

E-MOBILITY PROCESS AND CHALLENGES





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AIR POLLUTION CONTROL SALES DIRECTOR Camfil EMEA

- Sales Director in EMEA Region for dust, fume and mist extraction
- Member of E-mobility focus segment task force
- Over 15 years experience in Dust collector business, first as key component supplier and then with Camfil
- World cultures lover, travel enthusiast, passionate about technology



TAILORED CLEAN AIR SOLUTIONS

- The growth of electric vehicles is driving demand for lithium-ion batteries necessitating clean air
- Large demand for clean air to:
 - Maintain high quality standards
 - Protect operators and the environment from harmful pollutants.
- The diverse air filtration requirements of gigafactories call for a combination of different air filtration disciplines.
- This Industry requires competitiveness through the lowest possible operating costs without compromising on operational safety.
- Camfil, with its decades of experience in almost all industries, is ready to accompany you on this journey.



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EV BATTERY VALUE CHAIN & FILTRATION REQUIREMENTS



Filtration requirements : High req

High requirements

Medium requirements

None or minimal



PROCESSES & CHALLENGES



Clean air concern in battery cell manufacturing:

 Clean air to protect process and products











CLEAN AIR TO PROTECT PROCESS AND PRODUCTS THE PRODUCT QUALITY IS IMPACTED FROM THE PRODUCTION ENVIRONMENT

Why is "clean" so important?

- Safety concerns include inorganic and organic particles, chemicals, and gases.
- The current challenge is perceived as particles above 1 micron.
- Submicron and nano-sized particles are also crucial, given the evolving chemistries and increasing power densities.
- These particles can compromise product quality, personnel safety, and risk cross contamination.

Why is "dry" so important? 🚫 🍐

- Moisture reacts with lithium in batteries, causing an explosive exothermic reaction.
- This reaction produces soluble lithium hydroxide and flammable hydrogen gas.
- Even minimal moisture can cause corrosion in battery manufacturing, affecting components and equipment.

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AIR RECIRCULATION AND ENERGY SAVINGS: MANDATORY TO REDUCE OPEX - BUT CHALLENGING

Energy costs for production environmental control significantly affect manufacturing expenses. An efficient, less energy-intensive air filtration system that recirculates the dry and already conditioned air can reduce these costs.

- To obtain the required clean and safe level of air quality that allows recirculation, generated dust need to be captured at the source by properly designed capture solutions.
- Multiple filtration layers including dust collectors, HEPA filtration and molecular filtration units are key.
- To achieve the best results, an optimal interaction of the extraction system with the often individually developed battery production equipment is key.



Contaminated Process Air

Camfil can help to validate your process and machinery, so that the extraction and recirculation system fulfills or even outperforms local legislation and HSE regulations.



CLEAN AIR FOR PROTECTING ENVIRONMENT EMISSIONS: PARTICULATE CONTAMINANTS & VOC

- The selection of appropriate filtration technologies such as HEPA filters, dust collectors or molecular filtration solutions is fundamental.
- Effective control of particulate and VOC emissions is also essential for minimizing environmental pollution and protecting public health.
- It is essential to consider multiple filtration stages.
 - **Prefiltration** to eliminate large particles and extend HEPA filter life.
 - Post-filtration stages effectively remove smallest particles and gases prior exhausting or recirculation of the air.
- Continuous monitoring and adherence to regulatory standards_are also vital to ensure that emission control measures are both effective and sustainable.





CLEAN AIR TO CREATE SAFE WORKING ENVIRONMENTS PROTECTING PERSONNEL FROM TOXIC EMISSION AND EXPLOSION



FIRE AND EXPLOSION PROPERTIES

Most of handled dust mixture are explosive, ST1 Class.

Dry atmosphere need to be considered as sparks facilitators

CLEAN AIR TO CREATE SAFE WORKING ENVIRONMENTS PROTECTING PERSONNEL FROM TOXIC EMISSION AND EXPLOSION





- Managing **toxic dust** is crucial, especially with hazardous materials which have strict exposure limits.
- Employers must be aware of these limits and enforce measures to safeguard workers and the environment.
- Under the **ATEX-directive**, employers must assess risks to implement adequate fire and explosion safeguards.



