Wet Scrubbing Systems

Belco Technologies Corporation

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www.belcotech.com

DUPONT BELCO

Belco Technologies Corporation

- Worldwide Supplier of Technologies for Controls of Particulate, SO_X and NO_X emissions. Specializing on reduction of Oil Refinery Emissions.
- A leader in reduction of emissions from oil refineries. More scrubbing systems sold to oil refineries and more systems operating than ALL other competitors “COMBINED”
- Founded in 1968, was part of Foster Wheeler until 1989 at which time was purchased by LAB Group (France). Fully owned subsidiary of DuPont since 1 January 2006.
- Offering a wide range of solutions to better serve our customers
- Certified ISO 9001-2000

List of BELCO® 's Scrubbing Systems Sold to Oil Refineries from 1992 to February 2009

- **North America**
  - Valero (12 scrubbers)
  - Coastal
  - Marathon/Ashland (2 scrubbers)
  - Pennzoil
  - Irving Oil
  - Motiva
  - Conoco Phillips (6 scrubbers)
  - Premcor
  - Shell Oil
  - Lion Oil
  - Citgo (3 scrubbers)
  - Sun Oil (2 scrubbers)
  - BP
  - Frontier Oil
  - Placid Refining
  - Western Refining
  - Flint Hills

- **Europe**
  - Italy – ENI
  - Switzerland – Tamoil
  - Belgium - Total
  - Norway – ESSO

- **India**
  - IOCL (4 scrubbers)
  - ESSAR
  - HPCL (3 scrubbers)
  - NOCL
- **China**
  - Petrochina Lanzhou & Sichuan
  - Sinopec Qingdao, Yanshan & Guangzhou
  - West Pacific Dalian

- **Other**
  - Taiwan - Formosa (7 scrubbers)
  - Taiwan - CPC
  - Korea – SK (2 scrubbers)
  - Korea – GS Caltex
  - Korea - Hyundai
  - Qatar – QP (2)
  - Saudi Arabia - SAMREF
  - Russia – GAZPROM
  - Philippines – Petron Bataan
  - Thailand – Alliance Refining Co.
  - Brazil – Petrobras
  - UAE - Takreer

78 EDV Wet Scrubbing Systems in Refineries
(68 of them are on FCCU applications)

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Providing Proven Technologies

- EDV® Wet Scrubbing Systems
- Dual Alkali Scrubbing & Regeneration Systems
- LABSORB™ Regenerative SO_2 Scrubbing
- NOx Reduction Technologies (LoTOx™ and SCR)
- Shell Global Solutions TSS Systems

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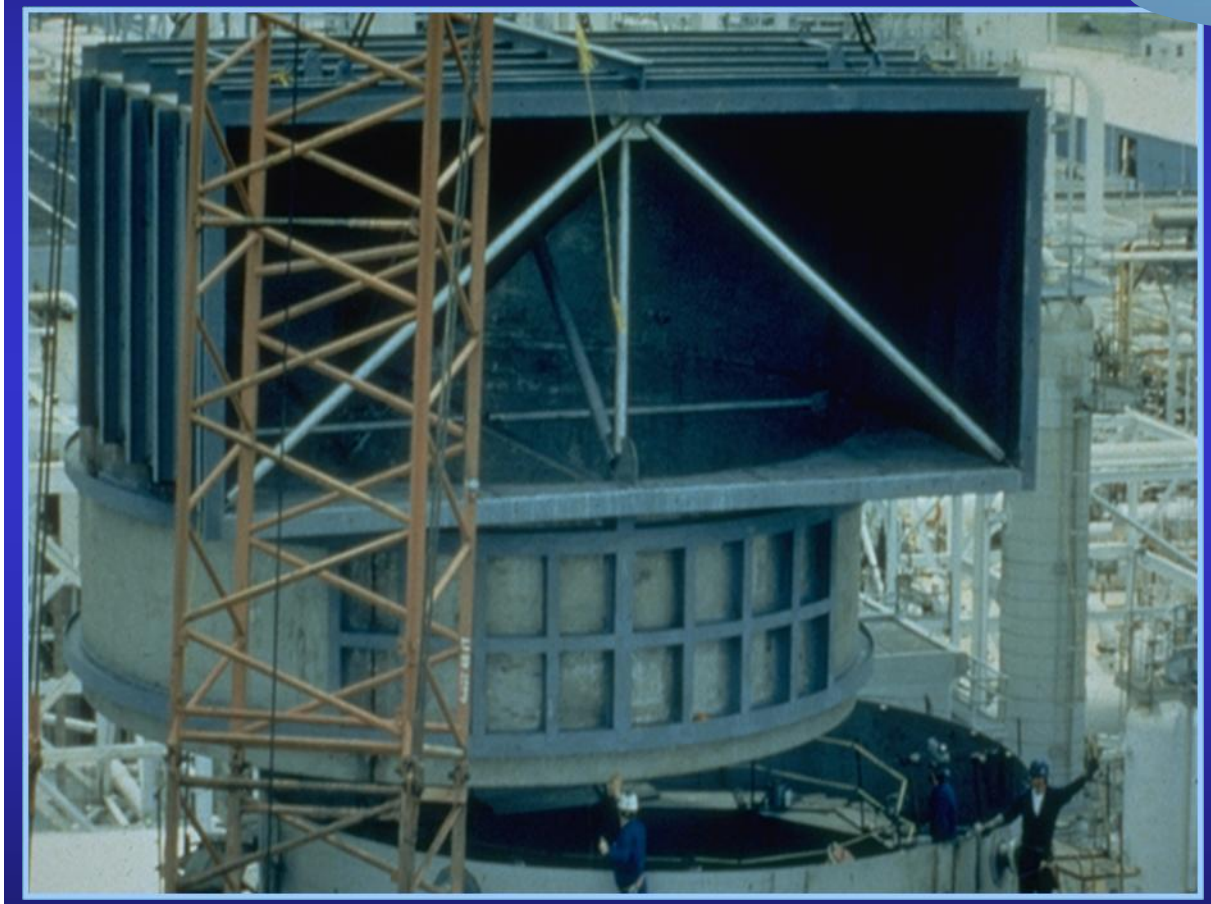
(LoTOx™ is a trademark of The BOC Group)

ONE BUSINESS
"Flue-gas cleaning systems"



- Feasibility Studies
- Process Design Packages
- Licensing
- Detailed Design
- Material Supply
- Field Erection in USA
- Start-Up Support
- Field Service & Spare Parts

Worldwide Focus on Oil Refining Emissions

Reduction of Emissions from:

- Fluid Catalytic Cracking Units
- Sulfur Recovery Units
- Oil Fired Heaters
- Oil Fired and Coal Fired Boilers within Oil Refineries
- Ship Engines

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EDV® Wet Scrubbing System

Reducing Particulate, SO_2, SO_3 and NOx in a single vessel

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EDV® Wet Scrubbing

Step 1 – Flue Gas is quenched and saturated in the Quench Section. Initial reduction of particulate, SO_2 and SO_3 is achieved in this step

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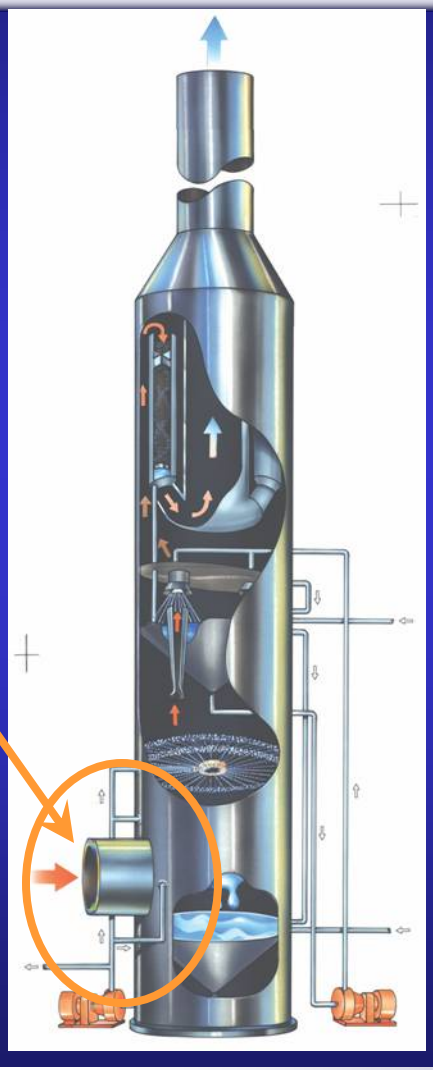
EDV® Quench Section

Quench Section



- Designed to fully saturate gas
- Unique design avoids Wet/Dry interface
- Can be designed to allow the full regenerator temperatures

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EDV® Wet Scrubbing

Step 2 – Reduction of SO_2 and Primary Particulate Control is achieved in <u>Absorber Section</u>

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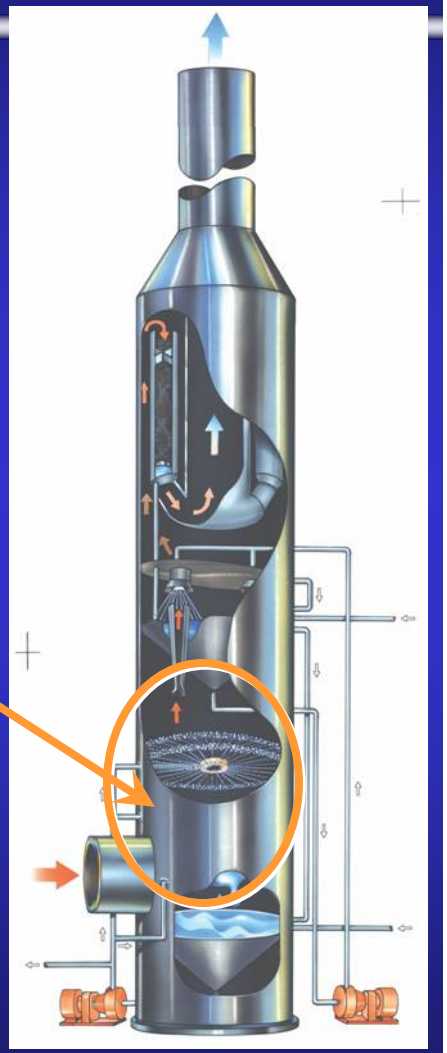
EDV® Wet Scrubbing System

Absorber Section



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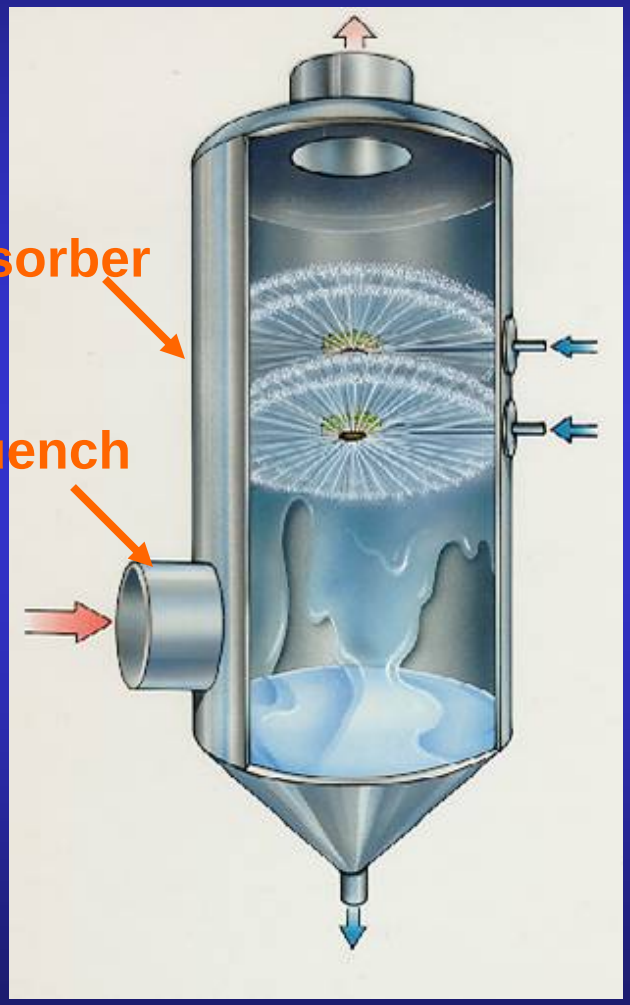
EDV® Wet Scrubbing
Absorber Section



