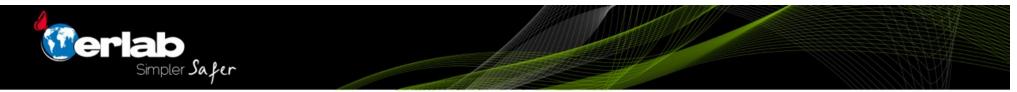


Safe and Appropriate Application of Filtered Fume Hoods

by Ken Crooks Director, GreenFumeHood Technology



Agenda

- Review advances in Filtered Fume Hoods.
- Determine safe and appropriate applications
- Understand best practices via case studies.



Image Credit: McMaster Univ.



Ductless Hoods (aka "filtered enclosures")



- Routine, repetitive procedures
- Limited chemical handlings
- User 'Ownership' and User-based safety
- Manual or minimal automatic filter testing
- Limited changes to usage
- Portable, lightweight, low cost



Filtered Hoods (aka "green hoods")



- Teaching / Instructional use
- Controlled research
- Greater chemical handlings
- Automatic, continuous filter testing
- Connectivity with EH&S and Facilities
- Broader range of change is acceptable
- Fixed in place, heavier, costlier than ductless



Ducted Hoods (aka "hoods")



- Research & Development
- Greatest chemical handlings
- Few limitations (e.g. Perchloric, Acid Digestion, Radioisotopes)
- Connectivity with EH&S and Facilities
- Broadest range of change is acceptable over life of hood
- Fixed in place, heavy, highest total first and operational costs



Filtered



Improvements:

Universal Filtration Detection Communication Hood Structure Sash Design Services/Utilities Sizes

Ductless



Image Credit: Labconco Corp.



Operational Protocols

• Ductless and Filtered Hoods:

- Personnel training proper usage
- Signage of limitations
- Administration-level control of chemicals introduced
- SOP for change of usage
- Scheduled maintenance (filters, sensors)



• Ducted Hoods:

- Anything goes? No, some limitations
- Scheduled Maintenance (fans, flow control device, etc.)
- Training



- All hoods:
 - Flow alarms (audible and visual)
 - Periodic testing (face velocity, containment)

FILTERED FUME HOOD

FOR USE WITH SUBSTANCES

that produce hazardous levels of airborne chemicals: gas, fumes, and vapors. HEPA filter required for: aerosols and dust.



DO NOT USE WITH: Organophosphoric Compounds Mercury Hydrogen Cyonide Rodosotope Percharia Acid Highly exothermic reactions

NOT RETAINED WELL: Helium and the Noble Gases

Hydrogen Ethane Ethylene Oxide Methane Carbon Monoxide Propylene Acetylone

SERVICE ACCESS

FILTERED FUME HOOD SAFETY PRACTICES

FOR USE WITH SUBSTANCES

that produce hazardous evels of airborne chemicals gas, turnes, and vapors. HEPA filter required for: aerosols and dust.

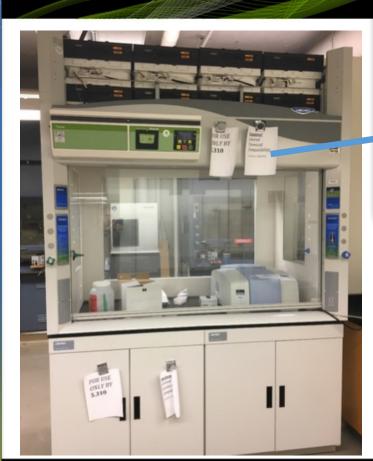
Do not put your head in the hood. Minimize diafts and suidden movements in front of the hoad. Wark a minimum of sk inches inside the hoad. Elevate equipment above the work surface. Keep sil and baffle unobstructed. Do not use the hoad for storage. Adjust the sash to smallest opening possible when in use. Close sash when unattended. Do not remove any of the hoad

Do not place flammable solvents near heat, flame or sparks. Do not evaporate large amounts of liquids.

Wipe up spills immediately. Routinely validate diffiow.

If airflow alarm indicates unsafe condition, immediately close sast discontinue hood operation and call for help.

