



Wet Air Scrubbing

A reliable technology for

chemical odor treatment

Presented by:

USFilter

RJ ENVIRONMENTAL / METITO

Georgios Ioannou, Product Manager

VEOLIA Environment

Odors

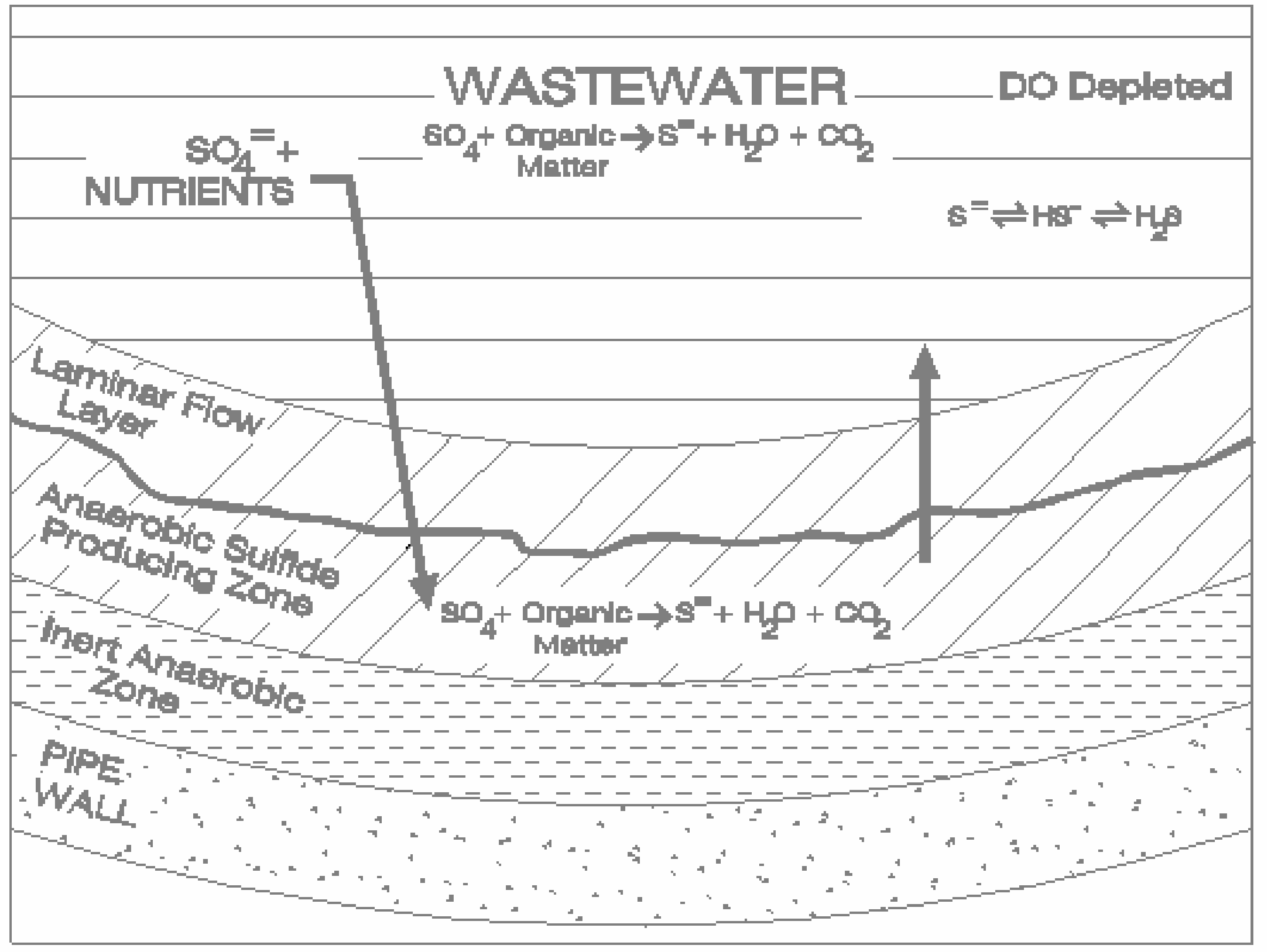
- Mainly formed where anaerobic conditions limit oxygen transfer to wastewater

- Typical Odor Causing Compounds
  - Hydrogen Sulfide - most common wastewater odor
  - Reduced Sulfides (Mercaptans, DMDS, DMS)
  - Ammonia

