

# **Regenerating a Long-Life Zinc-Oxide Sorbent for Moving-Bed Reactors**

**Robert J. Copeland**

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**TDA Research Inc. • Wheat Ridge, CO 80033 • [www.tda.com](http://www.tda.com)**

# Introduction

- **Coal gasifiers coupled with combined cycle power plants (IGCCs) are potentially the lowest cost source of baseload electricity**
- **Coal contains sulfur that is converted to H<sub>2</sub>S in the gasifier**
- **The H<sub>2</sub>S must be removed before the gases are fed to the gas turbine**

# Hot-Gas Cleanup

- It is better to remove the H<sub>2</sub>S (as well as COS and CS<sub>2</sub>) at high temperatures than to suffer the cost and inefficiencies involved with cooling the gases and removing sulfur at near-ambient temperature

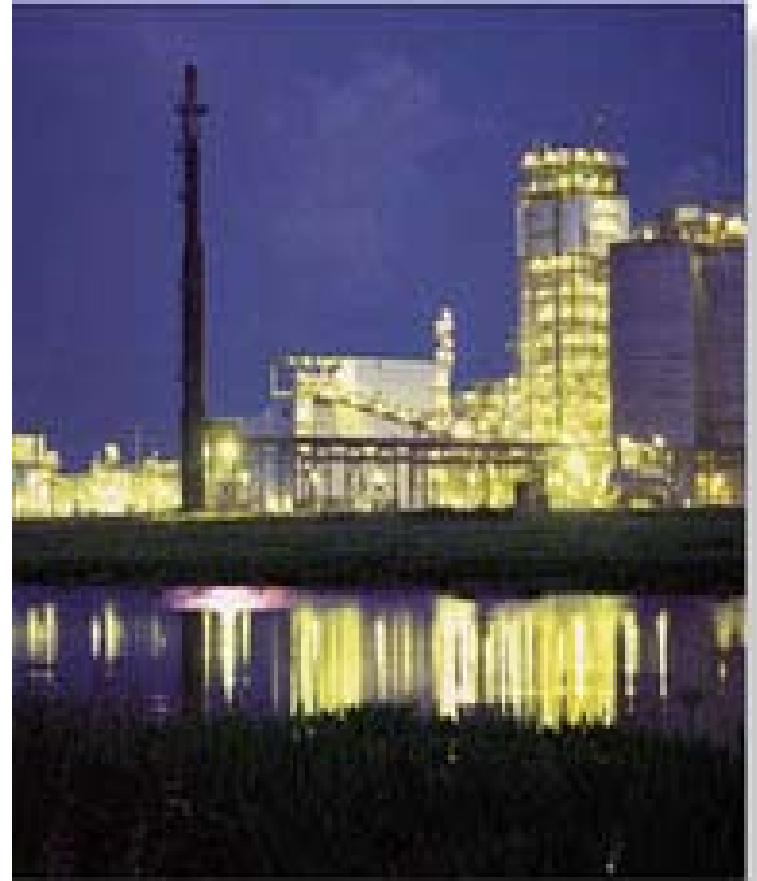
# Objective

- **Design a regenerable sorbent that removes H<sub>2</sub>S from hot reducing-gases**
- **Suitable for use in a moving-bed hot-gas cleanup system (for example, the G.E. Moving Bed System at the Tampa Electric Polk Power Station)**

# Polk County Plant

- **A state-of-the-art integrated coal gasification combined-cycle (IGCC) power plant, Tampa Electric's Polk Power Station produces enough electricity to serve 75,000 homes.**
- **250-megawatt IGCC facility is among the nation's cleanest, most efficient and most economical power generation units. The plant is a first-of-its-kind combination of two leading technologies.**
- **The first technology is called "coal gasification," which uses coal to create a clean-burning gas. The second technology is called "combined-cycle," which is the most efficient method of producing electricity commercially available today.**

**The plant combines coal with oxygen in the gasifier to produce the gaseous fuel. After processing, the clean coal gas is used in the combustion turbine to produce electricity.**



# The TNT- MB Sorbent

- **TDA and NORTON - Moving Bed**
- **Zinc Ferrite + Inert Binders**
- **Absorbs at 600°F - 900°F**
- **Regenerates at 700°F in 4% O<sub>2</sub>**
- **> 13 Lb (Sulfur) Per Ft<sup>3</sup> bed at design conditions**

# Previous Work On $\text{ZnFe}_2\text{O}_4$

- **GE Pilot Plant Run 2B > 1200°F Regeneration = *No Sulfate***
  - Cook et al. (1992) Twelfth Annual Gasification and Gas Stream Cleanup Systems Contractors Review Meeting
- **RTI: “Zinc Ferrite Sorbents Were Found to Be Limited to 550°C” (1022°F)**
  - Gangwal and Gupta (1991) Eleventh Annual Gasification and Gas Stream Cleanup Systems Contractors Review Meeting
- **RTI and SRI International: “Carbon Deposition Rate Exceeds the Rate of Removal by Steam, and Hence Carbon Is Likely to Accumulate on the Sorbent”**
  - Krishnan et al. (1991) *A Preliminary Study of Carbon Deposition on Zinc Ferrite Sorbents*, DOE/MC/25006-3057, contract AC21-88MC25006

