

Reinhold Environmental Ltd.



2009 APC Round Table & Expo Presentation

July 12-14, 2009, in The Woodlands, TX

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Kiewit

WHY FRP IN THE POWER INDUSTRY

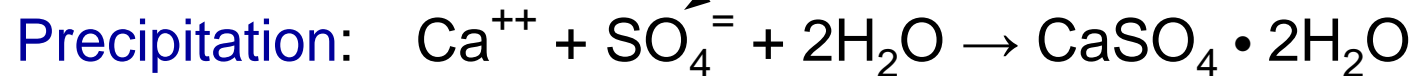
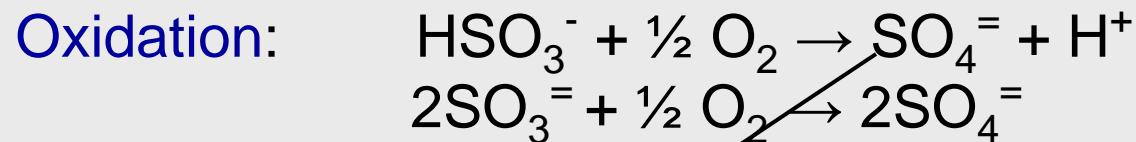
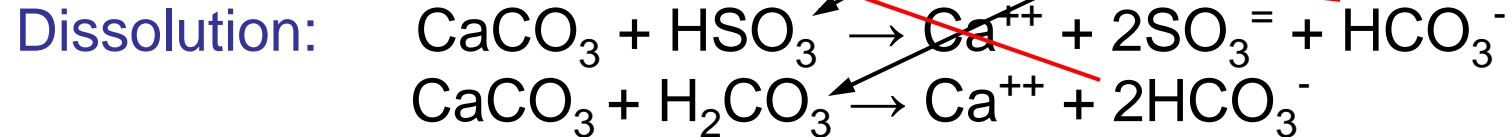
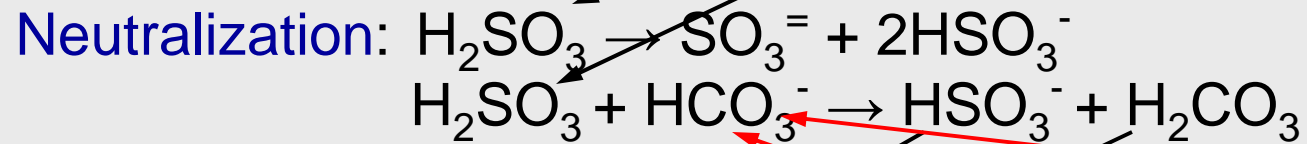
Pete Honeycutt
Kiewit Power Engineers
Manager Process/AQCS

Kiewit Overview

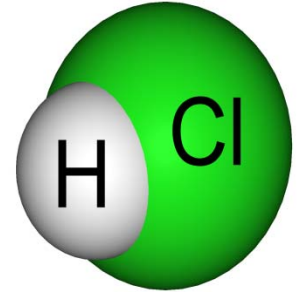
- Established 1884
- 19,000 Employees
- \$10.0B in revenue in 2008
- Employee owned
- Virtually unlimited bonding capacity
- ENR ranking of 2nd in Power
- Construction equipment, \$2.2 billion replacement value