- SO_2 & PM Removal
  - Liquid / Gas Contact
  - Staged Approach
- Open / Self Cleaning
- No Mist Formation
- Low Pressure Drop
- Can Operate for Particulate Control Only and later can be modified to scrub SO_2

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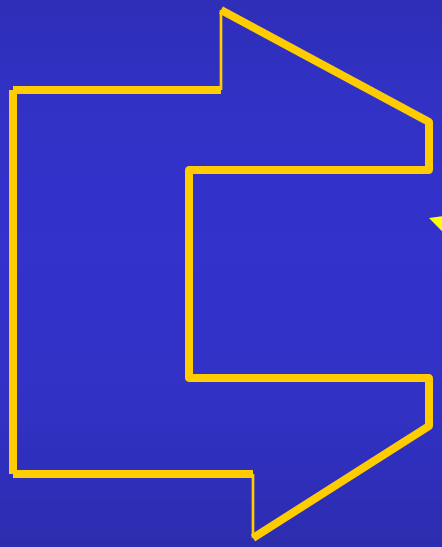
EDV® Wet Scrubbing

G® Nozzle



X -Section

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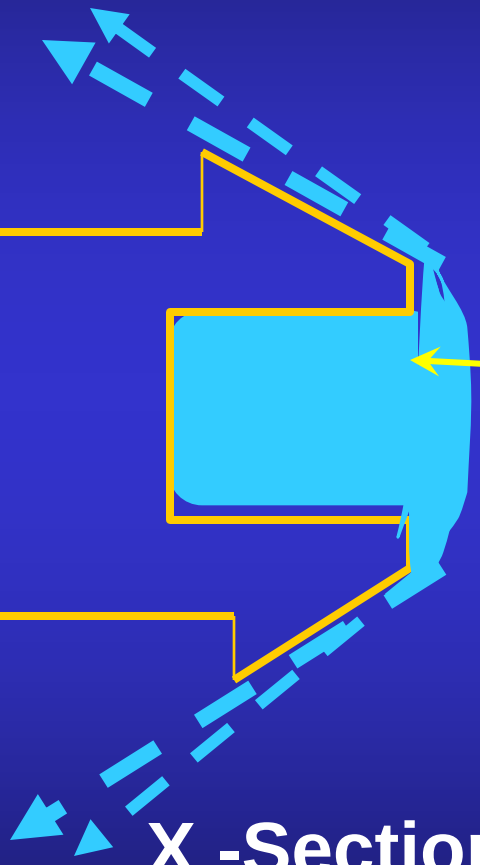
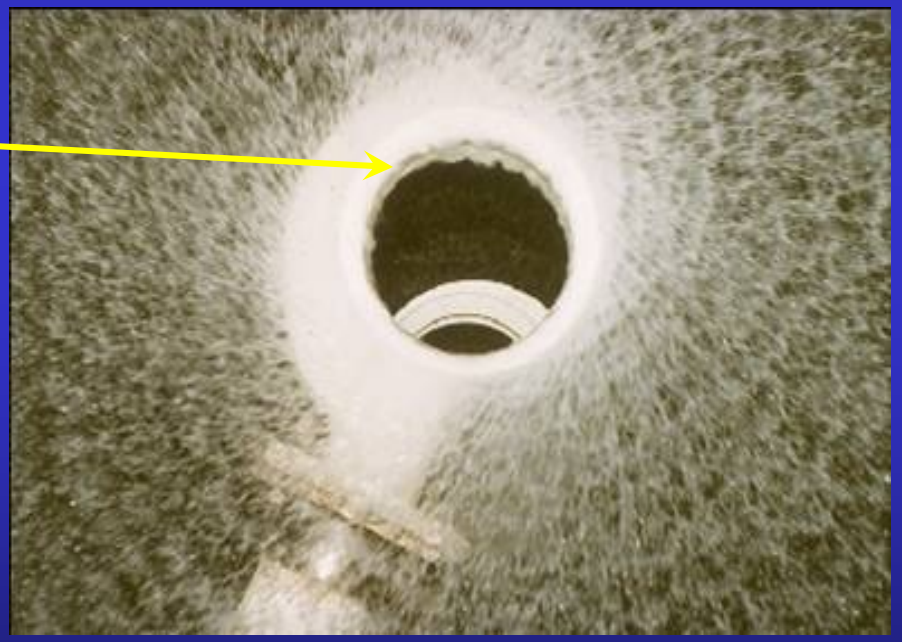
EDV® Wet Scrubbing

G® Nozzle



X -Section



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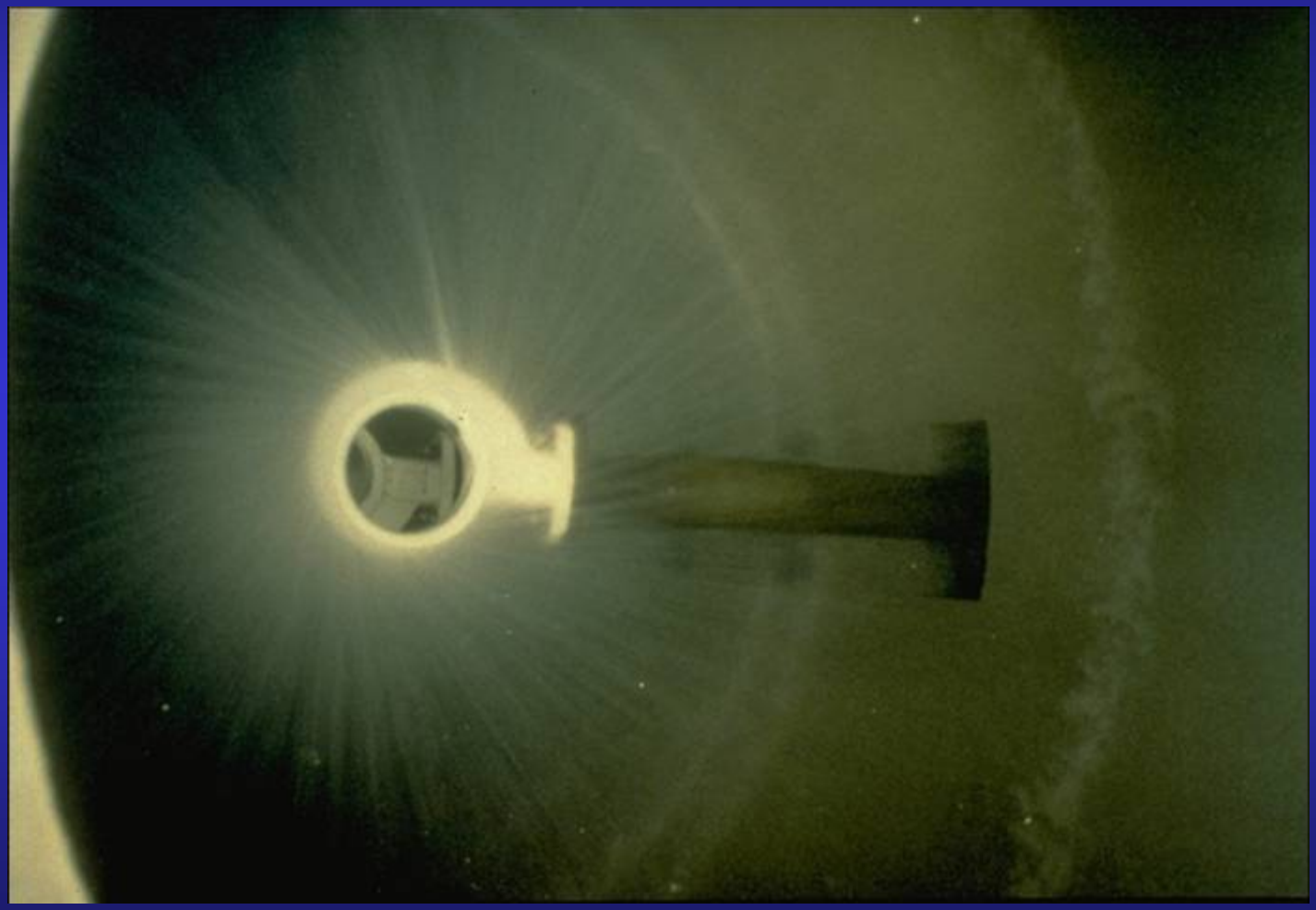
Single G® Nozzle Operation



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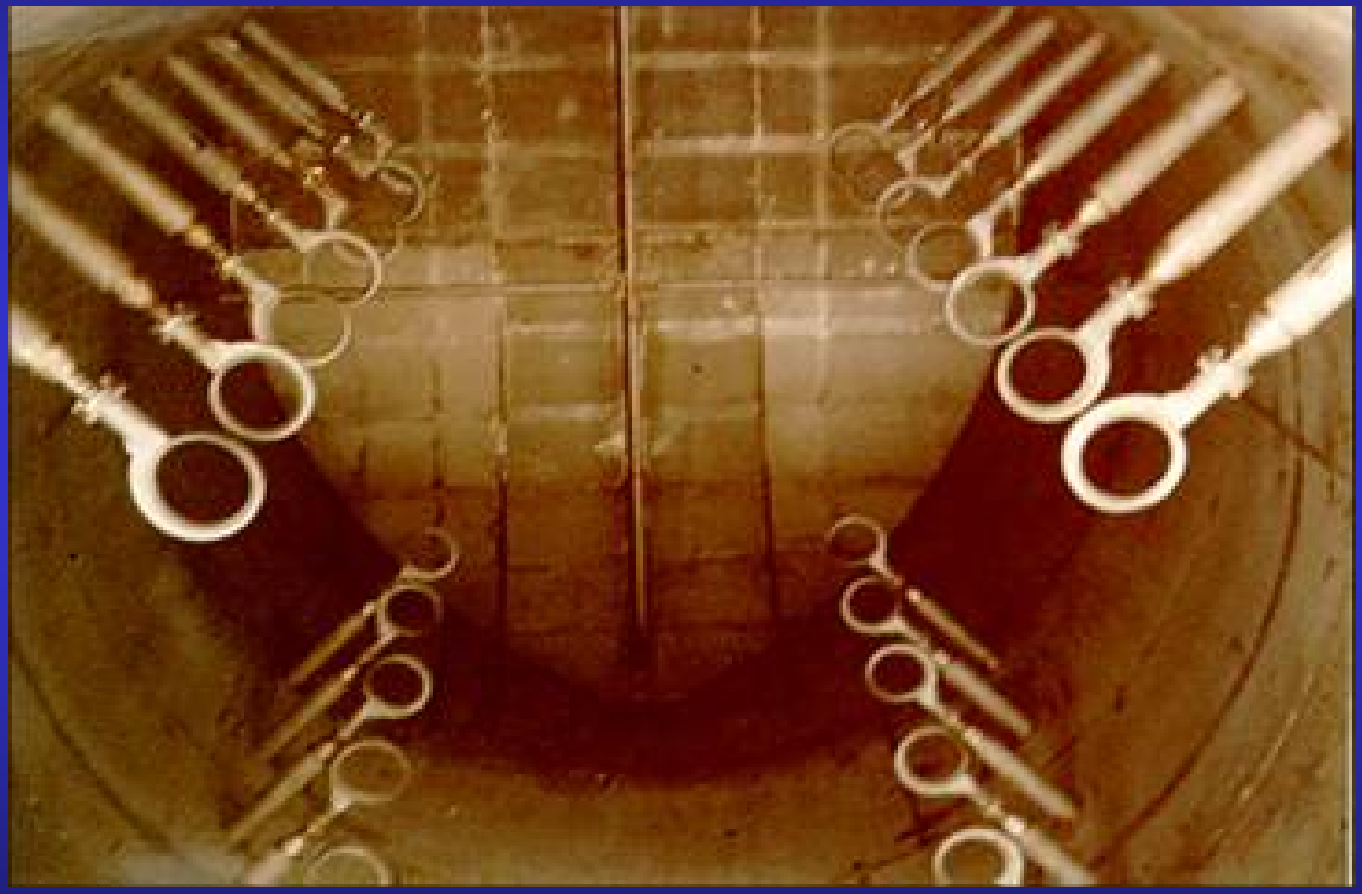
Multiple G® Nozzle Operation