CLEAN AIR TO CREATE SAFE WORKING ENVIRONMENTS OCCUPATIONAL EXPOSURE

Regular exposure to certain types of fine dust particles can:

- Produce minor allergic reactions on the skin such as dermatitis.
- Cause life-threatening conditions such as occupational asthma as well as chronic, long-term health issues including lung cancer.
- Battery may include hazardous chemistries including carcinogenic substances such as cobalt
- Industry employers are required to protect workers from exposure.







ADEQUATE FIRE AND EXPLOSION SAFEGUARDS WHAT IS A DUST EXPLOSION?

- When a combustible substance is dispersed as a fine dust cloud, the surface exposed to the air is increased 1,000's of times.
- If the dust is **ignited**, it will burn at a very high speed due to the large contact surface with the air.
- This high **combustion velocity** will release a lot of energy that generates a rapid increase of temperature and pressure. Shock waves are formed.
- This is also called the **primary explosion**.
- The pressure and flame from the explosion is managed in the dust collector by for example an explosion vent, but they will also travel back through the extraction system causing a very dangerous secondary explosion.



DUST COLLECTORS CAN EXPLODE



A dust collector is an enclosed vessel with four of five components required for an explosion.



ADEQUATE FIRE AND EXPLOSION SAFEGUARDS COMMON IGNITION SOURCES

- Mechanical sparks (grinding, impact) 26.2%
- The untrained maintenance guy, mistakes, **unknown** 24.4%
- Static electricity from none conductors
- Static electricity from conductors such as metal parts and antistatic bags
- Total for static electricity 8.7%
- Fire (accidental or from hot work) 7.8%
- Hot surfaces (motors, bearings) 4.9%
- Self ignition (organic material, some metals) 4.9%
 - > Human error is very common and hard to prevent by technical means.
 - > Protection against these consequences are almost always required!





WHAT WE SEE IN THE FIELD



What we see:

- Limited knowledge of air extraction in this application
- This is not microelectronics nor pharmaceutical
- Low maintenance practices
- Incomplete regulatory understandings regarding ATEX
- Commercially driven lowest CAPEX vs lowest TCO



What happens:

- Delay in project execution
- Production disruptions
- Brand damages
- Unpredicted costs
- Problem with local authorities



What we recommend:

- Training of operators
- Consolidating of suppliers
- Working with recognized experts
- Focus on lowest TCO



WHAT TO CONSIDER WHEN PLANNING THE FILTRATION



WHAT TO CONSIDER WHEN PLANNING THE FILTRATION: CLEAN AND DRY ROOM COMMON REQUIREMENT.

Electrodes Electrolyte Slurry Cell Coating Calendering Mixing Stacking Filling Cutting 000 Clean Room Classes Min 7, Temperature $22 \pm 2^{\circ}C$ Clean Room Classes: ISO 7-8, Temperature 22 ±2°C. Dew Point: -30°C to -60°C (dry to very dry) Dew Point: 5°C to -30°C depending on Technologies (dry to semi dry)





WHAT TO CONSIDER WHEN PLANNING THE FILTRATION: SUPPLY AIR: FILTERS FOR AHU'S AND DHU'S

In battery cell production, dry cleanrooms and process machinery require a significant amount of supply air to maintain safe and clean conditions.

PRE-FILTER

- Pre-filters are essential for
 - separating dust
 - extending HEPA filter life
 - reducing ventilation system costs, thus improving economic efficiency.

HEPA FILTER

- Box-format designed HEPA filters for high air volumes are also used directly in air conditioning and dehumidification systems.
- Their design should be energy-efficient and easy to maintain.
- Box-type HEPA filters not only protect downstream filter stages but can also be the final filter stage, depending on the air purity requirements.
- These filters can also be used in room exhaust air, separating harmful, ultra-fine particles.

Filters selection criteria's:

- Filter efficiency
- Dust holding capacity
- Energy use (TCO)
- Easy maintenance





WHAT TO CONSIDER WHEN PLANNING THE FILTRATION: SUPPLY AIR: DRY-CLEAN ROOM SOLUTIONS

- Determine cleanroom air supply requirements with an inside-out approach.
- Derive air cleanliness classes and volumes from process target requirements.
- Use Filter Fan Units (FFUs) for active air supply and terminal filter housings for passive control. Select technology based on space, airflow, and flexibility needs.
- Employ efficient Air Filters for pre-filtration in the air handling units and efficient HEPA/ULPA filter elements for particle removal to the extend filter life-time.

