



# Introduction to Gas Phase Filtration

- Industrial Applications





#### **Categories of Gaseous Contaminants**



Hydrogen Sulfide (H<sub>2</sub>S) Chlorine (Cl<sub>2</sub>) Sulfur Dioxide (SO<sub>2</sub>) Methyl Mercaptan (CH<sub>4</sub>S) Hydrogen Chloride (HCl) Hydrogen Sulfide (H<sub>2</sub>S) Chlorine (Cl<sub>2</sub>) Arsine (AsH<sub>3</sub>) Formaldehyde (CH<sub>2</sub>O) Ethylene Glycol ((CH<sub>2</sub>OH)<sub>2</sub>) Hydrogen Sulfide (H<sub>2</sub>S) Chlorine (Cl<sub>2</sub>) Ammonia (NH<sub>3</sub>) Acetone ((CH<sub>3</sub>)<sub>2</sub>CO) Isopropanol (C<sub>3</sub>H<sub>8</sub>O)





## **Contaminant Control Methods**

#### Ventilate – Exhaust or Dilute

- EXHAUST contaminants from a contaminated area
- DILUTE contaminants by supplying fresh air near to a contaminated area



#### **Challenges with Ventilation**

- Loss of conditioned air creates a need for make-up air
- Conditioning of make-up air can be expensive
- Required concentration levels may not be achieved





## **Contaminant Control Methods**

#### Source Control

• Relocate or eliminate the source that generates the contaminants



#### **Challenges with Source Control**

- May not be possible to isolate a point source
- Changing the process or chemicals unfeasible
- Examples: Pulp & Paper
  - Tire
  - Food Processing







## **Filtration of Contaminants**

#### **Active Removal of Contaminants**

- Effective removal of gas molecules from the airstream requires Gas-Phase media ("Chemical Filtration")
- Particulate filters, including HEPAs, are not effective

Carbon Filters, Chemical Filters, Chemical Scrubbers, Odor Scrubbers, Dry Scrubbing, Gas Phase Filtration, Vapor Phase Filtration

#### **Challenges with Filtration**

- Needs to be engineered correctly for specific contaminant
- Need to size scrubbers appropriately "<u>Smaller is better!</u>"









#### **Chemical Filtration Media**

Media Type		Impregnate	Target Gases	
SP-908		8% KMnO <sub>4</sub> - Potassium Permanganate	Acids, H <sub>2</sub> S, SO <sub>2</sub> , formaldehyde, ethylene, other corrosive gases	
EC-101		Virgin Activated Carbon	VOCs, O <sub>3</sub> , Cl <sub>2</sub>	
EC-102		KOH - Potassium Hydroxide	Acids, H <sub>2</sub> S, SO <sub>2</sub> , Cl <sub>2</sub>	
EC-103		H <sub>3</sub> PO <sub>4</sub> - Phosphoric Acid	NH <sub>3</sub>	
SP-904		4% KMnO <sub>4</sub> - Potassium Permanganate	Acids, H <sub>2</sub> S, SO <sub>2</sub> , formaldehyde, ethylene, other corrosive gases	





#### Media Blends

Media Type	Components	Target Gases
MB-185	SP-908 + EC-101	Acids, H <sub>2</sub> S, SO <sub>2</sub> , formaldehyde, ethylene, VOCs, O <sub>3</sub>
MB-285	SP-908 + EC-102	Corrosive gases, H <sub>2</sub> S, SO <sub>2</sub> , Cl <sub>2</sub> , formaldehyde, ethylene
MB-145	SP-904 + EC-101	Acids, H <sub>2</sub> S, SO <sub>2</sub> , formaldehyde, ethylene, VOCs, O <sub>3</sub>







## **Tub Scrubber**

- Available airflows include 500, 1000, 1500, 2000, 3000, 4000 cfm
- Deep bed design is well suited for the worst of contamination scenarios
- Standard stainless steel construction Optional aluminum construction
- Highest media to cfm ratio







## Air Filter Unit (AFU)

- Available airflows include 500, 1000, 1500, 2000, 3000, 4000 cfm
- Vertical orientation minimizes footprint in control rooms, datacenters or MCCs
- Standard Painted Steel-Aluminum Double-Wall Construction
- Proprietary Injection systems results in:
  - High R-value 6.5
  - High density 2.6 lbs/sq.ft.
  - No VOCs and low carbon emissions
- Standard controls package with fan variability, high pressure alarms, room temperature and humidity, and output signals for local SCADA systems







## **Side Access Housing**

- Side Access Housings can be designed with airflows ranging from 500 to 40,000 cfm
- Complete flexibility of molecular and particulate filtration to meet the requirements of many applications.
- Painted Steel-Aluminum Double-Wall Construction (standard)
  - Painted steel-galvanized (option)
  - Painted steel-304SS (option)
  - Aluminum-Aluminum (option)
- Highly variable with a variety of particulate and chemical filter options