SERVICE ACCESS



OR USE ONLY BY 5.310

<u>Caution!</u> Limited Chemical Compatibility

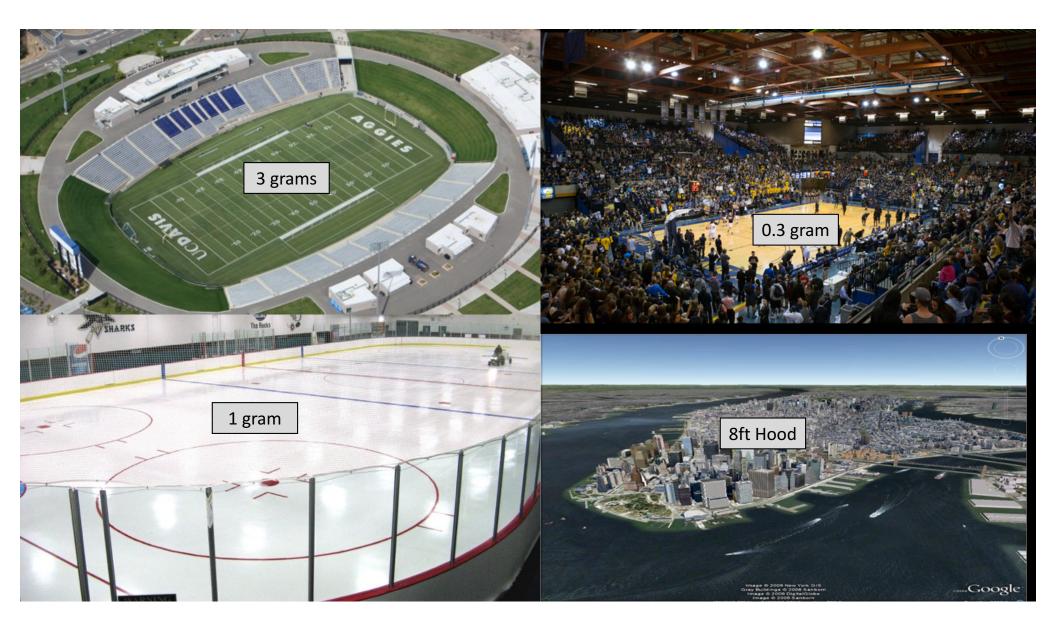
APPROVAL REQUIRED



Carbon-based Filtration, Activation Process

- Organized structure
- Steam & Heat creates spaces between carbon layers
- 15,000 ft² surface area per gram

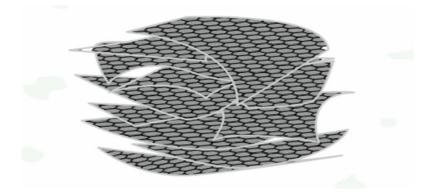






Activation Process

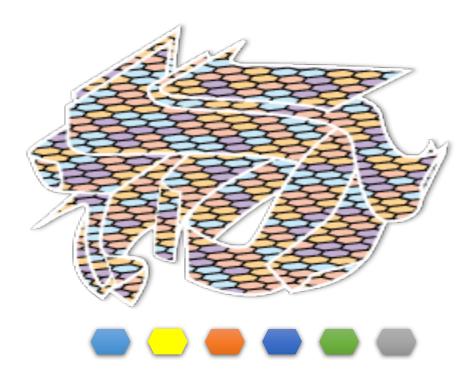
- Impregnation problem: decreases capacity
- Past use of heavy metals to increase capacity
- Specific filters types: (AS, BE, K, F, G...)

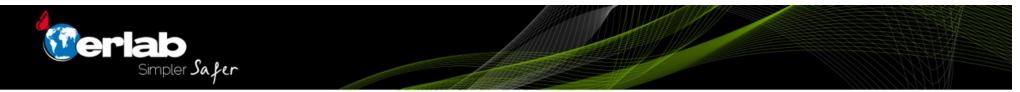




Filtered Fume Hood Media

- Universal filtration technology retains:
 - Polar organic solvents
 - Non-polar organic solvents
 - Inorganic Bases
 - Inorganic acids





Application Review

- Steps to Evaluate Acceptability are:
 - Chemical Lists as per AFNOR NFX 15-211
 - Detailed chemical questionnaire
 - Analysis report: Approved or Denied
 - Programming sensitivity of sensors



Chemical "Long List"

- 500+ chemicals, each tested with 6 or more different concentrations.
- Each test performed twice.
- Represents thousands of chemicals.