- Driving Forces for Controlling Odors
  - Worker Safety
  - Corrosion Protection
  - Good Neighbor
  - Nuisance Control

Typical Sewer

- **Anaerobic conditions cause odorous compounds to form, primarily hydrogen sulfide**



Hydrogen Sulfide Concerns

- **Odor:**
  - **Rotten Egg Odor, Low Odor Threshold, Highest Concentration among Odor Compounds**
- **Safety - Exposure Effects:**
  - **Odor (0 - 10 ppm)**
  - **Headache and Nausea (10 - 50 ppm)**
  - **Eye/Lung Damage (50 - 500 ppm)**
  - **Collapse and Death (500+ ppm)**
- **Corrosion:**
  - **Forms Sulfuric Acid in Condensate**

Hydrogen Sulfide - Odor and Toxicity

ppm

		ppm
Rotten Egg Odor Alarm	Odor Threshold	0.1
	Offensive Odor	3
	Headache, Nausea Throat and Eye Irritation	10
Serious Eye Injury	Eye Injury	50
Loss of Sense of Smell	Conjunctivitis, Respiratory Tract Irritation, Olfactory Paralysis	100
Imminent Life Threat	Pulmonary Edema	300
	Strong Nervous System Stimulation Apnea	500
Immediate Collapse	Death	1,000
		2,000

Hydrogen Sulfide - Corrosion

Oxidation to Sulfuric Acid:

$$H_2S + 2O_2 \longrightarrow H_2SO_4$$

Sulfuric Acid Reacts with Concrete, Metallic, and Composite Pipes and Structures

Conditions Which Promote Sulfide

Formation

- **Long Force Mains/ Long Detention Times**
  - **More Time, More Sulfate Uptake, More Sulfide**
- **High Temperature**
  - **Increased Biological Activity**

Release

- **Low pH**
  - **Decreases Sulfide Solubility**
- **High Temperature**
  - **Decreased Sulfide Solubility**
- **High Turbulence**
  - **Increases “Stripping”**

Other Problem Compounds:

- **Organic Sulfur Compounds: Mercaptans, Methyl Sulfides, Etc.**
  - **Usually Formed and Released with H_2S**
- **Ammonia and Amines**
  - **Usually Released from Sludge, Especially During pH Adjustment or Heat Treatment**

Odor Testing and Identification:

- **Identify the Odor Compounds & Concentrations**
- **Identify the Physical Site Conditions**
- **Identify the Operational Conditions**

Solving the Problem:

- **Take a Step-Wise Approach**
  - **Try Adjustments First**
  - **Employ “Outside” Technology Second**
- **If “Outside” Technology is Necessary:**
  - **Fully Understand the Problem**
  - **Evaluate the Economic *and* Process Characteristics of Alternatives**
  - **Choose the Right Solution!**

Treatment Alternatives

VAPOR PHASE

- **Provides Point-Source Solution**
- **Treats Wide Range of Compounds**
- **Provides Area Ventilation**

LIQUID PHASE

- **Prevents Atmospheric Sulfide**
- **Effective Odor and Corrosion Control**
- **Treats Multiple Odor Release Points**

Vapor Phase Odor Control Process

- **Absorption (Chemical Reaction)**
  - **Single-Stage Wet Scrubbers**
  - **Multiple-Stage Wet Scrubbers**
- **Adsorption (Physical Process)**
  - **Carbon Adsorbers**
  - **Biofilters**
- **Incineration (Thermal Oxidation)**
- **Dilution**

Technology Comparison - Carbon Adsorbers

- **Typically, least capital cost of odor technologies**
- **Minimal maintenance required**
- **High removal efficiency until break-through**
- **Expensive to operate unless H_2S is very low (typically under 10 ppm)**
- **Moderate footprint required (20 m/min velocity)**

Technology Comparison - Biofilters

- Relatively low operating cost
- Requires consistent loading or odor break-through will occur
- Requires acclimation period
- Biological process does not remove ammonia or amines
- Large footprint required (1 to 10 m/min velocity)

