ODOR CONTROL
Company Background

- Located in Poway California
- Founded by Roop Jain, Chief Executive Officer & President of IMS, founder of RJ Environmental products
- 25 Years of System Engineering & Project Execution
- Reputation for producing practical, cost effective and unique solutions to design problems and customer needs
– 20 years ago there was little talk of odor control. WWTP’s and PS were located out of town, and odor was not a problem.

– Today odor control is generally considered an essential process in sewage treatment plant design, and in many other industries.

Why? Because:

1) Odor is a nuisance (complaints)
2) In some cases odors may be a health hazard (risk to employees)
3) Odorous compounds can cause corrosion (damage to equipment)
### Nuisance vs. Hazardous Odors

<table>
<thead>
<tr>
<th>Compound</th>
<th>Typical Concentration Range*, ppm</th>
<th>Nuisance odor, ppm</th>
<th>Health Hazard, ppm</th>
<th>Explosion hazard, ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen Sulphide</td>
<td>0.05 to 500</td>
<td>0.001</td>
<td>20/100</td>
<td>40,000</td>
</tr>
<tr>
<td>Ammonia</td>
<td>0 to 200</td>
<td>17</td>
<td>50/300</td>
<td>15,000</td>
</tr>
<tr>
<td>Methyl Mercaptan</td>
<td>0.001 to 1</td>
<td>0.001</td>
<td>10/150</td>
<td>39,000</td>
</tr>
<tr>
<td>Carbon Disulphide</td>
<td>0.01 to 10</td>
<td>0.03</td>
<td>20/500</td>
<td>13,000</td>
</tr>
</tbody>
</table>
Hydrogen Sulfide Concerns

$\text{H}_2\text{S}$ is primary odour, typically 10 to 100 times more concentrated than other odors

- Rotten Egg Odor,
- Low Odor Threshold (~1 ppb)
- Typical concentrations from 10 to 500 ppm or more

Safety - Exposure Effects:

- Nuisance Odor (below 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
<table>
<thead>
<tr>
<th>Hydrogen Sulfide Odor and Toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rotten Egg Odor Alarm</strong></td>
</tr>
<tr>
<td><strong>Serious Eye Injury</strong></td>
</tr>
<tr>
<td><strong>Loss of Sense of Smell</strong></td>
</tr>
<tr>
<td><strong>Imminent Life Threat</strong></td>
</tr>
<tr>
<td><strong>Immediate Collapse</strong></td>
</tr>
<tr>
<td><strong>Odor Threshold</strong></td>
</tr>
<tr>
<td><strong>Offensive Odor</strong></td>
</tr>
<tr>
<td><strong>Headache, Nausea</strong></td>
</tr>
<tr>
<td><strong>Throat and Eye Irritation</strong></td>
</tr>
<tr>
<td><strong>Eye Injury</strong></td>
</tr>
<tr>
<td><strong>Conjunctivitis, Respiratory Tract Irritation, Olfactory Paralysis</strong></td>
</tr>
<tr>
<td><strong>Pulmonary Edema</strong></td>
</tr>
<tr>
<td><strong>Strong Nervous System Stimulation</strong></td>
</tr>
<tr>
<td><strong>Apnea</strong></td>
</tr>
<tr>
<td><strong>Death</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>100</td>
</tr>
<tr>
<td>300</td>
</tr>
<tr>
<td>500</td>
</tr>
<tr>
<td>1,000</td>
</tr>
<tr>
<td>2,000</td>
</tr>
</tbody>
</table>

*Integrity Municipal Systems*
Hydrogen Sulfide and Corrosion

- Bacteria Oxidize $\text{H}_2\text{S}$ to Sulfuric Acid
- $\text{pH}$, Temperature, and Turbulence release $\text{H}_2\text{S}$ to air
- Severe corrosion at water line as fluid washes away corrosion products exposing virgin material
- Bacteria Reduce Sulfate to Sulfide
Conditions Promoting Sulphide Generation

Level of B.O.D.
- High levels increase sulphide production and generate anaerobic conditions sooner

Sulphate Concentration
- Bacteria reduce sulphate to sulphide under anaerobic conditions

Temperature
- Higher temperatures promote biological activity

Stream Velocity
- Higher linear velocities lead to reduced thickness of slime layer

Surface Area
- Large surface areas support larger bacterial populations

Detention Time
- Long detention times allow for longer anaerobic zones
Conditions Promoting Hydrogen Sulphide Release

Temperature
- Solubility of $H_2S$ is temperature dependent per Henry’s Law.

pH
- Three species of Sulfides exist: $H_2S$, $HS^-$, $S^-$.
- Only $H_2S$ is volatile.
- The proportion of $H_2S$ to $HS^-$ is pH dependent.
- Low pH favors $H_2S$

Turbulence
- High velocities induce turbulence, which in turn increase the liquid/vapor mass transfer area.
Types of Odors

Hydrogen Sulfide ($H_2S$)
- Typically 100x higher concentration than other odorous compounds
- Masks other odors, which then become noticeable after $H_2S$ is removed
- Relatively easy to remove from air

Organic Sulfur Compounds (DMS, DMDS, Mercaptans, COS, CS$_2$)

