SULFUR PRODUCTION - NOTE SET

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BRIMSTONE STS, LTD.
Sulfur Symposium
Vail, Colorado USA
September 12-15, 2023

BRIMSTONE STS, LTD.
SULFUR RECOVERY SYMPOSIUM
CLAUS PROCESS NOTES

The following lined-pages highlight
some important Claus Process topics.

1. CHEMISTRY

$$H_2S + 3/2\ O_2 \rightarrow SO_2 + H_2O$$

$$2\ H_2S + SO_2 \rightarrow 3\ S + 2H_2O$$

Adding these equations gives:

$$H_2S + \tfrac{1}{2}\ O_2 \rightarrow S + H_2O$$

2. CLAUS CONFIGURATIONS

2.1 Furnace Arrangements

Straight-through ______________________________

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Split-flow ______________________________

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Preheat, Sulfur-recycle etc. ______________________________

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Superclaus ______________________________

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2.2 Non-furnace arrangements

Selectox ______________________________

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Clinsulf ______________________________

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2.3 Recovery Levels, 2 - 3 converter ____

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Refinery and Gas Processing applications contrasted ______________________________

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Oxygen enrichment: Temperature, pressure drop, WHB/condenser duties, affect on Tail Gas Clean-up Unit (TGCU) ____

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3. ENVIRONMENTAL REGULATIONS

Sulfur Recovery Emission Standards:

US (national and regional), NSPS, NESHAPS, BACT, MACT

Canadian and International

SO_x CO NMHC H_2S S NO_x RSH COS CS_2 Other sulfur compounds

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4. CLAUS DESIGN & COMPUTER SIMULATION

Typical Flowsheet ____

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Acid Gas H_2S/CO_2 ratio ____

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Tonnage ____

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Reheat schemes ____

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Turndown Required ____

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Steam generation levels: HP LP VLP BFW-preheat. Other heat removal methods - Hot Oil etc

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Tail Gas Composition ____

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Simulation Output ____

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5. OPERATING RELIABILITY & EFFICIENCY

Operating conditions - particularly temperatures ______________________________

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Feed impurities: hydrocarbons, NH_3, HCN, excessive water, trace sulfur (RSH etc), others

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Feed Gas analysis: acid gas, sour water stripper (SWS) gas ______________________

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Failure to meet required performance; plant testing ______________________________

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Turndown ____

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Supplemental fuel-gas firing; fuel gas quality ______________________________

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Start-up/Shutdown Procedures (include. TGCU), hot-relight ______________________

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Leak detection: WHB/condenser. Pits - cover, steam coils, eductor ______________

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Plugging/Fouling: Sulfur drains/seals, catalyst beds, piping, exchanger tubes, mesh pads, overall unit pressure drop ______________________________________

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6. REACTION FURNACE

Burner type & configuration ________________________________

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Residence time ______________________________________

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Refractory ____

Checker walls ____

Flame detection ____

Sight ports ____

Air purges ____

COS, CS_2 formation, actual/predicted ____________________________________

NH_3 destruction, temperature, burner type _________________________________

Affects of hydrocarbons in feed ____

Temperature measurement: thermocouple type, optical (IR), calibration ____________

7. OVERALL CLAUS PROCESS EQUIPMENT

Blower ______________________________

Furnace ______________________________

Burner ______________________________

Waste Heat Boiler ______________________________

Reheat Methods ______________________________

Converters ______________________________

Condensers ______________________________

Coalescers ______________________________

Incinerator/Thermal Oxidizer ______________________________

Catalytic Incineration ______________________________

8. CATALYST ISSUES

Types ____

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Sulfation ____

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Carbon Deposition ____

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Heat soak ____

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Start-up & shut-down ____

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Improving catalyst life and efficiency. Causes of Deactivation. ______________________________

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Bed Fires on Shutdown ____

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9. INSTRUMENTATION

Feed-forward ____

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Tail gas ratio-control (feed-back), dead-time. Trim air valve or adjust air/acid gas ratio ________

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Reaction Furnace ____

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10. SULFUR SPECIFICATIONS & PROPERTIES

Density, viscosity, various sulfur forms S_2 S_6 etc. ______________________________

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11. PRODUCED SULFUR HANDLING

Sulfur Seals ____

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Sulfur Pits ____

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Sulfur Pumps ____

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Sulfur Tanks ____

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Sulfur Degassing ____

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Sulfur Forming/Shipping ____

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12. OTHER ISSUES

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<u>SULFUR PRODUCTION - NOTE SET</u>

John Morgan, John M Campbell/Petroskills,
Elmo Nasato, P. Eng., Nasato Consulting, Assisting Editor

Brimstone STS, LTD
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2023

SULFUR PRODUCTION

A. Claus Process

The Claus process is the best-known and most widely-used sulfur production process in industry. It is a modification of a process first used in 1883. It is most applicable for production of sulfur from acid gas streams containing from about 20 to 100% H_2S.

The first step of the Claus process is the complete free-flame oxidation of 1/3 of the H_2S to SO_2 in a reaction furnace:

$$H_2S + 3/2\ O_2 \xrightarrow{\text{flame}} SO_2 + H_2O$$

The SO_2 and the remaining H_2S then undergo the Claus reaction in the reaction furnace and a series of catalytic reactors:

$$2\ H_2S + SO_2 \rightleftarrows 3S + 2\ H_2O$$

There are several variations of the Claus process with the two most common being the straight-through design and the split-flow design. The choice of the most suitable configuration depends on the composition of the feed gas, with the H_2S content of the acid gas being the most important variable. General guidelines are shown.

In the straight-through variation, the acid gas stream passes through the reaction furnace with the sufficient air to convert 1/3 of the H_2S fed to the furnace to SO_2. The primary requirement in the reaction furnace is to maintain a stable flame at a sufficiently high temperature to advance the reaction between H_2S and O_2. Gases leaving the furnace flow through the first pass of a waste heat boiler. In hot gas bypass reheat schemes, part of the gas enters the second pass of the boiler for further cooling. The hot gas which bypassed the second pass of the boiler is mixed with the reactor feed streams for reheat. The hot gas bypass reheat scheme is the most economical. However, it has important turndown limitations.

Sulfur produced in each stage is condensed and removed from the process. Tail gas from the last condenser pass is treated in a tail gas treating unit to remove residual sulfur compounds.

Among the advantage of the Claus process are:

- Well proven technology
- Can produce bright sulfur
- Can be designed to convert COS and destroy and NH_3 and HCN
- Relatively low operating costs due to credit for net steam production

The disadvantages of the Claus process include:

- Requires an acid gas feed stream relatively rich in H_2S (usually more than 15%) although significantly leaner feed can be handled
- Maximum recovery is about 97% on Claus which often therefore requires a subsequent tail gas cleanup unit

Heavier Hydrocarbons in the Feed

A better understanding of reaction furnace burner design and reaction furnace chemistry has allowed the successful treatment of acid gases containing progressively higher amounts of heavy hydrocarbons and other contaminants such as ammonia. So called “high intensity burners” permit the successful destruction of up to at least C_4 components in a straight-through reaction furnace.

Oxygen Enrichment

Oxygen enrichment of the air to the Claus Sulfur Process has been practiced in Europe, North America and elsewhere. There technology is particularly advantageous in increasing the capacity of existing Claus sulfur recovery units. A number of process licensors offer this technology. Oxygen is used over a wide range of plants from the mid-20’s air-enrichment, all the way to a few plants that use 100% oxygen.

B. SELECTOX

The traditional Claus sulfur plant has a fired reaction furnace as the first item of equipment. However, for very dilute acid gas streams (less than 10% H_2S, the balance CO_2) this reaction furnace does not operate stably even with acid gas and air preheat. There have been problems with the earlier all-catalytic processes to react H_2S with air to form sulfur. However, in the last few years, the Selectox process has been successfully operated as an all-catalytic process to convert the H_2S in relatively dilute acid gas streams into sulfur.

The Selectox process was developed by Union Oil Company of California, Ralph M. Parsons Company and Perry/Goar Sulfur Systems. It is intended for those acid gas streams that are to lean in H_2S to feed to a conventional Claus unit.

The Selectox catalyst selectively oxidizes H_2S to sulfur with air at low temperature without forming SO_3 or oxidizing significant amounts of hydrogen or light hydrocarbons. This process is entirely catalytic, there is no high-temperature combustion as in the Claus process.

When supplied with the proper amount of air, the oxidation of 1/3 of the H_2S to SO_2 and the reaction of SO_2 with the remaining two-thirds of H_2S occur simultaneously in the presence of the Selectox catalyst to form elemental sulfur.

$$H_2S + 3/2\ O_2 = SO_2 + H_2O$$

$$2\ H_2S + SO_2 = 3\ S + 2\ H_2O$$

The effective overall reaction (the same as for Claus) is therefore:

$$3\ H_2S + 3/2\ O_2 = 3\ H_2O + 3\ S$$

One variation of the Selectox process is used when the acid gas feed is below approximately 5% volume H_2S. The exothermic reaction with 5% H_2S gas results in a reasonable maximum reactor outlet temperature at about 700°F. After the Selectox reactor, the gas is cooled and sulfur is condensed.

When the gas feed contains more than 5% volume H_2S, some of the cooled lean gas from the sulfur condenser is reheated and recycled to the Selectox reactor inlet to maintain approximately 5% H_2S at the reactor inlet. This variation of the process is called Recycle Selectox.

In either process, gas from the sulfur condenser may been passed through one or two Claus stages, each with a re-heater, converter and sulfur condenser. The system for the Selectox and the Claus reactors is the same: heating gas to the desired inlet temperature, reaction in a converter, and cooling the gas and condensing sulfur in a condenser.

Sulfur recoveries are in the range of 90%. The first industrial plant using Selectox catalyst has been operating since 1978 and the first Recycle Selectox unit has been operating since December, 1981.

The Selectox process has the following advantages:

- Can process acid gas streams that are lean in H_2S ($\leq$ 5%).
- Produces high quality bright sulfur

The primary disadvantages of the Selectox process are:

- Inability to convert COS, present in the feed, to sulfur
- Inability to destroy and NH_3 and HCN upstream of the catalytic reactors
- Tail gas treating is needed to achieve 99+% sulfur recovery

Overall Claus Reaction

$$H_2S + 3/2\ O_2 \rightarrow H_2O + SO_2 \qquad (1)$$

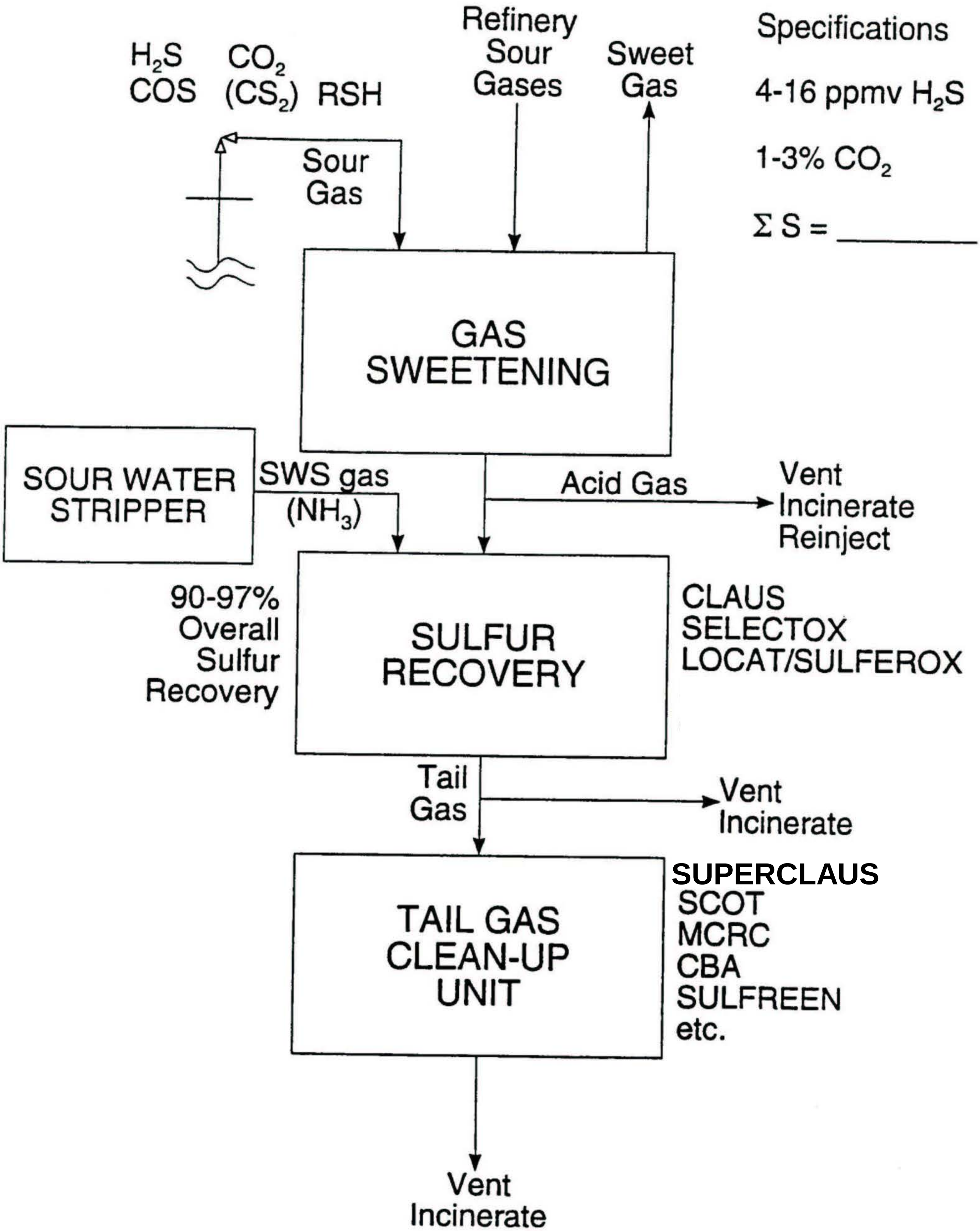
$$2\ H_2S + SO_2 \rightarrow 3\ S + 2\ H_2O \qquad (2)$$

Adding reactions 1 and 2 and cancelling gives:

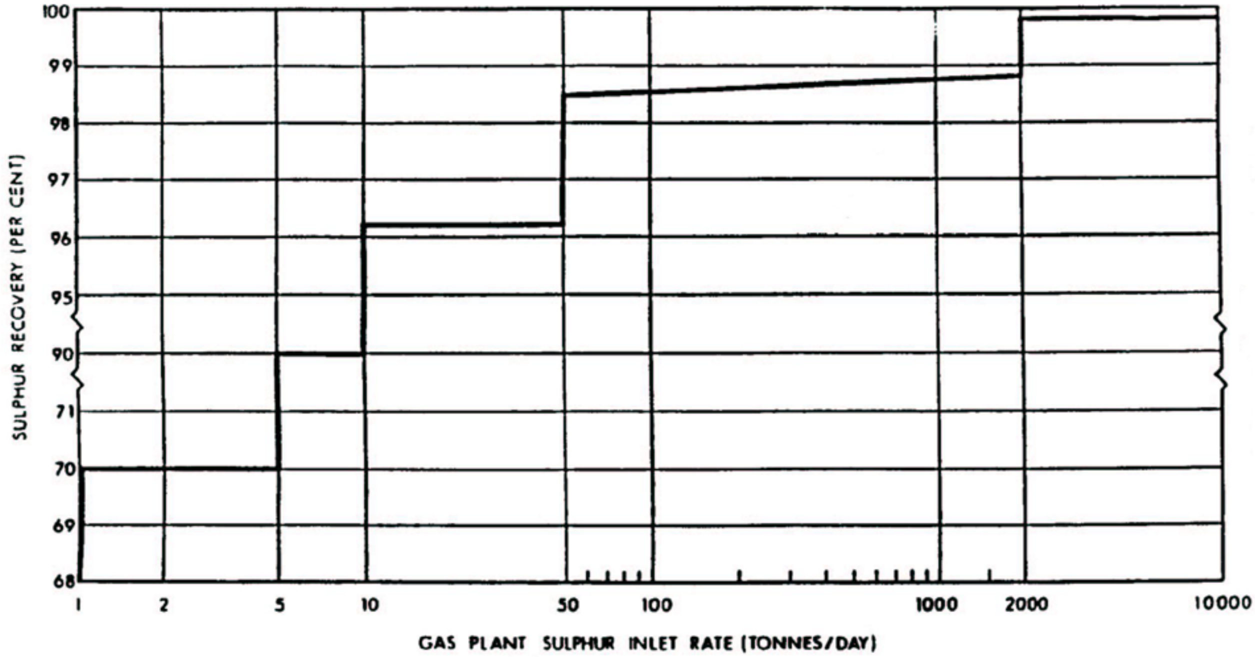
$$H_2S + \frac{1}{2}\ O_2 \rightarrow H_2O + S \qquad (3)$$

CLAUS PLANT CONFIGURATIONS

Feed H_2S Concentration, Mol %	Claus Variation Suggested
55 - 100	Straight-through
30 - 55	Straight-through or straight-through with acid gas and/or air preheat
15 - 30	Split-flow or straight-through with feed and/or air preheat
10 - 15	Split-flow with acid gas and/or air preheat
5 - 10	Split-flow with fuel added or with acid gas and air preheat, or direct oxidation or sulfur recycle
< 5	Sulfur recycle or variations of direct oxidation or other sulfur recovery processes

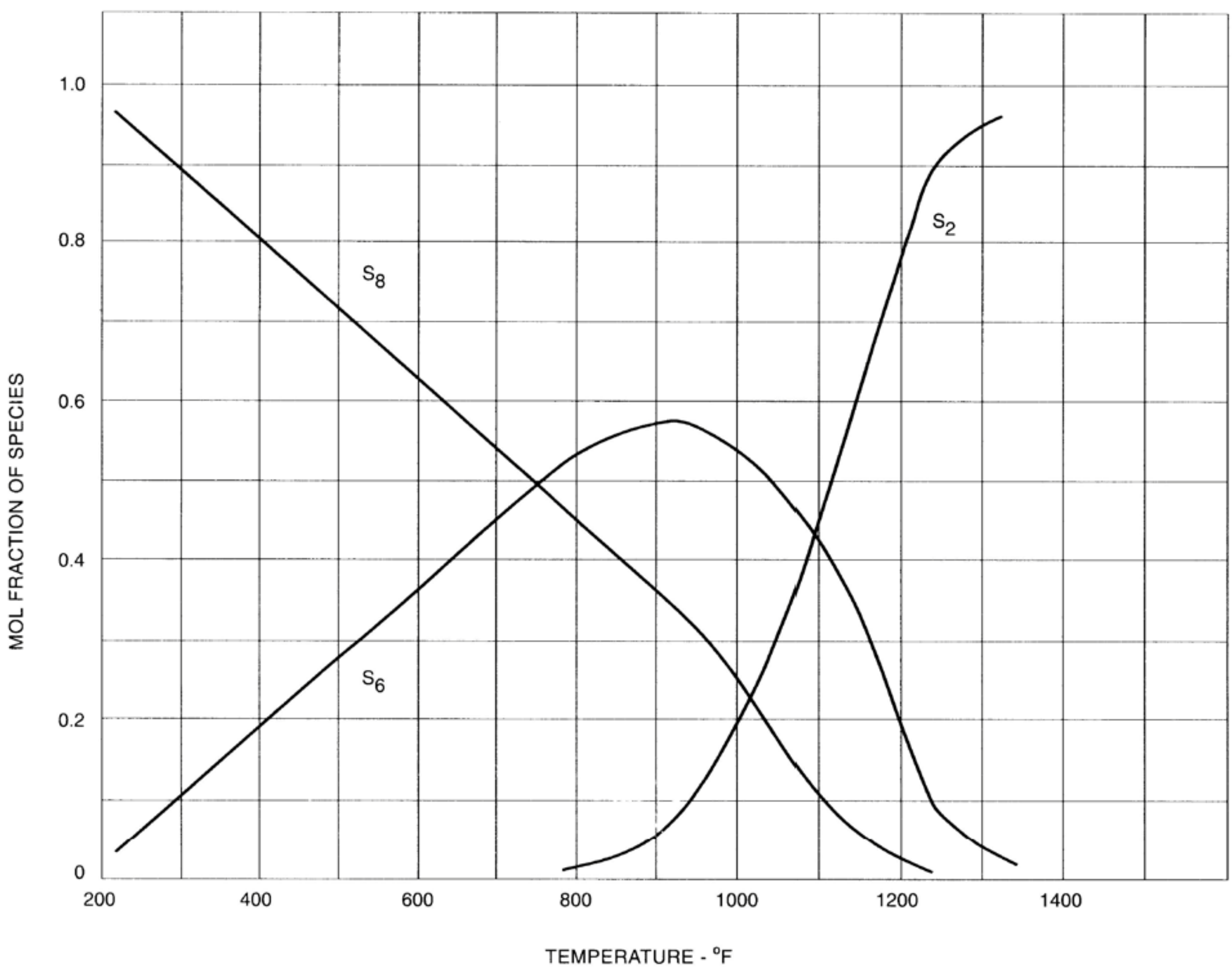


H_2S CO_2
COS (CS_2) RSH
Refinery Sour Gases
Sweet Gas
Specifications
4-16 ppmv H_2S
1-3% CO_2
Σ S = ________
Sour Gas
GAS SWEETENING
SOUR WATER STRIPPER
SWS gas (NH_3)
Acid Gas
Vent
Incinerate
Reinject
90-97% Overall Sulfur Recovery
SULFUR RECOVERY
CLAUS
SELECTOX
LOCAT/SULFEROX
Tail Gas
Vent
Incinerate
TAIL GAS CLEAN-UP UNIT
SUPERCLAUS
SCOT
MCRC
CBA
SULFREEN
etc.
Vent
Incinerate



Publication: ERCB Calgary, Canada

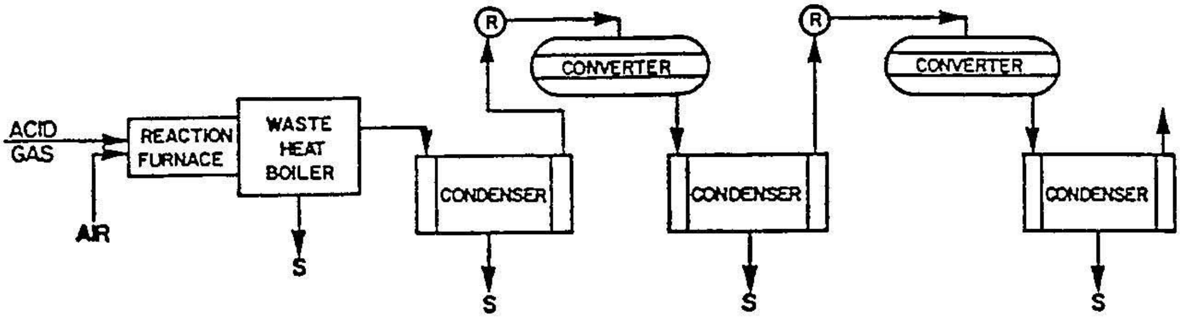
* At normal operating conditions, deduct 0.3% for quarterly average requirement.



