Thermal Oxidation for Halogens and Acid Gases

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Industries with Acid Gases

CHEMICAL

PHARMACEUTICAL

REMEDIATION

GAS INDUSTRY
AMINE TAIL GAS

ETHANOL

WASTEWATER TREATMENT

Chemical / Pharmaceutical Applications

Many of these applications contain halogens or acidic compounds

HALOGENS

- Chlorine
- Bromine
- Fluorine

ACIDIC STREAMS

- Carbonic acid (formed from carbon dioxide and water vapor)
- Sulfuric acid (oxidation of H2S and other sulfur containing compounds)
- Acetic acid and other organic acids

Oxidation Reaction

- Oxidation reaction produces an acid

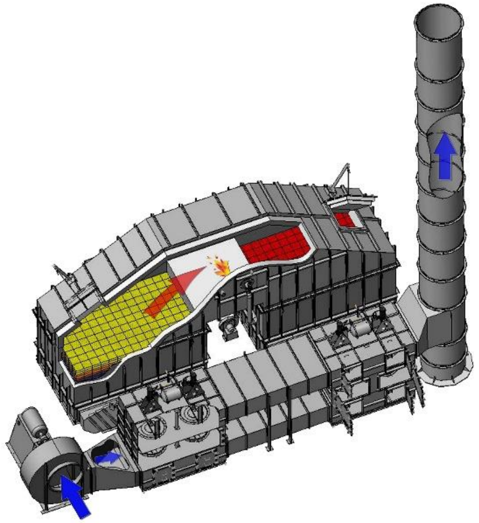
Halogenated Hydrocarbon + O_2 > CO_2 + H_2O + Heat + Inorganic Acid

- Scrubber neutralizes the acid

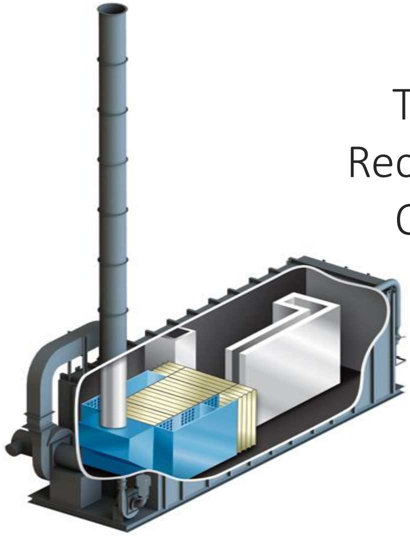
HCl + $NaOH$ > $NaCl$ + H_2O

Oxidizer Selection

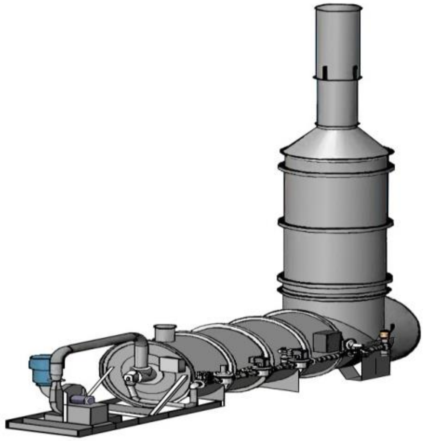
Removal of VOC / HAP by Combustion or Oxidation
Thermal Removal of VOC / HAP at High Temperatures
Catalytic Removal of VOC / HAP at Lower Temperature



★ Regenerative Thermal Oxidizer (RTO)

