Integrity
MUNICIPAL SYSTEMS

ODOR CONTROL

13135 Danielson Street, Suite 204
Poway, CA 92064

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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*

Why Odor Control?

– 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

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

Hydrogen Sulfide Concerns

H_2S 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)*

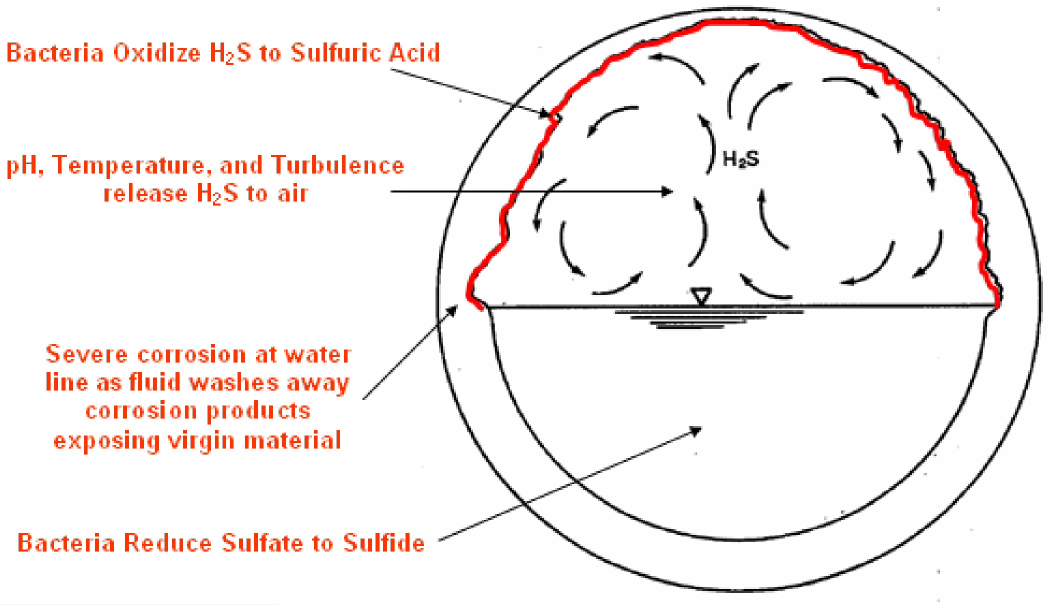
Corrosion:

- *Forms Sulfuric Acid in Condensate*

Hydrogen Sulfide Odor and Toxicity

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

Hydrogen Sulfide and Corrosion



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.*

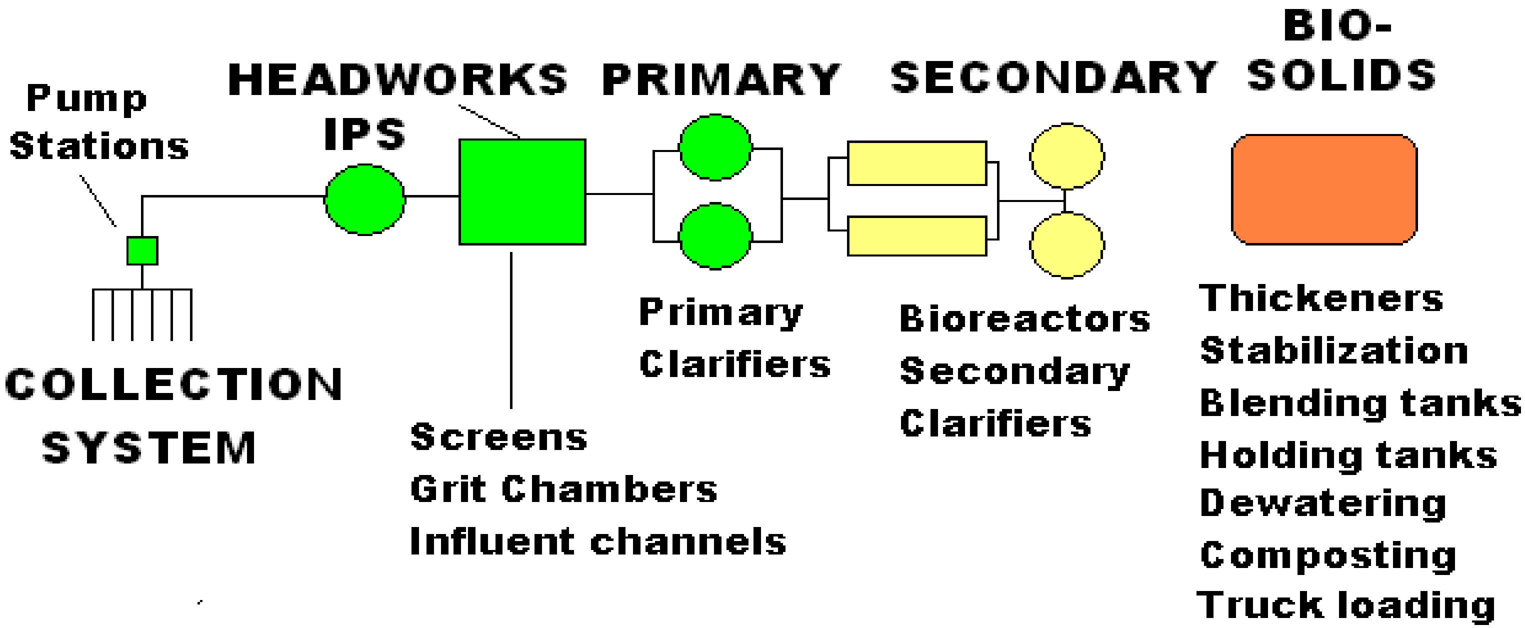
pH

- *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.*

Municipal Odor Control Applications



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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