Chemical Name	Chemical Name													
		· · · ·					Mana and a state of the state o		1120/11//					
	2-Butoxyethanol	Chemical Name		BELTWA (OF)			anna an Inn BR		8311/////					
I. 4-Dioxane	2-Butoxyethanol 2-Chioroacetaidehyde	4-Methyl 2-pentanone	Chemical Name	Chemical Name	· · · · · · · · · · · · · · · · · · ·									
	2-Chloroethanal	4-Methyl-2-pentanone	Aqua regia		Chemical Name	Chemical Name Formula C.A.S Nun		PEL-TWA (OSHA) PEL-STEL (OSHA)						
1,1,1-Trichloroethane	2-Chloroethanol	4-Methylaniline	Aqueous hydrogen bromide (i.e.	Butyl vinyl ether Butyric acid	Cyclohexyl ketone	tone Chemical Name		nical Name Formula C.A.S.Number PEL-TWA (OSHA) PEL-STEL (OSHA)						
1,1,2,2-Tetrabromoethane	2-Chloroethyl alcohol	4-tert-Butyl toluene	Aqueous hydrogen chloride (Le.	BUCHIC ACIO	Cyclohexylamine	Cyclopentane Erythrene DEA Essence of mirbane								
1,1,2,2-Tetrachloroethane	2-Chioropropylene oxide	5-Methyl-3-Heptanone	Arsenic (inorganic compounds, as As)	Cadnium										
1,1,2,2-Tetrachloroethane 1,1'-Biphenyl-4,4'-diamine	2-Ethoxy acetate	Absolute alcohol	Asbestos	Cadnium (dust and fume				Formic acid Chemical Name Formula C.A.S. Number PEL-TWA (OSHA) PEL-STEL (OSHA)						EL (OSHA)
I,I-Dichloroethane	2-Ethoxyethanol 2-Ethyl-1-hexanol	Acetaidehyde Acetic acid	Aspirin	Calcium carbonate	Decane			ormic aldehyde						
1,2-Dibromoethane	2-FuryImethanol	Acetic anhydre	Atrazine	Calcium hydroxide	Diacetone	E		Formonitrile	Chemical M	lame Form	nula C.A.S Nu	mber	PEL-TWA (OSHA)	PEL-STEL (OSHA)
1,2-Dichlorobenzene	2-FuryImethanol	Acetic oxide	Azide	Calcium hydroxide	Diacetone alcohol Diamine		Ethanoic acid F	urfuryl alcohol					1	
1,2-Dichloroethane	2-Heptanone	Acetone	Barium chloride	Calcium oxide	Diamine Dibutyl ether		Ethanol	Chemical Nar	me Formu	la C.A.S Num	nber PEL-TWA (O	SHA)	PEL-STEL (OSHA)	
1,2-Dichloroethylene	2-Hexanone	Acetonitrile	Benzenamine	Calcium sulfate	Dichloromethane		Ethanolamine Glacial a							
1,2-Epoxy-3-isopropoxypropane	2-Hydroxymethylfuran	Acetylene	Benzene	Carbon bromide	Dichloropropane 1, 2		Ethene	n-Butyl amir	ne C4H9N	H2 109-73-9)			200 ppm
1,2-Ethanediol	2-Methyl-1,3-butadiene	Acetylene dichloride	Benzene chioride	Carbon disulfide	Dicyclopentadiene		Ether C	n-Butyl chlori	ide C4H90	CI 109-69-3	1			
1,3-Cyclopentadiene	2-Methyl-I-propanol 2-Methylbutane	Acetylene tetrabromide	Benzene chloride	Carbon tetrabromide	Diethamine	ř	nidium promide					l l		
1,3-Dichloropropene	2-Methylpropyl acetate	Acetylealicilic acid	Benzine 35 80	Carbon tetrachloride	Diethanolamine		Chemical Name	Formula	C.A.S Number	PEL-TWA (OSHA)	PEL-STEL (OSHA)			
