CANSOLV®
SO_2 SCRUBBING SYSTEM

World Leading

SO_2 Control Technology

CANSOLV TECHNOLOGIES INC.

www.cansolv.com

OVERVIEW

- Company History
- *Cansolv SO_2 Scrubbing System* Technology
  - Process Chemistry
  - Diamine Absorbent
  - Process Description
- Piloting Experience
- Commercial Units
- Refinery Applications

COMPANY HISTORY

- *CANSOLV® SO_2 Scrubbing System* **invented in 1988 at Union Carbide**
- **Piloted 9 months at Suncor in 1991**
- **75 MW demonstration plant project team mobilized in 1992**
- **UCC abandoned project in 1993, due to a change in corporate strategic focus**
- **Key employee buyout of technology in 1997**

COMPANY HISTORY

- Technology optimization
- Demonstrated *CANSOLV® SO_2 Scrubbing System* technology in a dozen pilot plant campaigns in different applications
- Startup of three commercial units in 2002

CURRENT ACTIVITIES

- Cansolv SO_2 Control Process
  - Engineering, License, Amine, Reclamation
- R&D
  - SO_2 process improvements
  - NOx and mercury control (pilot plant)
  - CO_2 capture with amine in oxidizing environment

CANSOLV® SO_2 Scrubbing System

- A regenerable SO_2 absorption process
- Similar to H_2S/CO_2 amine treaters
- Uses conventional equipment
- Aqueous diamine solvent is highly selective for SO_2
- A very robust, easy to operate process
- Almost zero emissions at low cost
- Patented technology

PROCESS CHEMISTRY

- Buffering provides high capacity for SO_2 absorption
- Proprietary solvent has the proper absorption/desorption strength
- Solvent amine is non-volatile since it is always in salt form
- Regeneration provides pure, water saturated SO_2 as byproduct

PROCESS CHEMISTRY

$$SO_2 + H_2O \Leftrightarrow H^+ + HSO_3^- \quad (1)$$

$$HSO_3^- \Leftrightarrow H^+ + SO_3^{2-} \quad (2)$$

$$R_1R_2R_3N + H^+ \Leftrightarrow R_1R_2R_3NH^+ \quad (3)$$

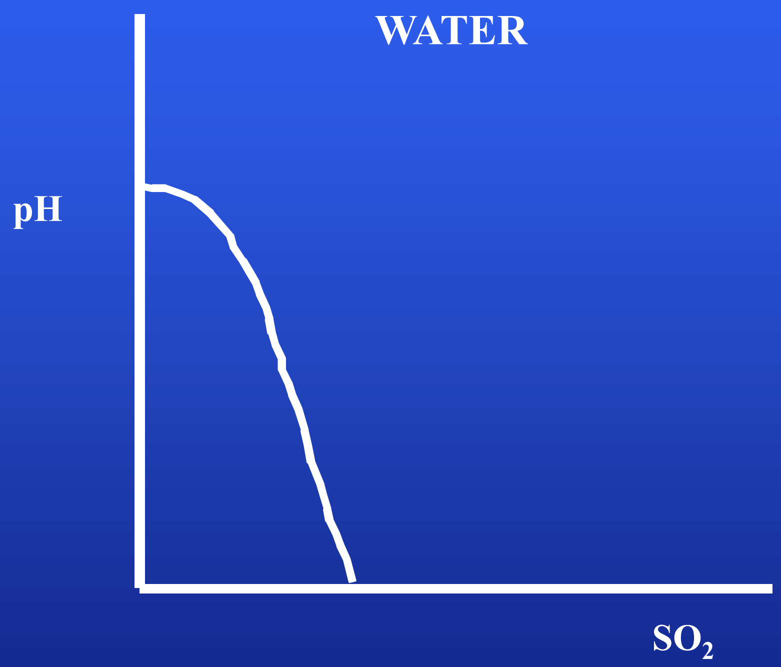
Eqns. 1 + 2

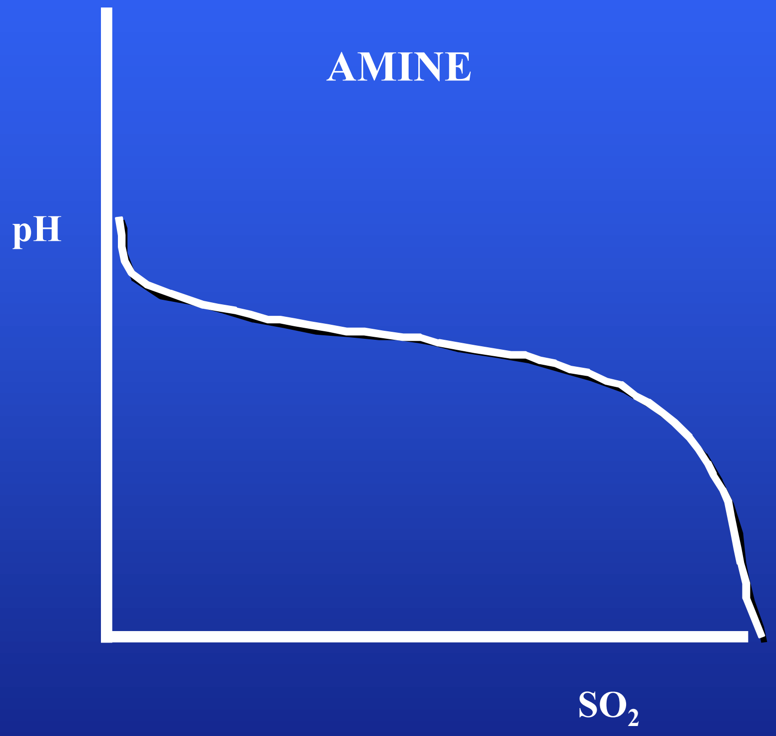
- Reversible hydration and ionization

Eqn. 3

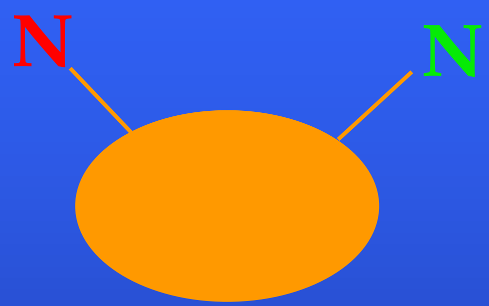
- The amine acts as a buffer
- Forms amine salts