Distribution of Sulfur Vapor Species **GPSA 12th Edition 2004**

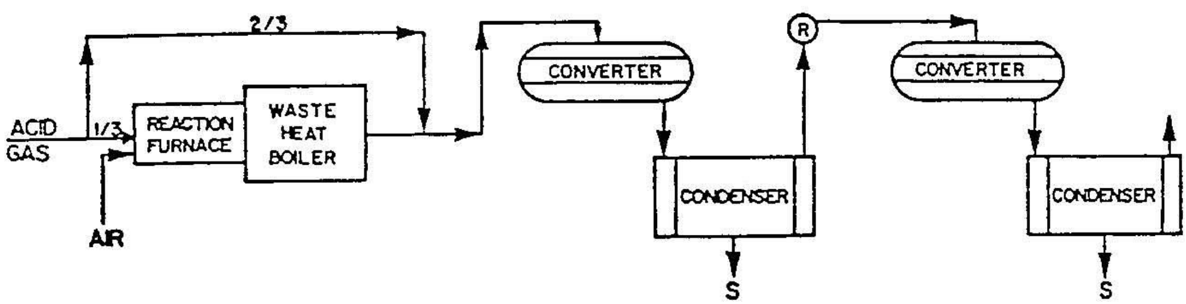
STRAIGHT THROUGH CONFIGURATION

Used when acid gas is 50% H_2S or higher



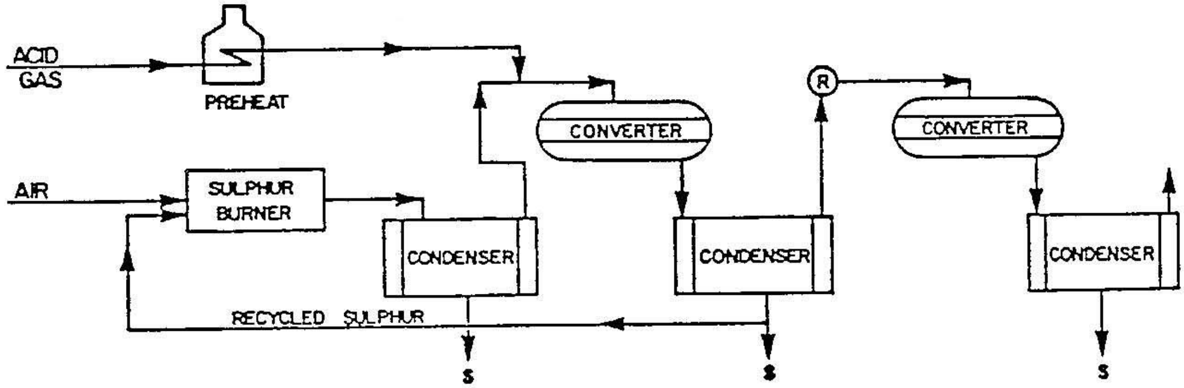
SPLIT FLOW CONFIGURATION

Used when acid gas is: 20-50% H_2S without preheat
-or-
10-25% H_2S with preheat



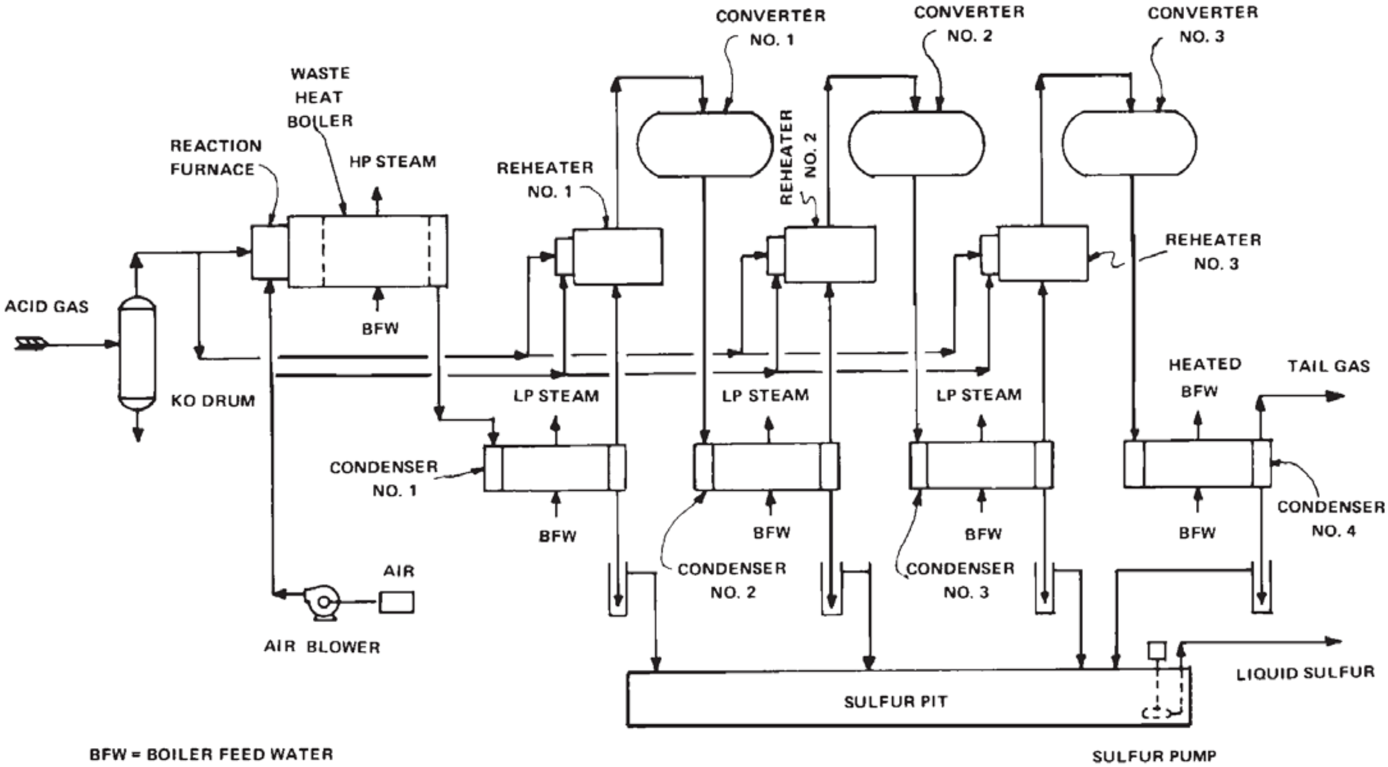
SULFUR RECYCLE CONFIGURATION

Used when acid gas is 10% H_2S or lower

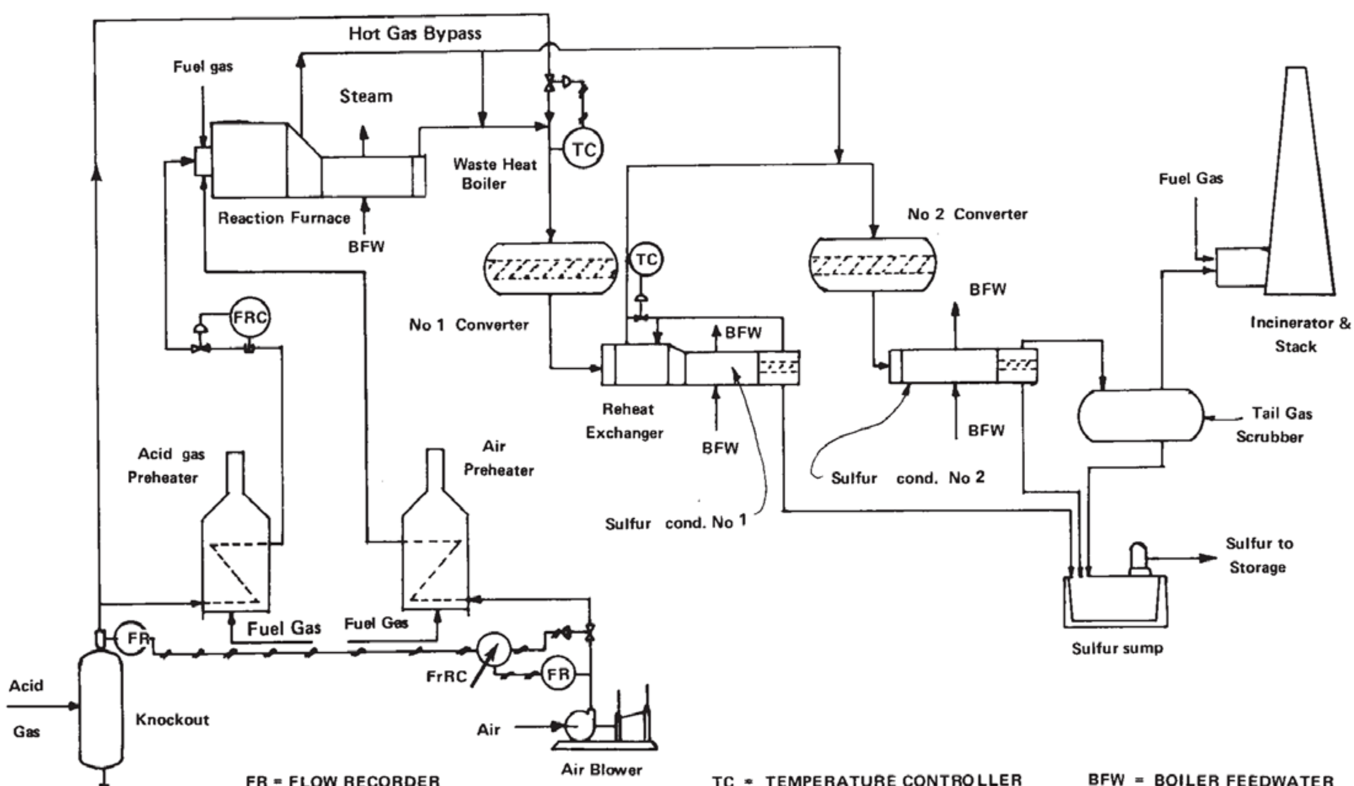


Modified – Claus Process Configurations

Example of Three-Stage Sulfur Plant
(Straight-through operating with acid gas-fueled inline burners for reheating)



Sulfur Recovery Process with Acid Gas and Air Preheat



FRC = FLOW RECORDER CONTROLLER

FrRC = FLOW RATIO RECORDER CONTROLLER

GPSA, 13th Edition 2012

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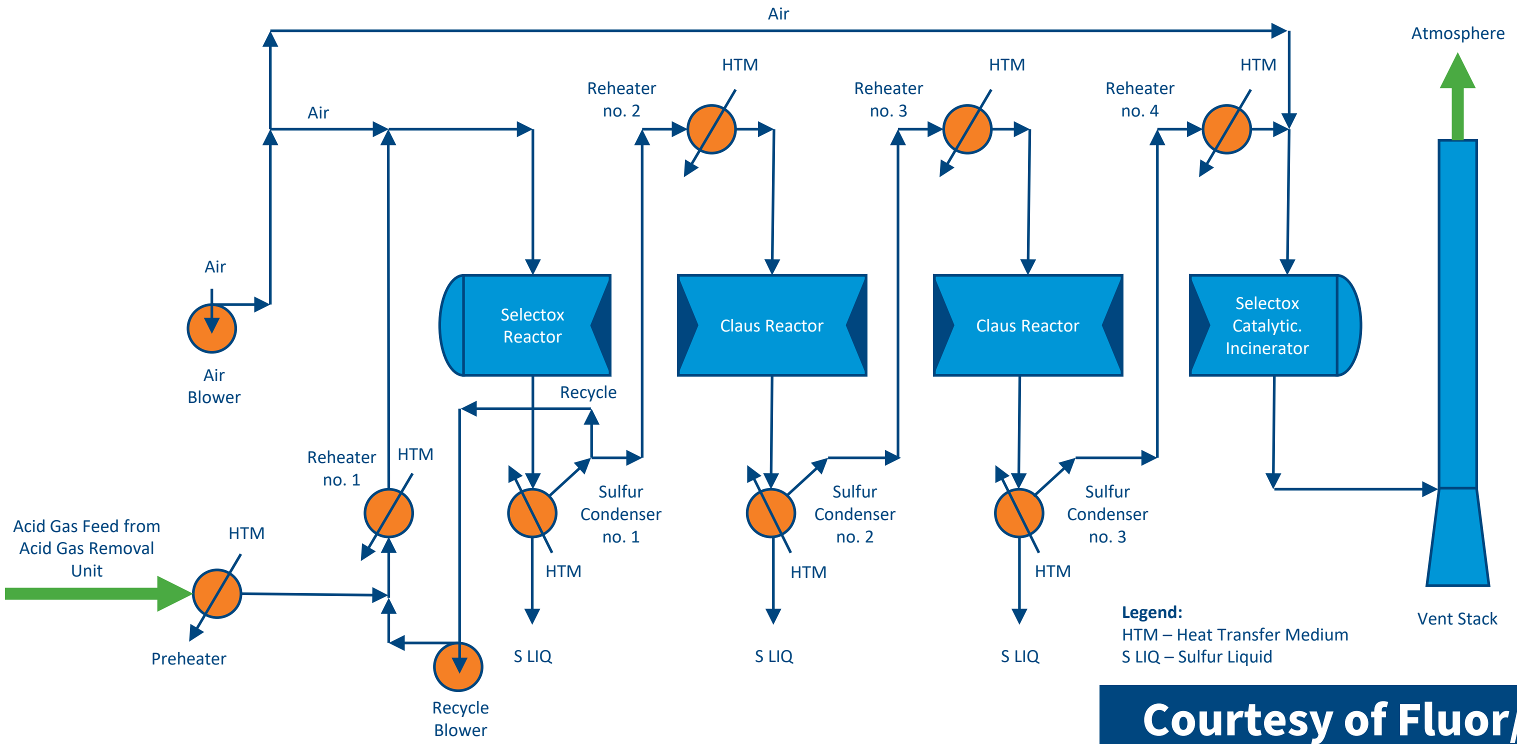
Recycle Seletox Sulfur Recovery Process

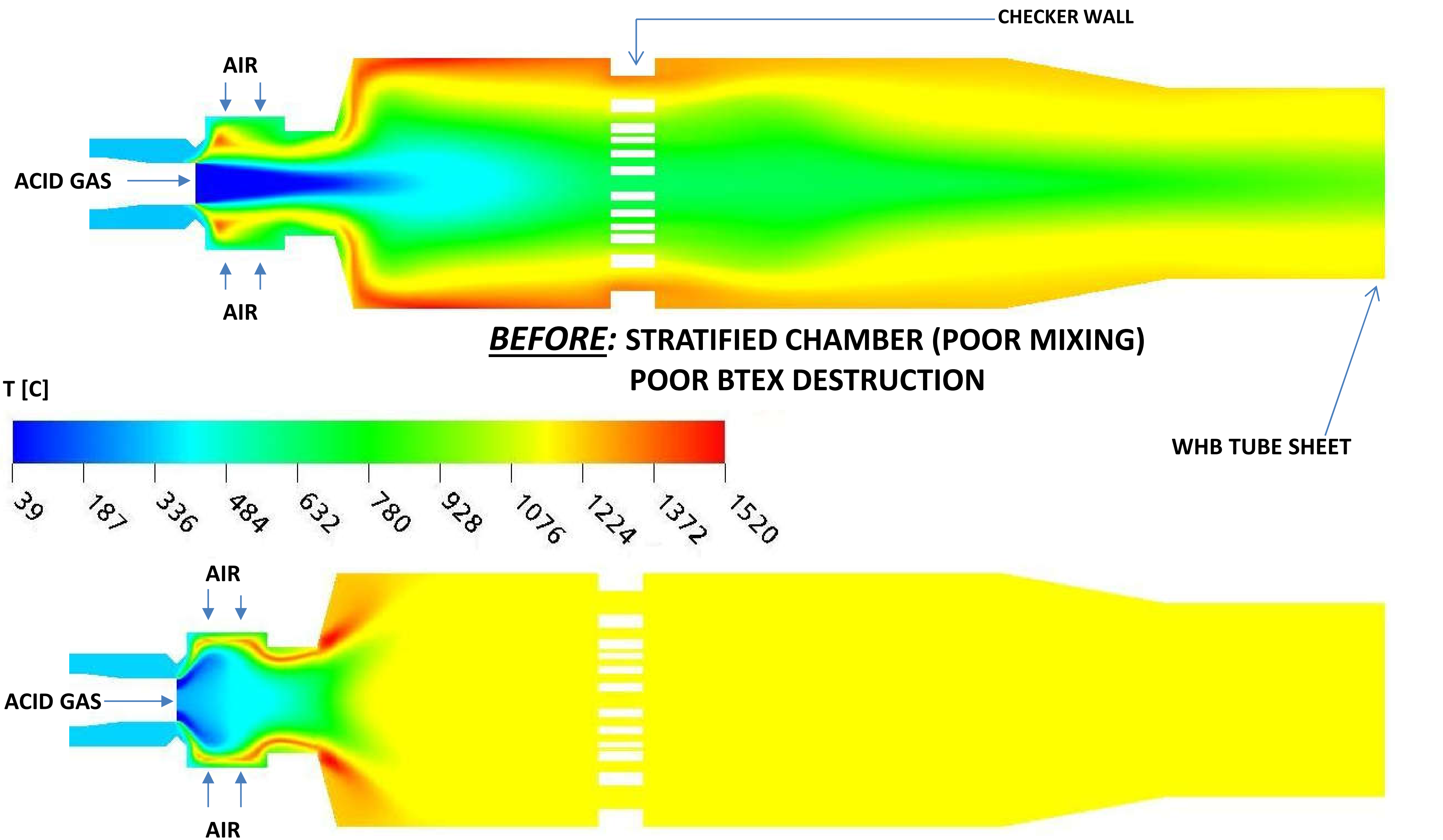


Legend:
HTM – Heat Transfer Medium
S LIQ – Sulfur Liquid

Courtesy of Fluor/GAA

HEC Technologies
SRU COMBUSTION SPECIALISTS

REACTION FURNACE BURNER PERFORMANCE COMPARISON BY CFD SIMULATION

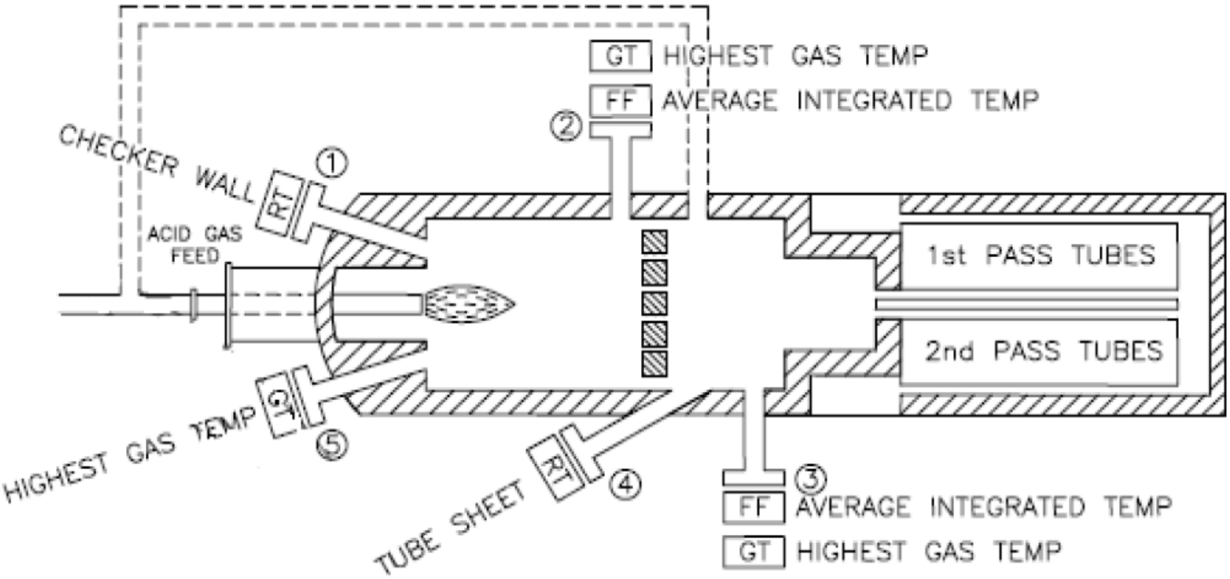


BEFORE: **STRATIFIED CHAMBER (POOR MIXING)**
POOR BTEX DESTRUCTION

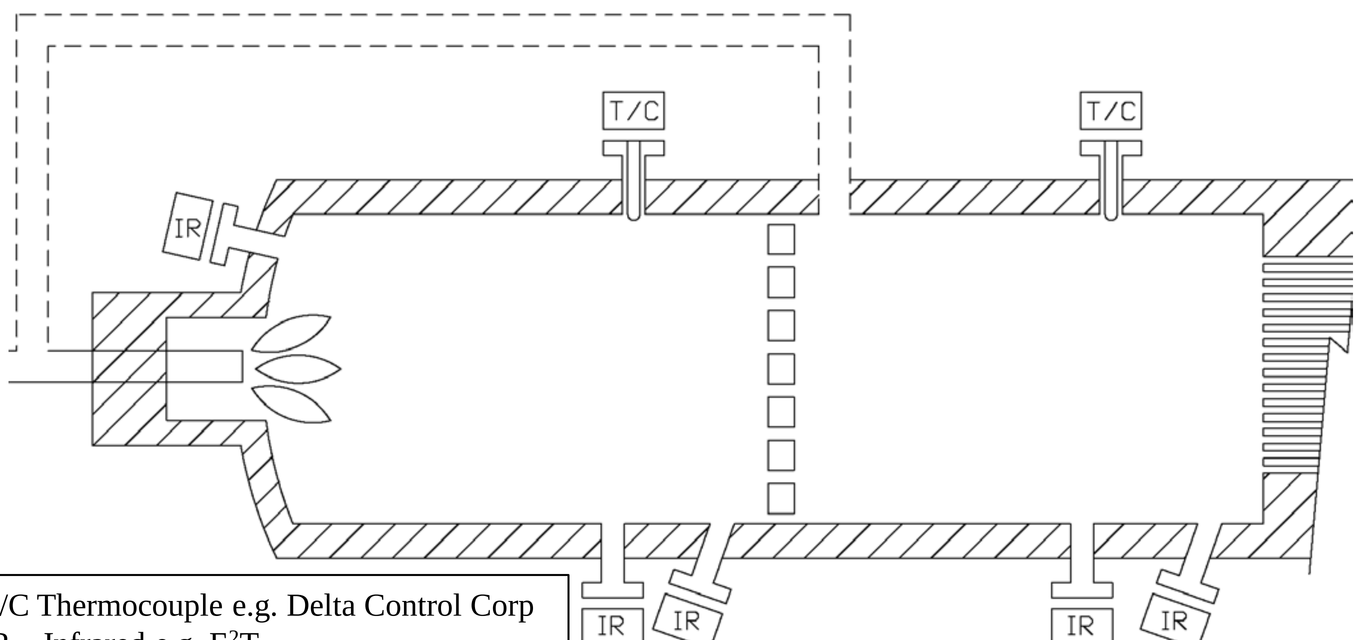
AFTER: **WELL MIXED CHAMBER**
COMPLETE BTEX DESTRUCTION

Infrared and Thermocouple Temperature Detectors

What do you want to measure?



Hampsten, Jim; "Critical Instrumentation in Sulfur Recovery Units"; Brimstone Sulfur Symposium, Vail, CO (Sep 9-12, 2008); p 9.2008



T/C Thermocouple e.g. Delta Control Corp
IR Infrared e.g. E^2T.

