Reinhold Environmental Ltd.

2006 APC Round Table & Expo Presentation

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International, Ltd.

FGD Materials of Construction

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2006 APC/PCUG Conference
Columbus, Ohio

What materials are available?

- Metals
- FRP
- Resin Based Linings
- Plastics
- Rubber
- Masonry

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Which is best for my scrubber?

- All of them
  - Every one of them has had success stories.
- None of them
  - Every one of them has had failure stories.

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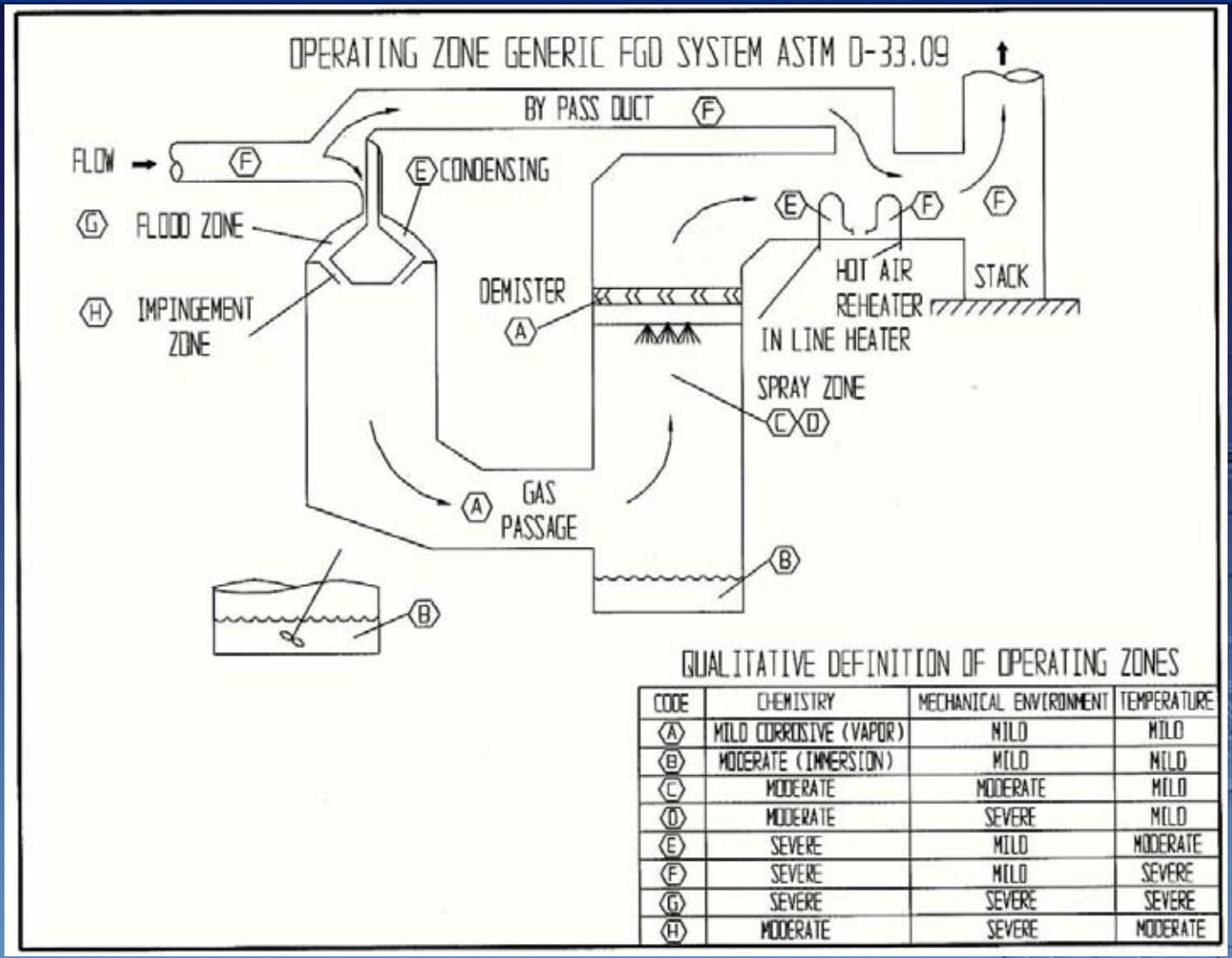
System Conditions



QUALITATIVE DEFINITION OF OPERATING 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	MODERATE
F	SEVERE	MILD	SEVERE
G	SEVERE	SEVERE	SEVERE
H	MODERATE	SEVERE	MODERATE

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Metals

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 25% Chromium Stainless Steels		SUPER AUSTENITIC STAINLESS STEEL 6% Molybdenum Stainless Steels		NICKEL ALLOY C276 ETC
SEVERE	pH 2.0	TYPE 317 LM STAINLESS STEEL			22% Cr DUPLEX STAINLESS STEEL					
VERY SEVERE	pH 1.0	TYPE 317 LMN STAINLESS STEEL		SUPER AUSTENITIC STAINLESS STEEL 6% Molybdenum Stainless Steels			NICKEL ALLOY 625 ETC			

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Metals (cont.)