Sulphur Compounds	Formula	Odour description	Odour Threshold ppb	Typical Ranges ppb
Hydrogen Sulphide	H_2S	Rotten eggs	0.5	50-500000
Dimethyl Sulphide	CH_3-S-CH_3	Decayed vegetables	0.1-2	10-1000
Dimethyl Disulphide	CH_3-S-S-CH_3	Decayed vegetables	0.1-2	1-100
Methyl Mercaptan	CH_3-SH	Decayed cabbage	0.7	10-1000
Ethyl mercaptan	CH_3-CH_2-SH	Decayed cabbage	0.2	1-100
Carbon disulphide	CS_2	Sweet, ether-like	25-160	1-100
Carbonyl sulphide	COS		100	1-100

*** 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

Nitrogen Compounds	Formula	Odour description	Odour Threshold ppb	Typical Ranges ppb
Ammonia	NH_3	Pungent	17	1000-200000
Methylamine	CH_3NH_2	Rotten fish	53	20-200
Dimethylamine	$(CH_3)_2NH$	Fishy, ammonia	49	20-200
Trimethylamine	$(CH_3)_3N$	Fishy, ammonia	40	20-200
Skatole	C_9H_9N	Fecal, repulsive	0.06	1-100
Indole	C_2H_6NH	Fecal, repulsive	1.4	1-100

Other Odorous Compounds	Formula	Odour description	Odour Threshold ppb	Typical Ranges ppb
Fatty acids		rancid, vinegar	0.1 to 1	
Aldehydes		rancid, acrid	2 to 400	10-1000
Ketones		sweet, fruity	200 to 4000	10-1000

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

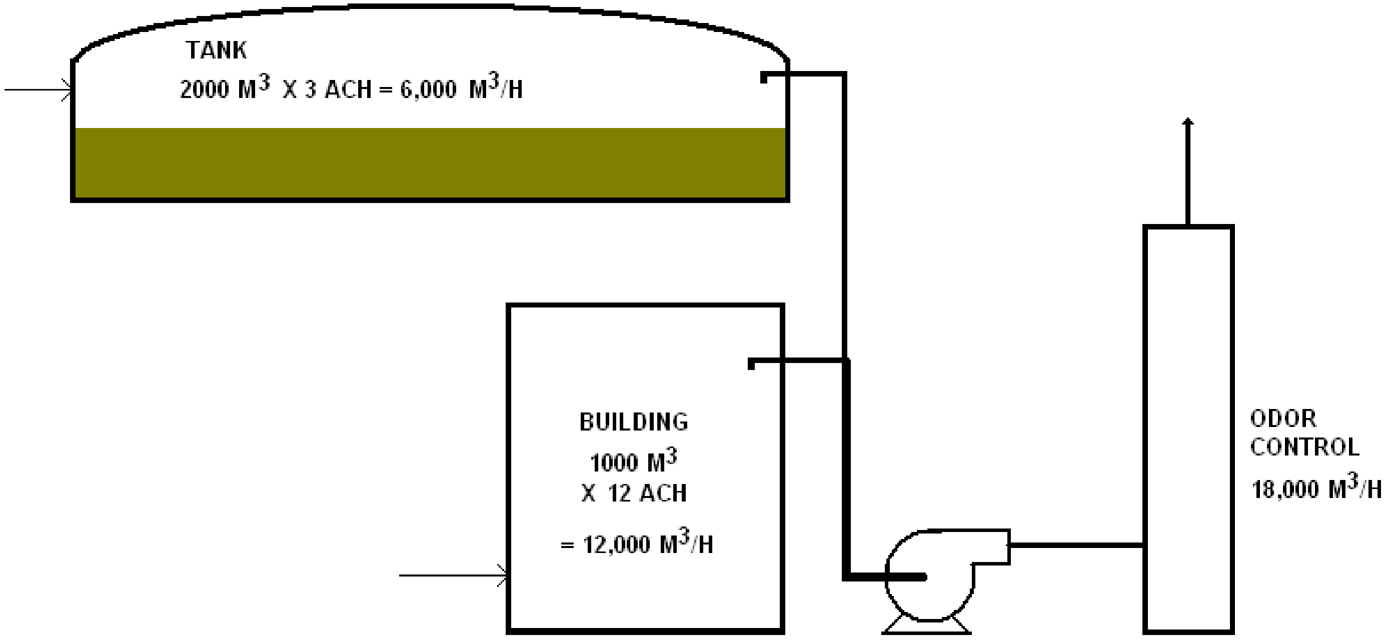
- Civil works, site preparation
- Mechanical installation
- Electrical installation
- Taxes, duties, customs clearance, handling, local transportation

Determining Airflow Rate Required

- **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

ACH X AIR VOLUME (M3) = AIR FLOW RATE (M3/H)



Localized OC vs. Centralized OC

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*

Collection Systems

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_2S 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_2S 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*

Bioreactors & Secondary Clarifiers

Characterized by:

- *99% H_2S 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 H_2S, < 1 ppm is typical*
- *Often not controlled because of high cost per odor reduction*

Biosolids Processing and Handling

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 (H_2S) 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 SO_2 (w/dilution)	0.001 to 100+

Chemical Systems

- Technology
- Design
- Features & Benefits
- Process Flow Diagram
- General Arrangement Drawing

Chemical Scrubber Design Configurations

- **<u>There are many ways to contact a liquid and a gas</u>**:
  - **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