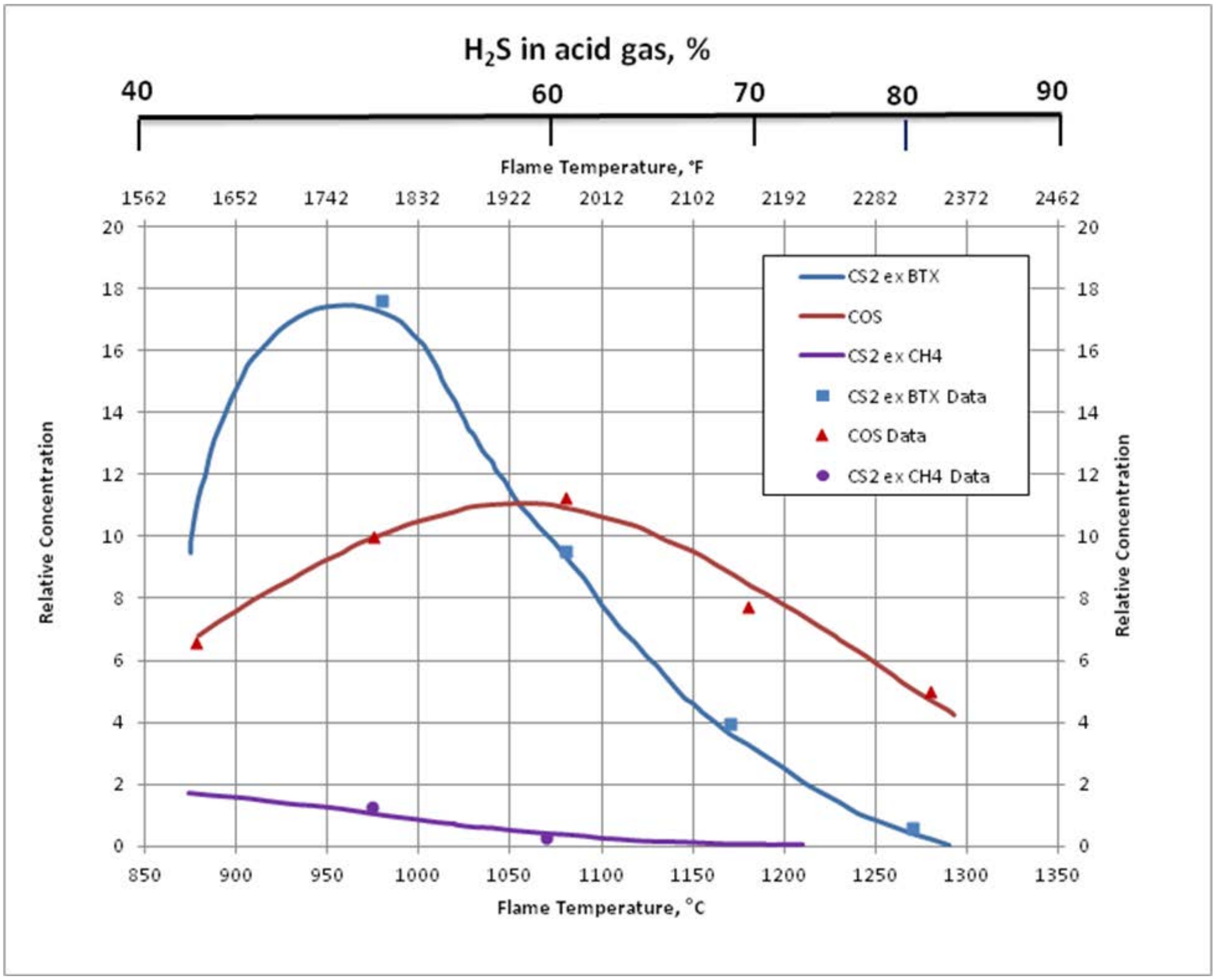
Croom, Steve; Delta Controls Corporation; (Aug 2013); Personal Communication

FLAME TEMPERATURES

Methane	2049°C	3720°F
Ammonia	1846°C	3354°F
H_2S	1859°C	3378°F
H_2S (1/3 Oxidized)	1463°C	2665°F
40% H_2S Acid Gas	927°C	1700°F
Add 5% CH_4	+83C°	+150F°

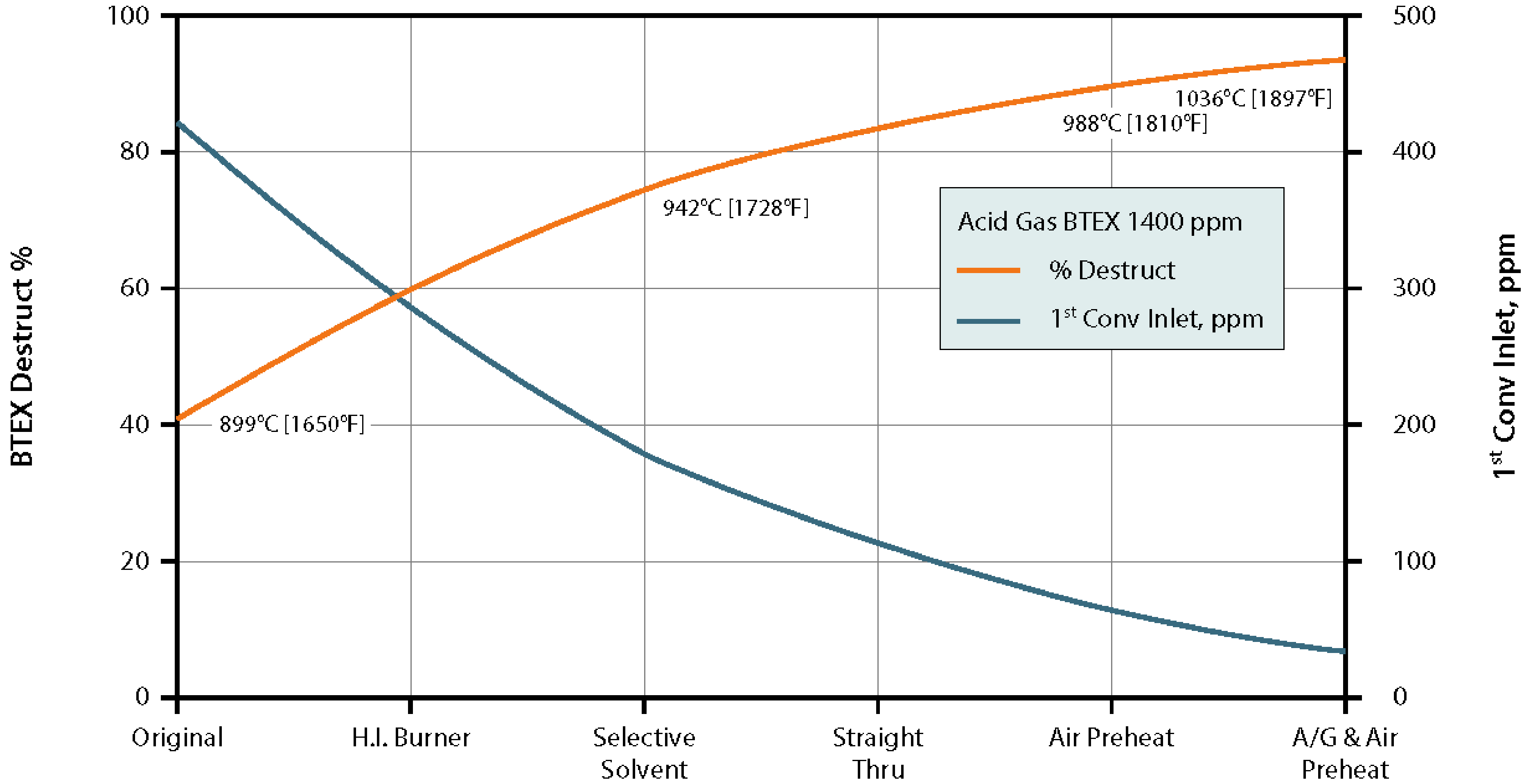
NOTE: The 5% CH_4 is a temperature increase.

Johnson, Johnny E., "Reaction Furnace: Review of Furnace Design & Operations", Brimstone Sulfur Symposium, Vail, CO (Sep. 19-22, 1995); p 21, 35.



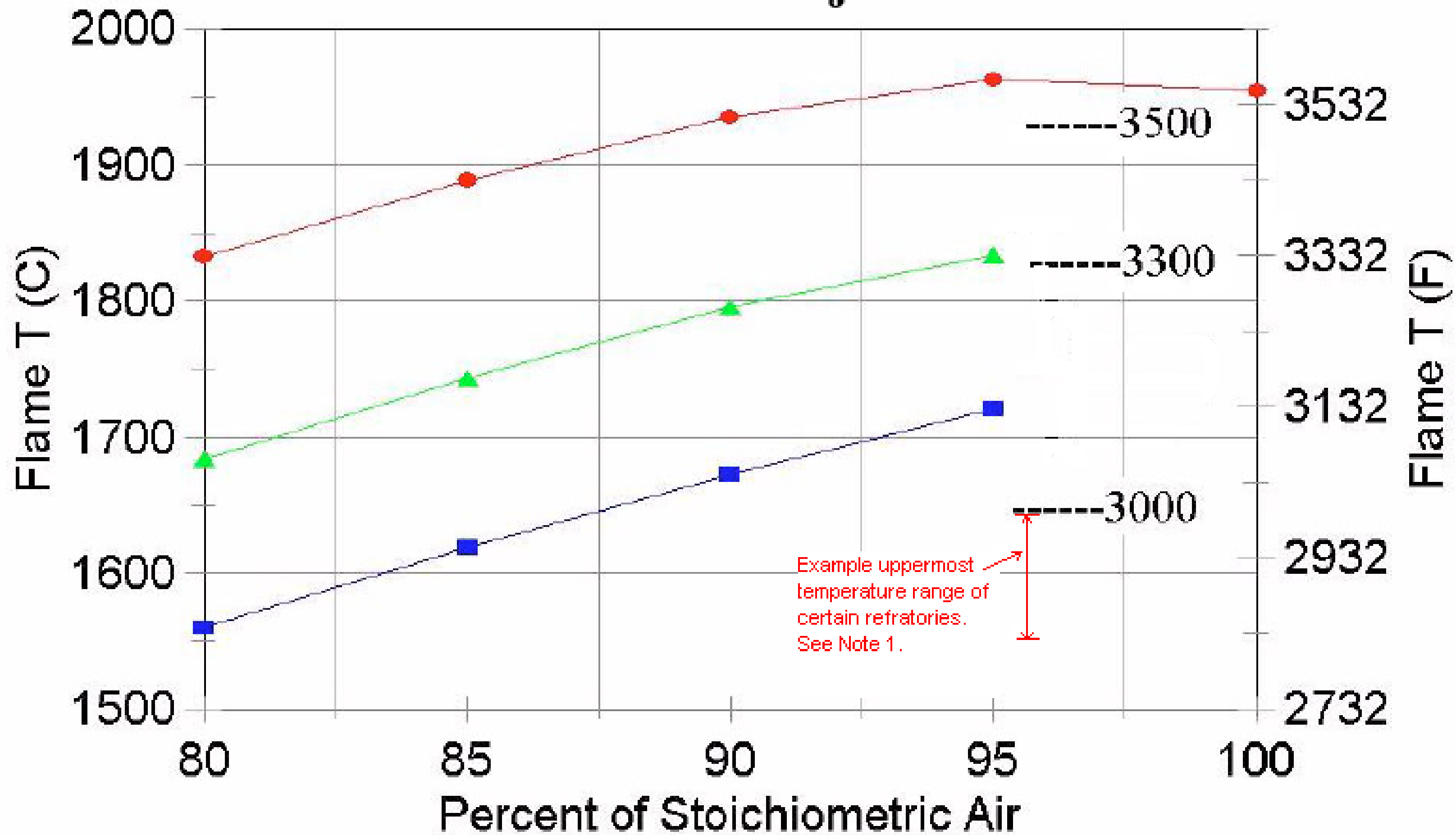
Johnson, Johnny E., "Reaction Furnace: Review of Furnace Design & Operations" Brimstone Sulfur Symposium, Vail, CO (Sep. 19-22, 1995); p 21, 35.

BTEX Destruct at Hanlan Robb



Hanlan, Robb; "BTEX Fouling of SRU Catalyst"; Brimstone Sulfur Symposium, Vail, CO (Sep 15-18, 1998); p 29

Flame Temperature as a function of Stoichiometric Air and Steam Injection



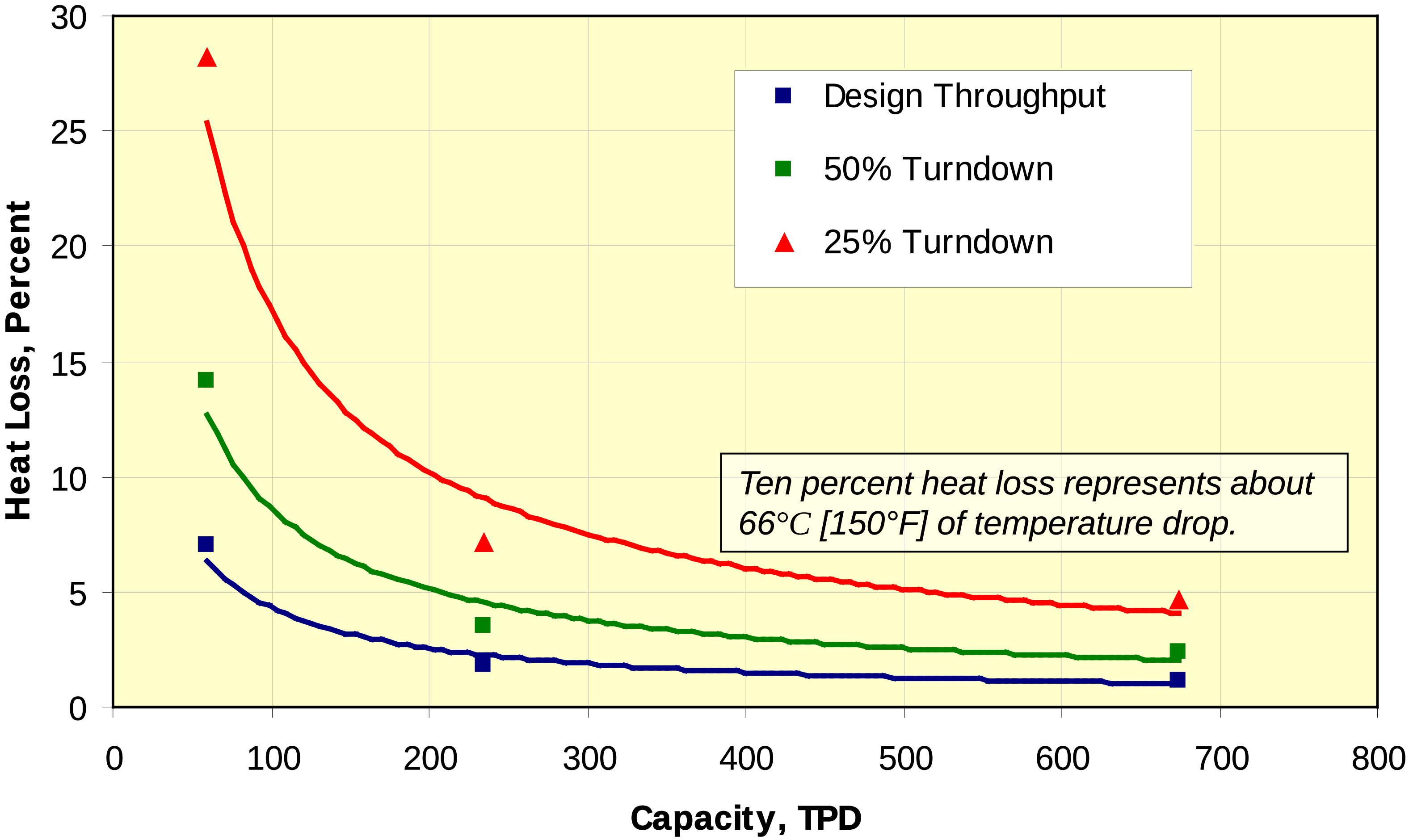
Note 1: The specific values for Maximum Design Temperature and Continuous Service Temperature should be established with the refractory supplier.

Air T = 90 C (194 F)

Mass Ratio — Steam/CH4 = 0 — Steam/CH4 = 1 — Steam/CH4 = 2

Adapted from Sikorski, Dave; Roussakis, Nick; Corriveau, Anthony; "Flame Temperature Issues in SRU Equipment"; Brimstone Sulfur Symposium, Vail, CO (Sep 12-16, 2005); p 4.

Reaction Furnace Heat Loss – Model Results



Blais, D'Arcy; Marshall, Chuck; Wissbaum, Dick; "How Hot is your Reaction Furnace - Really?"; Brimstone Sulfur Symposium, Vail, CO (Sep 11-14, 2012); p 8.

Table 2

Brick	Impurities (%)	Yield Point Reducing °C	°F
90% Al_2O_3	0.5	1593	2900
60% Al_2O_3	1.6 – 4.1	1482 - 1288	2700 – 2350
70% Al_2O_3	4.9	1204	2200
85% Al_2O_3 (Phos Bonded)	8.9	716	1320

Note 1: Brick selection to be based on reducing service in sulfur recovery applications.

Note 2: Not all 90% alumina is created equal, nor intended for sulfur service. The actual impurities will influence the performance.

Proctor, S. J.; Piper, Andy; "Engineered Refractory Practice for O2 Enriched SRU Operation"; Brimstone Sulfur Symposium, Vail, CO (Sep 12-16, 2005); p 3, 6.

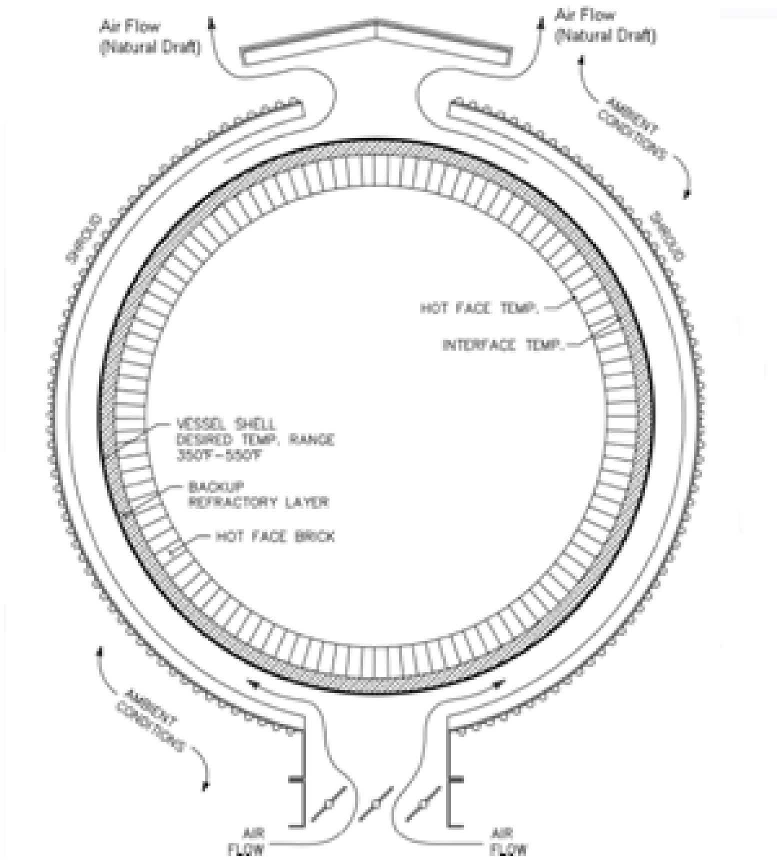


Diagram 1

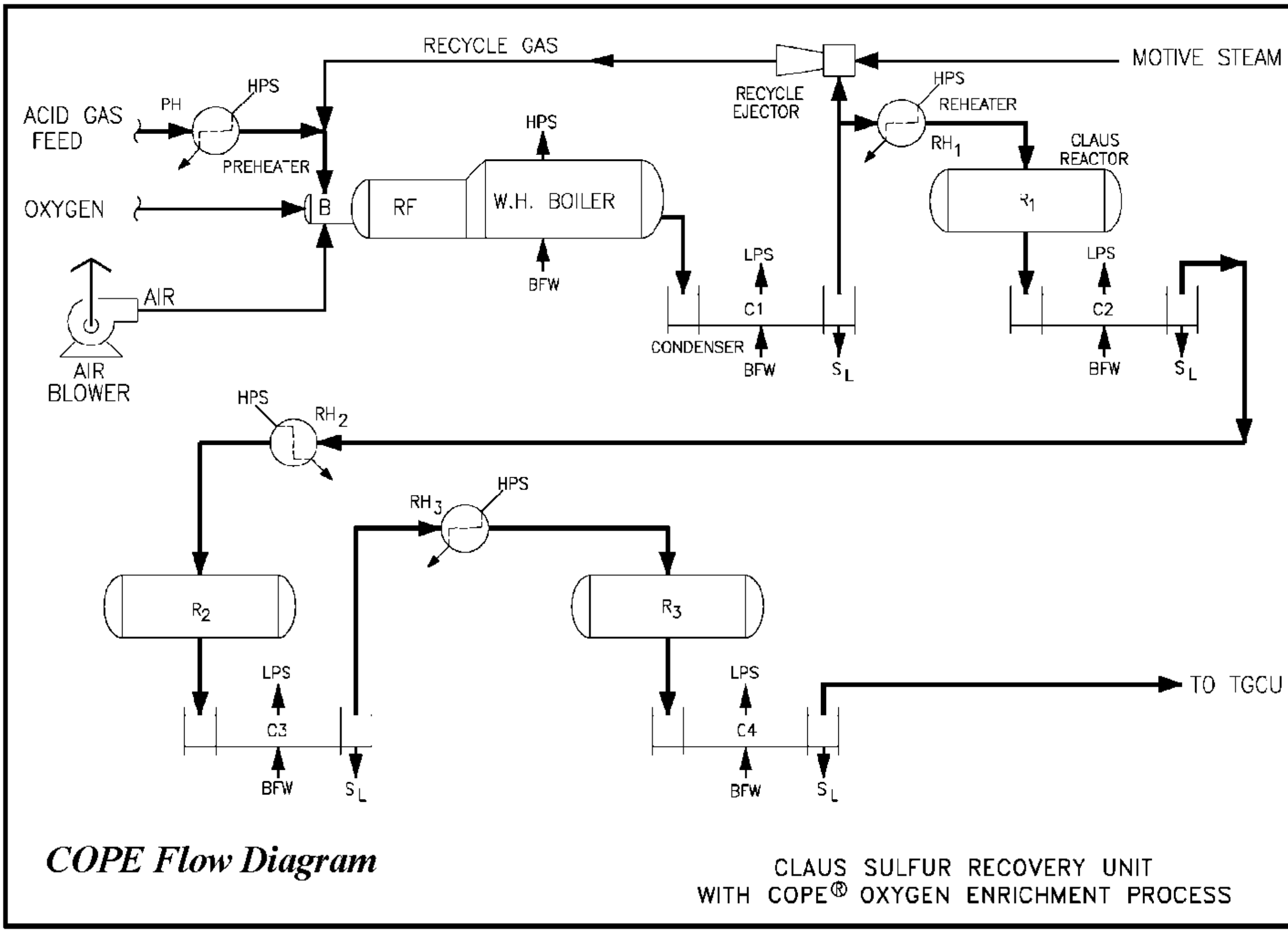
Benefit of shroud

- Moderate shell temperature; minimizes low temperature & high temperature corrosion
- Eliminates pinch (rain) spalling of refractory hotface due to sudden shell contractions

Difficulties due to shroud

- Requires complex thermal calculations due to heat transfer mechanism within the annulus
- Maintenance of shroud; damaged areas need to be repaired and air flow paths kept open

Proctor, S. J.; Piper, Andy, "Engineered Refractory Practice for O2 Enriched SRU Operation"; Brimstone Sulfur Symposium, Vail, CO (Sep 12-16, 2005); p 3, 6.



COPE Flow Diagram

Capacity Increase with Oxygen Enrichment

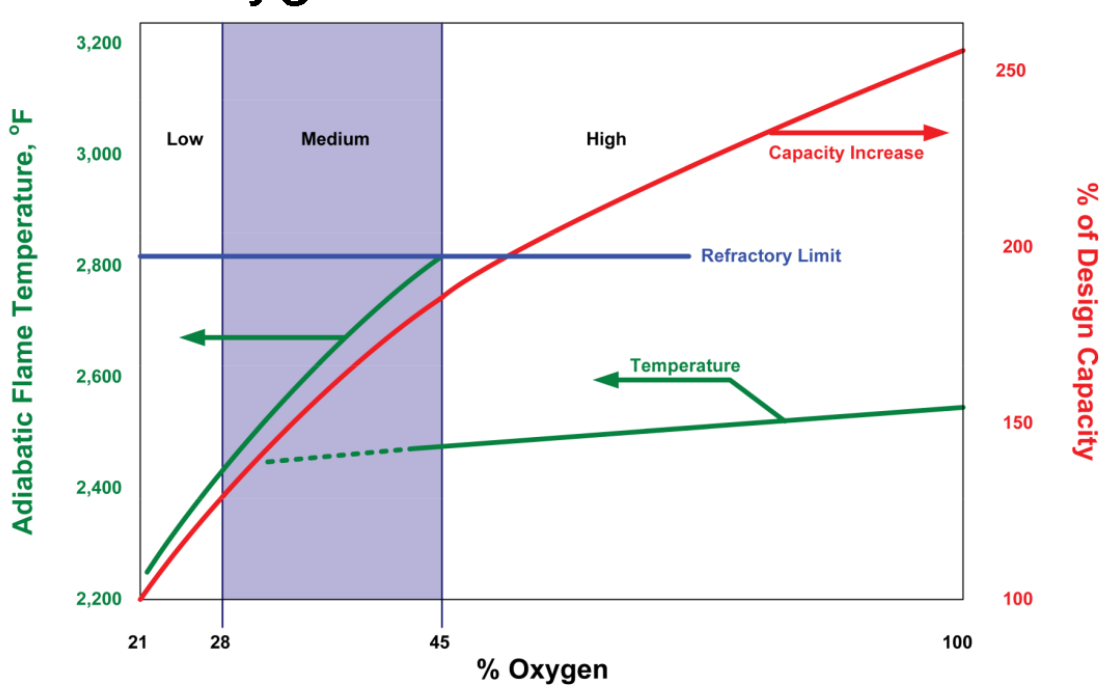
Oxygen Enrichment (%)	20.9 (Air)	25	50	100
Acid Gas Flow (mol/h)	100	113	170	226
Oxygen Flow (mol/h)	50	57	85	113
N_2 + Ar Flow (mol/h)	189	169	84	0
Total Flow to RF[1] (mol/h)	339	339	339	339
Total Flow to TGTU[2] (mol/h)	293	286	261	235

Basis:

1. Total flow to Reaction Furnace is constant but sulfur plant load increases with higher levels of oxygen enrichment.
2. Total flow to Tail Gas Treating Unit decreases with higher sulfur plant loads due to higher levels of oxygen enrichment.

