



# CORROSION CONTROL



Clean air solutions

# CORROSION CONTROL

## SENSITIVE ELECTRONICS

Automation is used in manufacturing businesses around the world. Many industries are completely reliant on electronic and electrical control equipment for the safe and efficient operation of complex and valuable manufacturing processes. In certain heavy industries, the external air around the facility is likely to be contaminated with acidic gases.

These gases originate from the raw materials used in the process or chemicals added to the process. The industries where these gases are most prevalent are; oil and gas, pulp and paper, mining and metal refining and waste water treatment.

At oil and gas facilities, the acidic gases arise from sulphur impurities present in crude oil. At pulp and paper facilities, the contaminants arise from chemicals used to digest and bleach wood and other cellulose based materials for the pulp making process.

Examples of acidic gases include hydrogen sulphide ( $H_2S$ ), sulphur dioxide and trioxide ( $SO_2$ ,  $SO_3$ ), chlorine ( $Cl_2$ ), nitrogen

dioxide ( $NO_2$ ) and hydrogen fluoride (HF). All of these gases are corrosive towards electronic and electrical control equipment.

If steps are not taken to protect the control assets then the likely consequence will be unscheduled breakdown caused by equipment failure. Process downtime is expensive and erodes profit and maintenance budgets.

The degradation of electrical control equipment by corrosive gases is a well-known effect. In fact, virtually all manufacturers of sensitive electronic/electrical equipment specify the required environmental conditions for their equipment as part of the warranty conditions. These specifications set limits for temperature, relative humidity and chemical contaminants as they all influence the rate of corrosion.

Many individual electronic components are afforded some protection from corrosive agents due to the fact they are encapsulated inside an airtight plastic or resin body. The components that are

most susceptible to damage are printed circuit boards (PCBs), exposed contacts and conductors.

There are several established techniques for PCB production. They differ in terms of cost, surface flatness, shelf life and corrosion resistance. The method that is gaining most popularity following the introduction of RoHS legislation (restriction of hazardous substances) which required the elimination of lead from solder is "Immersion Silver" (iAg or IM Ag). In this method, the copper tracks on the PCB are coated with a thin layer of silver (< 0.25 microns) prior to adding the on-board components. However, the exposed edges of the copper sub-track and the silver coating are susceptible to corrosion.

Molecular filtration using adsorption techniques is the industry accepted method to remove the corrosive agents from the air.

## ISA classification of reactive environments (ANSI/ISA 71.04-2013)

COPPER REACTIVITY LEVELS (Å/month)		G1 (MILD)	G2 (MODERATE)	G3 (HARSH)	GX (SEVERE)
		< 300	< 1,000	< 2,000	> 2,000
GROUP	GAS	GAS CONCENTRATION (parts per billion)			
A	Hydrogen sulfide (H <sub>2</sub> S)	< 3	< 10	< 50	50
	Sulfur dioxide (SO <sub>2</sub> )	< 10	< 100	< 300	300
	Sulfur trioxide (SO <sub>3</sub> )				
	Chlorine (Cl <sub>2</sub> )	< 1	< 2	< 10	10
	Nitrogen oxides (NO <sub>x</sub> )	< 50	< 125	< 1,250	1,250
B	Hydrogen fluoride (HF)	< 1	< 2	< 10	10
	Ammonia (NH <sub>3</sub> )	< 500	< 10,000	< 25,000	25,000
	Ozone (O <sub>3</sub> )	< 2	< 25	< 100	100

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# APPLICABLE STANDARDS FOR CORROSSION CONTROL

There are two commonly referenced standards that categorise environmental conditions in relation to the deployment and reliability of electronic equipment:

1. ANSI/ISA -71.04-2013.
2. IEC 60721-3-3

ANSI/ISA-71.04-2013 is the most popular and focusses on airborne contaminants and observed rates of corrosion for copper and silver metals. IEC 60721-3-3 categorises environmental conditions based on several parameters such as climatic conditions, biological and chemical contaminants and mechanical effects.

ANSI/ISA-71.04-2013 defines 4 classes of air quality that relate to different rates of reactivity or corrosion of copper and silver. These are; G1 Mild, G2 Moderate, G3 Harsh and GX Severe. Most original equipment manufacturers require provision of G1 Mild conditions

as part of their warranty conditions since the standard states for class G1 that “Corrosion is not a factor in determining equipment reliability”. The external ambient air at some heavy process industries will routinely be classified as GX Severe.

For reference, the standard tabulates concentrations of different gases that approximately correspond to the 4 categories of copper reactivity. It is worth noting that extremely low concentrations of some agents are required to achieve G1 Mild conditions. For example, at relative humidity = / < 50%, the concentration of hydrogen sulphide should be < 3 parts per billion (ppb) to achieve G1 conditions and the concentration only needs to rise to > 50 ppb for GX conditions to be achieved. It is known that external ambient levels of hydrogen sulphide in the air at some industrial facilities are likely to exceed 1 part per million (ppm).