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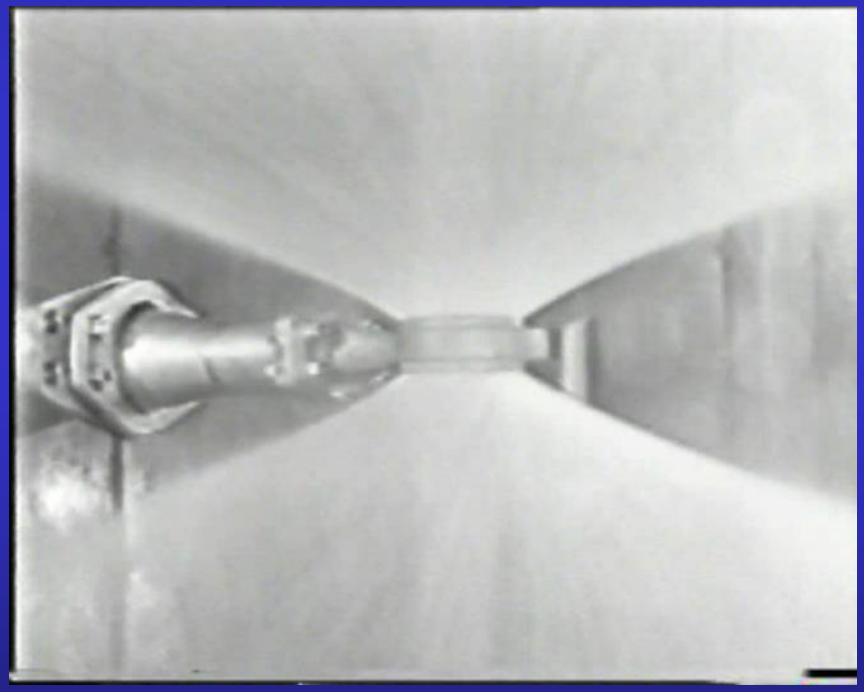
EDV® Wet Scrubbing System

G® Nozzle

Plan View

Side View



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EDV® Wet Scrubbing

Step 3 – Further reduction of fine particulate (PM 2.5 and below) and further reduction of SO_2 / SO_3 is achieved in Filtering Modules

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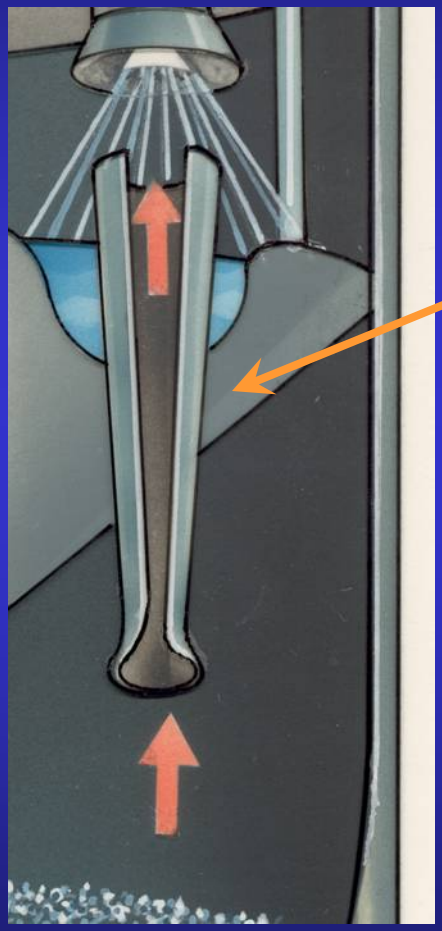
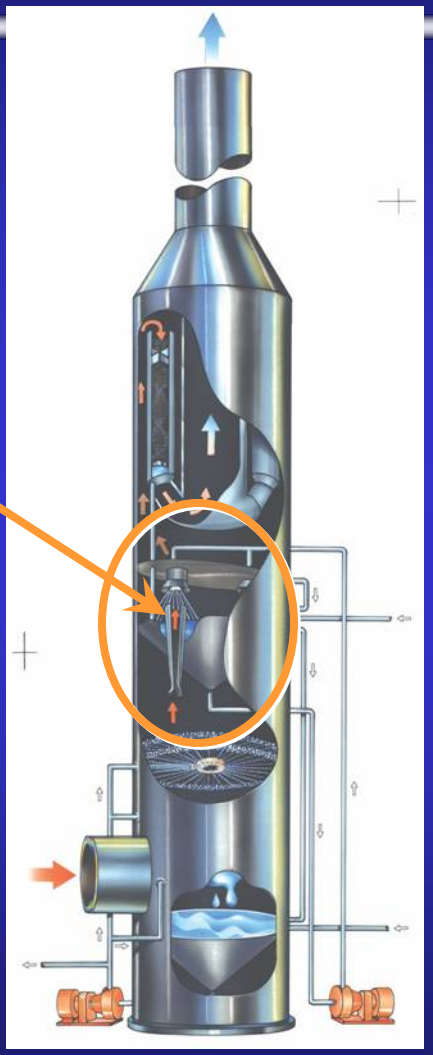
EDV® Wet Scrubbing System



Filtering Modules (FM)



(FM's are applicable only to EDV 5000 and 6000 models)

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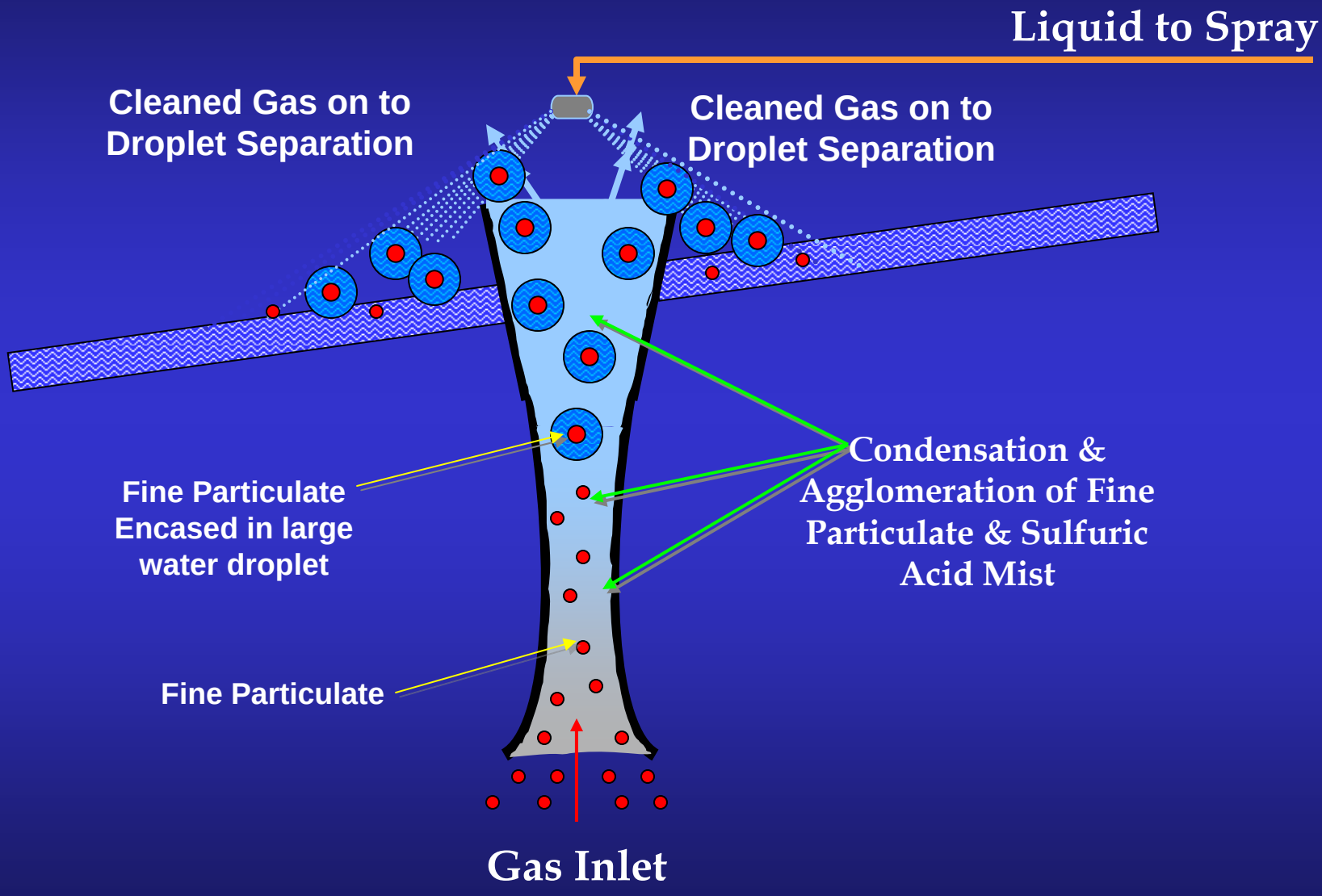
EDV® 5000 Filtering Module

Efficient Fine Particulate Control



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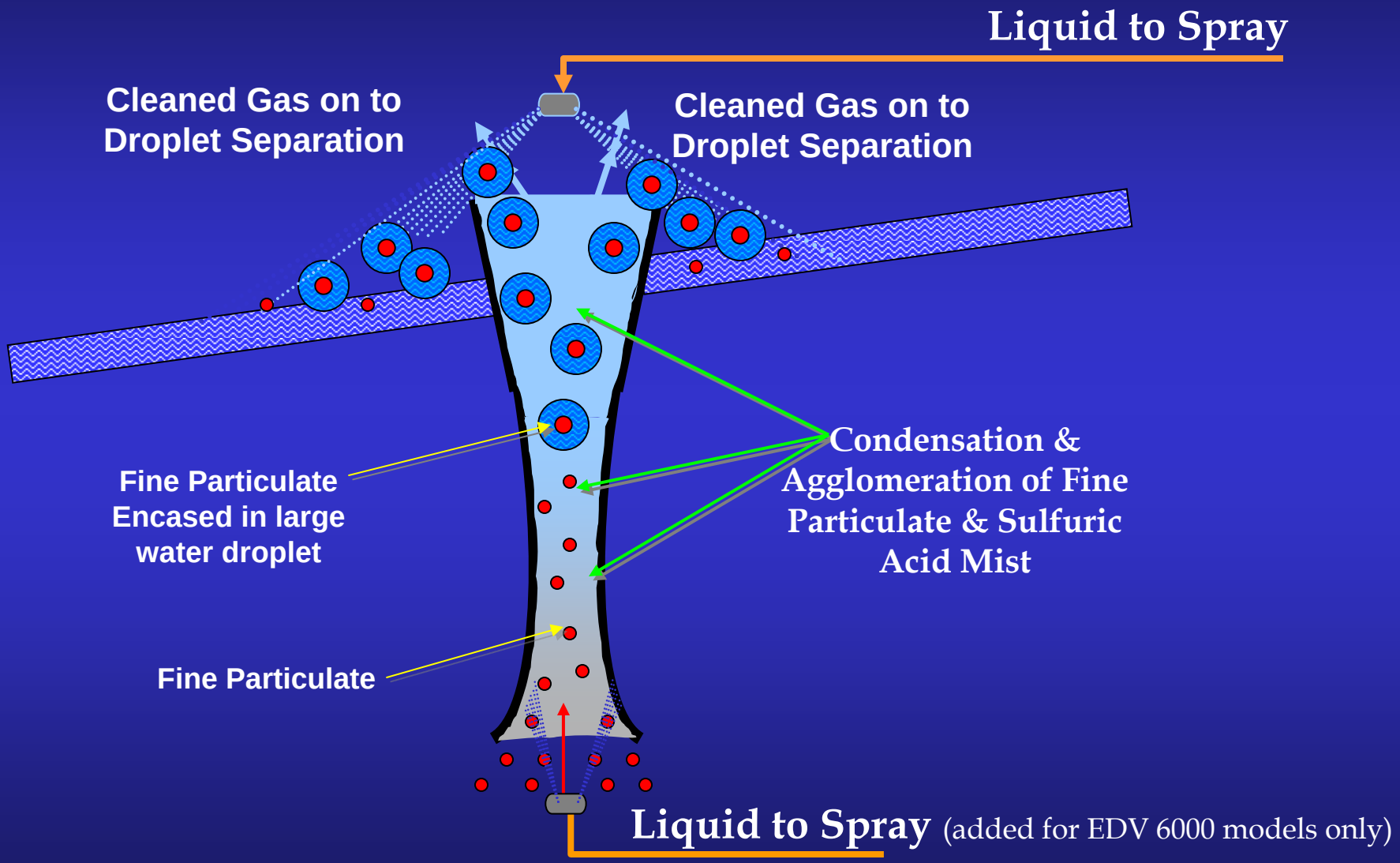
EDV® 6000 Filtering Module