# Sulfidation Conditions

## Simulated Texaco Gas Stream

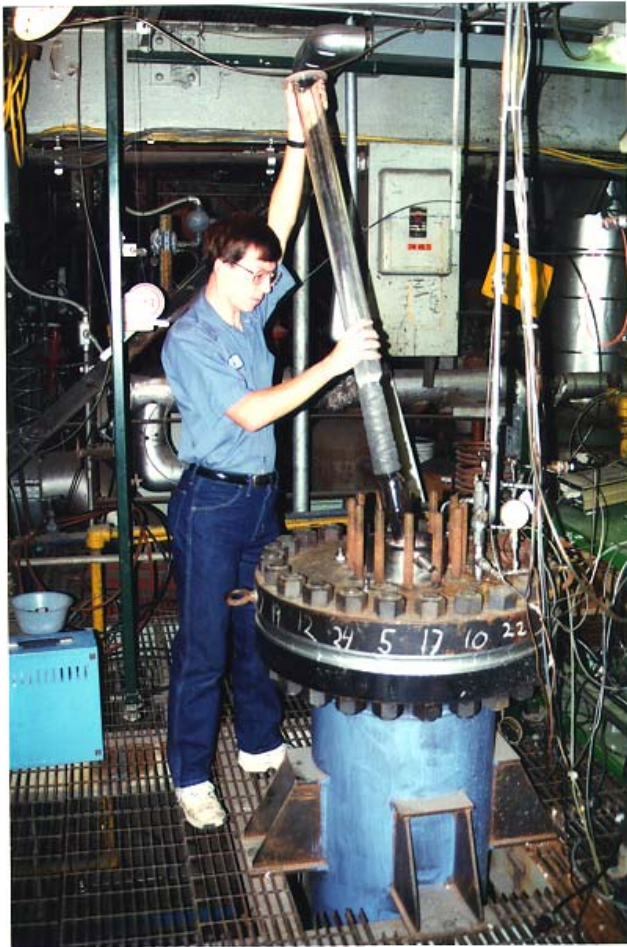
- **Carbon Monoxide** : **35.8 %**
- **Hydrogen** : **26.8 %**
- **Carbon Dioxide** : **12.2 %**
- **Hydrogen Sulfide** : **1.2 %**
- **Nitrogen** : **5.9 %**
- **Water** : **18.1 %**
- **Space Velocity** : **2000 hr<sup>-1</sup>**
- **Pressure** : **20 atm**

# Regeneration Conditions

- **Sulfur Dioxide** : **8%-10%**
- **Nitrogen** : **87%**
- **Oxygen** : **4.0%**
- **Space Velocity** : **2000 hr<sup>-1</sup>**
- **Pressure** : **7 atm**
- **Temperature** : **700-  
1300°F**

Oxygen turned off at breakthrough, makeup with Nitrogen.