Scrubber Chemistry – Simplified

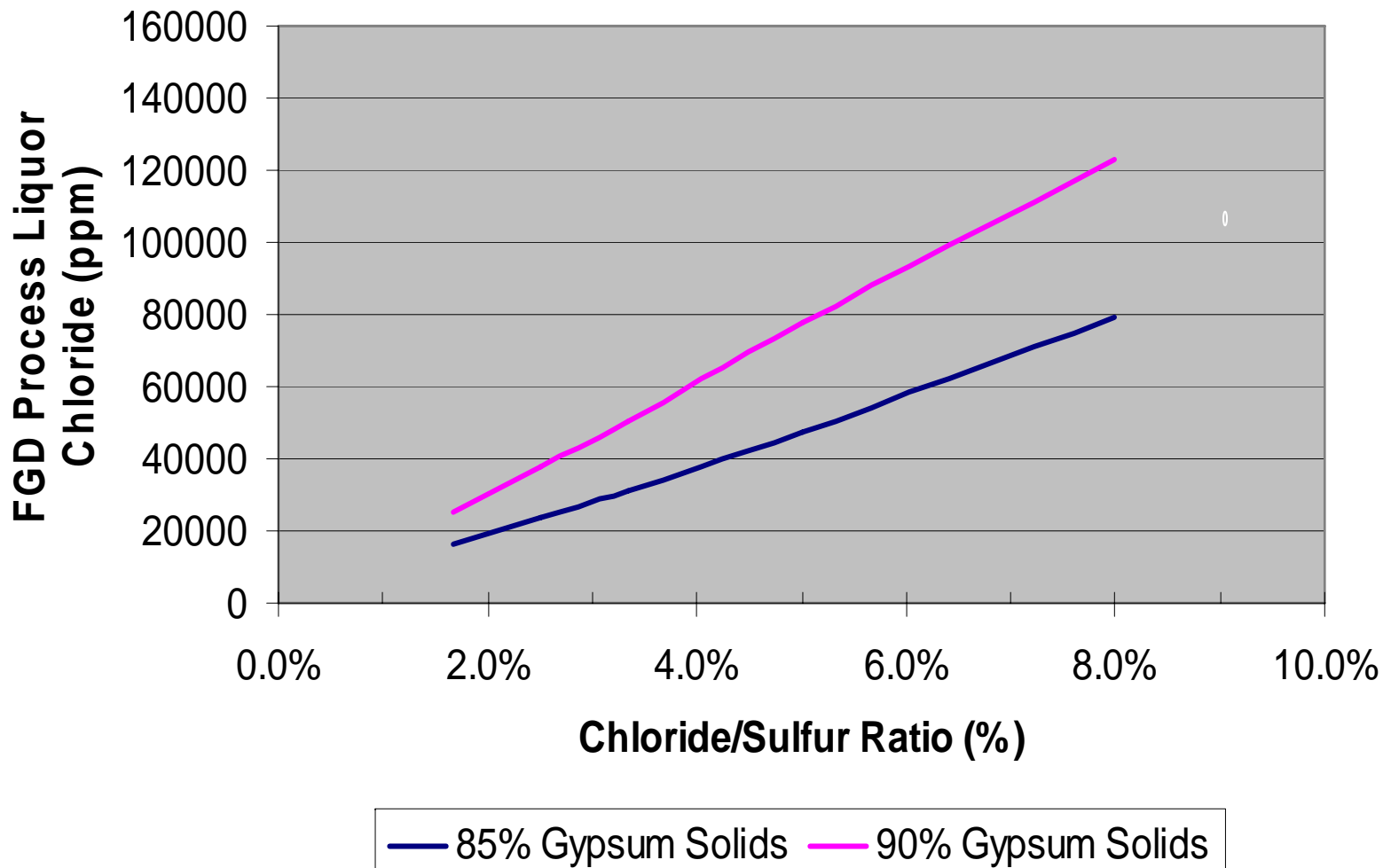


The Perverse Nature of Halogens



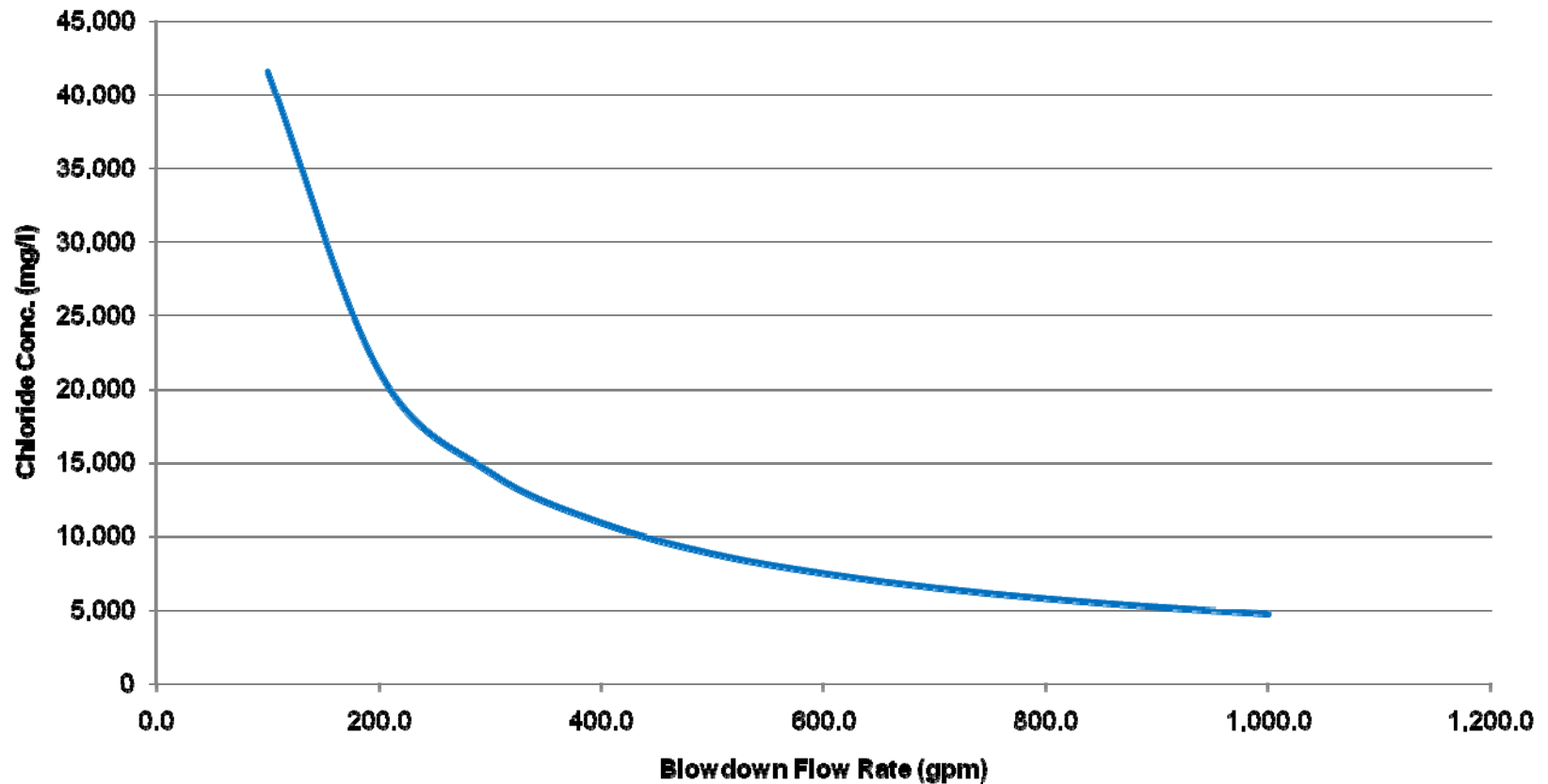
- In addition to SO₂, flue gas contains hydrogen halides formed when hydrogen combines with halogens forming a series of strong “acid gases”(HF, HCl, HBr, and HI). These gases in aqueous solution form hydrohalic acids which can dissociate into free halogen ions.
 - **Chloride and Fluoride ion increases corrosion potential in metal**
- Chloride ions are the most plentiful which concentrate during closed loop operation causing operational issues and increased corrosion
- One of the key design considerations for selection of materials of construction is the chloride concentration at which the FGD system will operate during its life

Dissolved Chloride Levels in Wet FGD Processes (Chloride Free Makeup Water & Closed Loop Operation)