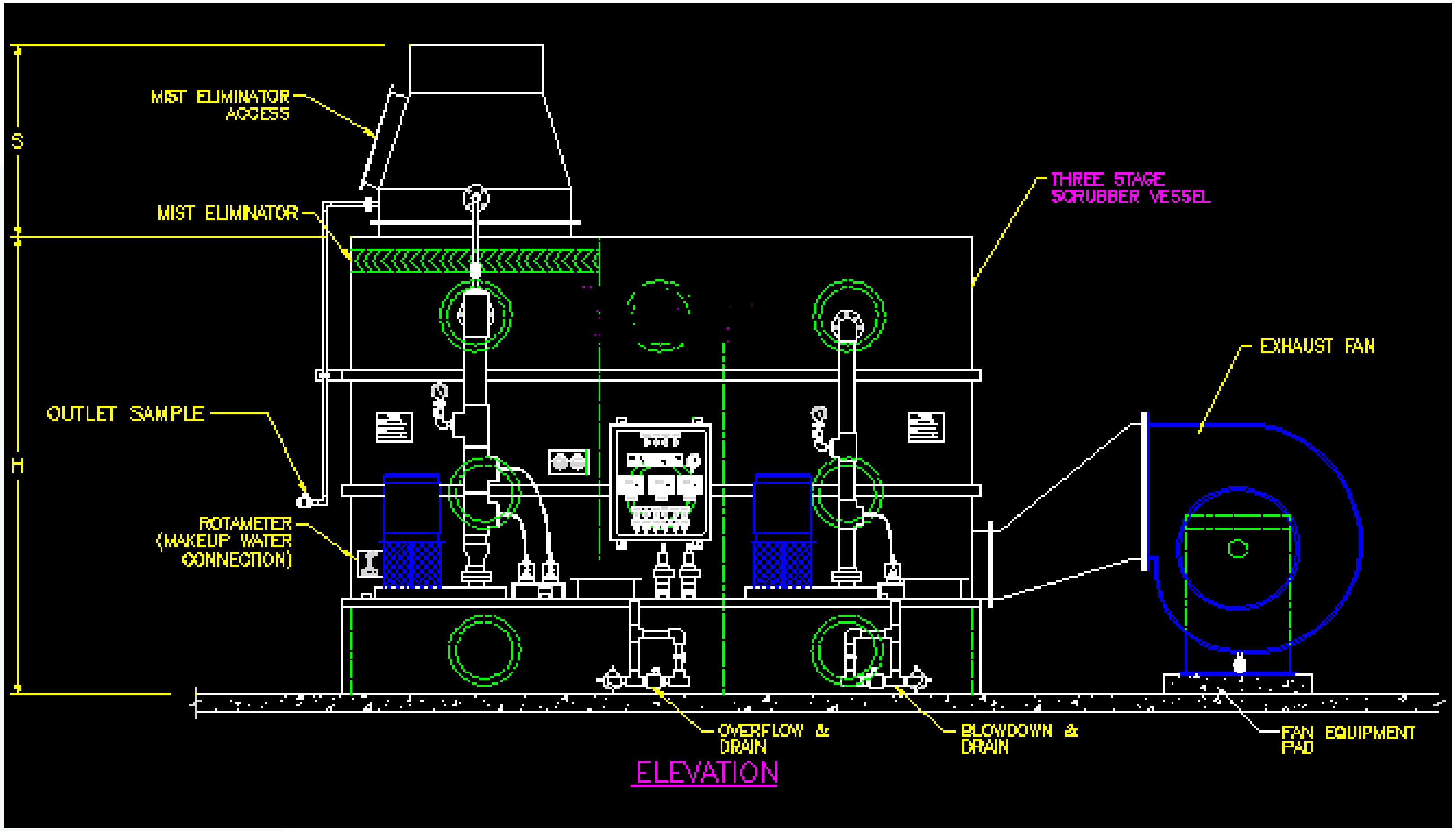
Minimal Chemical Consumption

- 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

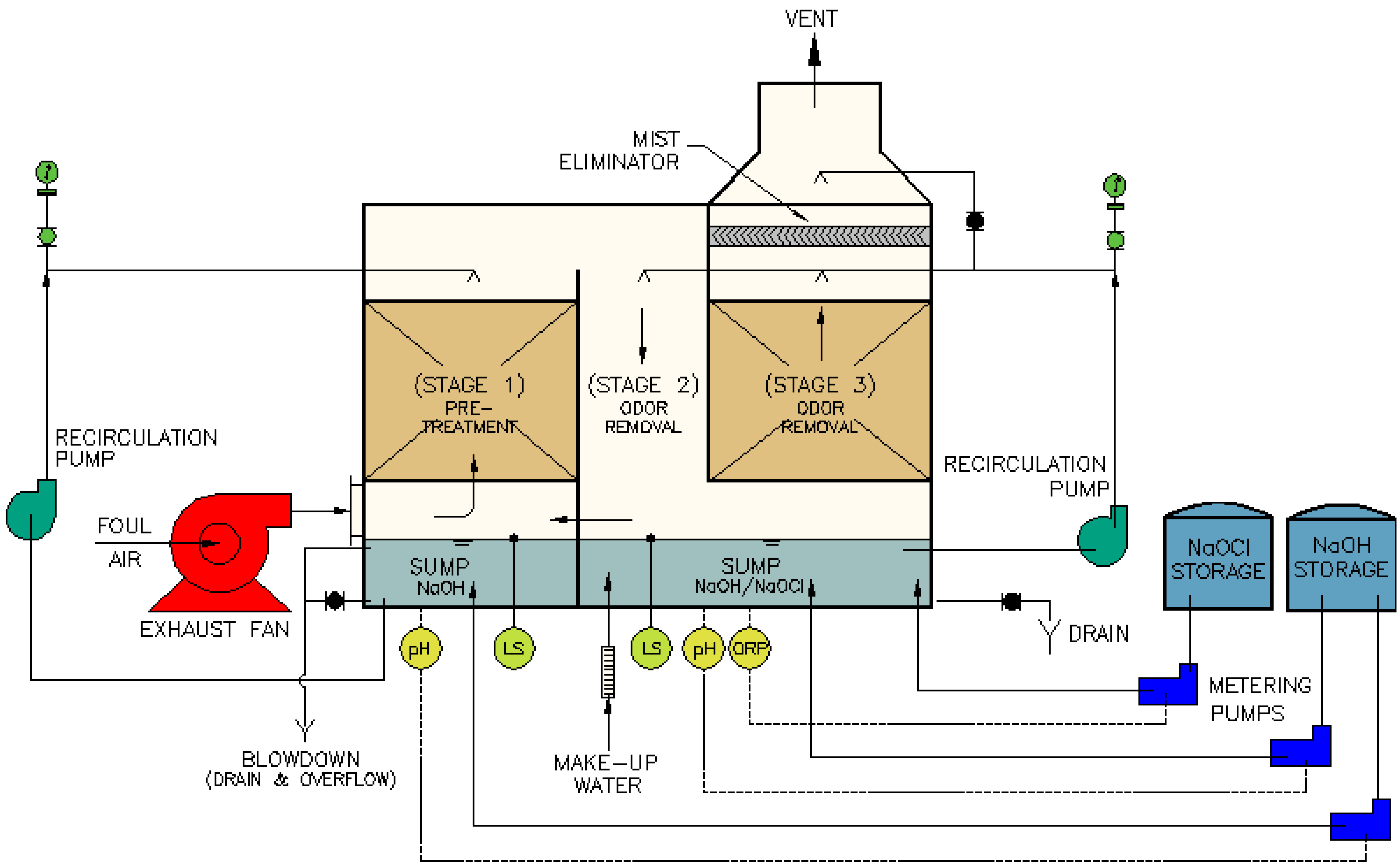
Multiple Chemistries

- 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

General Arrangement Drawing



Process Flow Diagram



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

$$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO$$

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

$$H_2S + 2NaOH \longrightarrow Na_2S + 2H_2O$$

H2S Final Polishing Stage

$$H_2S + 2NaOH + 4NaOCl \longrightarrow Na_2SO4 + 4NaCl + 2H_2O$$

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CONVENTIONAL SINGLE STAGE Caustic/Hypochlorite scrubbing chemistry

$$H_2S + 4NaOCl + 2NaOH \xrightarrow{pH > 9} 4NaCl + Na_2SO_4 + 2H_2O$$

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 → 1.14 kg H2S per hour

12.5% NaOCl required = 1.14 x 8.76 / 0.14 = 71 Liters/h

50% NaOH required = 1.14 x 2.35 / 0.77 = 3.5 Liters/h

Total = 71+3.5 = 74.5 liters/h of chemicals