# Photographs of IGT's Reactor

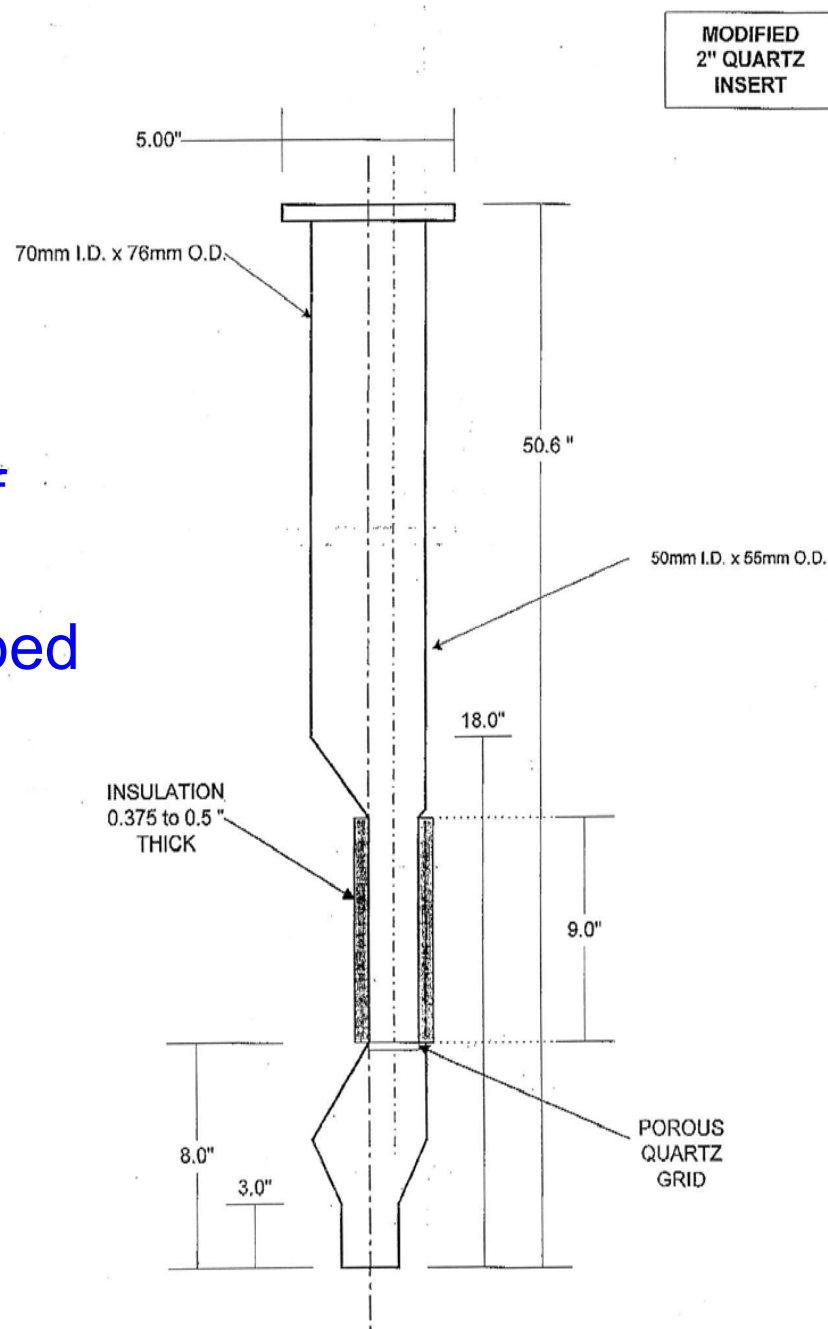


IGT

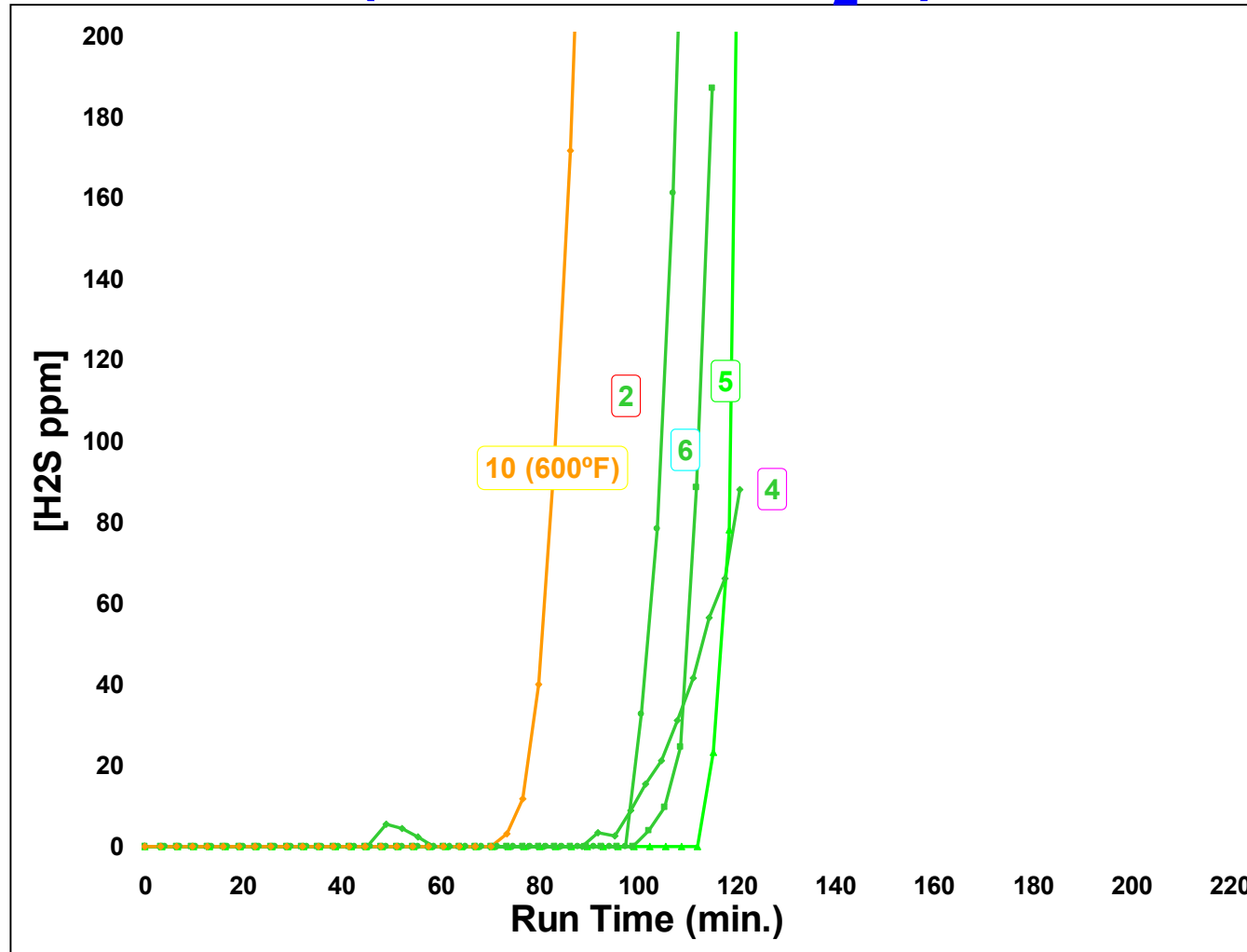
Reactor

Design:

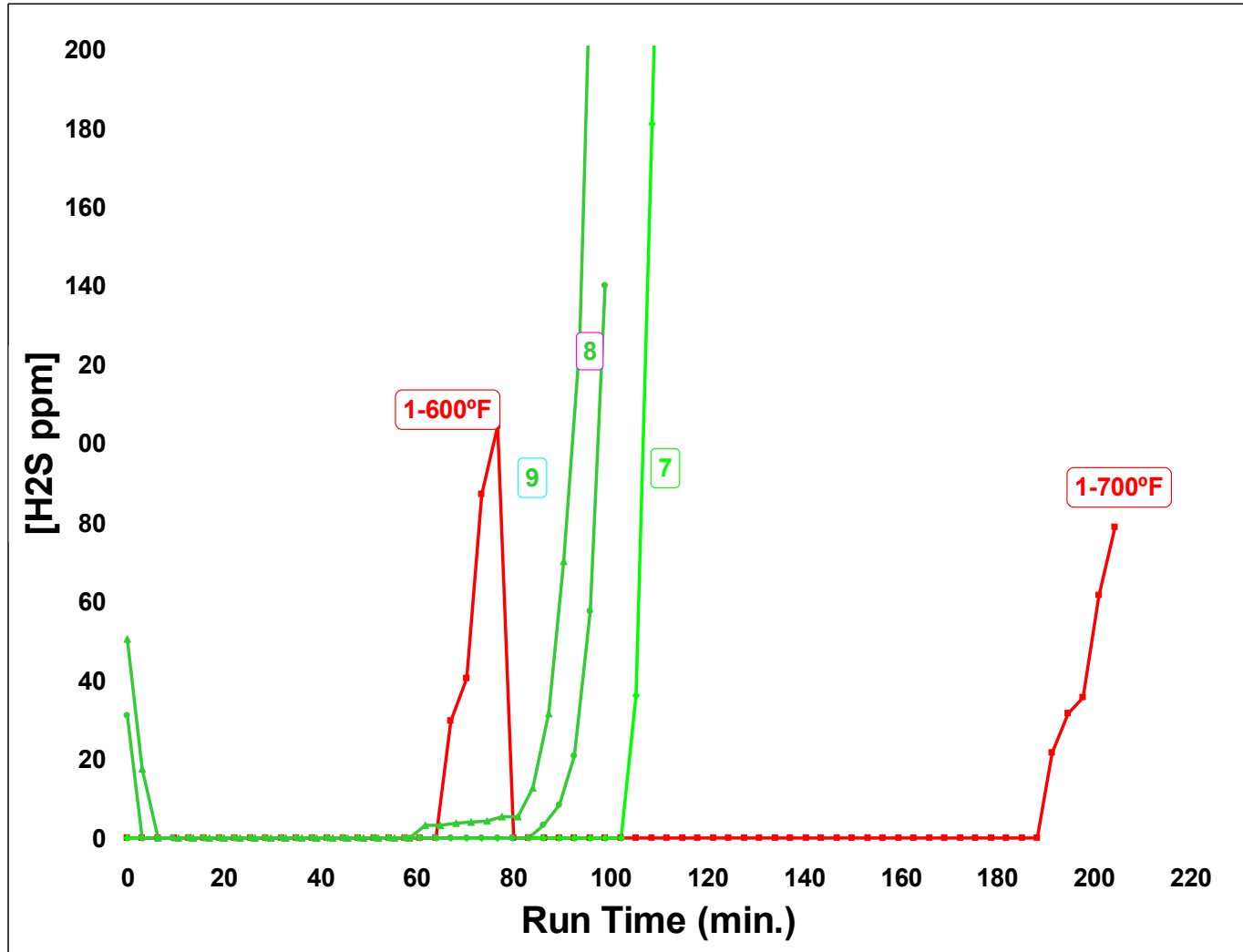
Upflow of  
gases  
through bed



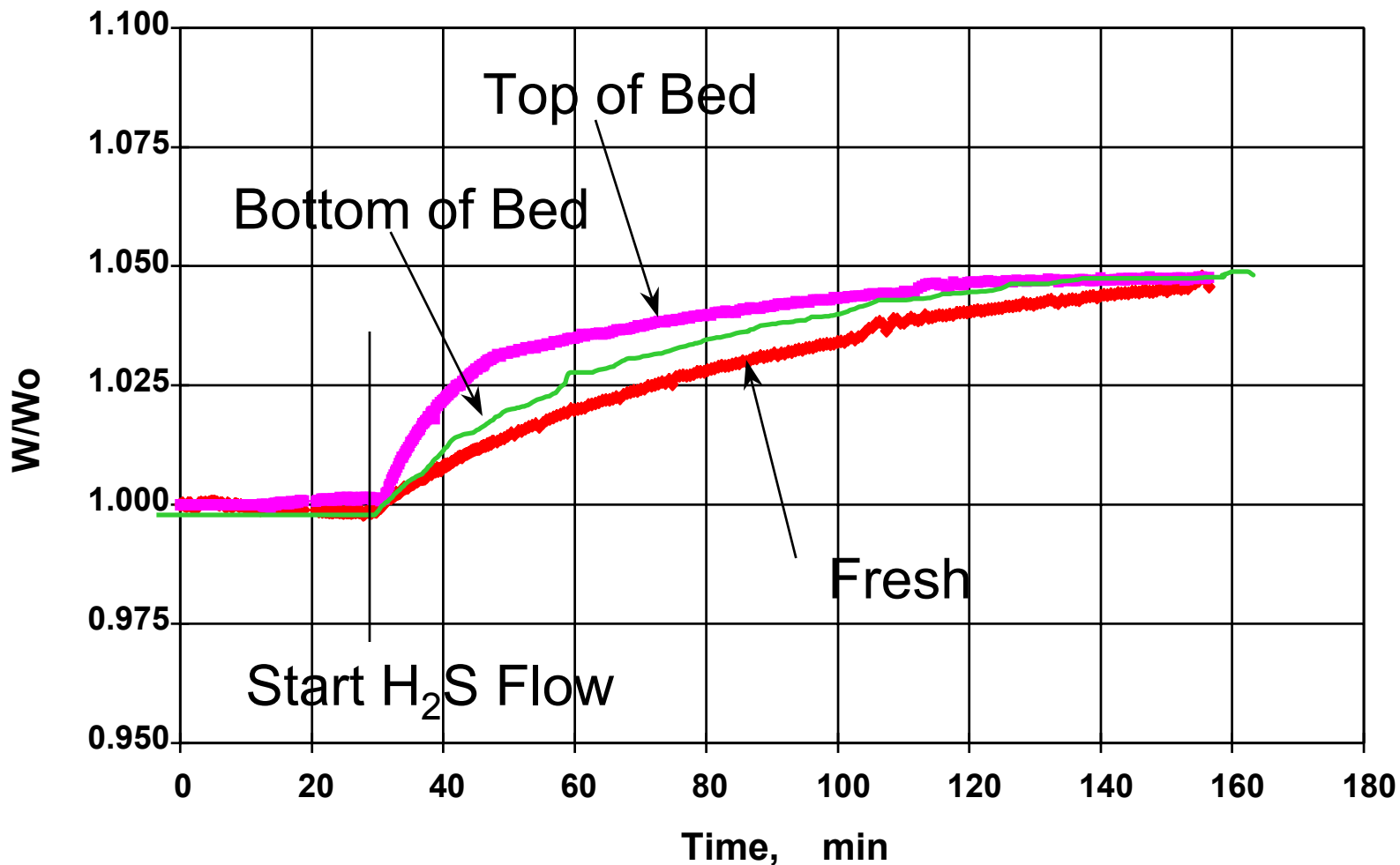
# Low Temperature Breakthroughs at 650°F at TDA (10.0-12.0% H<sub>2</sub>O)



