three moments are released at these support locations as this is a bolted connection which is considered pinned. The flexibility of the supporting plenum structure is considered by modeling springs at these four support nodes to represent the stiffness of the plenum. The spring stiffnesses are calculated on the next page.

Note that the hex coupling joints at the intersection between the first and second modules (Joints 201 to 204) are fixed for the X2, Y2, MY2, and MZ2 load cases only. This is used to determine the flexibility of a single 6 disk strainer module. These joints are fully released for all other load cases.

Joint 1000 at the bottom of the core tube for the bottom module is supported with spring support in the vertical direction for vertical downward load cases (DW, DEB, and PRES). All moments and Fx & Fz shears are released. A spring stiffness is input in the vertical direction equal to the average stiffness of the four corners calculated on the next page. This spring stiffness represents the flexibility of the plenum. Note that this joint is released for all other load cases.

Plenum Stiffness

The flexibility of the supporting plenum structure is input into the GTSTRUDL model using spring supports. The stiffness of the spring supports is calculated from the results of the GTSTRUDL run for the plenum included in Reference [14]. Several stiffness load cases are run in the plenum model as follows:

STIFFX - 1000 lbf unit load is applied in the X-direction at every strainer module node simultaneously

STIFFZ - 1000 lbf unit load is applied in the Z-direction at every strainer module node simultaneously

AEY - 1000 lbf unit load is applied in the Y-direction at Node AE1

BEY - 1000 lbf unit load is applied in the Y-direction at Node BE1

AEY1 - AEY4 - 250 lbf per node is applied at the four corner nodes for Module AE

STIFFX is used to determine the stiffness in the X-direction. This is the most flexible direction due to the flexibility of the support beam webs. The maximum displacement at any strainer center node is at Node AA1 and is 0.073 inches. Therefore the stiffness of the four support points is calculated as follows:

$$KFX := \frac{1000 \cdot lbf}{4 \cdot 0.073 \cdot in} \qquad KFX = 3.4 \times 10^3 \frac{lbf}{in}$$

Similarly, in the Z-directions, the maximum displacement is at Node CE1 and is 0.0075 inches.

$$KFZ := \frac{1000 \cdot lbf}{4 \cdot 0.0075 \cdot in} \qquad KFZ = 3.3 \times 10^4 \frac{lbf}{in}$$

(Note 3.4E4 used in the model, small difference OK)

In the Y-direction, strainers AE and BE were chosen due to the fact that these strainers are over the pit and the supporting structure is more flexible due to the flexibility of the beams that span the pit. Also reviewing the plenum model, Strainer Module AE has the biggest displacement and is influenced by having stiff supports on one corner and more flexible supports on the other corners. Based on review of the results, the stiffness of the AE module corners was chosen as the worst case. Based on the displacements from Reference [14], the stiffness of the four corners is taken as:

$$KFY1 := \frac{250 \cdot lbf}{0.000025 \cdot in} \qquad KFY1 = 1.0 \times 10^7 \frac{lbf}{in}$$

(Load AEY1, Node SR7)

$$KFY2 := \frac{250 \cdot lbf}{0.00011 \cdot in} \qquad KFY2 = 2.3 \times 10^6 \frac{lbf}{in}$$

(Load AEY2, Node SR8)

$$KFY3 := \frac{250 \cdot lbf}{0.00011 \cdot in} \qquad KFY3 = 2.3 \times 10^6 \frac{lbf}{in}$$

(Load AEY3, Node SR21)

$$KFY4 := \frac{250 \cdot lbf}{0.00068 \cdot in} \qquad KFY4 = 3.7 \times 10^5 \frac{lbf}{in}$$

(Load AEY4, Node SR22)

Note slightly different values are used in the GTSTRUDL analysis. The difference is negligible

6.4.5 Member Density Adjustments

The densities for some of the members are adjusted to account for the weight of the strainer components which are not directly included in the model. The disk faces, the internal wire stiffeners, and the gap disks are not directly included in the model, therefore the density of the edge channels and the tension rods are manually adjusted to account for this additional weight. A check of the total deadweight reactions from GTSTRUDL is used to confirm that the total deadweight included in the GTSTRUDL model is close to the total weight calculated in Section 6.1. The weight of the debris is also included in the density calculations for Load Combination # 1 & 5.

For these components, a portion of the weight is tributary to the inner rods (Group 'IROD'), and a portion is tributary to the outer channels (Group 'CHANNELS') (which in turn are supported by the outer rods). The inner rods support the perforated plate through the spacers. The percentage breakdown for how much weight is tributary to the inner rods, and how much is tributary to the outer edge channels will be based on the formulas from Case 2c of Table 24 of Roark and Young, Reference [16].

An equivalent outer radius "a" is determined based on a equivalent area

$$a := \sqrt{\frac{L1_{disk} \cdot L2_{disk}}{\pi}} \qquad a = 15.80\,\text{in} \qquad b := \frac{OD_{gap}}{2} \qquad b = 7.87\,\text{in}$$

$$r_o := b \qquad q := 1 \cdot \text{psi}$$

$$D := \frac{E_{eff} \cdot t_{perf}^{\,3}}{12 \cdot \left(1 - \nu_{eff}^{\,2}\right)} \qquad D = 567.46\,\frac{\text{lb} \cdot \text{ft}^2}{\text{sec}^2}$$

$$C_1 := \frac{1 + \nu_{eff}}{2} \cdot \frac{b}{a} \cdot \ln\left(\frac{a}{b}\right) + \frac{1 - \nu_{eff}}{4} \cdot \left(\frac{a}{b} - \frac{b}{a}\right)$$

$$C_3 := \frac{b}{4 \cdot a} \cdot \left[\left[\left(\frac{b}{a}\right)^2 + 1\right] \cdot \ln\left(\frac{a}{b}\right) + \left(\frac{b}{a}\right)^2 - 1\right]$$

$$C_7 := \frac{1}{2} \cdot \left(1 - \nu_{eff}^{\,2}\right) \cdot \left(\frac{a}{b} - \frac{b}{a}\right)$$

$$C_9 := \frac{b}{a} \cdot \left[\frac{1 + \nu_{eff}}{2} \cdot \ln\left(\frac{a}{b}\right) + \frac{1 - \nu_{eff}}{4} \cdot \left[1 - \left(\frac{b}{a}\right)^2\right]\right]$$

$$L_{11} := \frac{1}{64}\cdot\left[1 + 4\cdot\left(\frac{r_o}{a}\right)^2 - 5\cdot\left(\frac{r_o}{a}\right)^4 - 4\left(\frac{r_o}{a}\right)^2\cdot\left[2 + \left(\frac{r_o}{a}\right)^2\right]\cdot\ln\left(\frac{a}{r_o}\right)\right]$$

$$L_{17} := \frac{1}{4}\left[1 - \frac{1 - \nu_{eff}}{4}\cdot\left[1 - \left(\frac{r_o}{a}\right)^4\right] - \left(\frac{r_o}{a}\right)^2\cdot\left[1 + \left(1 + \nu_{eff}\right)\cdot\ln\left(\frac{a}{r_o}\right)\right]\right]$$

Using these coefficients, the reaction at the inner circle is determined as a percentage of the total pressure load.

$$Q_b := q\cdot a\cdot\frac{C_1\cdot L_{17} - C_7\cdot L_{11}}{C_1\cdot C_9 - C_3\cdot C_7} \qquad Q_b = 5.11\,\frac{lbf}{in}$$

$$K_{tube} := \frac{Q_b\cdot(2\cdot\pi\cdot b)}{q\cdot\pi\cdot\left(a^2 - b^2\right)} \qquad K_{tube} = 0.43$$

Using this ratio, the total masses in the vertical direction are distributed to the inner rods and to the outer channels

Tension Rods

The total length of the tension rods in the GTSTRUDL model goes from the centerline of the radial stiffener on one end, to the centerline of the radial stiffener on the other end. This length is broken up into two lengths, one for the middle section of the rods that is unthreaded, and another for the ends of the rods which are threaded. Note the rod ends are modeled with a smaller diameter to account for the reduction due to the threads. The rod lengths are calculated below:

$L_{rod.gt} := L_{strnr} - (W_{disk})$ $\qquad L_{rod.gt} = \begin{pmatrix} 8.10 \\ 9.71 \end{pmatrix} in$

$L_{rod.end.gt} := W_{disk} + t_{stfnr}$ $\qquad L_{rod.end.gt} = 0.87\,in$

The total volume of the inner rods is

$VOL_{rod.gt} := \frac{\pi}{4} \cdot OD_{rod}^{2} \cdot L_{rod.gt} \cdot \frac{N_{rod}}{2}$ $\qquad VOL_{rod.gt} = \begin{pmatrix} 6.36 \\ 7.63 \end{pmatrix} in^3$

$VOL_{rod.end.gt} := \frac{\pi}{4} \cdot OD_{tens}^{2} \cdot L_{rod.end.gt} \cdot \frac{N_{rod}}{2}$ $\qquad VOL_{rod.end.gt} = 0.49\,in^3$

Adding in the weight of the wire stiffeners, the face disks, and the gap disks to determine an equivalent density for the inner rods. In addition, the weight of the debris is added as well. Two load cases are considered, one that includes the weight of debris (Load Combination # 1 & 5) and one that does not (Load Combinations # 2, 3, 4, & 6).

$$\rho_{rod.0} := \frac{0.5 \cdot Wt_{rod} + Wt_{gap} + K_{tube} \cdot (Wt_{face} + Wt_{radial} + Wt_{circ} + WD)}{VOL_{rod.gt} + VOL_{rod.end.gt}} \qquad \rho_{rod.0} = \begin{pmatrix} 24.99 \\ 24.65 \end{pmatrix} \frac{lbf}{in^3}$$

$$\rho_{rod.1} := \frac{0.5 \cdot Wt_{rod} + Wt_{gap} + K_{tube} \cdot (Wt_{face} + Wt_{radial} + Wt_{circ})}{VOL_{rod.gt} + VOL_{rod.end.gt}} \qquad \rho_{rod.1} = \begin{pmatrix} 8.78 \\ 8.64 \end{pmatrix} \frac{lbf}{in^3}$$

Conservatively, the maximum density for either the 7 disk or 6 disk modules will be used for all members since the differences are small. Also slightly higher values were used in the model than those shown above. The differences are negligible.

Edge Channels

Similarly, the length and volume of the edge channels needs to be determined

$L_{ch.gt} := 2 \cdot L1_{circ.out} + 2 \cdot L2_{circ.out}$ $\qquad$ $L_{ch.gt} = 104.50\,in$

$VOL_{ch.gt} := A_{ch.x} \cdot L_{ch.gt} \cdot N_{disk}$ $\qquad$ $VOL_{ch.gt} = \begin{pmatrix} 111.2 \\ 129.7 \end{pmatrix} in^3$

Adding in the weight of the wire stiffeners and the face disks and debris to determine an equivalent density for the edge channels (note the gap disk weight is placed entirely on the inner rods),

$$\rho_{ch.0} := \frac{Wt_{edge} + (1 - K_{tube}) \cdot (Wt_{face} + Wt_{radial} + Wt_{circ} + WD)}{VOL_{ch.gt}} \qquad \rho_{ch.0} = \begin{pmatrix} 2.09 \\ 2.09 \end{pmatrix} \frac{lbf}{in^3}$$

$$\rho_{ch.1} := \frac{Wt_{edge} + (1 - K_{tube}) \cdot (Wt_{face} + Wt_{radial} + Wt_{circ})}{VOL_{ch.gt}} \qquad \rho_{ch.1} = \begin{pmatrix} 0.759 \\ 0.759 \end{pmatrix} \frac{lbf}{in^3}$$

$$\rho_{ch.2} := \frac{Wt_{edge}}{VOL_{ch.gt}} \qquad \rho_{ch.2} = \begin{pmatrix} 0.10 \\ 0.10 \end{pmatrix} \frac{lbf}{in^3}$$

Conservatively, the maximum density for either the 7 disk or 6 disk modules will be used for all members since the differences are small

6.4.6 Member Added Inertia

The mass of the internal wire stiffeners, disk faces, and gap disks are added via the MEMBER ADDED INERTIA command for the seismic analysis rather than adjusting the density. This is done because the direction of motion affects where the weights are being applied. In the vertical direction, the weights of the stiffener wires and the face and gap disks are considered to be carried by the edge channels and the inner tension rods (proportioned in the manner as for the densities in section 6.4.5). In both the lateral directions however, these weights are carried only by the tension rods. Note that the densities calculated in Section 6.4.5 above are used only for non seismic loadings such as the gravity load case. For the seismic case, standard steel density is used.

End Cover Mass

The weight of the end cover is included by inputting a member added inertia for the rigid links that connect the radial stiffeners to the end of the core tube. Only the members at the top of the core tube for the top module have an end cover. These rigid links are Members 'RIGID29' to 'RIGID32' and have a total length of 26.5 inches.

$$\delta_{ec} := \frac{Wt_{ec}}{26.5 \cdot in} \qquad \delta_{ec} = 0.305 \frac{lbf}{in}$$

Disk Mass

Vertical Direction

Apply to edge channels:

$$\delta_{disk.y} := \left(\overrightarrow{\frac{(1 - K_{tube}) \cdot (Wt_{face} + Wt_{radial} + Wt_{circ})}{N_{disk} \cdot L_{ch.gt}}} \right) \qquad \delta_{disk.y} = \begin{pmatrix} 0.12 \\ 0.12 \end{pmatrix} \frac{lbf}{in}$$

Apply to inner rods:

$$\delta_{inner.y} := \overrightarrow{\left[\frac{K_{tube} \cdot (Wt_{face} + Wt_{radial} + Wt_{circ}) + Wt_{gap}}{\frac{N_{rod}}{2} \cdot (L_{rod.gt} + L_{rod.end.gt})} \right]} \qquad \delta_{inner.y} = \begin{pmatrix} 1.61 \\ 1.59 \end{pmatrix} \frac{lbf}{in}$$

X Horizontal Direction

Apply to all rods:

$$\delta_{rod.x} := \left(\overrightarrow{\left[\frac{Wt_{face} + Wt_{gap} + Wt_{radial} + Wt_{circ}}{N_{rod} \cdot (L_{rod.gt} + L_{rod.end.gt})} \right]} \right) \qquad \delta_{rod.x} = \begin{pmatrix} 1.82 \\ 1.80 \end{pmatrix} \frac{lbf}{in}$$

Z Horizontal Direction

Apply to all rods:

$$\delta_{rod.z} := \overrightarrow{\frac{Wt_{face} + Wt_{gap} + Wt_{radial} + Wt_{circ}}{N_{rod} \cdot (L_{rod.gt} + L_{rod.end.gt})}} \qquad \delta_{rod.z} = \begin{pmatrix} 1.82 \\ 1.80 \end{pmatrix} \frac{lbf}{in}$$

Plenum Mass

A portion of the mass of the plenum is included in the four stack model on Members 'ELMNT17' to 'ELMNT20'. These members are the "rigid links" at the very bottom of the model connecting the four elastic support points. The magnitude of the mass was determined by trail and error during the benchmarking process in order to get a good match on the frequencies and mode shapes between the four stack model and the plenum model analyzed in Reference [14].

