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Sonic Enhanced Ash Agglomeration and Sulfur Capture

Quarterly Report
July - September 1995

Work Performed Under Contract No.: DE-AC21-89MC26288

For
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DISCLAIMER

PREFACE

This 25th Quarterly Technical Progress Report presents the results of work accomplished during the period July 1, 1995 through September 24, 1995 (July, August, and September) under Contract No. DE-AC21-88MC26288 entitled "Sonic Enhanced Ash Agglomeration and Sulfur Capture."

During this reporting period, design, design analysis and procurement proceeded as scheduled. An independent analysis of the structure was completed and the concrete pad was found to be inadequate. It will be re-designed.

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SECTION 1.0

INTRODUCTION

1.1 PROJECT DESCRIPTION AND WORK STATUS

A major concern with the utilization of coal in directly fired gas turbines is the control of particulate emissions and reduction of sulfur dioxide, and alkali vapor from combustion of coal, upstream of the gas turbine. Much research and development has been sponsored on methods for particulate emissions control and the direct injection of calcium-based sorbents to reduce SO_2 emission levels. The results of this research and development indicate that both acoustic agglomeration of particulates and direct injection of sorbents have the potential to become a significant emissions control strategy.

The Sonic Enhanced Ash Agglomeration and Sulfur Capture program focuses upon the application of an MTCI proprietary invention (Patent No. 5,197,399) for simultaneously enhancing sulfur capture and particulate agglomeration of the combustor effluent. This application can be adapted as either a "hot flue gas cleanup" subsystem for the current concepts for combustor islands or as an alternative primary pulse combustor island in which slagging, sulfur capture, particulate agglomeration and control, and alkali gettering as well as NO_x control processes become an integral part of the pulse combustion process.

The goal of the program is to support the DOE mission in developing coal-fired combustion gas turbines. In particular, the MTCI proprietary process for bimodal ash agglomeration and simultaneous sulfur capture will be evaluated and developed. The technology embodiment of the invention provides for the use of standard grind, moderately beneficiated coal and WEM for firing the gas turbine with efficient sulfur capture and particulate emission control upstream of the turbine. The process also accommodates injection of alkali gettering material if necessary. This is aimed at utilization of relatively inexpensive coal fuels, thus realizing the primary benefit being sought by direct firing of coal in such gas turbine systems. The proposed technology provides for practical, reliable, and capital (and O&M) cost-effective means of protection for the gas turbine from impurities in the coal combustor effluent.

1.2 PROGRAM OBJECTIVES

The major objective of the Phase I test program is to confirm the feasibility of the MTCI bimodal particle size approach to enhance particulate control by acoustic ash agglomeration. An ancillary objective of the Phase I effort is to demonstrate and confirm the feasibility of an acoustic field to enhance sulfur capture by increasing sorbent reactivity. Phase I tests are designed to cover the frequency range between 50 and 1400 Hz, establish monomodal baseline performance as a benchmark from which to measure the degree of enhancement expected from the bimodal approach, and, finally, to confirm the effectiveness of low-frequency fields over high-frequency fields for realistic particulate streams.

The program will demonstrate the effectiveness of a unique approach which uses a bimodal distribution composed of large sorbent particles and fine fly ash particles to enhance ash agglomeration and sulfur capture at conditions found in direct coal-fired turbines. Under the impact of high-intensity sound waves, sorbent reactivity and utilization, it is theorized, will increase while agglomerates of fly ash and sorbents are formed which are readily collected in commercial cyclones. The work will extend the concept from the demonstration of feasibility (Phase I), through proof-of-concept (Phase II) to the construction (Phase III) of a coal-fired pulsed combustor with in-furnace sorbent injection. For Phase I, Pennsylvania State University will conduct studies for enhanced sulfur capture in The Combustion Laboratory and agglomeration tests in the High Intensity Acoustic Laboratory.

1.3 SUMMARY STATUS FOR THE PERIOD

During this reporting period, design, design analysis and procurement proceeded as scheduled. An independent analysis of the structure was completed and the concrete pad was found to be inadequate. It will be re-designed.

SECTION 2.0

TECHNICAL DISCUSSION OF THE WORK ACCOMPLISHED DURING THE REPORTING PERIOD

2.1 TASK 2: ADDITIONAL TEST FACILITY MODIFICATIONS AND SHAKEDOWN TESTING

During this reporting period, design, procurement and fabrication was continued. Procurement is now 70 percent completed. Progress in design and fabrication of the PDU and components are shown in Table 1. Figure 1 shows the updated design of the pulse combustor-HGCU system. Figures 2 - 12 present further design development of the bimodal system components, and Figure 13 shows a draft of the supporting structure layout. Analysis of the design of the refractory lining of the pulse combustor, U-bend section, agglomeration chamber, and primary cyclone with refractory lining were also completed (Figures 14, 15, 16 and 17).

TABLE 1:

DESIGN AND FABRICATION PROGRESS CHART - BIMODAL PDU

Item No.	Description of Components	Design Accomplished, %	Fabrication Accomplished, %
1	Air Plenum	100	20
2	Coal Injector	100	100
3	Pilot Burner	100	90
4	Aerovalve	100	100
5	Water Jacket of Pulse Combustor	100	30
6	U-Bend Water Jacket	100	95
7	Agglomeration Chamber (60" dia.)	100	*
8	Slag-Handling Section	50	10
9	Ash Drain Section	50	10
10	Reburning Coal Injector	50	10
11	Primary Cyclone	100	10
12	Secondary Cyclone	30	10
14	Dipleg and Ash Recycle Section	30	10
15	Refractory and Insulation	75	0
16	Splitter of Coal and Air Mixture	0	0
17	Flue Gas Heat Exchanger	0	0
18	Steam Drum	0	0
19	Air Preheater in the Flare	0	0
20	Structure	50	0
21	Instrumentation and Control	20	0

* Top section is 75% complete, middle and bottom sections are 97% complete.

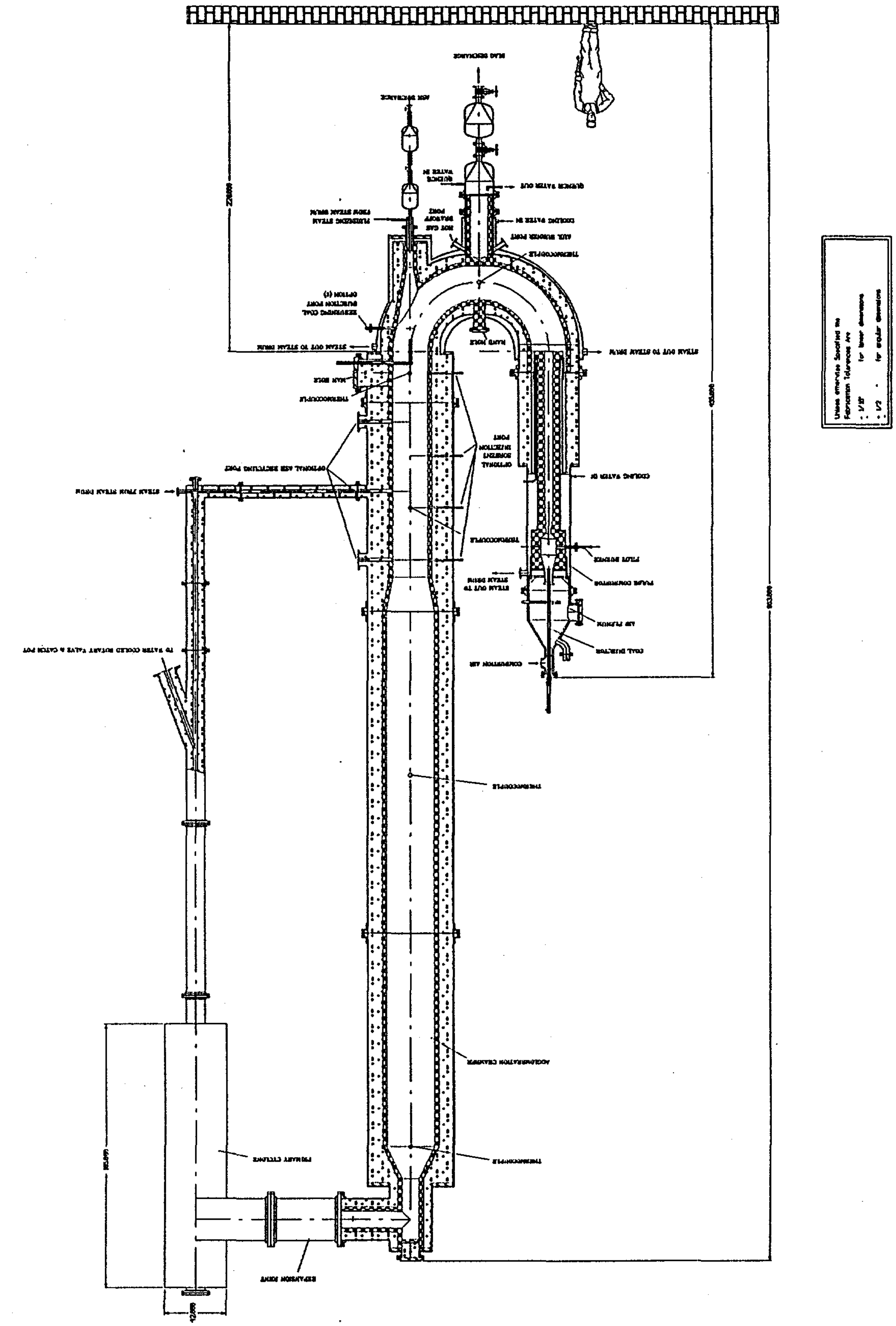


FIGURE 1: PULSE COMBUSTOR - HGCU FOR PDU (UPDATED)

ITEM	QTY	DWG NO.	DESCRIPTION	UNIT WT.	TOT WT.
1	1	830-011	COAL INJECTOR	1.40	1.40
2	1	830-012	AIR PLENUM ASSEMBLE	14.40	14.40
3	1	830-013	AEROVALVE	13.50	13.50
4	1	830-014	PILOT BURNER ASSEMBLE	0.32	0.32
5	1	830-015	REFRACTORY PULSE COMBUSTOR	0.20	0.20
6	1	830-016	WATER JACKET ASSEMBLE	6.20	6.20
7	1	830-015	ANNULAR REFRACTORY	0.20	0.20
8	1	830-010	FLAME DETECTOR PORT	0.20	0.20
9	1	830-010	TEMPERATURE MEASUREMENT PORT	0.20	0.20
10	1	830-010	PRESSURE MEASUREMENT PORT	0.20	0.20
11					
12					
				TOTAL WT.	29.82