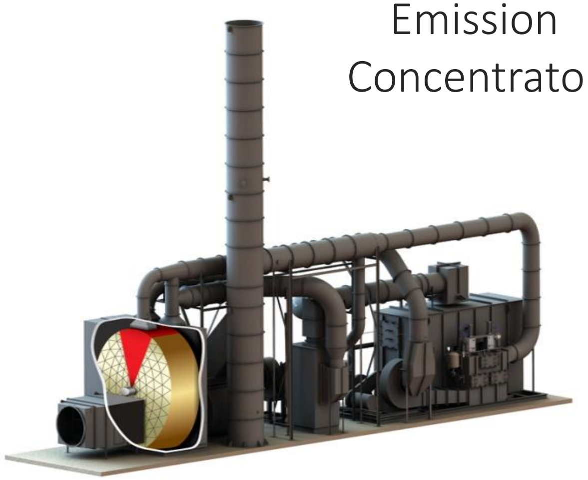


★ Thermal Recuperative Oxidizer

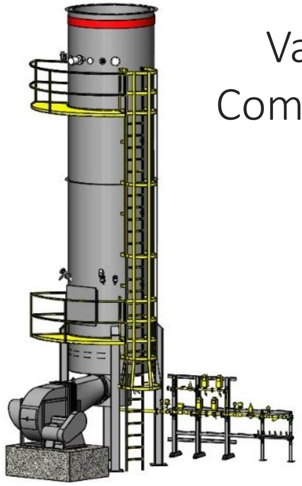


Direct-Fired Thermal Oxidizer (DFTO)

★ Catalytic Recuperative Oxidizer



Emission Concentrator



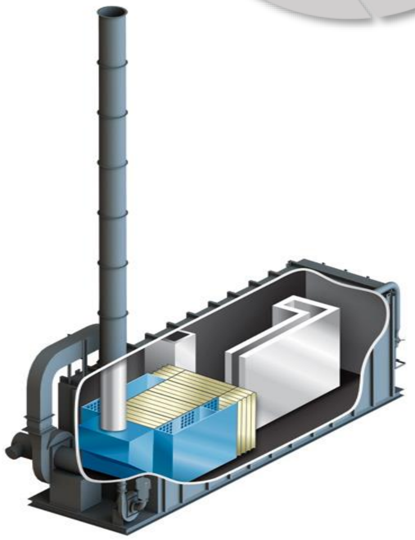
Vapor Combustor

Thermal Recuperative Oxidizer Overview

AIR FLOW RANGE	CONCENTRATION RANGE	THERMAL ENERGY RECOVERY	DESTRUCTION RATE EFFICIENCY (DRE)
100-30,000 SCFM Single Unit	0 – 50 % LEL	50-70%+	99%+

INDUSTRY FOCUS

- PHARMACEUTICAL
- COATING
- METAL DECORATING
- CHEMICAL
- EXPANDED POLYSTYRENE



Catalytic Oxidizer Overview

AIR FLOW RANGE	CONCENTRATION RANGE	THERMAL ENERGY RECOVERY	DESTRUCTION RATE EFFICIENCY (DRE)
100-40,000 SCFM Single Unit	0 - 25 % LEL	50-70%+	99%+