6.4.7 Tension Rod Preload

The tension rods and spacers are preloaded by torquing the rods. This preload is included in the GTSTRUDL model by inducing a negative temperature change on the tension rods. This makes the rods get shorter, while the spacers stay the same length, causing the rods to go into tension, and the spacers to go into compression. The core tube, cross bracing, and two of the module support nodes are released in the axial direction for the temperature load case such that these members do not pick up the compression as opposed to the spacers. This will be assured in the fabrication of the strainers by torquing down the tension rods before welding the top radial stiffener to the core tube and before securing the cross bracing to the welded radials. The magnitude of the negative temperature changes are calculated below.

The amount of the preload force is determined from the torque to preload conversion formula given in Good Bolting Practices (Reference [15]). Per Reference [15], use a nominal nut factor of 0.3 for stainless steel fasteners. Conservatively consider a 20% variation in the torque to preload conversion due to uncertainty. Also consider the possible variation in torque due to torquing tolerance (15%). In addition, preload relaxation is considered in the qualification of the spacers in Section 6.5. These uncertainties will be applied in the worst case combination (maximize the preload in the GTSTRUDL run to get the highest stresses, and minimize the preload when checking for separation in the spacers).

$K_{nf} := 0.3$

$F_{load.max} := \dfrac{T_{rod} \cdot 1.15 \cdot 1.20}{OD_{rod} \cdot (K_{nf})}$ $\qquad F_{load.max} = 3864\ \mathrm{lbf}$

Other parameters needed for this analysis include

$CTE = 8.77 \times 10^{-6}$

$A_{rod} := \dfrac{\pi}{4} \cdot OD_{rod}^{2}$ $\qquad A_{rod} = 0.20\ \mathrm{in}^2$

$A_{end.rod} := \dfrac{\pi}{4} \cdot OD_{tens}^{2}$ $\qquad A_{end.rod} = 0.14\ \mathrm{in}^2$

$A_{spcr} := \dfrac{\pi}{4} \cdot \left(OD_{spacer}^{2} - ID_{spacer}^{2}\right)$ $\qquad A_{spcr} = 0.32\ \mathrm{in}^2$

To calculate the temperature change required to induce the desired preload force on the rods and spacers, the amount of deflection for the spacers due to the temperature change must equal that of the total length of rod (middle section and end section at the threads).

$$e_{spcr} = \left(\frac{L}{A \cdot E_s}\right)_1 \cdot F_1 + \alpha_1 \cdot \Delta T_1 \cdot L_1$$ (deflection of spacers)

$$e_{rod} = \left(\frac{L}{A \cdot E_s}\right)_2 \cdot F_2 + \alpha_2 \cdot \Delta T_2 \cdot L_2$$ (deflection of middle of rods)

$$e_{end.rod} = \left(\frac{L}{A \cdot E_s}\right)_3 \cdot F_3 + \alpha_3 \cdot \Delta T_3 \cdot L_3$$ (deflection of ends of rods)

$$\alpha_1 = \alpha_2 = \alpha_3 = CTE$$

Solving first for e_{spcr} by setting ΔT_1 to zero and F_1 equal to the preload force, noting that F_{load} will be a compressive force for the spacers.

$$e_{spcr} := \frac{L_{strnr} + t_{stfnr}}{\frac{\pi}{4} \cdot \left(OD_{spacer}^2 - ID_{spacer}^2\right) \cdot E_{sa}} \cdot \left(-F_{load.max}\right) \qquad e_{spcr} = \begin{pmatrix} -0.0039 \\ -0.0046 \end{pmatrix} in$$

Now solve for the required temperature change for the tension rods by setting the change in length for both the middle of the rod and the ends of the rod equal to the change in length of the spacers. For simplicity, assume that the temperature changes for both the rod middle and ends are equal.

$$e_{rod} + e_{end.rod} = e_{spcr}$$

Solving the above equation for ΔT,

$$\Delta T := \frac{e_{spcr} - F_{load.max} \cdot \left(\frac{L_{rod.gt}}{A_{rod} \cdot E_{sa}} + \frac{L_{rod.end.gt}}{A_{end.rod} \cdot E_{sa}}\right)}{CTE \cdot \left(L_{rod.gt} + L_{rod.end.gt}\right)} \qquad \Delta T = \begin{pmatrix} -134 \\ -133.5 \end{pmatrix} \text{ degrees F}$$

This value is confirmed by reviewing the actual resulting preload from the GTSTRUDL results

6.4.7 Effective Length Coefficients

The effective length is automatically calculated by GTSTRUDL as the node to node length for each member. In special circumstances where intermediate nodes have been used for a collective member, effective lengths were manually inputted. This is done for the edge channels, external radial stiffeners, and the seismic stiffeners.

In addition to the effective length adjustments described above, the effective length factors in GTSTRUDL are used to account for stainless steel in place of standard carbon steel. An equivalent K-value must be computed to adjust the GTSTRUDL code check equations for the edge channels and the external radial stiffeners. The ANSI/AISC N690 code (Ref. [21]) provides equations for stainless steels and carbon steels (the latter being employed by GTSTRUDL). Upon further examination, only the compression equations are of interest. In order to force the GTSTRUDL allowables for carbon steel to reflect the allowables for stainless steel, a effective K-value is computed and inputted into GTSTRUDL.

$i := 1 .. 2$

$E_1 := \begin{pmatrix} E_{eff} \\ E_{sa} \end{pmatrix}$ $E_1 = \begin{pmatrix} 10784 \\ 27650 \end{pmatrix}$ ksi — E for Edge Channels; E for External Radial Stiffeners

$S_{y.a} := \frac{S_{ya}}{ksi}$ $S_{y.a} = 25.50$

$K_{eq} := \begin{pmatrix} 1 \\ 1 \end{pmatrix}$ $K_{eq} = \begin{pmatrix} 1.00 \\ 1.00 \end{pmatrix}$ — Edge Channels; External Radial Stiffeners.

$L_{rad} := \sqrt{\left(\frac{L1_{circ.out}}{2}\right)^2 + \left(\frac{L2_{circ.out}}{2}\right)^2} - \frac{OD_{debris}}{2}$ $L_{rad} = 10.85$ in (external radial stiffener unbraced length)

$L_{klr} := \begin{pmatrix} L2_{circ.out} \\ L_{rad} \end{pmatrix}$ $L_{klr} = \begin{pmatrix} 26.12 \\ 10.85 \end{pmatrix}$ in (Note these unbraced length are also inputted into GTSTRUDL)

$r_{klr} := \begin{pmatrix} R_{ch.z} \\ \frac{t_{stfnr}}{\sqrt{12}} \end{pmatrix}$ $r_{klr} = \begin{pmatrix} 0.2451 \\ 0.0722 \end{pmatrix}$ in — Note r for a rectangular section reduces down to equal to the thickness divided by the square root of 12.

$KLR := \overrightarrow{\frac{K_{eq} \cdot L_{klr}}{r_{klr}}}$ $KLR = \begin{pmatrix} 106.6 \\ 150.3 \end{pmatrix}$

The allowable compression stress in accordance with N690 (Reference [21]) for each of these members is:

$$F_{a.ss1_i} := \frac{S_{y.a}}{2.15} - \left(\frac{\frac{S_{y.a}}{2.15} - 6}{120}\right) \cdot \overrightarrow{\frac{K_{eq_i} \cdot L_{klr_i}}{r_{klr_i}}} \qquad F_{a.ss1} = \begin{pmatrix} 6.655 \\ 4.519 \end{pmatrix} \qquad \text{(Q1.5-11)}$$

$$F_{a.ss2_i} := S_{y.a} \cdot \left[0.40 - \frac{1}{600} \cdot \left(\frac{K_{eq_i} \cdot L_{klr_i}}{r_{klr_i}}\right)\right] \qquad F_{a.ss2} = \begin{pmatrix} 5.67 \\ 3.81 \end{pmatrix} \qquad \text{(Q1.5-12 from Supplement 1)}$$

$$F_{a.ss_i} := \text{if}\left(KLR_i \le 120, F_{a.ss1_i}, F_{a.ss2_i}\right) \qquad F_{a.ss} = \begin{pmatrix} 6.66 \\ 3.81 \end{pmatrix}$$

GTSTRUDL calculates the compression allowable dependent on the value of Cc. If you consider that KL/R exactly equals Cc, the GTSTRUDL would calculate the compression allowable as:

$$F_{a.cc} := \frac{\left(1 - \frac{1}{2}\right) \cdot S_{y.a}}{\frac{5}{3} + \frac{3}{8} - \frac{1}{8}} \qquad F_{a.cc} = 6.652 \qquad \text{(For KL/R = Cc)}$$

The Cc and the L/R ratio for the affected members are:

$$C_c := \sqrt{\frac{2 \cdot \pi^2 \cdot E_1}{S_{ya}}} \qquad C_c = \begin{pmatrix} 91.36 \\ 146.30 \end{pmatrix} \qquad \text{(Reference [21])}$$

$$LR_{klr} := \frac{L_{klr}}{r_{klr}} \qquad LR_{klr} = \begin{pmatrix} 106.6 \\ 150.3 \end{pmatrix}$$

If you consider that the effective KL/r in GTSTRUDL ends up being less than Cc, then the effective K value can be solved for by setting the GTSTRUDL equation equal to the actual compression allowable per N-690.

$K_{aCS1} := 1$ (initial guess)

$$K_{aCS1_i} := \mathrm{root}\left[\frac{\left[1-\frac{\left(\overrightarrow{\left(K_{aCS1}\cdot LR_{klr_i}\right)}\right)^2}{2\cdot\left(C_{c_i}\right)^2}\right]\cdot S_{y.a}}{\frac{5}{3}+\frac{3\cdot\left(\overrightarrow{\left(K_{aCS1}\cdot LR_{klr_i}\right)}\right)}{8\cdot C_{c_i}}-\frac{\left(\overrightarrow{\left(K_{aCS1}\cdot LR_{klr_i}\right)}\right)^3}{8\cdot\left(C_{c_i}\right)^3}}-F_{a.ss_i}, K_{aCS1}\right] \qquad K_{aCS1} = \begin{pmatrix}0.857\\1.165\end{pmatrix}$$

If you consider that the effective KL/r in GTSTRUDL ends up being greater than Cc, then the effective K value can be solved for by setting the GTSTRUDL equation equal to the actual compression allowable per N-690.

$$K_{aCS2} := \overrightarrow{\sqrt{\frac{1}{F_{a.ss}}\cdot\left(\frac{12\cdot\pi^2\cdot\frac{E_1}{ksi}}{23\cdot LR_{klr}^{\,2}}\right)}} \qquad K_{aCS2} = \begin{pmatrix}0.857\\1.286\end{pmatrix}$$

The applicable equation can be determined by comparing the N690 allowable to the GTSTRUDL allowable based on KL/R equal to Cc. Therefore, the effective length factor to use in GTSTRUDL is:

$$K_{aCS_i} := \mathrm{if}\left(F_{a.ss_i} \le F_{a.cc}, K_{aCS2_i}, K_{aCS1_i}\right) \qquad K_{aCS} = \begin{pmatrix}0.857\\1.286\end{pmatrix}$$

Kz Edge Channels
Ky External Radial Stiffeners

In addition to the equations for the allowable compression stress, N-690 also provides a lower allowable for F_e'. Equating the equation for F_e' of carbon steel to austenitic stainless steel and solving for the K-value of carbon steel,

$$K_{eCS} := \sqrt{\frac{12\cdot(2.15)\cdot K_{eq}^{\,2}}{23}} \qquad K_{eCS} = \begin{pmatrix}1.06\\1.06\end{pmatrix}$$

The effective K value to be used in GTSTRUDL is the maximum between these two values. Using the maximum between the two will provide a conservative result. These are the values input into GTSTRUDL. If the members fail the GTSTRUDL code check a detailed calculation can be performed.

$$K_{eff_i} := \max\left(K_{aCS_i}, K_{eCS_i}\right) \qquad K_{eff} = \begin{pmatrix}1.06\\1.29\end{pmatrix}$$

Kz Edge Channels
Ky External Radial Stiffeners

6.4.8 Loads and Load Combinations

The following load cases are applied in the GTSTRUDL model

Load Name	Description
WT	Dead Weight of the Strainers
PRELOAD	Temperature change used to induce preload into the tension rods
WT + DEB	Dead Weight of the Strainers + Debris weight
PRESSURE	Unbalanced pressure load on strainer end cap
RSOBEX, RSOBEY,RSOBEY2	Response spectra loads for OBE in the X-direction and Y-directions
RSSSEX, RSSSEY,RSSEY2	Response spectra loads for SSE in the X-direction and Y-directions
MMOBEX, MMOBEY,MMOBEY2	Missing mass load (ZPA) for OBE loads in the X-direction and Y-directions
MMSSEX, MMSSEY,MMSSEY2	Missing mass load (ZPA) for SSE loads in the X-direction and Y-directions

Note: Load cases with "Y" only are based on all cables being released, and load cases with "Y2" are based on all cables being active. Load cases with "X" have only X-tension cables active.

Loading For Stiffness Matrix and Benchmarking

CABLE	Static lateral load used to determine which cables are in compression
X1, Y1, MY1, MZ1	Loads used to determine flexibility of 7 disk pinned module (used in plenum calc)
X2, Y2, MY2, MZ2	Loads used to determine flexibility of 6 disk fixed module (used in plenum calc)
X2, Y2, MY2, MZ2	Load used to determine flexibility of 7 disk fixed module (used in plenum calc)
BENCHX	Load used for benchmarking the x-displacement (used in plenum calc)

Load Combinations:

Following load combinations are created for the code check.

DW	Steel weight + Preload
DW+DEB+P	Steel weight + Debris weight + Preload + Pressure
SEISOBE, SEISOBE2	OBEX + OBEY and OBEX + OBEY2
SEISSSE, SEISSSE2	SSEX + SSEY and SSEX + SSEY2
DW+OBE+, DW+OBE2+	DW + SEISOBE and DW + SEISOBE2
DW+SSE+, DW+SSE2+	DW + SEISSSE and DW + SEISSSE2
DW+OBE-, DW+OBE2-	DW - SEISOBE and DW - SEISOBE2
DW+SSE-, DW+SSE2-	DW - SEISSSE and DW - SEISSSE2

Note: Load combinations with "2" are based on all cables being active for the Y-earthquake. Load combinations without a "2" have all cables released for the Y-earthquake. For the X-earthquake, only tension cables are active.