Composition of Representative FGD Alloy Materials

Alloy Common Name	UNS Number	Nominal Composition, weight % Fe	Cr	Ni	Mo	Cu	N	Others
316L SS	S31603	Bal.	17	12	2.5	-	-	-
317L SS	S31703	Bal.	19	13	3.5	-	-	-
317LM SS	S31725	Bal.	19	16	4.5	-	-	-
317LMN SS	S31726	Bal.	19	16	4.5	-	0.15	-
317LN SS	S31753	Bal.	19	13	3.5	-	0.16	-
254 SMO	S31254	Bal.	20	18	6.3	0.8	0.2	-
2205 Duplex	S31803	Bal.	22	5.5	3.0	-	0.14	-
255 Duplex	S32550	Bal.	26	5.5	3.4	2.0	0.18	-
Zeron 100	S32760	Bal.	25	7	3.5	1.0	0.25	-
904L	N08904	Bal.	21	26	4.5	1.5	-	-
904hMo	N08925	Bal.	20	25	6.5	1.2	0.15	-
1925hMo	N08926	Bal.	21	25	6.4	0.9	0.22	-
AL-6X	N08366	Bal.	21	25	6.5	-	-	-
AL-6XN	N08367	Bal.	21	25	6.5	0.8	0.22	-
JS-700	N08700	Bal.	21	25	4.7	0.5	-	-
20	N08020	Bal.	20	35	2.5	3.5	-	0.5Cb + Ta
20 Mo-6	N08026	Bal.	24	35	5.9	3.0	-	-
825	N08825	Bal.	22	42	3.0	2.3	-	0.9Ti
G	N06007	20	22	Bal.	6.5	2.0	-	2.2Cb + Ta, 1.0W, 2.5Co
G-3	N06985	20	22	Bal.	7.0	2.0	-	0.5Cb + Ta, 1.5W, 5.0Co
H-9M	N06920	19	22	Bal.	9.0	-	-	2.0W, 5.0Co
Allcorr	N06110	-	31	Bal.	10.0	-	-	2.0W
625	N06625	5.0	22	Bal.	9.0	-	-	3.7Cb + Ta
C-276	N10276	5.5	15	Bal.	16.0	-	-	3.8W, 2.5Co
C-4	N06455	3.0	16	Bal.	16.0	-	-	0.7Ti, 2.0Co
C-22	N06022	3.0	22	Bal.	13.0	-	-	3.0W, 2.5Co
59	N06059	1.5	23	Bal.	16	-	-	-

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FRP

- FRP is an engineered material that is designed for each specific application.
- The fiberglass can be in the form of continuous filaments for winding, woven fiber mat, or chopped fiber mat.
- The resins used can be thermoplastics (melt with heat) or thermosets (harden with heat) with a wide range of chemical and physical properties.

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Resin Based Linings

- Most are based on the thermosetting (hardens with heat) polyester and vinyl ester resins.
- Recently some urethane based linings are being used.
- The resins have a much higher expansion coefficient than steel.
- Most of the resins aren’t very abrasion resistant.

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Resin Based Linings (cont.)

- Most of the resins are permeable to liquid
- Because of this, fillers are added to the resin to modify the expansion coefficient, reduce the permeability, and resist abrasion.
- For FGD service one of the most widely used filler materials is glass flakes.
- These linings are typically applied in multiple layers.

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Plastics

- PVC
- HDPE (High Density Polyethylene)
- Mist Eliminators
  - PVC
  - Polypropylene
  - Noryl
  - Ryton
  - Ultem
  - Polysulfone

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Rubber

- It is abrasion resistant which allows it to survive the pounding of erosive slurry particles.
- It can withstand pH and chloride values that would attack most of the metal alloys.
- Different types of rubbers have different flexibilities. (Durometer reading)
- All rubber must be vulcanized before it achieves it final physical properties.

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Rubber (cont.)

- All rubber is also permeable to gases and liquids.
- Unfortunately for FGD operators, the softer rubbers are the most permeable.
- Thus rubber selection is a compromise between Durometer reading and permeability to give the desired longevity of service in a particular application.

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Rubber (cont.)

- Some of the rubber failures that have occurred in FGD systems can be attributed to improper vulcanization of the rubber lining.
- Other failures have been attributed to improper surface preparation and application
- Other cases have been attributed to manufacturing problems of the rubber itself or to improper storage of the rubber before it was applied.

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Masonry

- Concrete is a porous material that can readily be penetrated by the soluble chloride ions.
- Sulfate attacks the concrete itself.
- A resin based lining properly installed over concrete can prevent this attack.

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Masonry (cont.)

- Stebbins Engineering offers a ceramic tile product that has been used extensively in the pulp and paper industry.
- It is finding use in the FGD market due to its chemical and abrasion resistance.
- The ceramic tile can be used as a lining in a vessel.
- The ceramic tile can be used as part of the erection of the vessel.

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Conclusion

- If the materials of construction are selected based on actual system conditions, the outcome will probably be successful.
- If the materials of construction are selected based on price or because it was used elsewhere, the chance for disaster is great.

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