Nitrogen Compounds: Ammonia and amines

Other Volatile Organic Compounds (VOCs)
- Aldehydes
- Ketones

Fatty Acids
### Odorous Compounds found in Sewage Treatment Process

<table>
<thead>
<tr>
<th>Sulphur Compounds</th>
<th>Formula</th>
<th>Odour description</th>
<th>Odour Threshold (ppb)</th>
<th>Typical Ranges (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen Sulphide</td>
<td>H$_2$S</td>
<td>Rotten eggs</td>
<td>0.5</td>
<td>50-500000</td>
</tr>
<tr>
<td>Dimethyl Sulphide</td>
<td>CH$_3$-S-CH$_3$</td>
<td>Decayed vegetables</td>
<td>0.1-2</td>
<td>10-1000</td>
</tr>
<tr>
<td>Dimethyl Disulphide</td>
<td>CH$_3$-S-S-CH$_3$</td>
<td>Decayed vegetables</td>
<td>0.1-2</td>
<td>1-100</td>
</tr>
<tr>
<td>Methyl Mercaptan</td>
<td>CH$_3$-SH</td>
<td>Decayed cabbage</td>
<td>0.7</td>
<td>10-1000</td>
</tr>
<tr>
<td>Ethyl mercaptan</td>
<td>CH$_3$-CH$_2$-SH</td>
<td>Decayed cabbage</td>
<td>0.2</td>
<td>1-100</td>
</tr>
<tr>
<td>Carbon disulphide</td>
<td>CS$_2$</td>
<td>Sweet, ether-like</td>
<td>25-160</td>
<td>1-100</td>
</tr>
<tr>
<td>Carbonyl sulphide</td>
<td>COS</td>
<td></td>
<td>100</td>
<td>1-100</td>
</tr>
</tbody>
</table>

* There are no “typical sewage odours” for design purposes. Compounds and concentrations vary widely from source to source, site to site, hour to hour, and day to day.
# Odorous Compounds found in Sewage Treatment Process

<table>
<thead>
<tr>
<th>Nitrogen Compounds</th>
<th>Formula</th>
<th>Odour description</th>
<th>Odour Threshold ppb</th>
<th>Typical Ranges ppb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia</td>
<td>NH₃</td>
<td>Pungent</td>
<td>17</td>
<td>1000-200000</td>
</tr>
<tr>
<td>Methylamine</td>
<td>CH₃NH₂</td>
<td>Rotten fish</td>
<td>53</td>
<td>20-200</td>
</tr>
<tr>
<td>Dimethylamine</td>
<td>(CH₃)₂NH</td>
<td>Fishy, ammonia</td>
<td>49</td>
<td>20-200</td>
</tr>
<tr>
<td>Trimethylamine</td>
<td>(CH₃)₃N</td>
<td>Fishy, ammonia</td>
<td>40</td>
<td>20-200</td>
</tr>
<tr>
<td>Skatole</td>
<td>C₉H₉N</td>
<td>Fecal, repulsive</td>
<td>0.06</td>
<td>1-100</td>
</tr>
<tr>
<td>Indole</td>
<td>C₂H₆NH</td>
<td>Fecal, repulsive</td>
<td>1.4</td>
<td>1-100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other Odorous Compounds</th>
<th>Formula</th>
<th>Odour description</th>
<th>Odour Threshold ppb</th>
<th>Typical Ranges ppb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatty acids</td>
<td></td>
<td>rancid, vinegar</td>
<td>0.1 to 1</td>
<td></td>
</tr>
<tr>
<td>Aldehydes</td>
<td></td>
<td>rancid, acrid</td>
<td>2 to 400</td>
<td>10-1000</td>
</tr>
<tr>
<td>Ketones</td>
<td></td>
<td>sweet, fruity</td>
<td>200 to 4000</td>
<td>10-1000</td>
</tr>
</tbody>
</table>
About VOC’s

• **Volatile Organic Compounds (VOCs)** are a large group of carbon-based chemicals that easily evaporate at room temperature. While some VOCs are odorous, many other VOCs are not. There are thousands of different VOCs produced and used in our daily lives.

• **In sewage treatment the odorous VOC’s are primarily amines, organic sulfides, mercaptans and some organic acids.**

• **Hydrocarbons are VOC’s that are regulated because they contribute to photochemical smog. Although many are odorous, they are not generally a major contributor to municipal odors.**

• **Control of hydrocarbons requires very different technology from control of sewage odors.**
There are many requirements beyond the Systems

- Odor containment (covers, buildings)
- Odor conveyance (ductwork, dampers)
- Odor control equipment
- Chemical dosing (chemical tanks, piping, dosing pumps)
- Blowdown streams (neutralization, drainage)
- Exhaust Stack (dispersion modeling)
- Odor monitoring (on-line monitors, performance tests)
- Controls & instrumentation

- Civil works, site preparation
- Mechanical installation
- Electrical installation
- Taxes, duties, customs clearance, handling, local transportation
Air Changes per hour (ACH) = ventilation rate

Occupied spaces “typically” use 12 to 20 ACH

- Headworks building
- Dewatering building
- Pump Stations

Unoccupied spaces “typically” use 3 to 6 ACH

- Storage Tanks
- Clarifiers
- Wet wells
Determining Airflow Rate Required

\[ \text{ACH} \times \text{Air Volume (M3)} = \text{Air Flow Rate (M3/H)} \]

- **Tank**: 2000 M³ × 3 ACH = 6,000 M³/H
- **Building**: 1000 M³ × 12 ACH = 12,000 M³/H
- **Odor Control**: 18,000 M³/H
LOCALIZED ODOR CONTROL uses several smaller odor control systems located near each odor source. Sizes and technology may vary from one location to another.