6.5 GTSTRUDL Results

The results from the GTSTRUDL run are provided below. GTSTRUDL performs a code check of all of the members for both the OBE and SSE load combinations. The results of the code checks are summarized below:

Component	Interaction Ratio	Load Comb.	Member No.	Summary
Welded Radial Stiffeners (including Collar)	$IR_{stfnr} := \begin{pmatrix} 0.24 \\ 0.70 \\ \frac{1.02}{1 + CT_{rect}} \end{pmatrix}$	DW+DEB+P DW+OBE DW+SSE	COL1 COL8 COL8	$IR_{stfnr} = \begin{pmatrix} 0.24 \\ 0.70 \\ 0.85 \end{pmatrix}$
Tension Rods	$IR_{rod} := \begin{pmatrix} 0.46 \\ 0.46 \\ \frac{0.54}{1 + CT} \end{pmatrix}$	DW+DEB+P DW+OBE DW+SSE	IROD108 IROD108 OROD708	$IR_{rod} = \begin{pmatrix} 0.46 \\ 0.46 \\ 0.42 \end{pmatrix}$
Edge Channels	$IR_{chan} := \begin{pmatrix} 0.20 \cdot K_{pp} \\ 0.29 \cdot K_{pp} \\ \frac{0.40 \cdot K_{pp}}{1 + CT} \end{pmatrix}$	DW+DEB+P DW+OBE DW+SSE	EC1002 EC1002 EC1002	$IR_{chan} = \begin{pmatrix} 0.51 \\ 0.73 \\ 0.78 \end{pmatrix}$
Cross Bracing Cables	$IR_{cable} := \begin{pmatrix} 0.0 \\ 0.30 \\ \frac{0.53}{1 + CT} \end{pmatrix}$	DW+DEB+P DW+OBE DW+SSE	N/A CABLE5 CABLE5	$IR_{cable} = \begin{pmatrix} 0.00 \\ 0.30 \\ 0.41 \end{pmatrix}$
Hex Couplings	$IR_{hex} := \begin{pmatrix} 0.19 \\ 0.28 \\ \frac{0.39}{1 + CT} \end{pmatrix}$	DW+DEB+P DW+OBE DW+SSE	HEX3 HEX2 HEX4	$IR_{hex} = \begin{pmatrix} 0.19 \\ 0.28 \\ 0.30 \end{pmatrix}$
Core Tube (including Core Tube Sleeves)	$IR_{tube} := \begin{pmatrix} 0.033 \cdot K_{ct} \\ 0.019 \cdot K_{ct} \\ \frac{0.032 \cdot K_{ct}}{1 + CT} \end{pmatrix}$	DW+DEB+P DW+OBE DW+SSE	CT1 CT1 CT1	$IR_{tube} = \begin{pmatrix} 0.18 \\ 0.11 \\ 0.14 \end{pmatrix}$

Component	Interaction Ratio	Load Comb.	Member No.	Summary
Bent up Portions of Radial Stiffeners	$IR_{bent} := \begin{pmatrix} 0.06 \\ 0.19 \\ \frac{0.33}{1 + CT_{rect}} \end{pmatrix}$	DW+DEB+P DW+OBE DW+SSE	BENT1 PA6 PA6	$IR_{bent} = \begin{pmatrix} 0.06 \\ 0.19 \\ 0.28 \end{pmatrix}$
Spacers	$IR_{spcr} := \begin{pmatrix} 0.80 \\ 0.86 \\ \frac{0.98}{1 + CT_{rect}} \end{pmatrix}$	DW+DEB+P DW+OBE DW+SSE	SPCR502 SPCR602 SPCR602	$IR_{spcr} = \begin{pmatrix} 0.80 \\ 0.86 \\ 0.82 \end{pmatrix}$

Spacers

The spacers are qualified by comparing the maximum stresses due to seismic, with the initial compression load. As long as the seismic stress is less than the preload (with an allowance for relaxation in preload over time), then the spacers will always be in compression. If the extreme fiber seismic stress were to exceed the prestress, then there is the potential for a gap to open at one of the splices (because the spacers can not take tension because they are not continuous). However, in this case, this does not constitute a failure of the strainer, this just represents the maximum linear elastic capacity of the spacers. In this case any additional load is taken solely by the tension rods.

The reduction in preload due to relaxation is based on Reference [26]. As per Section 4.4 of Reference [26], an average loss of about 5% of the preload can be considered to occur immediately upon completion of the torquing. An additional relaxation of about 6% typically occurs over the long term. Relaxation is expected to increase with grip length. See these tension rods have a very long grip length, with many connected spacers additional relaxation beyond these values may result. Therefore 15% relaxation is conservatively considered (about 40% increase over the standard industry relaxation of 11%). Note that since the normal operating temperature of the strainers is moderate (less than 140 degrees), additional creep associated with high temperature service need not be considered. In addition, uncertainty in the applied bolt torque and the torque to preload conversion is considered to account for minimum possible preload.

$$\sigma_{spcr.seis1} := \left(\frac{\sqrt{183^2 + 60^2} \cdot in \cdot lbf}{0.048 \cdot in^3} \right) + \frac{3878 \cdot lbf - 3863 \cdot lbf}{A_{spcr}}$$

$$\sigma_{spcr.seis2} := \left(\frac{\sqrt{161^2 + 97^2} \cdot in \cdot lbf}{0.048 \cdot in^3} \right) + \frac{3878 \cdot lbf - 3754 \cdot lbf}{A_{spcr}}$$

Max moment on the spacers [Member 'SPCR503' or SPCR707 per Attachment B] divided by the section modulus from GTSTRUDL plus induced tension divided by area.

$\sigma_{spcr.seis} := \max(\sigma_{spcr.seis1}, \sigma_{spcr.seis2})$ $\qquad \sigma_{spcr.seis} = 4303 \text{ psi}$

The minimum preload in the spacer is

$$F_{load.min} := \frac{T_{rod} \cdot 0.85 \cdot 0.80 \cdot 0.85}{OD_{rod} \cdot (K_{nf})} \qquad F_{load.min} = 1618.4\,lbf$$

(0.85 for under torque tolerance)
(0.80 for torque to preload conversion uncertainty
(0.85 for preload relaxation)

$$\sigma_{spcr.pre} := \frac{F_{load.min}}{A_{spcr}} \qquad \sigma_{spcr.pre} = 5057\ psi$$

$$IR_{spcr.s} := \frac{\sigma_{spcr.seis}}{\sigma_{spcr.pre}} \qquad IR_{spcr.s} = 0.85$$

(Conservative)

6.6 Disk Pressure Loads

Loads are applied to the strainer disk faces depending on the type of load. Seismic loads are applied in proportion to the tributary mass acting on each strainer component. These tributary masses are calculated in Section 6.4.

Differential pressure loads act across the perforated plate and attempt to collapse the strainer during operation. The differential pressure is based on the worst case head loss through the debris covered strainer.

The pressure loads on the strainer is broken down into the various strainer components, or surfaces. The break down is as follows:

End Disk - The outside faces of the end disks.

Middle Disk - The faces of the interior, or middle disks.

End Cover - The plate covering the very end of the core tube.

Outer Rim - The perforated plate webs of the edge channels at the outside diameter of the disk

Inner Gap - The curved inner gap perforated plate in between disks.

Axial loads are applied to the end disks, the middle disks, and the core tube end cap. Vertical and lateral loads are applied to the outer rim and inner gap perforated plates.

6.6.1 Axial Loads

The equivalent pressure acting on each disk face is determined by multiplying the accelerations by the tributary volume (or mass). The mass takes into account the weight of the steel, the weight of the debris. Two load combinations are examined, Load Combination # 0 (DW + DP + DEB), and Load Combination # 2 (DW + SSE).

End Disk Face (controls over first disk and inner faces of end disks)

$$q_{end.disk.0} := DP + \left(t_{perf} \cdot PR_{disk} \cdot \rho_{steel} + \max\left(\frac{WD}{A_s}\right)\right)$$

$$q_{end.disk.0} = 1.56 \text{ psi}$$

$$q_{end.disk.2} := \left[t_{perf} \cdot PR_{disk} \cdot \rho_{steel} + \frac{Wt_{radial_1} + Wt_{circ_1}}{N_{disk_1} \cdot \left(L1_{disk} \cdot L2_{disk} - \frac{\pi}{4} \cdot OD_{gap}^2\right)}\right] \cdot \left(1 + 1.5 \cdot a_{v_2}\right)$$

$$q_{end.disk.2} = 0.035 \text{ psi}$$

Middle Disk Face

$$q_{mid.disk.0} := DP + \left(t_{perf} \cdot PR_{disk} \cdot \rho_{steel} + \max\left(\frac{WD}{A_s}\right)\right)$$

$$q_{mid.disk.0} = 1.56 \text{ psi}$$

$$q_{mid.disk.2} := \left[t_{perf} \cdot PR_{disk} \cdot \rho_{steel} + \frac{Wt_{radial_1} + Wt_{circ_1}}{N_{disk_1} \cdot \left(L1_{disk} \cdot L2_{disk} - \frac{\pi}{4} \cdot OD_{gap}^2\right)}\right] \cdot \left(1 + 1.5 \cdot a_{v_2}\right)$$

$$q_{mid.disk.2} = 0.035 \text{ psi}$$

Core Tube End Cover (End Core)

$$q_{end.core.0} := DP + t_{perf} \cdot PR_{disk} \cdot \rho_{steel} + \max\left(\frac{WD}{A_s}\right) \qquad q_{end.core.0} = 1.56\ psi$$

$$q_{end.core.2} := t_{perf} \cdot PR_{disk} \cdot \rho_{steel} \cdot \left(1 + 1.5 \cdot a_{v_2}\right) \qquad q_{end.core.2} = 0.011\ psi$$

6.6.2 Lateral Loads

Lateral loads are determined similarly to the axial loads calculated above. Lateral loads are split into two components, loads acting on the edge channels, and loads acting on the inner gaps. Similar to axial loads, for acceleration loads, the portion acting on each component is based on the tributary water volume acting on each segment. Also, applied pressures are divided by two as 1/2 is applied as a positive pressure to the front face, and 1/2 is applied as a negative pressure on the back face.

Edge Channel

$$q_{chan.0} := DP \qquad q_{chan.0} = 1.52\ psi$$

$$q_{chan.2} := \left(\frac{Wt_{edge_1}}{N_{disk} \cdot 2 \cdot L_{disk} \cdot L1_{disk}}\right) \cdot 1.5 \cdot a_{h_2} \qquad q_{chan.2} = 0.005\ psi$$

Inner Gap

$$q_{gap.0} := DP \qquad q_{gap.0} = 1.52\ psi$$

$$q_{gap.2} := \left(\frac{Wt_{gap_1}}{L_{gap_1} \cdot 2 \cdot OD_{gap}}\right) \cdot 1.5 \cdot a_{h_2} \qquad q_{gap.2} = 0.023\ psi$$

6.6.3 Disk Pressure Summary

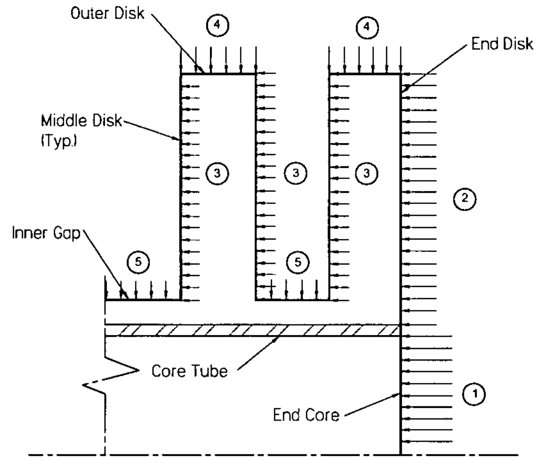


Figure 6.6-1 Disk Face Pressure Summary

	Operating Conditions	Seismic Conditions (SSE)
Surface 1, End Core	$q_{end.core.0} = 1.56$ psi	$q_{end.core.2} = 0.011$ psi
Surface 2, End Disk	$q_{end.disk.0} = 1.56$ psi	$q_{end.disk.2} = 0.035$ psi
Surface 3, Middle Disk	$q_{mid.disk.0} = 1.56$ psi	$q_{mid.disk.2} = 0.035$ psi
Surface 4, Edge Channel (Lateral)	$q_{chan.0} = 1.52$ psi	$q_{chan.2} = 0.005$ psi
Surface 5, Inner Gap (Lateral)	$q_{gap.0} = 1.52$ psi	$q_{gap.2} = 0.023$ psi

6.7 Perforated Plate Evaluation

The perforated plate is analyzed as an equivalent solid plate. The thickness used is the actual thickness, however an equivalent Modulus of Elasticity and Poison's ratio is used to account for the holes from a stiffness perspective. When determining stresses however, the stresses need to be factored up to account for the holes in the plate. Article A-8000 of the ASME B&PV Code (Reference [4]) is used to determine the actual stresses in the perforated plate using the results from an equivalent solid plate analysis. Note that this perforated plate does not meet the thickness limitation of A-8110 (a)(5), however per Reference [19] (which is the paper from which A-8000 is based) this limitation was associated with the figures provided for the equivalent elastic modulus and Poisson's ratio and therefore does not impact the stress equations given in A-8000.

A-8142.1 provides the following equations:

$$S = \frac{P}{h}\cdot\sqrt{\left(\frac{\Delta p\cdot R}{t} + \frac{W}{\pi\cdot t\cdot R}\right)^2 + \sigma_{r.bar}^2} < S_m$$

$$S = K\cdot\left(\frac{P}{h}\right)\cdot\sigma_{ave} \qquad < 1.5\ S_m$$

Where:

S_m = ASME allowable stress intensity
K = Stress multiplier to convert principal stress into stress intensity (from Fig. A-8142-1)
P = Pitch (spacing) between holes
h = Ligament width between holes
σ_{ave} = Maximum principal stress (larger of radial or tangential)

These two equations are basically the membrane and membrane plus bending checks for the plate. The term under the radical for the first equation is just the formula used for a circular perforated plate to calculate the membrane stress by hand. The K factor is a function of the biaxiality ratio (ratio of σ_r to σ_θ) and is just used to convert the maximum principal stress to the maximum stress intensity. To determine this factor, a closer inspection of Figure A-8142-1 from Article A-8000 is required. Since this strainer is considered a Class II component, stress intensities are not calculated and only the maximum principal stresses are considered. Therefore the K factor is not applied. The allowable stress is taken as 1.5 S as per Reference [29].

The stresses in the perforated plate are examined at five locations as follows:

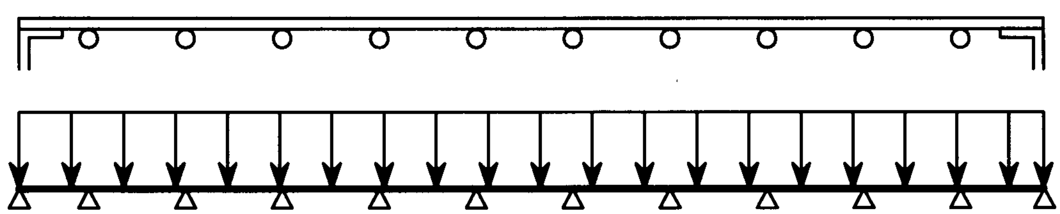
The front disk face is defined as the disk face where the pressure is pushing the perforated plate against the stiffening wires. In this case, the perforated plate is supported by the wires, spanning between the two adjacent wires. This face is subjected both to gravity plus seismic loads, as well as operating differential pressure (DP).

The back disk face is defined as the disk face where the pressure is trying to pull the perforated plate away from the wires. In this case the perforated plate is supported by discrete points at the rivet locations and the rod spacers. This plate bends in a 2-way action between the rivets. This back face is only subjected to gravity plus seismic pressure as the operating differential pressure (DP) only acts inward.

