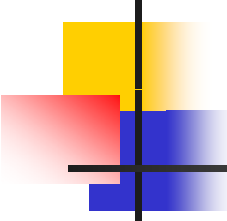


***Corrosion of various metals under
simulated WTE conditions;
and Sequestration of HCl in WTE
Combustion Chambers***

**WTERT Bi-Annual Meeting
New York, NY**

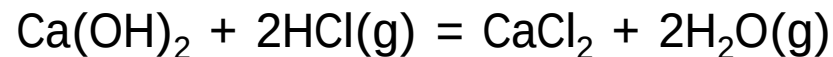
Shang-Hsiu Lee
Columbia University
10/16/2008





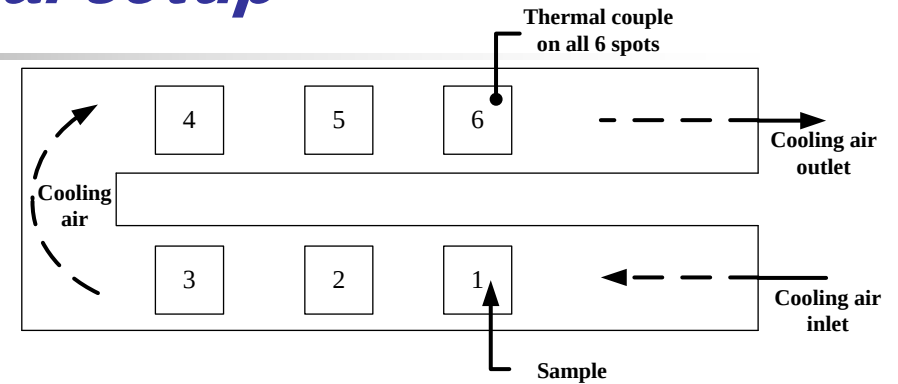
Research progress since last meeting

- In 2006 WTERT meeting
 - Corrosion survey results (distributed in 2005)
 - Chemical analysis of slag from WTEs
- Corrosion experiments
 - Verification of chlorine induced corrosion mechanism
 - Corrosion kinetics – 10, 25, 40, 80, and 100 hrs
 - Effect of various HCl gas concentrations on corrosion rates – 0, 500, 1000 ppm HCl
- HCl/Cl₂ sequestration tests
 - Injecting a slurry of calcium hydroxide into the combustion chamber that reacts with HCl to form calcium chloride

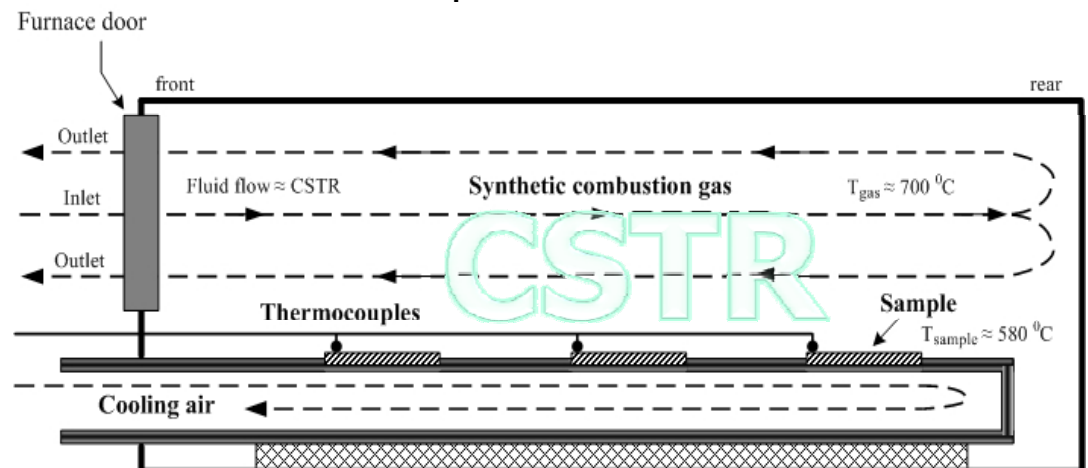


Corrosion experimental setup

- The thermal gradient between the gas and test metal surface
 - Condensation of vaporized species
- Composition of the synthesis gas
 - Simulating the flue gas composition of the WTEs



- 6 samples per test
- Sample dimensions: 1"x 1" x 0.04"