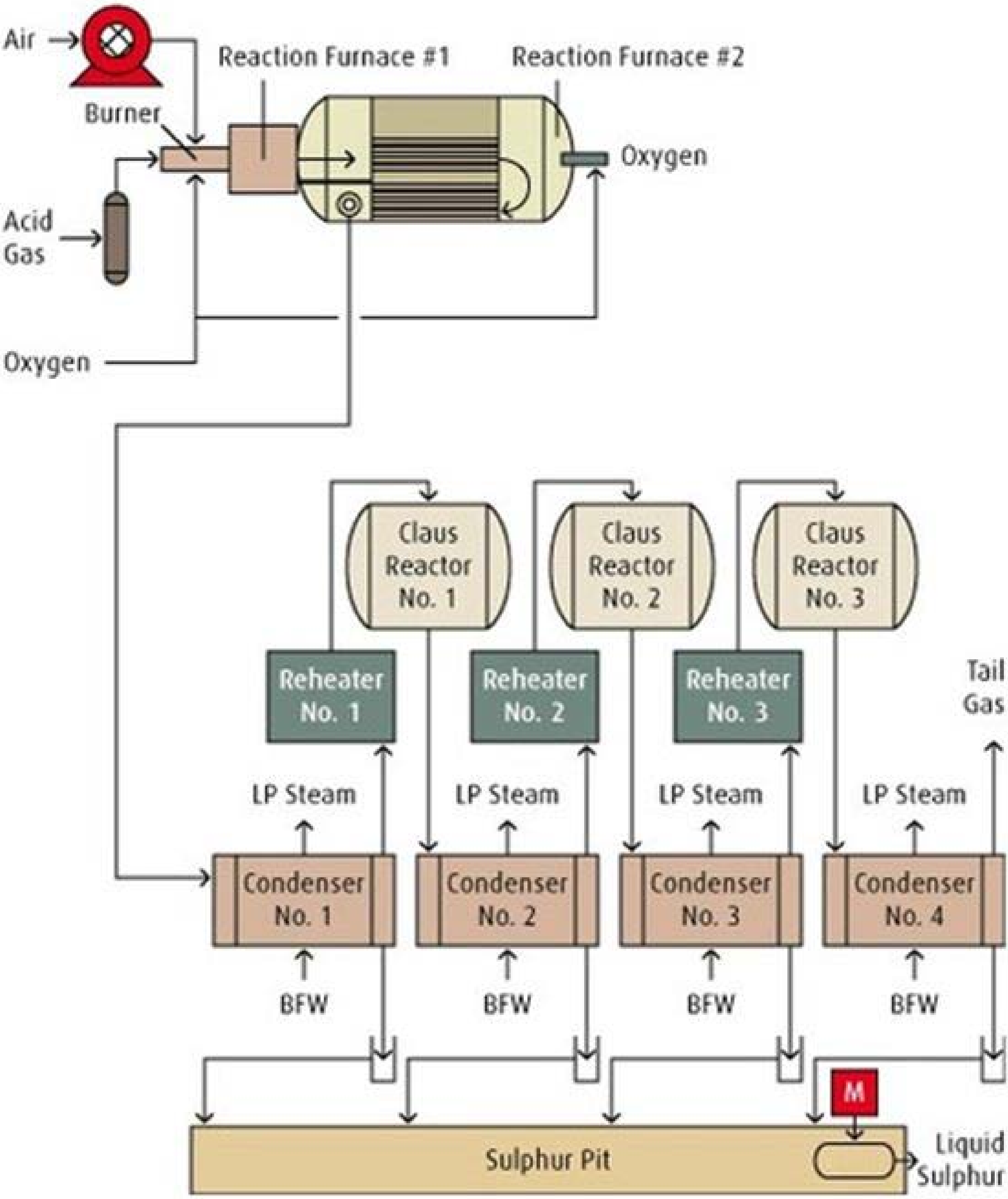
Nasato, Elmo; Parekh, Uday N.; "Industrial Gas Supply for the Sulfur Recovery Industry"; Brimstone Sulfur Symposium, Vail, CO (Sep 15-18, 2009); p 11.

Oxygen Enrichment Levels



Wong, Vincent W.; Sanchez, Arnold E.; Flowers, Jason; Chow, Thomas K.; Sikorski, Dave; Roussakis, Nick; "Key Design Features for a Successful SRU Operation Implemented with Oxygen Enrichment Technology"; Brimstone Sulfur Symposium, Vail, CO (Sep 14-17, 2010); p 5.

Worley Parsons SURE™ Oxygen Configuration



Angela Slavens, Worley Parsons, Ltd.
Personal Communication 2013

Figure 1. Option for Seal Weld Procedure

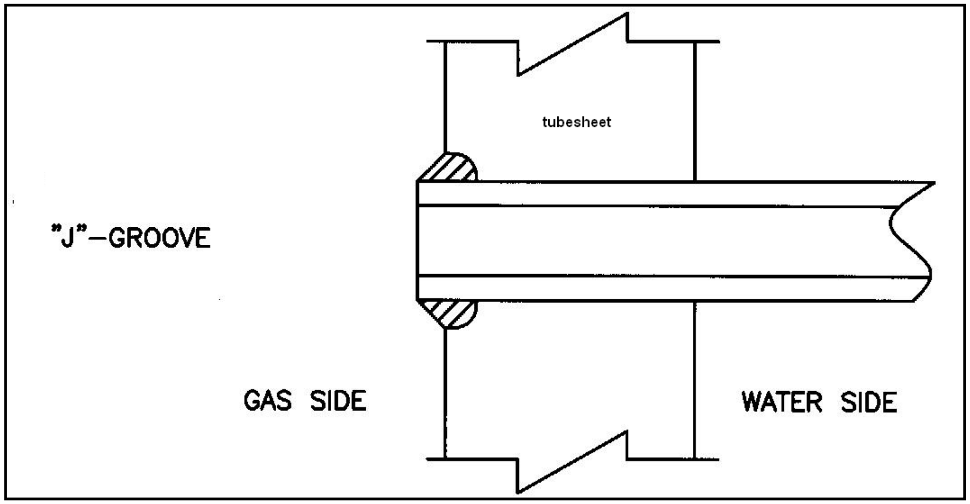
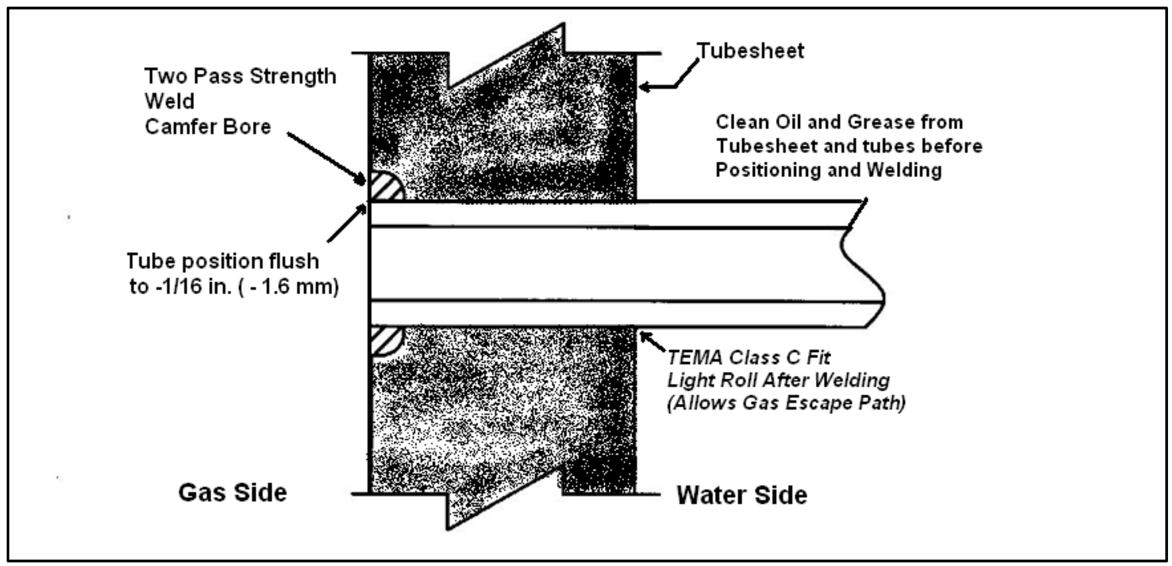


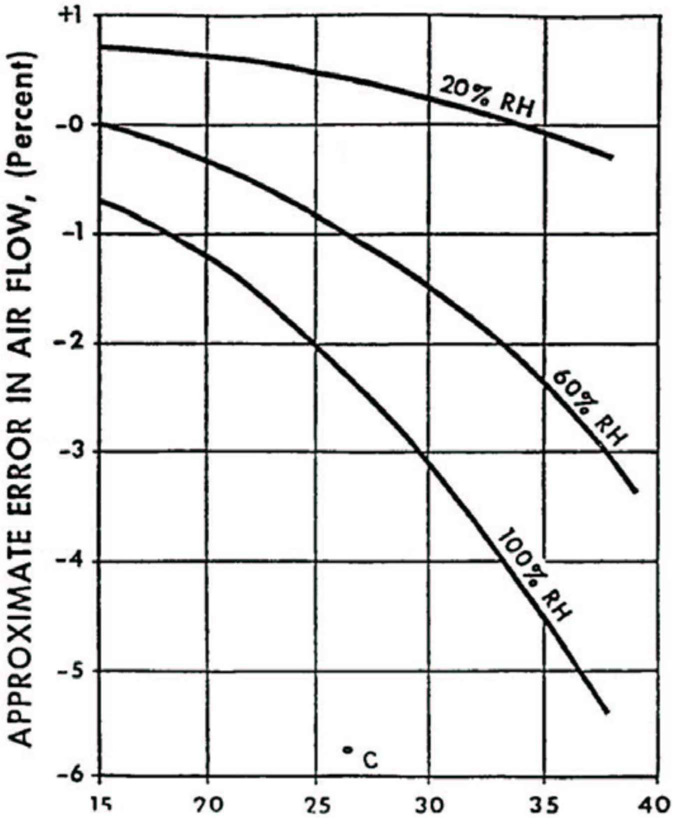
Figure 2. Option for Strength Weld Procedure.



Nasato, Elmo; "Utility Considerations for Sulfur Recovery Units"; Brimstone Sulfur Symposium, Vail, CO (Sep 12-15, 2006); p 5, 12.

Table 4 **Recommended Boiler Water Limits**				
Drum Pressure (psig)	Range Total Dissolved Solids Boiler Water – maximum (ppmw)	Range Total Alkalinity Boiler Water (ppmw)	Suspended Solids Boiler Water – maximum (ppmw)	Range Total Dissolved Solids Steam (ppm)
0 – 300	700 – 3500	140 – 700	15	0.2 – 1.0
301 - 450	600 – 3000	120 – 600	10	0.2 – 1.0
451 – 600	500 – 2500	100 – 500	8	0.2 – 1.0
601 – 750	400 – 2000	80 – 400	6	0.2 – 1.0
751 – 900	300 – 1500	60 – 300	4	0.2 – 1.0
901 – 1000	250 – 1250	50 - 250	2	0.2 – 1.0

Nasato, Elmo; "Utility Considerations for Sulfur Recovery Units";
Brimstone Sulfur Symposium, Vail, CO (Sep 12-15, 2006); p 5, 12.



Approximate Error in Air Flow Based on Assumption of Constant 15.5° C Dry Bulb and 60% Relative Humidity

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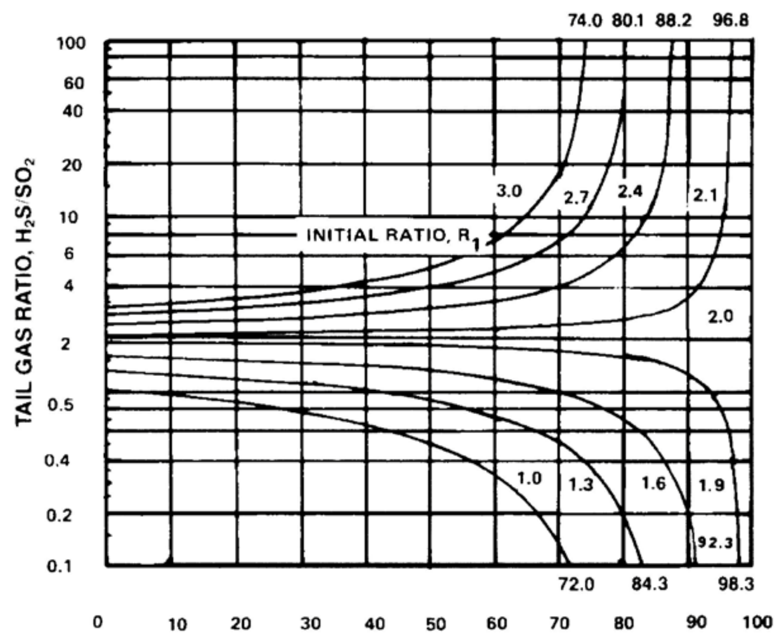
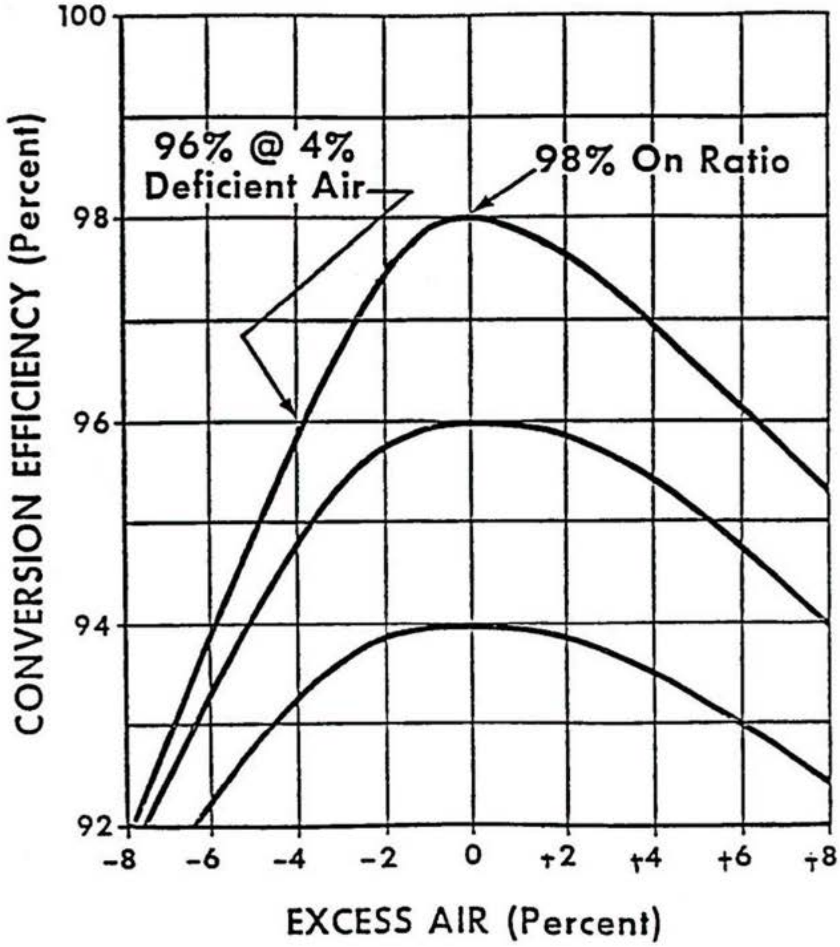
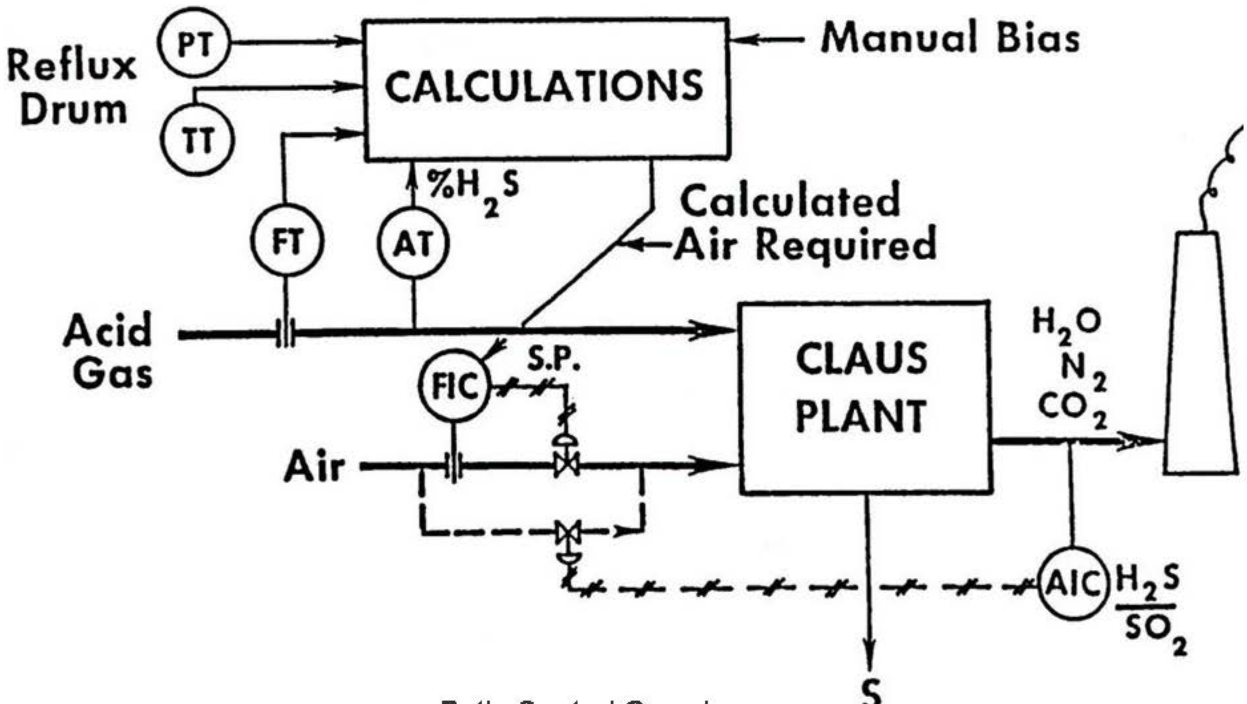


GPSA, 12th Edition 2004

Plot shows that a slight change in air to acid gas ratio at the head end of the plant will make a significant change in the Tail Gas Ratio, H_2S/SO_2



Efficiency Loss as a Function of Excess Reaction Air



Ratio Control Overview

SULFUR RECOVERY

AIR REQUIREMENTS AND TAIL GAS COMPOSITION

$$H_2S + \frac{1}{2} O_2 \rightarrow S + H_2O$$

A. Dry basis no hydrocarbons

Acid gas	15% CO_2	
	85% H_2S	= 42.5 mols O_2 demand
	100% or	100 mols

B. Dry basis but add 2% hc

			O_2 demand
15	CO_2		0
83	H_2S		41.5
1	CH_4	$C + O_2 \rightarrow CO_2$	2
		$2H_2 + O_2 \rightarrow 2H_2O$	
1	C_2H_6	$2C + 2O_2 \rightarrow 2CO_2$	3.5
		$3H_2 + \frac{3}{2} O_2 \rightarrow 3H_2O$	
		$5.5\ O_2 \rightarrow 5H_2O + 3CO_2$	47.0

Note: 2% hydrocarbons caused a 10% increase in O_2 demand

C. Dry basis, 2% hc and 96% increase in O_2 demand

Of the 4% S not recovered as sulfur in the pit assume:

half is $S_v + S_L + COS + CS_2$
half is unreacted H_2S; SO_2

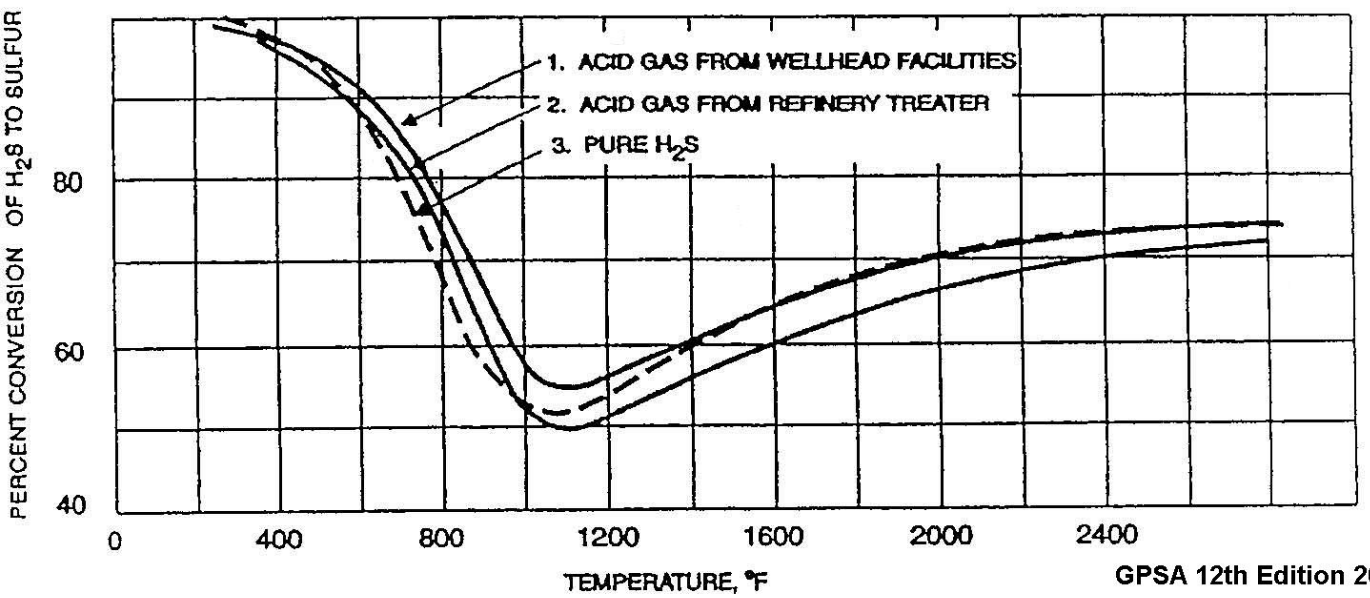
Thus example tail gas for 100 mols dry acid gas

15 + 3 (from hc) → CO_2	18.0
83 × (0.96) H_2S + 39.8 O_2 → H_2O	84.7 (incl. $5H_2O$ from hc)
(39.8 + 5.2) O_2 @ 21:79 O_2:N_2 → N_2	170.4
2% of the 83 H_2S is 1.6 mols $S_v + S_L + COS + CS_2$	1.7 S_1 equivalent
and 2% is unreacted H_2S, SO_2	1.7 S_1 equivalent
	276.5 mols tail gas

Note: Tail gas volume is 2½ times acid gas
Tail gas is mainly N_2 and H_2O
Tail gas composition is approximately:

CO_2	6.5
H_2O	30.6
N2	61.7
$S_v + S_L + COS + CS_2$	0.6
H_2S, SO_2	0.6
	100%

Tail gas will also contain H_2 & CO



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Theoretical Equilibrium Percent Conversion of Hydrogen Sulfide to Sulfur

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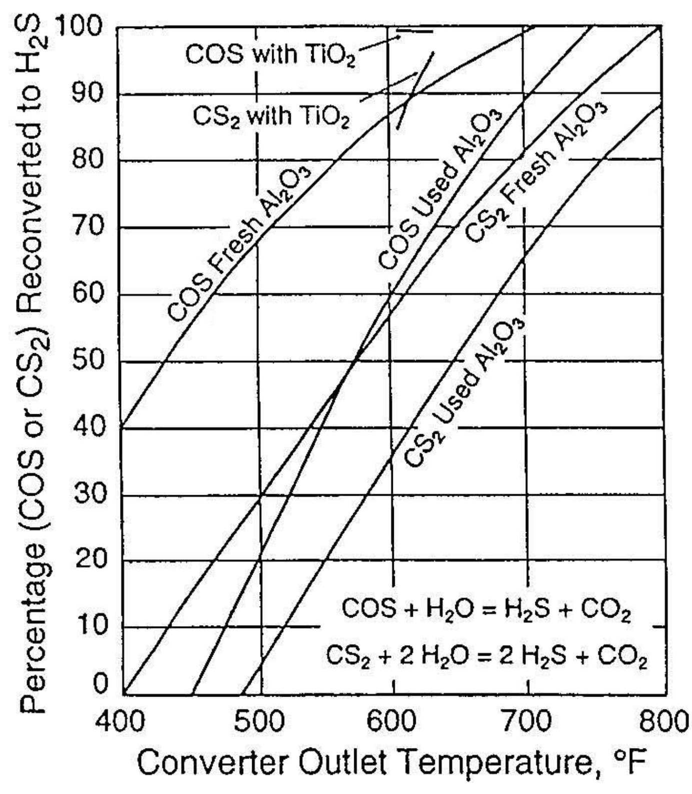