The outer rims are subjected to both seismic load and operating differential pressure. The outer rim is essentially the web of the edge channels and is continuously supported along the edges by the disk faces through the rivets. Since the depth of the disk is only 1/2", the outer rim stress is much less than the disk face stress and is therefore OK by comparison.

The inner gap plates simply consist of a thin, flat, circular ring. The gap plates are supported at discrete points by the inner rods. Because of the complex stress distribution due to the curvature and the discrete support points, the stresses in the inner gap are calculated using finite element analysis using ANSYS software. Buckling is also evaluated.

The stresses for the front face are calculated by hand based on Reference [17]. A unit width of perforated plate is considered, subjected to a uniformly distributed load. The plate acts as a continuous beam simply supported at each radial wire, and simply supported at the edges. Since the beam is continuous, the stresses in the perf plate are based on a fixed-fixed beam with a span equal to the maximum wire spacing. The figure below depicts this model.



6.7.1 End Disk Perforated Plate

Check Front Disk Face

Per Timoshenko (Reference [17]), the stresses in the plates acting as tension members can be determined as follows:

The maximum span between wires for the vertical sides was calculated previously in section 6.1 and found to be:

$L_s := \max(S1_{rad}, S2_{rad})$ $\qquad$ $L_s = 3.20\,in$

The pressure acting on the perforated plate on the end disk was calculated in section 6.7 as:

$q := q_{end.disk.0}$ $\qquad$ $q = 1.56\,psi$

The ends can be considered fixed because of the continuity of the perforated plate, therefore, refer to Section 3, of Chapter 1, of Reference [17].

$$D := \frac{E_{eff} \cdot t_{perf}^{\,3}}{12 \cdot \left(1 - \nu_{eff}^{\,2}\right)} \qquad D = 211.6\,in \cdot lbf$$

$$U_1 := \left[\frac{E_{eff}}{\left(1 - \nu_{eff}^{\,2}\right) \cdot q} \cdot \left(\frac{t_{perf}}{L_s}\right)^4\right]^2 \qquad U_1 = 0.8506$$

Solving Eq. (15) for u

$u := 0.08$ (initial guess)

$$u := \mathrm{root}\left(U_1 + \frac{81}{16 \cdot u^7 \cdot \tanh(u)} + \frac{27}{16 \cdot u^6 \cdot \sinh(u)^2} - \frac{27}{4 \cdot u^8} - \frac{9}{8 \cdot u^6}, u\right) \qquad u = 0.09$$

$$\psi := \frac{3 \cdot (u - \tanh(u))}{u^2 \cdot \tanh(u)} \qquad \psi = 1.0$$

(direct tensile, or membrane stress)

$$\sigma_1 := \frac{E_{eff} \cdot u^2}{3 \cdot \left(1 - \nu_{eff}^2\right)} \cdot \left(\frac{t_{perf}}{L_s}\right)^2 \cdot K_{pp} \qquad \sigma_1 = 0.029 \text{ ksi}$$

(bending stress)

$$\sigma_2 := \frac{q}{2} \cdot \left(\frac{L_s}{t_{perf}}\right)^2 \cdot \psi \cdot K_{pp} \qquad \sigma_2 = 5.70 \text{ ksi}$$

The membrane plus bending maximum principal stress is,

$$\sigma_{front} := \left(\sigma_1 + \sigma_2\right) \qquad \sigma_{front} = 5.73 \text{ ksi}$$

The allowable stress is defined in Section 3.0 as

$$S_{all.pl} := 1.5 \cdot S \qquad S_{all.pl} = 26.85 \text{ ksi}$$

$$IR_{face.dp} := \frac{\sigma_{front}}{S_{all.pl}} \qquad IR_{face.dp} = 0.21$$

The deflection at midspan between stiffeners is,

$$f_1 := \frac{24}{u^4} \cdot \left(\frac{u^2}{2} + \frac{u}{\sinh(u)} - \frac{u}{\tanh(u)}\right) \qquad f_1 = 1.0 \qquad \delta := \frac{q \cdot L_s^4}{384 \cdot D} \cdot f_1 \qquad \delta = 0.002 \text{ in}$$

Check End Disk Face for Back Pressure

For the differential pressure case the internal wire stiffeners provide support to the perforated plate because the pressure acts inward. However the gravity plus seismic pressure due to acceleration can act either inward, or outward. The outward pressure case is like a back pressure trying to pull the perforated plate off of the strainer. in this case the only thing holding the plate on is the rivets at the edge channels, and the inner gap plates for the middle disk faces, or the collar for the end disk face.

To analyze this condition, consider the plate as an annular plate with an equivalent area, simply supported at both the inner and outer edges. The analysis is based on Roark and Young (Reference [16], Table 24, Case Number 2c.). This is the same case evaluated in Section 6.4.2 to determine how much load is tributary to the edge channels, or to the inner rods, therefore all of the C and L constants are already defined. Reference 16 also provides the formula for the moment in the plate as a function of the radius. A solve block is used to solve for the maximum moment because the location of this maximum moment is unknown. Note that the units must be removed prior to entering the solve block. The maximum seismic stress is calculated (SSE) and conservatively compared to standard allowables.

$q_{bp.obe} := \frac{q_{end.disk.2}}{psi}$ $\quad E_{bp} := \frac{E_{eff}}{psi}$ $\quad t_{bp} := \frac{t_{perf}}{in}$

$D := \frac{E_{bp} \cdot t_{bp}^3}{12 \cdot (1 - v_{eff})}$ $\quad M_{rb} := 0$

An equivalent outer radius "a" is determined based on a equivalent area

$a := \sqrt{\frac{L1_{disk} \cdot L2_{disk}}{\pi}}$ $\quad a = 15.80\,in$ $\quad b := \frac{OD_{gap}}{2}$ $\quad b = 7.87\,in$

$a := \frac{a}{in}$ $\quad a = 15.80$ $\quad b := \frac{b}{in}$ $\quad b = 7.88$ $\quad r_o := b$

The rotation and reaction at the inner edge are solved for based on the previously determined constants

$$\theta_b := \left(\frac{-q_{bp.obe} \cdot a^3}{D} \cdot \frac{C_3 \cdot L_{17} - C_9 \cdot L_{11}}{C_1 \cdot C_9 - C_3 \cdot C_7} \right) \qquad \theta_b = -0.00$$

$$Q_b := \left(q_{bp.obe} \cdot a \cdot \frac{C_1 \cdot L_{17} - C_7 \cdot L_{11}}{C_1 \cdot C_9 - C_3 \cdot C_7} \right) \qquad Q_b = 0.18$$

Initial guesses must be made for all variables within the solve block prior to entering the solve block.

Initial guesses:

$$r := \frac{a+b}{2} \qquad F_7 := \frac{1}{2}\cdot\left(1-\nu_{eff}^2\right)\cdot\left(\frac{r}{b}-\frac{b}{r}\right)$$

$$F_8 := \frac{1}{2}\cdot\left[1+\nu_{eff}+\left(1-\nu_{eff}\right)\cdot\left(\frac{b}{r}\right)^2\right] \qquad F_9 := \frac{b}{r}\cdot\left[\frac{1+\nu_{eff}}{2}\cdot\ln\left(\frac{r}{b}\right)+\frac{1-\nu_{eff}}{4}\cdot\left[1-\left(\frac{b}{r}\right)^2\right]\right]$$

$$G_{17} := \frac{1}{4}\cdot\left[1-\frac{1-\nu_{eff}}{4}\cdot\left[1-\left(\frac{r_o}{r}\right)^4\right]-\left(\frac{r_o}{r}\right)^2\cdot\left[1+\left(1+\nu_{eff}\right)\cdot\ln\left(\frac{r}{r_o}\right)\right]\right]\cdot\left(r-r_o\right)^0$$

$$M_r\left(r,F_7,F_8,F_9,G_{17}\right) := \theta_b\cdot\frac{D}{r}\cdot F_7+M_{rb}\cdot F_8+Q_b\cdot r\cdot F_9-q_{bp.obe}\cdot r^2\cdot G_{17}$$

Solve Block

Given

$$F_7 = \frac{1}{2}\cdot\left(1-\nu_{eff}^2\right)\cdot\left(\frac{r}{b}-\frac{b}{r}\right)$$

$$F_8 = \frac{1}{2}\cdot\left[1+\nu_{eff}+\left(1-\nu_{eff}\right)\cdot\left(\frac{b}{r}\right)^2\right]$$

$$F_9 = \frac{b}{r}\cdot\left[\frac{1+\nu_{eff}}{2}\cdot\ln\left(\frac{r}{b}\right)+\frac{1-\nu_{eff}}{4}\cdot\left[1-\left(\frac{b}{r}\right)^2\right]\right]$$

$$G_{17} = \frac{1}{4}\cdot\left[1-\frac{1-\nu_{eff}}{4}\cdot\left[1-\left(\frac{r_o}{r}\right)^4\right]-\left(\frac{r_o}{r}\right)^2\cdot\left[1+\left(1+\nu_{eff}\right)\cdot\ln\left(\frac{r}{r_o}\right)\right]\right]\cdot\left(r-r_o\right)^0$$

$$Var := Maximize\left(M_r,r,F_7,F_8,F_9,G_{17}\right) \qquad Var^T = \left(11.49 \quad 0.35 \quad 0.82 \quad 0.23 \quad 0.04\right)$$

$M_{bp} := M_r(Var_1, Var_2, Var_3, Var_4, Var_5)\cdot lbf$ $\quad M_{bp} = 0.26\,\frac{in\cdot lbf}{in}$

Disk face stresses:

$\sigma_{back} := 6\cdot\frac{M_{bp}}{t_{perf}^2}\cdot K_{pp}$ $\quad \sigma_{back} = 1.13\,ksi$

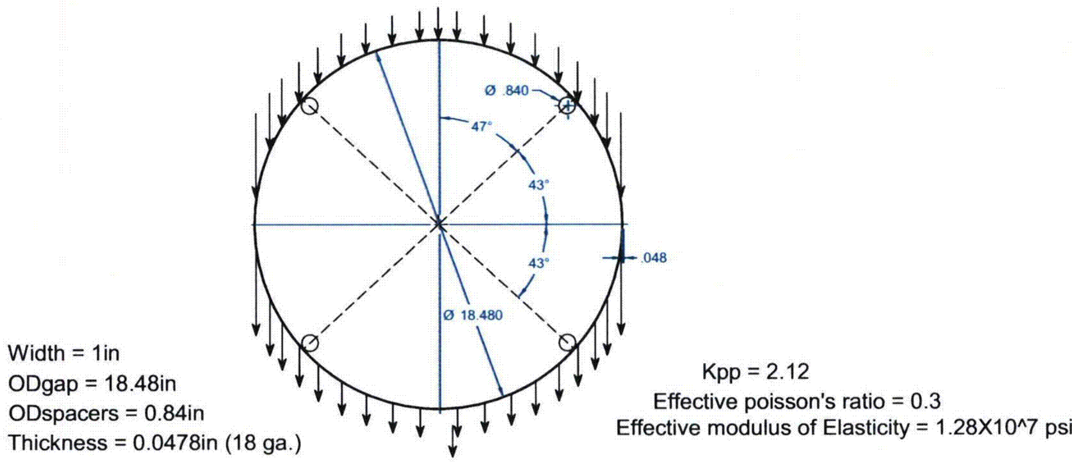
$IR_{face.bp} := \frac{\sigma_{back}}{S_{all.pl}}$ $\quad IR_{face.bp} = 0.04$

6.7.2 Middle Disk Perforated Plate

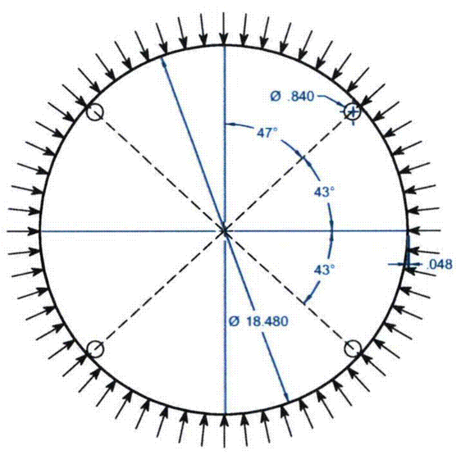
The geometry and pressure on the middle disk faces is the same as for the end disk as is the geometry, therefore the stresses in the middle disk faces are bounded by those calculated above for the end disk faces.

6.7.3 Inner Gap Perforated Plate

The stresses in the inner gap are determined using finite element analysis using ANSYS to take advantage of the added strength associated with the curvature of the inner gap. The parameters used in the ANSYS model are shown below. Note these don't match the Watts Bar configuration however the stresses are adjusted later to account for the differences between the model and the actual configuration.



Case 1 - Seismic Pressure



Case 3 - Differential Pressure

Figure 6.7-1 ANSYS Model of Inner Gap Perforated Plate

The model includes the full 360 degrees of the gap plate. The cross section is just a thin flat plate, modeled as an equivalent plate to account for the perforations. The model is supported at four discrete points along the circumference at the inner rod locations. One way supports are used such that they only restrain the plate from displacing inward, but offer no resistance if the plate wants to pull away from the rods. Three cases of unit load pressure (1 psi) are applied. Case 1 is for all the pressure in the vertical direction. Case 2 is similar, but with the pressure acting in the lateral direction. Case 3 is for the differential pressure (operating pressure) with all pressure acting radially inward. A fourth combined case is run with the initial guesses for the actual pressures in each direction. The stresses shown below are from the combined case using the actual pressures. The pressures used in the ANSYS model and the actual calculated pressures are as follows:

Load Case	Used in ANSYS	Actual Pressures
Case 1 - Vertical	$q_{y.ans} := 0.07 \cdot psi$	$q_{gap.2} = 0.02$ psi
Case 2 - Horizontal	$q_{z.ans} := 0.15 \cdot psi$	$q_{gap.2} = 0.02$ psi
Case 3 - Radial	$q_{r.ans} := 1.37 \cdot psi$	$q_{gap.0} = 1.52$ psi

The ANSYS results are scaled up by the worst case increase from any of the three load cases. Stress plots are included on the following pages. The scale factor (Kp) accounts for changes in pressure, the Kpp factor, and the thickness of the perf plate in relation to the parameters used in the actual analysis

$$K_p := \max\left(\frac{q_{gap.2}}{q_{y.ans}}, \frac{q_{gap.2}}{q_{z.ans}}, \frac{q_{gap.0}}{q_{r.ans}}\right) \cdot \frac{K_{pp}}{2.12} \cdot \frac{0.0478 \cdot in}{t_{perf}} \qquad K_p = 1.06$$

Note that the ANSYS model was run for a 18.5" OD Gap ring which is larger than the 15.75" gap ring for Watts Bar. The use of a larger diameter is conservative.