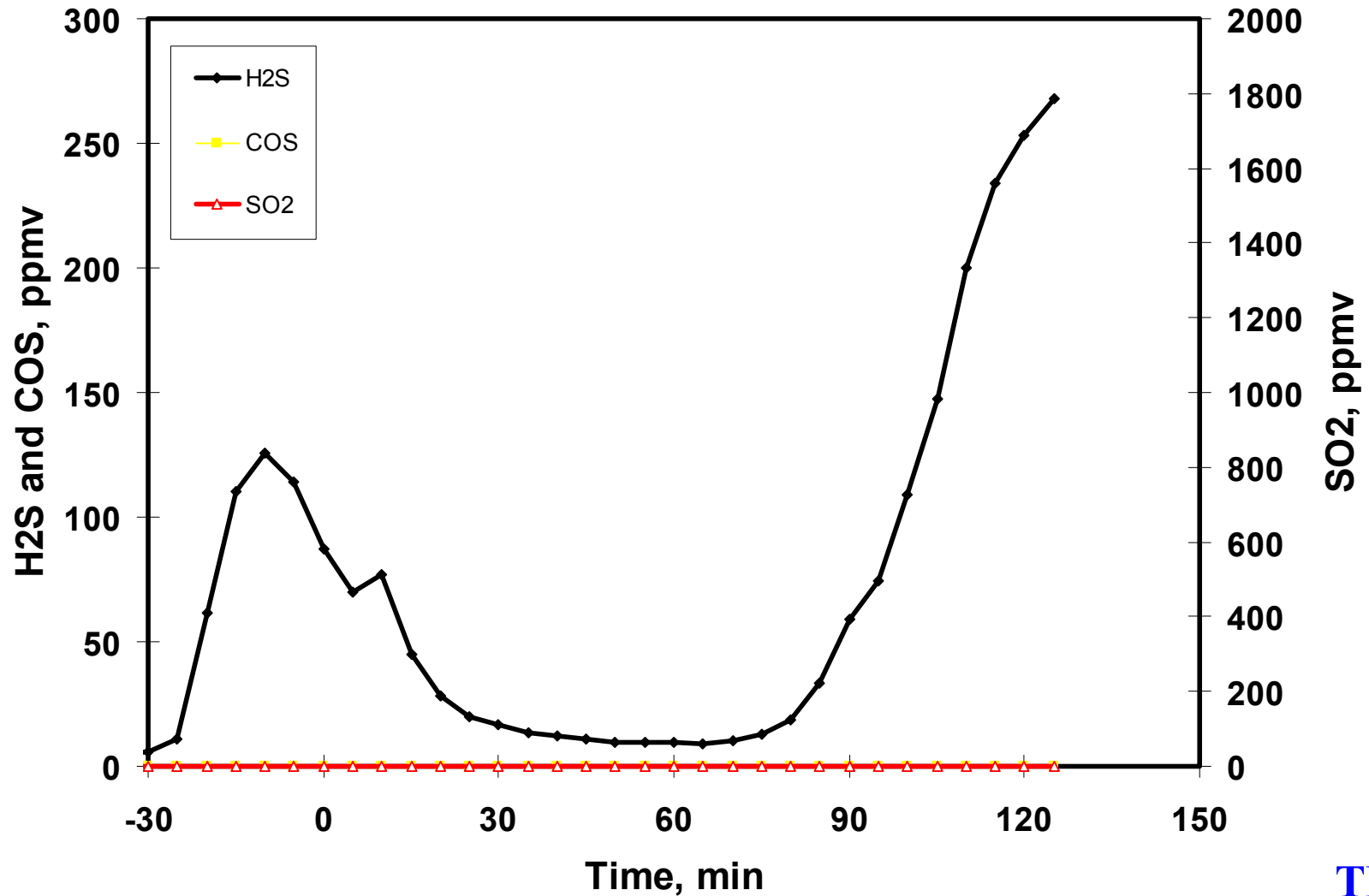
# Low Temperature Breakthroughs at 650°F at TDA (17.5-19.5% H<sub>2</sub>O)



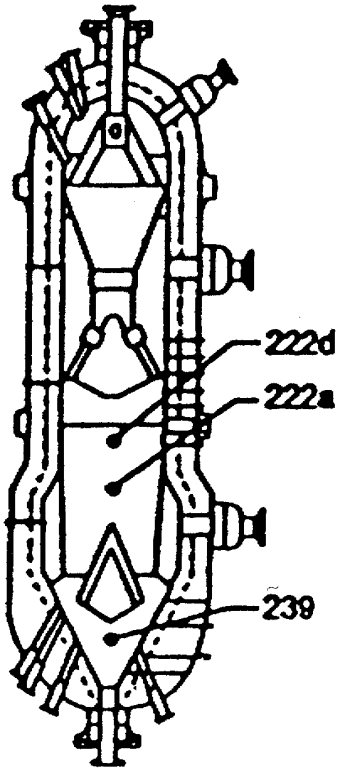
# Sorbent: TNT-MB (114) FRESH Top, & Bottom after 10 cycles



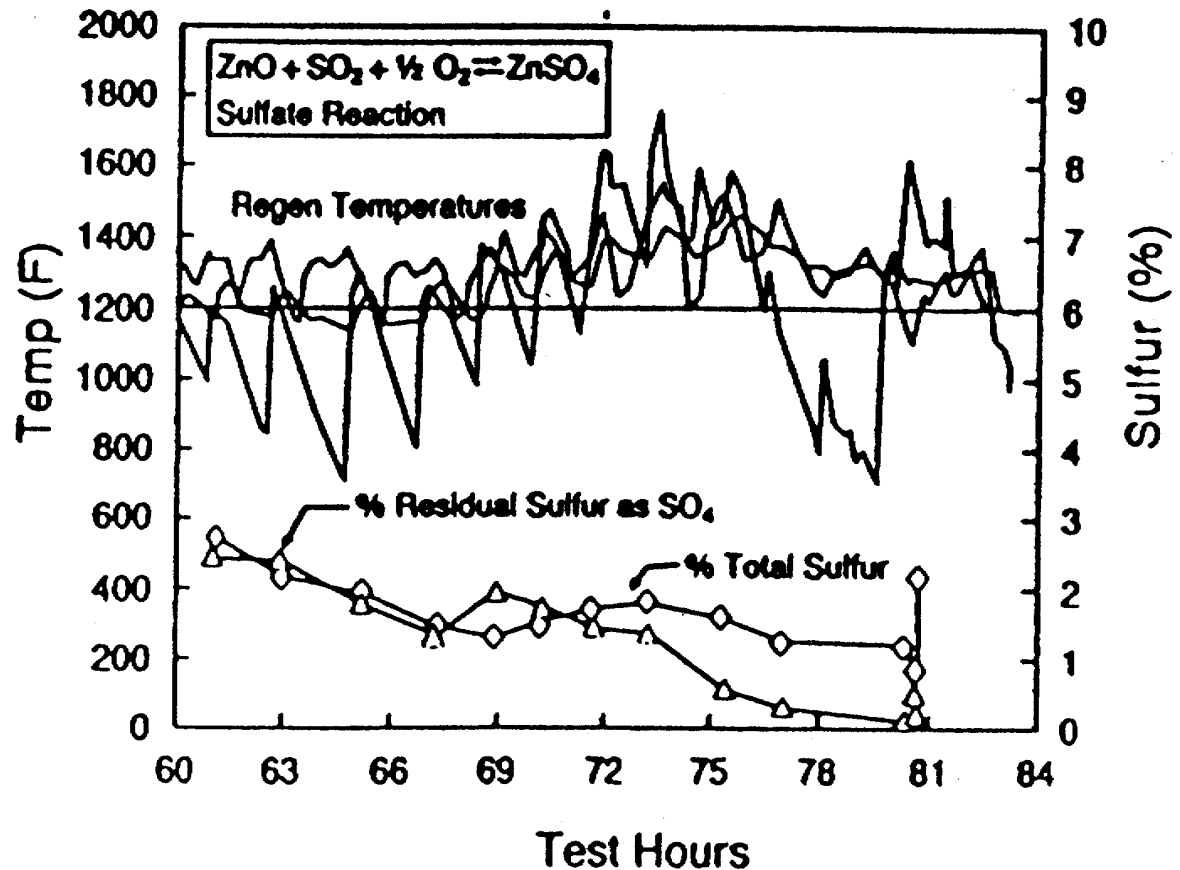
# 24<sup>th</sup> 900°F Sulfidation at IGT