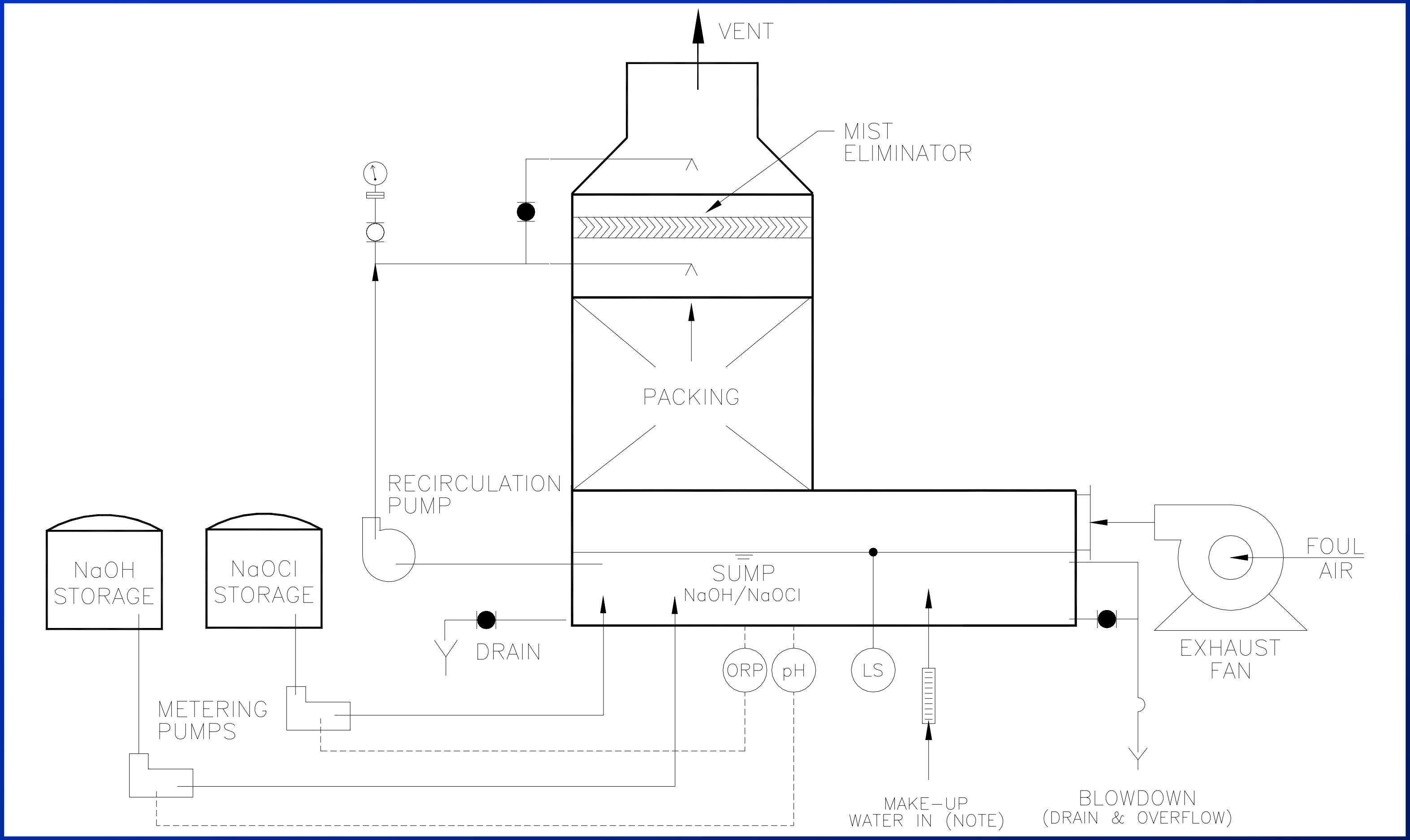
Technology Comparison - Wet Scrubbers "Packed Towers"

- **Benefits**
  - **Most reliable and flexible vapor phase treatment technology**
  - **High removal efficiency (99.5%+)**
  - **Can respond instantly to changing H_2S loads**
  - **Small footprint required (150 m/min velocity)**
  - **Can remove any water soluble compound**
  - **Can run intermittently**
- **Drawback**
  - **Chemicals required, typically sodium hydroxide (NaOH) and sodium hypochlorite (NaOCl), which can be costly**
- **Types:**
  - **Vertical, counter-current (most efficient)**
  - **Horizontal, cross-flow**