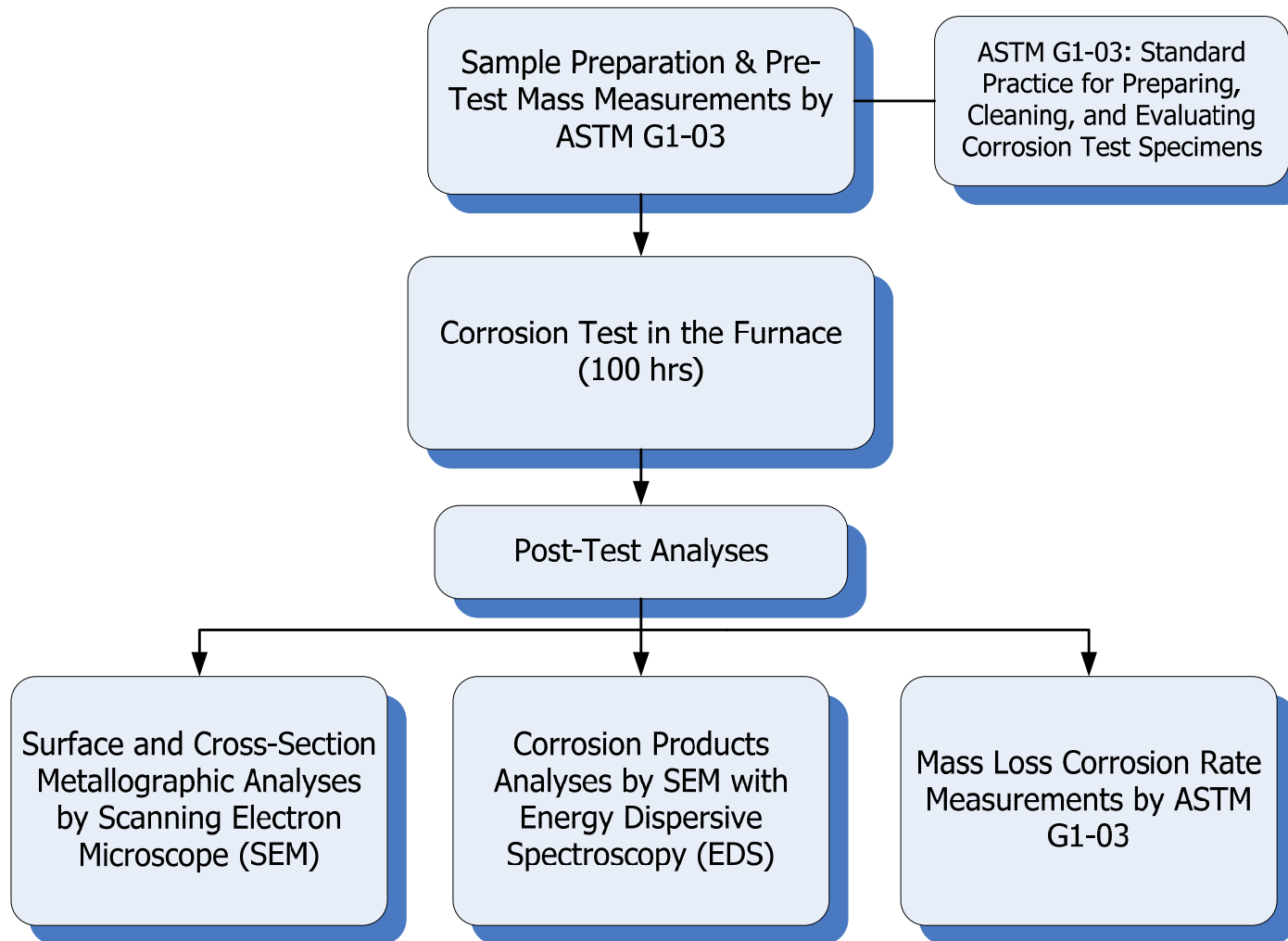


Corrosion experimental matrix

- Duration of each test: 100 hrs

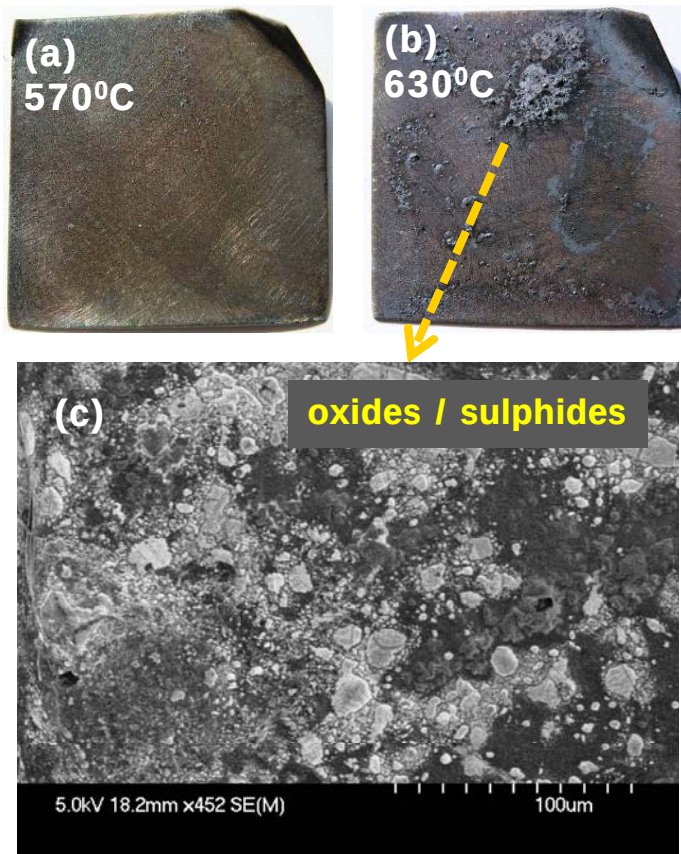
Test sample											Test environment (atmosphere)		
materials	major composition (wt. %)									metal temp.	composition	gas temp.	flow rate
	C	Si	Mn	P	S	Ni	Cr	Mo	Fe				
SA178A	0.07	0.06	0.47	0.01	0.004	0.054	0.016	0.01	>99	500°C ~630 °C (932°F~ 1166°F)	8% O ₂ , 12% CO ₂ , 15% Water Vapor, 0-1000ppm HCl, 100ppm SO ₂ , and bal. N ₂	750°C (1400 °F)	500 ml/min
SA213 T11	0.08	0.28	0.43	0.014	0.002	-	1.05	0.52	97.6				
NSSER-4	0.04	2.5	0.8	-	-	13.1	17.3	2.5	63.8				

