Item 10
Claus Oven Operation

Hydrogen Sulfide	m^3/hr	1100-1500
Air Blast	"	1760-2400
Wash-CO_2	"	495-520
Water Spray above	l/hr	60-90
Water Spray below	l/hr	360-425
Before Filter:		
H_2S	%	1.38-2.15
SO_2	%	0.46-0.64
After Filter		
H_2S	%	1.13
SO_2	%	0.69
Pressures before Contact I	mm WS	480-730
Intermediate	"	360-570
Multiclon E	"	330-530
" A	"	270-420
After Cont. II	"	270-420
Oven exit	"	180-290
After H_2S Blower	"	1600-1710
After Air Blower	"	1500-1600
Wash Tower E	"	160-260
Wash Tower A	"	160-260

Temperatures:

Boiler Exit	°C.	280-300
Before Contact I	"	275-295
In Contact I	"	345-355
Under Grate I	"	330-345
Multiclon Entrance	"	280-295
" exit	"	255-270
Before Contact II	"	255-260
In " "	"	270-280
Under " "	"	270-290
Under Grate II	"	270-285
Liquid Sulfur	"	130-135
Oven exit	"	135-150
Filter Entrance	"	140-155
Filter Exit	"	140-150
CO_2	"	172-174
Water Spray	"	136-147
Under Steam Super Heater	"	420-460
Water Lower Preheater below	°C.	315-355
" top "	"	305-325

Waste Heat Boiler Installation

Water Pressure before rebulator	oC.	18.5-19.5 atm.
Temperature before preheater	"	120-160
Temperature after preheater	"	170-202
Steam pressure in boiler	"	14.5-16.0 atm.
Temperature	"	325-365
Quantity	t/hr	1.8-2.2
Hydrogen sulfide boiler burner	m3/hr	500-600
Aux. burner	"	20
Wind air boiler burner	"	825-1010
Aux. burner	"	40
Water spray oven 1 a	l/hr	50-76
Water spray oven 1 b	"	91-102
Before filter:		
H_2S	%	1.12-1.48
SO_2	%	0.50-0.70
After filter:		
H_2S	%	1.01
SO_2	%	0.46
Pressure after blower	mm WS	1600-1710
Pressure before contact oven 1 a	"	930-1040
Pressure after contact oven 1 a	"	620-740
Pressure before contact oven 1 b	"	630-740
Pressure after contact oven 1 b	"	240-330
Pressure exit oven 1 b	"	220-310
Entrance wash tower	"	160-260
Exit wash tower	"	160-260
Temperature boiler burner	oC.	950-975
Under superheater	"	390-415
Under lower preheater	"	380-405
Under upper preheater	"	240-270
Boiler exit	"	280-305
Before contact I	"	275-300
Middle of contact I	"	340-365
Under of contact I	"	345-364
Liquid sulfur oven 1 a	"	220-245
Oven exit	"	230-250
Auxiliary burner	"	585-650
Before contact II	"	245-260
Middle of contact II	"	260-290
Under contact II	"	260-290
Liquid sulfur oven 1 b	"	120-155
Filter entrance	"	120-140
Filter exit	"	115-130
Wash tower entrance	"	130
Wash tower exit	"	25-29
Waste heat boiler	Atu	18.8-20.0
Feed water pressure from regulator	oC.	94-118
Temperature before preheater	"	195-200
Temperature after preheater	"	
Steam pressure in boiler	Atu	14-15.6
Steam quantity	t/hr	0.66-0.86

Claus Oven : Heats of Reaction

Claus oven-Reaction:

$$H_2S + 1/2\ O_2 = S + H_2O + 53\ Kcal.$$

1 Nm^3 H_2S = 2390 Kcal.

Burning:

$$H_2S + 1\tfrac{1}{2}\ O_2 = SO_2 + H_2O + 124\ Kcal.$$

1 Nm^3 H_2S = 5587 Kcal.

Conversion with SO_2:

$$2H_2S + SO_2 = 3S + 2H_2O + 35\ Kcal.$$

1 Nm^3 H_2S = 790 Kcal.

Boiler Reaction:

$$H_2S + 1/2\ O_2 = 0.7S + 0.8\ H_2O + 0.2\ H_2S + 0.1\ SO_2 + 49.5\ Kcal.$$

1 Nm^3 H_2S = 2230 Kcal.

Claus Oven Operation

Boiler reaction $H_2S + \frac{1}{2}\ O_2 = 0.7\ S + 0.8\ H_2O + 0.2\ H_2S + 0.1\ SO_2$