Vertical, Counter-Current Wet Scrubbers

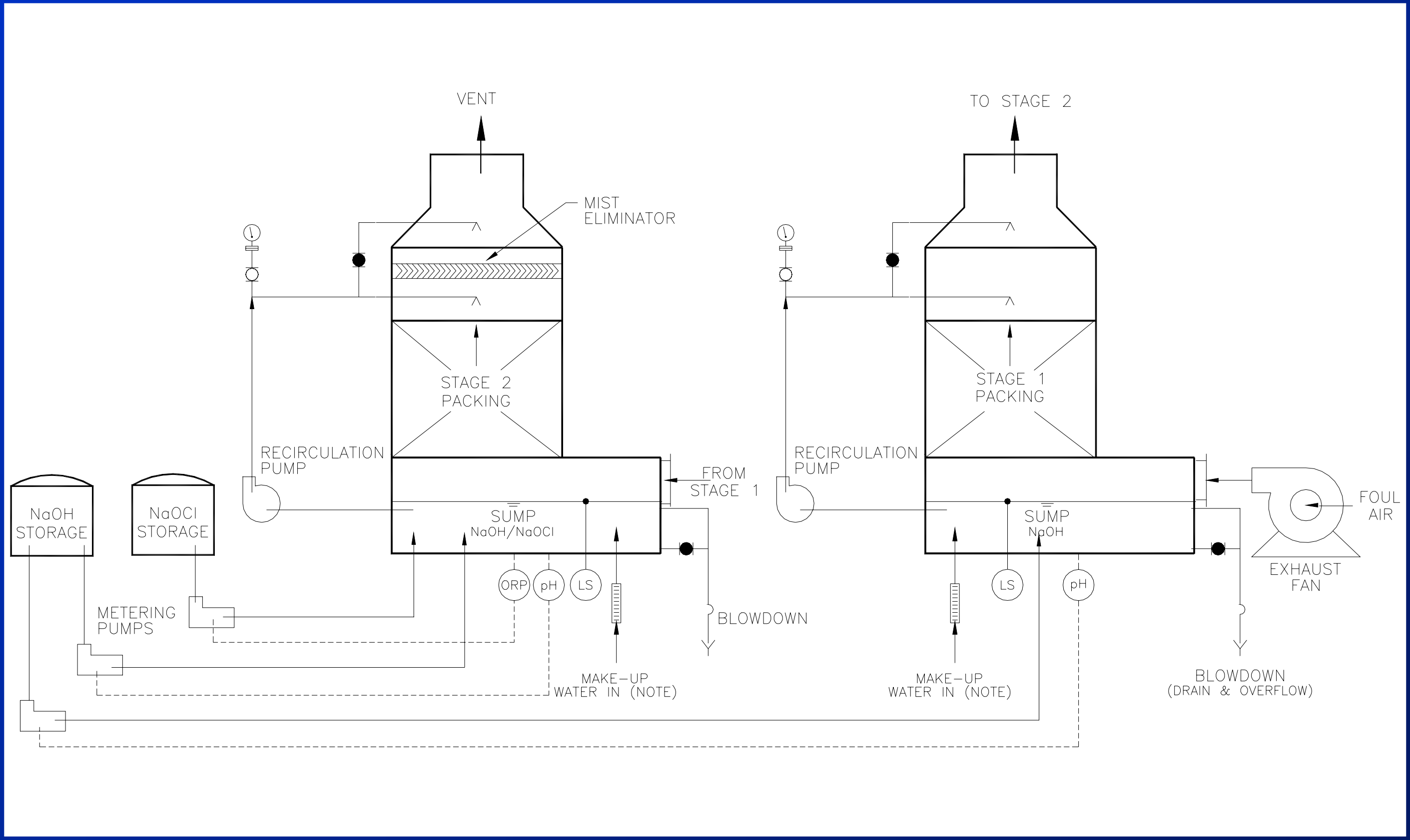
- Odorous air is forced (via fan) into the bottom of the scrubbing tower and water supplemented with NaOH and NaOCl is circulated to the top of the tower (via recirculation pump)
- Plastic packing media traps the liquid and air and the turbulent contact removes the odors from the air into the liquid and the chemical reactions occur
  - $2NaOH + H_2S \rightarrow Na_2S + H_2O$ (2.35 kg NaOH per kg H2S)
  - $4NaOCl + 2NaOH + H_2S \rightarrow 4NaCl + Na_2SO_4 + 2H_2O$ (2.35 kg NaOH and 8.75 kg NaOCl per kg H2S)
- Water is continuously fed and overflowed out of the sump to remove the salt by-products
- ORP (Oxidation-Reduction Potential) and pH probes and analyzers monitor the levels and alter the injection rates of the chemical feed pumps to ensure the right amount of chemical in the system