Hydrolysis of COS and CS_2 in Sulfur Converter

(Reproduced from GPSA with permission)

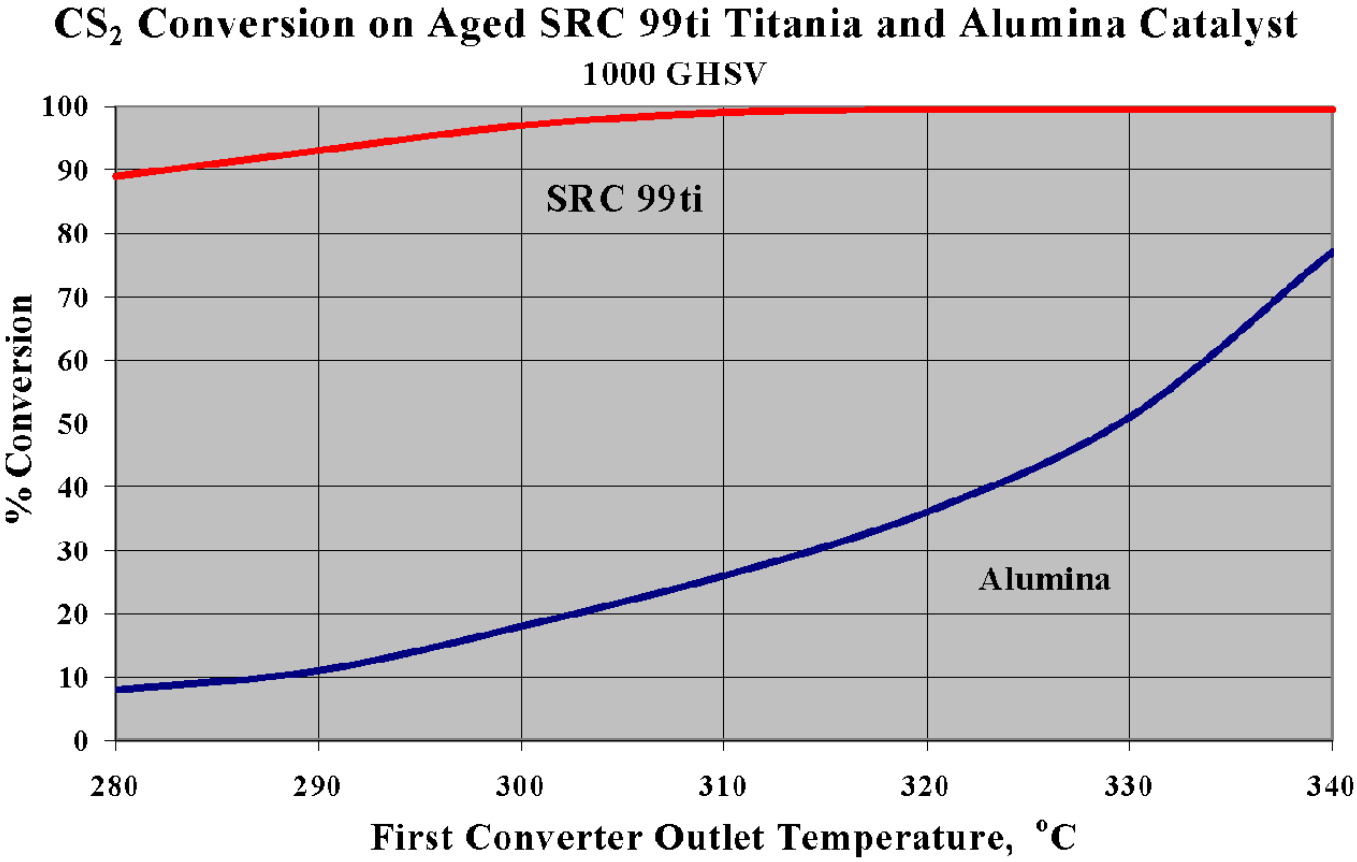
GPSA 12th Edition 2004

Available Claus SRU Catalysts and Their Applications

	Application	Surface Area m^2/g	Macropore Volume, cc/g > 750 A	Bulk Density lb/ft^3	Average Crush Strength lbs (5 mesh)
Activated Alumina Claus Catalyst**					
BASF S-100	Standard SRU's	295-340	0.15-0.20	41-43	37
BASF S-400	Standard SRU's	300-350	0.15-0.20	41-43	37
BASF DD-431	Standard SRU's	350-400	0.16-0.21	39-42	35
Axens CR, 3x5 mesh	Standard SRU's	290	NR	42	45
Porocel Maxcel 727, 3x6 mesh	Standard SRU's	350-390	0.19-0.23	39-42	35
UOP/Euro Support S-2001/ESM-221	Standard SRU's	320-400	0.15-0.29	38-45	33
Promoted Alumina Catalysts for High COS, CS_2, Oxygen Removal and/or Sulfation Resistance					
BASF DD-831	Higher COS/CS_2 Conversion	300	0.12	47	25
UOP/Euro Support S-501/ESM 251	Higher COS/CS_2 Conversion	300	0.19	45	20
Axens CR 3S	Higher COS/CS_2 Conversion	340	0.2	42	31
Axens CSM 31	Protection from BTEX	300	NR	47	20
Porocel Maxcel 747	Higher COS/CS_2 Conversion	300	0.15	44	20
Axens AM***	O_2 Scavenger/catalyst	280	NR	47	45
UOP/Euro Support S-601/ESM 261***	O_2 Scavenger/catalyst	280	NR	47	40
Porocel Maxcel 740***	O_2 Scavenger/catalyst	310	0.08	46	40
BASF S-100SR***	O_2 Scavenger/catalyst		0.1	45	35
Titania Catalyst for Ultra High COS and CS_2 Conversion and Resistance to Sulfation Deactivation					
Porocel Maxcel 777*		130	NR	56	28
Axens CRS-31*		130	NR	54	28
Axens CRS-31 TL		150	NA	44	15 daN
BASF Ti-1100e and SRC-99ti*	Higher COS/CS_2 Conversion	130	NR	52	25
DD-931 (4 mm)	Higher COS/CS_2 Conversion	260	0.12	48	20
UOP/Euro Support S-7001/ESM-271 QL*	Higher COS/CS_2 Conversion	125	NR	51	NA
Subdewpoint Catalysts					
Porocel Maxcel SD-C****	Subdewpoint SRU (carbon)	1000	n/a	31	5kg/particle
UOP/Euro Support S-2001/ESM-221	Subdewpoint SRU (alumina)	360	0.15-0.29	38-45	33
Porocel Maxcel SD-A	Subdewpoint SRU (alumina)	370	0.25-0.22 min[1]	38	35

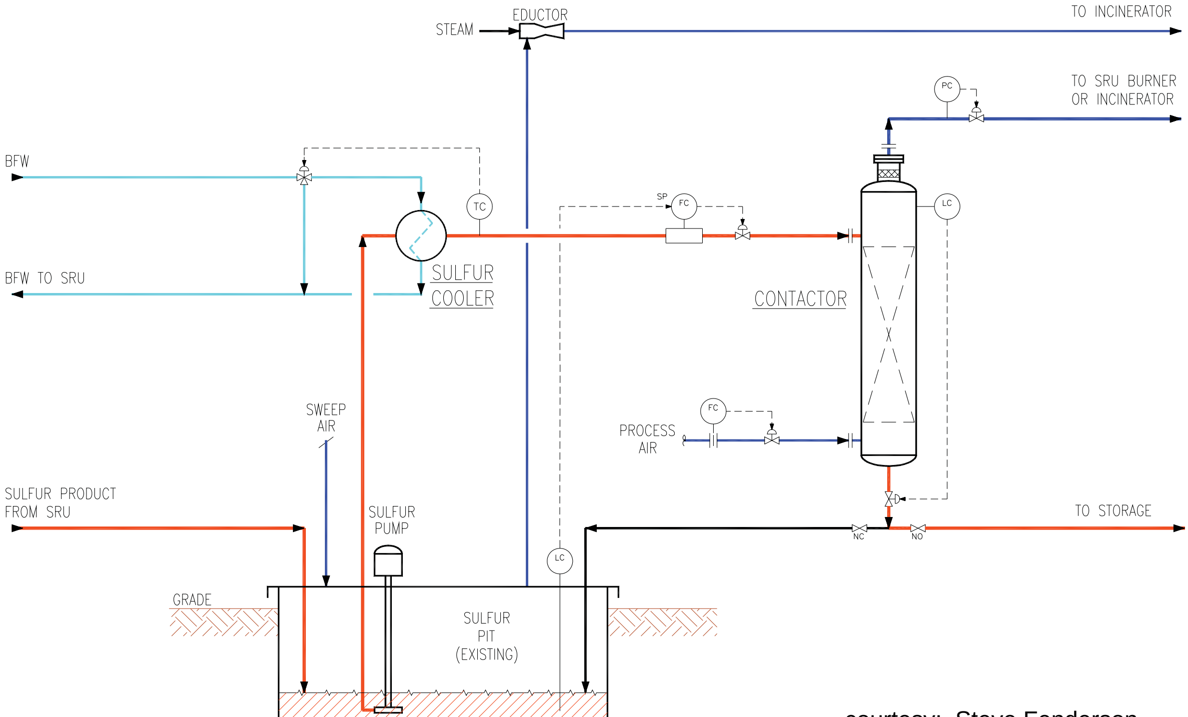
*Extrudate **Analyzed Samples ***Oxygen Scavenger ****Pellets

1. Macroporosity>750 A°



Pearson, Michael J.; Mophett, Elise M.; "New Claus Catalyst Options from Alcoa for Higher Sulfur Recovery"; Brimstone Sulfur Symposium, Vail, CO (Sep 12-15, 2000); pg 5.

Typical D'GAASS Flow Diagram



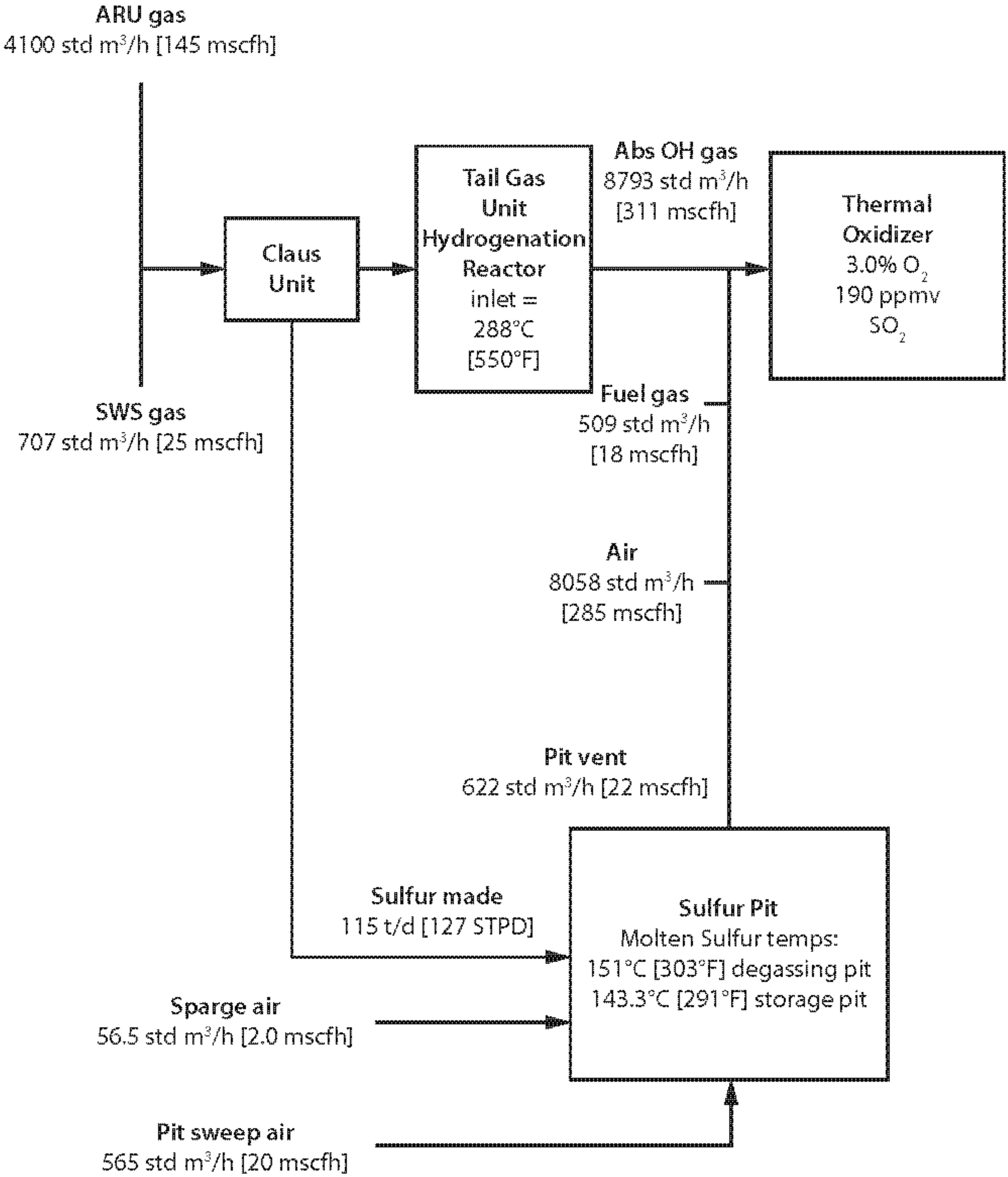
courtesy: Steve Fenderson

Summary data are listed below for the Sulfur rundown and gas streams

Sulfur Rundown	Dissolved, ppm		
Sample Source	H_2S	H_2S_x	Total
SRU WHB Rundown	440	196	636
SRU Cond 1 Rundown	263	285	548
SRU Cond 2 Rundown	58	53	111
SRU Cond 3 Rundown	12	10	22
SRU Cond 4 Rundown	2	1	3
SRU Degassed (pit)	42	41	83

Qui, Grant; Keller, Al; "Minimize Sulfur Pit Vent Contribution to Stack Emissions"; Brimstone Sulfur Symposium, Vail, CO (Sep 13-16, 2011); p 3, 4.

Example Process Conditions with Pit Vent Gas (Claus, TGCU & Pit)



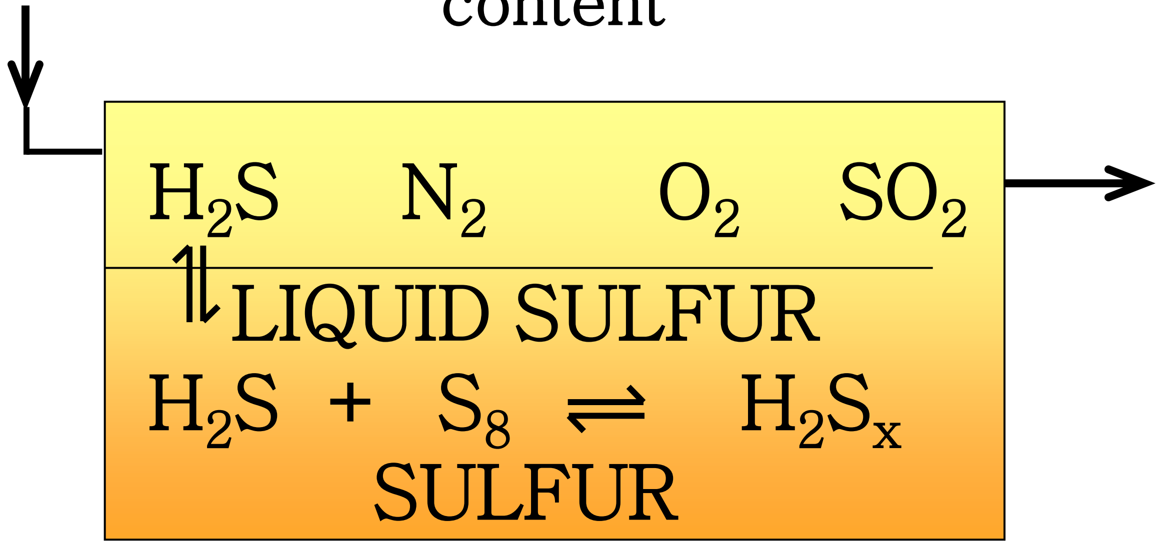
Qui, Grant; Keller, Al; "Minimize Sulfur Pit Vent Contribution to Stack Emissions"; Brimstone Sulfur Symposium, Vail, CO (Sep 13-16, 2011); p 3, 4.

Experimental Design to Test Removal of H_2S/ SO_2 and $S_{(vap)}$ from a Simulated Pit Effluent

Air

High (~20%) O_2 content

Temperature = 130ºC



Air : 95.4
H_2S : 0.5 vol.%
SO_2 : 0.12 vol.%
$S_{(vap)}$: 0.1 vol.%
N_2 : 3.9 vol.%

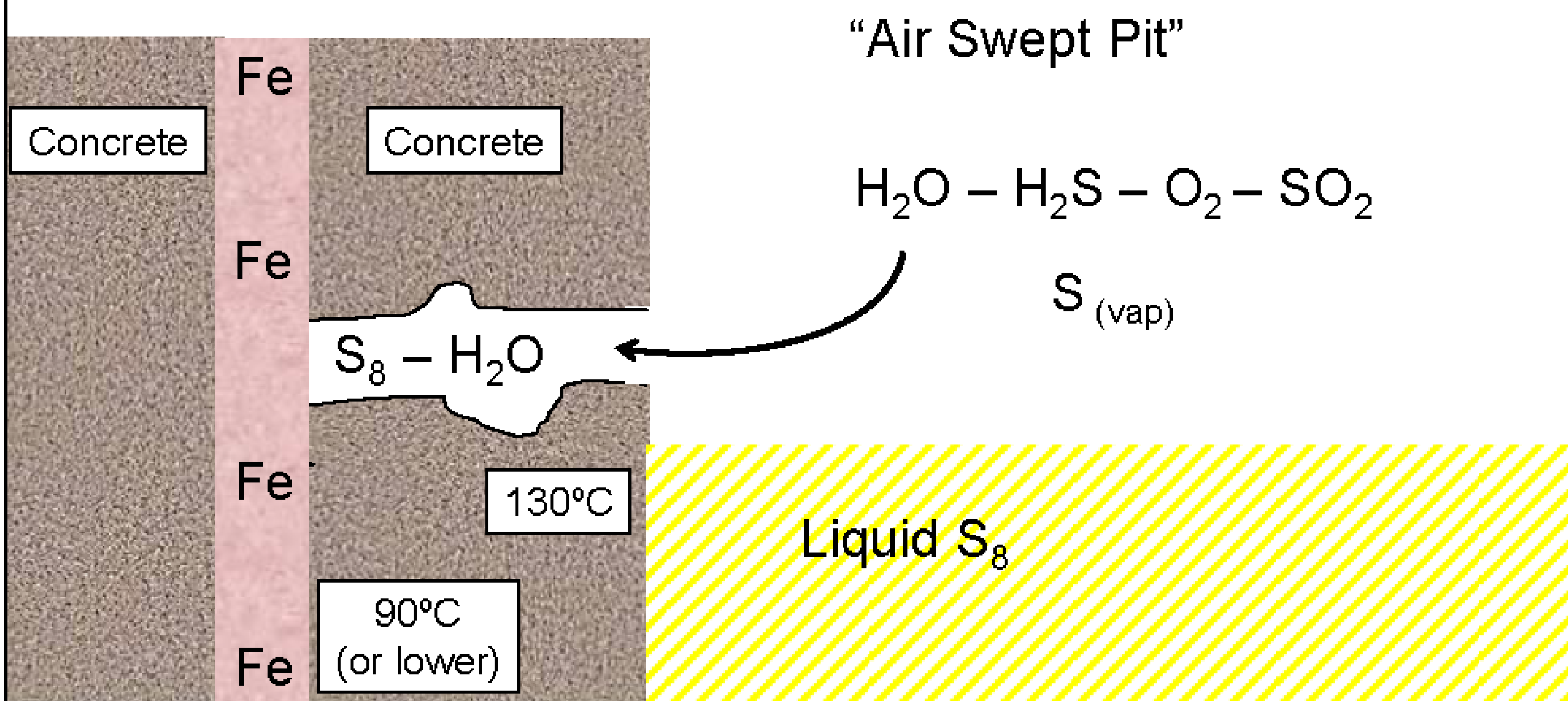
Field Parameters and Assumptions:

1) Air flow is such so as to keep $H_2S \leq 0.5$ vol.%.
2) Some SO_2 is formed in the head space.
3) Air is saturated with sulfur vapor.

Clark, P. D.; Huang, M.; Dowling, N. I.; "Control of Sulfur Run-Down Pits and Liquid Sulfur Storage Tanks Emissions"; Brimstone Sulfur Symposium, Vail, CO (Sep 11-14, 2007); p 4.

Sulfur Pit Construction: Materials Selection

Re-enforcing steel rod corrosion



$$Fe + {}^{1}/_{8}\, S_8 \xrightarrow{\text{Condensed } H_2O} FeS \text{ [pyrophoric iron sulfide]}$$

Consequence: Loss of structural integrity

Clark, P. D.; Dowling, N. I.; Bernard, F.; "Corrosion Pathways in Liquid Sulfur Run-Down Pits and Other Liquids Sulfur Handling Facilities"; Brimstone Sulfur Symposium, Vail, CO (Sep 15-18, 2009); p 7.

SRU/TGTU Improvements
(Rahija 2007)

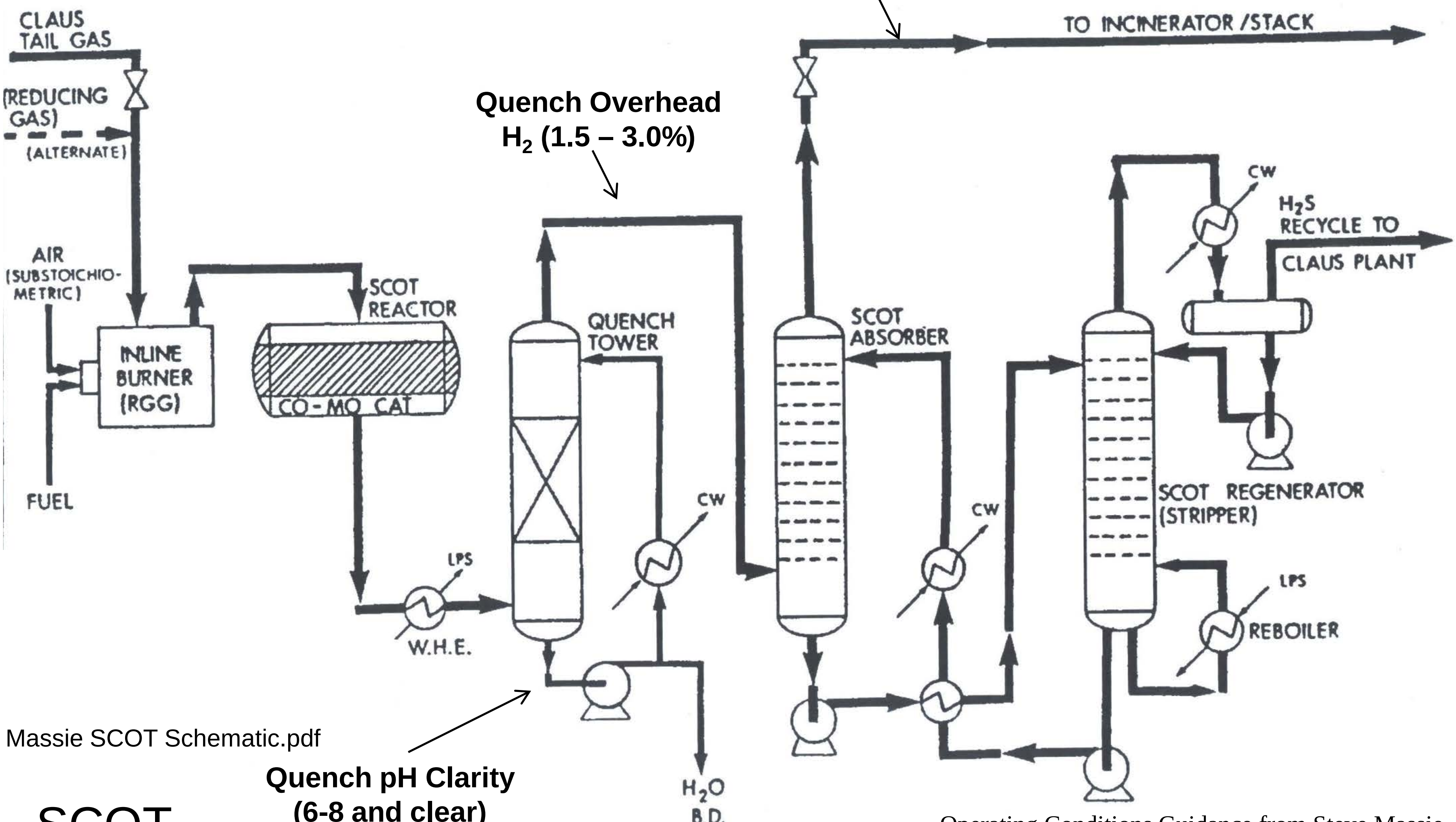
1. Flame Scanners – Redundant IRIS 550 (UV/IR)
2. Redundant front chamber pyrometers
3. Updated rear chamber pyrometer
4. Emergency Isolation Valves – Class 6 Tight Shutoff
5. *STACKMATCH* ignition system
6. Ametek 900 Series for Ratio Analyzer

7. Routed start-up vent into incinerator
8. Voting safety shutdown system
9. Instrument air purge supply changed from burner air plenum to supply header with nitrogen as back-up
10. Three SLS 500 PLC's changed to one Allen Bradley control logic processor with redundancy.
11. New catalyst system – 33% Titanium in converter 1, Pre-activated Low Temperature TGTU Catalyst
12. Incinerator waste heat boiler operation

Rahija, Joe; "Improving Sulfur Plant Performance and Instrumentation"; Brimstone Sulfur Symposium, Vail, CO (Sep 11-14, 2007); p 4, 16.