1,3-Dichloropropylene	2-Pentanone	a-Chlorotoluene	Benzyl alcohol	Caustic soda	Diethyl ether		Propyl alcohol	C3HBO	71-23-8	200 ppm				
1,3-Dioxolane	2-Pentanone	Acroleic acid	Benzyl chloride	Cellosolve "Acetate" Cellosolve®	Diethyl ketone			C3H85	107.03.9	200 ppm				
1,3-Divinylbenzene	2-Phenyl propane	Acrolein	Beryllium compounds (as Be) BET	Cellulose	Diethyl oxide		Propyl mercaptan							
I-Aminobutane	2-Propanol	Acrylic acid	beta-Aminoethyl alcohol	Chlorine	Diethylamine		Propylacetate	C5H10O2	109-60-4	200 ppm				
I-Aminopropane I-Butanethiol	2-Propanone	Acrylic aldehyde	beta-Chloroprene	Chlorine dioxide	Diethylaminoethanol-2 Diethylene dioxide		Propylamine	C3H9N	107-10-8					
I-Butanethiol	2-Propen-1-ol	Acryionitrile	beta-Methyl acrolein	Chlorine oxide	Diethylene dioxide		Propylbenzene	C9H12	108-67-8					
I-Butanol	2-Propenal	Alcohol	beta-Methylpropyl ethanoate	Chloro-I-nitropropane						2 ppm				
I-Chloro butane	2-Propenamide 2-Propenenitrile	Allyl alcohol	Bicyclopentadiene	Chlorobromomethan	Chemical Name	Formula	a C.A.S Number	PEL-TWA (OSHA)	PEL-STEL (OSHA)	75 ppm				
I-Chloro-2,3-epoxypropane	2-Propenoic acid	Allyl alcohol	Biotite	Chlorobutadiene	Toluol	C7H8	108-88-3	200 ppm	300 ppm	75 ppm				
I-Chloro-2,3-epoxypropane	2-Propenol	Allyl aldehyde	Borax	Chloroethane	Tribromomethane	CHBr3		0.5 ppm	200 ppm	100 ppm				
I-Mercaptobutane	2-Propyl acetate	Allyi chioride	Boron axide	Chloroethene	Trichloroacetic acid	CHERS		o,o ppm		1000 ppm				
I-Mercaptobutane	2-Propylamine	Allylene	Bromine Bromochioromethane	Chloroethylene	Trichloroethane-1,1,2	Carrense	10-02-7	10		10 ppm				
I-Mercaptobutane I-Methyl-2-pyrrolidinone	2-Propyn-1-ol	Allyiglycidylether	Bromoethane	Chloroform		C2H3CI3		10 ppm						
I-Propanethiol	2-Propynyl alcohol	Alumina Aluminium	Bromoethene	Chloromethane	Trichloroethanoic acid	C2HCI3O				5 ppm				
I-Propanol	3-Amino-1-propanol	Aluminum exide	Bromoethylene	Chloroprene	Trichloroethanoic acid	C2HCI3O				15 total dust mg/m3				
2, 2'-Dichlorodiethyl ether	3-Chloro-I-propene 3-Cresol	Aluminum trioxide	Bromoform	Chlorothene	Trichloroethene			100 ppm	200 ppm	30/(%silica+2) total dust mg/				
2, 4-Dimethyl pentane	3-Cresol	Amino-benzene	Butanoic acid	Chromic acid	Trichloroethylene	C2HCB		100 ppm	200 ppm	m3				
2,4-Dimethyl-3-pentanone	3-Methoxy-3-methyl-1-butanol	Aminocyclohexane	Butyl acrylate	Chromic oxide	Trichloromethane	CHCI3			50 ppm	10 mg/m3				