Packed Tower Process Flow Diagram



Two-Stage Packed Tower Scrubber

- Pre-Treatment Stage Eliminates Approximately 70% of Odors Using a Less Expensive Chemical (NaOH alone)
- Complete Utilization of Chemicals Prior to Discharge with Multiple Sumps
- Optimal Process Control

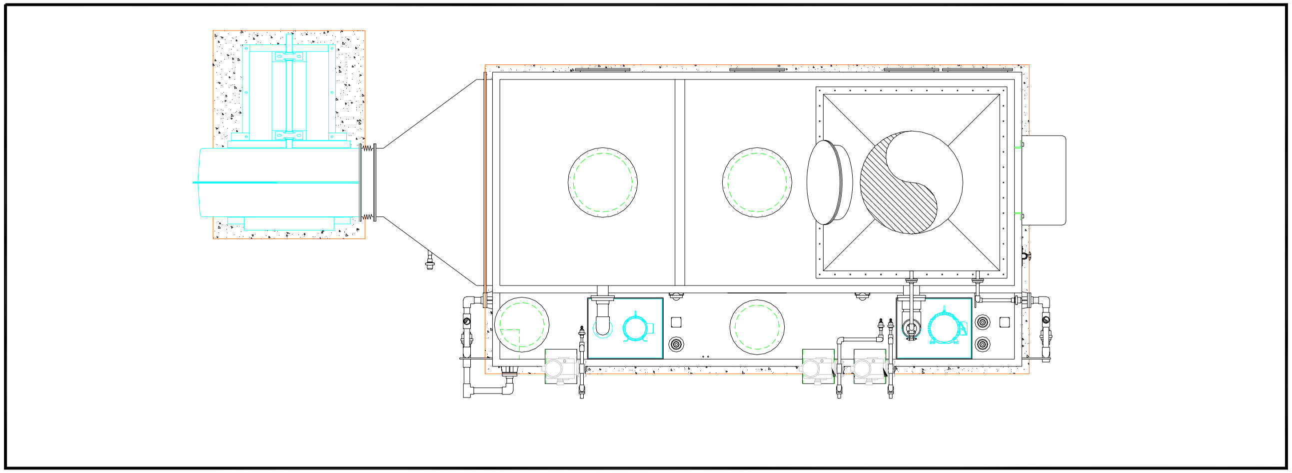


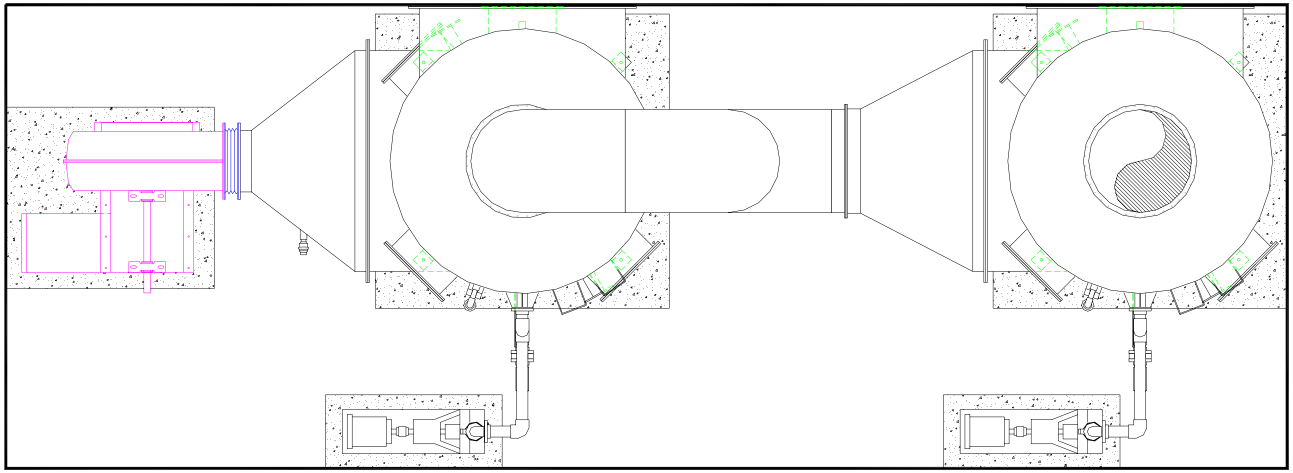
New Low-Profile Packaged Units

- **Typical vertical, counter-current "Packed Towers" are often 6.0 meters or more in height.**
- **Past footprint constraints alleviated by "turning the tower" on its side, which causes the air to travel perpendicular through the vessel in a horizontal, cross-flow arrangement. This arrangement causes some air to short-circuit across the top of the media.**