Multi-stage scrubbing chemistry (2-STAGE)

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

1. $H_2S + 2NaOH \longrightarrow Na_2S + 2H_2O$

H2S Stage 3: Reacts with ~ 30% of H2S

2. $H_2S + 2NaOH + 4NaOCl \longrightarrow Na_2SO4 + 4NaCl + 2H_2O$

Example:

12.5% NaOCl required = (0.3 x 1.14) x 8.76 / 0.14 = 21.4 Liters/h

50% NaOH required = 1.14 x 2.35 / 0.77 = 3.5 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. $H_2S + 2NaOH \longrightarrow Na_2S + 2H_2O$

H2S Stage 3: Reacts with ~10% of H2S

2. $H_2S + 2NaOH + 4NaOCl \longrightarrow Na_2SO4 + 4NaCl + 2H_2O$

Example:

12.5% NaOCl required = (0.1 x 1.14) x 8.76 / 0.14 = 7.1 Liters/h

50% NaOH required = 1.14 x 2.35 / 0.77 = 3.5 Liters/h

Total = 3.5 + 7.1 = 10.6 liters/h

Biological Odor Control Systems

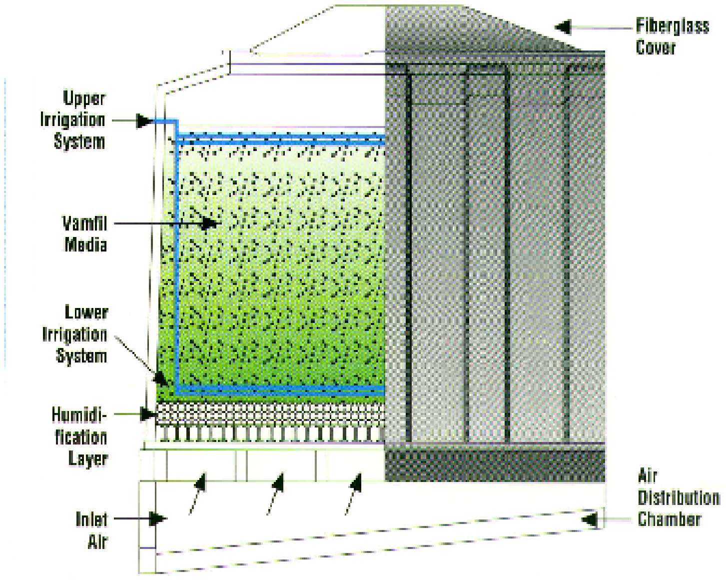
Biological Process

- *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*



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Requirements of Sulfur-Oxidizing Bacteria