Efficient Fine Particulate Control



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EDV® Wet Scrubbing

Step 4 – Removal of entrained droplets prior to exit through stack

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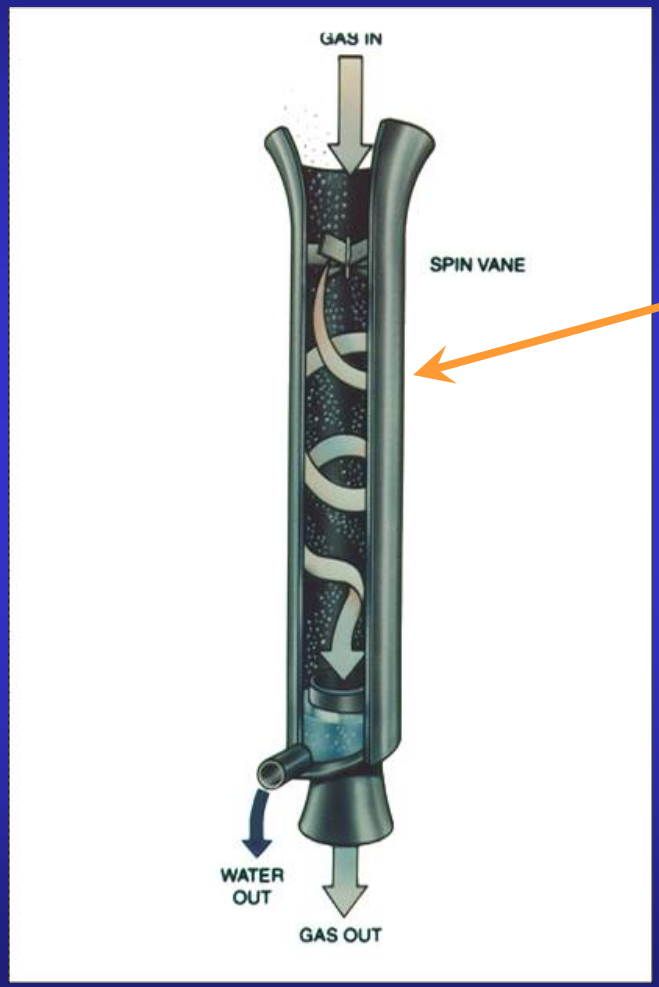
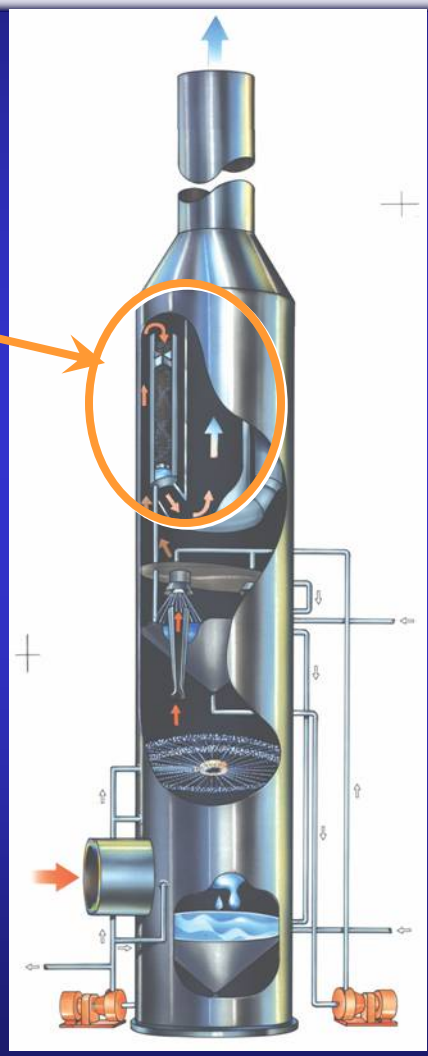
EDV® Wet Scrubbing System

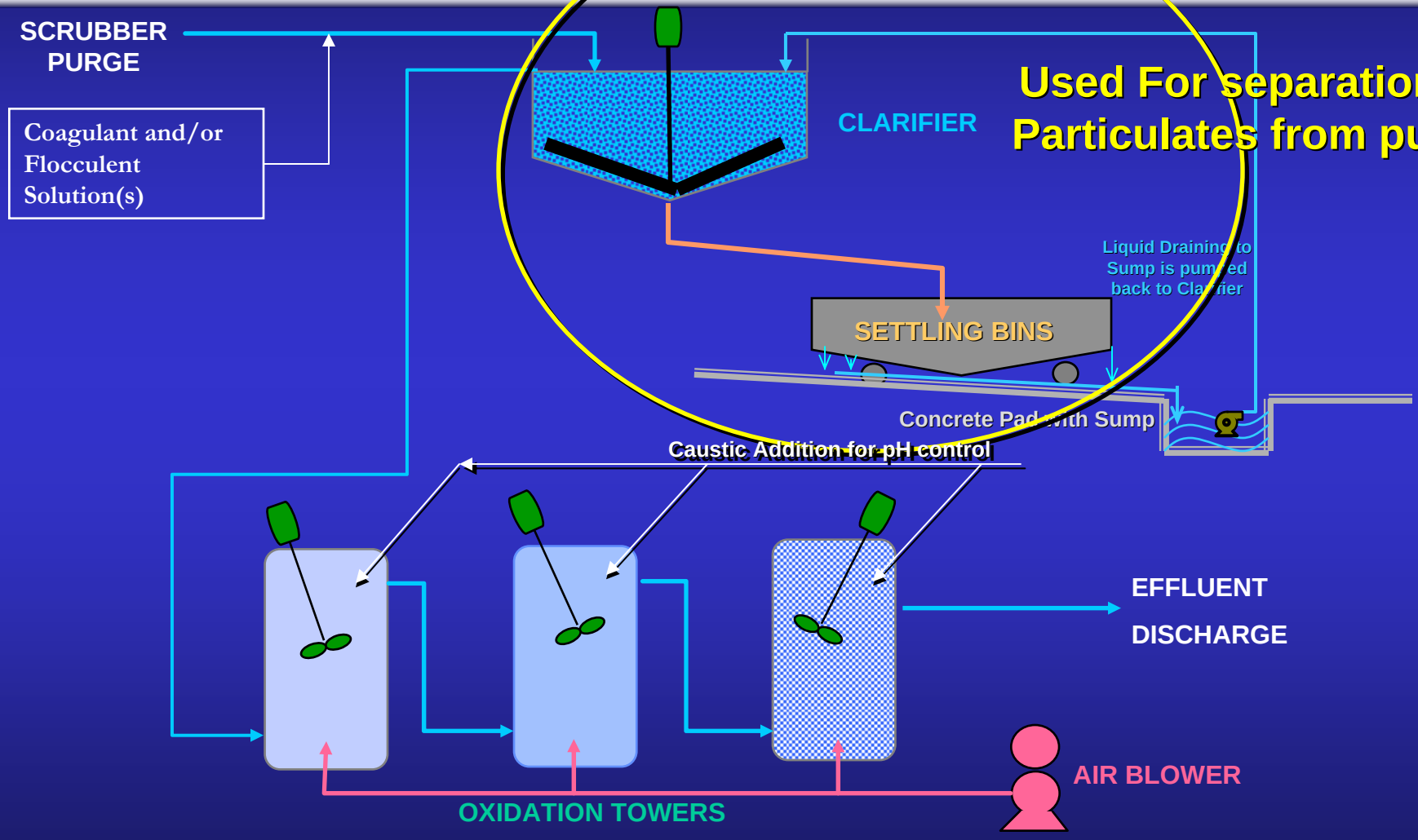


Droplet Separators



Step 5 – Treatment of Scrubber Purge in Purge Treatment Plant (PTU)

EDV® Wet Scrubbing
Purge Treatment Unit



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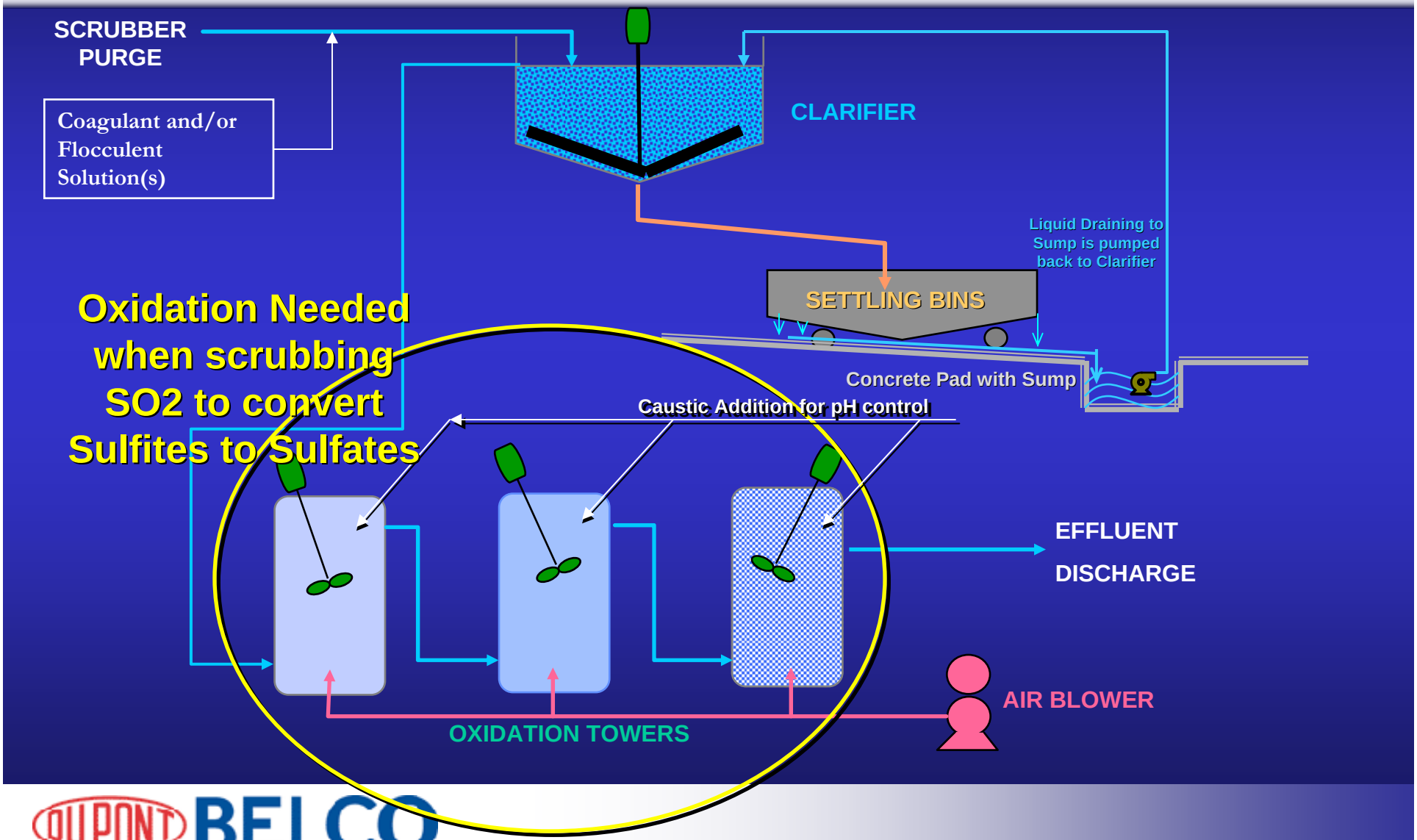
EDV® Wet Scrubbing
Purge Treatment Unit