Corrosion experimental procedures

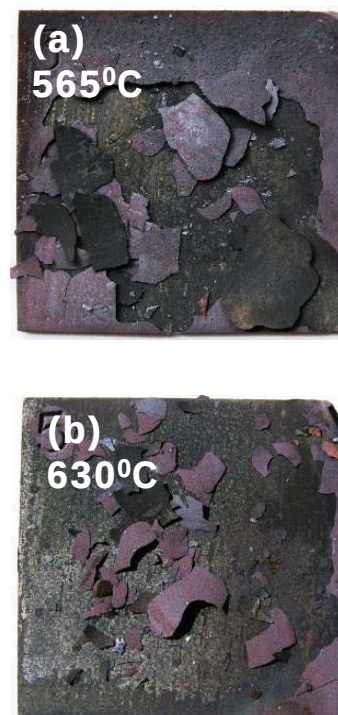


Surface morphologies of samples after 100 hr test

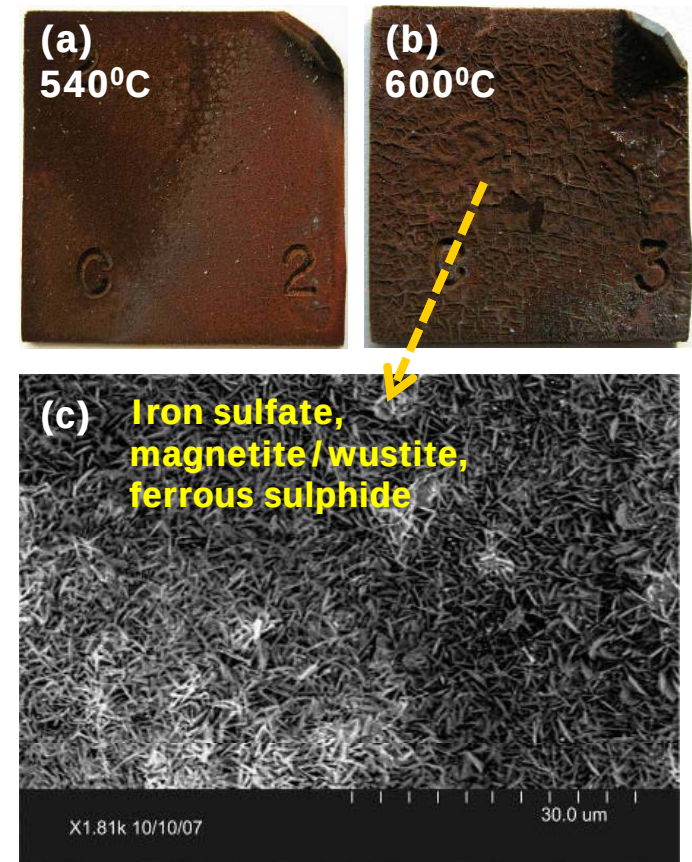
■ Alloy NSSER-4



■ Alloy SA213 T11



■ Alloy SA178A

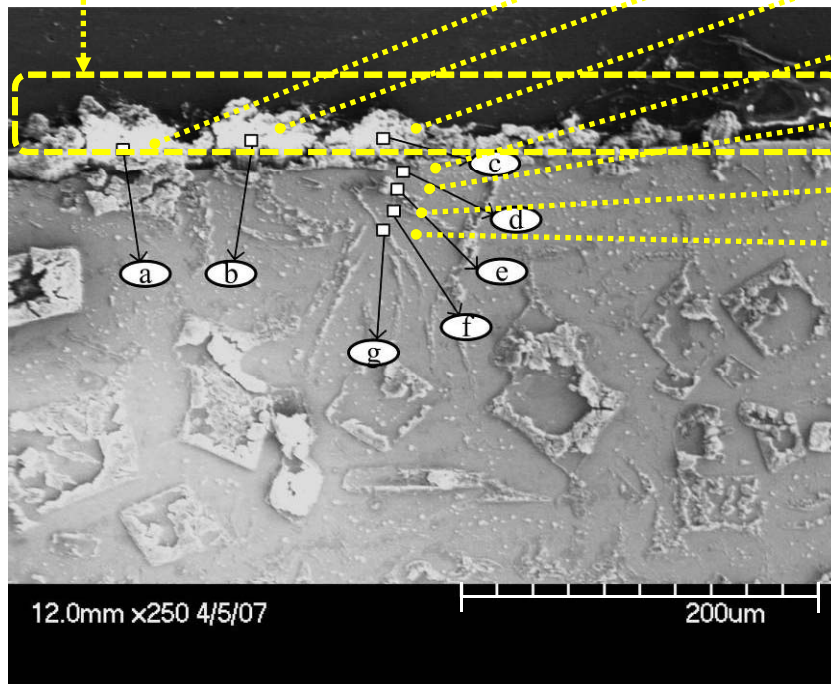