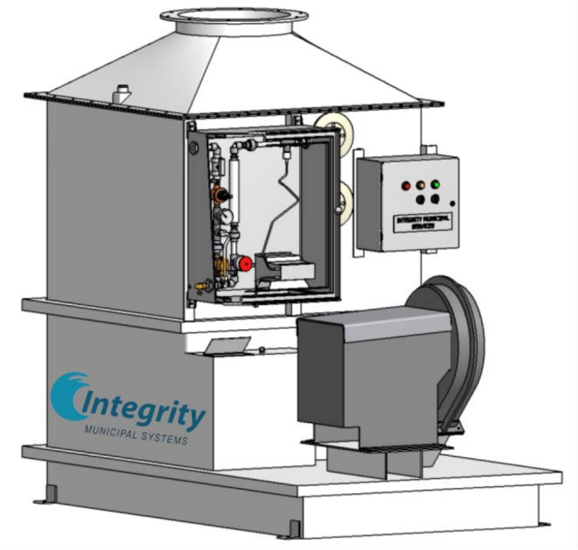
- *Energy source:*
  - *H_2S and other sulfur compounds*
- *Carbon source:*
  - *Organic matter (heterotrophic bacteria)*
  - *Carbon dioxide (autotrophic bacteria)*
- *Nutrients: nitrate, phosphate, potassium*
- *Water*
- *Oxygen ($H_2S + O_2 \rightarrow H_2SO_4$)*
- *Temperature (10 to 50^oC)*
- *Time (for absorption and reaction)*

Sulfur-Oxidizing Bacteria

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

Biological Odor Control System

- *Two-stage biological system that provides point source odor control.*
- *Biological reaction phase for the removal of H_2S in the first stage with an inert inorganic media widely used for biological treatment*
- *Polishing Second stag for H_2S and organic odors*
- *Compact design*
- *99 +% removal Efficiency*
- *Capacities up to 6000 m^3/h*
- *Plug & Play Installation*

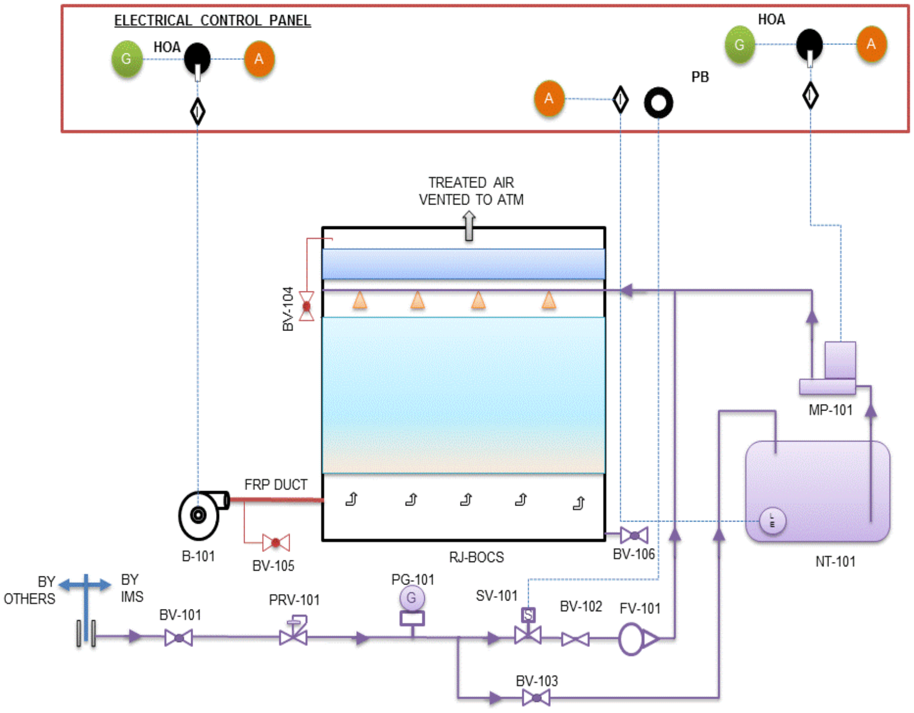


I-BOx™

How It Works

The system is comprised of two distinct process stages that can 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.*



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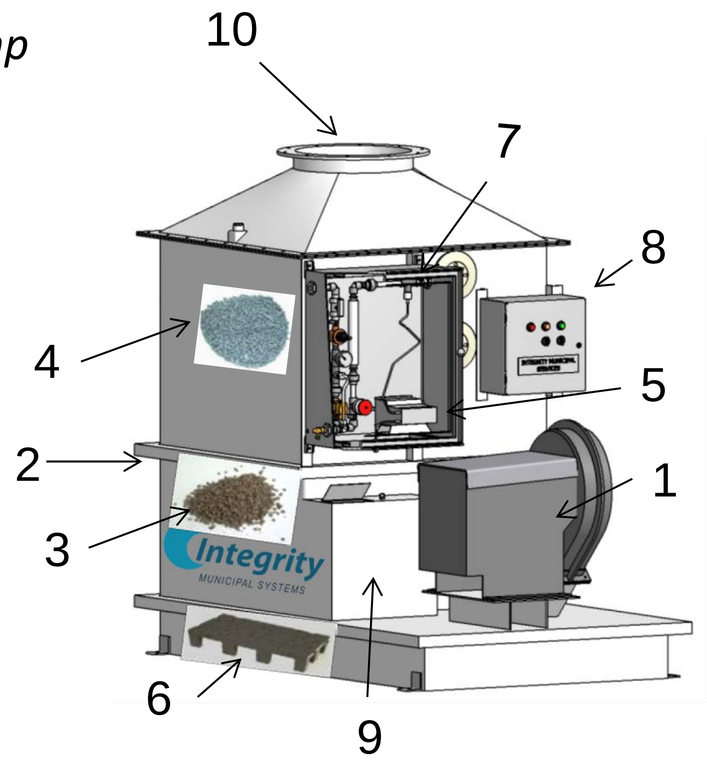
Major System Components