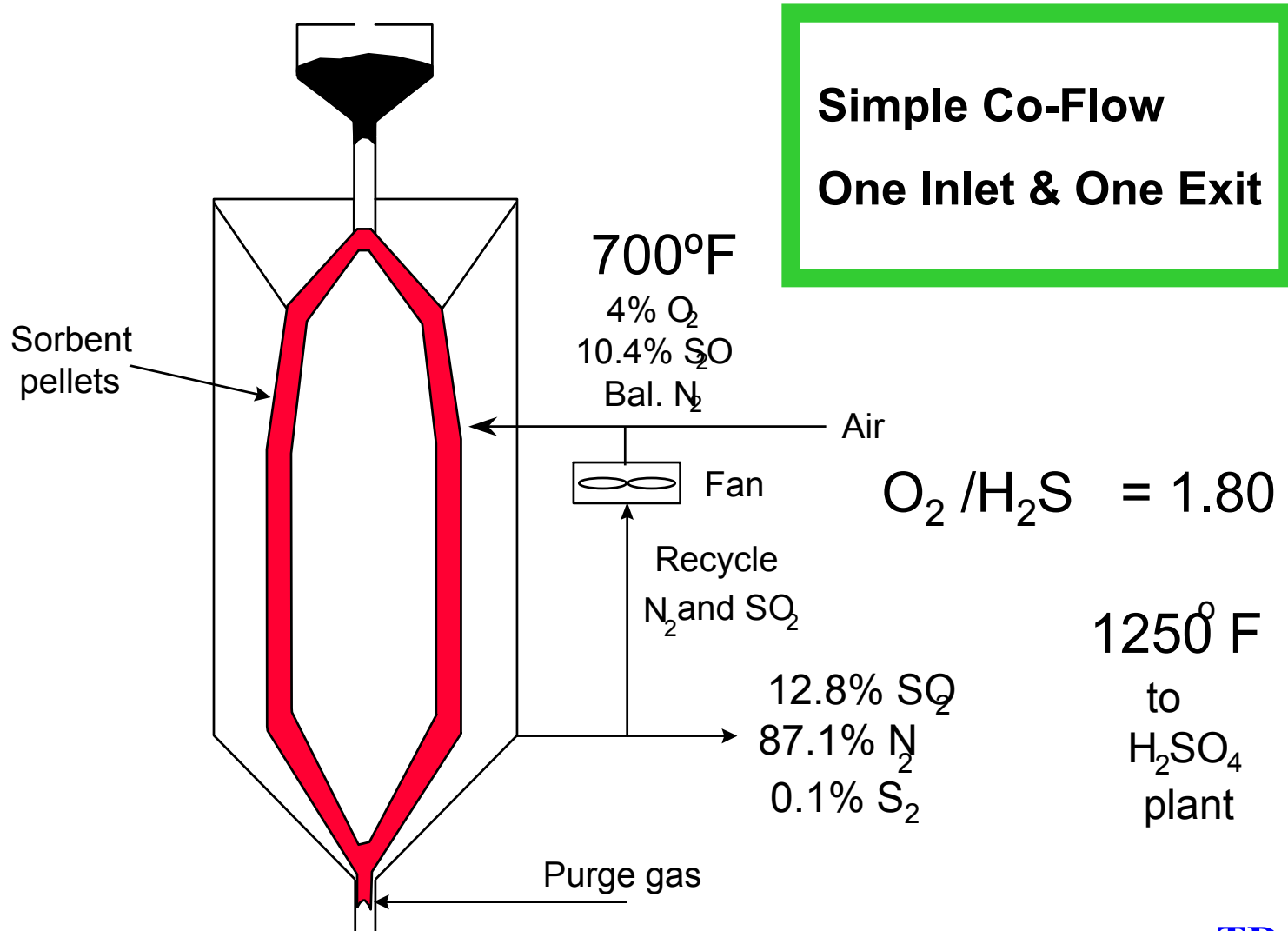
# GE HGCU Regenerator Performance Run 2B, Zinc Ferrite (Cook Et Al. 1992)