Verification of the corrosion mechanism

■ Alloy NSSER-4

- Cross sectional SEM image of sample and elementary analysis of each spot

original oxide scale



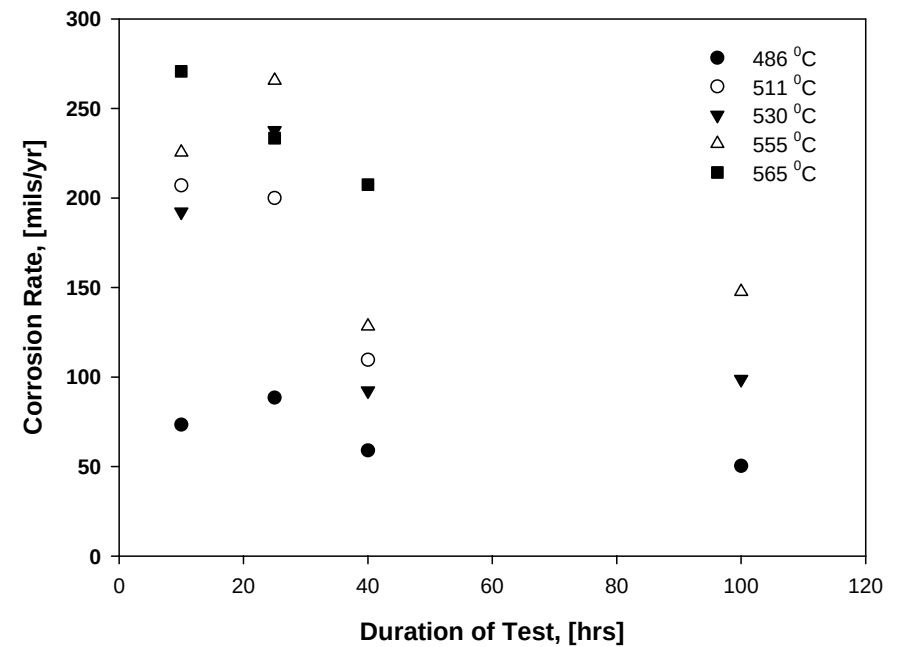
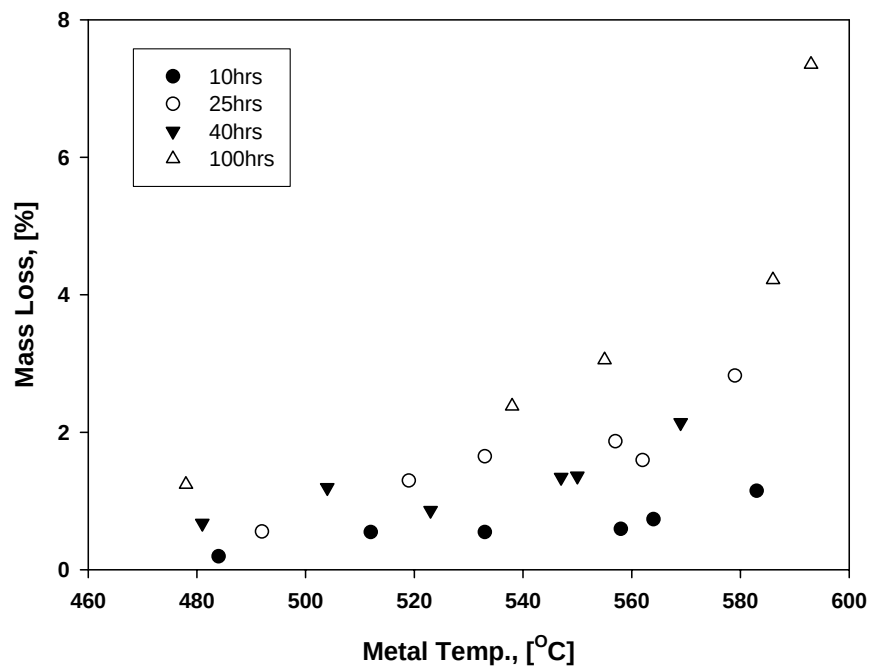
Composition wt. %