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EDV® Wet Scrubbing

Purge Treatment Unit (PTU) – Settling Bins

Clarifier Underflow Dumping
to Settling Bin

Drained Catalyst Fines
ready for disposal

EDV® Wet Scrubbing
Purge Treatment Unit (PTU)

EDV® Wet Scrubbing

Purge Treatment Unit

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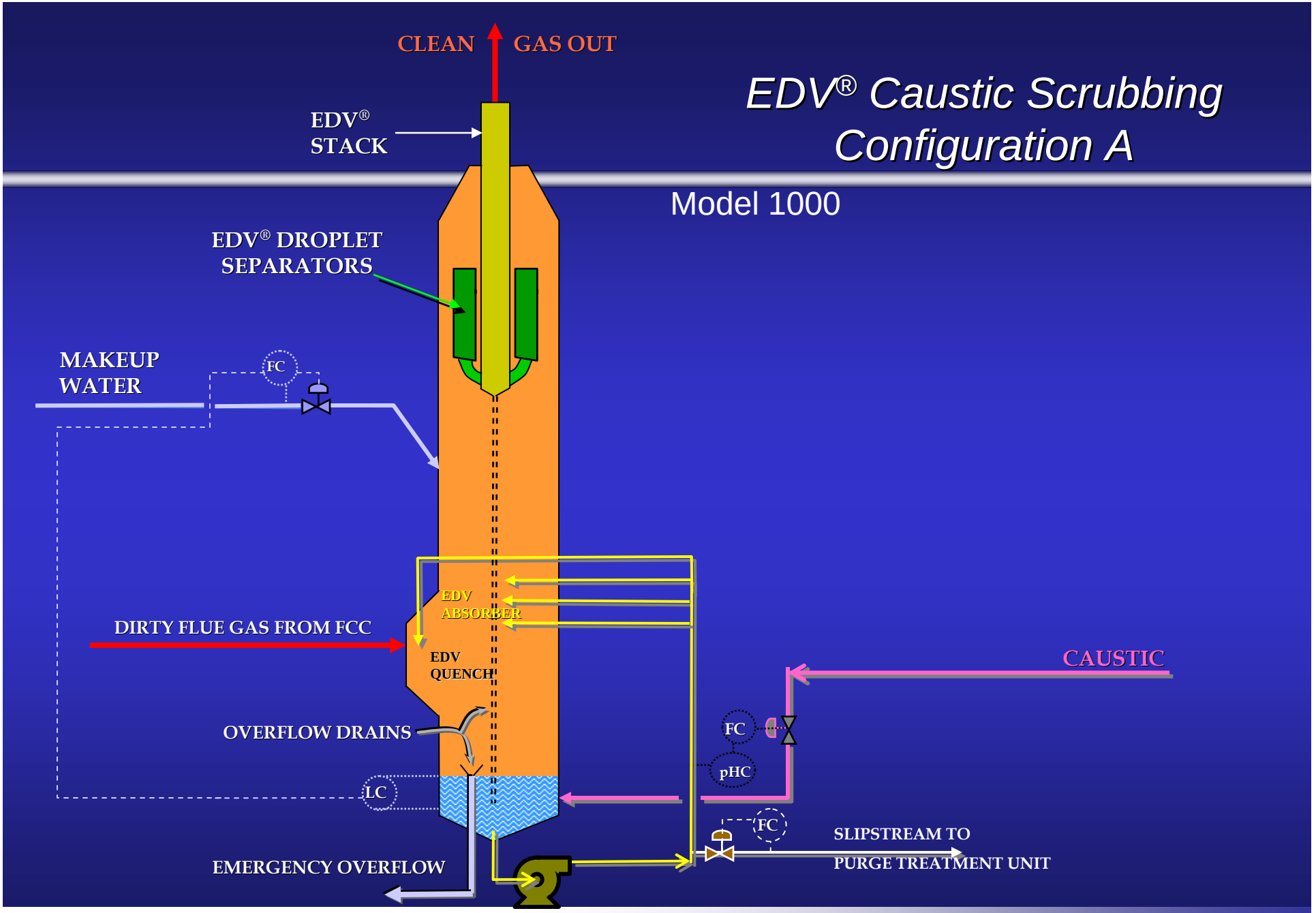
EDV® Wet Scrubbing

Simplified Schematic

EDV® Caustic Scrubbing Configuration A

Model 1000



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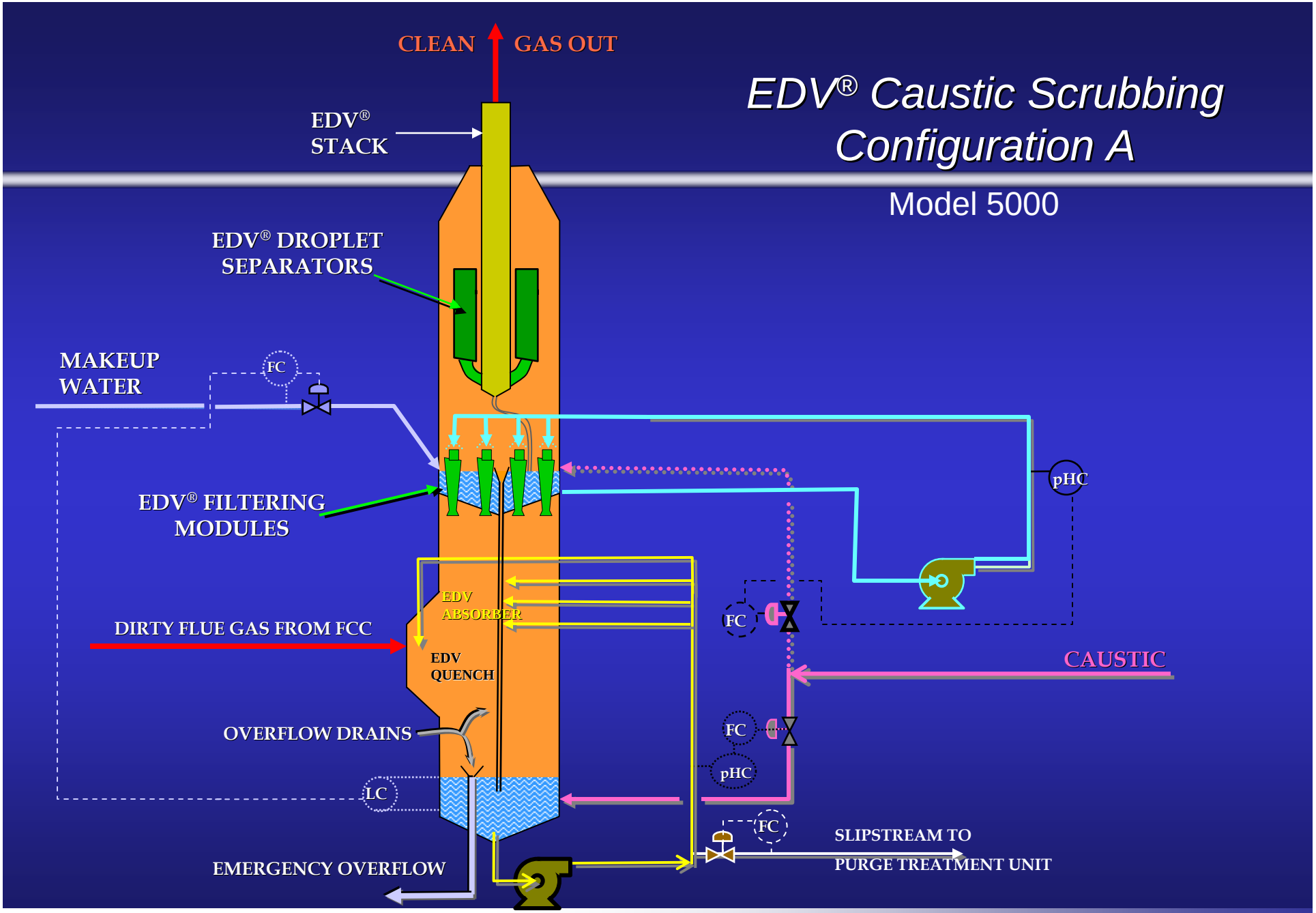
EDV® Caustic Scrubbing Configuration A

Model 5000



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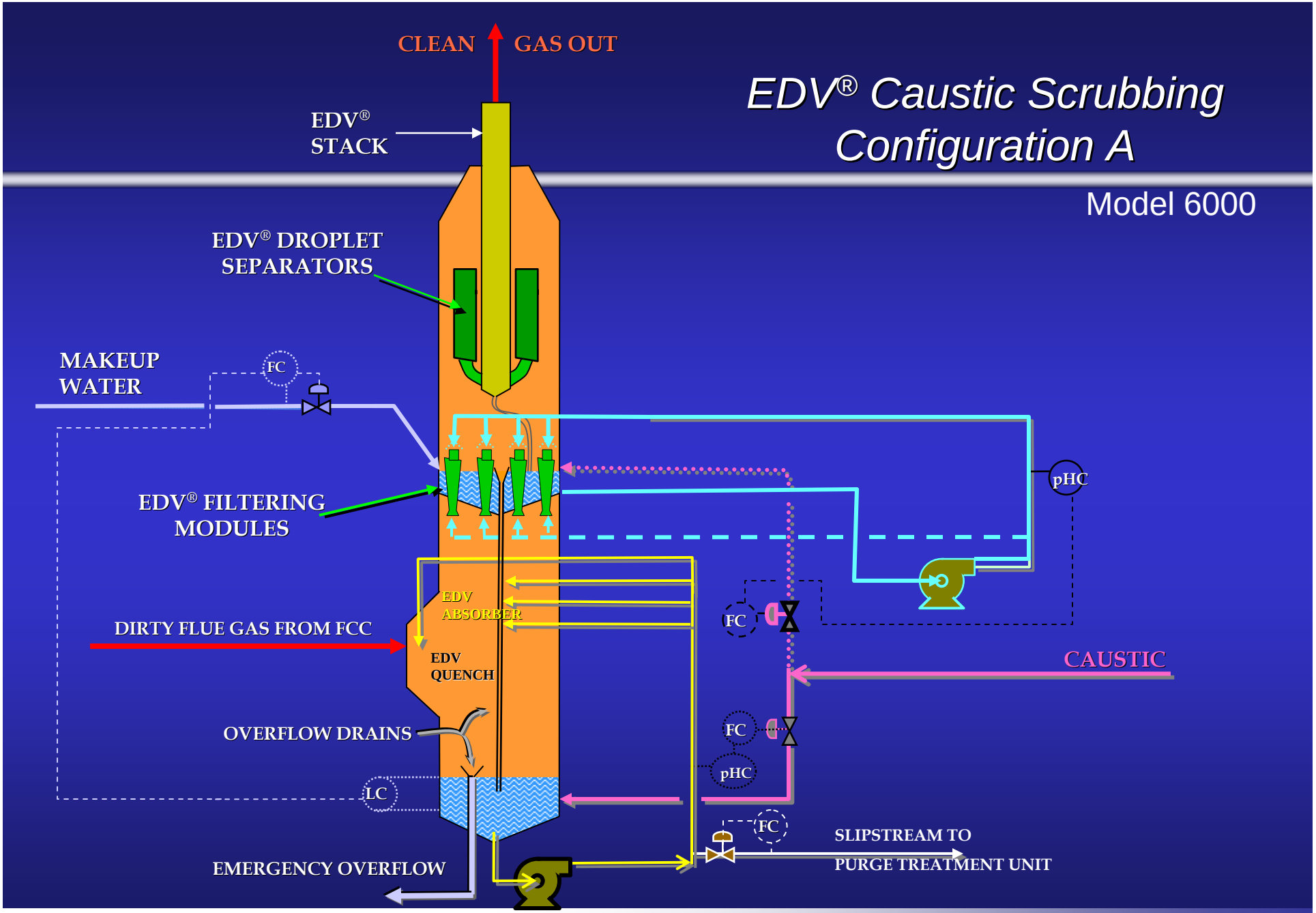
EDV® Caustic Scrubbing Configuration A

Model 6000



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NO_x Reduction with EDV® + LoTOx™