2,6-Dimethyl-4-heptanone	3-Methyl phenol	Aminoethane	Butyl alcohol	Chromium(VI) oxide (I	Triethylamine	C6H15N		25 ppm		15 Inhalable aerosol mg/m3				
2-Amino I-propanol	3-Methyl-3-penten-2-one	Aminomethane	Butyl alcohol sec	Cinamene	Trifluoroacetic acid	C2HF3O2				150 ppm				125 ppm
2-Amino butane 2-Amino pyridine	3-Octanone	Ammonia	Butyl alcohol sec	Clay Copper (dusts and mists, a	Trimethyl methane	C4H10				100 ppm				
2-Aminoethanol	3-Pentanone	Ammonium chioride	Butyl alcohol ter Butyl alcohol ter	Copper (dusts and mists, a	Trimethyl pentane 2.2.4	CBHIR	540-84-1							125 ppm
2-Aminopropane	4,4'-Bianiline	Ammonium chioride (fumes)	Butyl carbinol				75-50-3							2 ppm
2-Butanol	4,4'-Biphenyidiamine	Ammonium hydroxyde sol Amorphous silica	Butyl Cellosolve®	1, 4-Dioxane to			108-67-8			80/ % silica total dust mg/m3			200 ppm	
2-Butanone	4,4'-Diaminobiphenyi 4-Aminotoluene	Amyl alcohol n	Butyl ether	1 ±,	, 4-Dioxaiie		7440-33-7			15 total dust mg/m3			200 Main	
2-Butenal	4-Cresol	Anhydrous hydrogen bromide	Butyl glycidyl ether				8006-64-2	100 ppm		0,01 mg/m3				
	4-Hydroxytoluene	Anhydrous hydrogen bromide	Butyl glycol		Zinc oxide	د	75-01-4	I ppm	5 ppm	2 mg/m3				
	I,2-Dich	Aniline	Butyl lactate			- •	108-05-4							
	1,2-Dicin	Aqua fortis	Butyl metacrylate	1 10			593-60-2							
			Butyl vinyl ether	(1	3) Pages lo	ngl	107-18-6	2 ppm		2 mg/m3				5 ppm
	1,2-Dichloroethane			1 (*			75-01-4	I ppm	5 ppm	500 ppm		1		
	-,						107-13-1	2 ppm	10 ppm					
	1.2 0:41	oroothylono		COLLOCI	Vinyl ethylene	C4H6	106-99-0	I ppm	15 ppm	0,15 mg/m3	200			
	1 / 11261	ARAAFBUIABA			Vinyl toluene	C9H10	25013-15-4	100 ppm		100 ppm	200 ppm		200 ppm	
					Vinyl trichloride	C2H3CI3	3 79-00-5	10 ppm	-	5 ppm			300 ppm	
					Vinylbenzene	CBHB	100-42-5	100 ppm	200 ppm	I mg/m3				
					White spirit	85% Nonane/15% t benzene		500 ppm		100 ppm				
					Xylene (isomers)	CBHI0	1330-20-7	100 ppm		200 ppm				
					Xylol	C9H10	103.38.3	50 ppm		100 ppm				
					Zinc oxide	ZnO	1314-13-2	15 mg/m3		100 ppm				
					2 mc oxide									
				L						100 ppm	200 ppm			1
							Tetrachloromethane	CCI4	56-23-5	10 ppm	25 ppm			1
							Tetrahydrofuran	C4H8O	109-99-9	200 ppm				1
							TFA	C2HF3O2	76-05-1				10 ppm	1
							THF	C4H8O	109-99-9	200 ppm				1
						1	Tin (inorganic compounds, as §	Sn) Sn	7440-31-5			F		i -
							Tin(IV) oxide (as Sn)	O2Sn	18282-10-5					
							Titanium dioxide	TIO2	3463-67-7	5 total dust mg/m3				
							Titanium dioxide	TIO2 C3H9N	13463-67-7 75-50-3	15 total dust mg/m3				
							TMA	C3H9N	75-50-3		300 pom			
										15 total dust mg/m3 200 ppm	300 ppm			