- Eliminates complex ductwork and air flow balancing
- Can use smaller and more focused technology for each source
- Easy to install

CENTRALIZED ODOR CONTROL uses ductwork to convey odors from odor sources to common central odor control system.

- Allows easier redundancy
- Common parts
- Simpler maintenance
Characterized by:

- 99% $H_2S$ odors, 1% organic sulphides, low ammonia & amines

- $H_2S$ can range from < 1ppm to > 500 ppm, with wide daily and seasonal variations

- Smaller air flow requirements: 100 to 2000 m$^3$/h typical. Unoccupied with 3-6 ACH typical

- Residential locations, aesthetics and noise equally important

- Remote, un-manned locations
  - Low maintenance
  - Reliable operation
  - Simple process
  - Safety/vandal resistant
Influent Pump Station & Headworks

Characterized by:

• 99% H$_2$S odors, 1% organic sulphides, low ammonia and amines

• Large air flow requirements: 5,000 to 50,000 m$^3$/h typical. Occupied buildings require more ventilation (12+ ACH)

• Located at WWTP, footprint can be important, tall towers okay

• High H$_2$S possible, 10 to 50 ppm is typical, with 300+ ppm not uncommon

• Highly variable concentration with spikes to 10x the average
Primary Clarifiers

Characterized by:

- **Low** $H_2S$ odors, may be some organic sulphides, no ammonia and amines
- **Large air flow requirements**: 20,000 to 50,000 $m^3/h$ typical. Unoccupied requiring 3-6 ACH
- **Located at WWTP**, footprint can be important, tall towers okay
- Lower $H_2S$, 1 to 10 ppm is typical, with 50+ ppm not uncommon
- Can have variable concentration with spikes to 10x the average
Characterized by:

- 99% $\text{H}_2\text{S}$ odors, 1% organic sulphides, low ammonia and amines

- Very large air flow requirements: 50,000 to 100,000 m$^3$/h typical. Unoccupied requiring 3-6 ACH

- Located at WWTP, footprint can be important, tall towers okay

- Lower $\text{H}_2\text{S}$, < 1 ppm is typical

- Often not controlled because of high cost per odor reduction
Characterized by:

- Low $H_2S$ odours, higher organic sulphides, may be high ammonia and amines
- Medium air flow requirements: 5,000 to 10,000 m$^3$/h typical. Occupied buildings requiring 12+ ACH
- Located at WWTP, footprint can be important, tall towers okay
- Lower $H_2S$, < 10 ppm is typical
- May be 0.1 to 1 ppm of DMS, MM, DMDS, and other organic sulphides
- May be 100+ ppm of NH$_3$, and 1-10 ppm of amines
Digesters (bio-gas)

Characterized by:

- High $H_2S$ odours, with 50% methane and 30% $CO_2$ typical
- Medium to low air flow requirements: 2,000 to 5,000 $m^3/h$ typical.
- Explosive gas.
- High $H_2S$, 500 to 2000 ppm is typical
- High pressure gas (positive or vacuum)
Odor Measurement

– Hydrogen Sulphide (H2S) typically used as indicator of odor level

Grab Samples
• Jerome Analyzer (gold film technology) 0.005 to 50 ppm
• Wet chemical sensors (Interscan) 0.1 to 100 ppm
• Odalog – data logger 0.01 to 200 ppm
• Indicator tubes 0.1 to 10%

• Continuous Monitors
  • Wet chemical sensors (Scott) 0.1 to 100 ppm
  • Odalog – CEM 0.01 to 200 ppm
  • Paper tape 0.1 to 10%
  • Converter SO2 (w/dilution) 0.001 to 100+
Chemical Systems

- Technology
- Design
- Features & Benefits
- Process Flow Diagram
- General Arrangement Drawing
There are many ways to contact a liquid and a gas:

- **Countercurrent vs. Co-current Flow**
  - Refers to relative direction air and liquid flow
  - Countercurrent is more efficient, requiring 50-100% less packing to achieve equivalent performance

- **Single Stage vs. Multiple Stage**
  - Multiple stage provides more process chemistry options and can reduce chemical usage by 50% or more

- **Vertical Flow vs. Horizontal Flow**
  - Vertical countercurrent flow gives most efficient mass transfer.
  - Horizontal air flow with vertical downward liquid flow does not provide reactant evenly over packing cross section
Features & Benefits

• Systems are pre-assembled and factory tested, delivered as a single unit
• Small footprint & profile
• Minimal installation and start-up
• Minimal chemical consumption
• Multiple chemistries
• Low Maintenance
Minimal Chemical Consumption

- Pre-treatment stage eliminates approximately 70% of odors using a less expensive chemical
- Complete utilization of chemicals prior to discharge with multiple sumps
- Counter-current chemistry
- Optimal process control
Multiple stages and sumps allow removal of different odor compounds such as ammonia and reduced sulfides.