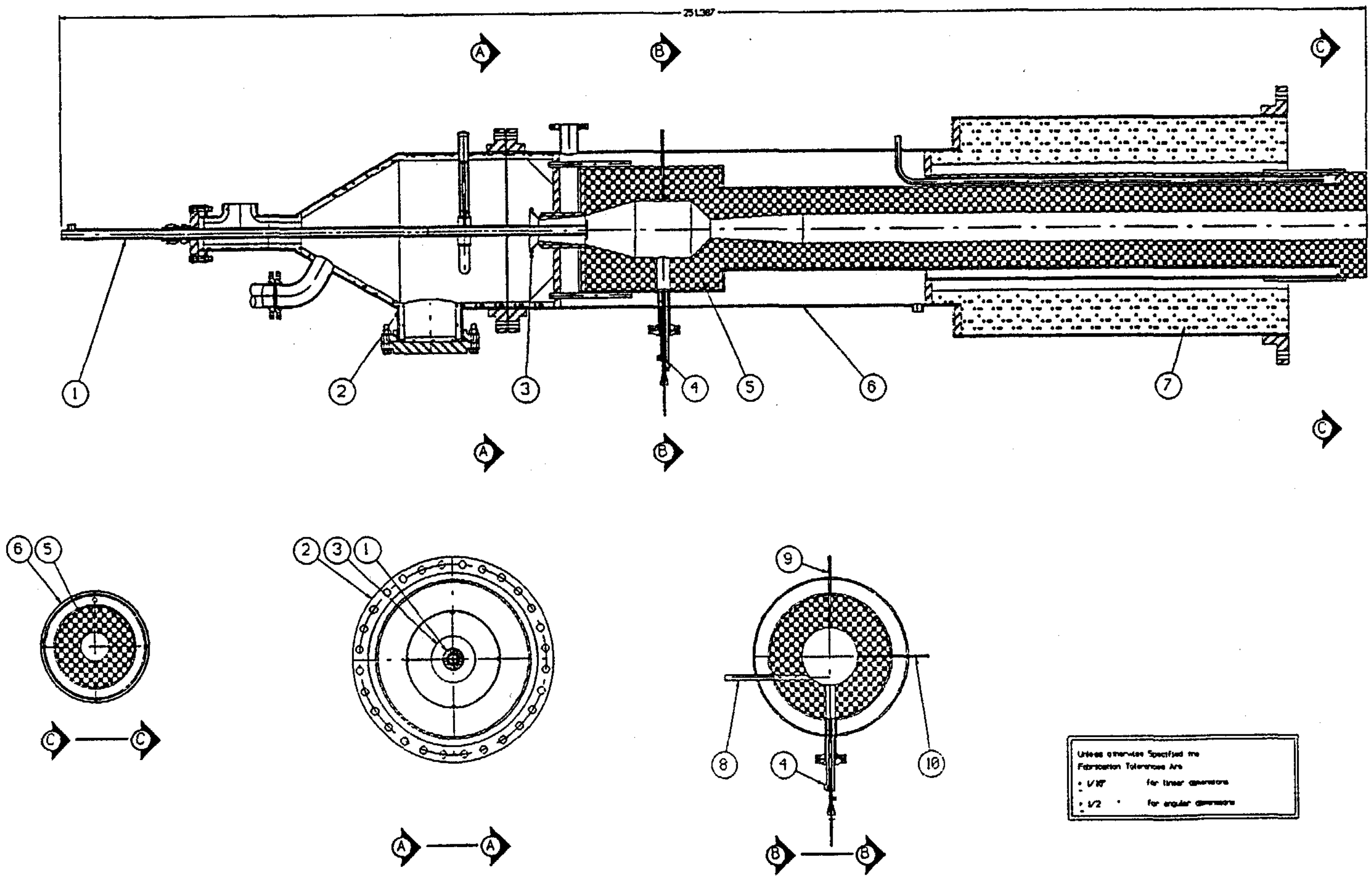
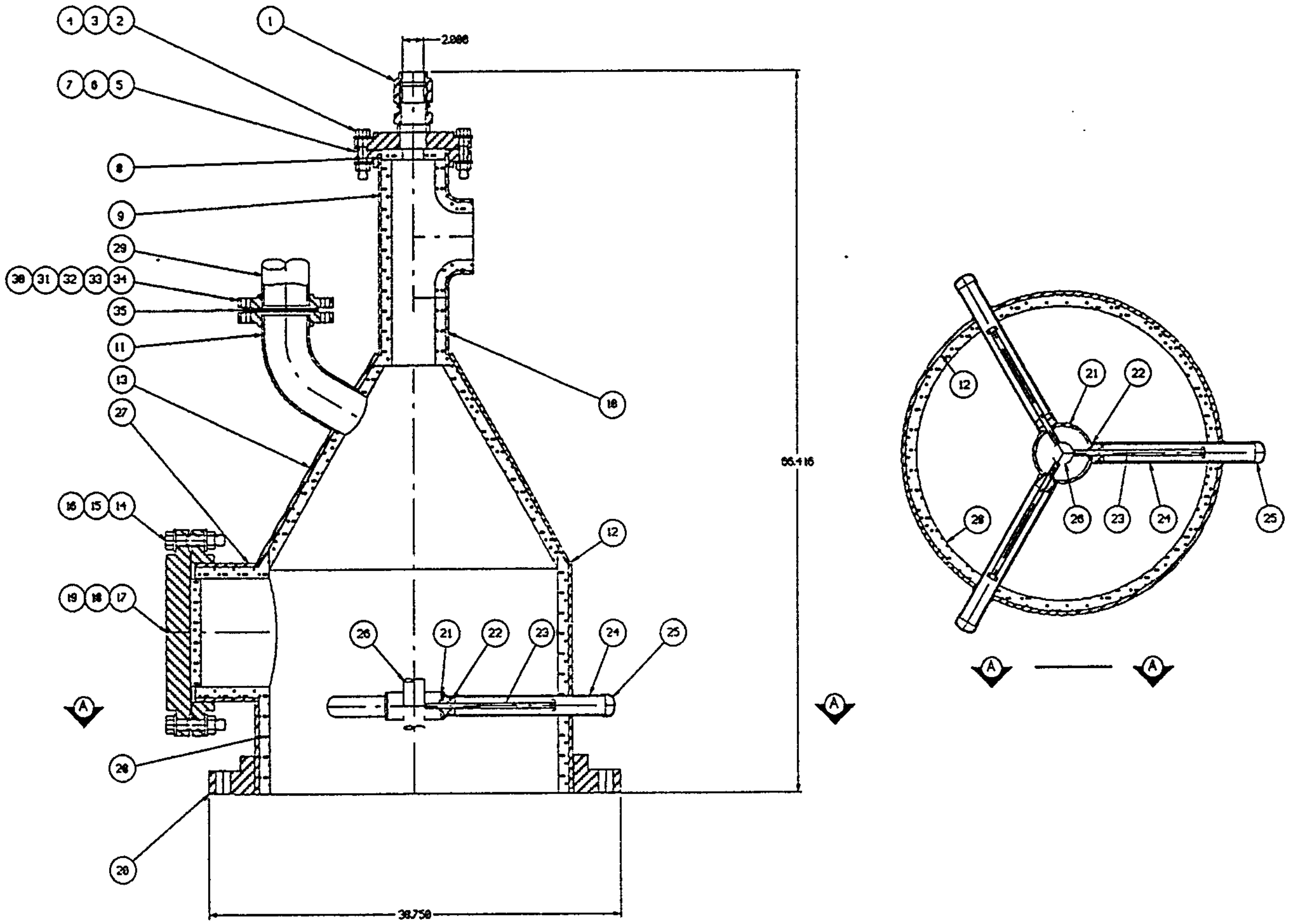
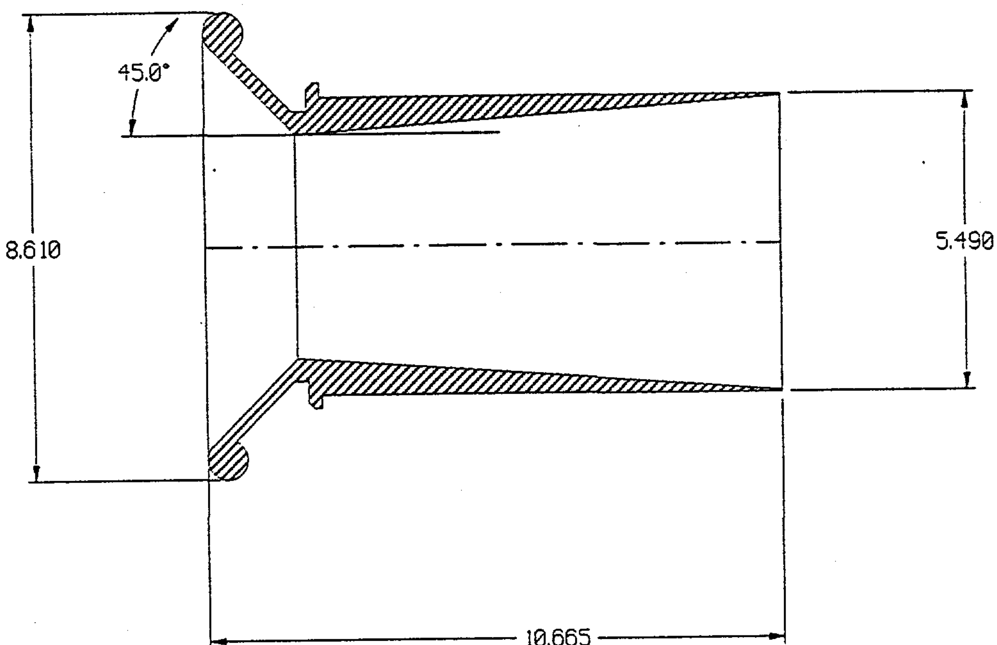


FIGURE 2: PULSE COMBUSTOR ASSEMBLY



ITEM	QTY	DWG NO.	DESCRIPTION	UNIT WT.	TOT WT.
1	1	830-012	SWAGELOK 2" S.S.	3.40	3.40
2	8	830-012	BOLTS 3/4" C.S. L=4"	0.80	6.40
3	8	830-012	NUTS 3/4" C.S.	0.20	[illegible]
4	16	830-012	WASHERS 3/4" C.S.	0.10	[illegible]
5	1	830-012	SLIP-ON FLANGE 8" 150 LB C.S.	[illegible]	[illegible]
6	1	830-012	BLIND FLANGE 150 LB C.S.	[illegible]	[illegible]
7	1	830-012	GASKET FOR 8" FLANGE	1.00	1.00
8	1	830-012	PIPE 8" SCH40 C.S. L=2"	3.20	3.20
9	1	830-012	TEE 8" STD C.S.	12.30	12.30
10	1	830-012	PIPE 8" SCH40 C.S. L=[illegible]"	[illegible]	[illegible]
11	1	830-012	ELBOW 4" R=8" ANGLE 120 DEGREE	9.00	9.00
12	1	830-012	PIPE 30" STD C.S. L=20.875"	[illegible]	[illegible]
13	1	830-012	CONE C.S. THICKNESS=0.375" L=[illegible]"	[illegible]	[illegible]
			OD(S)=8.625" OD(L)=29.125"		
14	12	830-012	BOLTS 7/8" C.S. L=5.5"	1.20	14.40
15	12	830-012	NUTS 7/8" C.S.	0.20	2.40
16	24	830-012	WASHERS 7/8" C.S.	0.10	2.40
17	1	830-012	SLIP-ON FLANGE 12" C.S. 150 LB	[illegible]	[illegible]
18	1	830-012	BLIND FLANGE 12" C.S. 150 LB	[illegible]	[illegible]
19	1	830-012	GASKET FOR 12" FLANGE	3.00	3.00
20	1	830-012	FLANGE 30" C.S. 150 LB	[illegible]	[illegible]
21	1	830-012	PIPE 3" C.S. SCH40 L=2.5"	4.00	4.00
22	3	830-012	HOME MAKE NUT 1/2"	1.00	3.00
23	3	830-012	BOLTS 1/2" C.S. L=12"	[illegible]	[illegible]
24	3	830-012	PIPE 1.5" SCH40 C.S. L=14.5"	3.00	[illegible]
25	3	830-012	CAPS 1.5" SCH40 C.S.	[illegible]	[illegible]
26	1	830-011	COAL INJECTOR ASSEMBLE	[illegible]	[illegible]
27	1	830-011	PIPE 12" SCH40 C.S. L=4"	32.00	32.00
28	1	830-011	KAOWOOL 1" THICK	25.00	25.00
29	1	830-011	PIPE 4" SCH40 C.S. L=20"	[illegible]	[illegible]
30	2	830-011	SLIP-ON FLANGE 4" C.S. 150 LB	[illegible]	2.62
31	2	830-011	GASKET THICKNESS=1/8"	0.05	0.10
32	8	830-011	BOLTS 5/8" C.S. L=3"	[illegible]	[illegible]
33	8	830-011	NUTS 5/8" C.S.	0.05	0.40
34	16	830-011	WASHERS 5/8" C.S.	[illegible]	[illegible]
35	1	830-011	RUPTURE DISC 4" S.S.	0.20	0.20
				TOTAL WT.	[illegible]