Run 2B  
Configuration

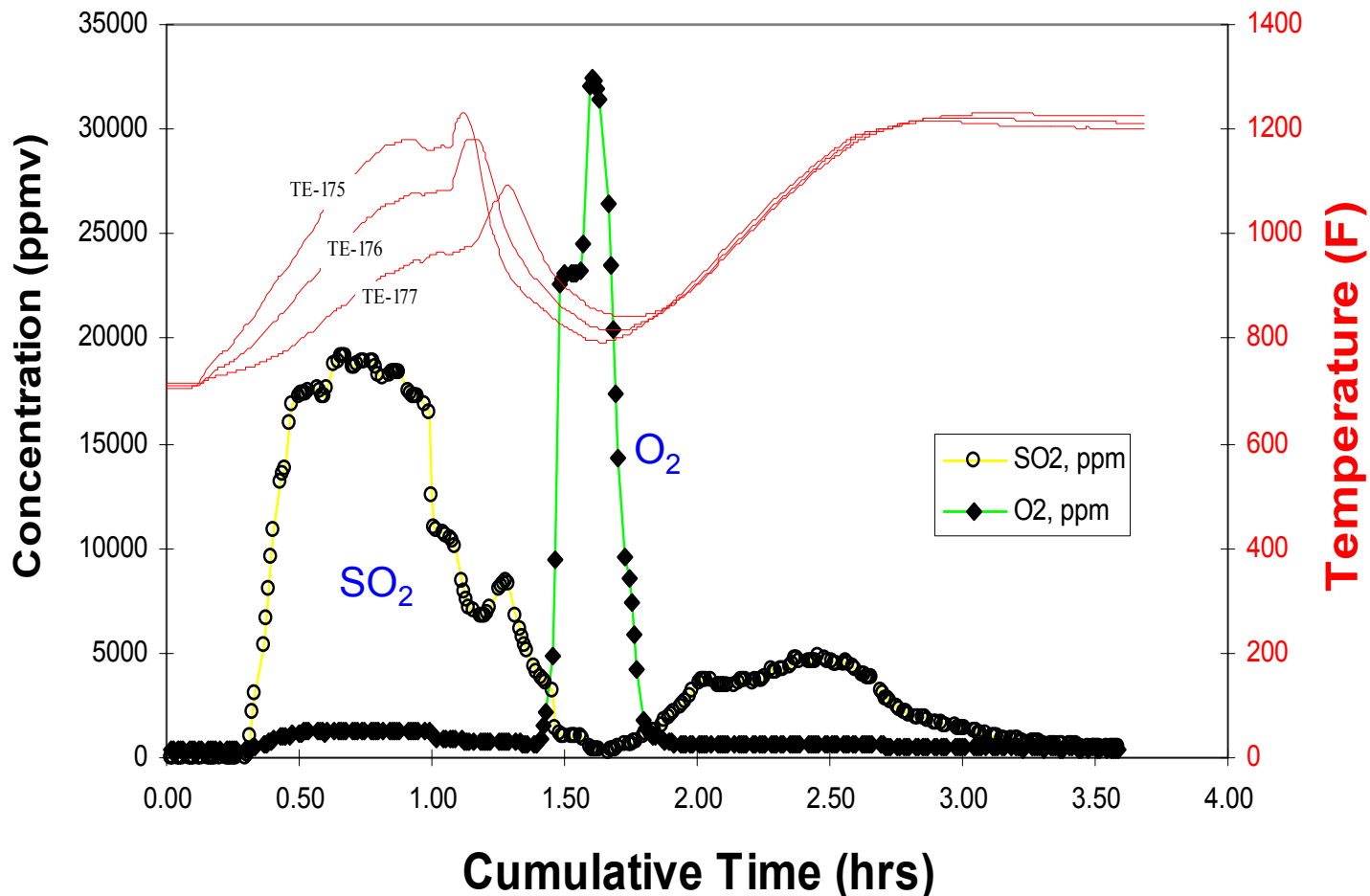


# Regeneration of TNT-MB

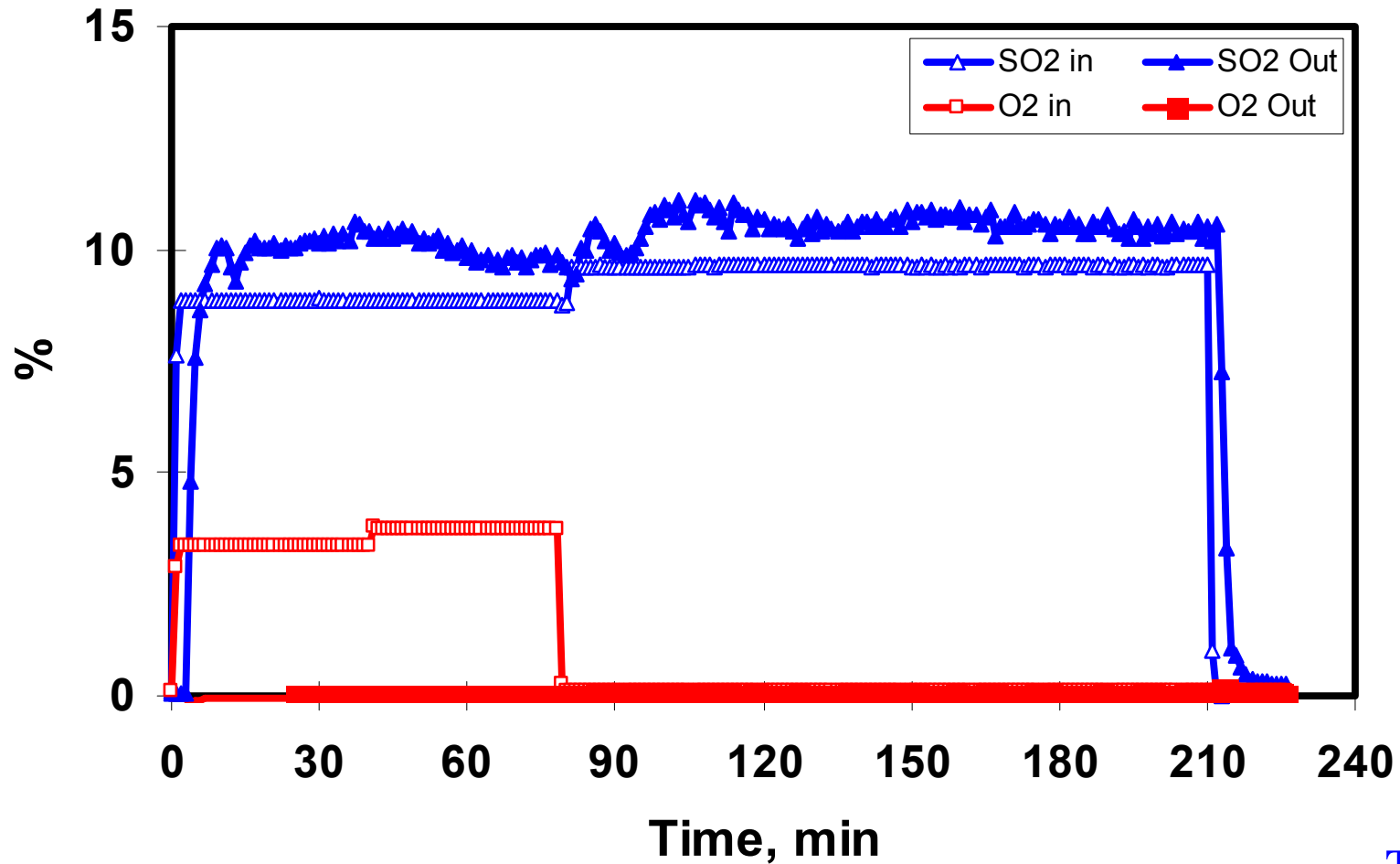


# Regeneration of TNT-MB "114" at 700°F (372°C), No Inlet SO<sub>2</sub>

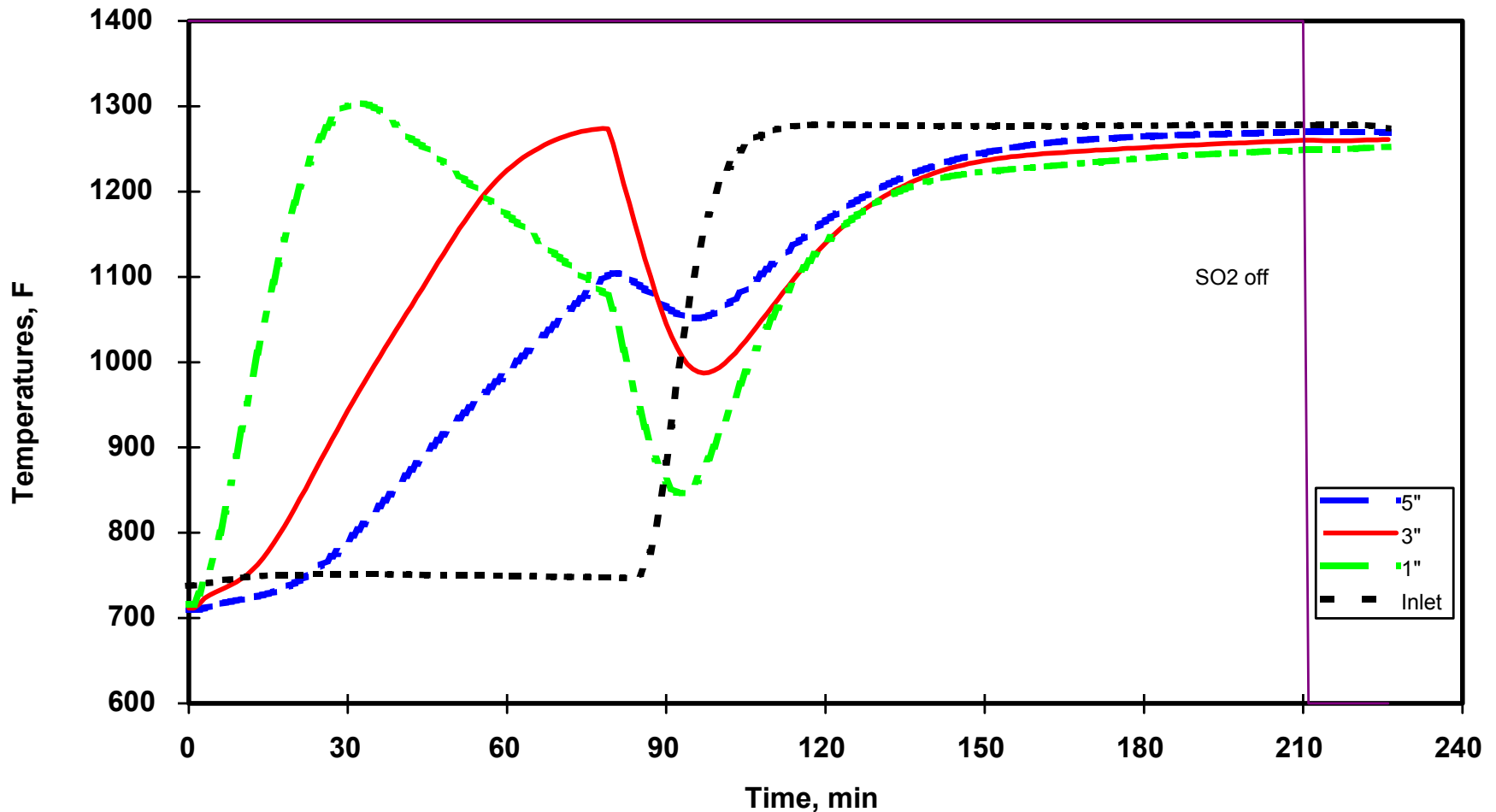
## HPHGD-60 Regeneration 5



# Regeneration at IGT 5 atm, Cycle No. 23 with 10% SO<sub>2</sub>



# 23th Regeneration at IGT Cycle No. 23 with 10% SO<sub>2</sub>



# Properties of Norton Produced TNT-MB Sorbent (298)

## 10-Cycle Low Temperature Testing at TDA

	Attrition wt%	Crush Strength lbs.	Surface Area m <sup>2</sup> /g	Porosity g/cc	Median Pore Diameter μm	Bulk Density lbs/ft <sup>2</sup>	Sulfur wt%	Carbon wt%
As Sintered (TDA)	2.22	31.3	2.55	.2395	.3084	1.35		
As Sintered (Norton)	1.90	31.0	2.76	.2420	.3290	na		
10A - Inlet	1.99	33.4	2.30	.2309	.3093	1.48		
10A-Outlet	1.99	29.9	3.63	.1643	.3544	1.44		
10R - Inlet	1.63	30.4	2.55	.2175	.3296	1.38		
10R - Outlet	1.50	33.3	2.53	.2262	.3184	1.38		

600°F - 700 °F Sulfidations at TDA, No SO<sub>2</sub> in Regenerations