PROCESS CHEMISTRY

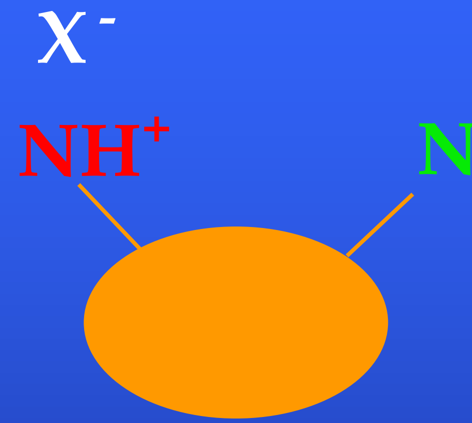




DIAMINE ABSORBENT



FREE DIAMINE



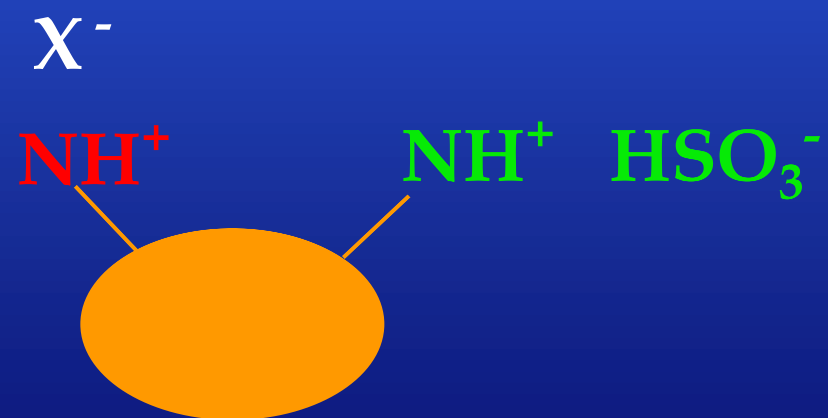
LEAN AMINE

N : Strongly basic amine functionality

N : "Sorbing nitrogen"

X^- : Strong acid anion

HSO_3^- : Absorbed SO_2



RICH AMINE

DIAMINE ABSORBENT

- **The unique diamine absorbent is the key to the *CANSOLV® SO_2 Scrubbing System* technology**
- **The first amine group is always in salt form providing absorbent non-volatility**
- **The second amine has the optimum strength for balanced absorption and regeneration**

COMPARISON OF AMINES

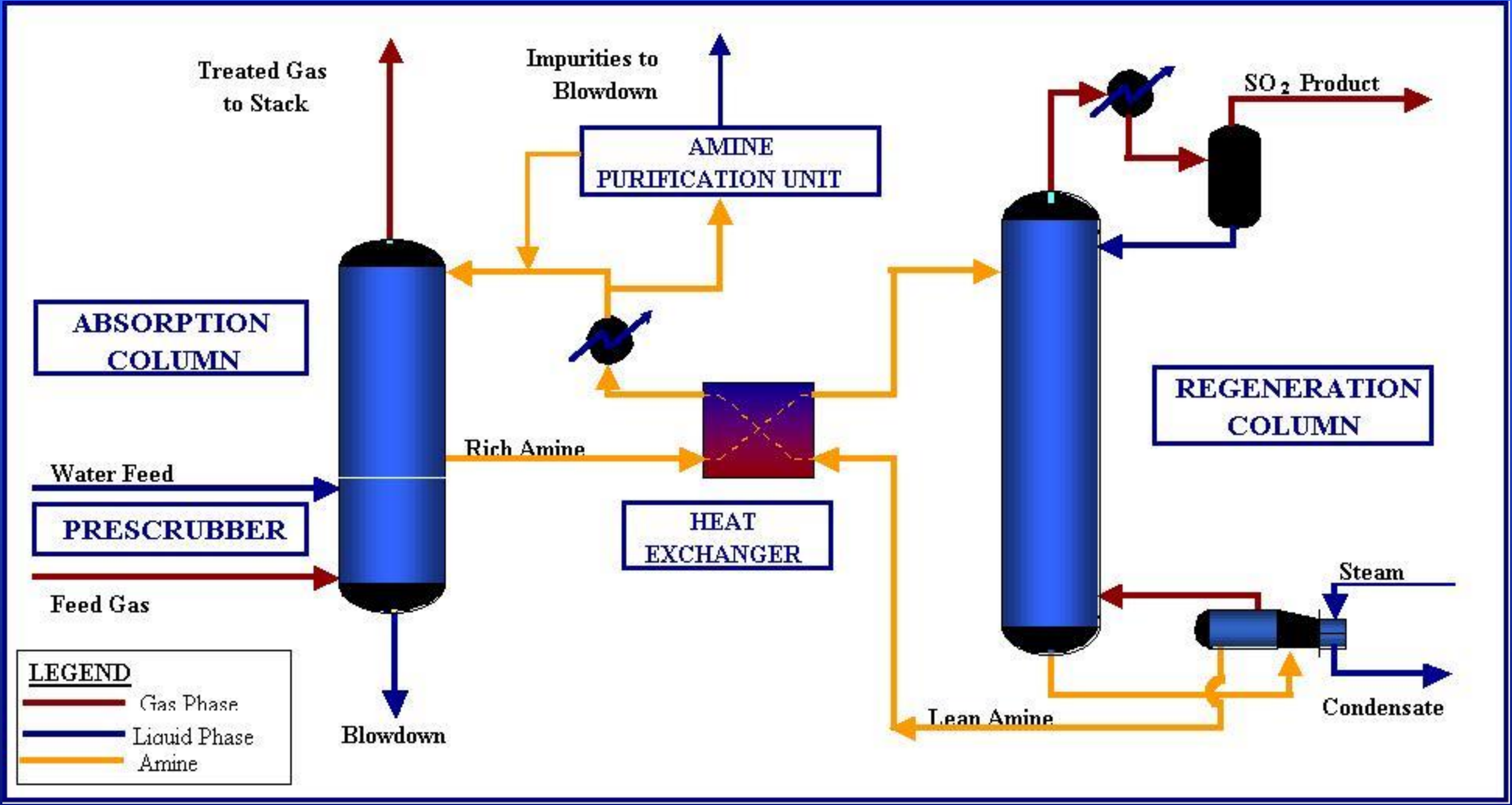
- **CANSOLV PROCESS**
  - Diamine salt absorbent
  - Absorbent non-volatile
  - 100% slip of CO_2
  - Stainless steel metallurgy
  - Corrosion allowance minimal
  - No Fe S formation
  - Only source of solids is feed gas
  - Filter rich amine stream
- **CONVENTIONAL AMINE**
  - Conventional mono-amine
  - Amine volatile
  - Difficulty in slipping CO_2
  - Carbon steel metallurgy
  - Corrosion allowance important
  - Fe S formation
  - Fe S precipitation and scaling source of solids
  - Filter lean amine stream