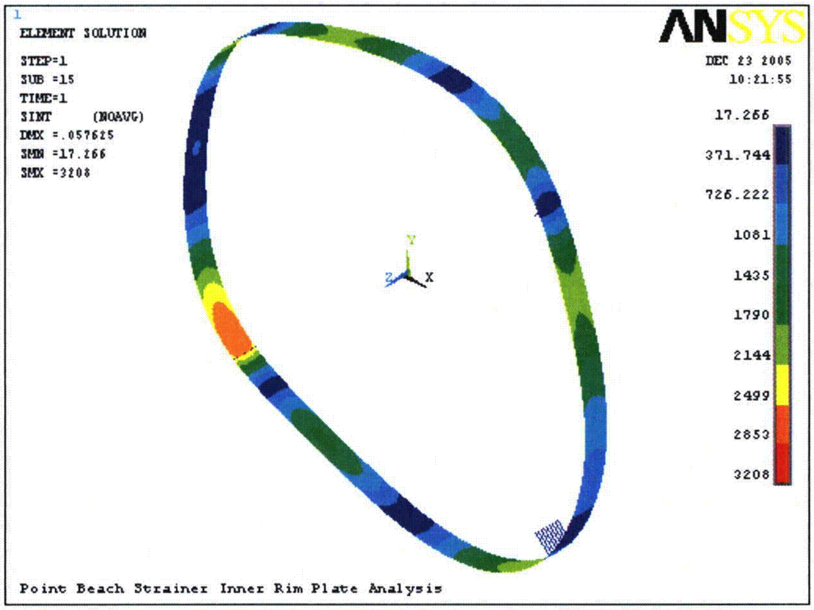


Figure 6.7-2 Inner Gap Plate Membrane Plus Bending

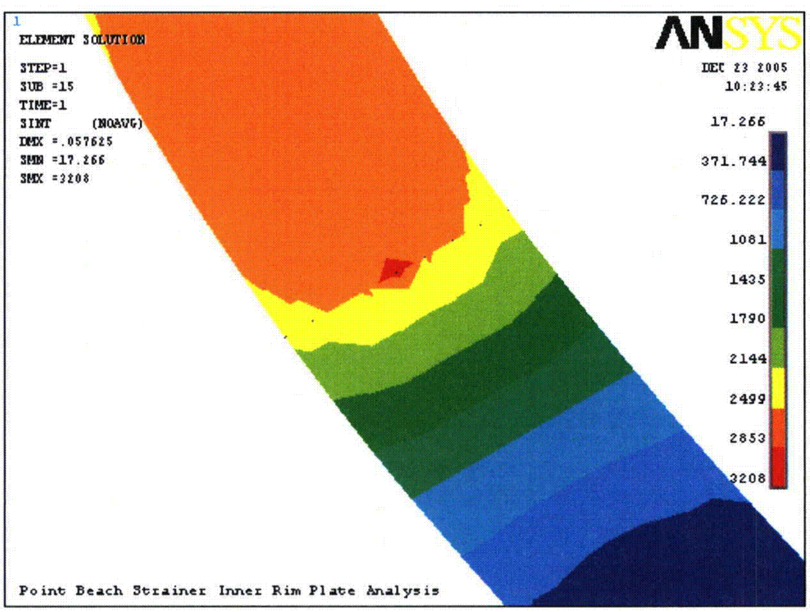


Figure 6.7-3 Inner Gap Plate Membrane Plus Bending (Close-Up)

Figure 6.7-4 Inner Gap Plate Membrane Stress

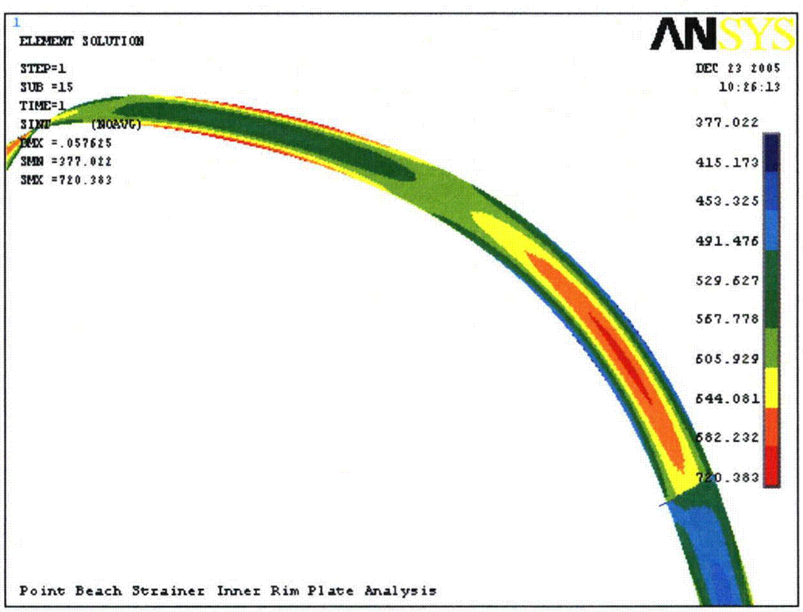


Figure 6.7-5 Inner Gap Plate Membrane Stress (Close-Up 1)

Client: Performance Contracting Inc.	Revision: 2
Station: Watts Bar Unit 1	Prepared By: Curtis J. Warchol
Calc. Title: Structural Evaluation of Advanced Design Containment Building Sump Strainers	Reviewed By: Kishore D. Patel
Safety Related Yes [X] No [ ]	Date: 08/25/06

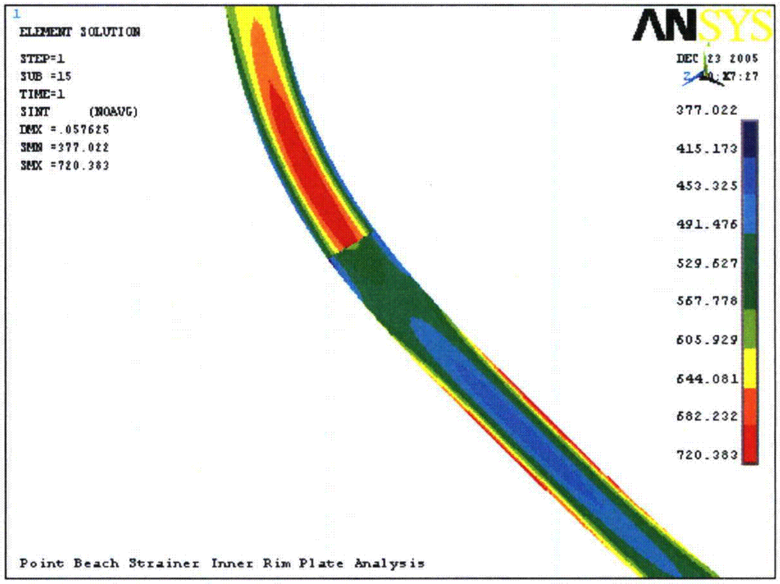


Figure 6.7-6 Inner Gap Plate Membrane Stress (Close-Up 2)

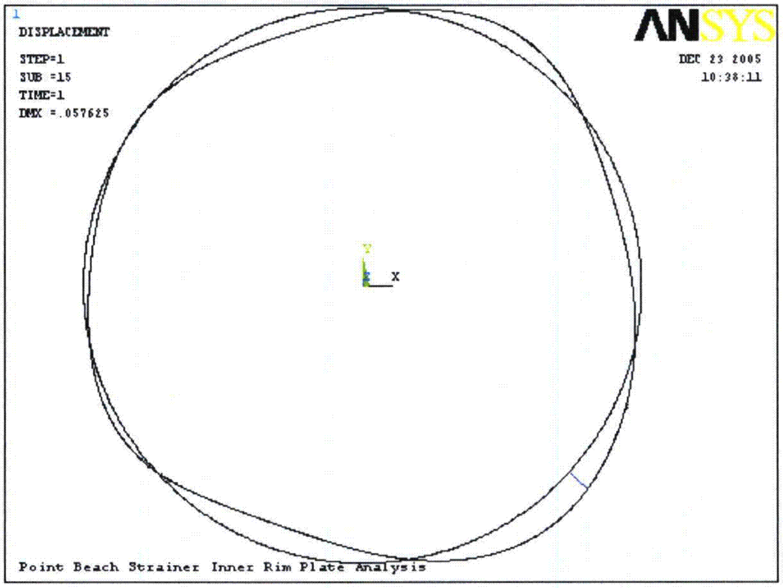


Figure 6.7-7 Inner Gap Plate Displaced Shape

The ANSYS output is included as Attachment D. The maximum membrane principal stresses occur at the support locations. These stress are already adjusted in ANSYS to account for the Kpp factor. The stresses from ANSYS are scaled down on the ratio of Kp.

$\sigma_{gap.mem} := 720 \cdot psi \cdot K_p$ $\qquad \sigma_{gap.mem} = 0.76\,ksi$

$\sigma_{gap.ben} := 3200 \cdot psi \cdot K_p$ $\qquad \sigma_{gap.ben} = 3.39\,ksi$

The allowable stresses are taken from Section 3.0 as

$S_{mem} := 1.0 \cdot S$ $\qquad S_{mem} = 17.90\,ksi$

$S_{ben} := 1.5 \cdot S$ $\qquad S_{ben} = 26.85\,ksi$

The Interaction Ratio is therefore:

$IR_{gap} := \max\left(\frac{\sigma_{gap.mem}}{S_{mem}}, \frac{\sigma_{gap.ben}}{S_{ben}}\right)$ $\qquad IR_{gap} = 0.13$

In addition to bending stresses calculated on an elastic basis, buckling of the inner gap ring is also examined. A buckling evaluation is performed based on Sections 7.3 through 7.6 of Timoshenko's Theory of Elastic Stability (Reference [32]).

Since the gap disk will be supported at the tension rods and periodically between each tension rod by tabs off of the strainer disks, the buckling mode of the gap disk will reflect the higher modes of buckling for the circular ring discussed in Section 7.3 of Reference [32]. Due to symmetry, the equations for the circular arch under uniform pressure discussed in Section 7.6. will have the same results as the circular ring from Section 7.3. This can be seen by comparing equation 7-20 from Section 7.6, where $\alpha=\pi/2$, with equation 7-12 from Section 7.3.

The critical pressure that will cause buckling is calculated using equation 7-20 of Reference [32], since the modes of buckling of equation 7-12 have the same result in equation 7-20 by changing the value of θ such that $2\pi/\theta$ is the mode represented in equation 7-12.

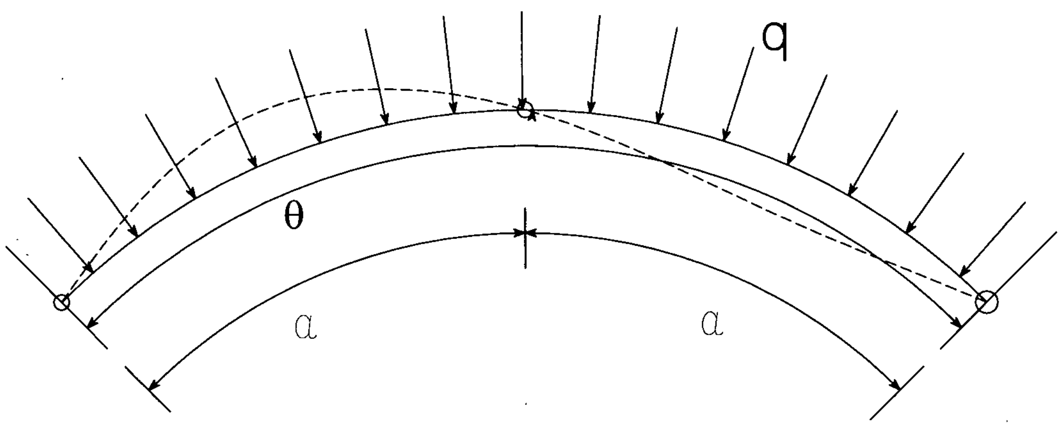


Fig. 6.7-8 Inner Gap Buckling

The parameters for the evaluation are as follows:

$\alpha := 30 \cdot deg$	$\alpha = 0.52$	maximum angle between supports (Reference [6x])
$h_g := t_{perf}$	$h_g = 0.0595\,in$	Perforated plate thickness
$R := \frac{OD_{gap}}{2}$	$R = 7.87\,in$	Radius of gap ring

Since the buckling of this arch depends on the inextensional deformation of the arch, the buckling mode resembles that of the second mode of buckling of a column, with an inflection point in the center. It is possible that a support, tab or tension rod, may occur at this inflection point. The radial span of the arch, $\theta = 2\alpha$, is then the span between three supports. Since higher modes of buckling have higher critical pressure, and the odd modes of buckling for a circular ring are rather complex, the critical pressure of the gap disk for the maximum support spacing will be determined.

$$q_{cr} = \frac{E_{eff} \cdot h_g^3}{12\left(1 - \nu_{eff}^2\right) \cdot R^3} \cdot \left(\frac{\pi^2}{\alpha^2} - 1\right)$$ Eq. 7-20, Reference [32]

A factor of safety consistent with AISC buckling allowables is applied to the gap disk pressure:

$$FS_{qcr} := \frac{23}{12}$$

The critical pressure resulting from the assumed mode, if the maximum support spacing was spread around the entire gap disk, is:

$$q_{cr} := \frac{E_{eff} \cdot h_g^3}{12\left(1 - \nu_{eff}^2\right) \cdot R^3} \cdot \left(\frac{\pi^2}{\alpha^2} - 1\right) \qquad q_{cr} = 15.17 \text{ psi}$$

The Interaction Ratio for the buckling of the gap disk is:

$$IR_{gap.buck} := \frac{q_{gap.0} \cdot FS_{qcr}}{q_{cr}} \qquad IR_{gap.buck} = 0.19$$

6.8 Wire Stiffener Evaluation

The radial wire stiffeners support the perforated plate for the differential pressure condition (operating pressure) The radials on each side support the adjacent face. The radials themselves are supported by the circumferential wire stiffeners in between the two radials. The length and support span of the radial stiffeners was previously calculated in Section 6.1 as:

$L1_{wire} = 5.91\,in$ $\qquad$ $L2_{wire} = 5.91\,in$

$S1_{rad} = 3.20\,in$ $\qquad$ $S2_{rad} = 3.20\,in$

The bending moment in the wire is conservatively calculated as a pin-pin beam supported between circumferential wires.

$$M_{rad} := \max\left[\frac{(q_{end.core.0}\cdot S1_{rad})\cdot\left(\frac{L1_{wire}}{N_{circ}+1}\right)^2}{8}, \frac{(q_{end.core.0}\cdot S2_{rad})\cdot\left(\frac{L2_{wire}}{N_{circ}+1}\right)^2}{8}\right]$$

$M_{rad} = 5.44\,in\cdot lbf$

$S_{wire.rad} := \frac{\pi}{32}\cdot d_{wire.rad}^{\,3}$ $\qquad$ $S_{wire.rad} = 0.00054\,in^3$

$\sigma_{wire} := \frac{M_{rad}}{S_{wire.rad}}$ $\qquad$ $\sigma_{wire} = 9.99\,ksi$

$S_{all.bar} := 0.75\cdot S_{ya}$ (per 1.5.1.4.3 of AISC (Reference [9])) $\qquad$ $S_{all.bar} = 19.13\,ksi$

$IR_{wire} := \frac{\sigma_{wire}}{S_{all.bar}}$ $\qquad$ $IR_{wire} = 0.52$

Note the corner radials are OK by comparison as they have near a similar span, but they are doubled up so there are two wires side by side to carry the load.