## **Drum Scrubber**

- Available airflows include 100, 300, 500, 1000 cfm
- Corrosion resistant HDPE drum and cast aluminum fan
- Available in powered and passive models
- High media to cfm ratio
- Easy to install and power
- Routed grate allows for best air distribution with open plenum









#### Well-Suited Applications for Chemical Filtration

- 1. Corrosion Control of Electronics
- 2. Corrosion Control of Equipment (Compressors)
- 3. Energy Savings through Treating Exhaust Air
- 4. Control of Wastewater and Process Odors





## **Corrosion Control of Electronics**





#### **Electronics at Industrial Facilities**

- Computer systems have been used in industry for over 50 years as a means of improving processes and process yields.
- Advancements in microelectronics has generally followed Moore's Law.

 the observation that the number of transistors in a dense integrated circuit
 doubles about every two years.

• As a result, computer components continue to become smaller and in closer proximity to each other on a circuit board.







#### **Electronics at Industrial Facilities**

- Computer systems produce a tremendous amount of heat and need to be cooled to prevent failures.
- Computer rooms are pressurized with conditioned (cooled and dehumidified) air but in most cases the air is contaminated with corrosive gases.
- The corrosive gases are typically a by-product of the process or periodic leaks in chemical supply lines.
- When brought into the computer rooms, they can cause corrosion of computer components.







## **Types of Corrosion**

#### **Copper Creep Corrosion**

- Copper plating on printed circuit boards is converted into copper sulfide (Cu<sub>2</sub>S)
- Creeping copper sulfide travels over the circuit board and electrically shorts other circuit components

#### **Corrosion of Silver Terminations**

- Silver terminations in surface-mounted components are converted into silver sulfide (Ag<sub>2</sub>S)
- Silver whiskers (or flowers) lead to open circuiting of components









## **Corrosion Standards**



#### ISA 71.04-2013

Environmental Conditions for Process Measurement and Control Systems

#### ASHRAE TC 9.9

Gaseous and Particulate Contamination Guidelines

for Datacenters

#### **Corrosion Classification System**

Classification	Å / 30 days		Description	
Classification	Copper	Silver	Description	
G1 Mild	<300	<200	Acceptable - Environment sufficiently controlled.	
G2 Moderate	<1000	<1000	Not acceptable - Corrosion may lead to failure.	
G3 Harsh	<2000	<2000	Not acceptable - High probability of failure.	
GX Severe	>2000	>2000	Not acceptable - Only hardened equipment survives.	



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## **Testing for Corrosive Gases**

- Place Corrosion Analysis Coupon in the environment for 30 days.
- Corrosion Coupon consists of copper and silver test strips mounted on a plastic panel.
- Coupons react with gases in the environment forming corrosion or tarnish films on the coupons.





 $Cu + H_2S \rightarrow Cu_2S$ 

 $Ag + H_2S \rightarrow Ag_2S$ 





## **Corrosion Report**

- Summarizes the condition evaluated in regards to their suitability for electronics.
- Calculates the total amount of corrosion in 30-day period.
- Breakdowns the corrosion film into major categories.
  - Chlorides: Cl<sub>2</sub>, HCl, ClO<sub>2</sub> •
  - Sulfides:  $H_2^{\acute{S}}$ ,  $SO_2^{\acute{}}$ , mércaptans Oxides:  $O_3^{\acute{}}$ ,  $NO_x^{\acute{}}$ ٠
  - •