COMPARISON OF AMINES

- **CANSOLV PROCESS**
  - Rate of formation of HSS higher
  - Continuous reclaimer (ED)
  - Amine stable to O_2
  - Amine degradation lower by factor of 2 to 3
  - Operation and control similar
  - Can achieve low (<10 ppmv) SO_2
  - Foaming not an issue

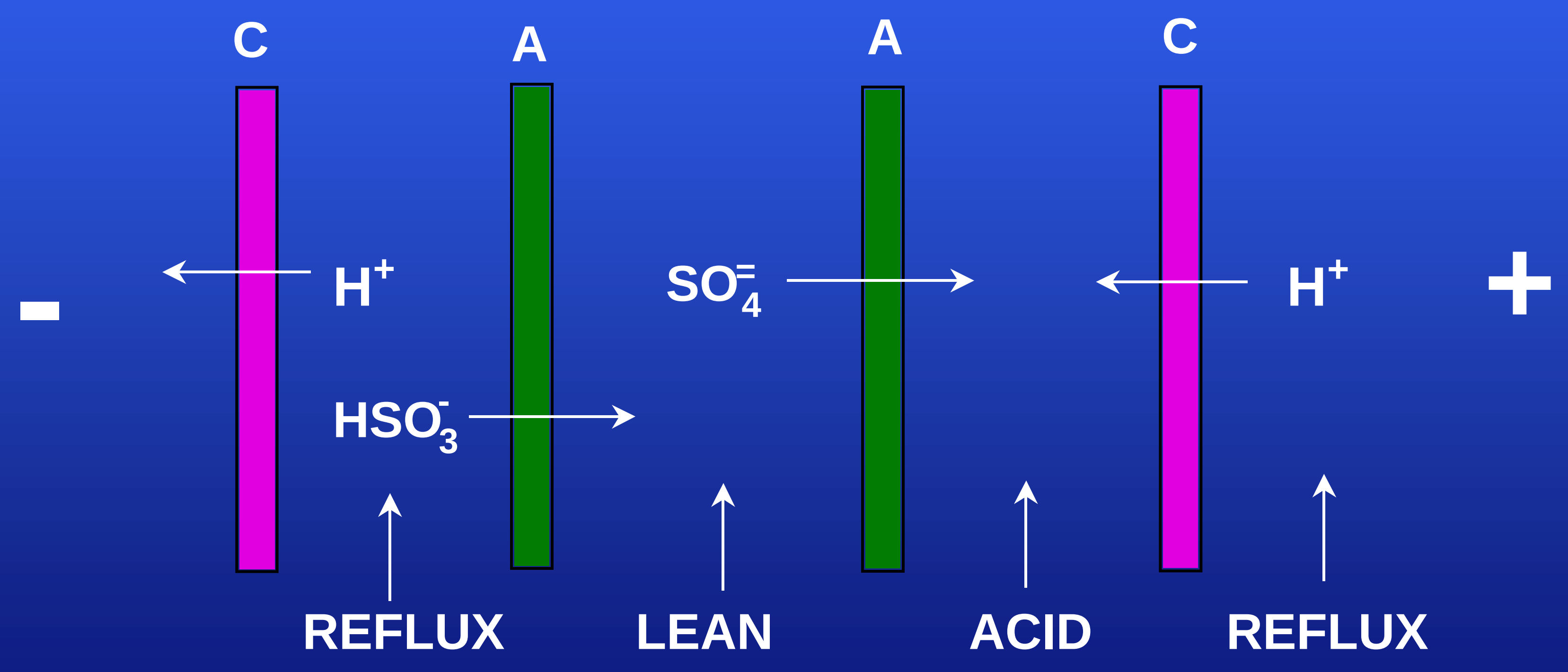
- **CONVENTIONAL AMINE**
  - Low rate of HSS formation
  - Reclaiming often ad-hoc
  - Amine not stable when exposed to O_2
  - Amine degradation important
  - Operation and control similar
  - Can achieve low ppmv H_2S but CO_2 can be a problem
  - Foaming can be a problem