Chemical "Short List"

Not retained well (gases):

- 1. Hydrogen
- 2. Helium and all Noble Gases
- 3. Methane
- 4. Ethane
- 5. Ethylene Oxide
- 6. Carbon Monoxide
- 7. Carbon Dioxide
- 8. Nitrogen Monoxide
- 9. Propylene
- 10. Propyne, Propane
- 11. Acetylene
- 12. SOx and NOx

Applications not recommended:

- Perchloric Acid, Radioisotope or Acid Digestion Hoods
- Highly exothermic reactions
- Mercury Well retained but remains extremely toxic (TLV = 0.05 ppm) and difficult to detect
- Evaporations

Use Best Practices:

 Large volumes of Methanol, Ethanol, Acetonitrile need condensers or closed containers.



Chemical Review Spreadsheet

Type of handling	CHEMICAL NAME	TYPE OF CONTAINER	Opened 7 Closed		Temperature (°C)	Handling Frequency	Handling Quantity	Duration (min)
CONCENTRATION	ACETIC ACID	VOLUMETRIC FLASK	Opened	0.82%		From 1 to 2	From 26 to 50 ml (or g)	From 46 to 60 min.
CONCENTRATION	BENZOIC ACID	VOLUMETRIC FLASK	Opened	0.99%	22°C	From 1 to 2	From 26 to 50 ml (or g)	From 46 to 60 min.
CONCENTRATION	HYDROCHLORIC ACID	VOLUMETRIC FLASK	Opened	0.38%	22°C	From 1 to 2 handlings/month	From 76 to 150 ml (or g)	From 46 to 60 min.
EVAPORATION	BUTYL ALCOHOL	VOLUMETRIC FLASK	Opened	0.99%	22°C	From 1 to 2 handlings/month	From 26 to 50 ml (or g)	From 46 to 60 min.
EVAPORATION	ETHYL ALCOHOL	VOLUMETRIC FLASK	Opened	0.82%	22°C	From 3 to 4 handlings/month	From 76 to 150 ml (or g)	From 46 to 60 min.
EVAPORATION	ISOPROPYL ALCOHOL	VOLUMETRIC FLASK	Opened	0.99%	22°C	From 3 to 4 handlings/month	From 76 to 150 ml (or g)	From 46 to 60 min.
EVAPORATION	METHYL ALCOHOL	VOLUMETRIC FLASK	Opened	0.99%		From 3 to 4 handlings/month	From 26 to 50 ml (or g)	From 46 to 60 min.
DILUTION, WEIGHING	SODIUM BICARBONATE	VOLUMETRIC FLASK	Opened	1%		From 1 to 2 handlings/month	From 0 to 5 ml (or g)	From 46 to 60 min.
DILUTION, WEIGHING	SODIUM BROMIDE	VOLUMETRIC FLASK	Opened	1%	22°C	From 1 to 2 handlings/month	From 0 to 5 ml (or g)	From 46 to 60 min.
DILUTION, WEIGHING	CALCIUM CARBONATE	VOLUMETRIC FLASK	Opened	0.9%	22 [.] C	From 1 to 2 handlings/month	From 0 to 5 ml (or g)	From 46 to 60 min.
DILUTION, WEIGHING	SODIUM CARBONATE	VOLUMETRIC FLASK	Opened	1%	22°C	From 1 to 2 handlings/month	From 0 to 5 ml (or g)	From 46 to 60 min.
EVAPORATION	CYCLOHEXANE	VOLUMETRIC FLASK	Opened	100%	22 [.] C	From 1 to 2 handlings/month	From 11 to 25 ml (or g)	From 46 to 60 min.
EVAPORATION	CYCLOHEXENE	VOLUMETRIC FLASK	Opened	95%		From 1 to 2 handlings/month	From 11 to 25 ml (or g)	From 46 to 60 min.
DILLITION WEIGHING	BARILIM CHI ORIDE	VOLUMETRIC ELASK	Onened	97%		From 1to 2	From O to 5 ml (or a)	From 46 to 60 min



Chemical Review – Analysis & Report

GFH Approval Level: 1-4

1 Containment	Approved	
2 Detection	Approved	
3 Neutrodine Compatibility	Approved	
4 Neutrodine Estimated Life Expectancy	Approved	

Comments

Solvent trigger: 3600 Expected filter lifetime: M2: 24 Months M3: 24 Months M4: 24 Months M5: 24 Months

Cedric Herry (PhD) R&D Manager

Feasibility Study performed by: Cedric Herry, PhD - ERLAB ERLAB has approved the use of the GFH technology based on the information provided by the client. Client acknowledges that the GFH technology should always be used in accordance with approved usage.