-- Low Temperature Oxidation --

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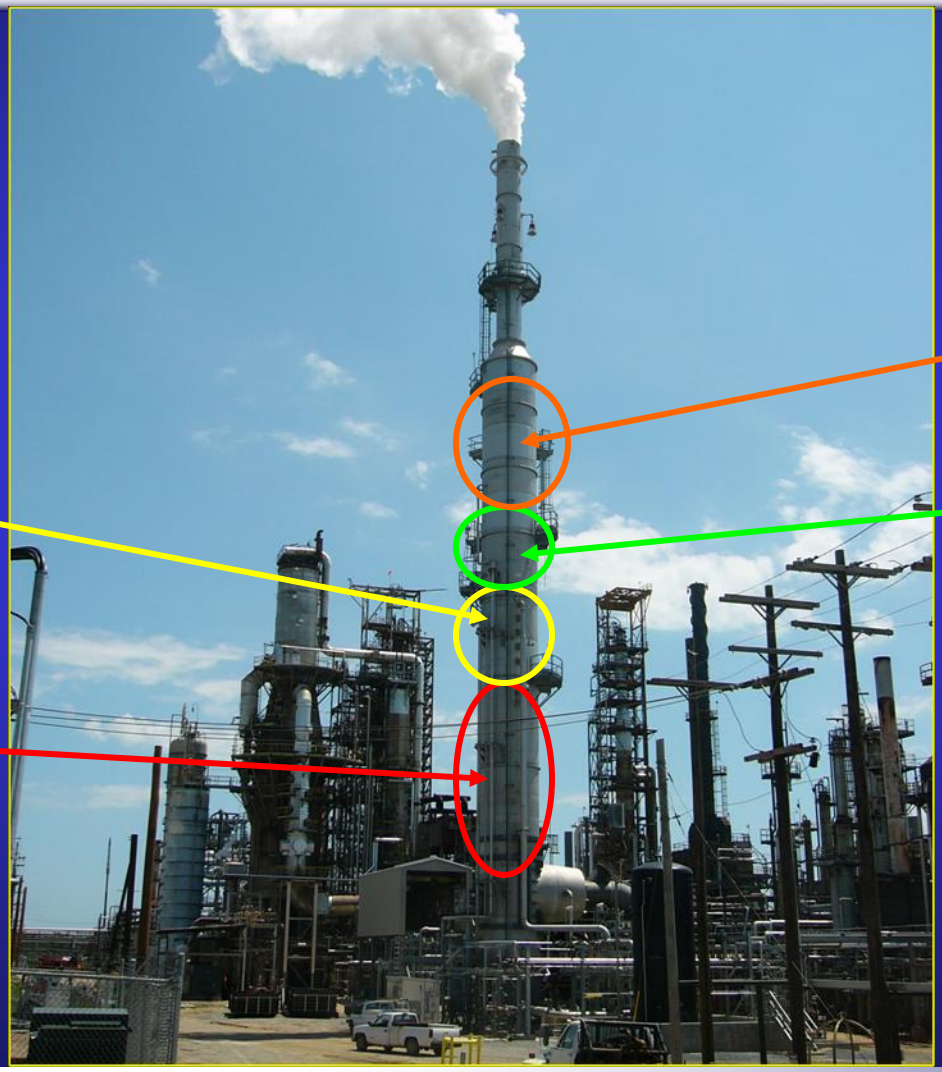
$LoTO_x^{TM}$ Installation on an FCCU

EDV® Wet Scrubber with $LoTO_x^{TM}$



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LoTOx™ NOx Reduction Technology

- LoTOx™ is sold to refineries worldwide by BELCO® under license from The BOC Group
- Patented Process of Injecting Ozone into gas stream to control NOx. Applied following Quench in EDV® Scrubbing System
- Ozone Reacts with NO_X to Form N_2O_5
- Contact with liquid droplets Forms Nitric Acid
- Nitric Acid is Stabilized with Caustic to Form Sodium Nitrate
- Greater than 90% reduction of NOx is achieved
- Competitively priced
- Successfully operating on several FCC units

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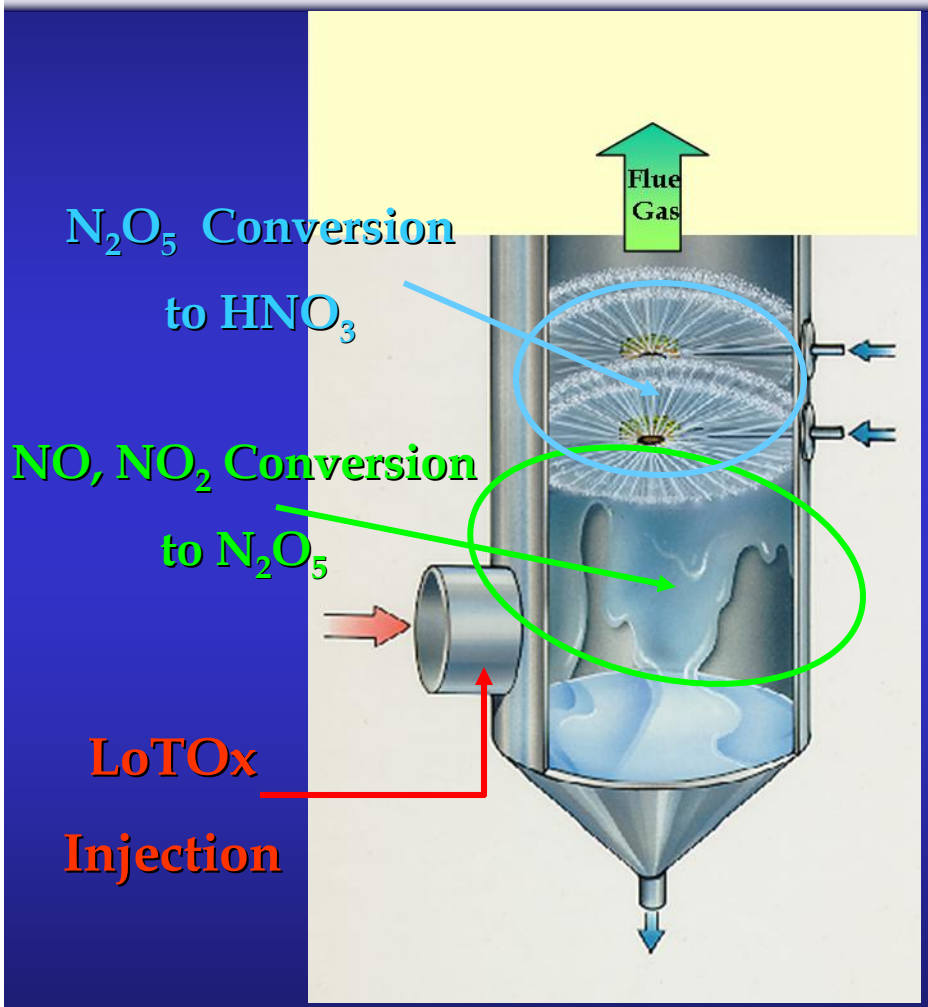
List of LoTOx™ Installations and Pre-Investments

Location	Capacity	NO_x In/Out	Start-up
Southern California	400 HP	150-70-30ppm/2-5ppm	1997
Southern California	1000 HP	30-40ppm/4ppm	January '02
Ohio	25 MW	200ppm/10ppm	October '01
Pennsylvania	--	1000-3400ppm/100ppm	February '00
Southern California	--	50ppm/10ppm	February '02
Lion Oil,, El-Dorado, Arkansas	**20,000 bpsd**	**Confidential**	**June '07**
Valero, Ardmore, Oklahoma	40,000 bpsd	Confidential	TBD
Valero, Three Rivers, Texas	28,000 bpsd	Confidential	TBD
Valero, Texas City, Texas	**65,000 bpsd**	**Confidential**	**4th quarter '07**
ConocoPhillips, Borger, Texas	30,000 bpsd	(SCRUBBER NOT BUILT)	(Project Cancelled)
Valero, Houston, Texas	**58,000 bpsd**	**Confidential**	**April '07**
Marathon, Texas City, Texas	**72,000 bpsd**	**Confidential**	**February '07**
BP, Texas City, Texas	**130,000 bpsd**	**Confidential**	**June '07**
DuPont Morses Mill Plant, Linden, NJ	**880 tons/day acid**	**90 ppm / <10 ppm**	**4rd Quarter '07**
Placid Refining, Port Allen, LA	30,000 bpsd	Confidential	TBD
Star Alliance Refinery, Thailand	40,000 bpsd	Confidential	TBD
Frontier Refining, El Dorado, KS	40,000 bpsd	Confidential	TBD
Flint Hills, Corpus Christi, TX	**45,000 bpsd**	**Confidential**	**2009**
Petrobras, REFAP, Brazil	**7,000 m^3/day**	**Confidential**	**2009**
Western/Giant, Gallup, NM	**11,000 bpsd**	**Confidential**	**2009**
Valero, St. Charles, LA	**100,000 bpsd**	**Confidential**	**2010**
Valero, Delaware City, DE	**75,000 bpsd**	**Confidential**	**2010**
New Award (not yet disclosed)		**Confidential**	**2011**

EDV® Wet Scrubbing
Spray Tower for LoTO$_x$™



- Ozone Injection after Quench
- Conversion to N_2O_5
- Conversion to Nitric Acid
- Conversion to Sodium Nitrate
- Removed in Scrubber Purge

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EDV® scrubbing with LoTOx™ Process

Ozone Injection Grid in Quench Section

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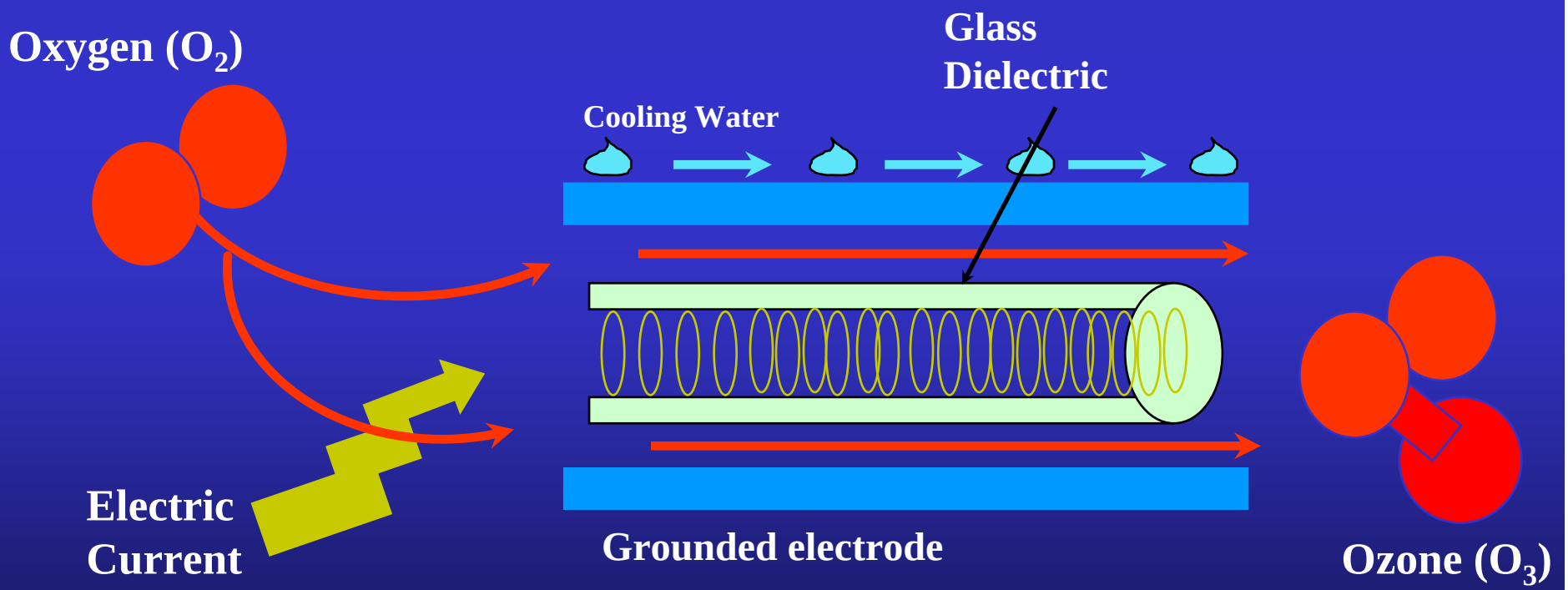
NOx Control