- Chemical costs reduced by using less expensive chemical in first stage for pre-treatment.
- Odors that are difficult to scrub can be eliminated in first stage with the 2nd/3rd stage as polishers.
- High inlet concentrations can be scrubbed.
Multiple Stage Process Configurations

- The multi-stage Process Can Be Configured in Several Ways:
- (2-Stage or 3-Stage designs)

  - For H2S removal up to 100 ppm
    Stage 1 = NaOH,
    Stage 2 = NaOCl + NaOH

  - For high H2S (> 100 ppm)
    Stage 1 & Stage 2 = NaOH
    Stage 3 = NaOH + NaOCl

  - For NH3/amines and H2S/sulfides
    Stage 1 = H2SO4
    Stage 2 = NaOH
    Stage 3 = NaOCl + NaOH

  - For high mercaptans and organic sulfides
    Stage 1 = NaOCl + NaOH
    Stage 2 = NaOH
Multi-stage Scrubber Chemistry

Ammonia Stage: Optional

\[ 2\text{NH}_3 + \text{H}_2\text{SO}_4 \rightarrow (\text{NH}_4)_2\text{SO} \]

H2S Pre-treatment Stage: may be one or more stages

\[ \text{H}_2\text{S} + 2\text{NaOH} \rightarrow \text{Na}_2\text{S} + 2\text{H}_2\text{O} \]

H2S Final Polishing Stage

\[ \text{H}_2\text{S} + 2\text{NaOH} + 4\text{NaOCl} \rightarrow \text{Na}_2\text{SO}_4 + 4\text{NaCl} + 2\text{H}_2\text{O} \]
CONVENTIONAL SINGLE STAGE
Caustic/Hypochlorite scrubbing chemistry

\[ \text{H}_2\text{S} + 4\text{NaOCl} + 2\text{NaOH} \rightarrow 4\text{NaCl} + \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O} \]

Reaction Requires:

- 8.76 kg of NaOCl + 2.35 kg of NaOH per kg of H2S
- 12.5% NaOCl contains 0.14 kg NaOCl per liter of solution
- 50% NaOH contains 0.77 kg NaOH per liter of solution

Example:

At 25 ppm and 32000 m3/h \(\rightarrow\) 1.14 kg H2S per hour

- 12.5% NaOCl required = \(1.14 \times 8.76 / 0.14 = 71 \text{ Liters/h}\)
- 50% NaOH required = \(1.14 \times 2.35 / 0.77 = 3.5 \text{ Liters/h}\)

Total = 71 + 3.5 = \(74.5 \text{ liters/h of chemicals}\)
Multi-stage scrubbing chemistry (2-STAGE)

H₂S Stage 1&2: Reacts with ~ 70% of H₂S

1. \( \text{H}_2\text{S} + 2\text{NaOH} \rightarrow \text{Na}_2\text{S} + 2\text{H}_2\text{O} \)

H₂S Stage 3: Reacts with ~ 30% of H₂S

2. \( \text{H}_2\text{S} + 2\text{NaOH} + 4\text{NaOCl} \rightarrow \text{Na}_2\text{SO}_4 + 4\text{NaCl} + 2\text{H}_2\text{O} \)

Example:

12.5% NaOCl required = \( (0.3 \times 1.14) \times 8.76 / 0.14 = 21.4 \text{ Liters/h} \)

50% NaOH required = \( 1.14 \times 2.35 / 0.77 = 3.5 \text{ Liters/h} \)

Total = 3.5 + 21.4 = 24.9 liters/h
Multi-stage scrubbing chemistry (3-STAGE)

H₂S Stage 1&2: Reacts with ~ 90% of H₂S

1. \[ \text{H}_2\text{S} + 2\text{NaOH} \rightarrow \text{Na}_2\text{S} + 2\text{H}_2\text{O} \]

H₂S Stage 3: Reacts with ~10% of H₂S

2. \[ \text{H}_2\text{S} + 2\text{NaOH} + 4\text{NaOCl} \rightarrow \text{Na}_2\text{SO}_4 + 4\text{NaCl} + 2\text{H}_2\text{O} \]

Example:

12.5% NaOCl required = \( (0.1 \times 1.14) \times 8.76 / 0.14 = 7.1 \text{ Liters/h} \)

50% NaOH required = \( 1.14 \times 2.35 / 0.77 = 3.5 \text{ Liters/h} \)

Total = 3.5 + 7.1 = 10.6 liters/h
Biological Odor Control Systems
Biological Process

- Biological odor control systems are designed to promote the growth of sulfur-oxidizing bacteria which under proper conditions will biologically oxidize $H_2S$ and other sulfur compounds to soluble sulfates.

- Requires a liquid film to transfer odorous compounds from the gas phase to liquid and make those compounds “bioavailable”.

- $H_2S$ is removed under acidic pH conditions and generates acid ($H_2SO_4$).