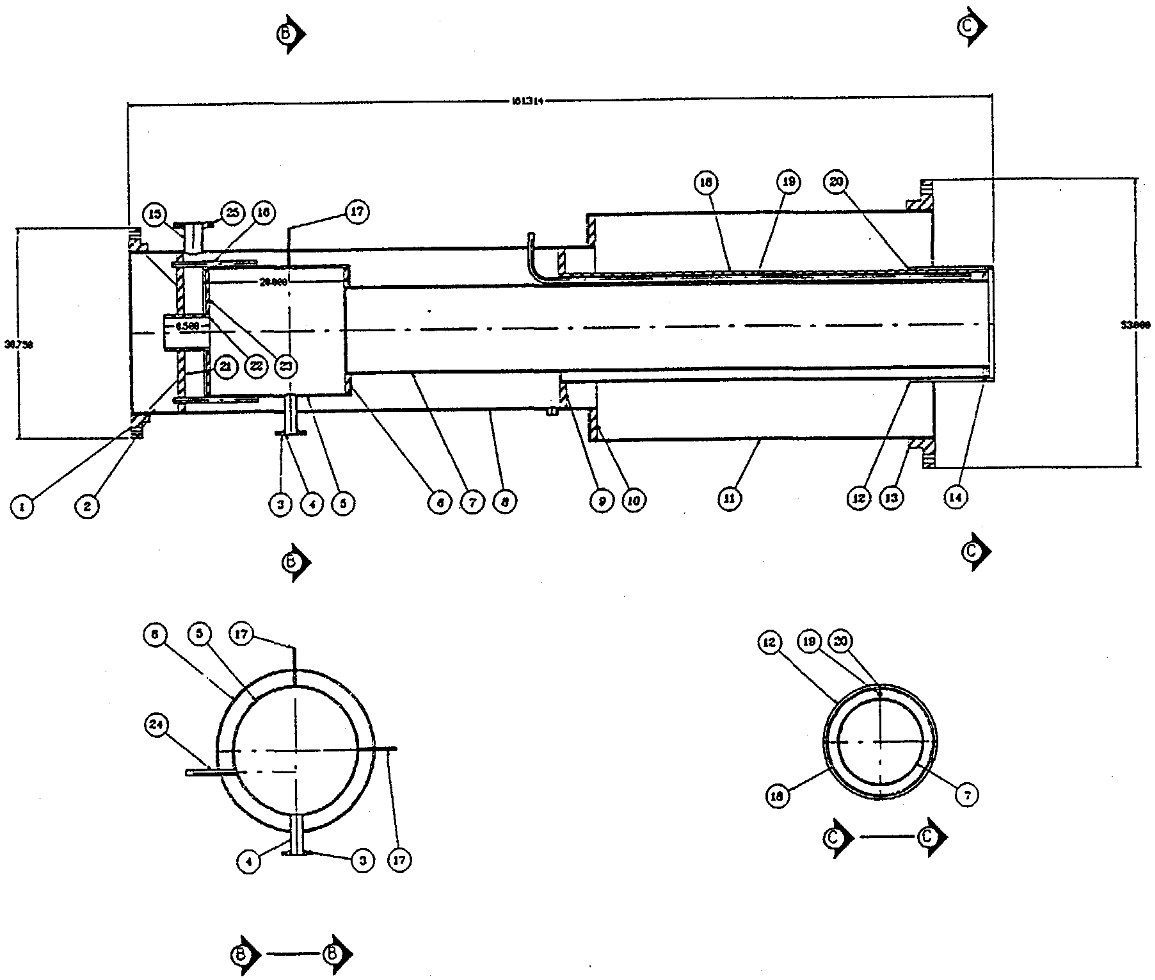
FIGURE 3: AIR PLENUM ASSEMBLY



QUANTITY: 1
MATERIAL: S.S. 304

Unless otherwise Specified the Fabrication Tolerances Are
± 1/16" for linear dimensions
± 1/2 ° for angular dimensions

FIGURE 4: AEROVALVE



ITEM	QTY	DWG NO.	DESCRIPTION	UNIT WT.	TOT WT.
1	1	830-014	FLANGE 30" 150 LB CS	300.0	300.0
2	4	830-014	GUSSETS THICK3/4"	7.6	30.4
3	1	830-014	FLANGE 2" 150 LB CS	5.0	5.0
4	1	830-014	PIPE 2" SCH40 CS L7-7/16"	1.9	1.9
5	1	830-014	PIPE 24" SCH40 CS L20"	210.2	210.2
6	1	830-014	RING CS THICK3/4"	45.3	45.3
			OD23-1/8" ID10-1/8"		
7	1	830-014	PIPE 16" SCH40 CS L119-7/16"	615.4	615.4
8	1	830-014	PIPE 30" STD CS L40-13/16"	847.8	847.8
9	1	830-014	RING CS THICK1-1/4"	121.8	121.8
			OD29-1/8" ID20-1/8"		
10	1	830-014	RING CS THICK1-1/4"	215.5	215.5
			OD41-1/8" ID30-1/8"		
11	1	830-014	PIPE 42" STD CS L64-3/16"	1122.2	1122.2
12	1	830-014	RADIATION SHIELD SS304 L16"	37.2	37.2
			OD21-1/4" ID21" THICK1/8"		
13	1	830-014	FLANGE 42" CS 150 LB	300.0	300.0
14	1	830-014	RING CS THICK3/4"	17.4	17.4
			OD18-1/8" ID16-1/8"		
15	1	830-014	PIPE 3" SCH40 CS L6"	2.8	2.8
16	4	830-014	BARS 1" DIA CS L16"	3.5	14.0
17	2	830-014	PIPE 1/2" SCH40 CS L7.5"	0.5	1.0
18	1	830-014	PIPE 20" STD CS L70-11/16"	515.0	515.0
19	1	830-014	PIPE 3/4" SCH40 CS L40-1/8"	6.3	6.3
20	8	830-014	GUSSETS SS304 THICK1/4"	0.1	0.4
21	1	830-014	RING CS THICK1-1/4"	221.0	221.0
			OD29-1/8" ID6-3/4"		
22	1	830-014	PIPE 6" SCH120 SS304 L6-1/2"	25.5	25.5
23	1	830-014	RING CS THICK3/4"	61.2	61.2
			OD23-1/8" ID6-3/4"		
24	1	830-014	PIPE 3/4" SCH40 CS L6"	0.9	0.9
25	1	830-014	FLANGE 3" CS 150 LB	9.0	9.0
				TOTAL WT.	4930.1

Unless otherwise Specified the Fabrication Tolerances Are
± 1/16" for linear dimensions
± 1/2 ° for angular dimensions

FIGURE 5: WATER JACKET OF PULSE COMBUSTOR

ITEM	QTY	DWG NO.	DESCRIPTION	UNIT WT.	TOT WT.
1	1	830-011	IMPACTOR PLATE S.S.310	1.40	1.40
2	1	830-011	2" TUBE 11G S.S.304	14.40	14.40
			THICKNESS 0.120", LENGTH 108"		
3	1	830-011	1.5" TUBE 10G S.S.304	13.50	13.50
			THICKNESS 0.134", LENGTH 108"		
4	1	830-011	1.25" HALF COUPLING S.S.304	0.32	0.32
5	1	830-011	1" HALF COUPLING S.S.304	0.20	0.20
6	1	830-011	2" FLEXIBLE HOSE S.S.304 L6"	1.20	1.20
				TOTAL WT.	31.12