The circumferential stiffeners are only in bearing and can easily accommodate the loads and do not require a detailed evaluation.

6.9 Core Tube End Cover Evaluation

6.9.1 End Cover Perforated Plate

The stiffening pattern for the end cover on the core tube is shown on Reference [6i]. The dimensions are given in Section 5.2. There is only inward pressure primarily due to DP. There is no outward pressure from seismic because the vertical seismic loads are less than deadweight thus there is no uplift on the end cover.

The method used to calculate stresses is similar to that used for the end disk in Section 6.7.1

Per Timoshenko (Reference [17]), the stresses in the plates acting as a tension member can be determined as follows:

The span between stiffeners is

$v := 1 .. N_{circ.end} + 1$

$$L_{s.end_v} := \begin{cases} \frac{OD_{tube}}{2} - R_{circ.end_v} & \text{if } v = N_{circ.end} + 1 \\ R_{circ.end_{v+1}} - R_{circ.end_v} & \text{otherwise} \end{cases} \qquad L_{s.end} = \begin{pmatrix} 3.62 \\ 2.50 \end{pmatrix} \text{in}$$

$$L_{s.max} := \max(L_{s.end}) \qquad L_{s.max} = 3.62\,\text{in}$$

The maximum pressure is

$$q := q_{end.core.0} \qquad q = 1.56\,\text{psi}$$

The ends can be considered fixed because of the continuity of the perforated plate, therefore, refer to Section 3, of Chapter 1, of Reference [17].

$$U_1 := \left[\frac{E_{eff}}{\left(1 - \nu_{eff}^2\right)\cdot q}\cdot\left(\frac{t_{perf}}{L_{s.max}}\right)^4\right]^2 \qquad U_1 = 0.3165$$

$$D := \frac{E_{eff}\cdot t_{perf}^3}{12\cdot\left(1 - \nu_{eff}^2\right)} \qquad D = 211.65\,\text{lbf}\cdot\text{in}$$

Solving Eq. (15) for u

$u := 0.1$ (initial guess)

$$u := \mathrm{root}\left(U_1 + \frac{81}{16\cdot u^7\cdot \tanh(u)} + \frac{27}{16\cdot u^6\cdot \sinh(u)^2} - \frac{27}{4\cdot u^8} - \frac{9}{8\cdot u^6}, u\right) \qquad u = 0.15$$

$$\psi := \frac{3\cdot(u - \tanh(u))}{u^2\cdot \tanh(u)} \qquad \psi = 1.00$$

(direct tensile, or membrane stress)

$$\sigma_1 := \frac{E_{eff}\cdot u^2}{3\cdot\left(1 - \nu_{eff}^{\;2}\right)}\cdot\left(\frac{t_{perf}}{L_{s.max}}\right)^2\cdot K_{pp} \qquad \sigma_1 = 0.062\ \mathrm{ksi}$$

(bending stress)

$$\sigma_2 := \frac{q}{2}\cdot\left(\frac{L_{s.max}}{t_{perf}}\right)^2\cdot\psi\cdot K_{pp} \qquad \sigma_2 = 7.29\ \mathrm{ksi}$$

The membrane plus bending maximum principal stress is,

$$\sigma_{front.end} := (\sigma_1 + \sigma_2) \qquad \sigma_{front.end} = 7.35\ \mathrm{ksi}$$

(membrane plus bending clearly controls.

$$IR_{front.end} := \frac{\sigma_{front.end}}{S_{all.pl}} \qquad IR_{front.end} = 0.27$$ (membrane plus bending clearly controls)

$$f_1 := \frac{24}{u^4}\cdot\left(\frac{u^2}{2} + \frac{u}{\sinh(u)} - \frac{u}{\tanh(u)}\right) \qquad f_1 = 1.00 \qquad \delta := \frac{q\cdot L_{s.max}^{\;4}}{384\cdot D}\cdot f_1 \qquad \delta = 0.003\ \mathrm{in}$$

(deflection at midspan between stiffeners)

6.9.2 End Cover Stiffener Evaluation

In this section, the end cover stiffeners are evaluated. The radial spokes are conservatively evaluated as independent beams spanning the ID of the core tube.

$L_{spoke} := D_{cap}$ $\qquad$ $L_{spoke} = 13.50\ in$

The load on the spoke is a function of the tributary width of each spoke. This is maximum at the edges of the core tube and reduces down to zero at the center of the core tube.

$$q_{spoke} := q_{end.core.0} \cdot \frac{\pi \cdot D_{cap}}{N_{spoke}} \qquad q_{spoke} = 8.25 \frac{lbf}{in}$$

The spoke is considered a pinned-pinned beam spanning the diameter of the end cover sleeve. The moment is maximum at center span. This determinate beam is shown below.

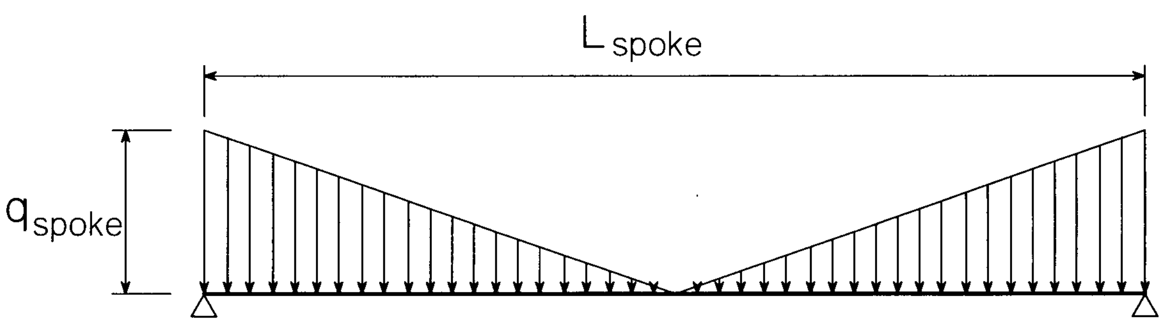


Figure 6.9-2 - Beam Diagram for End Cover Spokes

The reaction at the supports is

$$V_{spoke} := \frac{q_{spoke} \cdot L_{spoke}}{4} \qquad V_{spoke} = 27.83\ lbf$$

The maximum moment for such a load case occurs at center span (1/2 L_{spoke}), therefore, the moment at the center of the beam is:

$$M_{spoke} := V_{spoke} \cdot \frac{L_{spoke}}{6} \qquad M_{spoke} = 62.62\ lbf \cdot in$$

The properties of the spoke are:

$$A_{spoke} := w_{spoke} \cdot t_{end} \qquad A_{spoke} = 0.09\ in^2$$

$$S_{spoke} := \frac{1}{6} \cdot w_{spoke} \cdot t_{end}^2 \qquad S_{spoke} = 0.0059\ in^3$$

The stress in the radial spoke is

$$\sigma_{spoke} := \frac{M_{spoke}}{S_{spoke}} \qquad \sigma_{spoke} = 10.69\ ksi$$

$$IR_{spoke} := \frac{\sigma_{spoke}}{S_{all.pl}} \qquad IR_{spoke} = 0.40$$

The shear stress in the spoke is small

$$\tau_{spoke} := \frac{V_{spoke}}{A_{spoke}} \qquad \tau_{spoke} = 0.30\ ksi$$

6.9.3 End Cover Sleeve Evaluation

The "spider" end cover stiffener is welded to the end cover sleeve with a 1/8" two-sided all-around stitch weld. When analyzing the spokes of the end cover stiffener in Section 6.9.2, the spokes were conservatively considered pinned-pinned. However, for evaluation of the welds and sleeve, it is more appropriate to analyze the spoke as a fixed-fixed beam spanning the ID of the core tube end cover sleeve. The moment is then maximum at the connection to the sleeve. Based on this conservative assumption, an edge moment at the end of the end cover sleeve is produced by the front pressure case of the end cover perforated plate (seismic plus differential pressure, Section 6.9.1). Before analyzing the end cover sleeve, this moment must first be determined. The indeterminate beam is shown below. The moment is solved for by superposition. First the rotation for the pinned-pinned beam under the same loading is determined. Then this is superimposed with a pinned-pinned beam with edge moments that produces the same rotation to determine the edge moment. The rotation at the end of the pinned-pinned beam is determined by summing the area under the curvature diagram. The equation for the moment of the beam is solved for on the next page.

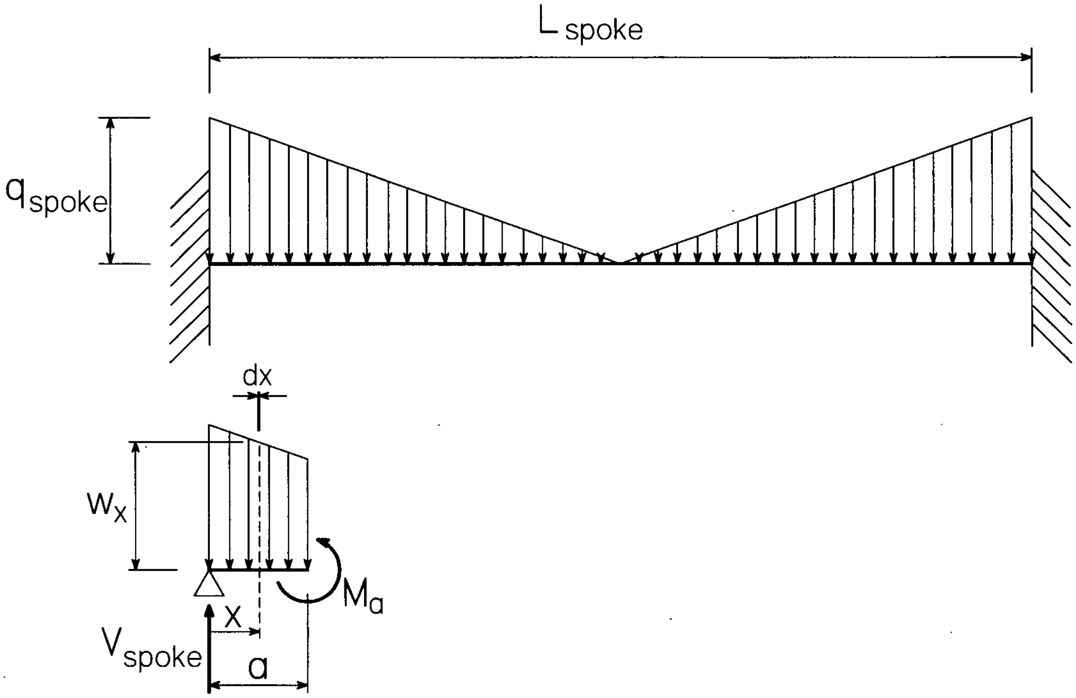


Figure 6.9-3 - Beam Diagram for End Cover Spokes (fixed-fixed)

The equation for the moment at any point "a" for the pinned-pinned beam is written as follows.

The reaction at the support is

$$V_{spoke} := \frac{q_{spoke} \cdot L_{spoke}}{4} \qquad V_{spoke} = 28\,\text{lbf}$$

The magnitude of the distributed load at any point a distance "x" from the support is

$$w_x = q_{spoke} \cdot \left(\frac{0.5 \cdot L_{spoke} - x}{0.5 \cdot L_{spoke}} \right)$$

Therefore, the equation for the moment at any point "a" is

$$M_a = \frac{q_{spoke} \cdot L_{spoke}}{4} \cdot a - \int_0^a q_{spoke} \cdot \left(\frac{0.5 \cdot L_{spoke} - x}{0.5 \cdot L_{spoke}} \right) \cdot (a - x)\, dx$$

This can be solved symbolically as

$$M_a = \frac{1}{4} \cdot q_{spoke} \cdot L_{spoke} \cdot a + \frac{1}{6} \cdot q_{spoke} \cdot a^2 \cdot \left(\frac{2 \cdot a - 3 \cdot L_{spoke}}{L_{spoke}} \right)$$

The deflection at the end is equal to the area under the moment diagram, or

$$\theta_A = \frac{1}{E \cdot I_{spoke}} \cdot \int_0^{0.5 \cdot L_{spoke}} M_a\, da \qquad \text{where,}$$

$$I_{spoke} := \frac{1}{12} \cdot w_{spoke} \cdot t_{end}^3 \qquad I_{spoke} = 0.00110\,\text{in}^4$$

$$\theta_A := \int_0^{0.5 \cdot L_{spoke}} \frac{\frac{1}{4} \cdot q_{spoke} \cdot L_{spoke} \cdot a + \frac{1}{6} \cdot q_{spoke} \cdot a^2 \cdot \frac{2 \cdot a - 3 \cdot L_{spoke}}{L_{spoke}}}{E_{sa} \cdot I_{spoke}}\, da \qquad \theta_A = 0.60\,\text{deg}$$

Per Reference [35], the rotation for a pinned-pinned beam subjected to equal and opposite end moments is

$$\theta_m = \frac{M_{spdr} \cdot L_{spoke}}{2 \cdot E \cdot I_{spoke}}$$

Setting θ_A equal to θ_m, M_{spdr} can be determined

$$M_{spdr} := \frac{2 \cdot E_{sa} \cdot I_{spoke}}{L_{spoke}} \cdot \theta_A \qquad M_{spdr} = 46.97\ \text{lbf} \cdot \text{in}$$

Therefore, the edge moment per unit length on the end cover sleeve becomes

$$M_o := \frac{M_{spdr} \cdot N_{spoke}}{\pi \cdot (D_{cap} + 2 \cdot t_{cap})} \qquad M_o = 8.70\ \frac{\text{lbf} \cdot \text{in}}{\text{in}}$$

In order to analyze the effect on the sleeve due to this edge moment, consider Case 3 of Table 29 (Reference [16]) for an edge moment along the entire circumference of a tube.

$$D_{cover} := \frac{E_{sa} \cdot t_{cap}^{\ 3}}{12 \cdot (1 - \nu^2)} \qquad D_{cover} = 4346\ \text{lbf} \cdot \text{in}$$

$$\lambda_{cover} := \left[\frac{3 \cdot (1 - \nu^2)}{\left(\frac{D_{cap} + 2 \cdot t_{cap}}{2} \right)^2 \cdot t_{cap}^{\ 2}} \right]^{\frac{1}{4}} \qquad \lambda_{cover} = 1.42\ \frac{1}{\text{in}}$$

$$C_{11} := \sinh(\lambda_{cover} \cdot w_{cap})^2 - \sin(\lambda_{cover} \cdot w_{cap})^2 \qquad C_{11} = 85.81$$

$$C_{14} := \sinh(\lambda_{cover} \cdot w_{cap})^2 + \sin(\lambda_{cover} \cdot w_{cap})^2 \qquad C_{14} = 85.91$$

The stress in the end cover sleeve due to the edge moment is

$$\sigma_{cvr.slv} := \frac{\left(\frac{M_o}{2 \cdot D_{cover} \cdot \lambda_{cover}^{\ 2}} \cdot \frac{C_{14}}{C_{11}} \right) \cdot E_{sa}}{0.5 \cdot D_{cap}} \qquad \sigma_{cvr.slv} = 2.05\ \text{ksi}$$

Therefore, the Interaction Ratio for the end cover sleeve is

$$IR_{cvr.slv} := \frac{\sigma_{cvr.slv}}{\begin{pmatrix} 0.6 \cdot S_{ya} \\ 0.9 \cdot S_{ya} \end{pmatrix}} \qquad IR_{cvr.slv} = \begin{pmatrix} 0.13 \\ 0.09 \end{pmatrix}$$

6.10 Weld Evaluations

6.10.1 End Cover Stiffener Weld Evaluation (Horizontal Strainer Module Only)

The "spider" configuration of the end cover stiffener is welded to the end cover sleeve with a 1/8" two-side all around weld (1" at 4" centers), see Figure 6.13-1 below. The weld pair acts as a force couple to resist the moment at this location caused by the pressure loads acting on the spider configuration (front pressure case of the end cover perforated plate controls, see Section 6.11.1). A normal force also acts on the welds due to the front pressure case.