CO/H_2 Ratio in Off Gas
(CO <100 ppm)

Quench Overhead
H_2 (1.5 – 3.0%)



Massie SCOT Schematic.pdf

Quench pH Clarity
(6-8 and clear)

SCOT

Operating Conditions Guidance from Steve Massie.
Also, Bruce Scott Papers Brimstone 1994.

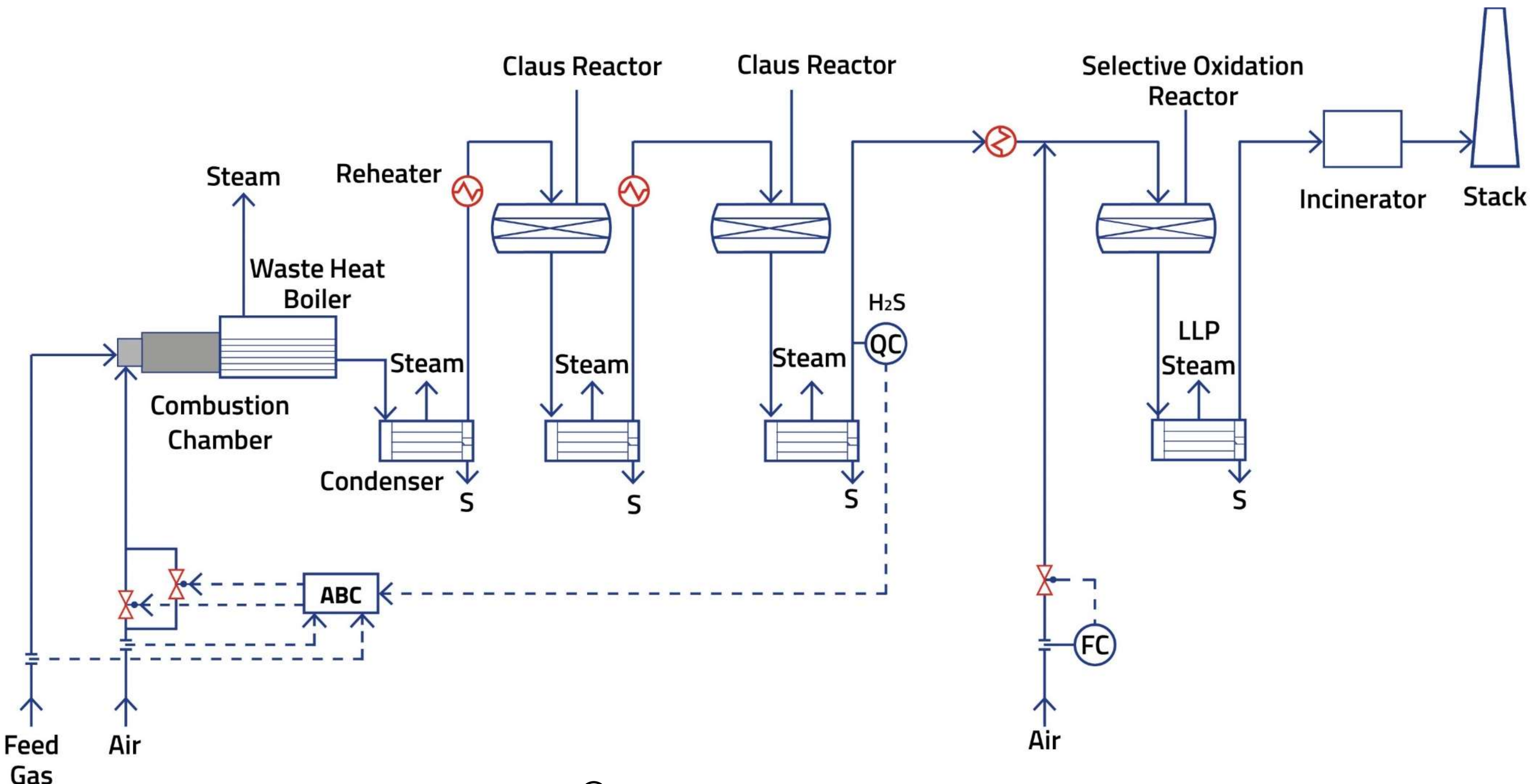
1. Direct - Oxidation reaction at end of Claus Process, 99% overall recovery
Normal Claus plant operation except the $H_2S:SO_2$ ratio is above 2:1 - that is an excess of H_2S.

2. The H_2S excess results in almost all of the SO_2 being consumed, leaving only 0.8-3.0 vol % H_2S along with other sulfur compounds such as COS, CS_2 after the second reactor.

3. Air is added ahead of the third reactor where direct oxidation of H_2S takes place:

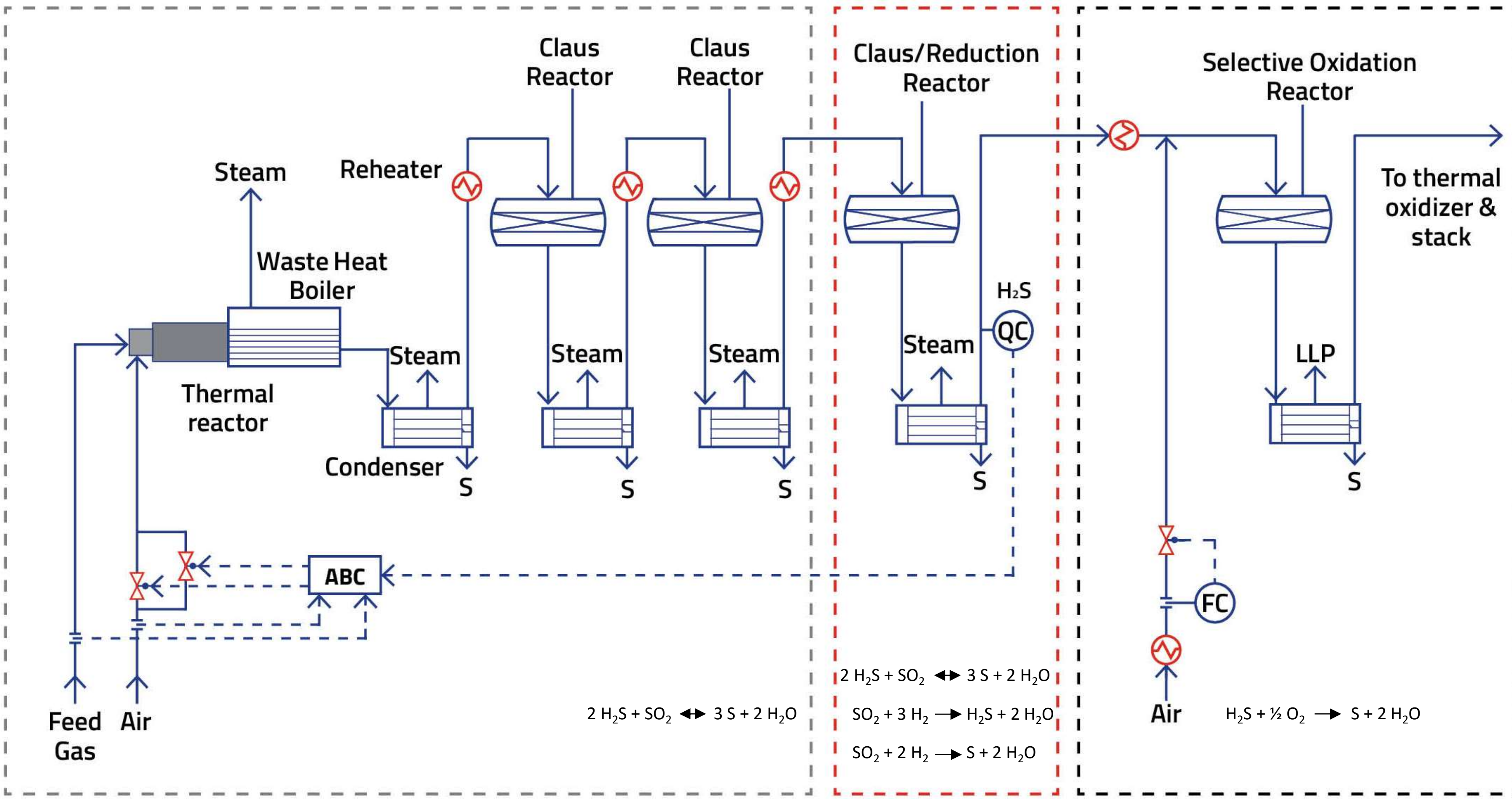
$$H_2S + \tfrac{1}{2} O_2 \rightarrow S + H_2O$$ **with very little SO_2 formation.**

Reference: Lagas, J.A., Borsboom, J., & Berben, P.H., "The SuperClaus Process", 38th Annual Laurance Reid Gas Conditioning Conference - Proceedings Addendum pp. 41-59, University of Oklahoma, Norman, Oklahoma, Mar. 7-9, 1988.

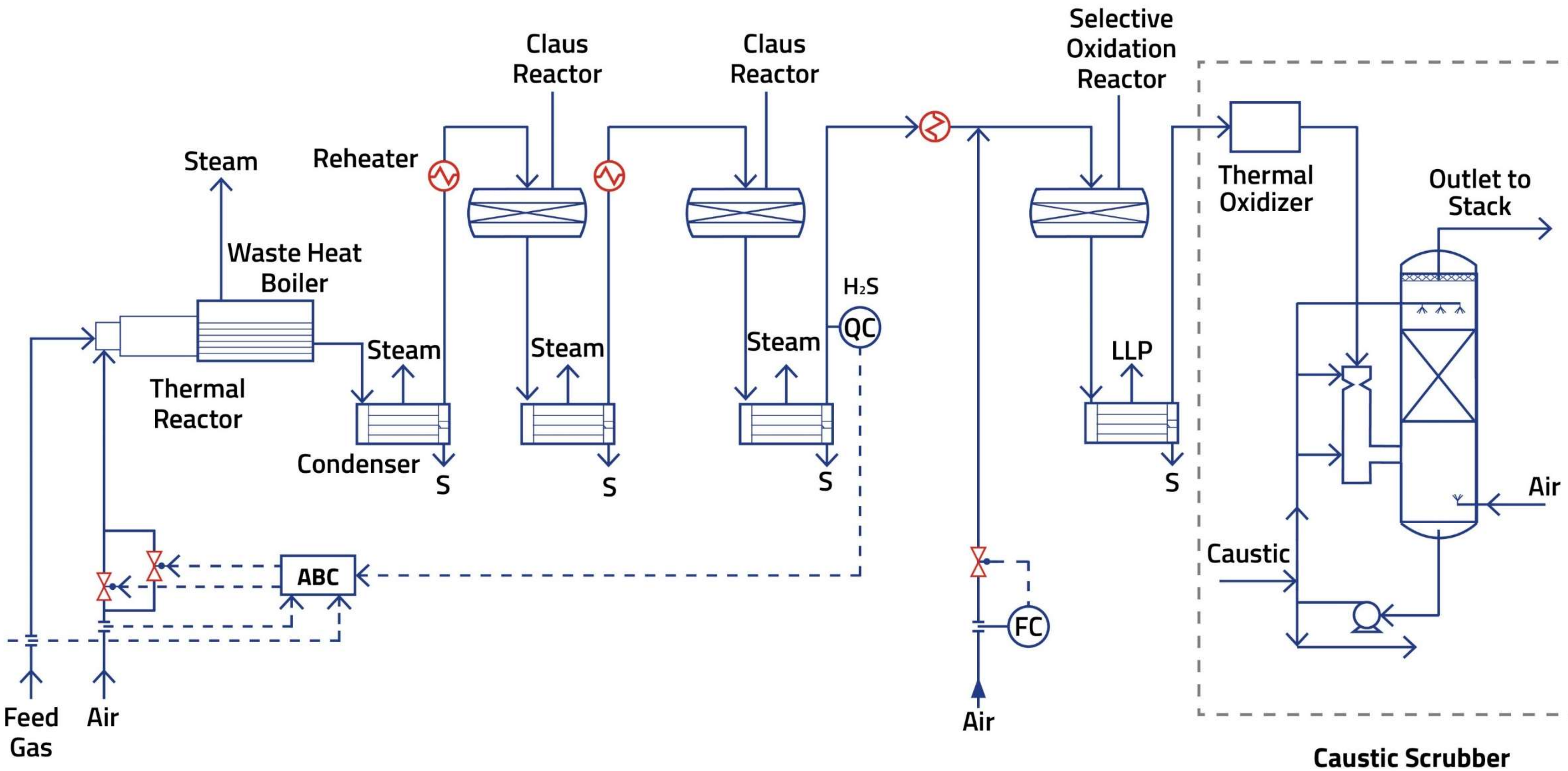


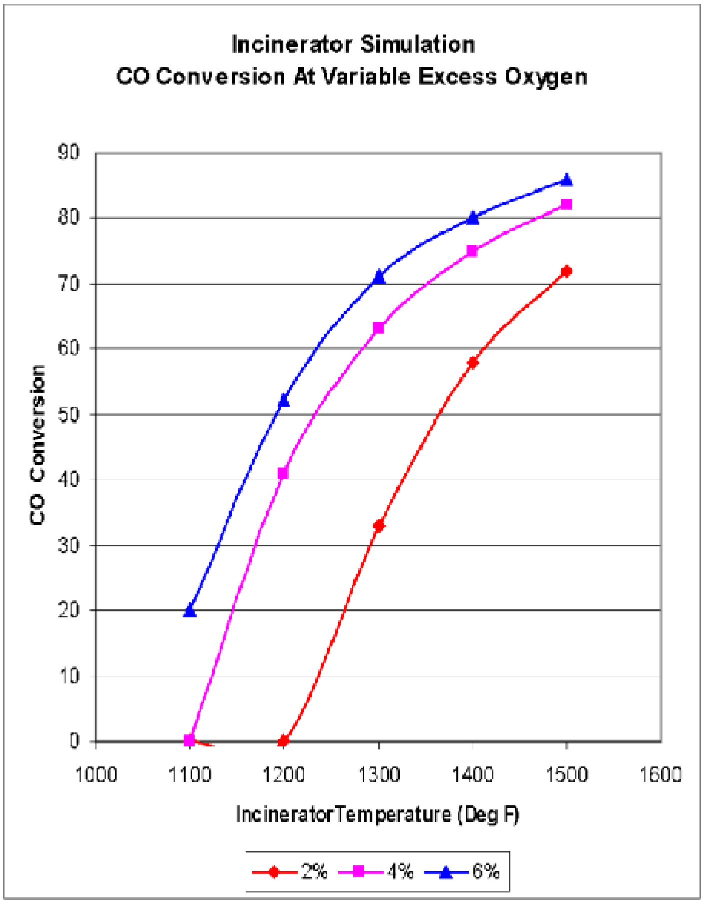
SUPERCLAUS® process

EUROCLAUS® process



SUPERCLAUS® with scrubber





- **1200 Deg F minimum in hot zone for CO oxidation**
- **One second residence time hampers oxidation efficiency**

- **As TGTU catalyst deactivates, CO load increases**
- **Optimum conditions for CO oxidation are 1400 Deg F and 4% excess oxygen.**

Rahija, Joe; "Improving Sulfur Plant Performance and Instrumentation"; Brimstone Sulfur Symposium, Vail, CO (Sep 11-14, 2007); p 4, 16.

TYPICAL EMISSIONS LEVELS – MID 90's EXAMPLE WITH 2% (WET) O_2

Operating Temperature	**649°C [1200°F]**		**816°C [1500°F]**	
H_2S	<10 ppm		<5 ppm	
TRS	<20 ppm		<10 ppm	
	g/GJ	**lb/MMBtu**	**g/GJ**	**lb/MMBtu**
CO	43	0.1	34	0.08
	(not including incoming levels)			
NO_x	43	0.1	43	0.1
VOC	43	0.1	21	0.05
$LoNO_x$ Burner	21	0.05	26	0.06

Connally, Carl; "Incinerator Design"; Brimstone Sulfur Symposium, Vail, CO (Sep. 19-22, 1995); p 15.

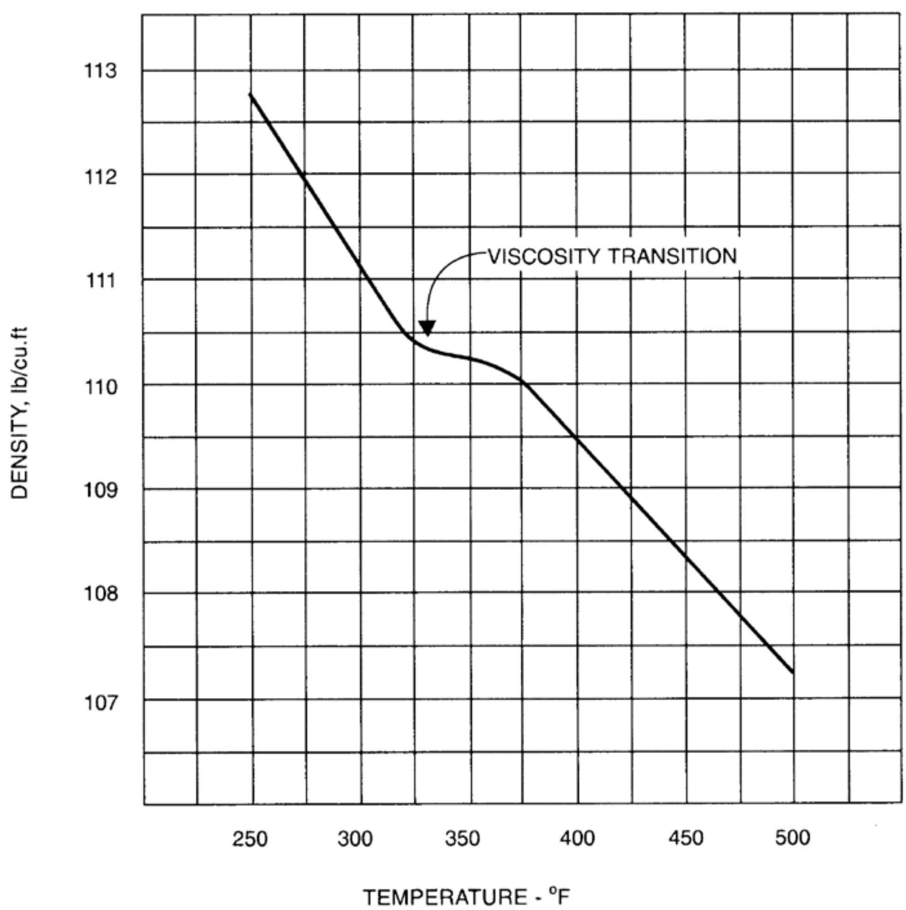
SULFUR PRODUCT SPECIFICATIONS

A sulfur product meeting the following specifications will normally satisfy the requirements of the major consumers of sulfur such as manufacturers of sulfuric acid, chemicals, fertilizers, etc.:

Purity	:	99.5%-99.8% by weight (dry basis)
Acidity (as H_2SO_4)	:	Less than 0.05% by weight
Moisture	:	Nil to 1.0% by weight
Ash	:	Less than 0.1% by weight
Carbonaceous Matter	:	Less than 0.15% by weight
Arsenic, Tellurium, Selenium	:	Commercially Free*
Color (see Note Below)	:	Bright yellow at ambient temperature

*Contents of less than 0.25 ppmw of arsenic and 2.0 ppmw of selenium and tellurium are usually considered as "commercially free".

NOTE: The color of sulfur is an important property because it gives an immediate indication of product purity. The sulfur is a bright yellow if the impurity content is less than about 0.02% by weight. Small amounts of carbon (soot) change the bright yellow color to dull yellow or green; "dark" sulfur in which the yellow color has a shade of gray or brown usually contains 0.1%-0.5% by weight of carbon. For sulfuric acid manufacturers, however, sulfur color is usually less important than ash and heavy metal contents.



Density of Liquid Sulfur **GPSA 12th Edition 2004**

BRIMSTONE STS, LTD.

SULFUR RECOVERY

SYMPOSIUM

COMPUTER SIMULATION

This section contains an abbreviated output for a refinery sulfur plant simulation. It is a non-optimized run. The output is summarized on a completed run summary sheet that follows the output pages. A blank summary sheet is also provided for the use of attendees at their work locations.

The simulation was run on the Bryan Research and Engineering, Inc., (BRE Group, Ltd.) ProMax® program. This program also contains elements of the earlier TSWEET® program.

Bryan Research & Engineering, Inc.
P.O. Box 4747
Bryan, Texas 77805
TEL (979) 776-5220
FAX (979) 776-4818
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Technical Sales
b.burr@bre.com

EXAMPLE CLAUS PLANT SIMULATION

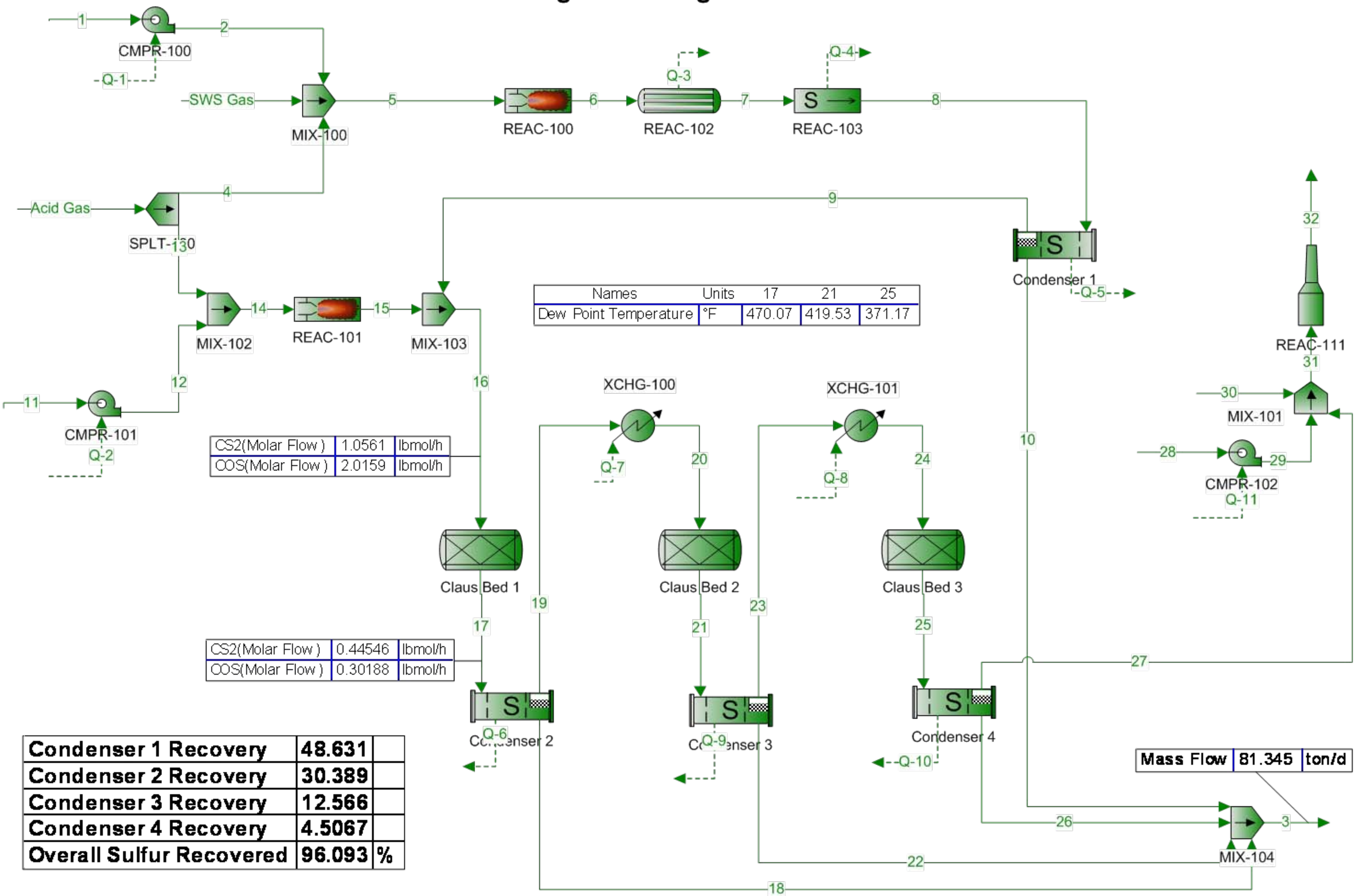
Bryan Research & Engineering, Inc – BR&E
ProMax® 2011

This is a non-optimized example simulation.

