Membrane WESP

- A Lower Cost Technology to Reduce PM2.5, SO_3 & Hg^{+2} Emissions

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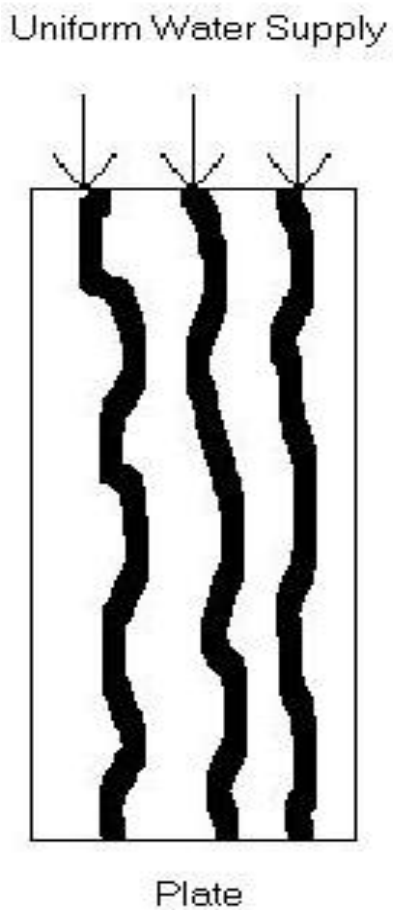
Overview

- Discussion of SO_3 Problem
- Compare metal plates with Membrane
- Pilot testing results
- Accelerated testing results
- NSP ‘build-up” test results
- SSCC Stevenson, AL - Unit details
- Condensing wet ESP advantage
- Cost comparison-Metal plate vs. Membrane WESP

Introduction

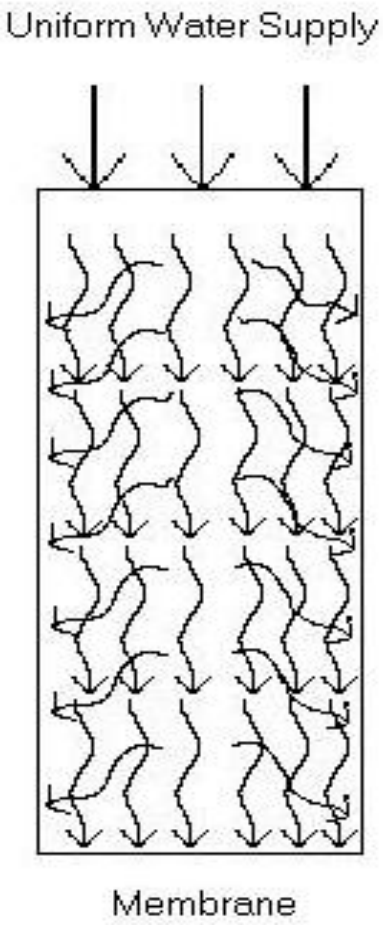
- More new Wet FGD Systems installed
- Increased SO_3 emissions after SCR's
- WESP - Best control for SO_3 emissions
- WESP - Excellent control for PM2.5 & Hg^{+2}
- Membrane WESP - Lower cost for SO_3 & PM2.5 control after FGD wet scrubber

Problems of Conventional Wet ESP



- Channeling and dry spots
- Wet-dry interface
- **Intermittent** collect/clean
- Spraying, misting, field disruptions
- Corrosion
- High Cost of Materials

Advantages of Wet Membrane Precipitation



- Water distribution
- Gravity assisted capillary action
- **Uniform** wetting of Membrane
- Convenient gas up-flow arrangement
- Low weight
- Low cost

Membrane Design Testing Results

- 1st Pilot - Fly Ash in Air Test
- Accelerated Chemical resistance tests
- 2nd Pilot - Lime Kiln–GP, Cedar Springs, GA
- 3rd Pilot - Bruce Mansfield SO_3, PM & Hg
- NSP “retrofit” for build-up evaluation
- First Commercial Installation-SSCC Stevenson, AL

