



MOLECULAR FILTRATION







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BUSINESS DEVELOPMENT MANAGER MOLECULAR Molecular filtration in North Europe

- Business development manager molecular Molecular filtration in North Europe
- 15 years experience filtration, molecular, clean process, surface treatment, gas turbine, dust collector
- Enjoys cooking and a good gin & tonic
- Swedish



AGENDA

How does molecular filtration work?

- Standards
- Testing
- Dimensioning



HOW DOES MOLECULAR FILTRATION WORK?



PHYSICAL ADSORPTION

The



CHEMICAL ADSORPTION



ADSORPTION PRINCIPLE



STANDARDS RELATED TO MOLECULAR FILTRATION PERFORMANCE

ISO 10121: 2014

Test method for assessing the performance of gas-phase air cleaning media and devices for general ventilation.

Parts 1 and 2

Media and full size filter testing, application realistic concentrations, many different challenge gases.

ASHRAE 145: 2015

Laboratory Test Method for Assessing the Performance of Gas-Phase Air Cleaning Systems: Loose Granular Media.

Parts 1 and 2

Media and full size filter testing, application realistic concentrations, many different challenge gases.

ASTM D6646 (2014)

BATTERY BUSINESS EVENT

Standard Test Method for Determination of the Accelerated Hydrogen Sulfide Breakthrough Capacity of Granular and Pelletized Activated Carbon.

Media only testing, artificial test conditions (highly accelerated)



Not representative of real-world conditions.



ASSESSING MOLECULAR FILTER PERFORMANCES

Part 1 = Media performance testing Part 2 = Filter performance testing



- Laboratory method
- Define conditions (Flow rate, Temperature)
- Challenge filter with test gas.
- Measure upstream and downstream conditions
- Produce efficiency / lifetime curve

ISO10121 is the preferred standard

- Globally applicable
- More flexible test method



VIDEO – MOLECULAR LABORATUR



MOLECULAR FILTRATION TEST RIGS



MOLECULAR FILTRATION TEST RIGS

MOLECULAR CONTAMINATION CONTROL LIFETIME DETERMINATION SOFTWARE

The most powerful tool ever developed for molecular filtration system design - All test data are added into this software

	☑ Ethyl methyl Carbonate (EMC) [100 ppb]	Filter : HDC panel : LGS048	Ø×	Number of filters 10 Airflow: 2 600 m³/h Number of stages 1 stage 2 stages 3 stages
T M	Ethyl methyl Carbonate (EMC) 100 ppb 0,428 mg/m ³ S Collapse		Efficiency,[%] 99,99	Life Time Hours,[hours] 12 997
			99,9	15 543
			99	18 097
	Chemical Formula Vapour Pressure	C4H8O3 3,6 kPa	95	19 921
	Molecular Weight	104,1 g/mol	90	20 747
	Boiling Point CAS No	107 ℃ 623-53-0	80	21 643
			70	22 238
Molecular Contamination Control Lifelime			60	22 727
Determination			50	23 174
			40	23 622
			30	24 111
Welcome to the Camfil's MCCLD Software.			20	24 706
			10	25 602

BATTERY BUSINESS EVENT

13

Customer Info	Site Info	Contamination	Solutions	Results	Report Generation	<pre> Previous Next > </pre>
						🏚 Program Setting
Operating Conditions						
Air Flow	2 600	m³/h				
Temperature	23	°C				
Relative Humidity	50 %					
Contamination 🛨						
Application AL	L					
Contraction 1						