- Organic odors require higher residence time and neutral pH conditions.
Requirements of Sulfur-Oxidizing Bacteria

- **Energy source:**
  - \( \text{H}_2\text{S} \) and other sulfur compounds

- **Carbon source:**
  - Organic matter (heterotrophic bacteria)
  - Carbon dioxide (autotrophic bacteria)

- **Nutrients:** nitrate, phosphate, potassium

- **Water**

- **Oxygen** \( \text{H}_2\text{S} + \text{O}_2 \rightarrow \text{H}_2\text{SO}_4 \)

- **Temperature** (10 to 50\(^\circ\)C)

- **Time** (for absorption and reaction)
# Sulfur-Oxidizing Bacteria

<table>
<thead>
<tr>
<th>Species</th>
<th>Primary Electron Donor</th>
<th>pH Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiobacillus - grow poorly in organic media</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thiobacillus thioparus</td>
<td>H₂S, sulfides, sulfur, thiosulfate</td>
<td>6 to 8</td>
</tr>
<tr>
<td>Thiobacillus denitrificans</td>
<td>H₂S, sulfur, thiosulfate</td>
<td>6 to 8</td>
</tr>
<tr>
<td>Thiobacillus neapolitanus</td>
<td>sulfur, thiosulfate</td>
<td>5 to 8</td>
</tr>
<tr>
<td>Thiobacillus thiooxidans</td>
<td>H₂S, sulfides, sulfur, thiosulfate</td>
<td>2 to 5</td>
</tr>
<tr>
<td>Thiobacillus acidophilus</td>
<td>sulfur</td>
<td>2 to 4</td>
</tr>
<tr>
<td>Thiobacillus ferroxidans</td>
<td>sulfides, sulfur, ferrous iron</td>
<td>1.5 to 4</td>
</tr>
<tr>
<td>Thiobacillus - grow well in organic media</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thiobacillus novellus</td>
<td>thiosulfates</td>
<td>6 to 8</td>
</tr>
<tr>
<td>Thiobacillus intermedius</td>
<td>thiosulfates</td>
<td>3 to 7</td>
</tr>
<tr>
<td>Other Sulfur-oxidizing bacteria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beggiatoa</td>
<td>H₂S, thiosulfate</td>
<td>6 to 8</td>
</tr>
<tr>
<td>Thiotrix</td>
<td>H₂S</td>
<td>6 to 8</td>
</tr>
<tr>
<td>Thiomicrospira</td>
<td>H₂S, thiosulfate</td>
<td>6 to 8</td>
</tr>
<tr>
<td>Thermothrix</td>
<td>H₂S, sulfite, thiosulfate</td>
<td>6.5 to 7.5</td>
</tr>
<tr>
<td>Sulfolobus</td>
<td>H₂S, sulfur</td>
<td>1 to 4</td>
</tr>
</tbody>
</table>
Biological Odor Control System

- Two-stage biological system that provides point source odor control.

- Biological reaction phase for the removal of \( \text{H}_2\text{S} \) in the first stage with an inert inorganic media widely used for biological treatment

- Polishing Second stage for \( \text{H}_2\text{S} \) and organic odors

- Compact design

- 99 +% removal Efficiency

- Capacities up to 6000 m\(^3\)/h

- Plug & Play Installation
The system is comprised of two distinct process stages that can be designed to be site specific depending on the type and concentration of odorous compounds.

- **Stage 1** is designed to remove primarily hydrogen sulfide ($H_2S$) by promoting the growth of acidophilic, sulfur-oxidizing bacteria.

- **Stage 2** is used to remove any remaining hydrogen sulfide as well as other odorous organic compounds.
1. FRP Exhaust Fan with Transition to Vessel Inlet
2. Premium Vinyl Ester FRP Vessel with Extended Sump
3. Inorganic Biological Media (Stage 1)
4. Activated Carbon Media (Stage 2)
5. Nutrient Pump
6. Air Distribution System
7. Water panel with Media Irrigation System
8. FRP Control Panel with VFD
9. Nutrient Tank
10. FRP Exhaust Stack
I-BOx™ Media

CLAY MEDIA

PELLETIZED CARBON MEDIA
I-BOx™ Advantages

• High air flow rate (~450 m³/h per m², compared to 100 m³/h per m² for conventional organic biofilters)

• Inorganic media biofilter → long media life, preferential development of autotrophic bacteria

• Quick acclimation → specialized media adsorbs odors during acclimation period, for immediate H₂S removal

