

# ADSORPTION CARTRIDGES

The following factors should be considered when designing a system which utilizes a vapor adsorption cartridge:

1. Adsorbents are effective for vapors. Since liquids will damage or inactivate most solid adsorbents, it is essential that a cartridge or DIA must be preceded by an efficient coalescing filter. (I.E. – 70C or 50C)
2. In contrast with Microfiber Filters, which operate at their initial efficiency throughout their life, adsorption cartridges have a limited holding capacity. When the adsorption capacity is reached, no further adsorption occurs. The limiting capacity, or “breakthrough” point, is not sharply defined, and the exit vapor concentration will increase rapidly as saturation approaches. To avoid unwanted vapor contaminants downstream, it is necessary to change the adsorption cartridge well before it has reached its ultimate adsorption capacity. **How is this determined? There is no definite answer since many factors are involved. A simple “Rule Of Thumb” is that most adsorbents will hold 20% of their weight. (See #3).**
3. The efficiency of a given adsorbent for a given vapor depends very much upon the specific operating conditions. Therefore, again in contrast to filtration, it is not possible to assign a single efficiency rating to an adsorbent. In addition to the relative affinity of the adsorbent for the vapor, other factors which influence the efficiency of adsorption include:
  - Temperature – Adsorption efficiency is usually much higher at low temperature than at high temperature.
  - Concentration Of Vapor - Percentage removal efficiency is higher at low impurity vapor concentration. However, total adsorption capacity is higher at high vapor concentration.
  - Contact Time – Adsorption efficiency increases with increased contact time. The lowest possible flow rate should be maintained for optimum results.
  - Presence Of Competing Vapors – Adsorption efficiency for a given vapor is generally reduced by the presence of another vapor for which the adsorbent is active. For example, the presence of a high concentration of water vapor will interfere with adsorption of other vapors by carbon, silica gel, or molecular sieves.
4. In general, adsorption is reversible – if operating conditions change a vapor may desorb rather than adsorb. This fact is the basis for regeneration of adsorbents by heating, treating with vacuum, or purging with gas of low contaminant concentration. However, it should be recognized that desorption can also occur inadvertently through change in process conditions. For example, if a temporary surge in vapor impurity concentration causes a relatively high concentration to be adsorbed on the solid, a subsequent decrease in inlet vapor composition will result in desorption of vapor from the solid to the gas stream.

While it is not possible to predict or guarantee an adsorption efficiency for any specific set of conditions, it is possible to enhance the conditions beneficial to adsorption and avoid conditions which interfere with adsorption.

**In closing, adsorption cartridges must be closely monitored for optimum service.**



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Adsorbent	Final Numbers In Designation	Vapor Adsorption Activity	
		Good To Excellent Adsorption	Little Or No Adsorption
Carbon	CC	Most C <sub>4</sub> and heavier hydrocarbons, ketones, alcohols, esters, ethers, organic acids, chlorinated organic, Freons, all aromatic hydrocarbons, carbon disulfide	Carbon monoxide, carbon dioxide, amines, ammonia, acetylene, most C <sub>3</sub> and lighter hydrocarbons, sulfur dioxide
Silica Gel	SG	Water vapor	Recommended only for water vapor adsorption
Molecular Sieve Type 4A	4A	Carbon Dioxide Ammonia Sulfur Dioxide Hydrogen Sulfide Acetylene Propylene Methane Ethane Water Vapor Ethylene Ethylene Oxide Carbon Disulfide	Organic compounds C <sub>4</sub> or larger, carbon monoxide
Molecular Sieve Type 13X	13X	All materials adsorbed by Type 4A Sieve plus: Methanol Straight Chain Mercaptans Freon 11 Freon 12 Freon 114 Sulfur Hexafluoride Straight Chain Hydrocarbons to C <sub>22</sub> Cyclohexane Diphenyl Butene-1 Isopentane Benzene, Toluene, Xylene Boron Trifluoride Triethylamine and Smaller Amines	Organic Compounds C <sub>7</sub> Or larger, Carbon Monoxide
Calgon Type HGR Sulfur –Impregnated Carbon	CC-RD	Mercury Vapor	Recommended only for mercury vapor adsorption
Mixed Sodium and Calcium Hydroxides	MB	All acidic gases, including: Sulfur Trioxide, Sulfur Dioxide, Nitrogen Dioxide, Carbon Dioxide, Hydrogen Sulfide, Hydrogen Chloride, Chloride, Phosphorus Chlorides	Inert and non-acidic gases
Potassium Permanganate Impregnated Aluminum	PP	Removal of SO <sub>x</sub> in stack gas	