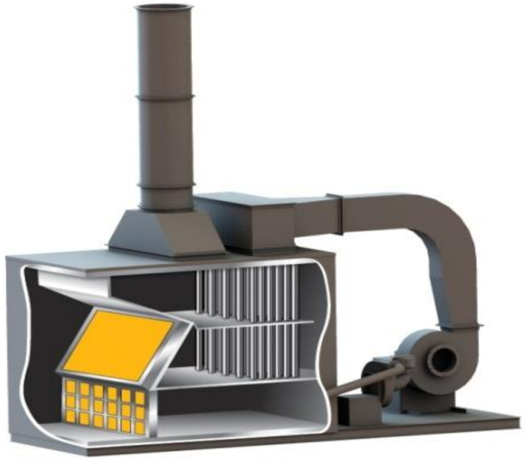
INDUSTRY FOCUS

PHARMACEUTICAL

COATING

PRINTING

CHEMICAL

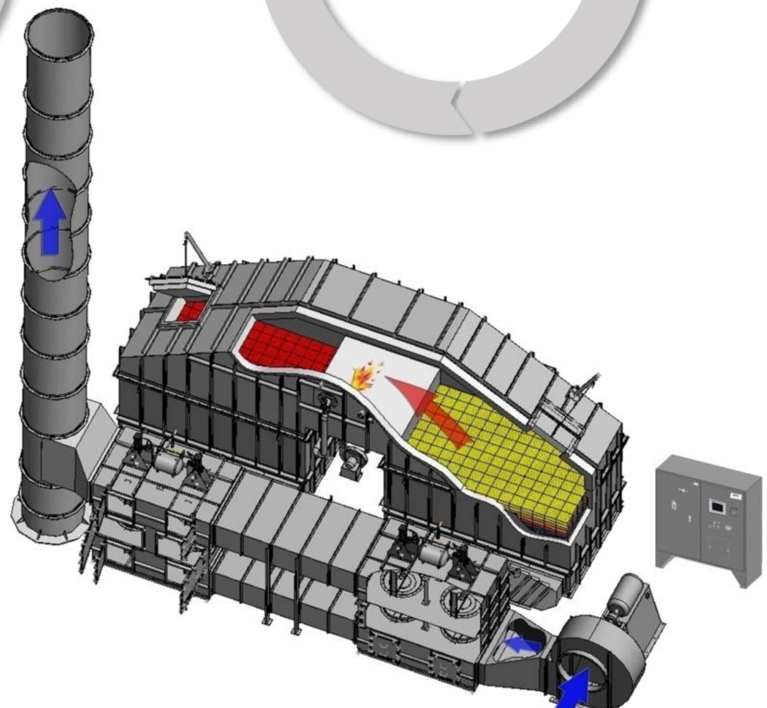


Regenerative Thermal Oxidizer (RTO) Overview

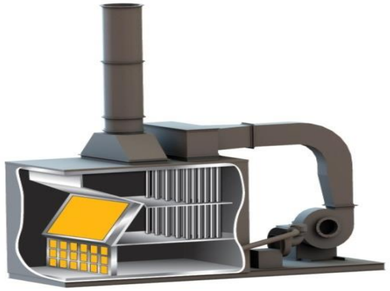
AIR FLOW RANGE	CONCENTRATION RANGE	THERMAL ENERGY RECOVERY	DESTRUCTION RATE EFFICIENCY (DRE)
2,500-70,000 SCFM Single Unit	0 – 25% LEL	True 95%+	99%+

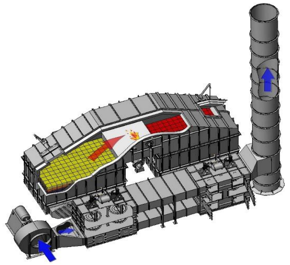
INDUSTRY FOCUS

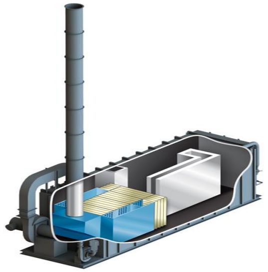
- OIL AND GAS
- COMPOSITES
- PAINTING
- CHEMICAL
- EXPANDED POLYSTYRENE
- PHARMACEUTICAL
- COATING
- METAL DECORATING
- WOOD FINISHING
- PRINTING



Temperature and Residence Time







Catalytic

- Catalyst operating temperature normally increases from 600°F to 890°F
- Higher residence time required = higher catalyst volume

Thermal

- Chamber temperature for halogens increases to 1650°F
- Residence time for halogens increases to 1.5 seconds

Upgraded Materials of Construction

Upgrade critical items to protect against potential corrosion from acids

Catalytic Oxidizers
Heat exchanger and inner reactor shell fabricated out of 316L stainless steel

Thermal Oxidizers
Corrosion resistant outer reactor shell (coated carbon steel, alloy shell material or shroud)

Thermal Recuperative Oxidizers
Heat exchanger fabricated out of higher alloy

Upgraded Materials of Construction

- RTOs:
  - Media support grid material upgraded
  - Higher thermal efficiency = lower outlet temperature= condensing concerns
  - Diverter valves/connection ducts upgraded to stainless steel or AL6XN

Dew Point Considerations

- If the acid dewpoint is reached in the oxidizer, the acid could condense, increasing corrosion potential.
- Will the addition of fresh, dilution air cause condensing? Fresh air may need to be heated.
- High RTO thermal efficiency leads to low outlet temperatures. Check acid dewpoint temperatures and select appropriate materials of construction.
- Approximate dew point temperatures (needs to be calculated for exact process conditions)

HCl, HBr, HF ~ 150°F
SO3 + H2O, Sulfuric Acid ~ 300-350°F

RTO Materials of Construction - Halogens

PREHEATING DESIGN APPROACH Preheat process and any dilution air to 50°F above the acid dewpoint temperature