Contents of full output file:

PFD (only the enlarged page)	1 page	included here
All Streams (Individual stream props.)	7 pages	included here
Energy Stream Report	1 page	included here
Blocks	36 pages	not included
(Equipment, Simulation blocks, etc)		
Claus Beds		
Compressors (Blowers)		
Condensers		
Mixers		
Reactors		
Splitters		
Heat Exchangers		
Environment & Environment Reports		
(i.e. Simulation defaults etc.)	2 pages	not included here
Calculator Report	5 pages	not included here
User Value Sets Report	3 pages	not included here
Recoveries Report	11 pages	only p. 8 (of 11 included)
Energy Budgets Reports	3 pages	included here

Morgan Refining Claus Train #1



Names	Units	17	21	25
Dew Point Temperature	°F	470.07	419.53	371.17

CS2(Molar Flow)	1.0561	lbmol/h
COS(Molar Flow)	2.0159	lbmol/h

CS2(Molar Flow)	0.44546	lbmol/h
COS(Molar Flow)	0.30188	lbmol/h

Mass Flow	81.345	ton/d

Condenser 1 Recovery	**48.631**	
Condenser 2 Recovery	**30.389**	
Condenser 3 Recovery	**12.566**	
Condenser 4 Recovery	**4.5067**	
Overall Sulfur Recovered	**96.093**	**%**

Process Streams Report
All Streams
Tabulated by Total Phase

Client Name:		Job:	
Location:			
Flowsheet:	Flowsheet1		

Connections

	Acid Gas	SWS Gas	1	2	3
From Block	--	--	--	CMPR-100	MIX-104
To Block	SPLT-100	MIX-100	CMPR-100	MIX-100	--

Stream Composition

Molar Flow	Acid Gas lbmol/h	SWS Gas lbmol/h	1 lbmol/h	2 lbmol/h	3 lbmol/h
NH3	0 *	38 *	0 *	0	2.78352E-10
N2	4 *	2 *	551.178 *	551.178	4.7013E-06
H2S	170 *	50 *	0 *	0	0.0150922
CS2	0 *	0 *	0 *	0	1.55522E-06
COS	0 *	0 *	0 *	0	1.2255E-07
SO2	0 *	0 *	0 *	0	1.48621E-05
H2	0 *	0 *	0 *	0	3.06491E-07
CO	0 *	0 *	0 *	0	3.93296E-08
CO2	20 *	5 *	0 *	0	6.69678E-06
H2O	10.981 *	65.36 *	7.06638 *	7.06638	1.68358E-05
CH4	4 *	2.5 *	0 *	0	0
C2H6	2 *	1.5 *	0 *	0	0
C3H8	0 *	1 *	0 *	0	0
O2	0 *	0 *	148.394 *	148.394	4.73012E-14
S1	0 *	0 *	0 *	0	0
S2	0 *	0 *	0 *	0	0.0120172
S3	0 *	0 *	0 *	0	0.00137028
S4	0 *	0 *	0 *	0	0.00129891
S5	0 *	0 *	0 *	0	0.134459
S6	0 *	0 *	0 *	0	4.69615
S7	0 *	0 *	0 *	0	2.71822
S8	0 *	0 *	0 *	0	20.435

Stream Properties

Property	Units	Acid Gas	SWS Gas	1	2	3
Temperature	°F	110 *	195 *	70 *	177.047	370.436
Pressure	psia	25 *	23 *	14.6959 *	22.7 *	17.5
Mole Fraction Vapor	%	99.9703	100	100	100	0
Mole Fraction Light Liquid	%	0.0297399	0	0	0	100
Mole Fraction Heavy Liquid	%	0	0	0	0	0
Molecular Weight	lb/lbmol	33.6908	23.7909	28.7504	28.7504	241.98
Mass Density	lb/ft^3	0.139299	0.0786376	0.0743637	0.0955041	110.015
Molar Flow	lbmol/h	210.981	165.36	706.638 *	706.638	28.0136
Mass Flow	lb/h	7108.13	3934.06	20316.1	20316.1	6778.73
Vapor Volumetric Flow	ft^3/h	51028	50027.8	273199	212725	61.6166
Liquid Volumetric Flow	gpm	6361.93	6237.23	34061.2	26521.5	7.68207
Std Vapor Volumetric Flow	MMSCFD	1.92154	1.50604	6.4358	6.4358	0.255138
Std Liquid Volumetric Flow	sgpm	18.09	10.0852	46.8184	46.8184	7.1693
Compressibility		0.989049	0.990426	0.999563	1.00008	0.00432084
Specific Gravity			0.821435	0.992672	0.992672	1.76393
API Gravity						-55.5716
Enthalpy	Btu/h	-6.18169E+06	-8.8543E+06	-771853	-242747	640227
Mass Enthalpy	Btu/lb	-869.665	-2250.68	-37.9922	-11.9485	94.4464
Mass Cp	Btu/(lb*°F)	0.249993	0.365115	0.243294	0.244453	0.306561
Ideal Gas CpCv Ratio		1.31286	1.29989	1.3977	1.39514	1.05485
Dynamic Viscosity	cP		0.0141661	0.0181119	0.0208487	350.883
Kinematic Viscosity	cSt		11.2461	15.2048	13.6282	199.109
Thermal Conductivity	Btu/(h*ft*°F)		0.0140076	0.0146553	0.0171165	0.0864803 ?
Surface Tension	lbf/ft					0.00377062

Remarks

Process Streams Report
All Streams
Tabulated by Total Phase

Client Name:		Job:
Location:		
Flowsheet:	Flowsheet1	

Connections

	4	5	6	7	8
From Block	SPLT-100	MIX-100	REAC-100	REAC-102	REAC-103
To Block	MIX-100	REAC-100	REAC-102	REAC-103	Condenser 1

Stream Composition

Molar Flow	4 lbmol/h	5 lbmol/h	6 lbmol/h	7 lbmol/h	8 lbmol/h
NH3	0	38	0.000517257	5.01279E-05	5.01279E-05
N2	3.85176	557.029	576.029	576.029	576.029
H2S	163.7	213.7	39.0048	58.7086	58.7086
CS2	0	0	0.765404	0.765404	0.765404
COS	0	0	1.86752	1.86752	1.86752
SO2	0	0	32.4063	26.0957	26.0957
H2	0	0	44.3541	18.2211	18.2211
CO	0	0	11.3547	5.16327	5.16327
CO2	19.2588	24.2588	26.4747	32.6661	32.6661
H2O	10.574	83.0004	297.322	303.752	303.752
CH4	3.85176	6.35176	1.42161E-08	0	0
C2H6	1.92588	3.42588	0	0	0
C3H8	0	1	0	0	0
O2	0	148.394	5.3431E-07	0	0
S1	0	0	0.0179213	1.58295E-07	0
S2	0	0	69.2591	58.8795	0.521527
S3	0	0	0.117131	1.6989	0.0558054
S4	0	0	0.000725843	0.211212	0.0356001
S5	0	0	9.34156E-06	0.159233	0.603936
S6	0	0	1.75043E-07	0.128326	6.12133
S7	0	0	2.8295E-09	0.0287913	3.99767
S8	0	0	0	0.00361437	7.05162

Stream Properties

Property	Units	4	5	6	7	8
Temperature	°F	110	165.318	2350.87	1200 *	640 *
Pressure	psia	25	22.7	22.2	21.7	21.1
Mole Fraction Vapor	%	99.9703	100	100	100	100
Mole Fraction Light Liquid	%	0.0297399	0	0	0	0
Mole Fraction Heavy Liquid	%	0	0	0	0	0
Molecular Weight	lb/lbmol	33.6908	28.9211	28.2944	28.6753	29.8514
Mass Density	lb/ft^3	0.139299	0.0980587	0.0208216	0.0349325	0.0533839
Molar Flow	lbmol/h	203.162	1075.16	1098.97	1084.38	1041.66
Mass Flow	lb/h	6844.7	31094.9	31094.9	31094.9	31094.9
Vapor Volumetric Flow	ft^3/h	49136.9	317105	1.49339E+06	890140	582476
Liquid Volumetric Flow	gpm	6126.16	39535.1	186189	110979	72620.4
Std Vapor Volumetric Flow	MMSCFD	1.85032	9.79216	10.009	9.87612	9.48702
Std Liquid Volumetric Flow	sgpm	17.4196	74.3232	68.1873	67.8078	67.8078
Compressibility		0.989049	0.998204	1.0002	1.00012	0.999792
Specific Gravity			0.998568	0.97693	0.99008	1.03069
API Gravity						
Enthalpy	Btu/h	-5.95259E+06	-1.50496E+07	-1.50496E+07	-2.80308E+07	-3.56162E+07
Mass Enthalpy	Btu/lb	-869.665	-483.991	-483.991	-901.461	-1145.4
Mass Cp	Btu/(lb*°F)	0.249993	0.260901	0.343135	0.305384	0.28559
Ideal Gas CpCv Ratio		1.31286	1.35906	1.25717	1.29349	1.30413
Dynamic Viscosity	cP		0.0186917	0.0558029 ?	0.0377523 ?	0.0287486 ?
Kinematic Viscosity	cSt		11.8999	167.31 ?	67.4672 ?	33.6191 ?
Thermal Conductivity	Btu/(h*ft*°F)		0.0155221	0.066291 ?	0.0389336 ?	0.0272716 ?
Surface Tension	lbf/ft					

Remarks

* User Specified Values
? Extrapolated or Approximate Values

ProMax 3.2.11188.0

Process Streams Report
All Streams
Tabulated by Total Phase

Client Name:		Job:	
Location:			
Flowsheet:	Flowsheet1		

Connections

	9	10	11	12	13
From Block	Condenser 1	Condenser 1	--	CMPR-101	SPLT-100
To Block	MIX-103	MIX-104	CMPR-101	MIX-102	MIX-102

Stream Composition

Molar Flow	9 lbmol/h	10 lbmol/h	11 lbmol/h	12 lbmol/h	13 lbmol/h
NH3	5.01278E-05	1.30362E-10	0 *	0	0
N2	576.029	3.176E-06	27.8743 *	27.8743	0.148239
H2S	58.6965	0.0121452	0 *	0	6.30016
CS2	0.765403	1.06181E-06	0 *	0	0
COS	1.86752	1.11344E-07	0 *	0	0
SO2	26.0957	1.13146E-05	0 *	0	0
H2	18.2211	2.02793E-07	0 *	0	0
CO	5.16327	2.64997E-08	0 *	0	0
CO2	32.6661	3.84331E-06	0 *	0	0.741196
H2O	303.752	8.3285E-06	0.357362 *	0.357362	0.406953
CH4	0	0	0 *	0	0.148239
C2H6	0	0	0 *	0	0.0741196
C3H8	0	0	0 *	0	0
O2	0	0	7.50461 *	7.50461	0
S1	0	0	0 *	0	0
S2	0.00140072	0.00812169	0 *	0	0
S3	0.00016384	0.000949276	0 *	0	0
S4	0.000154843	0.000896514	0 *	0	0
S5	0.0139492	0.0807075	0 *	0	0
S6	0.43742	2.52912	0 *	0	0
S7	0.268676	1.55243	0 *	0	0
S8	1.74282	10.0635	0 *	0	0

Stream Properties

Property	Units	9	10	11	12	13
Temperature	°F	400 *	400	70 *	180.48	110
Pressure	psia	20.7	20.7	14.6959 *	23 *	25
Mole Fraction Vapor	%	100	0	100	100	99.9703
Mole Fraction Light Liquid	%	0	100	0	0	0.0297399
Mole Fraction Heavy Liquid	%	0	0	0	0	0
Molecular Weight	lb/lbmol	26.9705	240.779	28.7504	28.7504	33.6908
Mass Density	lb/ft^3	0.0605605	109.399	0.0743637	0.0962456	0.139299
Molar Flow	lbmol/h	1025.72	14.2479	35.7362 *	35.7362	7.81891 *
Mass Flow	lb/h	27664.3	3430.59	1027.43	1027.43	263.426
Vapor Volumetric Flow	ft^3/h	456803	31.3585	13816.3	10675.1	1891.09
Liquid Volumetric Flow	gpm	56952.1	3.90963	1722.55	1330.92	235.772
Std Vapor Volumetric Flow	MMSCFD	9.34189	0.129764	0.325472	0.325472	0.0712117
Std Liquid Volumetric Flow	sgpm	64.1793	3.62847	2.36771	2.36771	0.670411
Compressibility		0.999251	0.00493833	0.999563	1.0001	0.989049
Specific Gravity		0.93122	1.75406	0.992672	0.992672	
API Gravity			-55.5808			
Enthalpy	Btu/h	-3.86201E+07	354444	-39034.3	-11415.5	-229092
Mass Enthalpy	Btu/lb	-1396.03	103.319	-37.9922	-11.1108	-869.665
Mass Cp	Btu/(lb*°F)	0.291717	0.293227	0.243294	0.2445	0.249993
Ideal Gas CpCv Ratio		1.33845	1.05485	1.3977	1.39503	1.31286
Dynamic Viscosity	cP	0.0236532	442.467	0.0181119	0.0209332	
Kinematic Viscosity	cSt	24.3825	252.492	15.2048	13.578	
Thermal Conductivity	Btu/(h*ft*°F)	0.022038	0.0909103 ?	0.0146553	0.0171937	
Surface Tension	lbf/ft		0.00370579			

Remarks

* User Specified Values
? Extrapolated or Approximate Values

ProMax 3.2.11188.0

Process Streams Report
All Streams
Tabulated by Total Phase

Client Name:		Job:	
Location:			
Flowsheet:	Flowsheet1		

Connections

	14	15	16	17	18
From Block	MIX-102	REAC-101	MIX-103	Claus Bed 1	Condenser 2
To Block	REAC-101	MIX-103	Claus Bed 1	Condenser 2	MIX-104

Stream Composition

Molar Flow	14 lbmol/h	15 lbmol/h	16 lbmol/h	17 lbmol/h	18 lbmol/h
NH3	0	3.70132E-06	5.38291E-05	5.38291E-05	9.14788E-11
N2	28.0225	28.0225	604.052	604.052	1.19951E-06
H2S	6.30016	0.0740734	58.7706	24.9943	0.00259079
CS2	0	0.290704	1.05611	0.445463	3.35619E-07
COS	0	0.148387	2.0159	0.301875	8.17838E-09
SO2	0	4.75577	30.8514	12.4957	3.03465E-06
H2	0	0.88721	19.1083	19.1083	8.04793E-08
CO	0	0.223292	5.38657	5.38657	1.00594E-08
CO2	0.741196	0.375291	33.0414	35.3661	2.01972E-06
H2O	0.764316	6.62203	310.374	344.15	5.50991E-06
CH4	0.148239	0	0	0	0
C2H6	0.0741196	0	0	0	0
C3H8	0	0	0	0	0
O2	7.50461	5.13048E-05	5.13048E-05	2.56524E-06	4.67964E-14
S1	0	0.0069068	0.0069068	0.00034534	0
S2	0	0.36666	0.36806	0.306026	0.0030232
S3	0	0.000101013	0.000264852	0.0295141	0.000332943
S4	0	0	0.000154843	0.0184978	0.000317858
S5	0	0	0.0139492	0.34333	0.0386034
S6	0	0	0.43742	3.64957	1.44613
S7	0	0	0.268676	2.25305	0.811653
S8	0	0	1.74282	4.27111	6.5368

Stream Properties

Property	Units	14	15	16	17	18
Temperature	°F	165.359	3044.17	518.202	610.04	360
Pressure	psia	23	22.9	20.7	20.3	19.9
Mole Fraction Vapor	%	100	100	100	100	0
Mole Fraction Light Liquid	%	0	0	0	0	100
Mole Fraction Heavy Liquid	%	0	0	0	0	0
Molecular Weight	lb/lbmol	29.6373	30.9017	27.1244	27.3892	242.522
Mass Density	lb/ft^3	0.101699	0.0188153	0.0535217	0.0484433	110.231
Molar Flow	lbmol/h	43.5551	41.773	1067.49	1057.17	8.83946
Mass Flow	lb/h	1290.85	1290.85	28955.1	28955.1	2143.76
Vapor Volumetric Flow	ft^3/h	12692.9	68606.7	540998	597711	19.448
Liquid Volumetric Flow	gpm	1582.5	8553.56	67449	74519.9	2.42469
Std Vapor Volumetric Flow	MMSCFD	0.396684	0.380453	9.72234	9.62833	0.0805066
Std Liquid Volumetric Flow	sgpm	3.03812	2.81093	66.9903	65.4826	2.26717
Compressibility		0.999279	1.00023	0.999664	0.999798	0.00497736
Specific Gravity		1.02329	1.06695	0.936531	0.945676	1.76739
API Gravity						-55.5677
Enthalpy	Btu/h	-240507	-240507	-3.88606E+07	-3.88606E+07	195574
Mass Enthalpy	Btu/lb	-186.316	-186.316	-1342.1	-1342.1	91.2291
Mass Cp	Btu/(lb*°F)	0.245987	0.319454	0.294282	0.299448	0.313248
Ideal Gas CpCv Ratio		1.37598	1.25184	1.33178	1.31996	1.05483
Dynamic Viscosity	cP	0.0196055	0.0671385 ?	0.0263505 ?	0.0282302 ?	381.265
Kinematic Viscosity	cSt	12.0349	222.761 ?	30.7353 ?	36.3797 ?	215.926
Thermal Conductivity	Btu/(h*ft*°F)	0.0159791	0.0701996 ?	0.0248423 ?	0.0273699 ?	0.0851027 ?
Surface Tension	lbf/ft					0.00379403

Remarks

Process Streams Report
All Streams
Tabulated by Total Phase

Client Name:		Job:	
Location:			
Flowsheet:	Flowsheet1		

Connections

	19	20	21	22	23
From Block	Condenser 2	XCHG-100	Claus Bed 2	Condenser 3	Condenser 3
To Block	XCHG-100	Claus Bed 2	Condenser 3	MIX-104	XCHG-101

Stream Composition

Molar Flow	19 lbmol/h	20 lbmol/h	21 lbmol/h	22 lbmol/h	23 lbmol/h
NH3	5.3829E-05	5.3829E-05	5.3829E-05	4.06319E-11	5.3829E-05
N2	604.052	604.052	604.052	2.74595E-07	604.052
H2S	24.9917	24.9917	9.80853	0.000320474	9.80821
CS2	0.445463	0.445463	0.445463	1.2071E-07	0.445463
COS	0.301875	0.301875	0.301875	2.4248E-09	0.301875
SO2	12.4957	12.4957	4.90411	4.47307E-07	4.90411
H2	19.1083	19.1083	19.1083	1.94018E-08	19.1083
CO	5.38657	5.38657	5.38657	2.33014E-09	5.38657
CO2	35.3661	35.3661	35.3661	6.52413E-07	35.3661
H2O	344.15	344.15	359.333	2.23775E-06	359.333
CH4	0	0	0	0	0
C2H6	0	0	0	0	0
C3H8	0	0	0	0	0
O2	2.56524E-06	2.56524E-06	1.28262E-07	4.97549E-16	1.28262E-07
S1	0	0	0	0	0
S2	0.000336718	0.000336718	0.0180212	0.000725343	6.80785E-05
S3	3.71098E-05	3.71098E-05	0.00193685	7.42872E-05	6.97732E-06
S4	3.54536E-05	3.54536E-05	0.00146869	7.13229E-05	6.7035E-06
S5	0.00430874	0.00430874	0.0605614	0.0119856	0.00112726
S6	0.161521	0.161521	1.10455	0.544153	0.0512121
S7	0.090715	0.090715	0.663119	0.275094	0.0259069
S8	0.731072	0.731072	2.32879	2.79911	0.263777

Stream Properties

Property	Units	19	20	21	22	23
Temperature	°F	360 *	450 *	488.978	320	320 *
Pressure	psia	19.9	19.6	19.1	18.7	18.7
Mole Fraction Vapor	%	100	100	100	0	100
Mole Fraction Light Liquid	%	0	0	0	100	0
Mole Fraction Heavy Liquid	%	0	0	0	0	0
Molecular Weight	lb/lbmol	25.6008	25.6008	25.7088	244.1	24.9506
Mass Density	lb/ft^3	0.0579671	0.0514257	0.0482533	111.048	0.05582
Molar Flow	lbmol/h	1047.29	1047.29	1042.88	3.63154	1039.05
Mass Flow	lb/h	26811.4	26811.4	26811.4	886.459	25924.9
Vapor Volumetric Flow	ft^3/h	462527	521361	555638	7.98266	464437
Liquid Volumetric Flow	gpm	57665.8	65000.9	69274.4	0.99524	57903.9
Std Vapor Volumetric Flow	MMSCFD	9.53829	9.53829	9.4982	0.0330747	9.46326
Std Liquid Volumetric Flow	sgpm	63.2154	63.2154	62.5414	0.937452	61.6039
Compressibility		0.999131	0.999498	0.999585	0.00491274	0.998984
Specific Gravity		0.883926	0.883926	0.887657	1.7805	0.861478
API Gravity					-55.5551	
Enthalpy	Btu/h	-4.1544E+07	-4.08129E+07	-4.08129E+07	68911.9	-4.23953E+07
Mass Enthalpy	Btu/lb	-1549.49	-1522.23	-1522.23	77.7384	-1635.31
Mass Cp	Btu/(lb*°F)	0.301455	0.304408	0.30662	0.385474	0.306169
Ideal Gas CpCv Ratio		1.34735	1.34264	1.33736	1.05488	1.3522
Dynamic Viscosity	cP	0.0228098	0.0248651 ?	0.0256835 ?	11.1248	0.0218964
Kinematic Viscosity	cSt	24.5651	30.1848 ?	33.2281 ?	6.25403	24.4885
Thermal Conductivity	Btu/(h*ft*°F)	0.0215651	0.0237739 ?	0.024866 ?	0.080706 ?	0.0207916
Surface Tension	lbf/ft				0.00388098	

Remarks

Process Streams Report
All Streams
Tabulated by Total Phase

Client Name:		Job:	
Location:			
Flowsheet:	Flowsheet1		

Connections

	24	25	26	27	28
From Block	XCHG-101	Claus Bed 3	Condenser 4	Condenser 4	--
To Block	Claus Bed 3	Condenser 4	MIX-104	MIX-101	CMPR-102

Stream Composition

Molar Flow	24 lbmol/h	25 lbmol/h	26 lbmol/h	27 lbmol/h	28 lbmol/h
NH3	5.3829E-05	5.3829E-05	1.58789E-11	5.3829E-05	0 *
N2	604.052	604.052	5.11995E-08	604.052	221.333 *
H2S	9.80821	4.41888	3.56576E-05	4.41885	0 *
CS2	0.445463	0.445463	3.70732E-08	0.445463	0 *
COS	0.301875	0.301875	6.0332E-10	0.301875	0 *
SO2	4.90411	2.20945	6.5591E-08	2.20945	0 *
H2	19.1083	19.1083	3.81751E-09	19.1083	0 *
CO	5.38657	5.38657	4.40371E-10	5.38657	0 *
CO2	35.3661	35.3661	1.81335E-07	35.3661	0 *
H2O	359.333	364.722	7.59671E-07	364.722	2.8376 *
CH4	0	0	0	0	0 *
C2H6	0	0	0	0	0 *
C3H8	0	0	0	0	0 *
O2	1.28262E-07	6.4131E-09	7.28788E-18	6.4131E-09	59.5896 *
S1	0	0	0	0	0 *
S2	6.80785E-05	0.00201803	0.000146944	1.14271E-05	0 *
S3	6.97732E-06	0.000210827	1.37758E-05	1.072E-06	0 *
S4	6.7035E-06	0.000173646	1.32131E-05	1.02889E-06	0 *
S5	0.00112726	0.0123341	0.00316226	0.000246403	0 *
S6	0.0512121	0.318669	0.176744	0.0137807	0 *
S7	0.0259069	0.176629	0.0790466	0.00616721	0 *
S8	0.263777	0.93415	1.03559	0.0808482	0 *