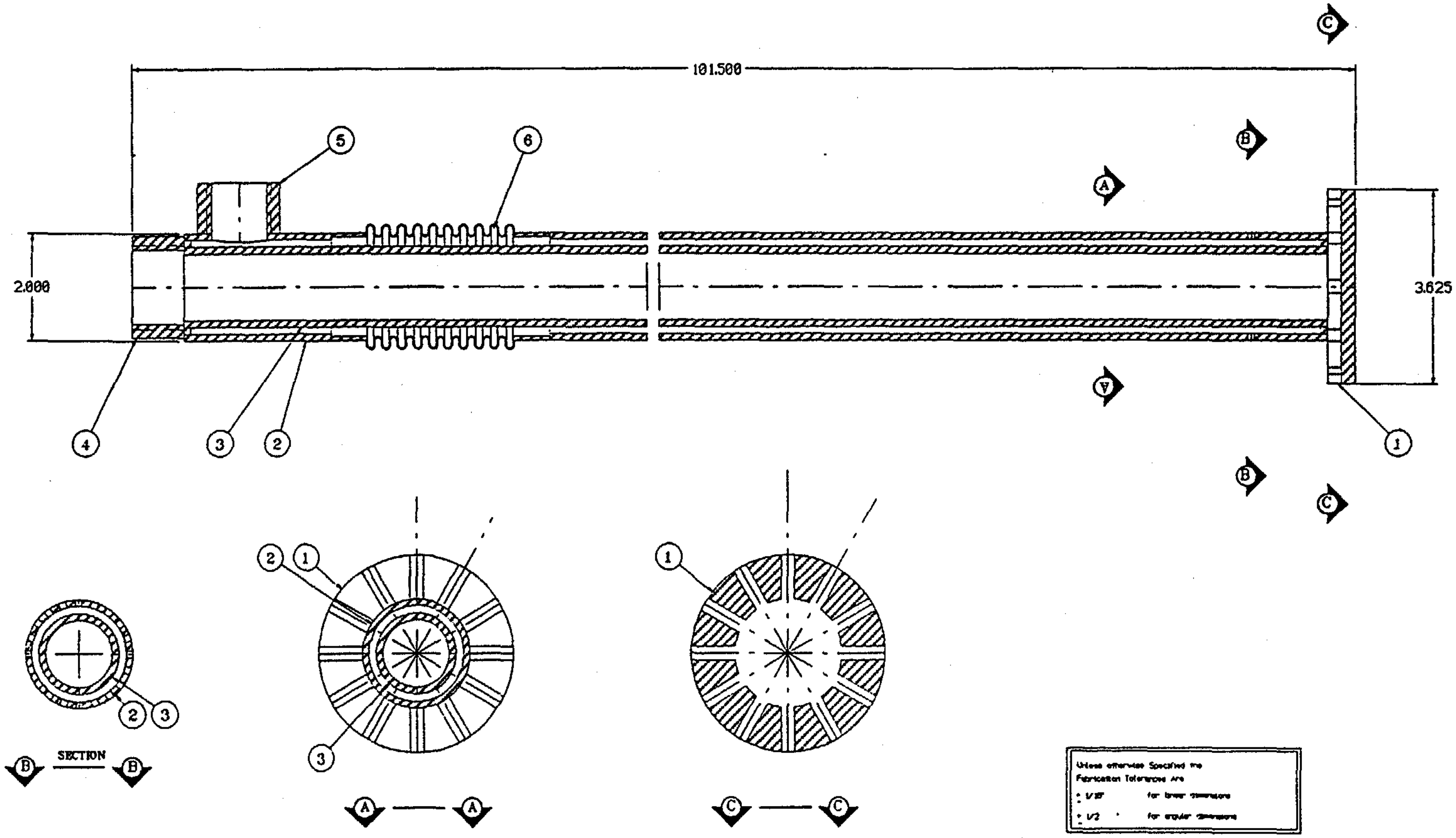
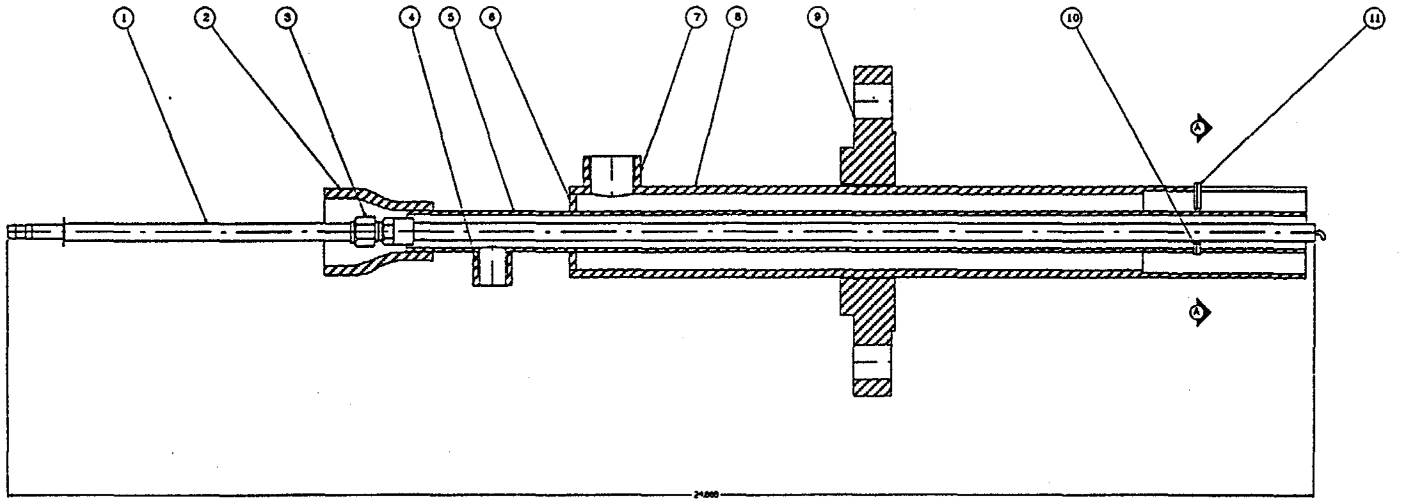
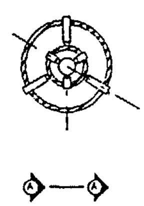


FIGURE 6: COAL INJECTOR

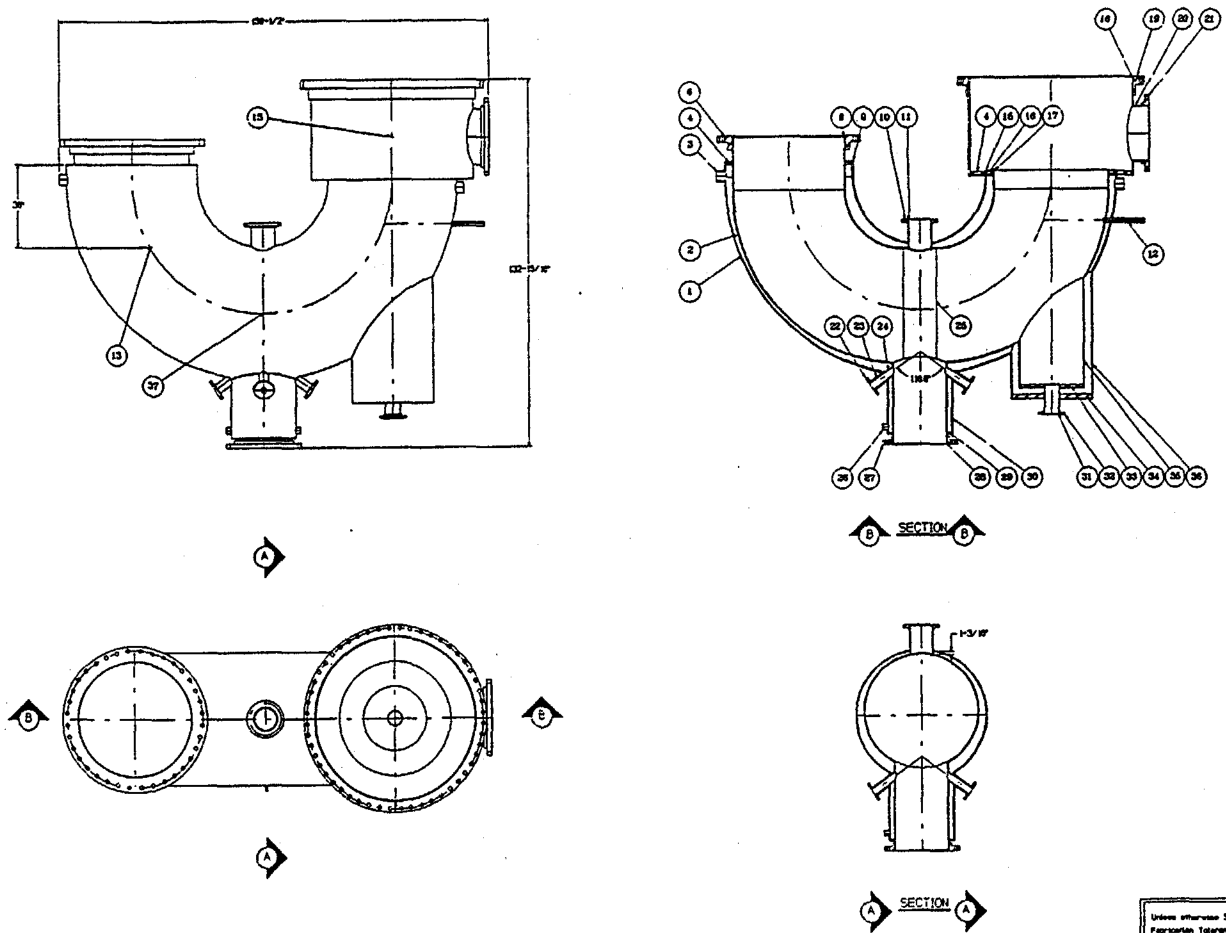
ITEM	QTY	DWG NO.	DESCRIPTION	UNIT WT.	TOT WT.
1	1	830-014	SPARK PLUG L=24"	0.40	0.40
2	1	830-014	REDUCER 1 × 1.5" S.S.304	0.20	0.20
3	1	830-014	SWAGELOK 5/16" S.S.304	0.10	0.10
4	1	830-014	HALF COUPLING 1/4" S.S.304	0.10	0.10
5	1	830-014	TUBE 3/4" S.S.304	0.20	0.20
			OD0.75" ID0.61" L=18.5"		
6	1	830-014	RING S.S.304 OD1.35" ID0.7"	0.05	0.05
			THICKNESS1/8"		
7	1	830-014	HALF COUPLING 3/8" S.S.304	0.10	0.10
8	1	830-014	PIPE 1.25" SCH40 S.S.304 L=13.5"	2.00	2.00
9	1	830-014	BLIND FLANGE 2" C.S.	2.00	2.00
10	3	830-014	SCREWS 1/8" S.S.304	0.01	0.03
11	3	830-014	SCREWS 1/8" S.S.304	0.01	0.03
				TOTAL WT.	5.21





Unless otherwise Specified the
Fabrication Tolerances Are
± 1/16" for linear dimensions
± 1/2 ° for angular dimensions

FIGURE 7: PILOT BURNER



ITEM	QTY	DWG NO.	DESCRIPTION	UNIT WT.	TOT WT.
1	2	830-020	48" ELBOW C.S. R 48" THICKNESS 3/8"	11910	23820
2	2	830-020	42" ELBOW C.S. R 42" THICKNESS 3/8"	9110	18220
3	2	830-020	3" PIPE LENGTH 32"	2.0	4.0
4	2	830-021	RING C.S. THICKNESS 1.00",	98.7	197.4
			OD 47-1/8", ID 42-1/8"		
5					
6	1	830-020	42" STD FLANGE 150 LB	2020	2020
7					
8	1	830-020	42" PIPE STD C.S. THICK 3/8" L 18.125"	145.0	145.0
9	1	830-020	48" PIPE STD C.S. THICK 3/8" L 6"	94.0	94.0
10	1	830-020	8" FLANGE STD C.S. 150 LB	27.0	27.0
11	1	830-020	8" PIPE STD C.S. LENGTH 11"	20.0	20.0
12	2	830-020	1-1/4" PIPE SCH40 C.S. LENGTH 11.75"	2.2	4.4
13	3	830-020	3/8" PIPE SCH40 C.S. LENGTH 6"	0.3	0.9
14	1	830-021	RING C.S. THICKNESS 1.50"	301.5	301.5
			OD 58-7/8, ID 49-1/8"		
15	1	830-020	48" PIPE STD C.S. THICK 3/8" L 3.25"	51.3	51.3
16	8	830-021	RING C.S. THICKNESS 1.25"	128.4	128.4
			OD 47-3/16", ID 42-1/16"		
17	1	830-020	42" PIPE STD C.S. THICK 3/8" L 0.75"	93.2	93.2
18	1	830-020	60" PIPE STD C.S. THICK 1/2" L 35.375"	636.7	636.7
19	1	830-020	60" FLANGE C.S. 150 LB	673.0	673.0
20	1	830-020	20" PIPE STD THICK 3/8" L 8"	51.0	51.0
21	1	830-020	20" FLANGE C.S. 150 LB	141.0	141.0
22	4	830-020	3" FLANGE C.S. 150 LB	9.0	36.0
23	4	830-020	3" PIPE SCH40 THICKNESS 0.216" L 7.5"	4.7	18.8
24	4	830-020	2" PIPE SCH40 THICKNESS 0.154" L 10.2	3.1	12.4
25	1	830-020	42" PIPE C.S. THICK 3/8" L 12"	105.7	105.7
26	2	830-020	1-1/2" HALF COUPLING C.S.	0.2	0.4
27	1	830-020	20" FLANGE C.S. 150 LB	141.0	141.0
28	1	830-021	20" PIPE C.S. THICK 3/8" L 32"	208.3	208.3
29	1	830-021	RING C.S. THICKNESS 0.375"	10.0	10.0
			OD 23-1/8", ID 20-1/8"		
30	1	830-020	24" PIPE C.S. THICK 3/8" L 22.4"	175.5	175.5
31	1	830-020	5" PIPE THICK 0.258" L 18.0"	23.1	23.1
32	1	830-020	5" FLANGE C.S. 150 LB	14.0	14.0
33	1	830-021	RING C.S. THICKNESS 1.00"	111.1	111.1
			OD 23-1/8", ID 5-11/16"		
34	1	830-021	RING C.S. THICKNESS 1.50"	270.6	270.6
			OD 29-1/8", ID 5-11/16"		
35	1	830-021	24" PIPE C.S. THICK 3/8" L 23.827"	234.5	234.5
36	1	830-021	28" PIPE C.S. THICKNESS 3/8" L 28"	353.7	353.7
				TOTAL WT.	100337