Air Requirements at various percentages of alkacid-sulfur

H_2S %	Auf 1 Vol. H_2S Vol. O_2	Vol. Luft
100	0,5	2.38
90	0.45	2.14
80		1.91
70		1.67
60		1.43
50		1.19
40		0.95
30		1.713

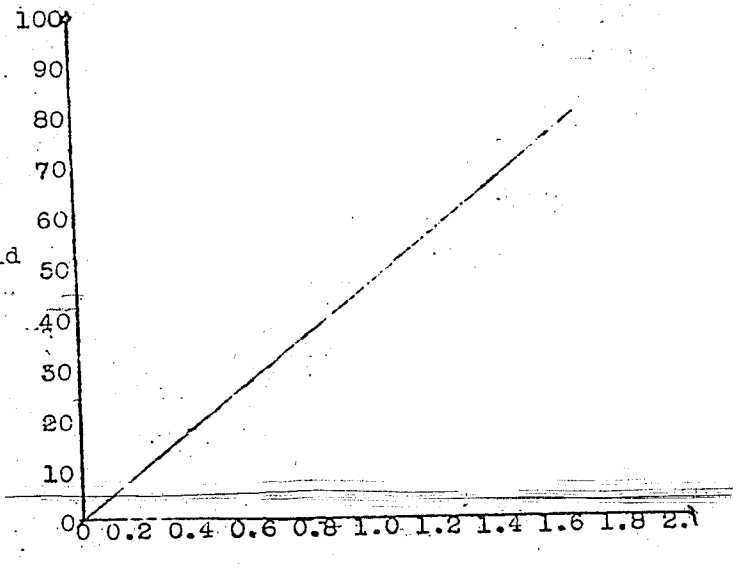
Alkacid-H_2S %

Factor for theoretical setting:

$$\frac{\%\ H_2S}{100} \cdot 2.38 = m^3 luft/m^3 Alkacid\ H_2S$$

Vol. air to 1 vol. Alkacid H_2S

Practically not used, but rather the exhaust gas analyses.



Claus Oven-Proposition (self contained)

2000 m^3/hr (735 mm and 15°C.) 60% alkacid-H_2S (Remainder CO_2) are to be converted to sulfur. Assume radiation and conduction losses of:

in boiler 20%
in oven 30% bezw. 20%
feed water Temp. 140°C.
Water spray temperature 140°C.

Reaction gases shall leave the boiler at 300°C. the oven at 150°C. and the sulfur flow out at 150°C.
The conversion of H_2S with SO_2 in a contact oven will be 90% complete.
Description of: Air requirements
Steam production- 15 atmospheres, 325°C.
Quantity water spray
Sulfur yield
Air Requirements (15°, 735.5 mm):
1 m^3 Alkacid-H_2S for boiler reaction.

$$H_2S + 0.5\ O_2 = 0.73\ R\ 0.8\ H_2O + 0.2\ H_2S + 0.1\ SO_2 + 49.5\ Kcal.$$

$$\frac{60}{100} \cdot 2.38 = 1.43\ m^3\ Air$$

2000 m^3 Alkacid-H_2S need 2860 m^3 air, = 2860 . 0.902 = 2580 Nm^3 Air

Steam production in boiler:

Heat of the boiler reaction 1 Nm^3 H_2S 2230 Kcal.
2000 m^3 Alkacid-H_2S 15°C. 735 2000 .0.902 = 1804 Nm^3 H_2S
1084 Nm^3 H_2S contain 60% = 1080 Nm^3 H_2S and 724 Nm^3 CO_2
1080 Nm^3 H_2S develop 1080 x 2230 = 2,410,000 Kcal/hr.

Boiler exhaust gas: Temperature 300°C.