Stream Properties

Property	Units	24	25	26	27	28
Temperature	°F	400 *	414.435	280	280 *	70 *
Pressure	psia	18.4	17.9	17.5	17.5	14.6959 *
Mole Fraction Vapor	%	100	100	0	100	100
Mole Fraction Light Liquid	%	0	0	100	0	0
Mole Fraction Heavy Liquid	%	0	0	0	0	0
Molecular Weight	lb/lbmol	24.9506	24.9889	245.542	24.7145	28.7504
Mass Density	lb/ft^3	0.0497945	0.0477121	111.854	0.0545505	0.0743637
Molar Flow	lbmol/h	1039.05	1037.46	1.29476	1036.11	283.76 *
Mass Flow	lb/h	25924.9	25924.9	317.918	25607	8158.21
Vapor Volumetric Flow	ft^3/h	520637	543361	2.84226	469418	109707
Liquid Volumetric Flow	gpm	64910.6	67743.8	0.35436	58524.8	13677.7
Std Vapor Volumetric Flow	MMSCFD	9.46326	9.44876	0.0117922	9.43652	2.58438
Std Liquid Volumetric Flow	sgpm	61.6039	61.3647	0.336202	61.0285	18.8006
Compressibility		0.99936	0.999413	0.00483962	0.998824	0.999563
Specific Gravity		0.861478	0.8628	1.79342	0.853324	0.992672
API Gravity				-55.5432		
Enthalpy	Btu/h	-4.17578E+07	-4.17578E+07	21297.3	-4.28986E+07	-309948
Mass Enthalpy	Btu/lb	-1610.72	-1610.72	66.9901	-1675.27	-37.9922
Mass Cp	Btu/(lb*°F)	0.308594	0.309388	0.247555	0.307248	0.243294
Ideal Gas CpCv Ratio		1.34829	1.34632	1.05501	1.3551	1.3977
Dynamic Viscosity	cP	0.0237437	0.0240551 ?	8.2681	0.0209609	0.0181119
Kinematic Viscosity	cSt	29.7677	31.4744 ?	4.61461	23.9878	15.2048
Thermal Conductivity	Btu/(h*ft*°F)	0.0227788	0.0231835 ?	0.077725 ?	0.0198685	0.0146553
Surface Tension	lbf/ft			0.00403942		

Remarks

* User Specified Values
? Extrapolated or Approximate Values

ProMax 3.2.11188.0

Process Streams Report
All Streams
Tabulated by Total Phase

Client Name:		Job:	
Location:			
Flowsheet:	Flowsheet1		

Connections

	29	30	31	32
From Block	CMPR-102	--	MIX-101	REAC-111
To Block	MIX-101	MIX-101	REAC-111	--

Stream Composition

Molar Flow	29 lbmol/h	30 lbmol/h	31 lbmol/h	32 lbmol/h
NH3	0	0 *	5.3829E-05	1.41876E-09
N2	221.333	0 *	825.385	825.385
H2S	0	0 *	4.41885	0
CS2	0	0 *	0.445463	0
COS	0	0 *	0.301875	0
SO2	0	0 *	2.20945	8.595
H2	0	0 *	19.1083	1.71822E-08
CO	0	0 *	5.38657	6.20603E-09
CO2	0	0 *	35.3661	59.548
H2O	2.8376	0 *	367.56	426.003
CH4	0	16.024 *	16.024	0
C2H6	0	0.50602 *	0.50602	0
C3H8	0	0.337347 *	0.337347	0
O2	59.5896	0 *	59.5896	2.64504
S1	0	0 *	0	0
S2	0	0 *	1.14271E-05	0
S3	0	0 *	1.072E-06	0
S4	0	0 *	1.02889E-06	0
S5	0	0 *	0.000246403	0
S6	0	0 *	0.0137807	0
S7	0	0 *	0.00616721	0
S8	0	0 *	0.0808482	0

Stream Properties

Property	Units	29	30	31	32
Temperature	°F	111.469	70 *	243.295	1199.98
Pressure	psia	17.5 *	17.5 *	17.5	17.4
Mole Fraction Vapor	%	100	100	99.995	100
Mole Fraction Light Liquid	%	0	0	0.00504506	0
Mole Fraction Heavy Liquid	%	0	0	0	0
Molecular Weight	lb/lbmol	28.7504	17.0243	25.4742	25.7548
Mass Density	lb/ft^3	0.0821065	0.0525723	0.0591515	0.0251557
Molar Flow	lbmol/h	283.76	16.8673 *	1336.74	1322.18
Mass Flow	lb/h	8158.21	287.155	34052.3	34052.3
Vapor Volumetric Flow	ft^3/h	99361.3	5462.09	575680	1.35366E+06
Liquid Volumetric Flow	gpm	12387.9	680.988	71773.1	168769
Std Vapor Volumetric Flow	MMSCFD	2.58438	0.153621	12.1745	12.0419
Std Liquid Volumetric Flow	sgpm	18.8006	1.85776	81.6868	79.977
Compressibility		0.999765	0.996968	0.999021	1.00021
Specific Gravity		0.992672	0.587804		0.889243
API Gravity					
Enthalpy	Btu/h	-227764	-548605	-4.3675E+07	-4.3675E+07
Mass Enthalpy	Btu/lb	-27.9184	-1910.49	-1282.58	-1282.58
Mass Cp	Btu/(lb*°F)	0.243668	0.517557	0.294056 ?	0.332962
Ideal Gas CpCv Ratio		1.39687	1.29234	1.3618	1.30147
Dynamic Viscosity	cP	0.019197	0.0109273		0.0402295
Kinematic Viscosity	cSt	14.596	12.9758		99.8362
Thermal Conductivity	Btu/(h*ft*°F)	0.0156217	0.0189572		0.0400306 ?
Surface Tension	lbf/ft				

Remarks

* User Specified Values
? Extrapolated or Approximate Values

Energy Stream Report

Client Name:		Job:	
Location:			
Flowsheet:	Flowsheet1		

Energy Streams

Energy Stream	Energy Rate		Power		From Block	To Block
Q-1	529106	Btu/h	207.946	hp	--	CMPR-100
Q-2	27618.8	Btu/h	10.8546	hp	--	CMPR-101
Q-3	1.29812E+07	Btu/h	5101.79	hp	REAC-102	--
Q-4	7.58537E+06	Btu/h	2981.16	hp	REAC-103	--
Q-5	2.64952E+06	Btu/h	1041.3	hp	Condenser 1	--
Q-6	2.48773E+06	Btu/h	977.716	hp	Condenser 2	--
Q-7	731012	Btu/h	287.299	hp	--	XCHG-100
Q-8	637566	Btu/h	250.573	hp	--	XCHG-101
Q-9	1.51347E+06	Btu/h	594.815	hp	Condenser 3	--
Q-10	1.11955E+06	Btu/h	440	hp	Condenser 4	--
Q-11	82183.8	Btu/h	32.2995	hp	--	CMPR-102

Remarks

Recoveries Report

Client Name:		Job:
Location:		

Component Recoveries - Sulfur Recovery [User Defined]

Status: Solved

Reference Stream Data Source - User Selection

Flowsheet	PStream	Flowsheet	PStream
Flowsheet1	Acid Gas	Flowsheet1	SWS Gas

Recovery Stream Data Source - User Selection

Flowsheet	PStream	Flowsheet	PStream
Flowsheet1	10	Flowsheet1	22
Flowsheet1	18	Flowsheet1	26

Parameters

Composition Basis	Molar Flow	* Atomic Basis	True
Calculate Ratios	True	Summation Only	False

Tabulated Data

Index	Flowsheet1:10 %	Flowsheet1:18 %	Flowsheet1:22 %	Flowsheet1:26 %
Hydrogen, Monatomic	0.0031913	0.000681749	8.47417E-05	9.56333E-06
Nitrogen, Monatomic	1.27042E-05	4.79823E-06	1.09846E-06	2.0483E-07
S1	48.6309	30.3894	12.5662	4.50672
Carbon, Graphite	1.21517E-05	5.71947E-06	1.87441E-06	5.288E-07
Oxygen, Monatomic	3.06964E-05	1.23767E-05	3.51584E-06	9.93E-07

Index	Summary Table %			
Hydrogen, Monatomic	0.00396735			
Nitrogen, Monatomic	1.88058E-05			
S1	96.0932			
Carbon, Graphite	2.02744E-05			
Oxygen, Monatomic	4.7582E-05			

Remarks

Component Recoveries - Flowsheet2 Inlets

Status: Solved

Recovery Stream Data Source - All Inlets in Flowsheet

Flowsheet	PStream	Flowsheet	PStream
Flowsheet2	1		

Parameters

* Composition Basis	Molar Flow	* Atomic Basis	False
* Calculate Ratios	False	* Summation Only	False

Tabulated Data

Index	Flowsheet2:1 lbmol/h	Summary Table lbmol/h		
NH3	0	0		
N2	28.0225	28.0225		
H2S	6.30016	6.30016		
CS2	0	0		
COS	0	0		
SO2	0	0		
H2	0	0		

Energy Budgets Report

Client Name:		Job:	
Location:			

Heat Budget - Project Power Budget

Status: Solved

Power Budget Data Source - All in Project

Flowsheet	Block	Flowsheet	Block
Flowsheet1	CMPR-100	Flowsheet1	CMPR-102
Flowsheet1	CMPR-101		

Parameters

Net Power	251.1 hp	Total Power Required	251.1 hp
Total Power Supplied	0 hp		

Tabulated Data

Index	Block Power hp	Compression Ratio	Delta P psi	Head ft
Flowsheet1:CMPR-100	207.946	1.54464	8.00405	13173.2
Flowsheet1:CMPR-101	10.8546	1.56506	8.30405	13596.9
Flowsheet1:CMPR-102	32.2995	1.1908	2.80405	5095.41

Remarks

Heat Budget - Project Heat Budget

Status: Solved

Heat Budget Data Source - All in Project

Flowsheet	Block	Flowsheet	Block
Flowsheet1	Condenser 1	Flowsheet1	REAC-103
Flowsheet1	Condenser 2	Flowsheet1	XCHG-100
Flowsheet1	Condenser 3	Flowsheet1	XCHG-101
Flowsheet1	Condenser 4	Flowsheet2	REAC-100
Flowsheet1	REAC-102		

Parameters

Net Duty	-2.81081E+07 Btu/h	Total Duty Required	1.36858E+06 Btu/h
Total Duty Supplied	2.94767E+07 Btu/h		

Tabulated Data

Index	Block Duty Btu/h	Block Highest Temperature °F	Block Lowest Temperature °F	
Flowsheet1:Condenser 1	-2.64952E+06	640	400	
Flowsheet1:Condenser 2	-2.48773E+06	610.04	360	
Flowsheet1:Condenser 3	-1.51347E+06	488.978	320	
Flowsheet1:Condenser 4	-1.11955E+06	414.435	280	
Flowsheet1:REAC-102	-1.29812E+07	2350.87	1200	
Flowsheet1:REAC-103	-7.58537E+06	1200	640	
Flowsheet1:XCHG-100	731012	450	360	
Flowsheet1:XCHG-101	637566	400	320	
Flowsheet2:REAC-100	-1.13986E+06	165.359	165.359	

Remarks

Heat Budget - Flowsheet1 Power Budget

Status: Solved

Energy Budgets Report

Client Name:		Job:	
Location:			

Power Budget Data Source - All in Flowsheet

Flowsheet	Block	Flowsheet	Block
Flowsheet1	CMPR-100	Flowsheet1	CMPR-102
Flowsheet1	CMPR-101		

Parameters

Net Power	251.1 hp	Total Power Required	251.1 hp
Total Power Supplied	0 hp		

Tabulated Data

Index	Block Power hp	Compression Ratio	Delta P psi	Head ft
Flowsheet1:CMPR-100	207.946	1.54464	8.00405	13173.2
Flowsheet1:CMPR-101	10.8546	1.56506	8.30405	13596.9
Flowsheet1:CMPR-102	32.2995	1.1908	2.80405	5095.41

Remarks

Heat Budget - Flowsheet1 Heat Budget

Status: Solved

Heat Budget Data Source - All in Flowsheet

Flowsheet	Block	Flowsheet	Block
Flowsheet1	Condenser 1	Flowsheet1	REAC-102
Flowsheet1	Condenser 2	Flowsheet1	REAC-103
Flowsheet1	Condenser 3	Flowsheet1	XCHG-100
Flowsheet1	Condenser 4	Flowsheet1	XCHG-101

Parameters

Net Duty	-2.69682E+07 Btu/h	Total Duty Required	1.36858E+06 Btu/h
Total Duty Supplied	2.83368E+07 Btu/h		

Tabulated Data

Index	Block Duty Btu/h	Block Highest Temperature °F	Block Lowest Temperature °F	
Flowsheet1:Condenser 1	-2.64952E+06	640	400	
Flowsheet1:Condenser 2	-2.48773E+06	610.04	360	
Flowsheet1:Condenser 3	-1.51347E+06	488.978	320	
Flowsheet1:Condenser 4	-1.11955E+06	414.435	280	
Flowsheet1:REAC-102	-1.29812E+07	2350.87	1200	
Flowsheet1:REAC-103	-7.58537E+06	1200	640	
Flowsheet1:XCHG-100	731012	450	360	
Flowsheet1:XCHG-101	637566	400	320	

Remarks

Heat Budget - Flowsheet2 Power Budget

Status: Solved

Parameters

Net Power	0 hp	Total Power Required	0 hp
Total Power Supplied	0 hp		

Remarks

Energy Budgets Report

Client Name:		Job:	
Location:			

Heat Budget - Flowsheet2 Heat Budget

Status: Solved

Heat Budget Data Source - All in Flowsheet

Flowsheet	Block	Flowsheet	Block
Flowsheet2	REAC-100		

Parameters

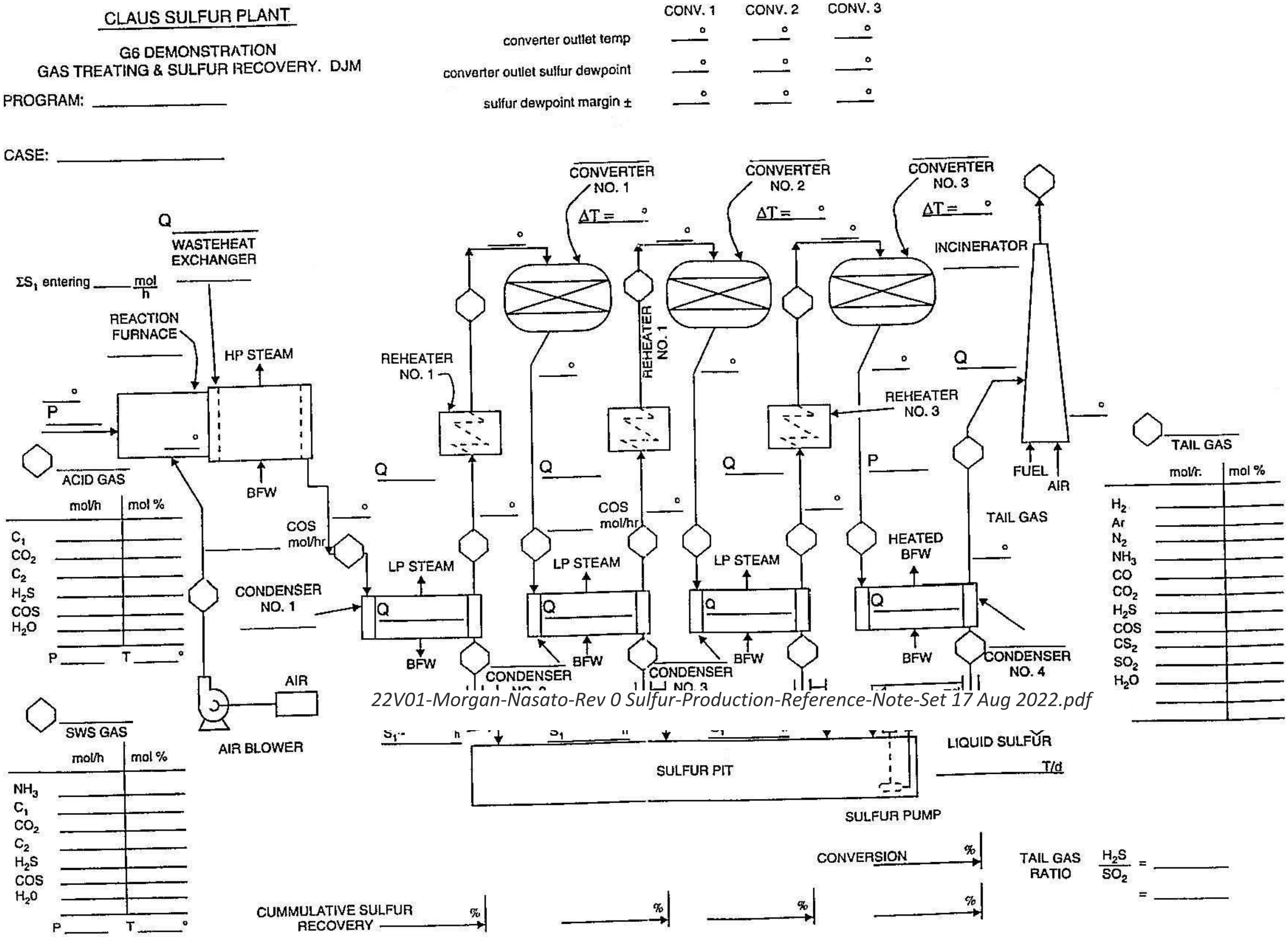
Net Duty	-1.13986E+06 Btu/h	Total Duty Required	0 Btu/h
Total Duty Supplied	1.13986E+06 Btu/h		

Tabulated Data

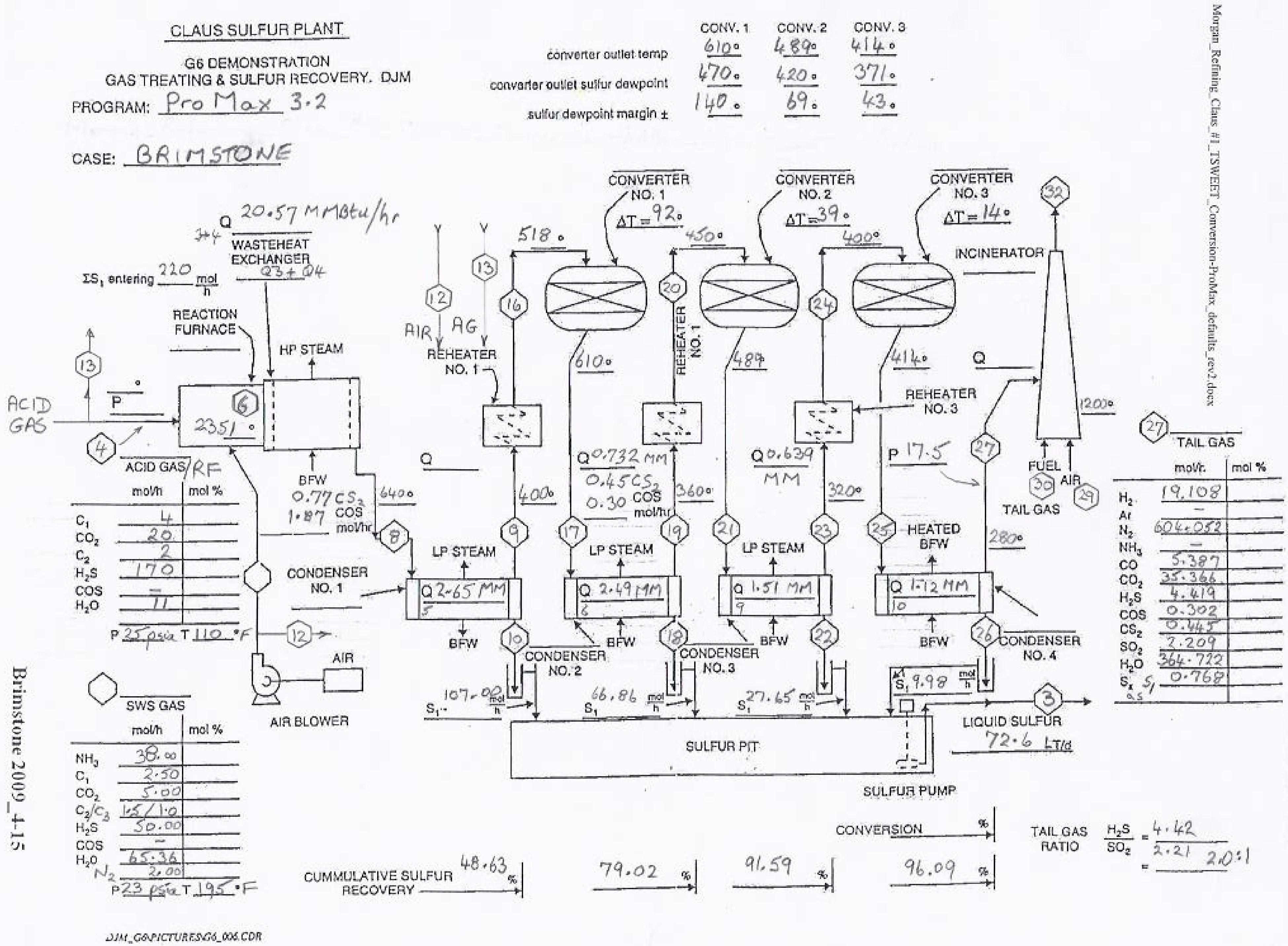
Index	Block Duty Btu/h	Block Highest Temperature °F	Block Lowest Temperature °F	
Flowsheet2:REAC-100	-1.13986E+06	165.359	165.359	

Remarks

END OF ABBREVIATED ProMax® OUTPUT



22V01-Morgan-Nasato-Rev 0 Sulfur-Production-Reference-Note-Set 17 Aug 2022.pdf


CLAUS SULFUR PLANT
G6 DEMONSTRATION
GAS TREATING & SULFUR RECOVERY. DJM
PROGRAM: Pro Max 3.2
CASE: BRIMSTONE
CONV. 1 CONV. 2 CONV. 3
converter outlet temp 610° 489° 414°
converter outlet sulfur dewpoint 470° 420° 371°
sulfur dewpoint margin ± 140° 69° 43°
CONVERTER NO. 1 ΔT = 92°
CONVERTER NO. 2 ΔT = 39°
CONVERTER NO. 3 ΔT = 14°
Q 20.57 MMBtu/hr
WASTEHEAT EXCHANGER Q3 + Q4
ΣS1 entering 220 mol/h
REACTION FURNACE
HP STEAM
ACID GAS
2351°
ACID GAS/RF
mol/h mol %
C1 4
CO2 20
C2 2
H2S 170
COS —
H2O 71
P 25 psia T 110 °F
BFW
0.77 CS2
1.87 COS
mol/hr
640°
CONDENSER NO. 1
AIR AG
REHEATER NO. 1
518°
610°
400°
Q 0.732 MM
0.45 CS2
0.30 COS mol/hr
360°
REHEATER NO. 1
450°
487
Q 0.639 MM
320°
400°
414°
REHEATER NO. 3
INCINERATOR
1200°
P 17.5
280°
FUEL AIR
TAIL GAS
HEATED BFW
LP STEAM
Q 2.65 MM
Q 2.49 MM
Q 1.51 MM
Q 1.12 MM
BFW
CONDENSER NO. 2
CONDENSER NO. 3
CONDENSER NO. 4
S1 107.02 mol/h
S1 66.86 mol/h
S1 27.65 mol/h
S1 9.98 mol/h
SULFUR PIT
SULFUR PUMP
LIQUID SULFUR 72.6 LT/d
AIR
AIR BLOWER
SWS GAS
mol/h mol %
NH3 38.00
C1 2.50
CO2 5.00
C2/C3 1.5/1.0
H2S 50.00
COS —
H2O 65.36
N2 2.00
P 23 psia T 195 °F
TAIL GAS
mol/h mol %
H2 19.108
Ar —
N2 604.052
NH3 —
CO 5.387
CO2 35.366
H2S 4.419
COS 0.302
CS2 0.445
SO2 2.209
H2O 364.722
Sx S1 0.768
CONVERSION %
CUMMULATIVE SULFUR RECOVERY 48.63 % 79.02 % 91.59 % 96.09 %
TAIL GAS RATIO H2S/SO2 = 4.42/2.21 = 2.0:1
DJM_G6PICTURES\G6_006.CDR
Brinstone 2009_4-15
Morgan_Refining_Claus_#1_TSWEET_Conversion-ProMax_defaults_rev2.docx

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