Unless otherwise Specified the Fabrication Tolerances Are
± 1/16" for linear dimensions
± 1/2 ° for angular dimensions

FIGURE 8: U-BEND SECTION ASSEMBLY (WITHOUT REFRACTORY)

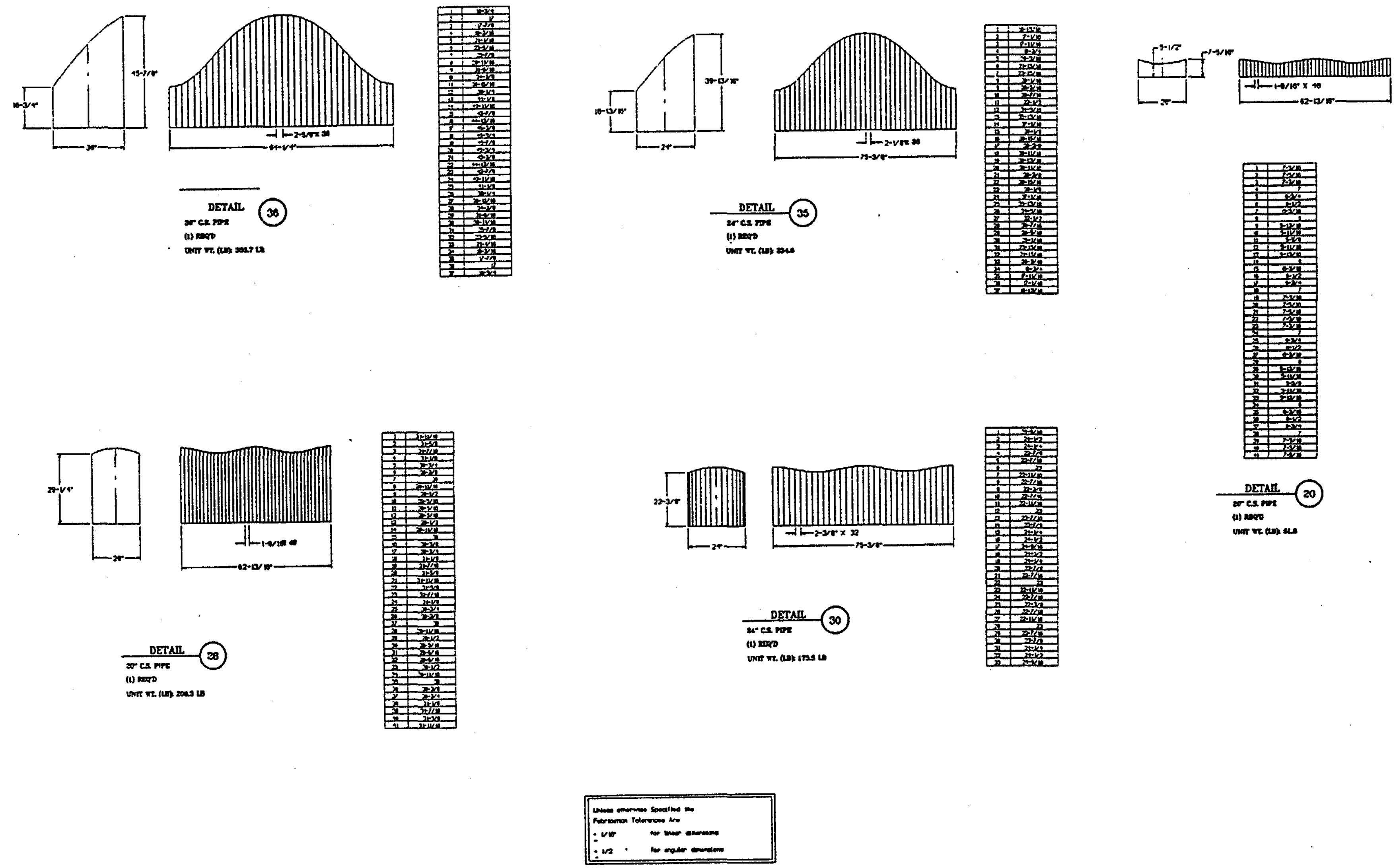


FIGURE 9: DETAILING OF U-BEND SECTION

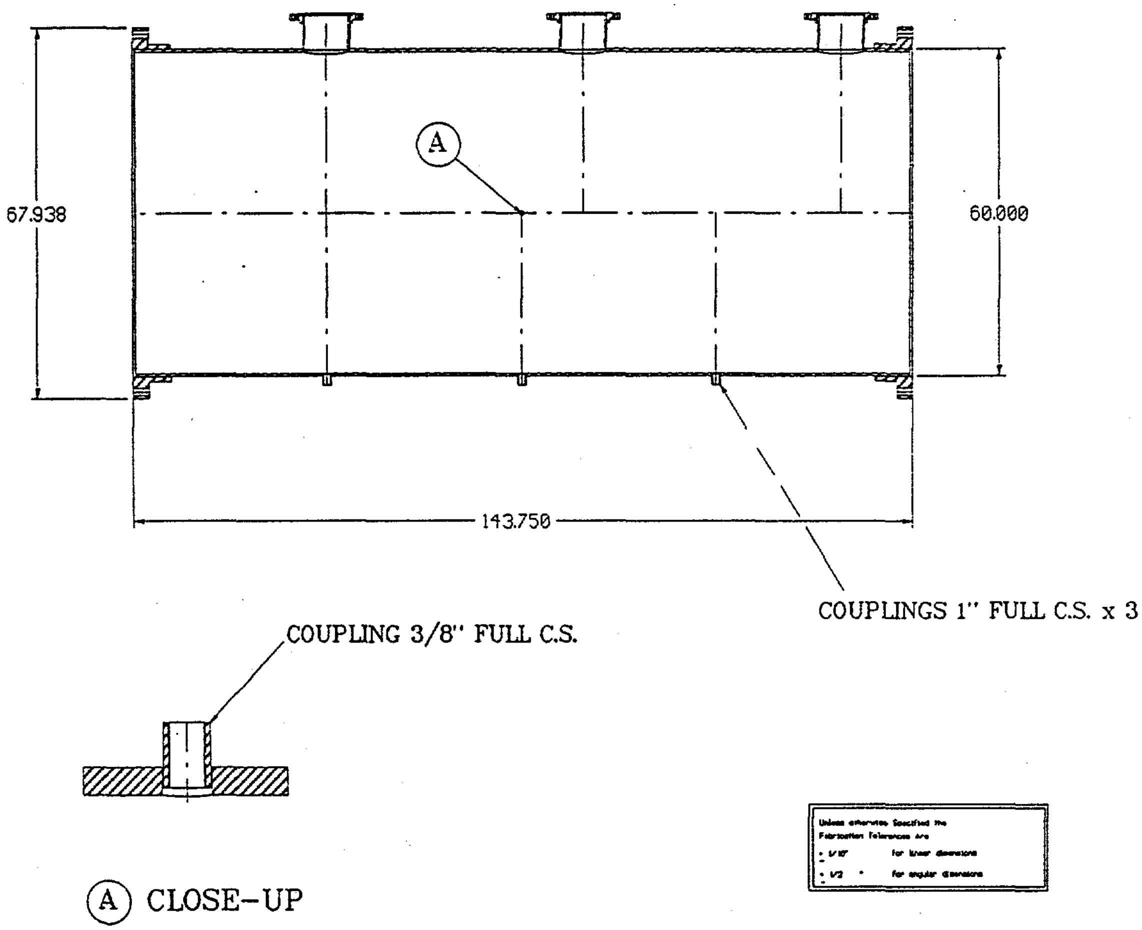


FIGURE 10: BOTTOM SECTION OF AGGLOMERATION CHAMBER