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TABLE				
Y		Denotes that chemical is Adsorb		
N		Denotes No Adsorption		
MB		Represents Mixed Bases		
PP		Represents Potassium Permanganate		
Chemical Substance	Formula	PP	MB	TLV (ppm)
Acetic Acid	CH <sub>3</sub> COOH	Y	Y	10
Acetone	CH <sub>3</sub> CO CH <sub>3</sub>	Y	N	750
Acrylic Acid	H <sub>2</sub> C CH COOH	Y	Y	
Alcohols	ROH (General)	Y	N	
Aldehydes	RCHO (General)	Y	N	
Allylchloride	H <sub>2</sub> C CHCH <sub>2</sub> Cl	Y	N	1
Ammonia	NH <sub>3</sub>	Y	N	25
Arsine	AsH <sub>3</sub>	N	Y	0.05
Bromoform	CHBr <sub>3</sub>	Y	N	0.05
Butyl Alcohol	CH <sub>3</sub> (CH <sub>2</sub> ) <sub>2</sub> CH <sub>2</sub> OH	Y	N	50
Carbon Dioxide	CO <sub>2</sub>	N	Y	5000
Carbon Oxysulphide	COS	N	Y	
Chloroform	CHCl <sub>3</sub>	Y	N	10
Diacetone Alcohol	CH <sub>3</sub> COCH <sub>2</sub> C(CH <sub>3</sub> ) <sub>2</sub> OH	Y	N	50
Diesel Fuel	General Hydrocarbons	Y	N	
Esters	General	Y	N	
Ethers	ROR (General)	Y	N	
Ethyl Acetate	CH <sub>3</sub> COOC <sub>2</sub> H <sub>5</sub>	Y	N	400
Ethyl Alcohol	C <sub>2</sub> H <sub>5</sub> OH	Y	N	1000
Ethyl Benzene	C <sub>6</sub> H <sub>5</sub> C <sub>2</sub> H <sub>5</sub>	Y	N	100
Ethylene	C <sub>2</sub> H <sub>4</sub>	Y	N	
Formaldehyde	HCHO	Y	N	1
Formic Acid	HCOOH	Y	Y	5
Gasoline	Hydrocarbon Mixture	Y	N	100
Hydrogen Chloride	HCl	N	Y	5
Hydrogen Cyanide	HCN	N	Y	10
Hydrogen Sulphide	H <sub>2</sub> S	Y	Y	10
Ketones	R <sub>1</sub> COR <sub>2</sub> (General)	Y	N	
Mercaptans	RSH (General)	Y	Y	
Methyl Alcohol	CH <sub>3</sub> OH	Y	N	200
Methyl Chloroform	CH <sub>3</sub> C Cl <sub>3</sub>	Y	N	
Methyl Ethyl Ketone	CH <sub>3</sub> COC <sub>2</sub> H <sub>5</sub>	Y	N	
Nitrogen Oxides	NO <sub>x</sub> (NO+NO <sub>2</sub> )	NO oxidized	N	
Ozone	O <sub>3</sub>	Decomposed	N	0.1
Petrols	Hydrocarbon Mixtures	Y	N	
Phenol	C <sub>6</sub> H <sub>5</sub> OH	Y	N	5
Phosphine	PH <sub>3</sub>	Y	N	0.3
Pyridine	C <sub>5</sub> H <sub>5</sub> N	Y	N	5
Stibine	SbH <sub>3</sub>	Y	N	
Sulphur Dioxide	SO <sub>2</sub>	Y	Y	2
Toluene	C <sub>6</sub> H <sub>5</sub> CH <sub>3</sub>	Y	N	100
Vinyl Acetate	CH <sub>3</sub> COOCHCH <sub>2</sub>	Y	N	10
Vinyl Chloride	CH <sub>2</sub> CHCl	Y	N	5
Xylene	C <sub>6</sub> H <sub>4</sub> CH <sub>3</sub> CH <sub>3</sub>	Y	N	



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