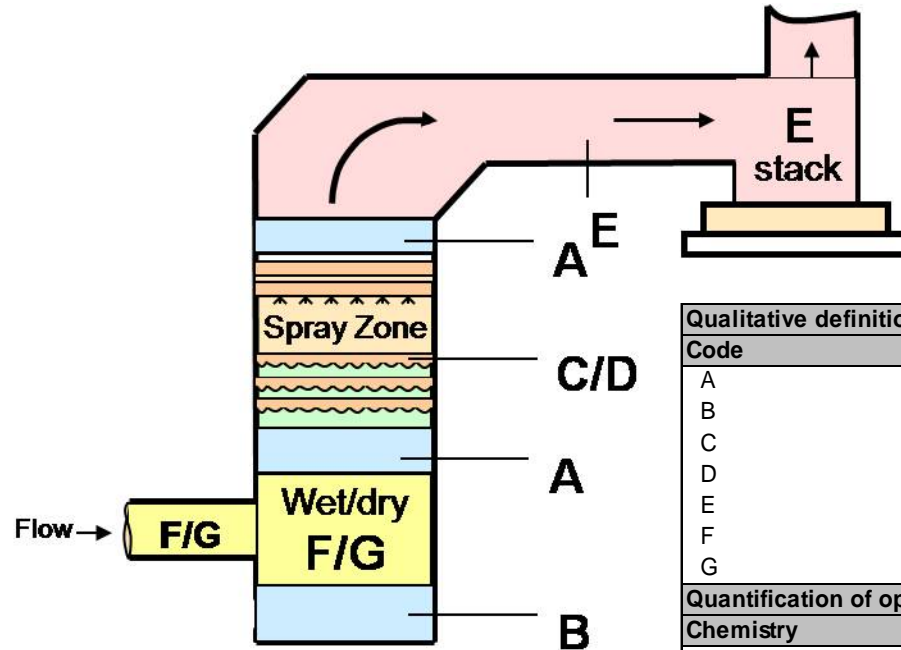
Blowdown Rate For Typical 500 MW Unit

Chloride Concentration versus Blowdown Flow Rate



FGD Systems and Their Environments

(Adapted from IEA Coal Research – Materials for FGD Systems)



Qualitative definition of operation zones			
Code	Chemistry	Mechanical environment	Temperature
A	mild corrosive (vapor)	mild	mild
B	moderate (immersion)	mild	mild
C	moderate	moderate	mild
D	moderate	severe	mild
E	severe	mild	mild
F	severe	mild	severe
G	severe	severe	severe
Quantification of operating zones			
Chemistry	Mechanical environment (abrasion level)		Temperature
mild	pH 3-8 Minor H ₂ SO ₄	agitated tank, walls, ducts, thickener	ambient to 150°F
moderate	pH 0.1-3 8-13.9 H ₂ SO ₄ 0-15%	spray zone tank bottoms	ambient to 200°F
severe	pH<0.1 H ₂ SO ₄ 15% HCL, HF present	impingement turning vanes, targets	ambient to 360°F

AQCS Material Choices

GUIDELINE STAINLESS STEEL AND NICKEL ALLOY SELECTION FOR FGD EQUIPMENT

		MILD		MODERATE		SEVERE		VERY SEVERE		
CHLORIDE ppm		100	500	1,000	5,000	10,000	30,000	50,000	100,000	200,000
MILD	pH 6.5	TYPE 316 L STAINLESS STEEL			TYPE 317 LMN			NICKEL ALLOY 625 ETC		
MODERATE	pH 4.5	STAINLESS STEEL			SUPER DUPLEX STAINLESS STEEL			SUPER AUSTENITIC STAINLESS STEEL		
SEVERE	pH 2.0	TYPE 317 LMN STAINLESS STEEL	20% Cr DUPLEX STAINLESS STEEL		25% Chromium Stainless Steels		6% Molybdenum Stainless Steels			NICKEL ALLOY C276 ETC
VERY SEVERE	pH 1.0	TYPE 317 LMN STAINLESS STEEL	SUPER AUSTENITIC STAINLESS STEEL			NICKEL ALLOY 625 ETC			6% Molybdenum Stainless Steels	

FIGURE 3

Source: "Selection of alloys for air pollution control equipment" by William L. Mathay

Cost Comparison of Construction Materials

(Courtesy of Don Kelly-Ashland)

Construction Material	Installed Cost	Cost Ratio
Shop Fabricated FRP	\$100 / Sq. Ft	1.0
Field Fabricated FRP	\$150 / Sq. Ft	1.50
	Raw Material Cost Only	
2205 stainless steel 3/8 inch plate	\$225 / Sq. Ft	2.25
C-276 clad carbon steel	\$330 / Sq. Ft.	3.30