TCO aspects should be always considered in the design and section of systems.





WHAT TO CONSIDER WHEN PLANNING THE FILTRATION: EXHAUST AIR



Extraction of metal, carbon, fiber and fine dust, laser fumes











WHAT TO CONSIDER WHEN PLANNING THE FILTRATION: EXHAUST AIR, AIR FILTRATION OR DUST EXTRACTION

- Hazardous substances in cleanrooms should be controlled and collected <u>at their source</u>
- Extraction at the processes and the ventilation of the cleanroom must therefore be coordinated.
- The objective is
 - Prevent health and environmental hazards.
 - Prevent fire and explosion hazards.
 - Ensure product quality.
 - Optimal solution for **Total Cost of Ownership (TCO)**.

It is advisable to differentiate between air filtration and dust extraction for CAPEX and OPEX reasons when deciding on the exhaust air solution.



WHAT TO CONSIDER WHEN PLANNING THE FILTRATION: EXHAUST AIR LOW CONCENTRATIONS, STATIC NON-CLEANABLE FILTERS

At low particle concentrations, static filtration solutions provide efficient, safe filtration and avoid unnecessary investments.

- The CamSafe 2 safety housing with <u>Bag-In Bag-Out system</u> is a proven solution for safety housings, specifically adapted to the requirements of battery cell manufacturing.
- This housing ensures reliable operation, safe filter changes, and is available with an electrostatic certificate.
- <u>Wall-mounted exhaust housings</u> are the ideal solution for cleaning exhaust air from cleanrooms prior to re-entry into the cleanroom. Available with recommended test probes for HEPA filter validation, ensuring robustness and energy efficiency.





WHAT TO CONSIDER WHEN PLANNING THE FILTRATION: EXHAUST AIR LOW CONCENTRATIONS, STATIC NON-CLEANABLE FILTERS





WHAT TO CONSIDER WHEN PLANNING THE FILTRATION: EXHAUST AIR HIGH CONCENTRATIONS, INDUSTRIAL DUST EXTRACTION

- Dust collectors are the best option for reducing total cost of ownership when particulate concentrations are too high for non-cleanable filters.
- There's a simple rule of thumb: "If the dust load is at or above 0.1 mg/m³, a dust collection system with pulse- cleaned filter elements will probably be the best option to handle the process dust as first filtration stage, providing a reasonable filter life."





EXHAUST AIR: HIGH CONCENTRATIONS DUST EXTRACTION SOLUTIONS

DRIVING DOWN THE OVERALL COST OF DUST COLLECTION

- ✓ Optimal air tightness class D: meet class "D" according to EN12237/ EN1507 and ensure minimal level of humidity is reintroduced into the process during air recirculation.
- ✓ Market leading safe change filter function. Uses BIBO (Bag-In Bag-Out) methodology.
- Continuous bin liner for safe bin bag change Tested up to OEB 5
- ✓ Provides production and maintenance personnel with the easiest and safest operation available.
- ✓ Modular Camsafe HEPA housing with BiBo Feature.
- ✓ Energy Efficient :
 - Pulse system uses less compressed air
 - ✓ Gold Cone filters reduce filter usage
 - VSD driven fan motors.
- ✓ Designed, tested and certified to NFPA & ATEX standards
- ✓ Modular Design adaptable to specific airflow

FULL CONTAINMENT Gold Series Camtain Camsafe 2 HEPA housing

Market leader for safe change filter function.