• Heat Recovery Chambers/ Combustion Chambers:	Carbon steel coated with a vinyl ester resin or hot shell design
• Media Support Grid:	Hastelloy
• Diverter Valves:	316L stainless steel
• Lower Hoppers:	316L stainless steel
• Purge Valves and Ducting:	316L stainless steel
• Inlet Header:	316L stainless steel
• Outlet Header:	316L stainless steel

RTO Materials of Construction - Halogens

DESIGN APPROACH WITHOUT PREHEATING

• Heat Recovery Chambers/ Combustion Chambers:	Carbon steel coated with a vinyl ester resin or hot shell design
• Media Support Grid:	Hastelloy
• Diverter Valves:	AL6XN
• Lower Hoppers:	AL6XN
• Purge Valves and Ducting:	AL6XN
• Inlet Header:	316L stainless steel or AL6XN
• Outlet Header:	AL6XN

Thermal Oxidizers: Hot Shell Design vs. Coatings

- An alloy reactor shell can be costly
- As an alternative the reactor shell can be designed to be kept warm with a shroud or coated with a corrosion resistant compounds
- Either one or the other can be used. They cannot be used together.
- Coating is temperature sensitive

Hot Shell Design - Shroud

- A shroud is placed around the thermal oxidizer outer shell. The reactor shell is kept warm, above the dewpoint temperature of the acid present.
- The inner insulation thickness is reduced to keep the shell warm.
- A 3”- 4” air gap is placed between the shell and the shroud. Allows for air flow in the gap. The shroud protects the shell from rain and weather that may cool the shell below the dewpoint.

Hot Shell Design - Shroud

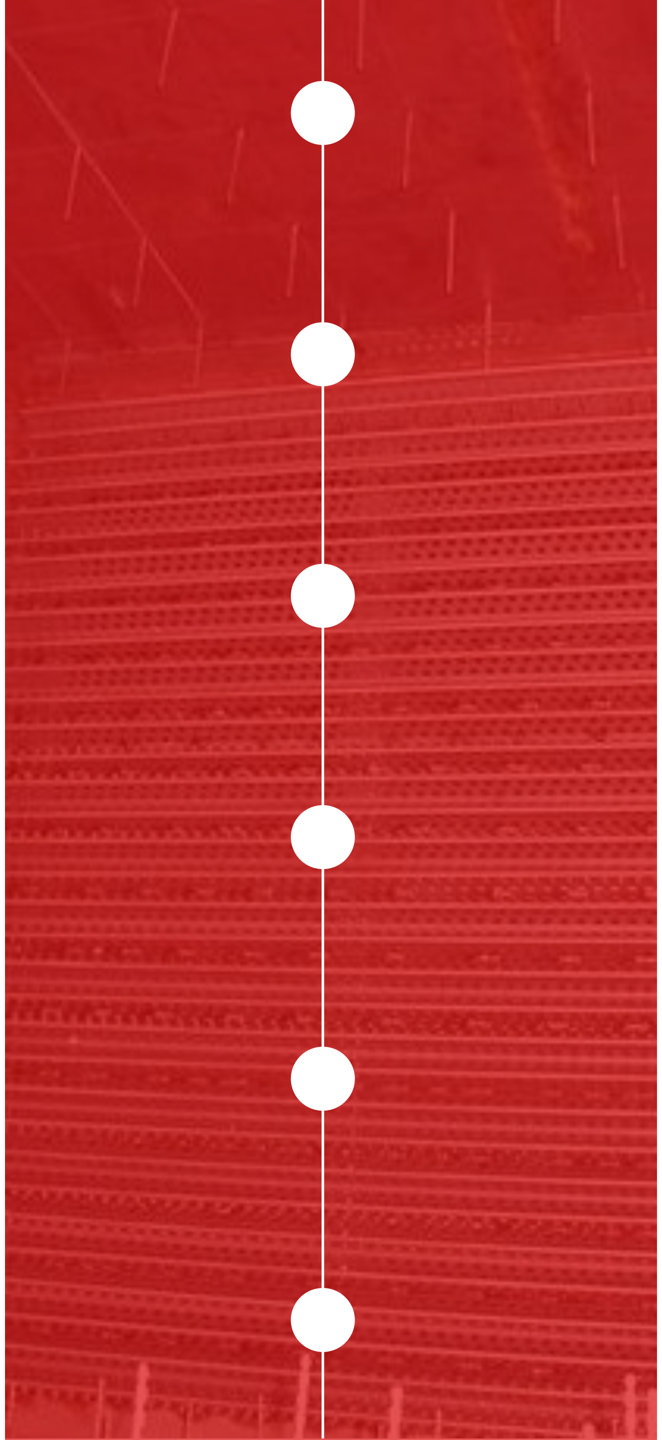
304L stainless steel shroud over a carbon steel reactor