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

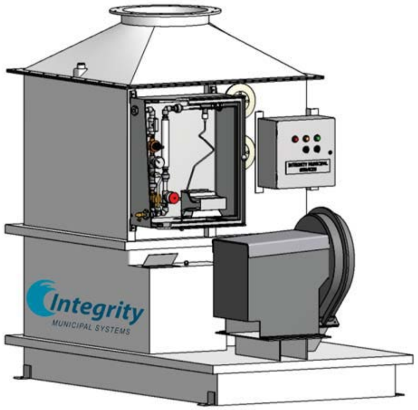
PELLETIZED CARBON MEDIA

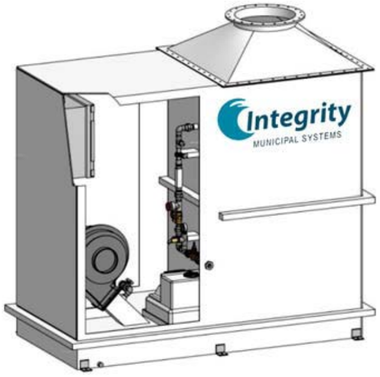
I-BOx™ Advantages

- *High air flow rate (~450 m^3/h per m^2, compared to 100 m^3/h per m^2 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 H_2S removal*
- *Targets inorganic (H_2S) and organic odors*
- *Compact Footprint*
- *Skid mounted for easy, low cost installation*
- *Low Operating Cost*

I-BOx™ 8000 Series Standard Models

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

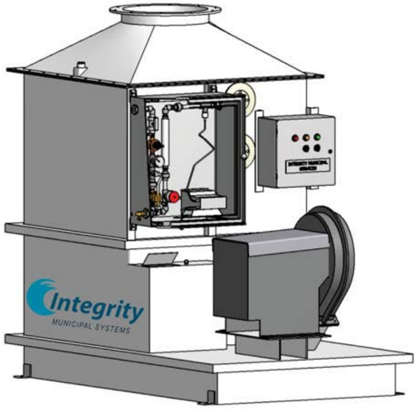


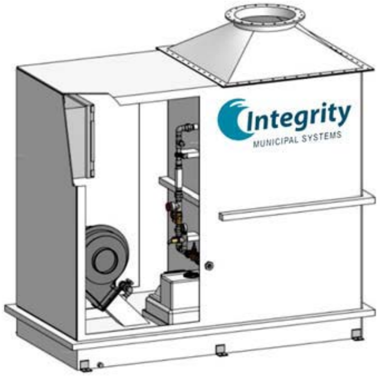


I-BOx™ with Optional Weather Enclosure

I-BOx™ 7000 Series Standard Models

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

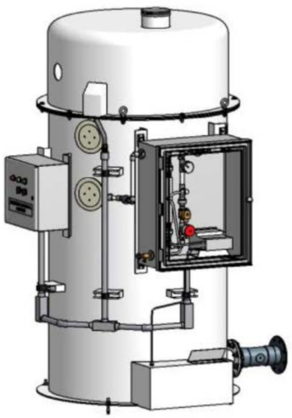




I-BOx™ with Optional Weather Enclosure

I-BOx™ Low Range Standard Models

Model	Airflow Rate CFM (m^3/h)	Overall Dimension (w/out Stack) L x W x H ft (mm)
I-BOx™-30	Up to 75 (Up to 125)	2.5 x 2.5 x 6.8 (762 x 762x 2073)
I-BOx™-42	75 - 150 (125 - 255)	3.5 x 3.5 x 6.8 (1067 x 1067 x 2073)
I-BOx™-54	150 - 250 (255 - 425)	4.5 x 4.5 x 6.8 (1372 x 1372 x 2073)



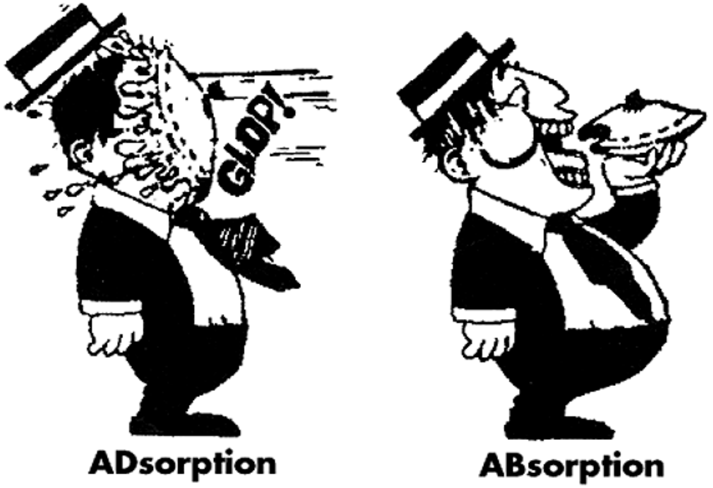
I-BOx™ with Optional Fan Cover

Carbon Odor Control Systems

ADSORPTION vs. ABSORPTION

ADsorption — *physical adherence of molecules to surface of media*

Absorption — *soaking up of molecules into media or solution*



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Available Odor Control Carbons

Standard, Untreated Granular or Pelletized Activated Carbon

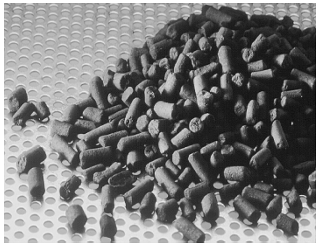
- *Bituminous Coal Based*
- *Coconut Shell Based*