Pilot Unit I

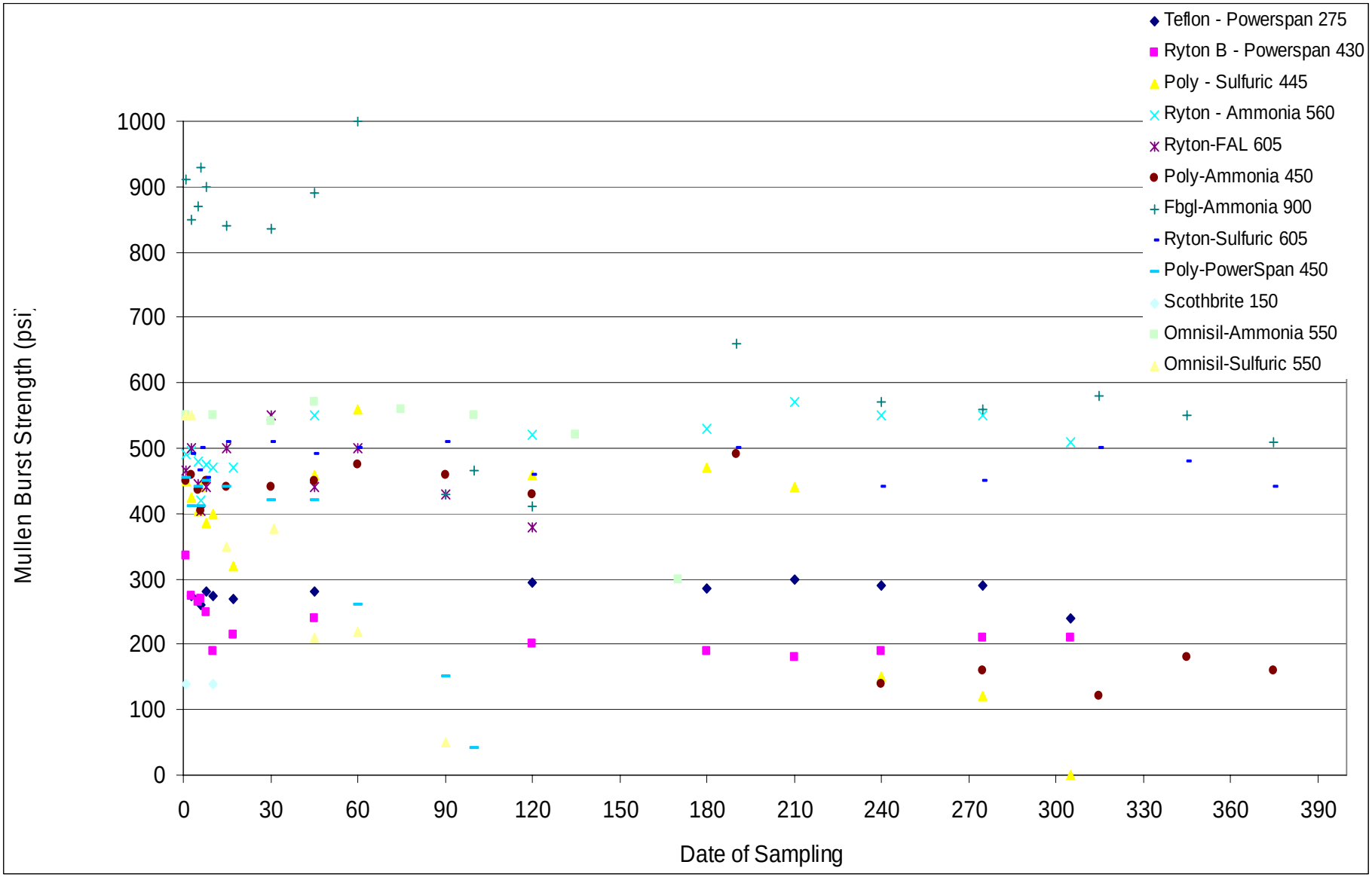
Pilot Unit I - Test Facilities

Pilot Unit I - Internals

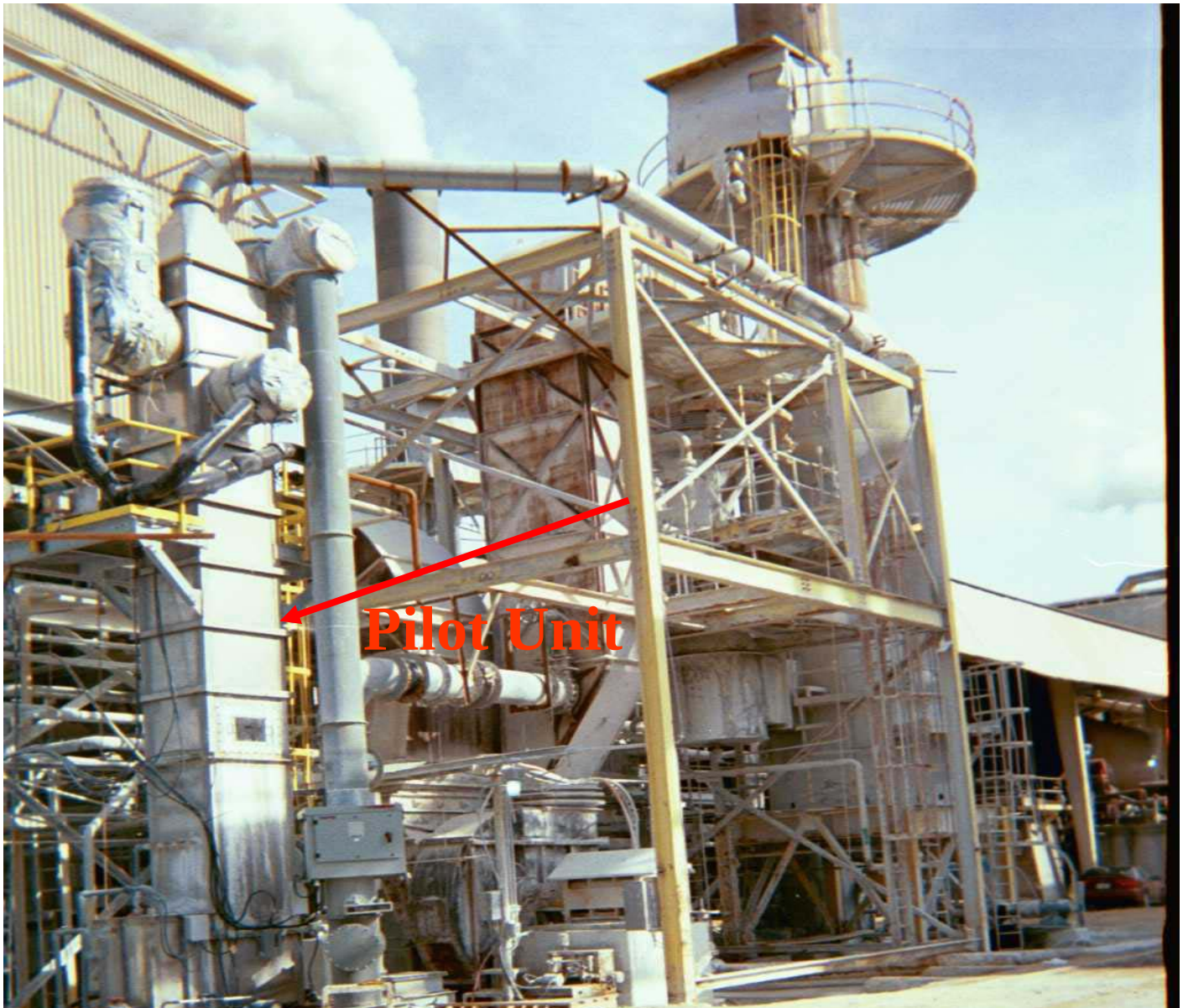
Power Off

Power On

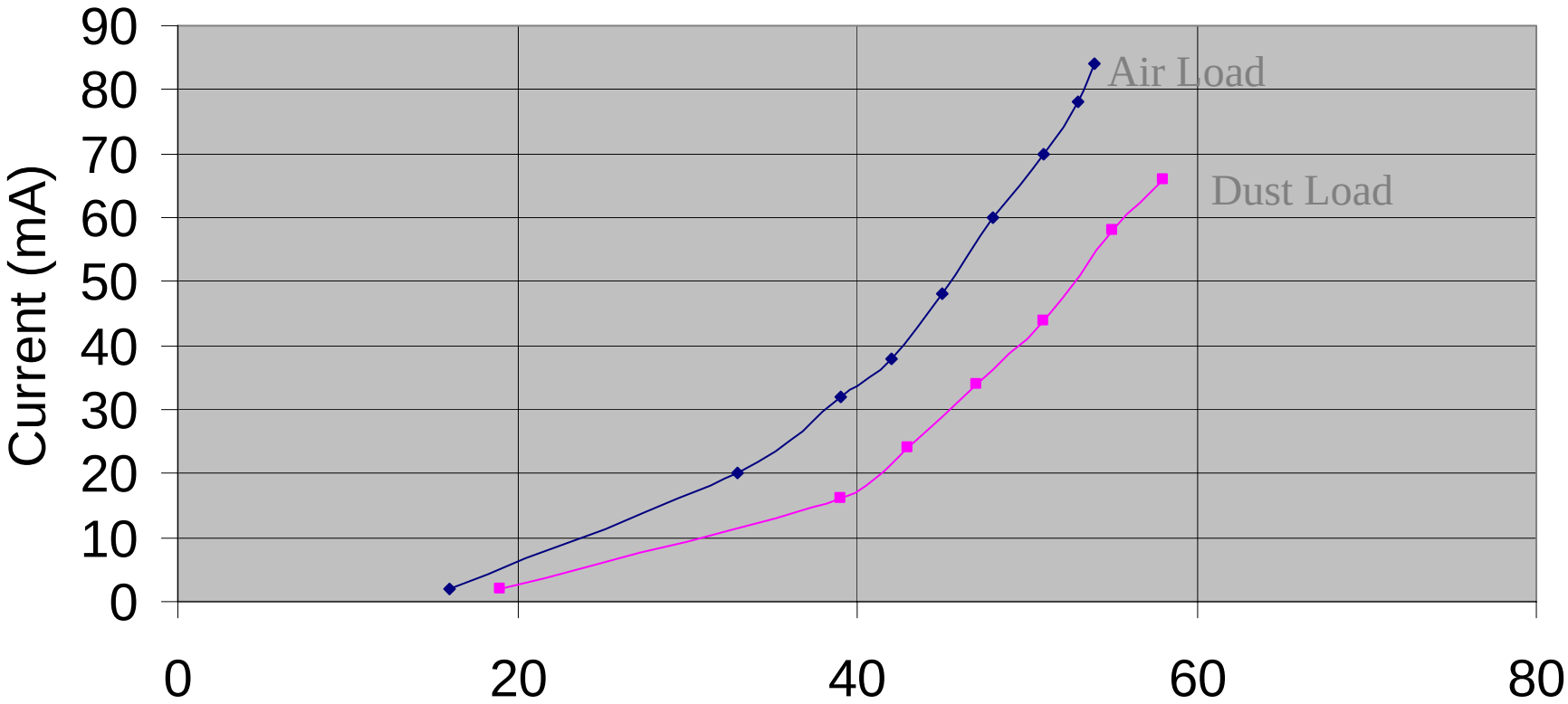
Accelerated Material Strength Testing



Pilot Unit 2-Lime Kiln – Cedar Springs



Voltage/Current Curves



Membrane Wet ESP Pilot-Cedar Springs
March 25, 2003

Top of Membrane Unit – After 6 Months

Membrane Tube in WESP – Top View

Pilot Unit 3-DOE Utility Pilot

WESP Performance Comparisons