304L stainless steel shroud over an AL6XN reactor

Coatings

- Vinyl ester resin – used on applications with HCl, HBr and sulfuric acid

Coating Applications



Sandblasting & Inspection

Surface and insulation pins are sandblasted to near white finsh.

First Coat

First coat is applied to surface and insulation pins.

First Inspection

First coating application is inspected by a third-party inspector.

Final Coat

Final coat is applied.

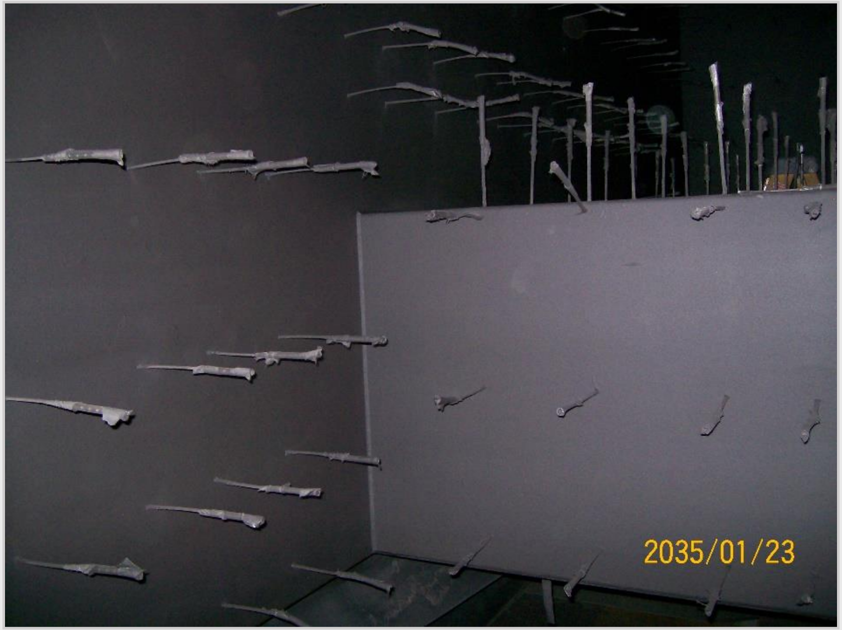
Final Inspection

Final coating application is inspected by a third-party inspector.

Infrared Imaging

Infrared images are taken during start-up to make sure that there are no hot spots present on the shell.

Coating Application



Forced Draft vs. Induced Draft

- For acid gas systems induced draft is preferred
- With induced, system is under negative pressure, at any leak point fresh air would be drawn into system; acid would not leak out
- Any odor or safety concerns, induced draft is preferred

Acid Gas Scrubber

- Acids may require further treatment after the oxidizer
- Typically hastelloy quench and FRP scrubber sump, tower and stack
- All controls, instrumentation and piping by Anguil
- Over 80 oxidation systems operating with scrubbers