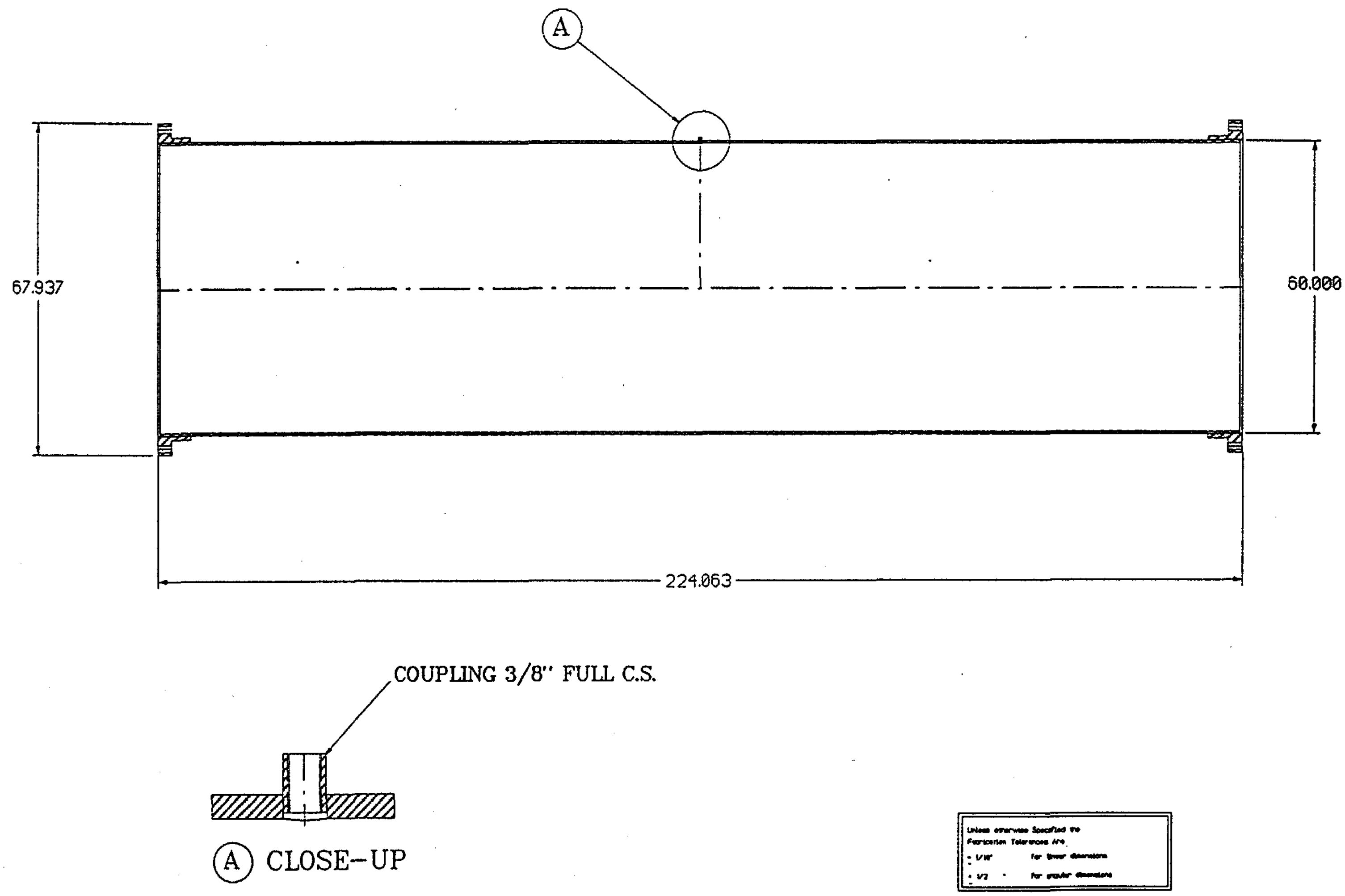


FIGURE 11: MIDDLE SECTION OF AGGLOMERATION CHAMBER

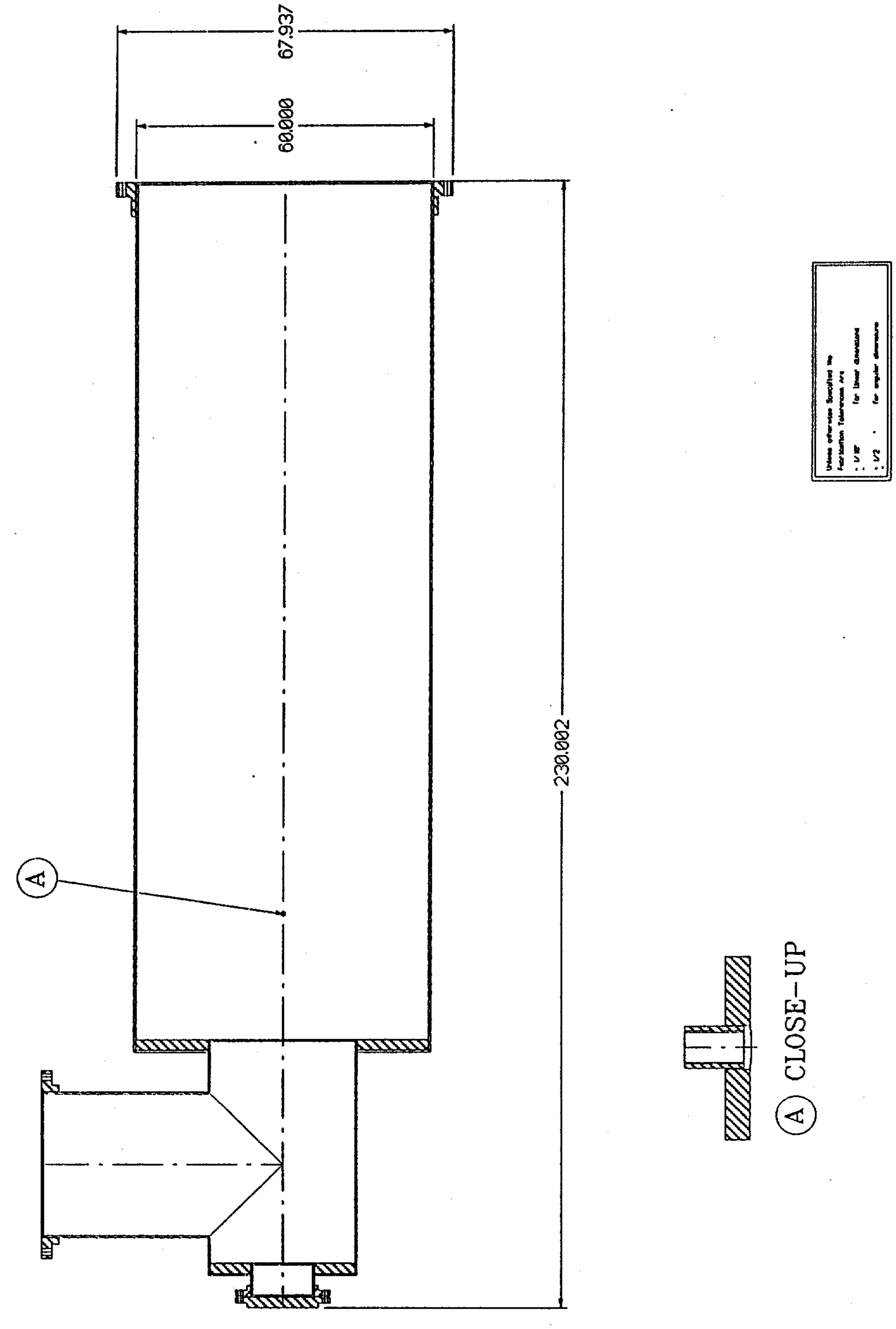
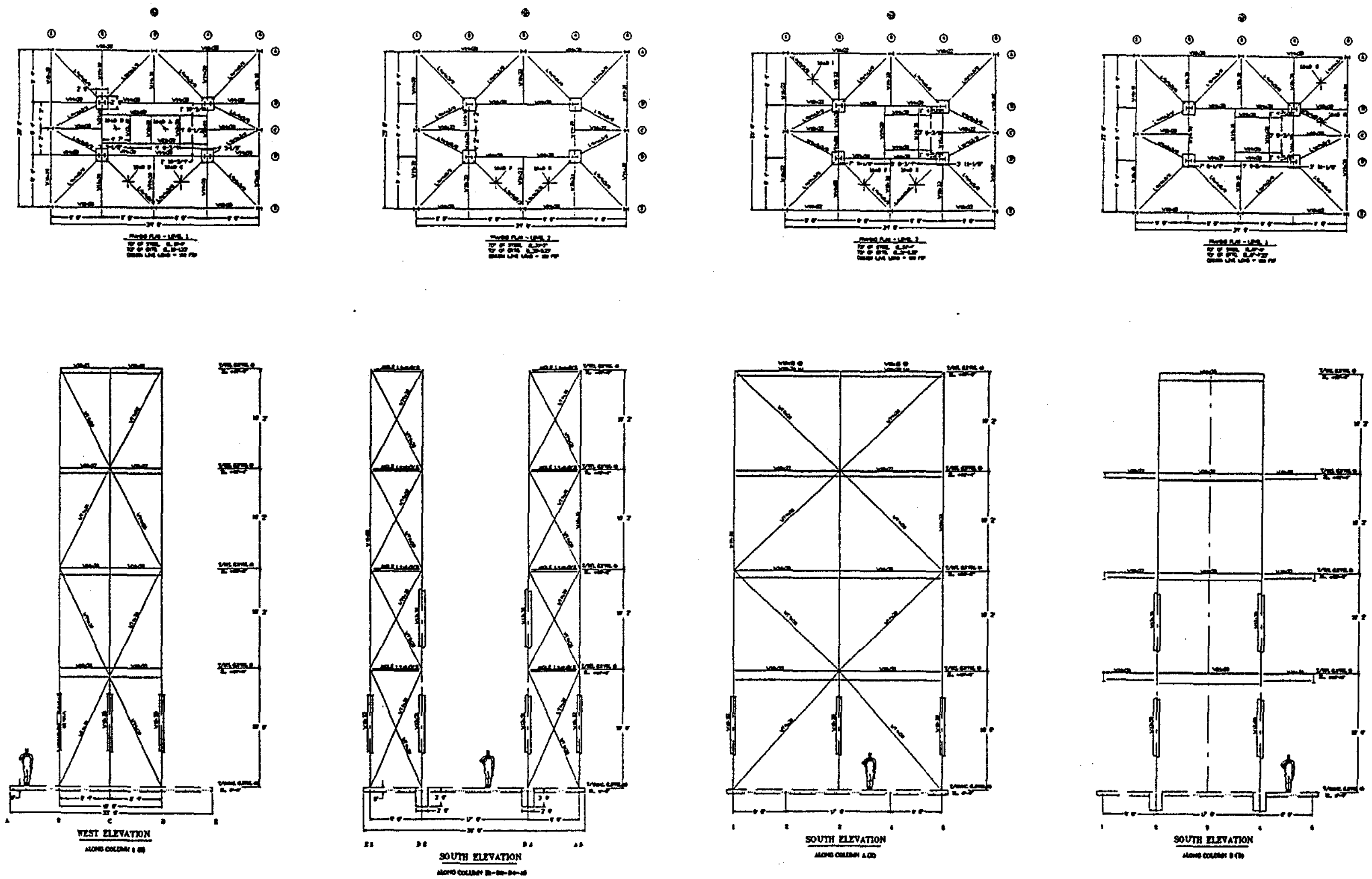


FIGURE 12: TOP SECTION OF AGGLOMERATION CHAMBER



LOAD	A	B	C	D	E	F	G	H	I
TONS	48.0	10.5	5.0	3.0	5.0	3.0	7.0	3.0	3.0

FIGURE 13: STRUCTURE LAYOUT (DRAFT)