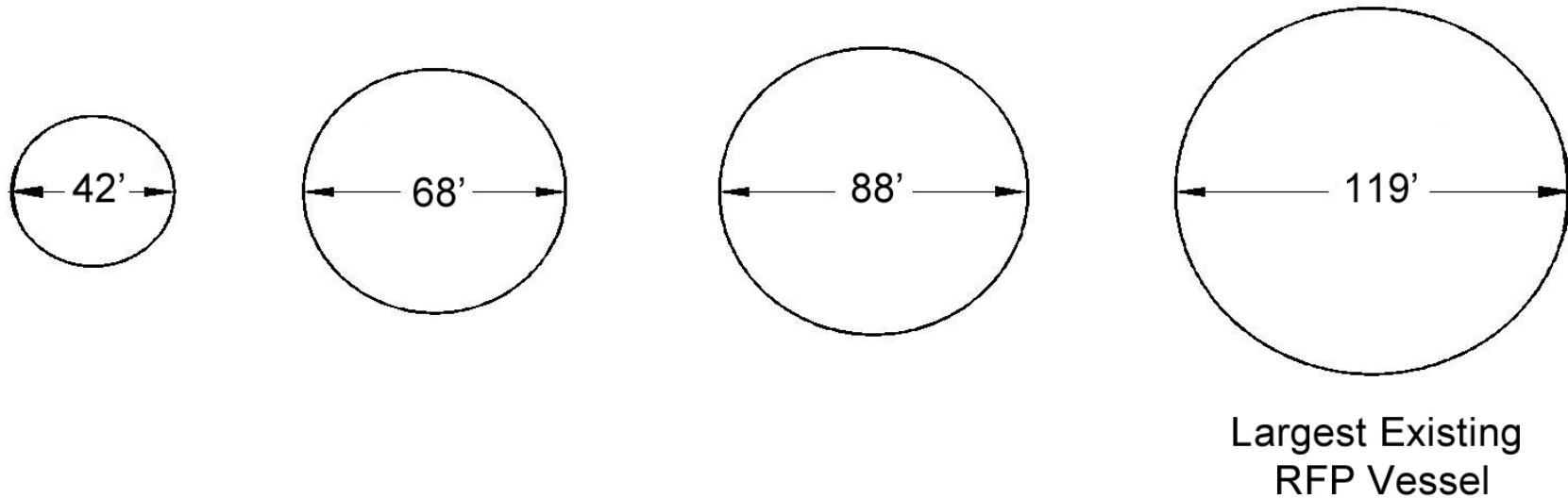
Common FRP Solutions

- Tanks and Process Vessels
- Ductwork
- Structural Beams
- Spray Pump Strainers
- Mist Eliminators
- Hydrocyclone Feed and Distribution
- Access Doors

Auxiliary Process Tanks



Evolution of Large Fiberglass Vessels for Process Vessels



Process Vessel



Process Vessel



Process Vessel – Pre-Scrubber, Spray Towers, Wet ESP



Ductwork



Rectangular Ductwork Vacuum Infused Process

(Courtesy of Non Metallic Resources)



Structural Beams

(Courtesy of Non Metallic Resources)