• Targets inorganic (H₂S) and organic odors

• Compact Footprint

• Skid mounted for easy, low cost installation

• Low Operating Cost
## I-BOX™ 8000 Series Standard Models

<table>
<thead>
<tr>
<th>Model</th>
<th>Airflow Rate CFM (m³/h)</th>
<th>Overall Dimension L x W x H ft. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-BOX™-4000</td>
<td>Up to 350 (Up to 600)</td>
<td>6.5 x 4.0 x 9.5 (1980 x 1220 x 2900)</td>
</tr>
<tr>
<td>I-BOX™-5000</td>
<td>350 - 580 (600 - 1000)</td>
<td>7.5 x 5.0 x 9.5 (2285 x 1525 x 2900)</td>
</tr>
<tr>
<td>I-BOX™-6000</td>
<td>580 - 850 (1000 - 1450)</td>
<td>8.5 x 6.0 x 9.5 (2590 x 1830 x 2900)</td>
</tr>
<tr>
<td>I-BOX™-7000</td>
<td>850 – 1,200 (1450 - 2100)</td>
<td>9.5 x 7.0 x 9.5 (2895 x 2134 x 2900)</td>
</tr>
<tr>
<td>I-BOX™-8000</td>
<td>1,200 – 1,500 (2100 - 2550)</td>
<td>12.00 x 8.0 x 9.5 (3658 x 2439 x 2900)</td>
</tr>
<tr>
<td>I-BOX™-8010</td>
<td>1,500 – 2,000 (2550 - 3400)</td>
<td>14.00 x 8.0 x 9.5 (4265 x 2439 x 2900)</td>
</tr>
<tr>
<td>I-BOX™-8015</td>
<td>2,000 – 3,000 (3400 - 5100)</td>
<td>19.25 x 8.0 x 9.5 (5865 x 2439 x 2900)</td>
</tr>
<tr>
<td>I-BOX™-8020</td>
<td>3,000 – 4,000 (5100 - 6800)</td>
<td>25.00 x 8.0 x 9.5 (7620 x 2439 x 2900)</td>
</tr>
<tr>
<td>I-BOX™-8025</td>
<td>4,000 – 5,000 (6800 - 8500)</td>
<td>29.75 x 8.0 x 9.5 (9068 x 2439 x 2900)</td>
</tr>
</tbody>
</table>
## I-BOx™ 7000 Series Standard Models

<table>
<thead>
<tr>
<th>Model</th>
<th>Airflow Rate CFM (m³/h)</th>
<th>Overall Dimension L x W x H ft. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-BOx™-4000</td>
<td>Up to 350 (Up to 600)</td>
<td>6.5 x 4.0 x 9.5 (1980 x 1220 x 2900)</td>
</tr>
<tr>
<td>I-BOx™-5000</td>
<td>350 - 580 (600 - 1000)</td>
<td>7.5 x 5.0 x 9.5 (2285 x 1525 x 2900)</td>
</tr>
<tr>
<td>I-BOx™-6000</td>
<td>580 - 850 (1000 - 1450)</td>
<td>8.5 x 6.0 x 9.5 (2590 x 1830 x 2900)</td>
</tr>
<tr>
<td>I-BOx™-7000</td>
<td>850 – 1,200 (1450 - 2100)</td>
<td>9.5 x 6.8 x 9.5 (2895 x 2083 x 2900)</td>
</tr>
<tr>
<td>I-BOx™-7010</td>
<td>1,200 – 1,700 (2100 - 2900)</td>
<td>14 x 6.8 x 9.5 (4265 x 2083 x 2900)</td>
</tr>
<tr>
<td>I-BOx™-7015</td>
<td>1,700 – 2,590 (2900 - 4400)</td>
<td>19.25 x 6.8 x 9.5 (5865 x 2083 x 2900)</td>
</tr>
<tr>
<td>I-BOx™-7020</td>
<td>2,590 – 3,500 (4400 - 6000)</td>
<td>25.00 x 6.8 x 9.5 (7620 x 2083 x 2900)</td>
</tr>
</tbody>
</table>

I-BOx™ with Optional Weather Enclosure
# I-BOx™ Low Range Standard Models

<table>
<thead>
<tr>
<th>Model</th>
<th>Airflow Rate CFM (m³/h)</th>
<th>Overall Dimension (w/out Stack)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I-BOx™-30</td>
<td>Up to 75 (Up to 125)</td>
<td>2.5 x 2.5 x 6.8 (762 x 762 x 2073)</td>
<td></td>
</tr>
<tr>
<td>I-BOx™-42</td>
<td>75 - 150 (125 - 255)</td>
<td>3.5 x 3.5 x 6.8 (1067 x 1067 x 2073)</td>
<td></td>
</tr>
<tr>
<td>I-BOx™-54</td>
<td>150 - 250 (255 - 425)</td>
<td>4.5 x 4.5 x 6.8 (1372 x 1372 x 2073)</td>
<td></td>
</tr>
</tbody>
</table>
**ADsorption** — physical adherence of molecules to surface of media

**Absorption** — soaking up of molecules into media or solution
Available Odor Control Carbons

Standard, Untreated Granular or Pelletized Activated Carbon
- Bituminous Coal Based
- Coconut Shell Based

Chemically Treated Activated Carbons
- Caustic Impregnated, KOH and NaOH
- KI Impregnated

“High Capacity” Carbons Based Adsorbents
- Water regenerable carbon
- Natural high mineral carbon media
- Sulfur Selective Odor Control Media
Carbon Capacity Comparison

Virgin Activated: 0.04
Caustic Treated: 0.25
Water Regenerated: 0.06, 0.12, 0.18
High Capacity: 0.75
Granular vs. Pelletized Carbons

Granular and Pelletized carbons have similar odor removal capabilities, however pelletized carbons have much lower pressure drop, and hence lower energy usage.
Factors That Influence the Carbon Loading Capacity

- Relative Humidity
- Temperature
- Contaminant Properties
- Contaminant Concentration
- Pressure (Vacuum)
- Gas Flow Rate (EBCT) and Superficial Velocity
- Heat of Adsorption
- System Configuration
How It Works

The exhaust fan operates continuously, pulling foul air from the process area and passing it through the carbon media. A volume control damper at the system inlet allows regulation of airflow through the carbon adsorber.