UNIT	EXCEL/ SHERBORG	LIME KILN	DOE METAL		DOE MEMBRANE	
Application	FRB Fired Boiler	Lime Dust	SO_3, PM, Hg		SO_3, PM, Hg	
Description	2 Fld Upflow Metal	1 Fld Upflow Membrane	2 Fld Upflow Metal		2 Fld Upflow Membrane	
Downstream of:	Rod Deck Scrub	Rod Deck Scrub	Wet FGD		Wet FGD	
Gas Vol. ACFM	245,000	7,000	8,000	15,000	8,000	15,000
Gas Temp. ^{0}F	120-150^0 F	130^0 F	125^0 F		125^0 F	
SCA--1st Fld. 2nd Fld	34 51	65	45 45	24 24	37 40	20 21
Gas Velocity thru WESP, fps	***9***	***11***	***9***	***16.7***	***9***	***16.7***
Outlet Opacity, %	<10	<5	<2	<5	<2	<5
Inlet PM Loading, Gr/ACF		0.04	0.054	0.05	0.046	0.05
Outlet Loading, Gr/ACF		0.0027	0.004	0.015	0.0017	0.01
PM Efficiency, %		***93%***	***93%***	***70%***	***96%***	***80%***
SO_3 Efficiency, %	N/A	N/A	***88%***	***65%***	***93%***	***71%***
Hg^{+2} Efficiency, %	N/A	N/A	***76%***	***50%***	***82%***	***61%***

Scrubber/Membrane WESP - Mercury Removal
Ontario Hydro Method

Species	%	Scrubber Inlet μg/m³	WESP Inlet μg/m³	Scrubber Eff. % wt.	WESP Outlet μg/m³	WESP Eff. % wt.
Ash Hg	33%	4.5	0.8	82%	0.2	*72%*
Hg+2	44%	5.8	1.8	69%	0.4	*78%*
Hg^{o}	23%	3.0	3.0	0%	2.7	*10%*
Combined		13.3	5.6	58%	3.3	*41%*

Efficiency (ash + Hg^{+2})=94%

NSP Membrane Buildup Test

Design/Operating Parameters for Test on One Module

• Gas Volume to WESP Module,	245,000 ACFM
• Gas Temperature,	135 °F
• ***Coal Type,***	***PRB w/high Ca Ash***
• Coal Sulfur Content,	<1% Wt.
• No. & Dimension of tubes,	400 tubes ea. 9” x 12”
• Length of tubes,	4 Ft.
• Gas Flow in Module,	Upflow at 9 fps
• No. of Tubes tested,	18
• Inlet loading to WESP,	0.03 Gr./ACF
• Time of Continuous Operation,	6 Months