$N_{spoke} = 8$

$D_{cap} = 14\,in$

$t_{end} = 0.38\,in$

$$V_{spdr.1} := \frac{DP\cdot\frac{\pi}{4}\cdot D_{cap}^2}{\pi\cdot D_{cap}}$$

$$V_{spdr.1} = 5.1\,\frac{lbf}{in}$$

$$V_{spdr.2} := \frac{M_o}{t_{end} - 0.125\cdot in}$$

$$V_{spdr.2} = 35\,\frac{lbf}{in}$$

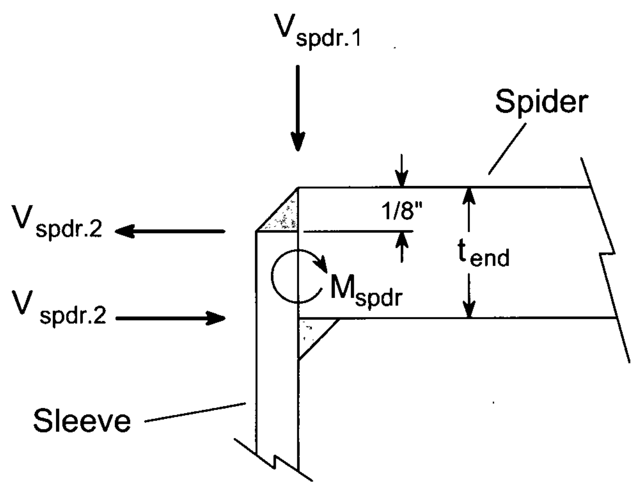


Figure 6.10-1 - End Cover Stiffener Welds

$$\sigma_{w.spdr} := \sqrt{V_{spdr.1}^2 + V_{spdr.2}^2}\cdot\left(\frac{4\cdot in}{1\cdot in}\right) \qquad \sigma_{w.spdr} = 141\,\frac{lbf}{in}$$

The ultimate tensile strength of the weld material employed (ER308 electrode) is:

$F_u := 75\cdot ksi$ (Reference [25])

Weld allowables are per the AISC Manual, Reference [9]

$F_{weld.1} := \begin{pmatrix} 0.3 \cdot F_u \cdot 0.707 \\ 0.3 \cdot F_u \cdot 0.707 \cdot 1.6 \end{pmatrix}$ (Shear on effective throat) $F_{weld.1} = \begin{pmatrix} 15.9 \\ 25.5 \end{pmatrix} ksi$

$F_{weld.2} := \begin{pmatrix} 0.4 \cdot S_{ya} \\ 0.9 \cdot \frac{S_{ya}}{\sqrt{3}} \end{pmatrix}$ (Base metal shear) $F_{weld.2} = \begin{pmatrix} 10.2 \\ 13.3 \end{pmatrix} ksi$

$F_{weld_h} := \min\left(F_{weld.1_h}, F_{weld.2_h}\right)$ $F_{weld} = \begin{pmatrix} 10.2 \\ 13.3 \end{pmatrix} ksi$

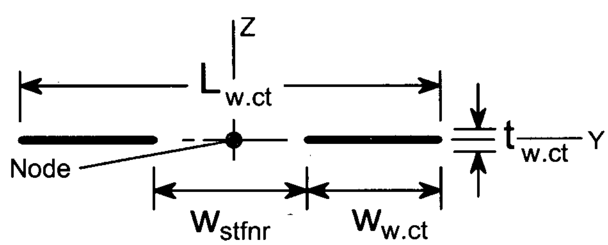
$F_{weld.spdr} := F_{weld} \cdot t_{w.spdr}$ $F_{weld.spdr} = \begin{pmatrix} 1275 \\ 1656 \end{pmatrix} \frac{lbf}{in}$

$IR_{w.spdr} := \frac{\sigma_{w.spdr}}{F_{weld.spdr}}$ $IR_{w.spdr} = \begin{pmatrix} 0.11 \\ 0.08 \end{pmatrix}$

6.10.2 Radial Stiffener to Core Tube Weld Evaluation

In this section, the weld between the end core stiffener collar and the core tube is evaluated. The weld pattern includes a 1.5" weld between the core tube and the stiffener collar on either side of a radial stiffener location such that there is a 1.5" space between two adjacent welds. This results in a total of 4 weld groups, at each end of the strainer module.

The weld properties are as follows:



$t_{w.ct} = 0.06\,in$

$w_{w.ct} = 1.50\,in$

$A_{w.ct} := 2 \cdot w_{w.ct}$ $A_{w.ct} = 3.00\,in$

$L_{w.ct} := 2 \cdot w_{w.ct} + w_{stfnr}$ $L_{w.ct} = 5.25\,in$

$$Z_{w.ct.z} := \frac{L_{w.ct}^3 - w_{stfnr}^3}{6 \cdot L_{w.ct}} \qquad Z_{w.ct.z} = 4.23\,in^2$$

$$J_{w.ct} := \frac{w_{w.ct}^3}{6} + \frac{(w_{w.ct} + w_{stfnr})^2 \cdot w_{w.ct}}{2} \qquad J_{w.ct} = 11.11\,in^3$$

The maximum axial forces, shear forces, and moments found at the stiffener-to-core tube weld locations for the OBE and SSE earthquake are extracted from the GTSTRUDL analysis (Attachment B). Load Combination # 0 is enveloped by Load Combination # 1 and is not specifically evaluated. The reactions from the end cover sleeve are also added to the shear in the z-direction.

$$P_{w.ct.x} := \begin{pmatrix} 0. \\ 0. \end{pmatrix} \cdot lbf \quad \begin{matrix} OBE \\ SSE \end{matrix} \qquad M_{w.ct.x} := \begin{pmatrix} 0 \\ 0 \end{pmatrix} \cdot lbf \cdot in$$

$$V_{w.ct.y} := \begin{pmatrix} 119 \\ 191 \end{pmatrix} \cdot lbf \qquad M_{w.ct.y} := \begin{pmatrix} 0 \\ 0 \end{pmatrix} \cdot lbf \cdot in$$

Members RIGID1 - RIGID32
End Joints

$$V_{w.ct.z} := \begin{pmatrix} 25 \\ 42 \end{pmatrix} \cdot lbf + V_{spdr.1} \cdot \frac{\pi \cdot D_{cap}}{4} \qquad M_{w.ct.z} := \begin{pmatrix} 0 \\ 0 \end{pmatrix} \cdot lbf \cdot in$$

$$f_{w.ct} := \overrightarrow{\left[\sqrt{\left(\frac{V_{w.ct.y}}{A_{w.ct}}\right)^2 + \left(\frac{V_{w.ct.z}}{A_{w.ct}} + \frac{M_{w.ct.x}}{J_{w.ct}} \cdot \frac{L_{w.ct}}{2}\right)^2 + \left(\frac{P_{w.ct.x}}{A_{w.ct}} + \frac{M_{w.ct.z}}{Z_{w.ct.z}}\right)^2} \right]} \qquad f_{w.ct} = \begin{pmatrix} 47.7 \\ 71.3 \end{pmatrix} \frac{lbf}{in} \quad \begin{matrix} OBE \\ SSE \end{matrix}$$

$$F_{weld.ct} := F_{weld} \cdot \min(t_{w.ct}, t_{tube}) \qquad F_{weld.ct} = \begin{pmatrix} 610 \\ 792 \end{pmatrix} \frac{lbf}{in}$$

$$IR_{weld.ct} := \overrightarrow{\frac{f_{w.ct}}{F_{weld.ct}}} \qquad IR_{weld.ct} = \begin{pmatrix} 0.08 \\ 0.09 \end{pmatrix}$$

6.10.3 <u>End Cover Mounting Tab Welds</u>

The strainer end core cover is secured to the end of the last strainer module via rectangular tabs that are welded to the side of the end cover. Holes are drilled into these tabs such that they fit over the inner tension rods, after which nuts are tightened down capturing the tabs and therefore securing the end cover to the strainer module. These tabs will only be subjected to a normal force at their ends when there is a force trying to pull the perforated plate off the core tube (back pressure). Since the end cover is not subjected to back pressure (dead weight exceeds seismic and acts down) the mounting tabs and their welds do not see any significant loads and are acceptable.

6.11 Evaluation of Local Stresses in Core Tube at Connection to Radial Stiffener

The local stresses that develop on the core tube at the weld of the radial stiffener are very small due to the presence of the collar. These welds primarily transfer shear to the core tube. Shear loads at the welds will produce very minor local stresses. As can be seen from the weld stress calculation, the weld stresses are very low.

6.12 Rivet Evaluations

In this section, the various rivets are evaluated to ensure they are capable of transferring the required loads. The rivets are broken into three subsets as follows:

Disk Face to Edge Channel Rivets

Inner Gap Hoop Rivets

End Cover Rivets

The rivets capacities are based on testing from Reference [18]. The capacity of the rivets is taken as the average value from six tests (for both shear and tension). During testing, the rivets were subjected to double shear. Some rivets being evaluated in this section are in single shear, therefore, the double shear ultimate capacities are halved. The ultimate capacities of the rivets are as follows:

$n1 := 6$

$$F_{rv.sh.ult} := \frac{1}{2} \cdot \begin{pmatrix} 1533.6 \\ 1289.3 \\ 1409.5 \\ 1526.6 \\ 1495.4 \\ 1300.3 \end{pmatrix} \cdot lbf \qquad \text{Test: } \begin{pmatrix} A1-A \\ A1-B \\ A1-C \\ A2-A \\ A2-B \\ A2-C \end{pmatrix}$$

$$F_{rv.ten.ult} := \begin{pmatrix} 892 \\ 970 \\ 897.2 \\ 879 \\ 798.4 \\ 931 \end{pmatrix} \cdot lbf \qquad \text{Test: } \begin{pmatrix} C1-A \\ C1-B \\ C1-C \\ C2-A \\ C2-B \\ C2-C \end{pmatrix}$$

$$F_{rv.sh.ult.avg} := \frac{\sum_{i=1}^{n1} F_{rv.sh.ult_i}}{n1} \qquad F_{rv.sh.ult.avg} = 712.89\ lbf$$

$$F_{rv.ten.ult.avg} := \frac{\sum_{i=1}^{n1} F_{rv.ten.ult_i}}{n1} \qquad F_{rv.ten.ult.avg} = 894.60\ lbf$$

Since the ultimate capacities of the rivets are found experimentally via a small sample group (n = 6), the ASCE Standard (Ref. [22]) is used to derive a factor of safety to qualify the rivets. The ASCE Standard is supplemented by the AISI Specification (Reference [5]) as needed for the Factor of Safety equation and for variable values not provided in ASCE. The following variables and their corresponding values can be found in section 6.2 of ASCE (Ref. [22]) or in subsection F1 of AISI (Ref. [5]) for screw connections when not specified by the ASCE Standard (Ref. [22]).

$$V_{p1} := \max\left[\frac{\sqrt{\frac{1}{n1-1}\cdot\sum_{i=1}^{n1}\left(F_{rv.sh.ult_i} - F_{rv.sh.ult.avg}\right)^2}}{F_{rv.sh.ult.avg}}, \frac{\sqrt{\frac{1}{n1-1}\cdot\sum_{i=1}^{n1}\left(F_{rv.ten.ult_i} - F_{rv.ten.ult.avg}\right)^2}}{F_{rv.ten.ult.avg}}\right]$$

$V_{p1} = 0.078$

$V_{P1} := \text{if}(V_{p1} > 0.065, V_{p1}, 0.065)$ $\qquad V_{P1} = 0.078$

$DOF1 := n1 - 1$ $\qquad V_{Q1} := 0.21$

$P_{m1} := 1.0$ $\qquad V_{M1} := 0.10$

$F_{m1} := 1.0$ $\qquad V_{F1} := 0.05$

$M_{m1} := 1.10$ $\qquad C_{P1} := \frac{n1-1}{n1-3}$ $\quad C_{P1} = 1.67$ (Eq. 6.2-3, Ref. [22])

$\beta_{o1} := 4$

$$\phi_{rivet} := 1.5\cdot(M_{m1}\cdot F_{m1}\cdot P_{m1})\cdot e^{-\beta_{o1}\cdot\sqrt{V_{M1}^2+V_{F1}^2+C_{P1}\cdot V_{P1}^2+V_{Q1}^2}}$$

$\phi_{rivet} = 0.59$ (Eq. 6.2-2, Ref. [22])

$$FS_{rivet} := \begin{bmatrix} \frac{1.6}{\phi_{rivet}} \\ \frac{1.6}{(CT+1)\cdot\phi_{rivet}} \end{bmatrix}$$

$FS_{rivet} = \begin{pmatrix} 2.72 \\ 2.10 \end{pmatrix}$ (Eq. F1.2-2, Ref. [5])

6.12.1 Disk Face Rivets

The shear and tension on the disk face rivets is calculated based on calculations performed in earlier sections of this calculation. The shear on the rivets is taken as the shear resulting from the shear transfer required for the edge channels and the perforated plate to act as a composite section, combined with the shear associated with the lateral loads on the disk rims and gaps.

The shear flow due to combined section is based on the following standard beam shear equation, or

$$q = \frac{V \cdot Q}{I}$$

where

V = the maximum shear carried by the combined perf plate / edge channel section

Q = the first moment of inertia of the cross sectional area supported by the rivets

I = the combined moment of inertia of the perf plate / radial stiffener section

The maximum shear force for the edge channels is taken from the GTSTRUDL analysis (Attachment B).

Member/Node

$$V_{rv} := \begin{pmatrix} 4.9 \\ 3.0 \end{pmatrix} \cdot lbf$$ OBE or DW+DEB / SSE (GROUP "CHANNELS')

The combined moment of inertia was calculated in Section 6.4.2 for the edge channel properties.

$$I_{rv} := I_{ch.z} \cdot in^4 \qquad I_{rv} = 0.0107\, in^4$$

Q is calculated below (the maximum Q values are used for each the end and middle disks)

$$Q_{rv} := b_{eff} \cdot t_{perf} \cdot \left(\frac{d_{chan} + t_{perf}}{2} \right) \qquad Q_{rv} = 0.0133\, in^3$$

Therefore, the shear per rivet, factoring in the rivet spacing, is

$$f_{rv.sh1} := \overrightarrow{\left(\frac{V_{rv} \cdot Q_{rv}}{I_{rv}} \cdot \max(S1_{rad}, S2_{rad}) \right)} \qquad f_{rv.sh1} = \begin{pmatrix} 19.6 \\ 12.0 \end{pmatrix} lbf$$

This shear needs to be combined with the direct shear from lateral loads acting on the edge channels.