LoTOx™ Process

Cross-Section of Single Ozone Generator Cell



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NOx Control

LoTOx™ Ozone Generator

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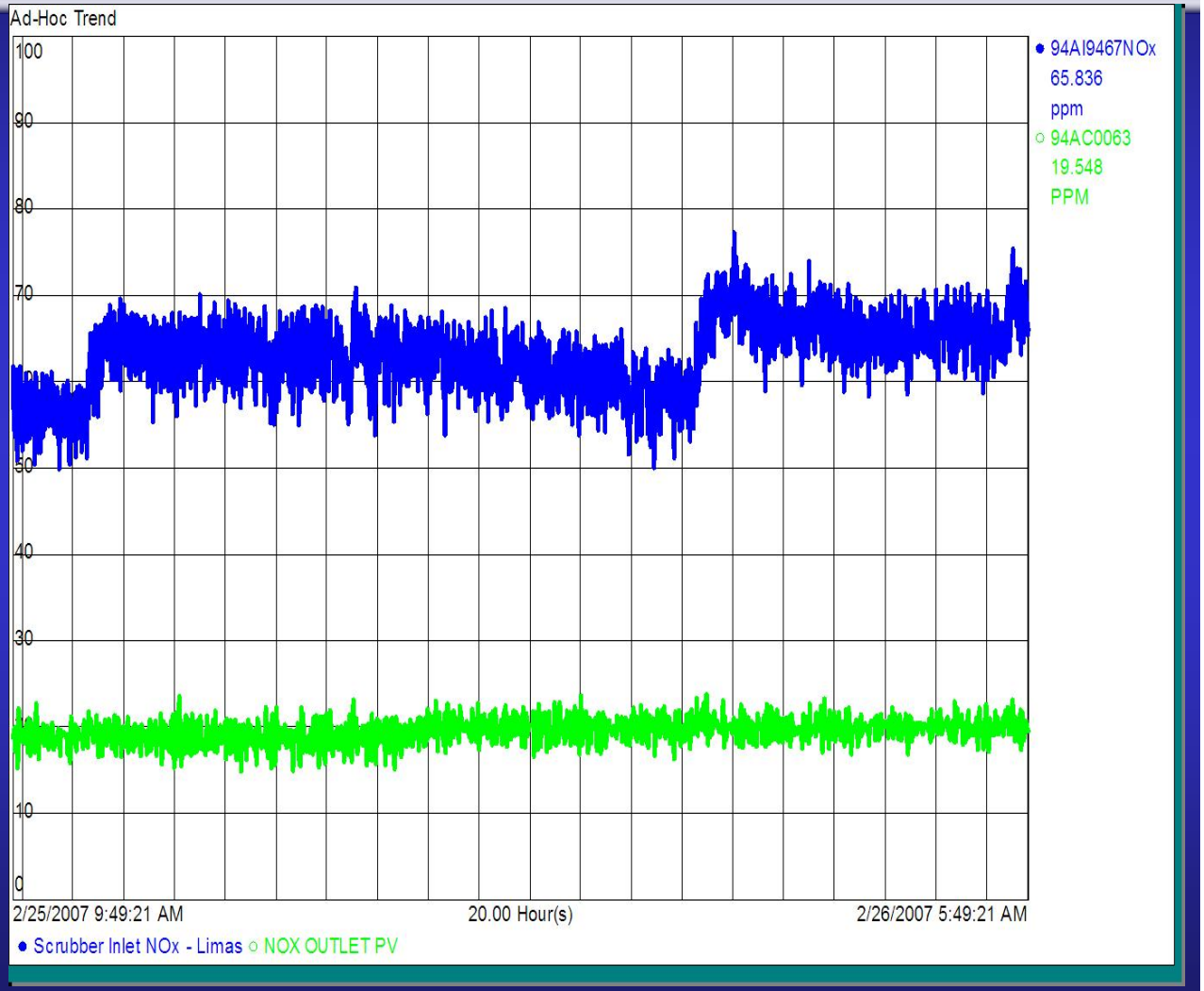
EDV® scrubbing with LoTOx™ Process

Commercial FCCU Application

LoTOx injection allows plant to set a desired stack emission NOx limit (the Set-Point) and adjusts itself to maintain that set-point even through flue gas or inlet NOx variations



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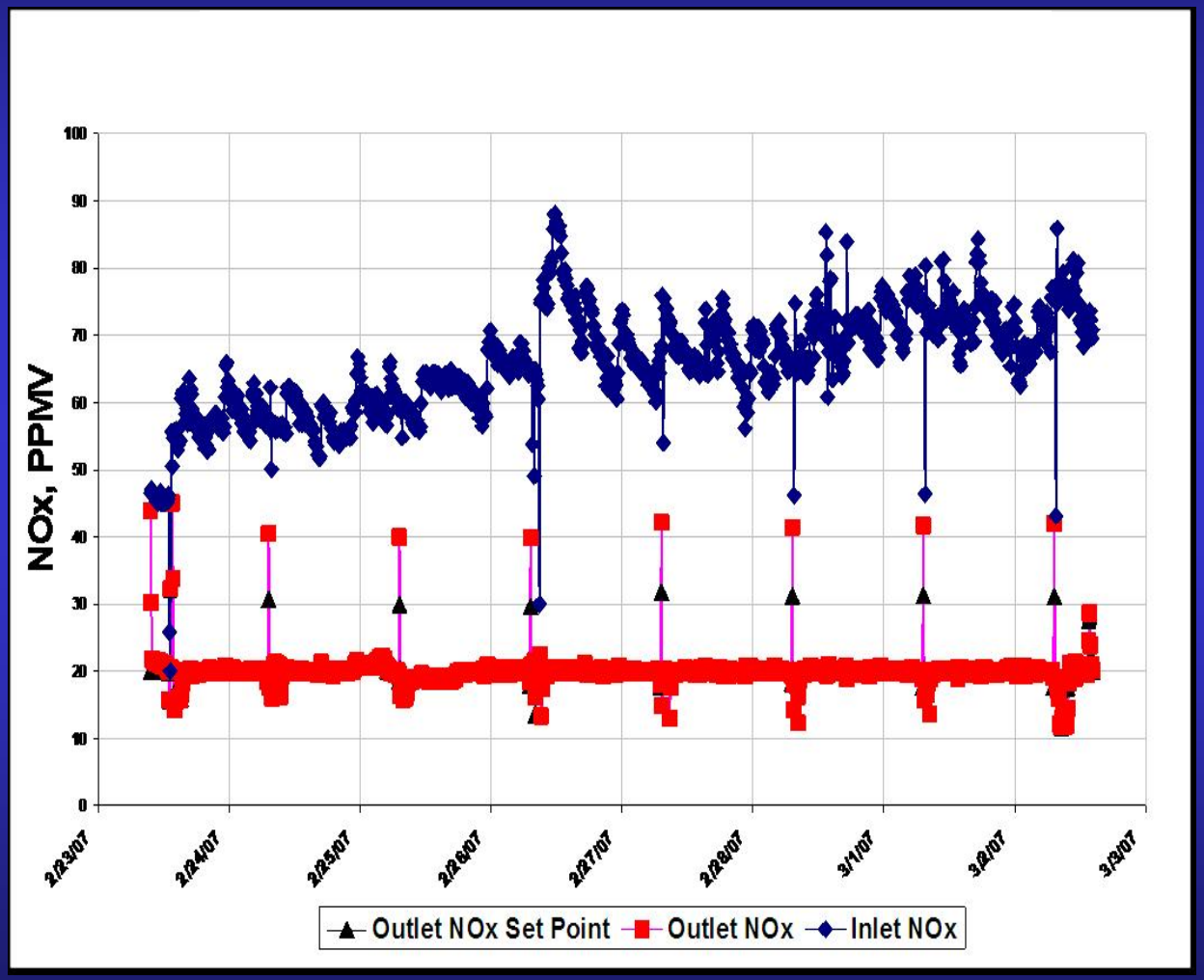
EDV® scrubbing with LoTOx™ Process

Commercial FCCU Application



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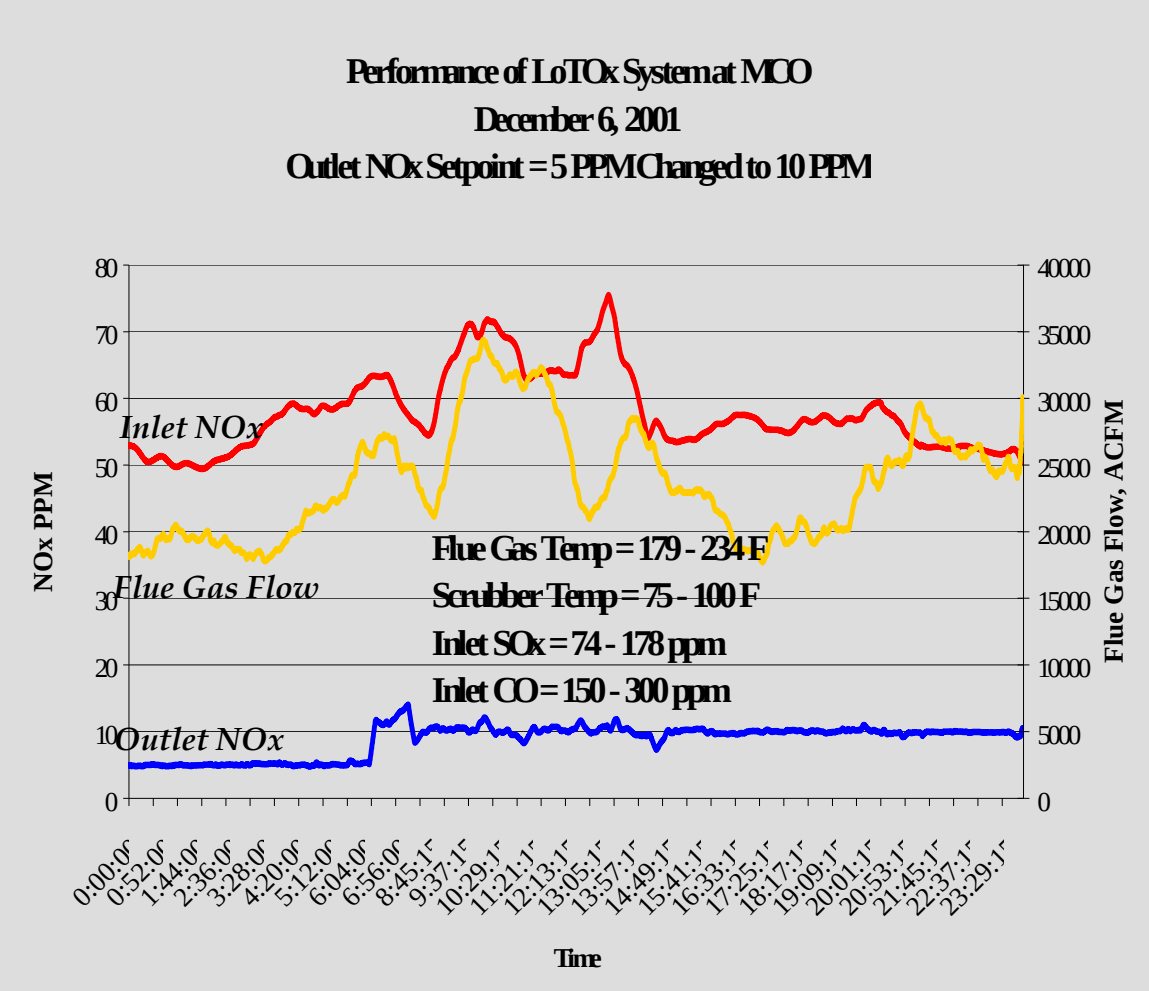
LoTOx™
Medical College of Ohio

Set-Point can easily be changed if desired.