Spot	O	Si	Cl	Cr	Fe	Mn	Ni	P	S
a	8.85	0.01	39.53	2.28	46.99	0.00	1.4 ₈	0.35	0.52
b	0.00	0.00	39.38	2.94	50.09	0.00	2.1 ₉	0.49	0.67
c	0.24	0.27	41.75	3.47	52.24	0.00	1.1 ₁	0.29	0.64
d	0.00	2.38	3.16	20.48	70.79	0.00	1.3 ₆	0.36	1.47
e	0.00	2.14	1.70	18.51	74.52	0.00	1.0 ₈	0.46	1.59
f	0.00	2.32	1.06	18.97	74.36	0.11	1.2 ₁	0.54	1.44
g	0.00	2.39	1.84	19.12	71.43	0.00	0.0 ₇	0.34	1.55

- Higher concentration of Cl on the surface of the remaining sample (scale/metal interface)

Corrosion kinetics

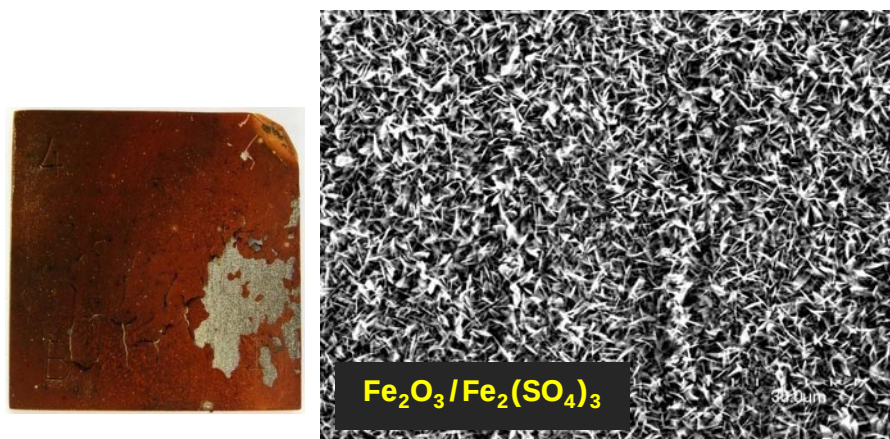
- Alloy SA178A
- Test duration: 10, 25, 40, and 100 hrs
- Gas temperature: 750 °C