CANSOLV® SYSTEM PFD



PROCESS DESCRIPTION

Electrodialysis Unit: 3-Loop Design



CANSOLV® SO_2 Scrubbing System Piloting Campaigns

DATE	APPLICATION	SO_2 ppmv in	SO_2 ppmv out	COMMENTS
Feb-Nov 1991	FGD	2,600	<100	Petroleum coke fired boiler
June 1998	Acid plant feed and tail gases	65,000 1,800	<100	
August 1998	Sulfite pulp mill	3,000-500,000	<100	VOC contaminated Inlet SO_2 swing
October 1998	Metal refining	---	---	SO2Safe Regeneratiom demonstration
May 1999	Incinerator + Claus tail gas	20,000	<100	Chlorides present
June 1999	Lead smelter	10,000	<100	High dust and tar levels

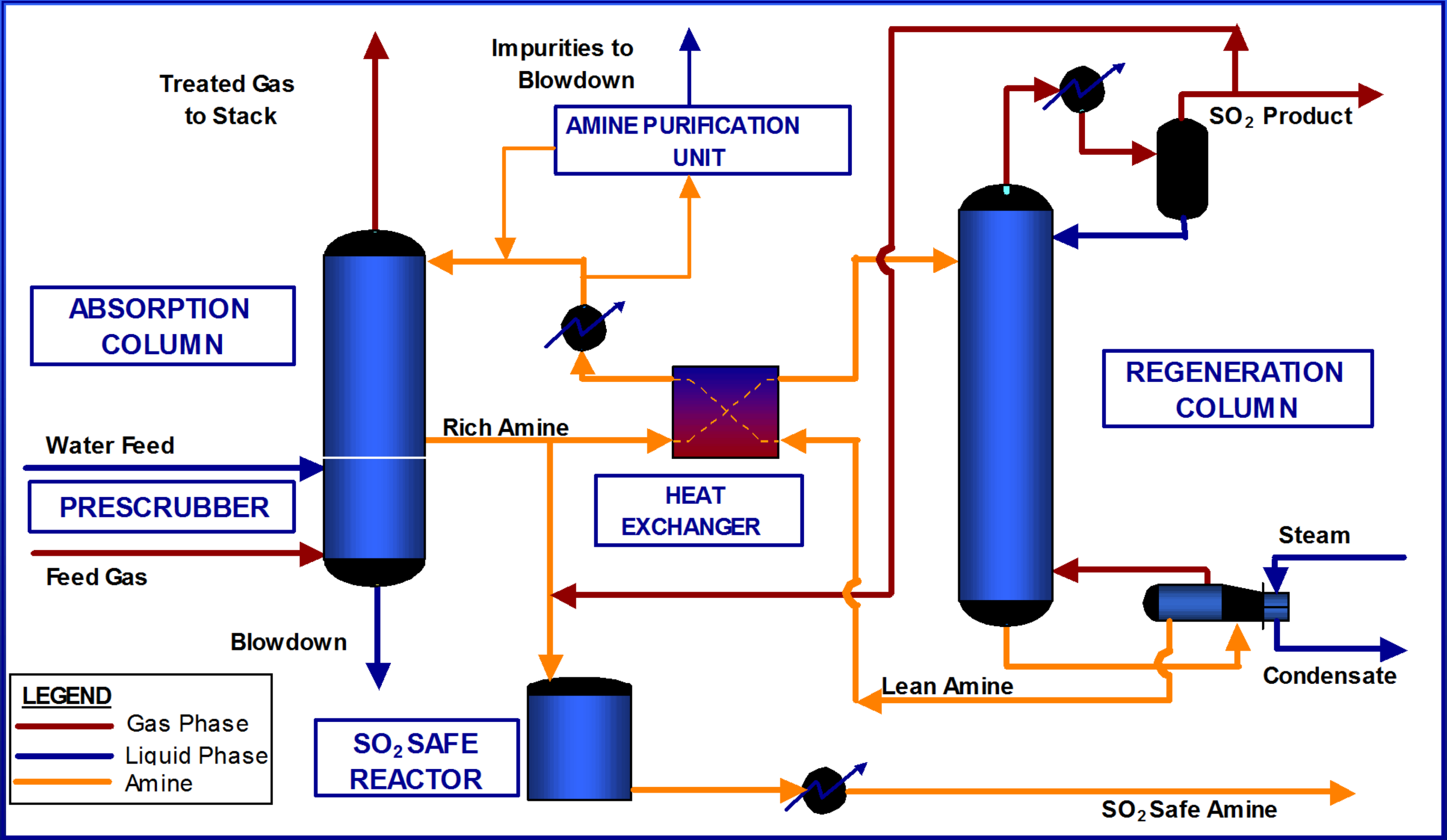
CANSOLV® SO_2 Scrubbing System Piloting Campaigns

DATE	APPLICATION	SO_2 ppmv in	SO_2 ppmv out	COMMENTS
October 1999	Acid plant feed gas	70,000-140,000	<100	SO_2 recovery
Nov. 1999	Refinery	2,500	<100	Boiler FGD
Jan-Feb 2000	Refinery	5,500	<10	Spent sulfuric acid recovery unit tail gas
April 2001	Sulphite Pulp Mill	15,000	<50	Recovery boiler flue gas
June 2002	Refinery	2,000	<20	Gasoline FGD; SO_2 recovery
July 2002	FGD	2,400	<50	Bitumen fired boiler
Sept. 2003	Lead Smelter	7,000	<35	Chlorides present

COMMERCIAL UNIT #1

- Startup May 2002 at a zinc smelter in Quebec
- SO_2SAFE™ process
- Reduce hazard of SO_2 storage and transportation
- Dissolve SO_2 in high capacity amine solvent
- Limit release of gaseous SO_2 in event of leak or spill
- Regenerate SO_2 in an automated unit