Detection at <1% TLV Exposure

- Suite of Detectors:
 - Acid
 - Solvent
 - Lab Ambient Air
 - Temperature
 - Sash Sensor



(side view of hood)



Standards / Certification

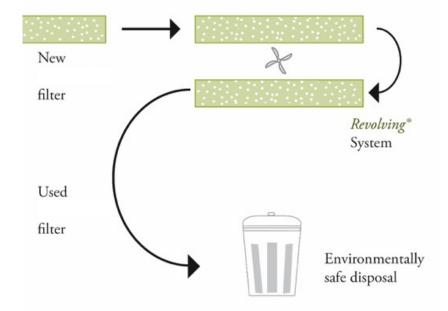
- Containment: ASHRAE Std. 110 in North America
- Retention: **AFNOR NFX 15-211** (as referenced in ANSI Z9.5-2012)
 - All (3) phases of operation
 - Class 1 (back-up filter)
 - Class 2 (no back-up filter)





Filter Replacement/Disposal

- Standard PPE
- Secondary filter becomes primary, new secondary installed
- Old filter incinerated through your established process and vendor, or TCLP testing.





Bridgestone Technical Center



- Akron, OH
- 4-story research building
- 265,000 Sq.Ft.
- (600) employees
- Wet Chem Lab
- (12) Fume hoods:
 - (11) Filtered
 - (1) Floor-Mounted
- LEED Gold (v2.2)

Image Credit: SoL Harris/Day Architecture



Bridgestone Technical Center

- Tested a filtered hood for 20 months, over 300 chemicals
- Purchased 10 more hoods
- \$5,000 annual energy savings per hood (\$60k/yr total)

 32% less total building energy consumption



Image Credit: SoL Harris/Day Architecture



Bridgestone Technical Center

Operational Costs:

- Filter replacements = \$4,000 in 3 years
- Acid Sensor replacements = <\$3,000
- Misuse repairs for acid digestion = \$11,240 (includes all new technology and filters)
- Estimated energy cost savings = \$165,000
- Net savings = \$146,000+ in 3 years





U of Rochester – Hutchinson Hall

- \$1.5mil, 6-month Renovation
- Organic Chemistry Teaching
- (15) Fume hoods:
 - (13) Filtered
 - (2) Ducted (Dispensing)
- Supply and Exhaust system 'challenges'





U of Rochester – Before





U of Rochester – After



- NYSERDA rebate: \$36.6k
- GFH portion: \$12,975
- Annual kWh Savings: 32,727
- Peak Reduction: 110.5 kWh
- Fuel Savings: 8,233 Therms

- Operating costs savings: \$136,100 annually
- 300% increase in hoods!

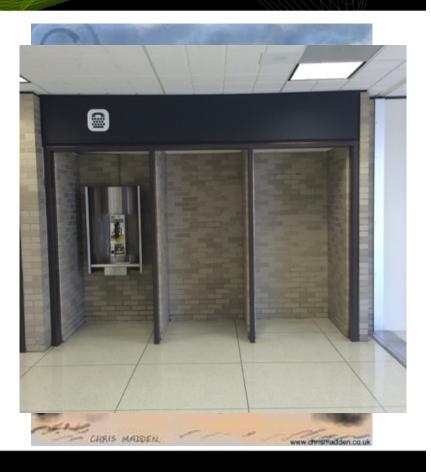
Image Credit: Univ. of Rochester



FINAL THOUGHTS

- Pollution is Pollution regardless of Dilution!
- Safety and increased flexibility.
- Lower first costs AND operational cost savings.

There is a better way!





Thank You

Ken Crooks

Director, GreenFumeHood Filtration Technology

Erlab, Inc.

kcrooks@Erlab.com 978-948-2216