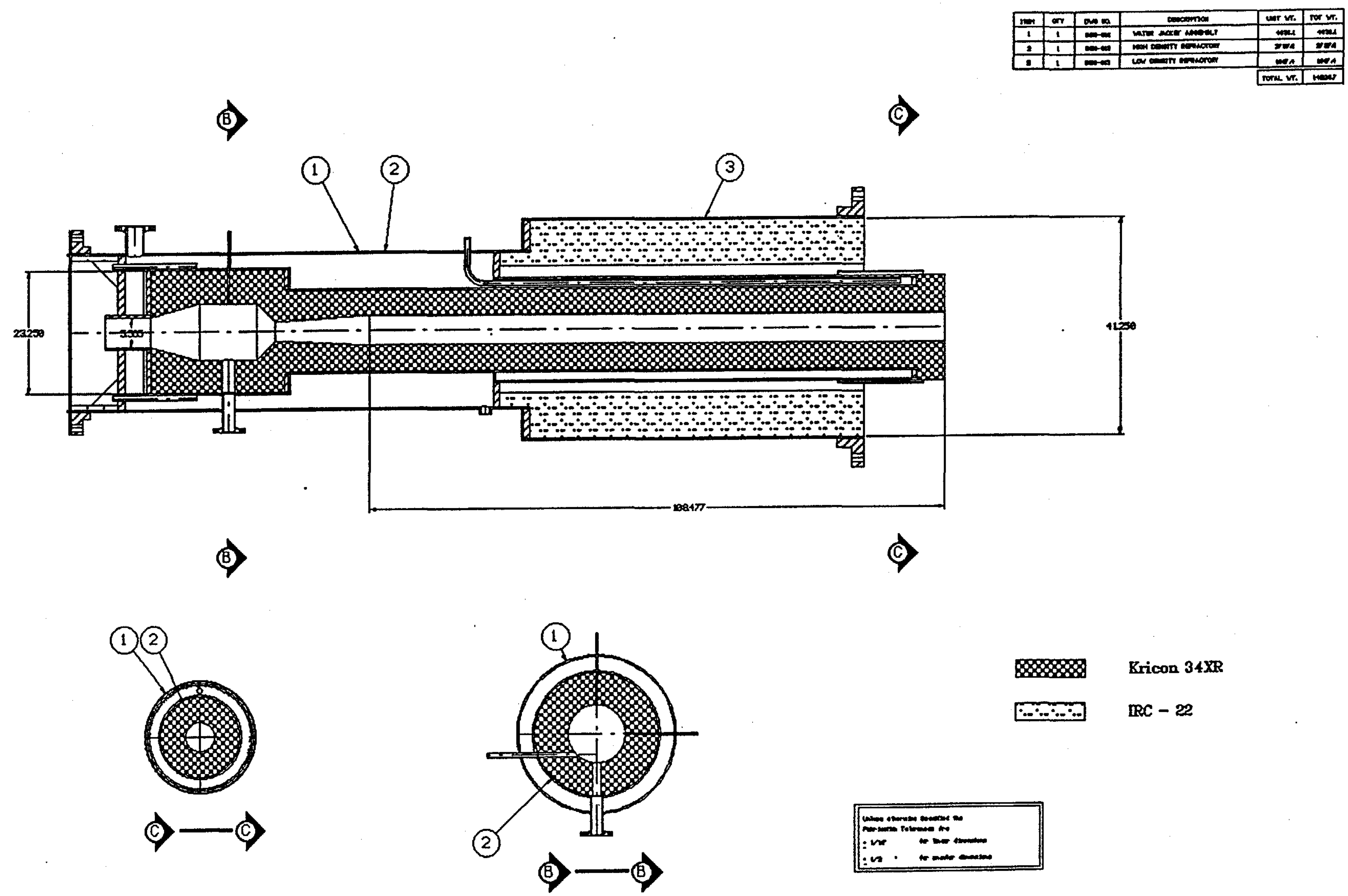


FIGURE 14: PULSE COMBUSTOR REFRACTORY

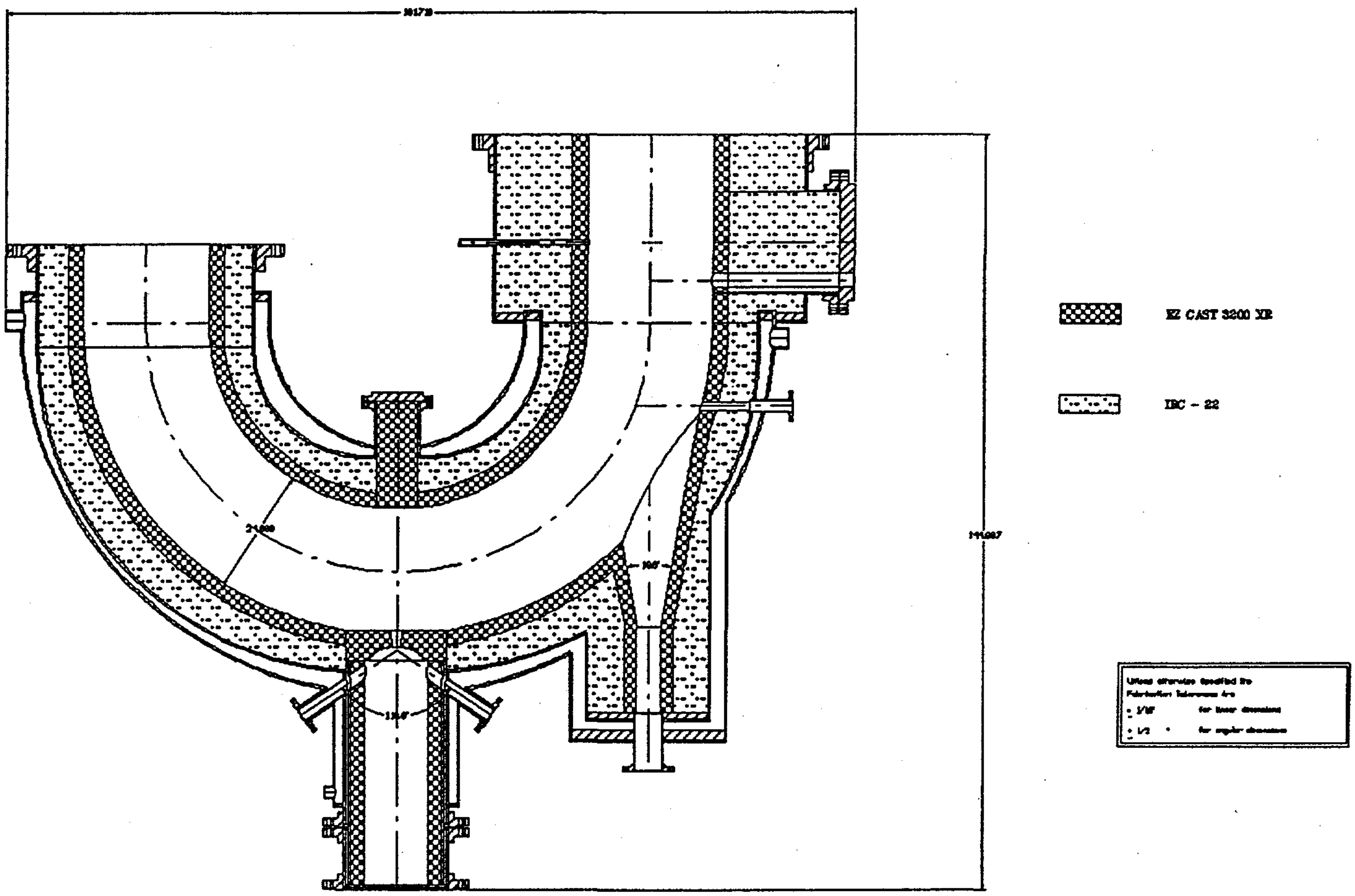


FIGURE 15: U-BEND SECTION REFRACTORY

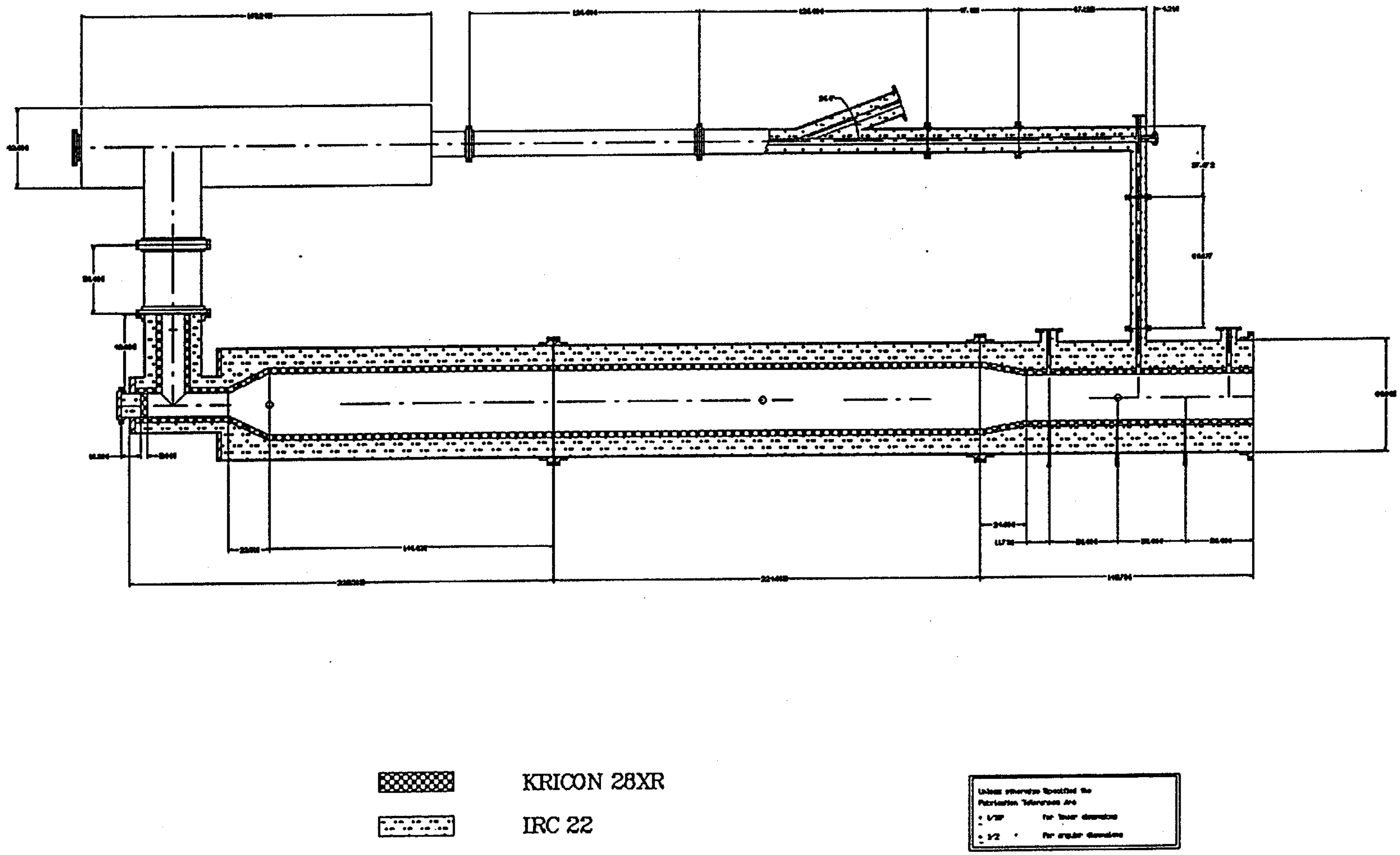
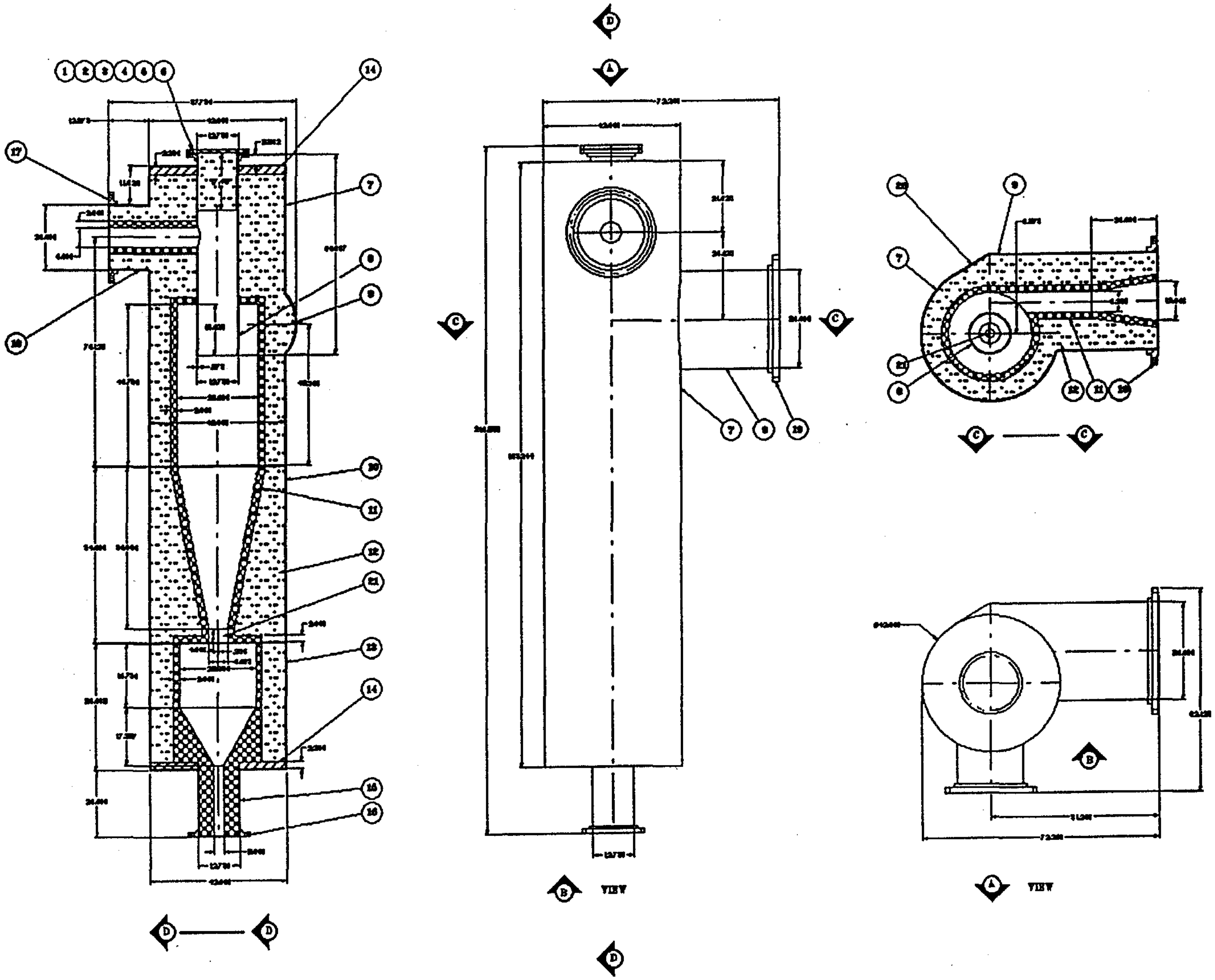