MCCLD SIMULATION TOOL

Scientific literature Data from ISO 10121 Feedback from actual MCC installations

MCCLD software Unique tool Air flow / [Contaminant] Filter / media / number

Initial efficiencies / evolution of efficiencies Lifetime estimation

MCCLD EXAMPLE – CARBONATES FROM FILLING STATION

Air stream				
2996 m ³ /h				
12400 m ³ /h				

[Carbonate] 120 mg/m³

DMC/EMC/EC 50/30/20

	2021 01 0018					
Customer	site information	Report prepared by				
Company		Company Camfil SAS				
Contact		Contact Fabrice Morvan				
Phone		Phone +337 84 56 33 10				
Email		Mobile				
Address		Fax				
		Email Fabrice.Morvan@camfil.com				
		Date 2021-Apr-29				
GENERAL						
	<u>ا</u> (ش))))))) (***			
Filter Group	ProCarb	ProCarb	ProCarb			
Filter Type	HDB5100	HDB5100	HDB5100			
Media	LGS048	LGS048	LGS048			
COMPARISON OF AIR						
Air Flow. [m³/h]	3996	3996	3996			
Temperature, [°C]	23	23	23			
Atm. Pressure, [hPa]	1013	1013	1013			
Relative Humidity [%]	50	50	50			
Concentration	120 mg/m ³ [32371,615 ppb]	120 mg/m3 [28011,864 ppb]	120 mg/m³ [33136,762 ppb			
COMPARISON OF CHEMICAL						
Contamination	Others	Others	Others			
Chemical Formula	CO3(CH3)2	C4H8O3	C3H4O3			
Molecular Weight, [g/mol]	90,08	104,1	88			
Boiling Point, [°C]	90,5	107	248			
Vapour Pressure, [kPa]	7,2 [52.50 mm hg]	1,733 [15.00 mm hg]	0,002 [0.01 mm hg]			
CAS No						
COMPARISON OF SOLUTION						
No of filters per stage	3 (Total filters : 3)	3 (Total filters : 3)	3 (Total filters : 3)			
Total Filter Stage	1	1	1			
Eff. Media Weight, [kg]	5179,05	5179,05	5179,05			
Total Weight, [kg]	7117,05	7117,05	7117,05			
Front Velocity, [m/s]	0,09	0,09	0,09			
Pressure Drop, [Pa]	143	143	143			
Contact Time, [sec]	9,15	9,15	9,15			

≪camfil CLD Comparison Report 2021 04 Carbonate filtration Customer site information Report prepared by Company Camfil SAS Company Fabrice Morvan Contact Contact +337 84 56 33 10 Phone Phone Email Mobile Address Fax Email Fabrice.Morvan@camfil.com

2021-Apr-29

Efficiency vs LifeTime Table

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Filter Group	ProCarb		Pro	Carb	ProCarb		
Filter Type	HDB5100		HD	B5100	HDB5100		
Media	LGS048		LG	S048	LGS048		
	Efficiency, [%]	LifeTime, [Hours]	Efficiency, [%]	LifeTime, [Hours]	Efficiency, [%]	LifeTime, [Hours]	
	99,99	1587	99,99	2412	99,99	4730	
	99,9	1621	99,9	2454	99,9	4789	
	99	1655	99	2495	99	4849	
	95	1679	95	2525	95	4891	
	90	1690	90	2538	90	4910	
	80	1702	80	2553	80	4931	
	70	1710	70	2563	70	4945	
	60	1716	60	2571	60	4956	
	50	1722	50	2578	50	4966	
	40	1728	40	2585	40	4977	
	30	1735	30	2593	30	4988	
	20	1743	20	2603	20	5002	
	10	1755	10	2617	10	5023	

Date

LifeTime Estimation - Graph

Page 2/2

HOW ARE THE MOLECULAR FILTER PERFORMANCE SPECIFIED BASED ON THE TEST RESULTS?

ISO 10121

- ISO 10121 test conditions are closely reflective of actual operating conditions of 5-100 ppm of H2S and other molecules.
- Provides performance curve over time at controlled RH and temperature conditions.
- Sizing of the molecular filtration system is based on various factors such as filter design, contact time and removal efficiency of the adsorbent over a period of time.

ASTM D6646

- ASTM D6646 test provides %wt/wt adsorption capacity of adsorbents with a "failure point" of 99.5%.
- Provides one capacity value in g/cc.
- Sizing of the molecular filtration system is solely based on the weight of media required to remove the targeted contaminant.

ISO 10121-1

Variable (0.1 - 0.2s, 0.2 - 0.8s)

Max 100 ppm (5 – 10 pm, 90-230 ppm)

Variable RH (50% ±3%) Variable T (23 °C ± 0,5 °C)

Various: SO2, NO2, H2S, NH3, Toluene, IPA, etc.

Various (pellet, granular, 3 dimensional, flat-sheet)

ASTM D6646-03

4.8s 10,000 ppm 80% T 25oC ± 2 H_2S <2.6* mm pellet and

granular. (*Larger media size require different set-up)

WHERE ARE THE MOLECULAR FILTERS?