COMMERCIAL UNIT #1



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COMMERCIAL UNIT #2

- Startup May 2002 at a chemical plant in Belgium
- CANSOLV® SO_2 Scrubbing System
  - Treat flue gas from an incinerator burning SRU unit tail gas and waste tar
  - 11,000 Nm^3/hr at 14,300 ppmv SO_2 inlet
- Process cost less than conventional tail gas treating
- Operation of plant has been stable and better than design

COMMERCIAL UNIT #2

- **Partial List of Performance Guarantees and Results**

Performance Guarantees		Actual Performance
SO_2 in Treated Gas	≤ 350 mg/Nm^3 dry	240 mg/Nm^3 average 100-160 mg/Nm^3 optimized
Steam Consumption	≤ 20 kg/kg SO_2	11 kg/kg SO_2 average to date; 7 kg/kg SO_2 optimized

- **Unit availability 100%**
- **Current steam consumption 25% less than design**
- **Degradation of the amine solvent is less than expected**
- **SO_2 emissions less as low as 50 mg/Nm^3 observed**

COMMERCIAL UNIT #2

COMMERCIAL UNIT #3

- Startup September 2002 at an oil refinery in Los Angeles
- CANSOLV® SO_2 Scrubbing System
- Treats sulfuric acid plant tail gas
- 25,000 SCFM (40,000 Nm^3/hr) at 0.3 to 0.5% SO_2 inlet concentration
- SO_2 emissions less than 10 ppmv, 30 mg/Nm^3
- Currently operating at 150% of design

COMMERCIAL UNIT #3

COMMERCIAL UNITS

- CTI has demonstrated the successful startup of the 3 initial *CANSOLV® SO_2 Scrubbing System* commercial applications
- Commercial units exceeded expectations
  - Cost
  - Removal Efficiency
  - Energy Consumption
  - Amine solvent stability
- Range of commercial applications demonstrates the versatility of *CANSOLV® SO_2 Scrubbing System*

Current Projects

- FCCU CO Boiler Flue Gas
- FCU CO Boiler Flue Gas
- SRU Tail Gas Unit
- Lead Smelter Off-Gas (Load Levelling)

FCCU CO BOILER FLUE GAS

- Gas rate: 800,000 Nm^3/hr
- SO_2 content: 1000 kg/hr
- Absorber diameter: 9 m
- Outlet SO_2 concentration less than 25 ppmv
- Particulate removal important
- Liquid effluent to be minimized

FCCU PROJECT DESIGN ISSUES

- Reliability: 5 year run length
- Total unit pressure drop: < 50″ WC
- No amine carryover to treated gas
- 35 psig (2.3 Barg) steam to reboiler limiting regeneration pressure

FCCU PROJECT DESIGN

- Open spray tower - gas quench and particulate removal
- Cansolv Absorber (3 sections)
- Bottom wash section (grid packing)
- Absorption section (structured packing)
- Polishing caustic scrubber (structured)

FCU CO BOILER FLUE GAS

- Gas rate: 400,000 Nm^3/hr
- SO_2 content: 1500 kg/hr
- Absorber diameter: 7 m
- Outlet SO_2 concentration less than 25 ppmv
- Particulate removal important
- Liquid effluent to be minimized

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SRU Tail Gas Unit

- **Objectives:**
  - **Claus tail gas unit (100 tons/day)**
  - **Increase SRU capacity by 25%**
  - **Eliminate O_2 enrichment**

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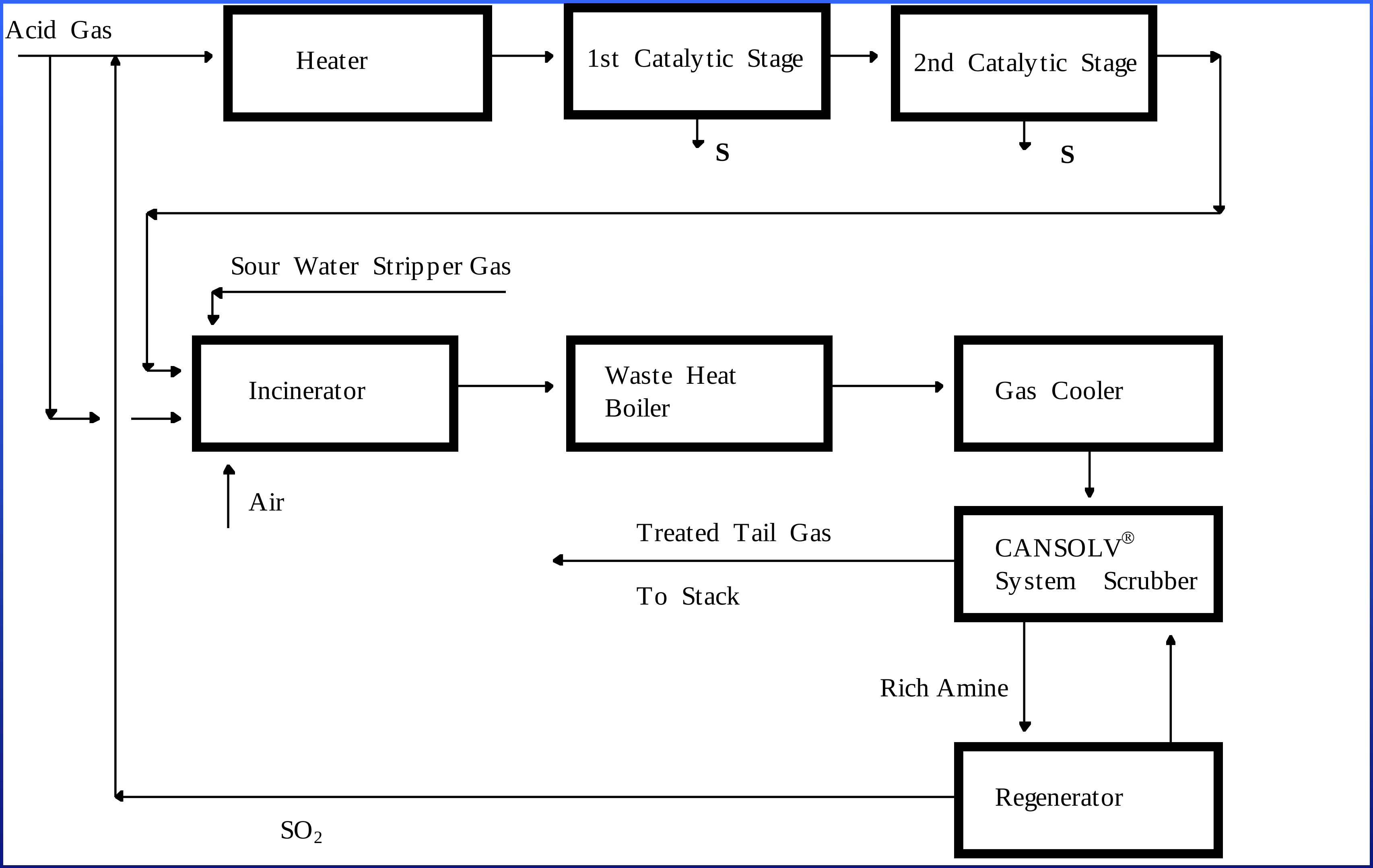
SRU Tail Gas Unit