Exhaust gas composition

	Nm^3		Vol. %		Spec heat of wet gases
	Dry	Wet	Dry	Wet	
H_2S	216	-	7.0	5.4	0.021
SO_2	108	-	3.5	2.7	0.012
CO_2	724	-	23.5	18.0	0.080
N_2	2040	-	66.0	50.4	0.157
H_2O	-	999	-	23.5	0.088
	3088	4027	100.0	100.0	0.358

From wet gas H_2O g/Nm^3 13.8 Nm^3 total: $1804 \cdot \frac{13.8}{1000} \cdot \frac{22.4}{18} = 31$

From wet air " " 13.8 Nm^3 " : $2580 \cdot \frac{13.8}{1000} \cdot \frac{22.4}{18} = 44$

Reaction water " " $1080 \cdot 0.8 = \frac{864}{939}$

Total " "

Sensible heat of the 300°C. hot exhaust gas:
$300.4027 \cdot 0.358 = 432{,}000$ Kcal. of the sulfur vapor in exhaust gas.

$(1080.0.7.1.43 = 1080$ kgS)
350 g S/Nm^3

$300 \cdot 1080 \cdot 0.28 = 90{,}700$

Total 522,700 Kcal.

With H_2S burning, heat developed is : 2,410,000 Kcal.
Lost from boiler in the exhaust gas 522,700 "
As radiant and conduction losses, estimated 482,000 "
Remaining for steam production 1,405,300 "
Heat content of steam 15 atu, 325°C. : 737 Kcal/Kg
Feed water temperature 140° 140 Kcal/Kg

Total heat for
1 kg superh. steam 597 Kcal/kg
There are produced in waste heat boiler $\frac{1405000}{597}$ = 2360 kg = 2.36 t

Water spray quantities
a. For extracting heat of condensation from the sulfur vapor
b. For cooling reaction gases to temp. of the contact oven, 150°C.
c. For extracting heat of reaction. $2\,H_2S + SO_2 = 3\,S + 2H_2O$
for 90% conversion
$2\,H_2S + SO_2 = 3\,S + 2H_2O + 35$ Kcal. 1 Nm^3 H_2S 790 Kcal.

$216 \cdot 0.9 \cdot 790 = 151{,}700$ Kcal
Heat content of steam 100°C. 639 Kcal/kg
Heat content of water spray at 140°C. 140 Kcal/kg

Used for vaporization 499 Kcal/kg
Superheating 150°C.
(150-100) 10,437 = 23 Kcal/kg

Total 522 Kcal/kg
Quantity water spray 291 Kg

After conversion with SO_2 as before.

	Nm^3	Vol. %	Spec. heat of the wet gases.
H_2S	22	0.6	0.002
SO_2	11	0.3	0.001
CO_2	724	19.4	0.086
N_2	2040	54.7	0.171
H_2O	939	25.0	0.093
	3736	100.0	0.353

Sensible heat of the 300° hot exhaust gas 522,700 Kcal
of the 150o hot exhaust gas 198,000 "
150 . 3736 . 0.353

By water spray must be taken 324,700 Kcal
Quantity water 620 kg.
Sulfur vapor from boiler 1080 kg 300° sensible heat 90,700 Kcal
Resulting heat of condensation
10 Kcal/Mol.
3.1 Kcal/kg.
1080 . 3.1 = 3350 Kcal
Resulting from conversion with SO_2
196 . 1.5 . 1.43 = 420 kg S 1,300 Kcal
Heat of condensation 420 . 3.1
Total 3350 + 1300 = 4650 Kcal
Cooling from 300° tp 150°
1080
420
1500 . 0.3 (300-150) = 75,000 Kcal
4,600 "
Total 79,600 "
152 kg

Spray water quantity
Spray water
a) 152 kg 14.3%
b) 620 kg 58.3%
c) 291 " 27.4%
Total 1063 kg.

If we count on losses in the oven, by radiation and conduction, of 30%

744 kg spray water are required 1063 . 0.70 744 kg
with only 20% radiation and conduction losses, 850 kg

Sulfur yield
Boiler reaction 1080 kg S
Oven conversion 420
1500 kg S
Actually in the H_2S 1540 kg S 97.3%