NSP Membrane Test after 6 Months

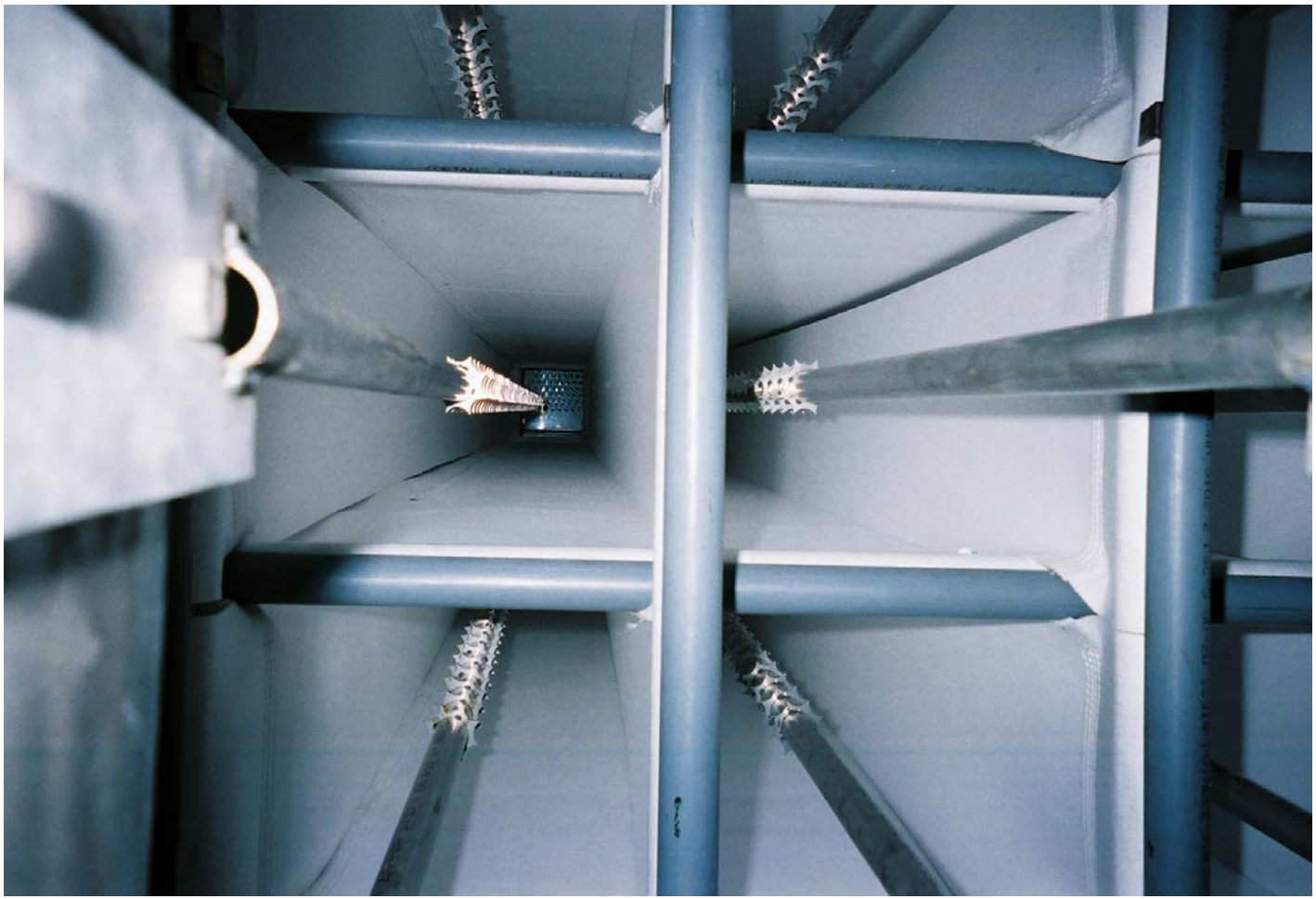
Smurfit-Stone Container Corp.
Stevenson, Alabama
Design Parameters for New Installation:

2 Boilers - WESP downstream of Na Scrubber

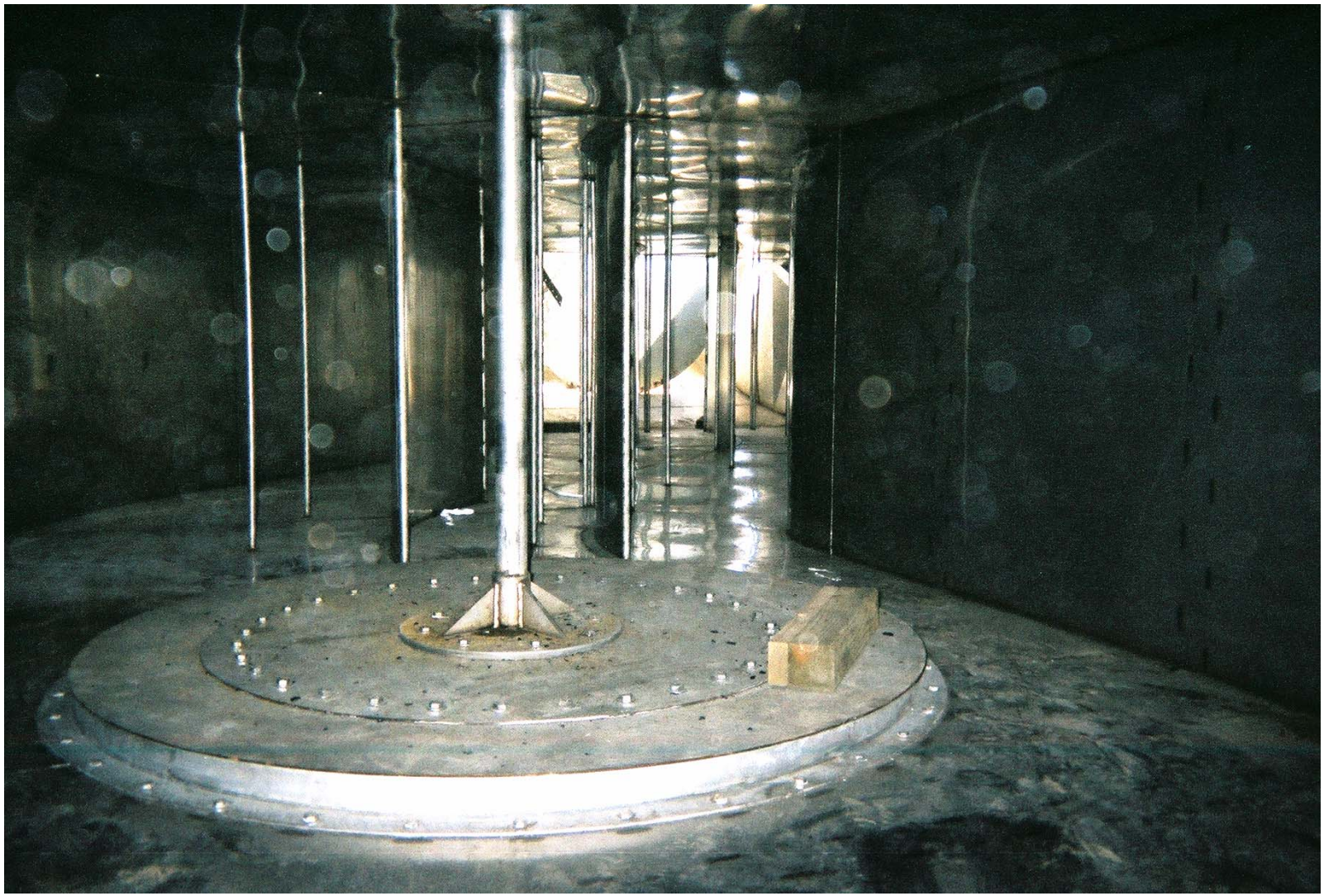
• Total Boilers Max. Firing Rate, MMBtu/hr	445
• Gas Volume to WESP, ACFM	125,000
• Gas Temperature, ^{o}F	135
• Fuel Type, Oil	#6 Bunker C
• Fuel Sulfur Content Max.	4% wt.
• Inlet loading to WESP, lb./MMBtu	0.2
• Inlet loading, lb./hr	90
• ***H_2SO_4 inlet concentration, ppmv***	***20 approx.***
• Outlet Emission Rate, lb./MMBtu	0.05
• Outlet Emission Rate, lb./hr	22
• Outlet Emission, Gr/ACF	0.02
• Removal Efficiency (PM & H_2SO_4)	75%

Two-Module Elevation View

View of top of Membrane Tubes w/RDE's



Poppet Damper Valve



Inlet/Outlet Temps. of E & W Modules

Cost Comparison-Metal Plate vs. Membrane WESP

WESP System	***Cost/kW***
3-field upflow Wet Membrane ESP-sitting on top of FGD scrubber	Approx. $20-25/kW
3-field horizontal flow Wet Membrane ESP-sitting on the grade	Approx. $30-35/kW
3-field horizontal flow Wet Metal Plate ESP-sitting on the grade	Approx. $40-45/kW

Assumptions:

1. Using 316 SS for material of construction
2. Erection cost not included
3. Ductwork not included for the grade mounted unit.

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Conclusions

- Membranes promote wetting and surface cleaning
- Several fabrics resist corrosion
- High collection efficiency demonstrated
- No dust build-up after 2+ years operation
- May not need make-up water for operation
- Can enhance the collection of oxidized mercury
- Lower cost design

Thank You!!!!