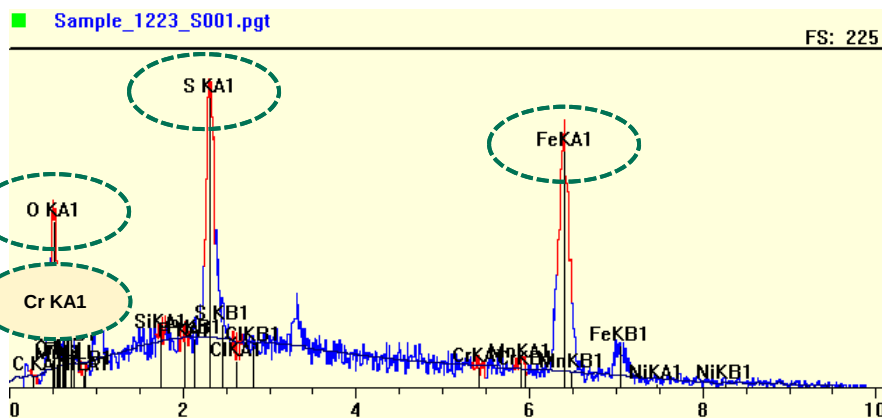
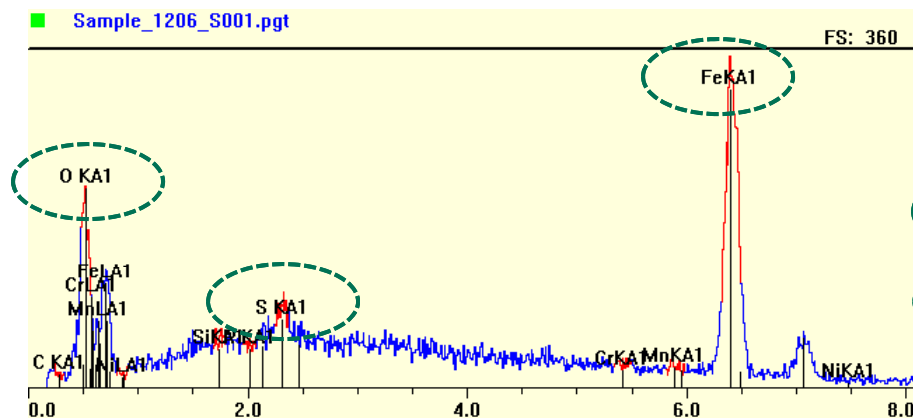
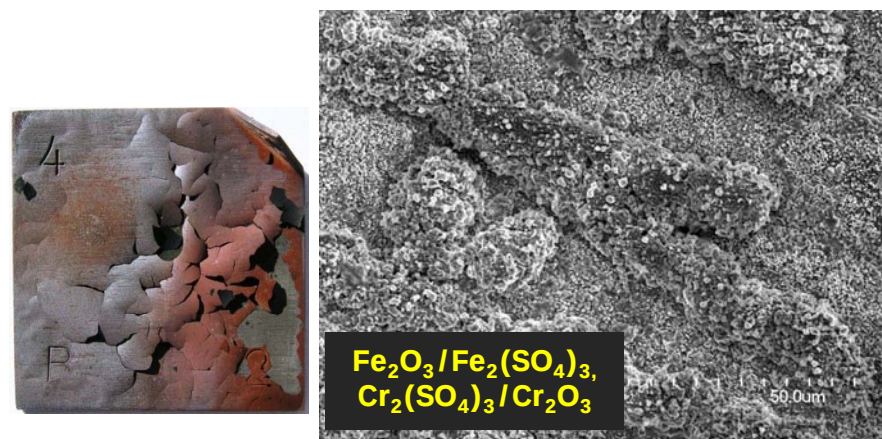
Effects of HCl gas concentrations on corrosion rates

■ Alloy SA213 T11

(a) 570°C, 100 hrs, non-HCl



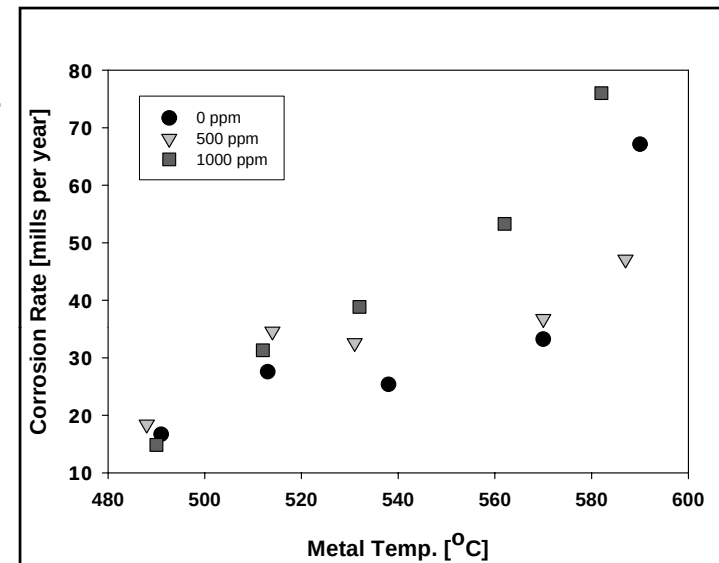
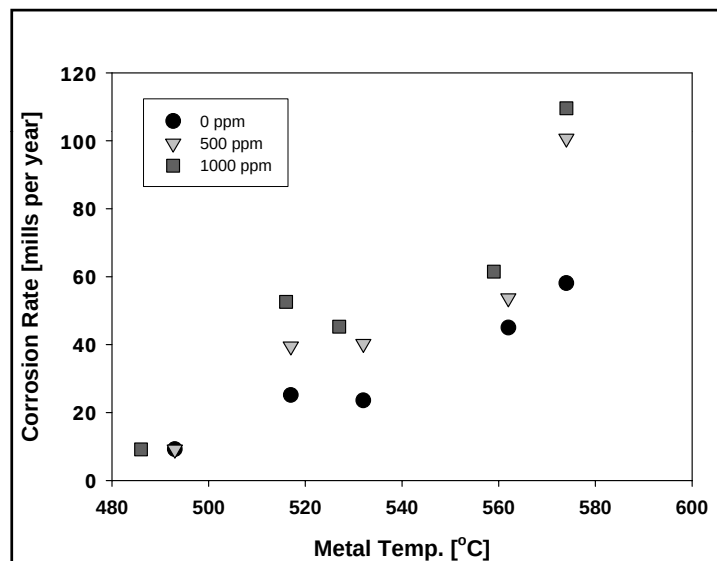
(b) 565°C, 100 hrs, 1000 ppm HCl