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*



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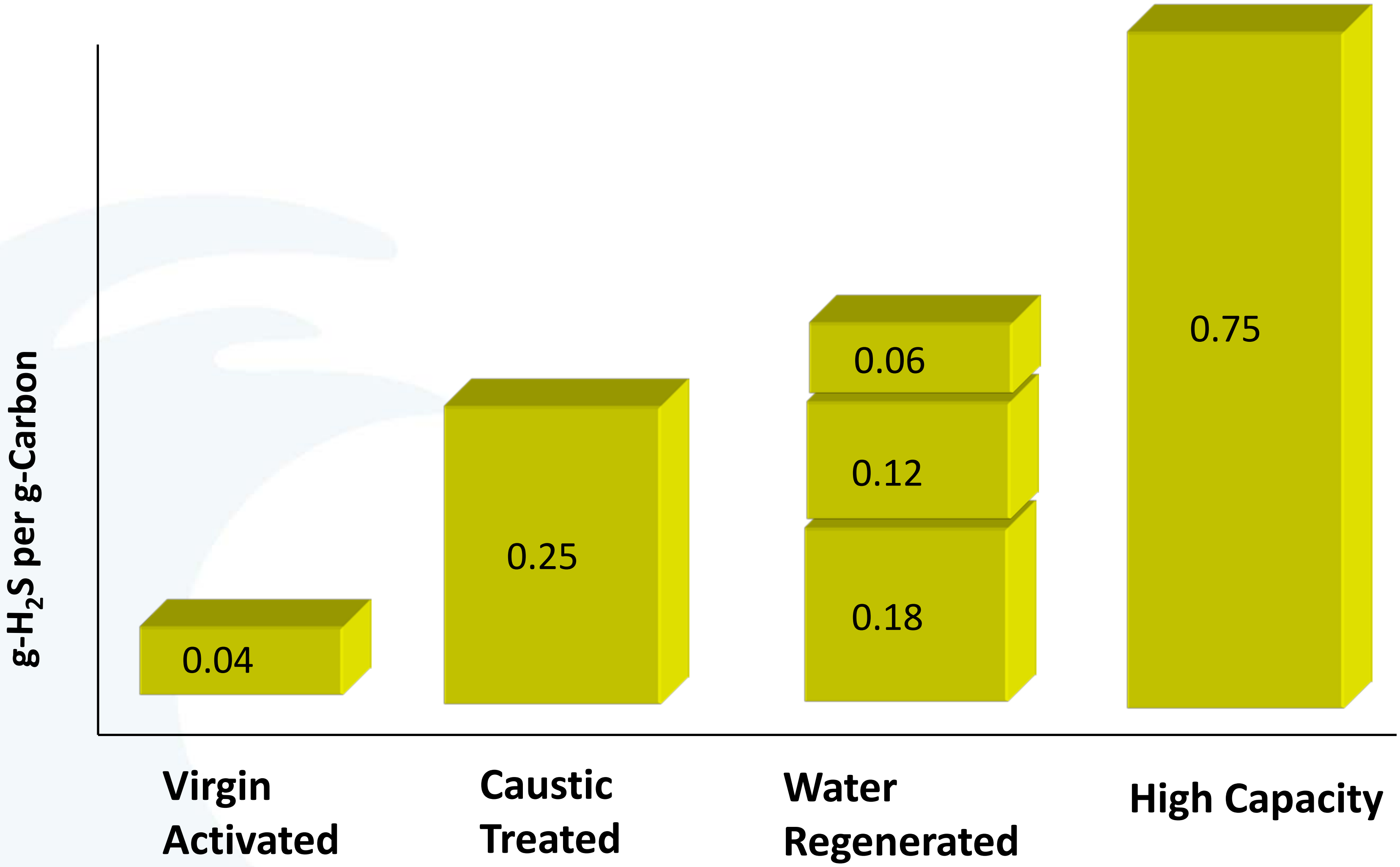
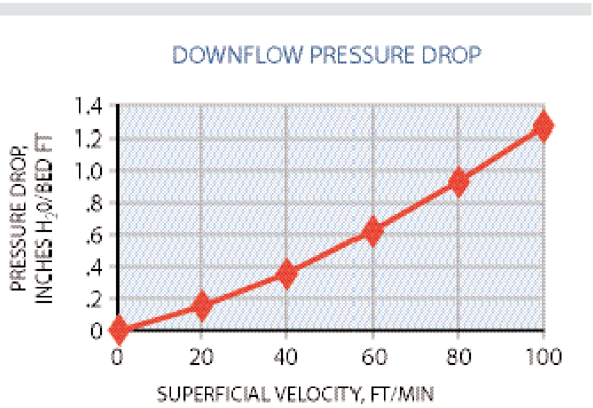
Carbon Capacity Comparison

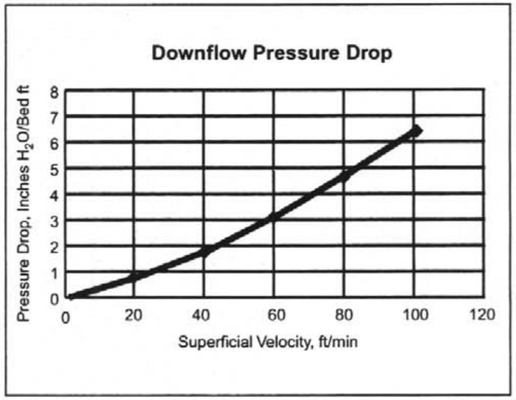


Granular vs. Pelletized Carbons

Granular and Pelletized carbons have similar odor removal capabilities, however pelletized carbons have much lower pressure drop, and hence lower energy usage.