Case Study – RTO with Scrubber

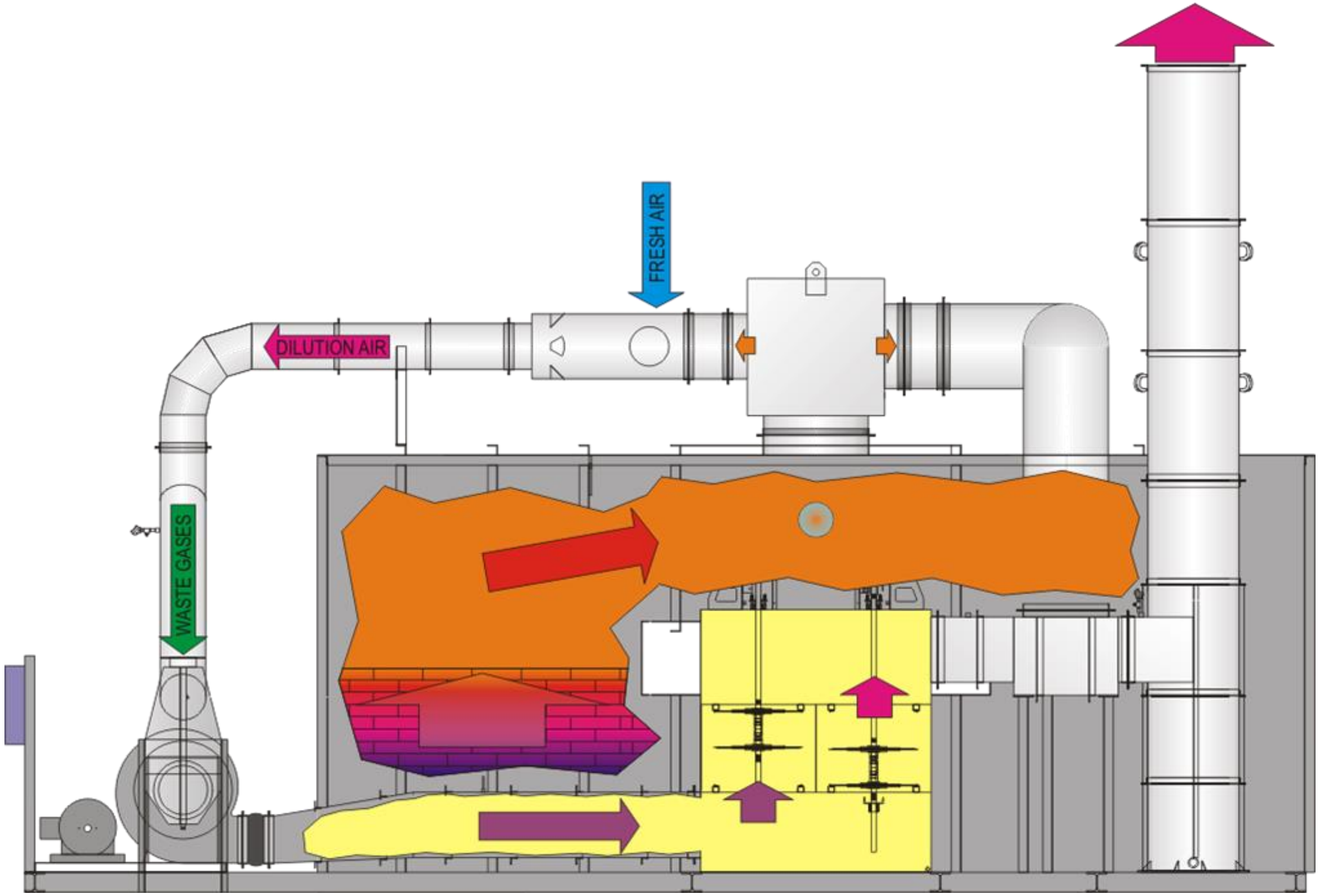
- Chemical application, HCl formed
- Carbon steel reactor with vinyl ester coating
- Hastelloy media support grid
- AL6XN poppet valves, crossover duct
- FRP induced draft fan after scrubber

Case Study – DFTO

- Chemical application, HBr
- Carbon steel reactor with 304L SS shroud
- FRP induced draft fan after scrubber
- Inert process stream sent to burner
- Dilution air introduced into chamber; eliminates condensing issues