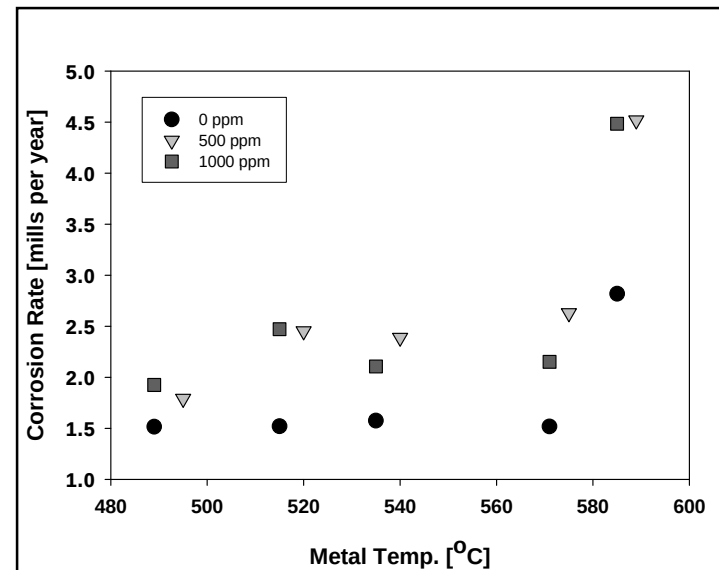
Effects of HCl gas concentrations on corrosion rates