Air Quality Analysis per ISA 71.04-2013			AS	
Date of Report: 8/2/19 Company: True White Paper Room Area: DC-24	Coupon Panel # Date installed: Date Removed Test Duration:	A06161511 5/28/19 6/28/19 31 Days	Page 1 of 2	
AddBonal Notes:	As Received for Analysis	Copper Coup	ion on	
Readings: Total reactivity (tarnished film) mea Total reactivity (tarnished film) mea Condusion: Coulometric reduction of surface films on m	sured on copper metal strip esured on silver metal strip etallic test samples(coupons)condu	(Å/30 days)= 1835 Å (Å/30 days)= 708 Å cted per ASTM B 825-02	standard	
indicate that there is a <u>Harsh (G3)</u> environment during the period of test expor time. Seasonal, temperature, and RH fluctur in an environment.	level of airborne molecular con sure. Please note that airborne mole ations affect the level and severity o	taminants present in the coular contaminants char f airborne molecular con	subject ige over taminants	Page 2 of 2 lex total film into a number of pability to identify the possible
Prepared by,	Certifi	ed by,		o main reducible film types
MASI Laboratory Technician	N	rekal Pelbain		pper
Pholy, August 2, 2019	Micha	el DelGais, BS ChE, N	IS EVE	_
For questions regarding this and	Ilysis please Michael DelGais MAS Innovations 5012 Southand Drive Woodstock, GA 30188 www.mas-innovations.com	at mdelgais@mas-ini MAS innovations has continuous product i and improvement an the right to change d	s a policy of esearch d reserves esign and	1980 5200
	Copper Films Cu <sub>2</sub> O	A / 30 days 446	AgCI	A / 30 days 0
	Cu <sub>2</sub> S Linknown Cu Species	1173	Ag <sub>2</sub> S Linknown Ag Sporior	613
	Unknown Cu Species	0	Unknown Ag Species	54
	Unknown Cu Species	0	Unknown Ag Species	0
	Totals (Å)	1835	Totals (Å)	708
	Copper Silver	Class	Descri	pition
	<300 <200	G1 Mild	Acceptable - Environmer	nt sufficiently controlled.
	<1000 <1000	G3 Harsh	Not acceptable - High	probability of failure.
				Annual Annual Annual Annual Annual
	>2000 >2000	GX Severe	Not acceptable - Only hard	sened equipment survives.





## **Corrosion Control of Equipment**





#### **Corrosion Control of Equipment**

#### **Centrifugal Air Compressors**

Symptom	Cause	Component Affected
Decreased compressor	Insulating properties of corrosion film impedes heat dissipation.     Thickness of corrosion film reduces the air flow area.	intercooler
efficiency	Corroded and leaking copper tubing	intercooler
Vibration of compressor	Dislodged corrosion by-products which pass through the intercooler attaching to the diffuser, therefore inhibiting air flow.	diffuser
	Dislodged corrosion by-products from the intercooler attach to the impeller.	impeller
	Dislodged corrosion by-products from the intercooler block the passage of air/water which can create an impacting effect.	impeller
Vibration of compressor & reduction in compressor efficiency	Corrosion on intercasing section	intercooler, impeller, diffuser, & casings

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#### **Rotary Screw Compressors**

Symptom	Cause	Component Affected
Wall perforations	Corrosive gases combine with condensate and accelerate stress corrosion at joints or bend lines.	air cooled heat exchangers, dryer heat exchangers
High coolant TAN (Total Acid Number)	Corrosive gases, particularly chlorine, entering compressor combines with coolant, increasing TAN, reduces lubricant efficiency.	bearings, rotor surfaces
Sludge formation in coolant	<ul> <li>Corrosive gases degrade coolant, increasing (or decreasing) viscosity of coolant.</li> </ul>	coolant life
	Separator element can become clogged, increasing pressure drop, causing loss of compressor efficiency.	separator element
	<ul> <li>Coolant change interval can be significantly shortened, increasing operating costs.</li> </ul>	coolant life
Malfunctioning condensate traps	Sludges or acids clog traps, corrode elements. Trap failure follows.	condensate traps

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## **Purifying Compressed Air**

- It is common practice to use vacuum dehydrators and desiccant to remove water vapor from compressed air to minimize the damage to the compressor and other process equipment.
- Using contaminated compressed air may introduce unwanted impurities to final product.
- By compressing the air, the concentrations of contaminants are increased on a volumetric basis.







#### **Examining Compressor Condensate**

- A more direct measure of problem to customer versus corrosion coupons.
- Condensate variables analyzed:
  - pH
  - Sulfides (H2S)
  - Chlorides (Cl2 & HCl)
- Applies to all types of compressors.
- Completely unique service.







#### Energy Savings through Treating Exhaust Air





## **Recycling Exhaust Air**

- Simple Concept
  - 1. Capture exhaust air
  - 2. Scrub the contaminated air
  - 3. Return the cleaned air to the building envelope
  - 4. Monitor
- Best used in manufacturing processes with light contamination loads or sporadic use, e.g. touch-up paint booth.
- Even if easily scrubbed, some contaminants may be toxic.
- Proper preventive maintenance policies are critical.





## Control of Wastewater and Process Odors





#### **Odor Control Opportunities**

#### Wastewater

- Wet Wells & Pump Stations

#### **Food & Product Process Lines**

- Extract fumes from a small point source
- Covered processes that require frequent opening of process chamber

#### Vents of Liquid Storage Tanks

- Vapors build as levels of liquid chemicals drop
- Vapors are compressed and released through emergency vent





## **Target Markets**

- Pulp & Paper
- Oil & Gas Refineries
- Tire
- Chemical
- Mining
- Steel
- Wastewater
- Food Processing
- Poultry Processing
- Garbage Disposal
- Research Laboratories