BATTERY PRODUCTION

Electrode material production & deposition

NMP N-Methyl Pyrrolidon

> Danger Irritation

Damage to unborn child Potential human reproductive hazard

Typical concentrations 20-120 mg/m3

 CH_3

BATTERY PRODUCTION

PROCARB SOLUTIONS FOR BATTERY PRODUCTION

CONSIDERATIONS

- Air Flow
- Contaminant
 concentrations
- Expected lifetime
- Available space
- Ease of maintenance

ProCarb HDB

- "Low" air flows
- Very high efficiency
- Long lifetime
- Quite compact
- Easy Maintenance

ProCarb VDBe

- Low pressure drop "Large" air flows
- High efficiency
- Long lifetime
- Large footprint needed
- Less easy maintenance

ProCarb HDC

- Wide range of air flows
- High efficiency in double stage configuration
- Reasonable lifetime
- Limited footprint needed
- Very easy maintenance

RE-CIRCULATION OF CLEAN AND DRY AIR & MOBILE SOLUTIONS

TAKE CONTROL IN BATTERY PRODUCTION

CLEAN ENVIRONMENT

Ensure high end filtration

DRY CONDITIONS

Lithium is highly reactive to moisture until covered (not all factory must be super dry), contact with moisture reduced the final product performance.

MOISTURE CONTROL

By maintaining controlled humidity levels, dehumidifiers help prevent moisture absorption by battery materials, such as electrodes and electrolytes. This ensures consistent performance and extends the longevity of the battery cells.

NO CORROSION

Removal of VOC's and other harmful molecules.

CONTAMINANT MITIGATION

Dehumidifiers also help minimize the risk of contamination during assembly. By reducing airborne particulates, dust, and pollutants, they create a clean and controlled environment for precise cell production.

ENERGY CONSUMPTION

Up to 43% of total energy consumption in the battery manufacturing process is used to keep the dry rooms super dry — that's a relative humidity of below 1% and dew points ranging from -40°C to -120°C.

Dry rooms Drying Notching Stacking Final sealing Other

81%

from raw material / mining etc.

19%

from production.

NEW EU LAW

SUSTAINABLE BATTERY LAW, IT'S THE RIGHT THING TO DO

New EU law Includes a framework for sustainable raw materials. production and recycling.

Proposed dates of implementation from the European Commission (EC) and European Parliament Environment Committee (EP):

- 1. Carbon Footprint declaration requirements: From July 1, 2024 (EP) and (EC)
- 2. Carbon footprint performance class labels: From July 1, 2025 (EP) and Jan 1, 2026 (EC)
- 3. Ban on the worst-performing batteries: From January 1, 2027 (EP) and July 1, 2027 (EC)

Source: https://www.europarl.europa.eu/news/en/pressroom/20220202IPR22435/meps-want-to-strengthen-new-eu-rules-forbatteries RAW MATERIALS

- BATTERY PRODUCTION
- BATTERY RECYCLING

NEW EU LAW

ENERGY CONSUMPTION IN GIGA FACTORY BATTERY PROD.

Note: Less than 1% r.H. is very tough to maintain, gas pressure is a greater force than air velocity.

Re-Circulation of Dry air from Clean Room

₹camfil

UDDER IN ARTITIKATION SINCE 1963 WWW CARFL COM PROCARB MOLECULAR FILTRATION UNIT

> Installed in Thailand and Norway

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BATTERY TESTING

CHALLENGING CONDITIONS

Mechanical stress Electrical stress Thermal stress **TEMPERATURE INCREASE** Solvent evaporation Carbonates

> Exhaust air treatment Environmental legislation Few hours/day or week

Moderate duty CamCarb or ProCarb solutions **FIRE SETTING** VOC emission Acids emission (HF / HCI)

Particles emission

MCC SOLUTIONS FOR BATTERY TESTING

CONSIDERATIONS

- Air Flow
- Temperature
- Contaminant
 concentrations
- Expected lifetime
- Available space
- Ease of maintenance

CamCube / CamCarb CM /CamCarb XG

- Limited air flows (might be increased by air bleed)
- 2-stage configuration needed (Acids / VOCs)
- Prefiltration is key
- Reasonable lifetime
- Limited footprint needed
- Very easy maintenance

ProCarb HDC

- Wide range of air flows
- High efficiency in double stage configuration (VOC / Acids)
- Longer lifetime
- Larger footprint needed
- Very easy maintenance

QUESTIONS