- Gas rate: 19,000 Nm^3/hr
- SO_2 content: 1200 kg/hr
- SO_2 inlet concentration 4.4%
- Outlet SO_2 concentration less than 150 ppmv

SRU Tail Gas Unit

- 10% acid gas bypassed to tail gas incinerator
- Incinerator is fired with excess air to 1,200°F (650°C)
- Gas cooled in WHB to 600°F (315°C), quenched and cooled to 140°F(60°C) in prescrubber
- SO_2 feed concentration of 4%
- Results in a 25% capacity increase without O_2 enrichment
- No need for support fuel in tail gas incinerator

CANSOLV SRU


Acid Gas
Heater
1st Catalytic Stage
2nd Catalytic Stage
S
S
Sour Water Stripper Gas
Incinerator
Waste Heat
Boiler
Gas Cooler
Air
Treated Tail Gas
To Stack
CANSOLV®
System Scrubber
Rich Amine
Regenerator
SO_2

Metallurgical Application

- Gas rate: 25,000 Nm^3/hr
- SO_2 content: 2200 kg/hr
- SO_2 concentration 1000 ppmv to 14%
- Outlet SO_2 concentration less than100 ppmv
- Cansolv unit delivers constant SO_2 feed to a sulphuric acid plant

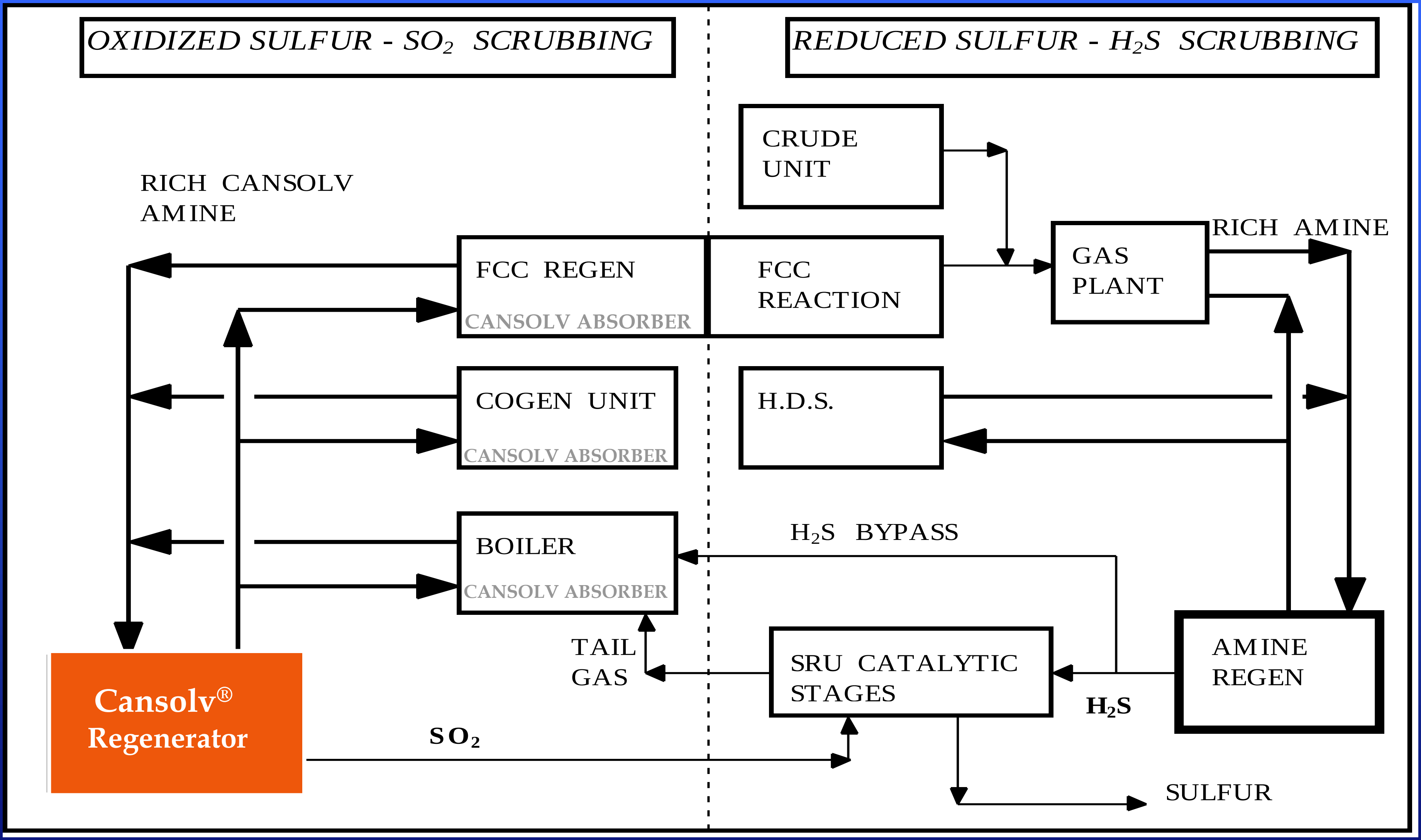
APPLICATIONS

Refineries

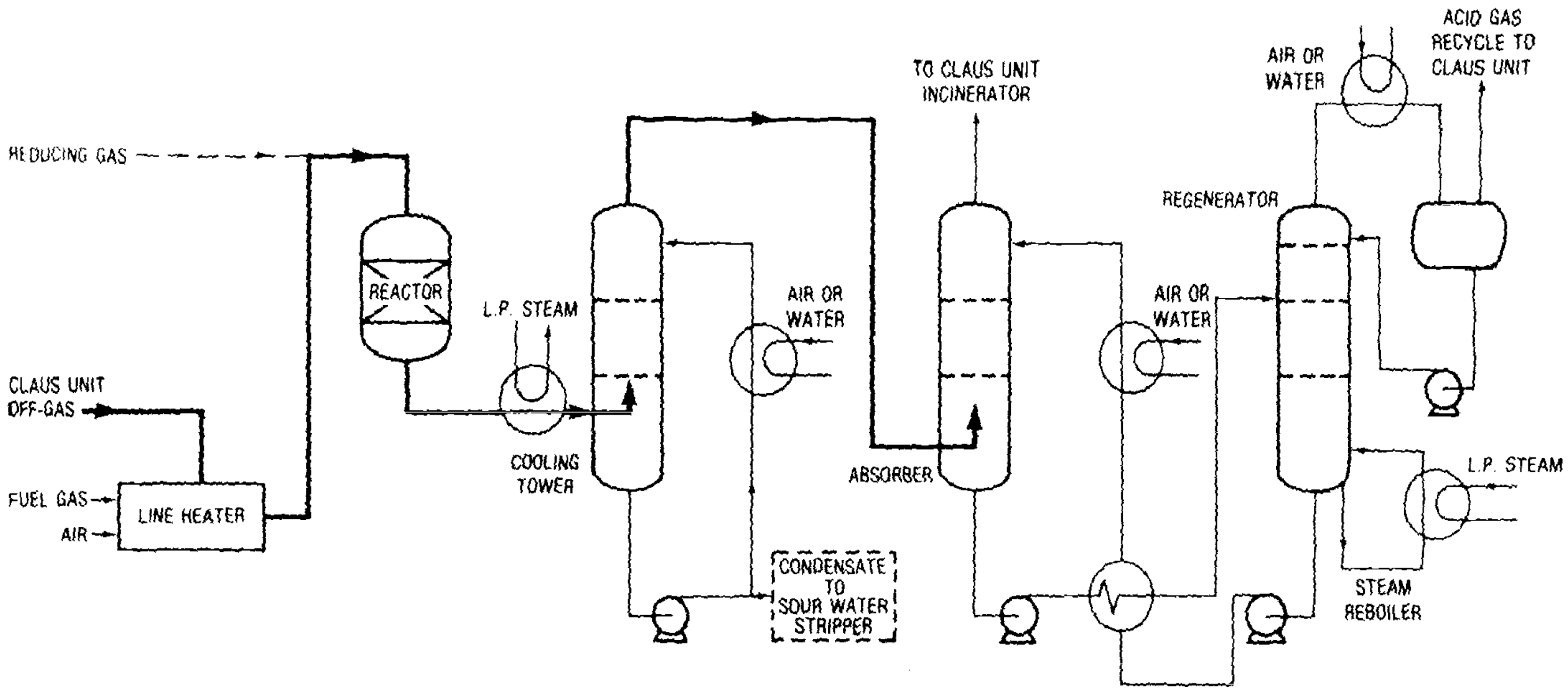
- SRU tail gas cleanup and capacity expansion
- Power boiler, co-generation FGD
- FCCU (CO boiler) tail gas
- Fluid Coker CO boiler flue gas
- Steam boiler and fired heater FGD
- Total sulfur management