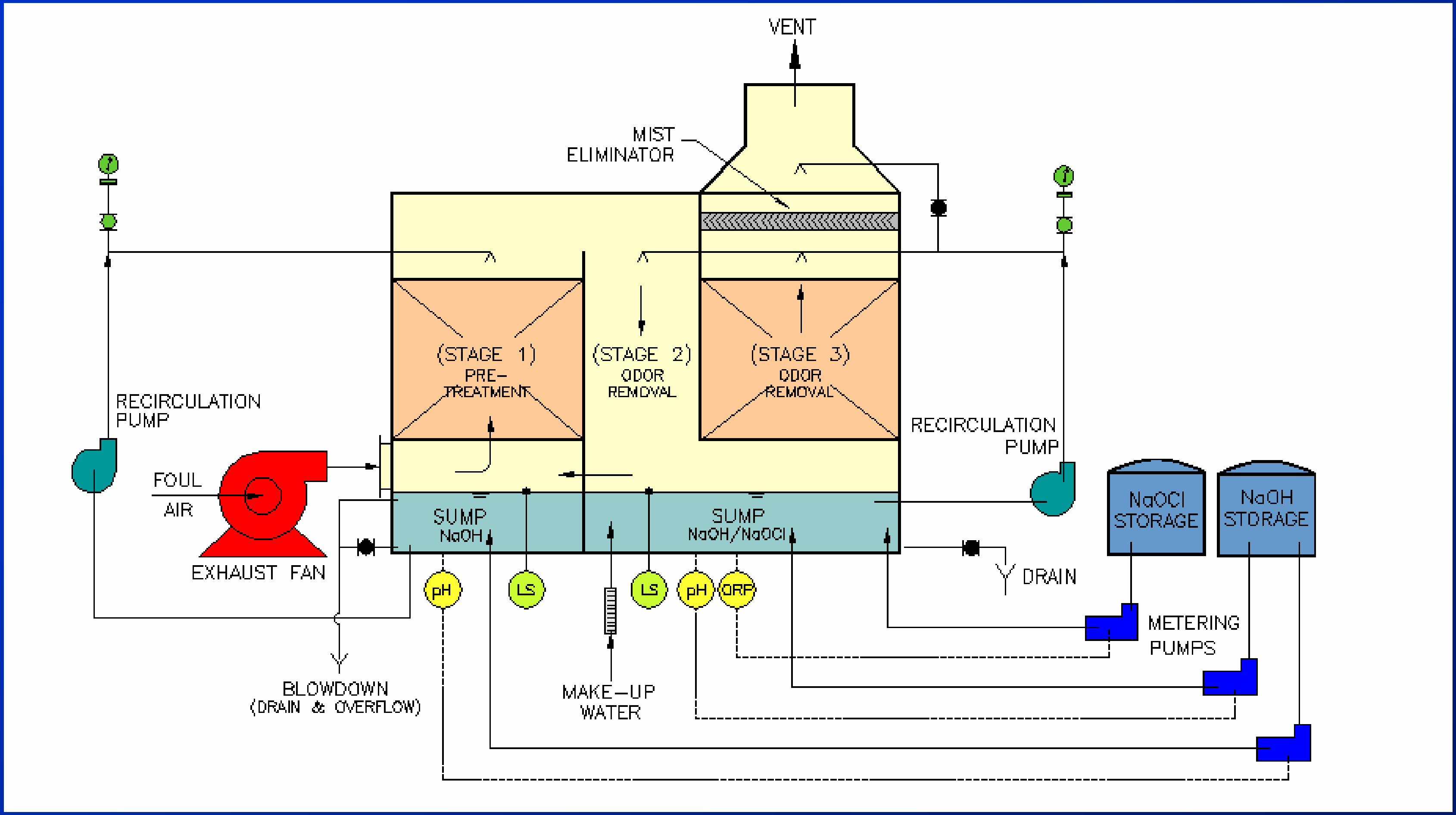
- **Low profile, rectangular, packaged units have multiple compartments of packing side-by-side and reduce the height to 3.5 meters or less. Generally, at least two of these compartments are vertical, counter-current arrangement. An extended sump allows pumps, probes, instruments and controls to be pre-installed and pre-wired.**