Although the standard indicates concentrations of individual gases that loosely correspond to the 4 classes of corrosivity, these have to be treated with caution. If multiple gases are present in the air, then there may be a synergistic effect on the observed rate of corrosion that is difficult to quantify. As a consequence, on-site monitoring for a single or multiple gases may not in itself predict or explain corrosion of silver and copper.

The information above defines the requirement for effective molecular filtration. It can be readily understood that to reduce gas concentrations from ppm levels down to very low ppb levels will require very high efficiency molecular filtration and devices that are not compromised by internal leaks or bypasses.

# MOLECULAR FILTRATION SOLUTIONS OVERVIEW

Rooms where electrical and electronic control equipment are installed are ventilated with temperature and humidity conditioned air to achieve the environmental conditions required under the warranty conditions imposed by equipment manufacturers.

The supply or make-up air will be taken from an external location and in certain process industries that air may be heavily contaminated with harmful corrosive agents, e.g. acidic gases. If these gases are not removed before the air enters the room, then the control equipment will be susceptible to damage and ultimately failure due to corrosion.

The gases can be removed by molecular filtration. The gas concentrations in the inlet air may be high; perhaps tens of parts per million (ppm). However, the manufacturer's warranty terms require in-room gas concentrations in the very

low parts per billion (ppb) range. It is clear therefore that the filter must operate with very high efficiency on a one-pass basis.

The Camfil VDBs filter is specifically designed for this purpose. The make-up air, which may account for up to 40% of the total room ventilation rate is used to positively pressurise the control room to prevent the ingress of fugitive gases.

The level of pressurisation can be compromised by unnecessary opening of doors and windows, leaks due to construction defects and leaks at service entry points. To provide additional protection from fugitive gases, additional molecular filtration can be installed in the return / recirculation air system.

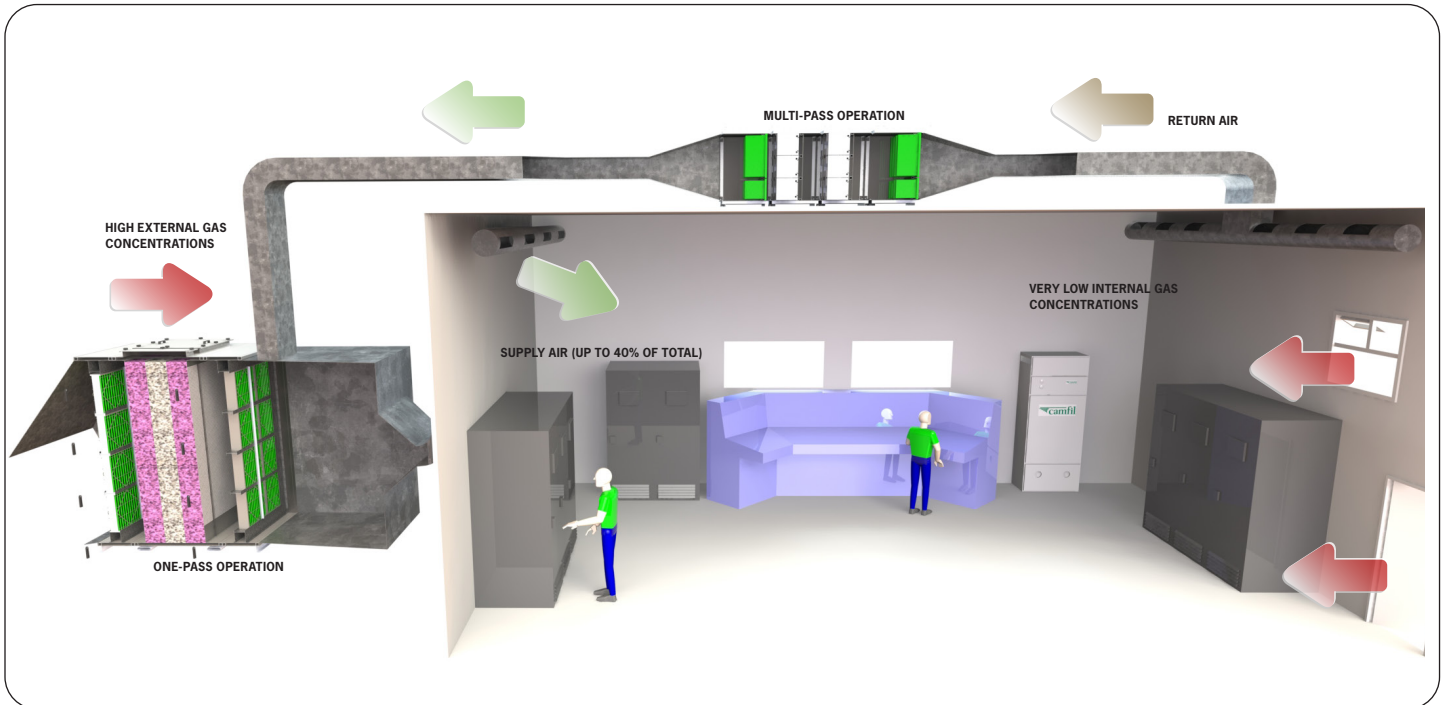
Concentrations of gases are much lower in the return air and a filter will operate on a multi-pass basis. A lighter duty filtration solution than that

used in the make-up air system will be appropriate. The Camfil PSSA housing fitted with CamCarb VG filter modules is intended for this specific application.