■ Alloy SA213 T11

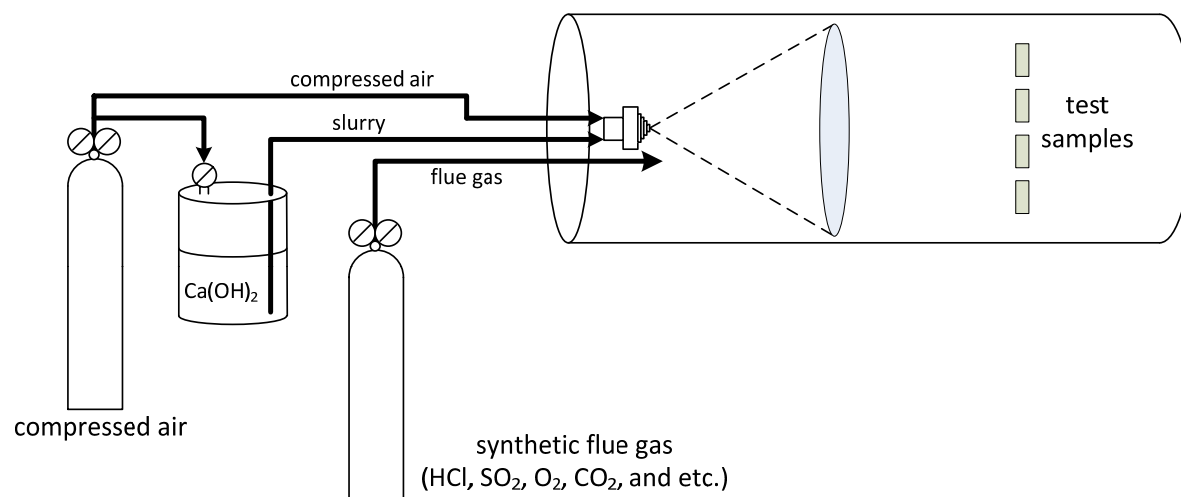
■ Alloy SA178A



■ NSSER-4

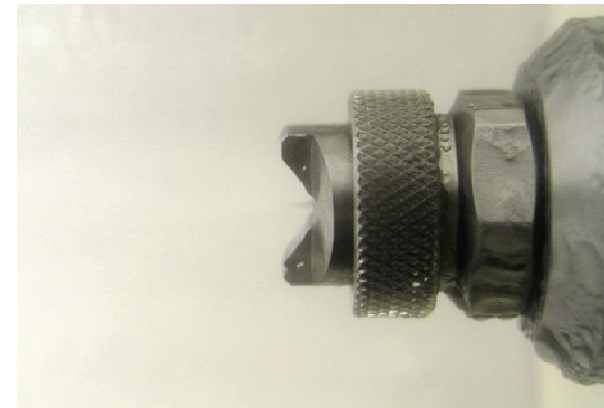
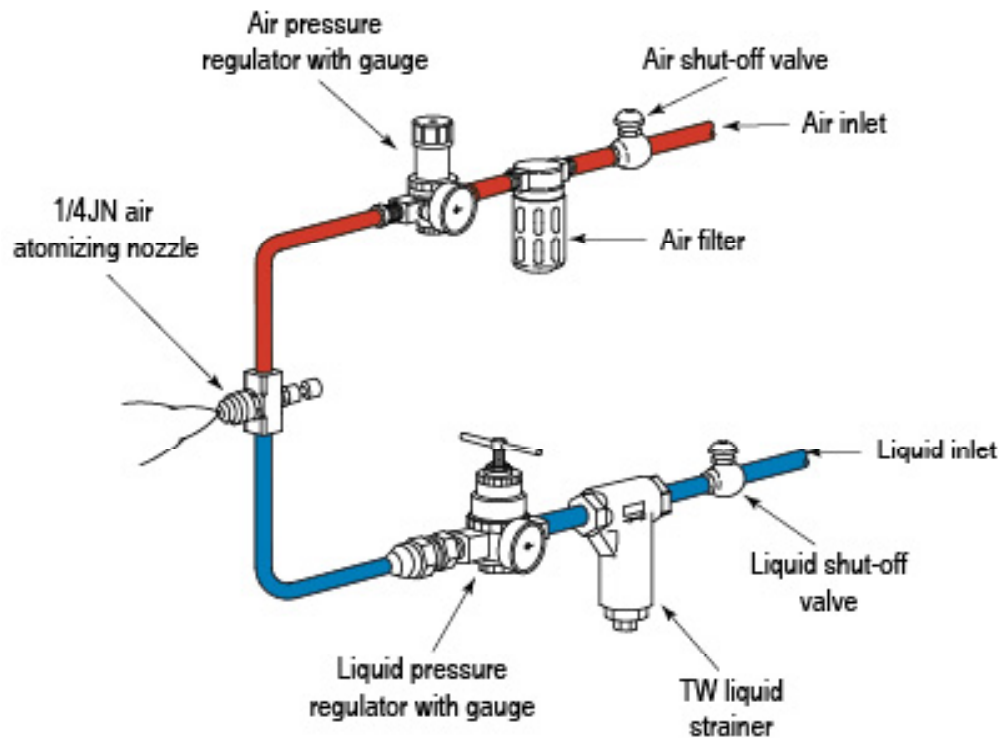


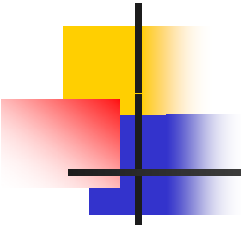
HCl/Cl₂ sequestration tests setup



HCl/Cl₂ sequestration tests setup

- Injection system – similar to the spray system of a SDA



A decorative graphic consisting of overlapping yellow, red, and blue squares with a black crosshair.

HCl/Cl₂ sequestration tests result

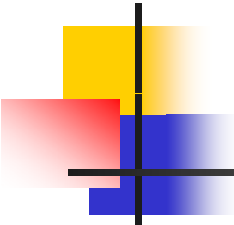
- Gas composition: 8% O₂, 12% CO₂, 10% Water Vapor, 1000 ppm HCl, 100 ppm SO₂, and bal. N₂
- Gas temperature: 750°C
- Metal temperature: 700°C

	SA178A	SA213 T11	NSSER-4
Baseline (no Ca(OH) ₂)	3058 (mpy)	3463 (mpy)	17 (mpy)
Ca(OH) ₂ : HCl = 2 : 1	2145 (mpy)	2824 (mpy)	12 (mpy)
Corrosion reduction	29.85%	18.46%	30.39%

Refinement of the sample carrier

- Sample carrier II – lower metal temperature and larger thermal gradient



A decorative graphic consisting of overlapping yellow, red, and blue squares with a black crosshair.

Acknowledgement

- This research has been supported by:
 - Waste-to-Energy Research and Technology Council (WTERT)
 - Integrated Waste Services Association (IWSA)
 - American Society of Mechanical Engineers (ASME)
 - Engineers of Covanta Energy Corporation