Inside the vessel, the foul air flows through a densely packed bed of activated carbon. The odorous compounds are removed from the airstream through a combination of physical adsorption and chemisorption.

Odorous compounds are physically adsorbed in the carbon pores, and some may undergo chemical reaction to form elemental sulfur and sulfuric acid. This process continues until the activated carbon pores are filled up and the odorous compounds break through and are released out the stack.
Single & Dual Bed Carbon Adsorbers

- Air flow rates to 6,800 cfm (11,600 m³/h) for single bed, and 20,000 cfm (34,000 m³/h) for dual bed
- FRP construction
- Fan, stack, dampers, duct ship separately for field installation
- Media must be field installed
- Optional Acoustic enclosure
- Optional Grease filter
- Media change out more difficult in dual bed designs
Skid Mounted Carbon Adsorbers

- Compact systems up to 1400 cfm (2,400 m³/h)
- Factory assembled & skid mounted
- FRP or polypropylene construction
- FRP Exhaust Fan
- Conventional or High Capacity carbon
- Variable speed fan option
- Acoustic enclosure option
- Grease filter option
Skid Mounted RJCS Adsorbers Standard Models

<table>
<thead>
<tr>
<th>Model</th>
<th>Airflow Rate CFM (m³/h)</th>
<th>Overall Dimension L x W x H (ft. mm)</th>
<th>Inlet Connection Inches (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RJCS-0150</td>
<td>Up to 130 (Up to 220)</td>
<td>4.3 x 3.2 x 5.0 (1300 x 975 x 1500)</td>
<td>4.0 (100)</td>
</tr>
<tr>
<td>RJCS-0200</td>
<td>105 - 235 (175 - 400)</td>
<td>5.3 x 3.5 x 5.0 (1600 x 1000 x 1500)</td>
<td>6.0 (150)</td>
</tr>
<tr>
<td>RJCS-0250</td>
<td>185 - 365 (315 - 620)</td>
<td>5.8 x 3.8 x 5.0 (1700 x 1100 x 1500)</td>
<td>6.0 (150)</td>
</tr>
<tr>
<td>RJCS-0300</td>
<td>290 - 530 (490 -1290)</td>
<td>6.3 x 4.1 x 5.0 (1900 x 1200 x 1500)</td>
<td>8.0 (200)</td>
</tr>
<tr>
<td>RJCS-0350</td>
<td>420 - 720 (715 - 1225)</td>
<td>7.7 x 4.9 x 5.50 (2300 x 1500 x 1700)</td>
<td>8.0 (200)</td>
</tr>
<tr>
<td>RJCS-0400</td>
<td>575 - 940 (980 - 1600)</td>
<td>8.3 x 4.9 x 5.50 (2500 x 1500 x 1700)</td>
<td>10 (250)</td>
</tr>
<tr>
<td>RJCS-0450</td>
<td>750 - 1190 (1275 - 2025)</td>
<td>8.8 x 5.2 x 5.50 (2500 x 1600 x 1700)</td>
<td>10 (250)</td>
</tr>
<tr>
<td>RJCS-0500</td>
<td>950 - 1400 (1615 - 2380)</td>
<td>9.1 x 5.6 x 5.50 (2700 x 1700 x 1700)</td>
<td>12 (300)</td>
</tr>
</tbody>
</table>

MAJOR SYSTEM COMPONENTS
- Epoxy Coated Steel Equipment Skid
- FRP Exhaust Fan
- FRP Transition Duct
- FRP Inlet Damper
- FRP Carbon Adsorber Vessel and Exhaust Stack
- Activated Carbon Media
- Electrical Control Panel
# Carbon Bulk RJCB Adsorbers Standard Models