Footprint Comparison: Two-Stage Packed Tower Scrubber vs. Low-Profile Unit (40,000 m^3/hr)





Low-Profile Process Flow Diagram



Low-Profile Systems

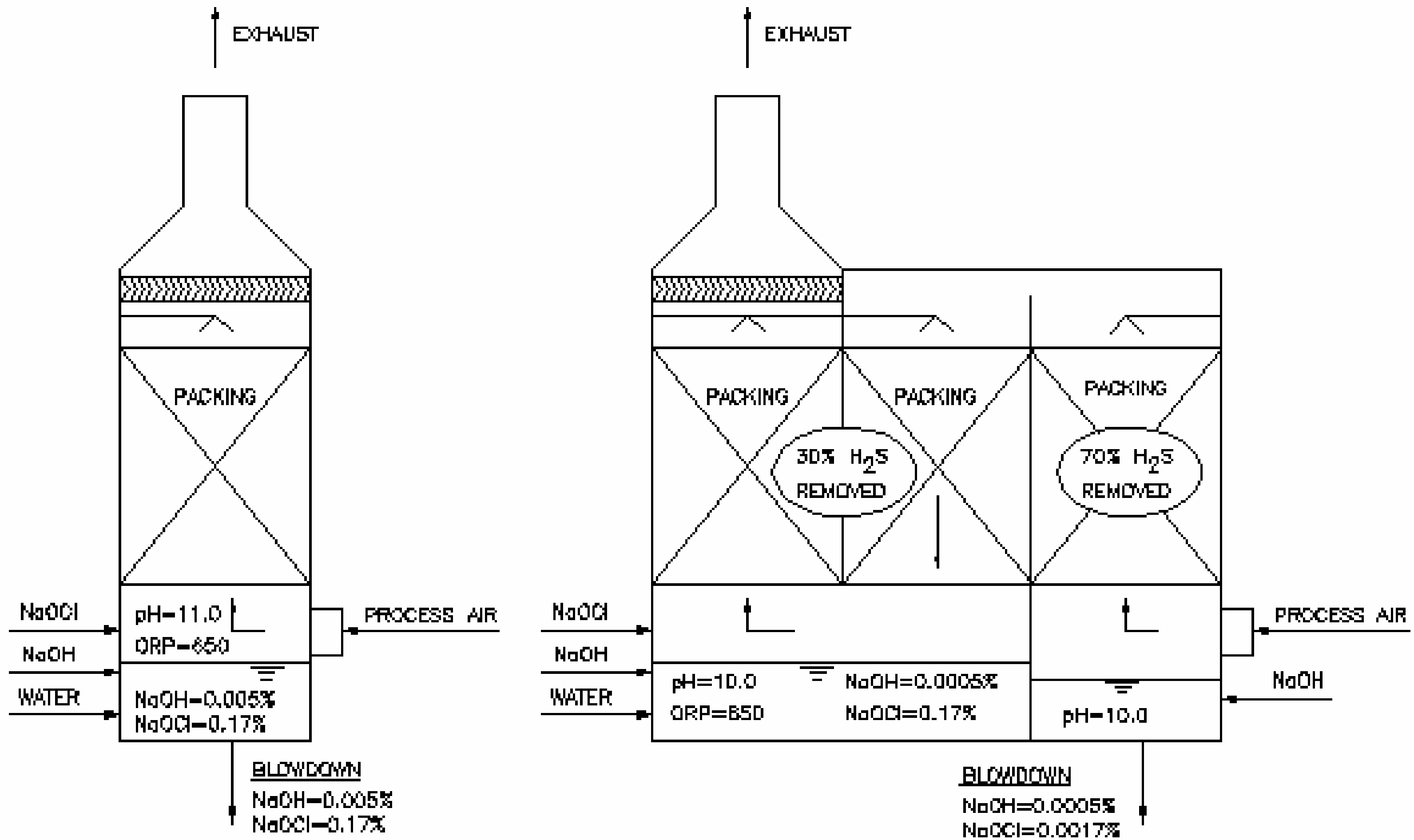
- **Provide the benefits of two-stages of scrubbing in a compact footprint**
- **Significantly reduced overall height (typically less than 3.5 meters vs. 6.0+ meters for a traditional packed towers**
- **All Components Pre-Installed**
- **Factory Assembled and Tested**
- **Field Assembly Limited to Fan, Stack and Chemical Storage Tanks**
- **Ease of Installation**
- **Start-up Simplicity**
- **System Responsibility**
- **Guaranteed Performance (99.5%+ Removal)**