$f_{rv.sh2} := q_{chan.0} \cdot d_{chan} \cdot \max(S1_{rad}, S2_{rad})$ $\quad f_{rv.sh2} = 2.43 \text{ lbf}$

The total shear acting along the axis of each radial stiffener is

$f_{rv.face} := \overrightarrow{\sqrt{f_{rv.sh1}^2 + f_{rv.sh2}^2}}$ $\quad f_{rv.face} = \begin{pmatrix} 19.8 \\ 12.3 \end{pmatrix} \text{lbf}$

<u>Find Tension for Disk Face Rivets</u>

The tension in the disk face rivets is based on the back face perforated plate evaluation in Section 6.7.1

$$T_{rv.bp} := \frac{q_{end.disk.2} \cdot \left(L1_{disk} \cdot L2_{disk} - \frac{\pi}{4} \cdot OD_{gap}^2 \right) - Q_b \cdot \frac{\text{lbf}}{\text{in}} \cdot \pi \cdot OD_{gap}}{2 \cdot L1_{disk} + 2 \cdot L2_{disk}} \cdot \max(S1_{rad}, S2_{rad})$$

$T_{rv.bp} = 0.33 \text{ lbf}$

These tension forces are very small and can be neglected. Therefore only rivet shear needs to be considered. Based on this, the Interaction Ratio for the disk face rivets is:

$IR_{rv.face} := \overrightarrow{\frac{f_{rv.face} \cdot FS_{rivet}}{F_{rv.sh.ult.avg}}}$ $\quad IR_{rv.face} = \begin{pmatrix} 0.08 \\ 0.04 \end{pmatrix}$

6.12.2 Inner Gap Hoop Rivets

These are the rivets used to hold the inner gap together in a hoop. The finite element analysis assumes the hoop is continuous. The shear load on the rivets can be determined from the finite element analysis (Attachment D). A hoop tension force can conservatively be estimated from the maximum membrane stress in the hoop. Assuming the membrane stress in all in the hoop direction is constant through the width of the hoop, the maximum tension (or compression) force would be,

$$T_{hoop} := \sigma_{gap.mem} \cdot \frac{W_{gap} \cdot t_{perf}}{K_{pp}} \qquad T_{hoop} = 17.97 \text{ lbf}$$

$$f_{rv.gap.hoop} := \frac{T_{hoop}}{N_{rivet.hoop}} \qquad f_{rv.gap.hoop} = 9 \text{ lbf}$$

Therefore, the Interaction Ratio is

$$IR_{rv.gap} := \overrightarrow{\frac{f_{rv.gap.hoop} \cdot FS_{rivet}}{F_{rv.sh.ult.avg}}} \qquad IR_{rv.gap} = \begin{pmatrix} 0.03 \\ 0.03 \end{pmatrix}$$

6.12.3 End Cover Rivets

These are the rivets that secure the perforated plate on the end cover to the end cover stiffener. These rivets are only subjected to tensile loads during a seismic event (shear is negligible). Note the end cover stiffener supports the load during operation under differential pressure.

$$q_{end.core.2} = 0.011 \text{ psi}$$

$$f_{rv.end} := \frac{q_{end.core.2} \cdot \frac{\pi}{4} \cdot ID_{tube}^{\ 2}}{N_{rivet.end}} \qquad f_{rv.end} = 0.09 \text{ lbf}$$

$$IR_{rv.end} := \frac{f_{rv.end} \cdot FS_{rivet}}{F_{rv.ten.ult.avg}} \qquad IR_{rv.end} = \begin{pmatrix} 0.0003 \\ 0.0002 \end{pmatrix}$$

6.13 Connecting Bolt Evaluation

The loads on the bolts that connect the modules are taken from the hex coupling internal forces. The maximum tension, shear and bending on any hex couple is

$P_{hex} := \begin{pmatrix} 435 \\ 586 \end{pmatrix} \cdot lbf$ $\qquad P_{hex} = \begin{pmatrix} 435 \\ 586 \end{pmatrix} lbf$ DW+OBE / DW+DEB+P, DW+SSE

$V_{hex} := \sqrt{\left[\begin{pmatrix} 383 \\ 478 \end{pmatrix} \cdot lbf\right]^2 + \left[\begin{pmatrix} 452 \\ 590 \end{pmatrix} \cdot lbf\right]^2}$ $\qquad V_{hex} = \begin{pmatrix} 592 \\ 759 \end{pmatrix} lbf$ DW+OBE / DW+DEB+P, DW+SSE

$M_{hex} := \sqrt{\left[\begin{pmatrix} 625 \\ 818 \end{pmatrix} \cdot in \cdot lbf\right]^2 + \left[\begin{pmatrix} 552 \\ 698 \end{pmatrix} \cdot in \cdot lbf\right]^2}$ $\qquad M_{hex} = \begin{pmatrix} 834 \\ 1075 \end{pmatrix} in \cdot lbf$ DW+OBE / DW+DEB+P, DW+SSE

The moment on the hex couplings results in additional tension on the bolts due to prying action. The maximum bolt tension is therefore:

$T_{bolt} := P_{hex} + \frac{2 \cdot M_{hex}}{OD_{hex}}$ $\qquad T_{bolt} = \begin{pmatrix} 1877 \\ 2446 \end{pmatrix} lbf$

$V_{bolt} := V_{hex}$ $\qquad V_{bolt} = \begin{pmatrix} 592 \\ 759 \end{pmatrix} lbf$

The bolts are 1/2" A-193 Grade B8, Class II bolts. The allowable stresses are based on Reference [22]

1/2" diameter bolts are used to connect the strainers to the support tracks. The bolts are qualified in single shear (threads excluded) according to section 5.3.4 of the ASCE Standard (Reference [22]). Factors of Safety are found in Table D of Reference [22] for both the tensile and shear cases of bolted connections.

$\Omega_{ten} := 3$ $\qquad \Omega_{sh} := 3$

In order to account for the high temperatures that these bolts are subjected to, a factor is calculated based on the ratio of the ultimate strength of Type 304 Stainless Steel at -20 to 100° F to Type 304 Stainless Steel at 190° F.

$S_{u.304} := 75 \cdot ksi$ (Ultimate Strength of Type 304 Stainless Steel at -20 to 100° F, Reference [3])

$\beta_{temp} := \frac{S_{uo}}{S_{u.304}}$ $\qquad \beta_{temp} = 0.98$

Per Table 6 of ASCE, the allowable nominal tensile and shear stress for stainless steel bolts with threads included in the shear plane are:

$$F_{t.bolt} := \begin{pmatrix} \dfrac{93.7 \cdot ksi \cdot \beta_{temp}}{\Omega_{ten}} \\ \dfrac{1.6 \cdot 93.7 \cdot ksi \cdot \beta_{temp}}{\Omega_{ten}} \end{pmatrix} \qquad F_{t.bolt} = \begin{pmatrix} 30.57 \\ 48.91 \end{pmatrix} ksi$$

$$F_{v.bolt} := \begin{pmatrix} \dfrac{56.2 \cdot ksi \cdot \beta_{temp}}{\Omega_{sh}} \\ \dfrac{1.6 \cdot 56.2 \cdot ksi \cdot \beta_{temp}}{\Omega_{sh}} \end{pmatrix} \qquad F_{v.bolt} = \begin{pmatrix} 18.33 \\ 29.33 \end{pmatrix} ksi$$

The nominal bolt area is:

$$A_{bolt} := \frac{\pi \cdot OD_{bolt}^2}{4} \qquad A_{bolt} = 0.20\, in^2$$

$$\sigma_{bolt} := \frac{T_{bolt}}{A_{bolt}} \qquad \sigma_{bolt} = \begin{pmatrix} 9.56 \\ 12.46 \end{pmatrix} ksi$$

$$\tau_{bolt} := \frac{V_{bolt}}{A_{bolt}} \qquad \tau_{bolt} = \begin{pmatrix} 3.02 \\ 3.87 \end{pmatrix} ksi$$

The combined shear and tension loads on the bolt are evaluated in accordance with Section 5.3.4 of the ASCE Standard (Reference [22]).

$$F_t := 1.25 \cdot F_{t.bolt} - 2.4 \cdot \tau_{bolt} \qquad F_t = \begin{pmatrix} 30.97 \\ 51.85 \end{pmatrix} ksi$$ (Equation 5.3.4-3, Reference [22])

$$F_{t.bolt_h} := \min\left(F_{t.bolt_h}, F_{t_h}\right) \qquad F_{t.bolt} = \begin{pmatrix} 30.57 \\ 48.91 \end{pmatrix} ksi$$

Therefore the bolt Interaction Ratio is:

$$IR_{bolt_h} := \max\left(\frac{\sigma_{bolt_h}}{F_{t.bolt_h}}, \frac{\tau_{bolt_h}}{F_{v.bolt_h}}\right) \qquad IR_{bolt} = \begin{pmatrix} 0.31 \\ 0.25 \end{pmatrix}$$

Required Preload

The bolt/stud must be preloaded to ensure the joint doesn't separate during a seismic event. Using a methodology similar to that used for the spacer separation check in Section 6.4.8. Preload relaxation is not considered in this case because this joint is less likely to experience preload relaxation in comparison to the strainer tension rods.

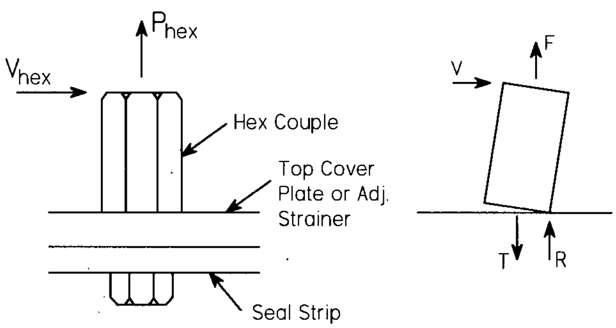


Figure 6.13-1 Hex Couple Connection

To determine the required torque to prevent joint separation, examine the free body diagram of the hex couple above. The stud tension (T) initially is equal to the preload, which is also equal to the prying force (R). As the connection is loaded, the tension force from the strainer (F) effectively reduces the reaction force (R) by almost the exact magnitude (there will be slight differences due to the various stiffnesses of the bolts and connecting members). The stud tension (T) essentially remains equal to the initial preload until the point where the joint separates. In order to prevent joint separation, the preload must be greater than the applied force (F), but in addition, the preload must be sufficient to resist the moment resulting from the shear force (V). By summing the moments about the corner prying point of the hex couple, the stud tension (T), or the preload, times the lever arm, must exceed the moment in the hex couple due to the shear load (V). Therefore, the required preload is calculated based on the following formula.

$K_{nf} = 0.30$ (from Section 6.4.8)

$$T_{req} := \frac{\max\left(P_{hex_2}, \frac{M_{hex}}{\frac{1.156 \cdot in}{2}}\right) \cdot OD_{bolt} \cdot K_{nf}}{0.85 \cdot 0.80}$$

$T_{req} = 34.2$ ftlbf

Use 40 ft-lbs plus or minus 15%

(Note that a higher torque is permissible as long as the bolt is not structurally damaged during installation).

where:

(0.85 for under torque tolerance)
(0.80 for torque to preload conversion uncertainty)

7.0 RESULTS AND CONCLUSIONS

The results of this calculation indicate that the strainers meet the acceptance criteria for all applicable loadings. A summary of the maximum stress Interaction Ratios (calculated stress divided by allowable stress) is provided below. For the 3 column arrays, the first number shown is for Load Comb. #1 (DW+DEB+P), the second number is for Load Comb. #2 (DW+OBE), and the 3rd number is for Load Comb #6 (DW+SSE).

Strainer Component	Ref. Section	Interaction Ratio
Welded Radial Stiffener (Including Collar)	6.5	$IR_{stfnr}^T = (0.24 \quad 0.70 \quad 0.85)$
Tension Rods	6.5	$IR_{rod}^T = (0.46 \quad 0.46 \quad 0.42)$
Edge Channels	6.5	$IR_{chan}^T = (0.51 \quad 0.73 \quad 0.78)$
Cross Bracing	6.5	$IR_{cable}^T = (0.00 \quad 0.30 \quad 0.41)$
Hex Coupling	6.5	$IR_{hex}^T = (0.19 \quad 0.28 \quad 0.30)$
Core Tube	6.5	$IR_{tube}^T = (0.18 \quad 0.11 \quad 0.14)$
Bent up Portions of Radial Stiffeners	6.5	$IR_{bent}^T = (0.06 \quad 0.19 \quad 0.28)$
Spacer	6.5	$IR_{spcr}^T = (0.80 \quad 0.86 \quad 0.82)$
Spacer Separation	6.5	$IR_{spcr.s} = 0.85$
Perforated Plate (DP Case)	6.7.1	$IR_{face.dp} = 0.21$
Perforated Plate (Seismic Case)	6.7.1	$IR_{face.bp} = 0.04$

RESULTS AND CONCLUSIONS (Cont.)

Strainer Component	Ref. Section	Interaction Ratio	
Perforated Plate (Inner Gap)	6.7.3	$IR_{gap} = 0.13$	
Inner Gap Buckling	6.7.3	$IR_{gap.buck} = 0.19$	
Wire Stiffener	6.8	$IR_{wire} = 0.52$	
Perforated Plate (Core Tube End Cover DP Case)	6.9.1	$IR_{front.end} = 0.27$	
Radial Stiffening Spokes of the End Cover Stiffener	6.9.2	$IR_{spoke} = 0.40$	
Core Tube End Cover Sleeve	6.9.3	$IR_{cvr.slv} = \begin{pmatrix} 0.13 \\ 0.09 \end{pmatrix}$	
Weld of End Cover Stiffener to End Cover Sleeve	6.10.1	$IR_{w.spdr} = \begin{pmatrix} 0.11 \\ 0.08 \end{pmatrix}$	Note 1 Note 2
Weld of Radial Stiffener to Core Tube	6.10.2	$IR_{weld.ct} = \begin{pmatrix} 0.08 \\ 0.09 \end{pmatrix}$	Note 1 Note 2
Edge Channel Rivets	6.12.1	$IR_{rv.face} = \begin{pmatrix} 0.08 \\ 0.04 \end{pmatrix}$	Note 1 Note 2
Inner Gap Hoop Rivets	6.12.2	$IR_{rv.gap} = \begin{pmatrix} 0.03 \\ 0.03 \end{pmatrix}$	Note 1 Note 2
End Cover Rivets	6.12.3	$IR_{rv.end} = \begin{pmatrix} 0.00 \\ 0.00 \end{pmatrix}$	Note 1 Note 2
Connecting Bolts	6.13	$IR_{bolt} = \begin{pmatrix} 0.31 \\ 0.25 \end{pmatrix}$	Note 1 Note 2

Notes:

1. Envelope of Load Combination 1 (DW+DEB+P) and 2 (DW+OBE)
2. Load Combination 6 (DW+SSE)

8.0 REFERENCES

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