<table>
<thead>
<tr>
<th>Model</th>
<th>Carbon Bed(s)</th>
<th>Airflow Rate CFM (m³/h)</th>
<th>Overall Dimension L x W x H ft.</th>
<th>Vessel Diameter Ft. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RJCB-600</td>
<td>Single</td>
<td>1000-1700 (1700 - 2900)</td>
<td>11 x 8 x 8 (3300 x 2400 x 2400)</td>
<td>6 (1800)</td>
</tr>
<tr>
<td>RJCB-800</td>
<td>Single</td>
<td>1700 - 3000 (2900 - 5100)</td>
<td>15 x 10 x 8 (4500 x 3000 x 2400)</td>
<td>8 (2400)</td>
</tr>
<tr>
<td>RJCB-1000</td>
<td>Single</td>
<td>3000 - 4700 (5100 - 8000)</td>
<td>17 x 12 x 8 (5100 x 3600 x 2400)</td>
<td>10 (3000)</td>
</tr>
<tr>
<td>RJCB-1200</td>
<td>Single</td>
<td>4700 - 6800 (8000 - 11600)</td>
<td>20 x 14 x 8 (6000 x 4200 x 2400)</td>
<td>12 (3600)</td>
</tr>
<tr>
<td>RJCB-1000D</td>
<td>Dual</td>
<td>6800 - 9400 (11600 - 16000)</td>
<td>19 x 12 x 13 (5700 x 3600 x 3900)</td>
<td>10 (3000)</td>
</tr>
<tr>
<td>RJCB-1100D</td>
<td>Dual</td>
<td>9400 - 11400 (16000 - 19400)</td>
<td>20 x 13 x 13 (6000 x 3900 x 3900)</td>
<td>11 (3300)</td>
</tr>
<tr>
<td>RJCB-1200D</td>
<td>Dual</td>
<td>11400 - 13600 (19400 - 23000)</td>
<td>21 x 14 x 13 (6300 x 4200 x 3900)</td>
<td>12 (3600)</td>
</tr>
<tr>
<td>RJCB-1400D</td>
<td>Dual</td>
<td>13600 - 20000 (23000 - 34000)</td>
<td>23 x 16 x 13 (6900 x 4800 x 3900)</td>
<td>14 (4200)</td>
</tr>
</tbody>
</table>

### MAJOR SYSTEM COMPONENTS

- FRP Exhaust Fan
- FRP Transition Duct
- FRP Inlet Damper
- FRP Carbon Adsorber Vessel and Exhaust Stack
- Activated Carbon Media
- Electrical Control Panel
Is Carbon a Viable Technology?

**Advantages:**

- Lower capital cost
- Treat H2S and many organic odors
- Moderate air flow capacity (1000 m3/h/m2)
- Good response to odor spikes

**Disadvantages:**

- Limited H2S/odor capacity
- Can be high operating cost because media replacement/regeneration can be expensive
- Limited capacity for some organics odors

**Best Application:**

- Low odor levels (< ~1-20 ppm)
- Polishing stage behind chemical or biological systems
Factors to Consider

For any given application, the selection of the best technology may be based on many factors, including:

- Capital cost for Equipment
- Installed cost
- Operating cost
- Source of funding and budget
- Maintenance requirements
- Reliability
- Safety
- Performance (% removal)
- Size (footprint, height)
Each Technology has its Niche

There is no one technology that is best in every application. Each technology has it’s niche.

**Wet Chemical Scrubbers:**

- *Can treat larger air flows in a single vessel*

- *Have more compact footprint*

- *Are less sensitive to variations in actual vs. design $H_2S$ loadings*

- *And are effective for a wider range of odorous compounds ($H_2S$, $NH_3$, amines, organic sulfides).*
Each Technology has its Niche

**Biological Systems:**

- Have very low operating and maintenance costs
- Do not require handling of hazardous chemicals.
- Operating cost is not proportional to $H_2S$ concentration (hence they are well suited to high $H_2S$ applications)
Activated Carbon Systems:

- Are the simplest and lowest maintenance systems (until you need to change out the carbon)

- Require only electrical power to operate (no water, no chemicals)

- Are efficient for a wide range of compounds.
## Summary OC Technology Selection

<table>
<thead>
<tr>
<th>TYPE</th>
<th>CAPITAL COST</th>
<th>OPERATING COST</th>
<th>MAINTENANCE</th>
<th>FOOTPRINT</th>
<th>ODOR REMOVAL</th>
<th>H2S PPM</th>
<th>H2S % REMOVAL</th>
<th>NH3?</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEMICAL SCRUBBERS</td>
<td>$$</td>
<td>$$$</td>
<td>$$</td>
<td>Small</td>
<td>&gt; 95%</td>
<td>0 - 50 +</td>
<td>99.9%</td>
<td>YES</td>
</tr>
<tr>
<td>BIO-TRICKLING SCRUBBERS</td>
<td>$$$</td>
<td>$</td>
<td>$$</td>
<td>Large</td>
<td>75-90%</td>
<td>2 - 500 ppm</td>
<td>99.0%</td>
<td>Some</td>
</tr>
<tr>
<td>HIGH CAPACITY CARBON</td>
<td>$</td>
<td>$$+</td>
<td>$+</td>
<td>Medium</td>
<td>&gt; 90%</td>
<td>0-20 ppm</td>
<td>99.9%</td>
<td>NO</td>
</tr>
<tr>
<td>VIRGIN ACTIVATED CARBON</td>
<td>$</td>
<td>$$+</td>
<td>$+</td>
<td>Medium</td>
<td>&gt; 90%</td>
<td>&lt; 1 ppm</td>
<td>99.9%</td>
<td>NO</td>
</tr>
</tbody>
</table>
Applications

Information needed to select appropriate technology

- Air Flow Rate or Ventilation Rate
- \( \text{H}_2\text{S} \) Concentration (average and peak)
- Required level of odor removal (\( \text{H}_2\text{S} \) and OU)

- Detailed performance and equipment specifications if available
- Testing requirements
- Concentration of other odorous compounds present
- Site location
- Temperatures (ambient air and odor stream)
- Need freeze protection?
- Indoor or Outdoor location?
- Hazardous area classification?
- Local 3-phase and 1-phase voltage and Hertz
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