Three units treating 125,000 m3/hr

Options Overview by Air Flow Rate:

Air Flow rate (cfm)	Scrubbing Options
<2000	Biological Carbon (dry) Chemical (LO/PRO®, Polystage)
2000-6000	Chemical (wet): - LO/PRO® - Polystage
>6000	Chemical: (LO/PRO®) most economical)

Operating Cost Differentiation



Present Worth Analysis

Type of System	Low-Profile Packaged System	Single-Stage Packed Tower	Two-Stage Packed Tower
Air Flow Rate per System, cfm	7,500	7,500	7,500
Inlet H2S Concentration, ppmv	25	25	25
Minimum Removal Effic, %	99.5%	99.5%	99.5%
No. of Stages	Three	One	Two
Capital Cost (Installed)	$170,400	$148,500	$256,500
Operating Cost ($/Yr)	$27,775	$59,304	$25,886
Maintenance ($/Yr)	$2,778	$5,930	$2,589
Total Recurring Cost ($/Yr)	$30,553	$65,234	$28,475
Annaluized Capital Cost ($/Yr)	$22,408	$19,528	$33,730
Total Annual Cost ($/Yr)	$52,960	$84,762	$62,204
PRESENT WORTH	**$402,828**	**$644,723**	**$473,142**

Notes: Assumed installation of 30% of capital cost for packaged unit and 40% of capital costs for towers.
Power assumed to be $0.06/kwh, NaOH assumed to be $1.00/gal, NaOCl assumed to be $0.65/gal.
Maintenance is assumed to be10% of operating cost.
Present Worth: linear depreciation, 15 yr lifetime, 10% cost of money.
All amounts in USDollars.
For example only.

Qualitative Comparison of Vapor-Phase Technologies

	Single-stage Wet scrubber	Multistage Wet scrubber	Engineered Biofilter	Carbon adsorption
Sulfide/Sulfur compounds treated	Yes	Yes	Yes	Yes
Ammonia/nitrogen compounds treated	Yes	Yes	No	No
Sulfur & nitrogen compounds treated	No	Yes	No	No
Footprint (based on 142 m3/min) system	Small (20 ft x 20 ft) Includes Chem Tank	Medium (20 ft x 25 ft) Includes Chem Tank	Large (30 ft x 40 ft)	Small (15 ft x 20 ft)
Cyclical operation (on-off capability	Yes	Yes	No	Yes

Economic Comparison of Vapor-phaseTechnologies

	Single-stage wet scrubber	Multistage wet scrubber	Engineered biofilter	Carbon adsorption
Capital cost	$75 000	$110 000	$180 000	$90 000
Annual power cost[1]	$5150 13 kW (17 hp)	$7800 15 kW (20 hp)	$4600 7 kW (10 hp)	$4600 7 kW (10 hp)
Annual sodium hydroxide cost[2]	$4600 106 L/d (28 gal/d)	$4600 106 L/d (28 gal/d)	Not applicable	Not applicable
Annual sodium hypochlorite cost[3]	$47 600 681 L/d (180 gal/d)	$11 000 155 L/d (41 gal/d)	Not applicable	Not applicable
Annual carbon cost[4]	N/A	N/A	N/A	$67 000 19 000 kg/yr (42,000 lb/yr)
Annual media cost[5]	N/A	N/A	$34 000	N/A
Annual maintenance labor cost[6]	$3900 (3 h/wk)	$3900 (3 h/wk)	$2600 (2 h/wk)	$2600 (2 h/wk)
Total annual operating cost	$63 900	$24 650	$41 200	$74 200
Total present-value cost, 10-year life	$467 000	$261 000	$433 000	$546 000

[1] Based on $0.07 per kW/h.
[2] Based on 25% solution, $1.70/L ($0.45/gal).
[3] Based on 12.5% solution, $2.76/L ($0.73/gal).
[4] Based on $0.73/kg ($1.60/lb).
[5] Annualized based on complete media replacement in 5 years.
[6] Based on $25/h.

Note: All comparisons are based on a 142-m^3/min (5000-ft^3/min), 50 ppm hydrogen sulfide system treating ventilation air.

QUESTIONS ?

RJ ENVIRONMENTAL / METITO

THANK YOU