\* **Limit of Detection**

# Sorbent Properties After 25 Cycles at IGT

	Attrition	Surface Area	Porosity	Sulfur	Sulfate sulfur	Carbon
	wt%	m <sup>2</sup> /g	cc/g	wt%	wt%	wt%
As Sintered (fresh) (max sulfur)	1.67	2.55	0.2395	0.46 (10.36)	0.27 (0.42)	0.02
25A - Inlet (bottom) (max sulfur)	3.06	3.73	0.1752	9.27 (9.81)	1.40 (1.20)	<0.01
25A-Outlet (Top) (max sulfur)	4.78	2.63	0.1990	7.19 (12.79)	1.35 (0.74)	<0.01
24R - Inlet (bottom)	7.14	4.40	0.1910	5.49	2.82	<0.01
24R - Outlet (top)	3.30	2.19	0.1966	7.59	1.99	<0.01

# Closure

- TNT-MB is a **NON-SPALLING** Zinc Ferrite Sorbent
- The Sorbent Retains Its Activity for Multiple Cycles
- The Sorbent has significant low temperature activity
  - 600°F (316°C) limited
  - 700°F (371°C) to 900°F (482°C)

# Acknowledgments

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  - Ron Staubly, Initial Project Manager
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  - Institute of Gas Technology
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