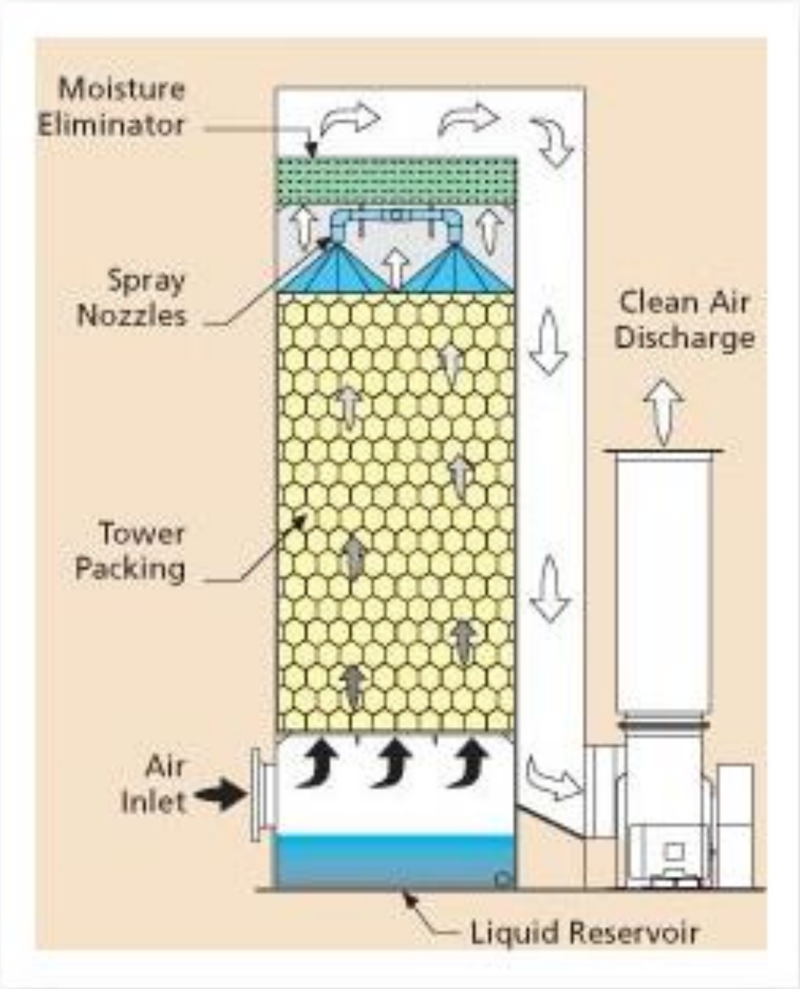
Case Study – Amine Tail Gas Plant RTO

- Sulfuric Acid concerns, H2S present
- Fresh air / process gas is heated to 350F with slip stream from hot side bypass
- 316L SS media support and poppet valves
- Internal coating