- Proper design of SO_2 return to SRU important

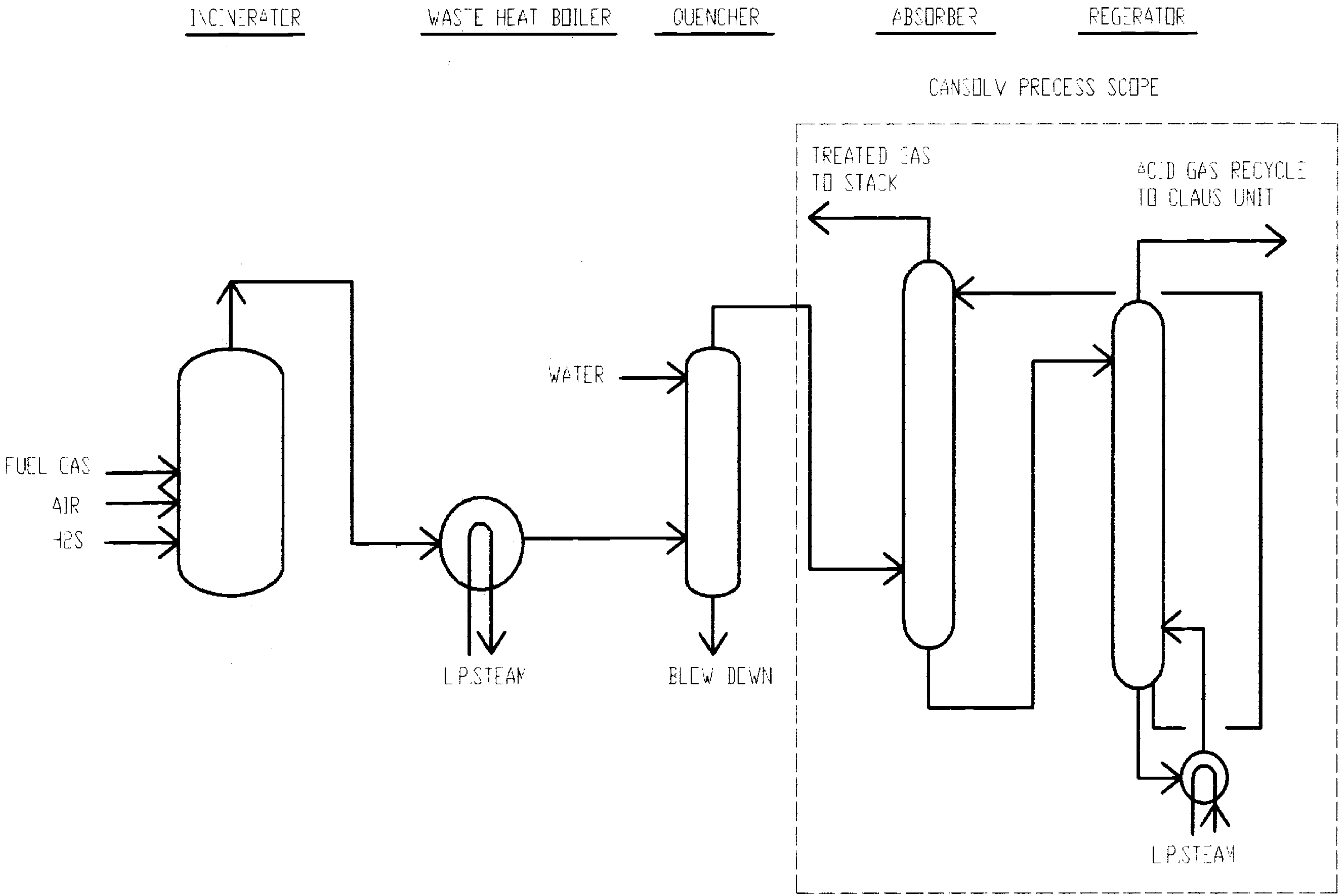
Refinery Sulphur Management



SCOT PROCESS SCHEMATIC FLOW DIAGRAM



CANSOLV PROCESS SCHEMATIC FLOW DIAGRAM



Cansolv vs. SCOT

SCOT/Cansolv TGU Capital Cost Estimate

	SCOT Design	Cansolv 10 TPD	Cansolv 32TPD
CAPITAL COST, Million $US			
ISBL			
SCOT TGU/Cansolv TGU	$8.00	$5.70	$6.50
Tail Gas Incin	$1.50	$2.00	$2.50
Total ISBL	$9.50	$7.70	$9.00
Contingency, 15%	$1.43	$1.16	$1.35
Product Storage	N/A		
OSBL, 20%	$1.90	$1.54	$1.80
Engineering, 15%	$1.43	$1.16	$1.35
Owner's Costs, 10%	$0.95	$0.77	$0.90
Total Project Cost	$15.20	$12.3	$14.4

Cansolv vs. SCOT

			SCOT Design Case 1		Cansolv 10 TPD		Cansolv 32TPD
OPERATING COST, $/Year							
Fixed Costs							
Operators	85000	0	$0		$0		$0
Maintenance		3.00%	$456,000		$369,600		$432,000
Operating Supplies		0.50%	$76,000		$61,600		$72,000
Insurance		1.00%	$152,000		$123,200		$144,000
Local Taxes		0.10%	$15,200		$12,320		$14,400
Miscellaneous		0.10%	$15,200		$12,320		$14,400
Subtotal			$714,400		$579,040		$676,800
Variable Costs							
Power, kW	$0.034	80	$23,827	107	$31,876	185	$55,113
Import Steam,	$5.00	400	$17,520	14000	$613,340	28000	$1,226,680
BFW, GPM	$6.58	6	$20,755	8	$27,668	10	$34,584
Proc. Water, C	$1.00						
CW, GPM	$0.10	1,400	$73,584	2300	$120,888	3200	$168,192
Fuel Gas, MS	$3.50	200	$367,920	312	$573,955	0	$0
Hydrogen, MS	$2.10	300	$241,583	0	$0	0	$0
50% Caustic,	$200.00						
Chemicals, $/Yr		13,000	$13,630		$20,000		$42,500
Steam Credit,	($5.00)			17000	-$744,770	17000	-$744,770
Miscellaneous		0.0	$20,237		$55,000		$70,000
Subtotal			$779,056		$697,957		$852,299
Total Operating Cost, $/Yr			$1,493,456		$1,276,997		$1,529,099
Total Equiv. Sulfur, Tons/Day		10.5	$3,773,456	10.6	$3,124,997	32.4	$3,689,099
Total Operating Cost, $/Ton Equiv. S			$402		$330		$129
Total Costs, $/Ton Equiv.S			$983		$808		$312

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Clients

- Bayer
- BP
- Chevron Texaco
- ConocoPhillips
- Encana
- ExxonMobil
- Hindustan Zinc
- Marathon Ashland
- Motiva(Shell/Aramco) - Premcor
- Noranda
- PetroCanada
- TotalFinaElf

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CONCLUSION

- Cansolv SO_2 Recovery Process is now in commercial use
- A number of new units are currently in the design phase
- The process is especially attractive if high performance with minimum waste is required.

WHERE TO FIND

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