In this picture the set point was changed from 5 ppm to 10 ppm



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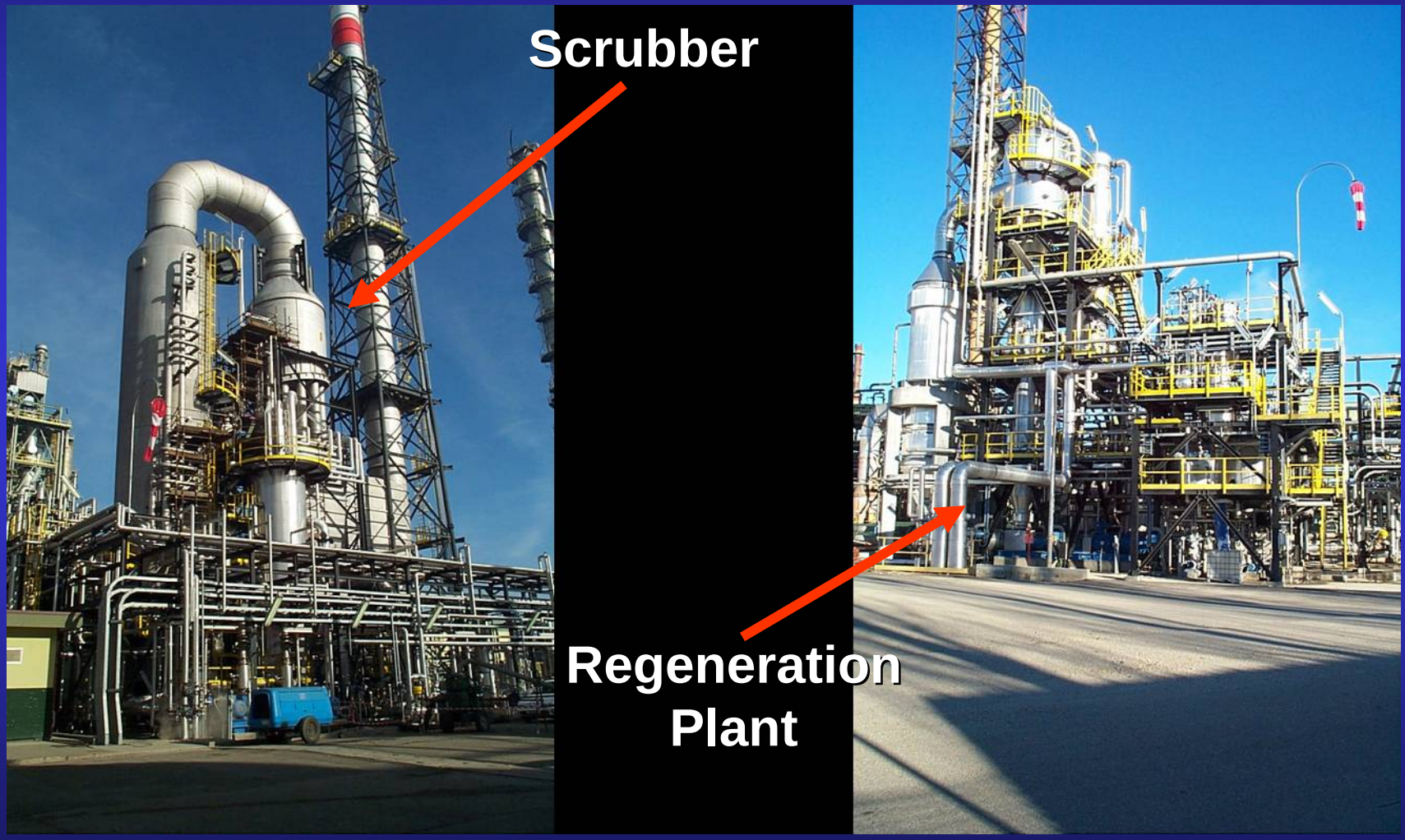
LABSORB™ Regenerative SO_2 Scrubbing System



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LABSORB™
Regenerative Wet Scrubbing

- Uses EDV® System to Scrub SO_2 in Flue/Process Gas Streams
- Reduces Operating Costs by Regenerating The Scrubbing Buffer
- Produces a By-Product Compatible With Refineries (a concentrated SO_2 stream (90+%) that is sent to SRU or Sulfuric Acid Plant)
- Virtually Eliminates Liquid Effluent Discharge from Scrubber
- BELCO Holds Exclusive worldwide License

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LABSORB™
Regenerative Wet Scrubbing

- **Installed more than 10 years ago as SRU tail gas treater at a Refinery in Europe**
- **Operating on a 40,000 bpsd FCCU in Italy since June 2003**
- **Operating on a 60,000 bpsd FCCU in the USA since October 2004**

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LABSORB™
Regenerative Wet Scrubbing

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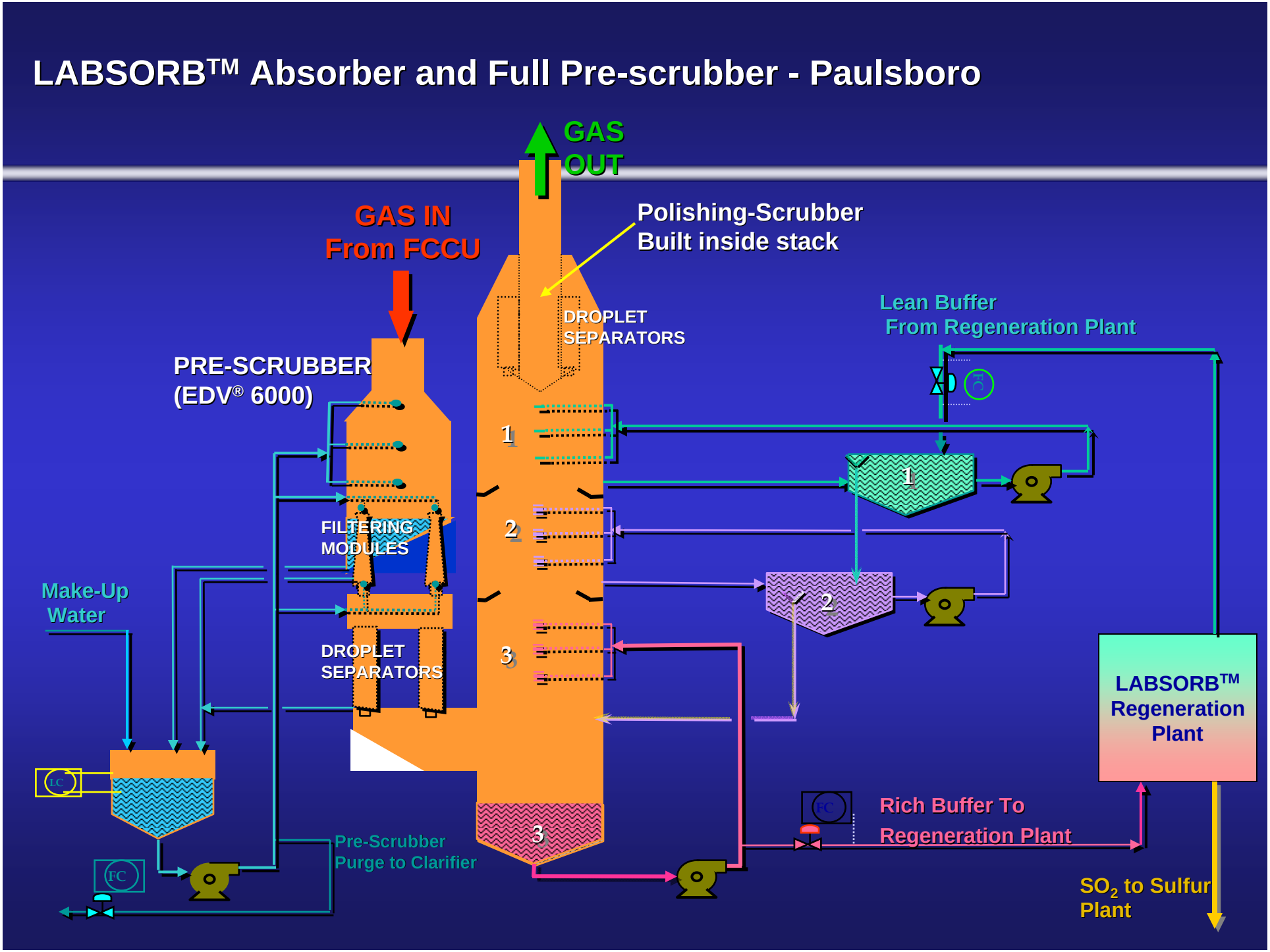
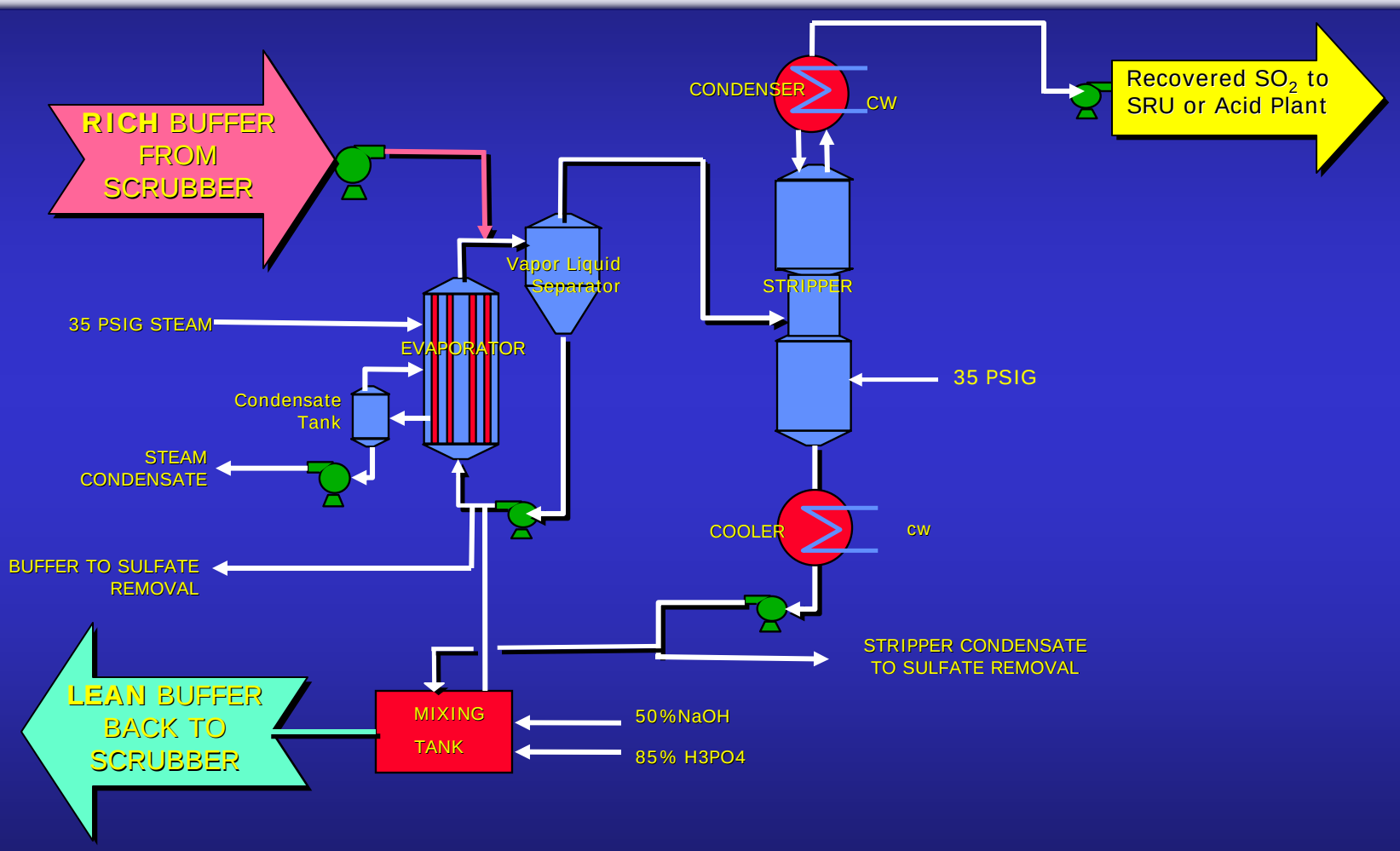
LABSORB™ Absorber and Full Pre-scrubber - Paulsboro



LABSORB™ Regeneration Plant (simplified)
"SINGLE EFFECT" EVAPORATION



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Questions?

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