Pump Suction Strainer



Mist Eliminator After 11 Years



Hydrocyclone Assembly



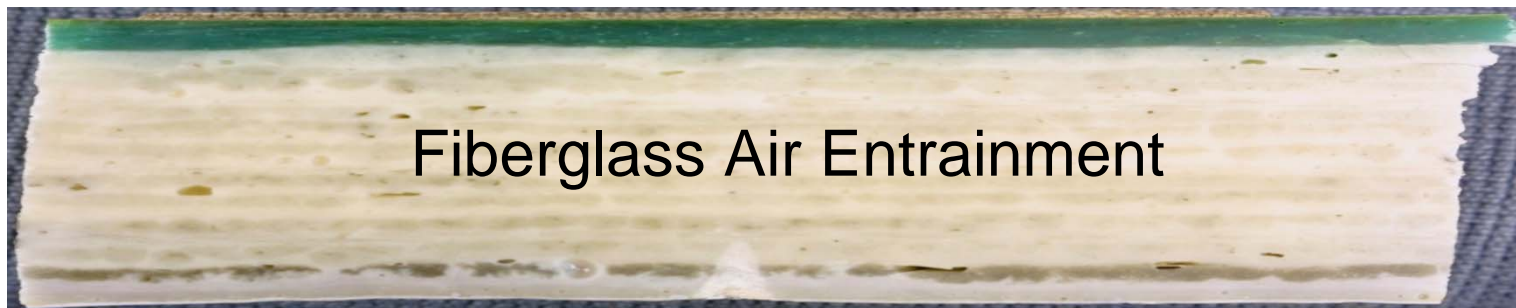
FRP Access Door



Fiberglass High Temp Damage



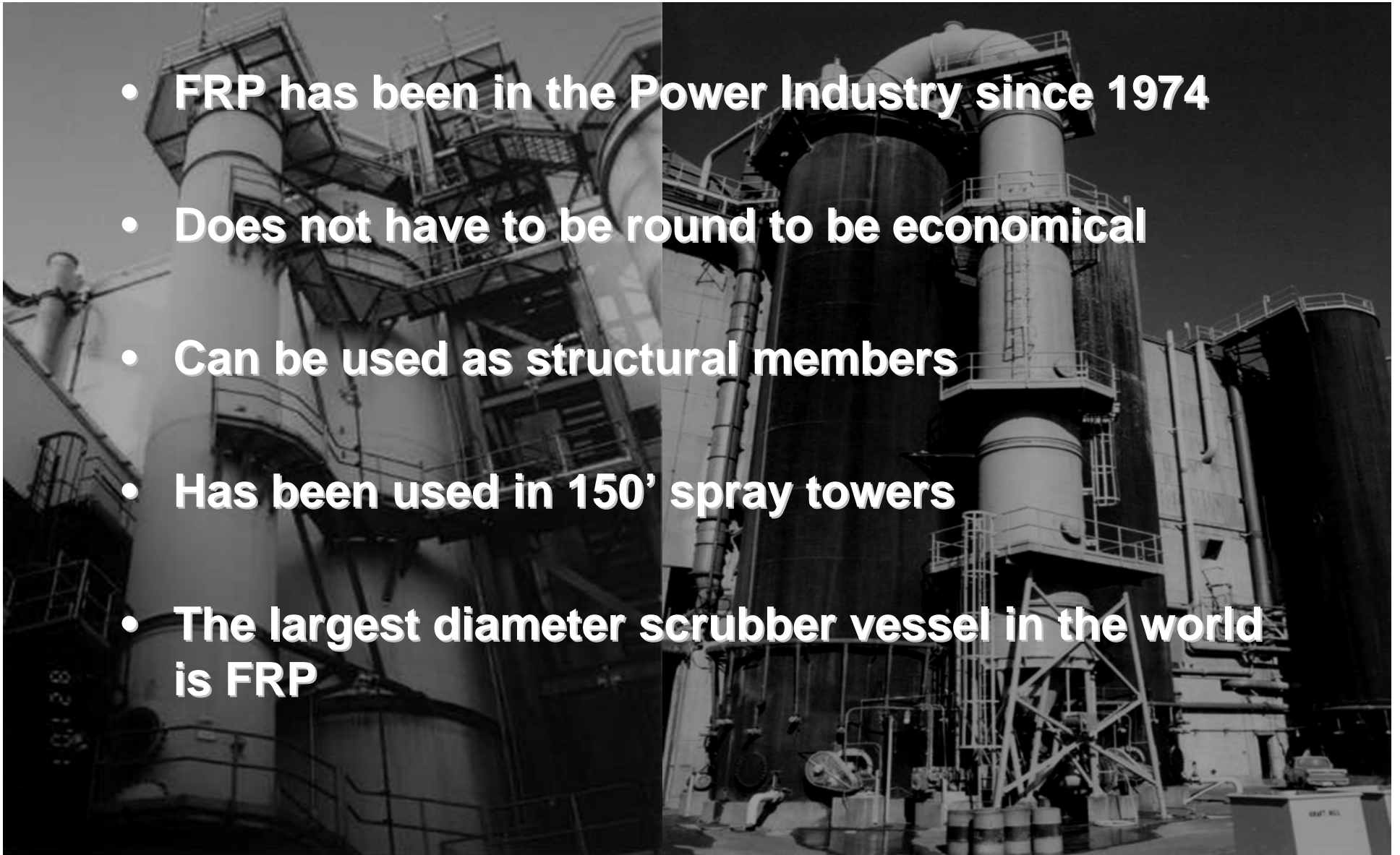
Fiberglass Abrasion Damage



Fiberglass Air Entrainment

FRP SUMMARY

- **FRP has been in the Power Industry since 1974**
- **Does not have to be round to be economical**
- **Can be used as structural members**
- **Has been used in 150' spray towers**
- **The largest diameter scrubber vessel in the world is FRP**





QUESTIONS?