NO CONTAINMENT Gold Series X-Flow Integrated ISMF HEPA Filter

Reduced footprint with Int. ISMF HEPA Filter





WHAT TO CONSIDER WHEN PLANNING THE FILTRATION: MOLECULAR FILTRATION FOR VOC EMISSION SOLUTIONS

Electrodes Electrolyte **Slurry Mixing** Coating Calendering Cell Stacking Filling Cutting TOP VIEW Typical solutions for Typical solutions for Premises NMP VOC / HF CamCarb Cylinders CamCarb Cylinders Laboratory **ProCarb HDC** ProCarb HDC ProCarb HDC ProCarb HDC **Pilot plant** ProCarb HDB ProCarb HDB NMP recovery systems ProCarb VDB Gigafactory ProCarb HDB Mobile filtration solution Carbon supply

WHAT TO CONSIDER WHEN PLANNING THE FILTRATION: MOLECULAR FILTRATION FOR VOC EMISSION SOLUTIONS

- Throughout the battery manufacturing process, there are numerous molecular contaminants (i.e. gases or vapours) that are emitted, affecting health, processes and the environment.
 - N-Methyl Pyrrolidone (NMP), used in cathode material production, poses health risks.
 - Alkyl carbonate solvents in electrolytes, like DMC, DEC, EMC, harm the environment.
 - Ozone and Nitrogen Oxides from welding can impact worker health and corrode equipment.
- Molecular filtration <u>adsorption methods</u> like physisorption or chemisorption, are key for industrial air purification.
 - This technology is versatile, fitting various media, sizes, and designs, suitable for battery labs to Gigafactories.
 - Activated or impregnated carbon filters are industry and authorities approved for effectively cleaning air.

The ability to reuse very dry air after "cleaning" it with a molecular filter is a way to make the <u>entire</u> battery production process more <u>cost effective</u> by reducing the amount of dry air that needs to be produced.





WHAT CAMFIL CAN OFFER



Make use of our expertise to determine the right filtration solution for your process:



✓ Design Consultation



✓ Clean Air Solutions



✓ Service & Maintenance



✓ Replacement Filters



LEADING THE WAY IN CLEAN AIR TECHNOLOGY



IAQ LAB

HEPA LAB



MOLECULAR LAB



DUST LAB



PROJECTS



GIGAFATORY – EUROPE

Scope of Supply : 12 GSX Dust collector, 50 fans and accessories.

Application : Dust extraction & recirculation from battery cell production machineries. Most of these processes are performed in clean and dry rooms

Key to success :

Camfil was selected considering our wide product range, Technical supports, close collaboration with Engineering consultant and Application Knowledge.

Process	Dust Type		Explosive Dust	Recirculation	Camfil Solution
Slurry mixing Anode	SiOx, Graphite, DI-water, CNT dispersion, SBR		Yes	yes	GSX08P ISMF (x2)
Slurry mixing Cathode	NPM, Nickel, Manganese, Cobalt Oxide		Yes	No	GSX10
Calendering, Notching Anode	Copper, SiOx, Graphite	36840	No	No	GSX24
Notching welding.	Alluminum, Nickel, Manganese, Cobalt	6900	No	No	GSX04
Calendering, Notching Cathode	Alluminum, Nickel, Manganese, Cobalt	61840	Yes	Yes	GSX40 ISMF
Cell assembly welding	Alluminum, Copper, SiOx, Nickel, Manganese, Cobalt	22000	Yes	No	GSX16SQ GSX08P (x2)
Cell assembly	Alluminum, Copper, Nickel, Manganese, Cobalt	174720	Yes	Yes	GSX60 (x2) GSX12S
Stacking dust collection	Alluminum, Copper, Nickel, Manganese, Cobalt	115200	Yes	Yes	GSX72 ISMF GSX12S (x6) ISMF
Stacking low-pres vacuum	Alluminum, Copper, Nickel, Manganese, Cobalt	115200	Yes	Yes	GSX72 ISMF
Stacking dust collection	Alluminum, Copper, Nickel, Manganese, Cobalt	115200	Yes	Yes	GSX72 ISMF





GIGAFATORY – EUROPE

Scope of Supply : 135 units of our CamSafe ; APC 6 x MF Dust collectors; MCC Procarb Molecular Filtration Units.

Application: Extraction and filtration solutions for the entire downstream of their battery cell production line, starting from the slurry mixing process up to the cell assembly. Most of these processes are performed in clean and dry rooms

Key to success :

- ✓ Early Involvement in design,
- ✓ Collaboration with Contractor and Final User
- ✓ Step by step solution development with all stakeholders involved.



QUESTIONS