FIGURE 16: AGGLOMERATION CHAMBER AND DIPLEG REFRACTORY



ITEM	QTY	DWG NO.	DESCRIPTION	UNIT WT.	TOT WT.
1	1	830-010	FLANGE 12" SLIP-ON C.S. 150 LB	[illegible]	[illegible]
2	1	830-010	FLANGE 12" BLIND C.S. 150 LB	[illegible]	[illegible]
3	1	830-010	GASKET 1/4" THICK 250 F	[illegible]	[illegible]
4	12	830-010	BOLTS 7/8" 4" LONG CS.	1.2	14.4
5	12	830-010	NUTS 7/8" CS.	0.2	2.4
6	24	830-010	WASHERS 7/8" CS.	0.1	1.2
7	1	830-011	PIPE 42" STD CS. [illegible] LONG	[illegible]	[illegible]
8	1	830-010	PIPE 12" STD SS304 [illegible] LONG	2400	2400
9	1	830-011	PIPE 30" STD CS.	4395	4395
10	1	830-010	PIPE 42" STD CS. [illegible] LONG	[illegible]	[illegible]
11	1	830-010	HIGH DENSITY REFRACTORY	[illegible]	[illegible]
12	1	830-010	LOW DENSITY REFRACTORY	[illegible]	[illegible]
13	1	830-010	PIPE 42" STD CS. [illegible] LONG	5052	[illegible]
14	2	830-010	RING C.S. 2.25" THICK	734.4	[illegible]
			41.125" OD [illegible] ID		
15	1	830-010	PIPE 12" STD C.S. [illegible] LONG	[illegible]	[illegible]
16	1	830-010	FLANGE 12" SLIP-ON C.S. 150 LB	[illegible]	[illegible]
17	1	830-010	FLANGE 30" SLIP-ON CS. 150 LB	[illegible]	[illegible]
[illegible]	1	830-010	PIPE 30" STD CS. [illegible] LONG	[illegible]	[illegible]
[illegible]	1	830-010	PIPE 30" STD CS. [illegible] LONG	[illegible]	[illegible]
[illegible]	1	830-011	PIPE 30" STD CS. (SEE DETAIL)	[illegible]	[illegible]
[illegible]	4	830-010	CROSS SS304 1/4" THICK 30" LONG	[illegible]	[illegible]
			4" WIDE		
				TOTAL WT.	[illegible]

Unless otherwise Specified the Fabrication Tolerances Are
± 1/16 for linear dimensions
± 1/2 ° for angular dimensions

FIGURE 17: PRIMARY CYCLONE

MTCI received quotes from three refractory subcontractors: Chiz Bros. Inc., Lynn Whitsett Corporation, and French Construction Services, Inc. Chiz Bros. Inc. was selected because they offered a warranty, have cooperative relationships with National Refractories & Minerals Company, and their cost bid was between each of the other respondents.

MTCI contracted for an independent design review of the preliminary structural design with Dr. Glenn Hazen of the Civil Engineering Department, Ohio University. Their review indicated some minor changes were required for the structure but that the concrete pad was totally inadequate. Changes to the pad are being made and will be re-submitted for analysis. The following is Dr. Hazen's analysis report:

Introduction

For this project we analyzed a four-story steel frame intended to support wind loads, mechanical piping, and a 100-psf live load. Also analyzed was a concrete pad intended to support the frame and all of its loads. All steel allowable loads were determined by allowable stress design as outlined in the AISC manual of steel construction, ninth edition. For the analysis of the frame, SAP90 structural analysis software was used. This software is based on the assumption of stresses only in the elastic range. The concrete pad was analyzed using procedures of the ACI building code for reinforced concrete (1992 revision).

Results

The preliminary design of this structure was logical and well carried out. However, there were problems with some of the members intended to carry significant loads. On each of the four levels, mid-span point loads ranging from 5 to 14 kips are placed on 4"x 4" x 3/8" angles. These members are too small to carry loads of this magnitude.

On the first level, W21 x 50 beams intended to carry the 96-kip load of a pipe were too small. On the top level, W10 x 15 beams also failed in flexure. Both beams were only marginally underdesigned.

The foundation on the other hand is extremely underdesigned. Many assumptions were made in the analysis of the slab but it seems obvious that it is far too weak to carry the loading.

Conclusions

The frame is well-designed and if the above discrepancies are corrected, the frame should be satisfactory for the intended purpose. The most significant problem is the direct loading of the angles. The loads either need to be moved to the joints of the connection or the member size significantly increased. The concrete slab, as stated above, is entirely too weak to carry the loads. No analysis was performed on the soil due to lack of information.

2.2 PENN STATE UNIVERSITY

WORK ON AGGLOMERATION OF SORBENT PARTICLES

Currently, work is being done on two different aspects. A small experiment is being conducted which seeks to verify the effects of an acoustic field on sulfation of large sized (~500 micron) sorbent particles. The sorbent particles will be suspended in an entrained flow reactor in an acoustic field and tests will compare sulfation results with and without sound. It is planned to verify the sorbent model predictions for long residence times (~60 seconds) and low temperatures (~800-900 C). The second part continues with the study on acoustic agglomeration.

There are many different ways in which transport of sorbent/coal particles in a combustor can be modeled. Since the physical impossibility of tracking every particle is manifest, a statistical approach will be adopted. A transport equation for the particle number density can be written for 2-D axisymmetric flows. Such a transport equation will account for convective as well as turbulent diffusive transport. Following the approach of Song,[1] and in the presence of an acoustic field, the transport equation can be suitably modified to account for acoustic agglomeration using an Acoustic Agglomeration Frequency Function, hereafter called AAFF. Although there is still a great deal of uncertainty about the precise mechanism that is responsible for acoustic agglomeration, the AAFF takes into account the agglomeration of individual particles and breakup of agglomerates in a statistical fashion. Hoffmann[2] in his thesis describes the different mechanisms in a comprehensive review. Briefly, acoustic wave-particle interaction phenomena can occur due to linear (orthokinetic interaction, first order scattering interaction) or non-linear (radiation pressure force, mutual radiation pressure by scattered waves, or acoustic wake effects due to asymmetric flow fields around particles). Hoffmann, however, has pointed out that the acoustic wake effect is potentially a major contributor to the agglomeration phenomenon. Hoffmann derived an expression for the relative velocity of the two particles for a single orientation, i.e., the on-axis case, where the axis of the particles is in the same direction as the acoustic field. However, this is not enough, and we are trying to get an approximate analytical expression for the relative convergent velocity for any arbitrary orientation. Further details will be forthcoming in the near future.

Song derived the AAFF for the orthokinetic and hydrodynamic contributions to the agglomeration frequency function. However, the hydrodynamic contribution consists of both the radiation pressure interaction and the acoustic wake interaction. Song disregarded any effects of the acoustic wake effect. Efforts are currently underway to obtain an agglomeration kernel based on the acoustic wake effect. To derive the AAFF based on the acoustic wake effect, the procedure outlined by Song will first be followed.

The procedure involves obtaining an expression for the relative convergent velocity between two particles due to the acoustic field for any arbitrary orientation. Once this expression is obtained using it in the expression for the acoustic agglomeration frequency function as shown by Song gives us the desired result.

It therefore appears possible to derive an AAFF which incorporates the effects of the phenomena mentioned above, whereby the transport equation for the particle number density has a source/sink term describing the interaction of particles of different/similar sizes with each other and the resulting breakup or agglomeration of that particle. While Song used a 1-dimensional transport equation, the current version will be 2- dimensional and axisymmetric.

<u>References</u>

1) Song, L., Modeling of Acoustic Agglomeration of Aerosol Particles, Ph.D Thesis, The Pennsylvania State University, 1990.

2) Hoffmann, T., Visualization of Particle Interaction and Agglomeration in an Acoustic Field, Ph.D Thesis, The Pennsylvania State University, 1993.

SECTION 3.0

PLANS FOR NEXT PERIOD

- Continue the design of the PDU.

- Continue the fabrication of the PDU.