Pelletized Carbon



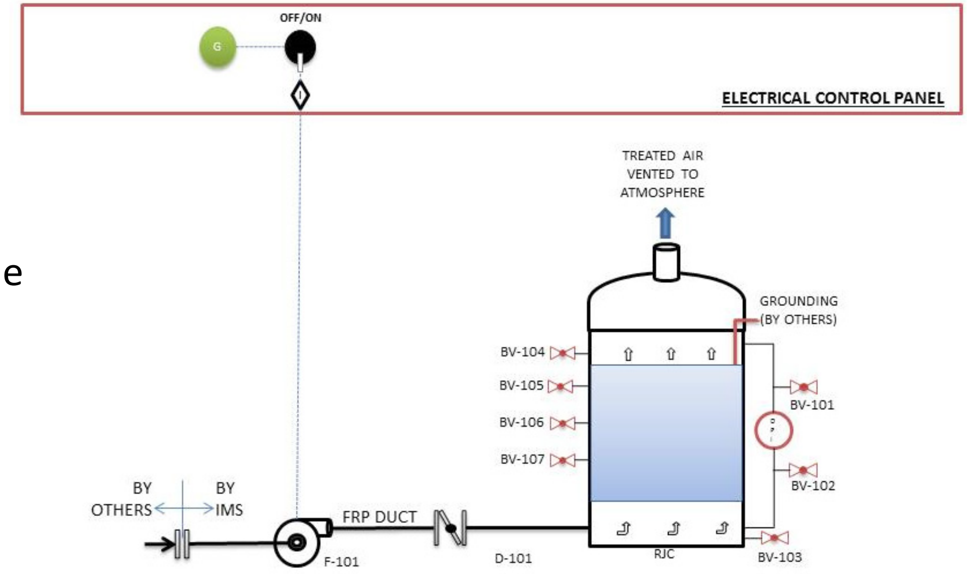
Granular carbon

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 m^3/h)*
- *Factory assembled & skid mounted*
- *FRP or polypropylene construction*
- *FRP Exhaust Fan*
- *Conventional or High Capacity carbo*
- *Variable speed fan option*
- *Acoustic enclosure option*
- *Grease filter option*

Skid Mounted RJCS Adsorbers Standard Models

Model	Airflow Rate CFM (m^3/h)	Overall Dimension L x W x H ft. (mm)	Inlet Connection Inches (mm)
RJCS-0150	Up to 130 (Up to 220)	4.3 x 3.2 x 5.0 (1300 x 975 x 1500)	4.0 (100)
RJCS-0200	105 - 235 (175 - 400)	5.3 x 3.5 x 5.0 (1600 x 1000 x 1500)	6.0 (150)
RJCS-0250	185 - 365 (315 - 620)	5.8 x 3.8 x 5.0 (1700 x 1100 x 1500)	6.0 (150)
RJCS-0300	290 - 530 (490 -1290)	6.3 x 4.1 x 5.0 (1900 x 1200 x 1500)	8.0 (200)
RJCS-0350	420 - 720 (715 - 1225)	7.7 x 4.9 x 5.50 (2300 x 1500 x 1700)	8.0 (200)
RJCS-0400	575 - 940 (980 - 1600)	8.3 x 4.9 x 5.50 (2500 x 1500 x 1700)	10 (250)
RJCS-0450	750 - 1190 (1275 - 2025)	8.8 x 5.2 x 5.50 (2500 x 1600 x 1700)	10 (250)
RJCS-0500	950 - 1400 (1615 - 2380)	9.1 x 5.6 x 5.50 (2700 x 1700 x 1700)	12 (300)

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

Model	Carbon Bed(s)	Airflow Rate CFM (m^3/h)	Overall Dimension L x W x H ft. (mm)	Vessel Diameter Ft. (mm)
RJCB-600	Single	1000-1700 (1700 - 2900)	11 x 8 x 8 (3300 x 2400 x 2400)	6 (1800)
RJCB-800	Single	1700 - 3000 (2900 - 5100)	15 x 10 x 8 (4500 x 3000 x 2400)	8 (2400)
RJCB-1000	Single	3000 - 4700 (5100 - 8000)	17 x 12 x 8 (5100 x 3600 x 2400)	10 (3000)
RJCB-1200	Single	4700 - 6800 (8000 -11600)	20 x 14 x 8 (6000 x 4200 x 2400)	12 (3600)
RJCB-1000D	Dual	6800 - 9400 (11600 - 16000)	19 x 12 x 13 (5700 x 3600 x 3900)	10 (3000)
RJCB-1100D	Dual	9400 - 11400 (16000 - 19400)	20 x 13 x 13 (6000 x 3900 x 3900)	11 (3300)
RJCB-1200D	Dual	11400 - 13600 (19400 - 23000)	21 x 14 x 13 (6300 x 4200 x 3900)	12 (3600)
RJCB-1400D	Dual	13600 - 20000 (23000 - 34000)	23 x 16 x 13 (6900 x 4800 x 3900)	14 (4200)

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*

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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).*

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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)*

Each Technology has its Niche

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

TYPE	CAPITAL COST	OPERATING COST	MAINTEN-ANCE	FOOT-PRINT	ODOR REMOVAL	H2S PPM	H2S % REMOVAL	NH3?
CHEMICAL SCRUBBERS	$$	$$$	$$$	Small	> 95%	0 - 50 +	99.9%	YES
BIO-TRICKLING SCRUBBERS	$$$	$	$$	Large	75-90%	2 - 500 ppm	99.0%	Some
HIGH CAPACITY CARBON	$	$$+	$+	Medium	> 90%	0-20 ppm	99.9%	NO
VIRGIN ACTIVATED CARBON	$	$$+	$+	Medium	> 90%	< 1 ppm	99.9%	NO

Applications

Information needed to select appropriate technology

- *Air Flow Rate or Ventilation Rate*
- *H_2S Concentration (average and peak)*
- *Required level of odor removal (H_2S 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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