Acid Gas Scrubber

- HCl + NaOH → NaCl + H_2O
- Countercurrent packed bed scrubber



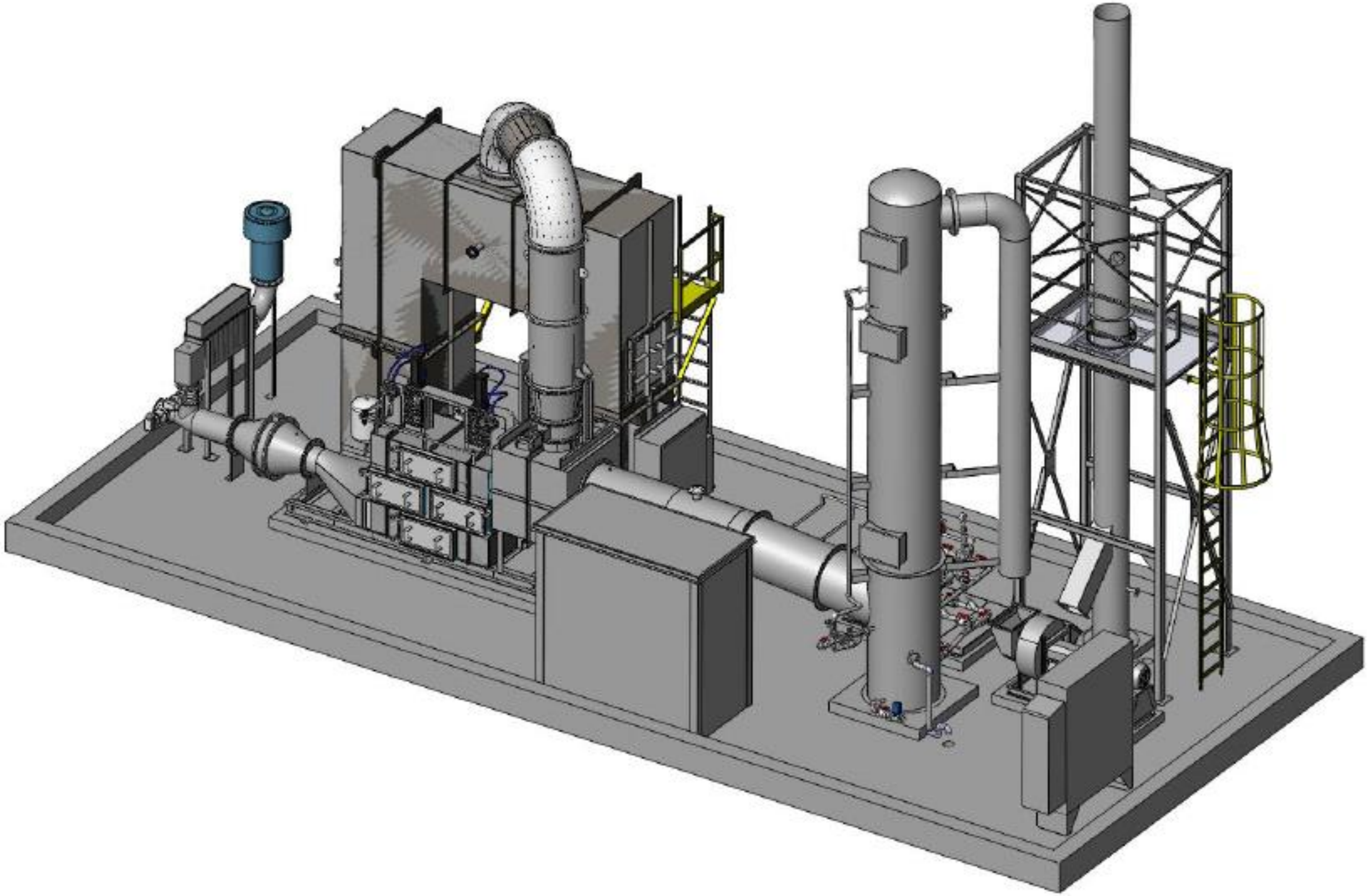
Acid Gas Scrubber

Estimated Caustic Use in Scrubber

Acid gas	NaOH (100% Solution) Required
HCl 1 lb	1.1 lb
HBr 1 lb	.49 lb
HF 1 lb	2.0 lb

We typically recommend a 25% solution of NaOH

Complete RTO / Scrubber System



15,800 Nm^3/h (10,000 SCFM) RTO with Scrubber

- Pharmaceutical, HCl formed
- AL6XN crossover duct
- Hastelloy quench
- FRP scrubber tower
- FRP induced draft fan after scrubber

7,900 Nm^3/h (5,000 SCFM) RTO with Scrubber

- Soil remediation, HCl formed
- AL6XN crossover duct
- Hastelloy quench
- FRP scrubber tower
- Rubber lined induced draft fan after scrubber

55,200 Nm^3/h (35,000 SCFM) Three Chamber RTO with Scrubber

- Pharmaceutical, HCl formed
- Hastelloy crossover duct
- Hastelloy quench
- FRP induced draft fan after scrubber

55,200 Nm^3/h (35,000 SCFM) Three Chamber RTO with Scrubber

47,300 Nm^3/h (30,000 SCFM) Chamber RTO and Scrubber

- Pharmaceutical, HCl formed
- Shroud over RTO
- Hastelloy quench
- FRP induced draft fan after scrubber

141,300 Nm^3/h (90,000 SCFM) Catalytic and Scrubber

- PTA process, HBr formed
- Steam preheaters to preheat process
- 316L stainless steel heat exchanger and crossover duct
- Hastelloy quench

205,000 Nm3/hr (Dual 65,000 SCFM RTO)

- PTA process, HBr formed
- Steam pre-heater to preheat process
- 316 SS valves, RTO coldface
- Internal coating for corrosion protection

2,350 Nm^3/h (1,500 SCFM) Thermal Oxidizer and Scrubber

- Pharmaceutical, HCl formed
- Alloy 800 (nickel-chromium) heat exchanger
- Hastelloy quench
- Rubber lined induced draft fan after scrubber

Questions?

Thank You!