An alternative molecular filtration solution would use PSSA housings and Camcarb VG in both the supply and return air systems. The heavier duty VG300 modules should be selected for the supply air and lighter duty VG440 modules should be used in the return air.

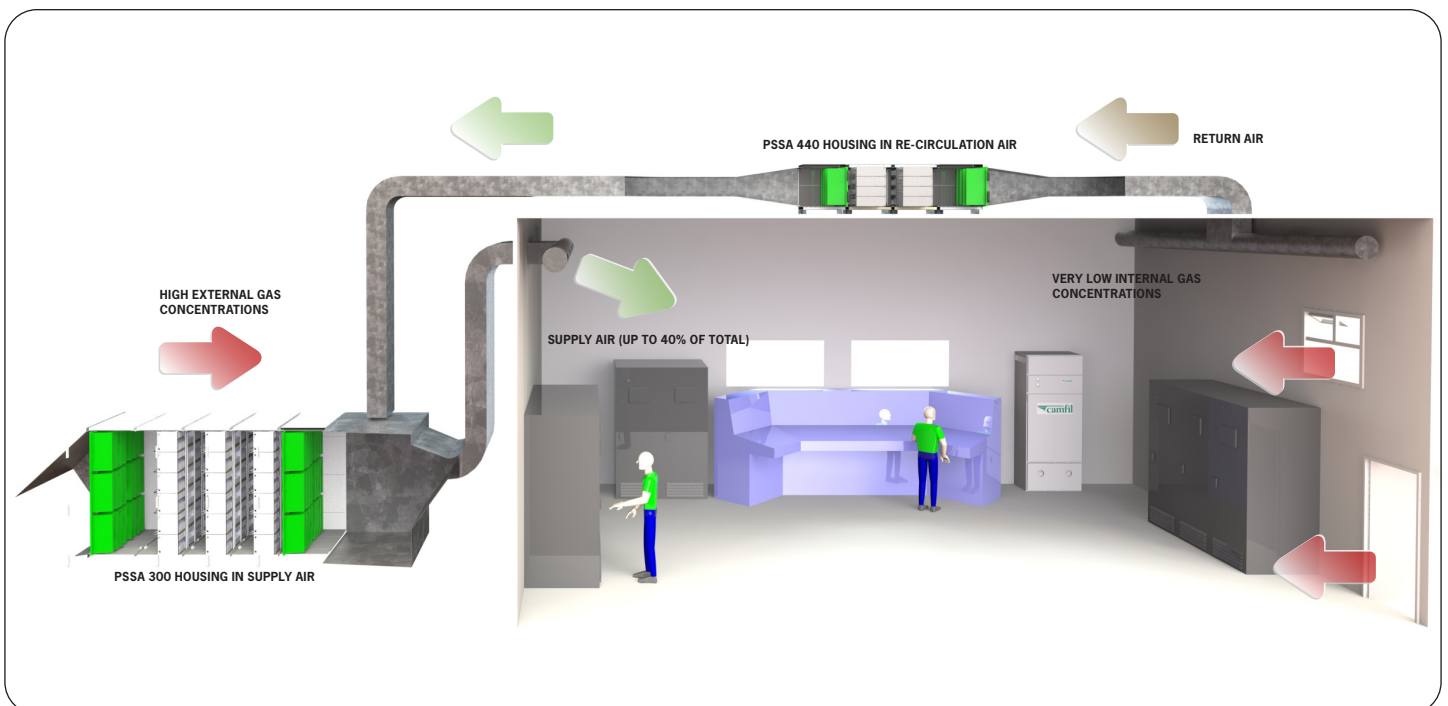
This methodology can be used when external gas concentrations are considered to be low to moderate or intermittent in nature. To handle multiple gases or to provide an acceptable lifetime, it might be necessary to use more than 1 stage of VG300 modules in the supply air.

# TYPICAL CONTROL ROOM VENTILATION AND FILTRATION SYSTEM



VDBs filter in supply air and PSSA housing with CamCarb VG modules in the return air.

# ALTERNATIVE CONTROL ROOM VENTILATION AND FILTRATION SYSTEM



Multi-stage PSSA housing with VG300 modules in supply air and PSSA housing with VG440 modules in the return air.

# PROCARB MOLECULAR FILTRATION SOLUTIONS

The Camfil ProCarb family of molecular filters are designed for industrial applications and provides...

*“The very highest levels of performance in those applications where plant reliability and elimination of corrosive gases,*

*toxic gases and odours is essential for operational security and regulatory compliance.”*

Inherently leak-free design and construction, the appropriate filter media and extended contact time ensure the

highest levels of removal efficiency and longest possible lifetime, even in single pass configurations handling high gas concentrations.

## PROCARB VERTICAL DEEP BED FILTER (VDBs)

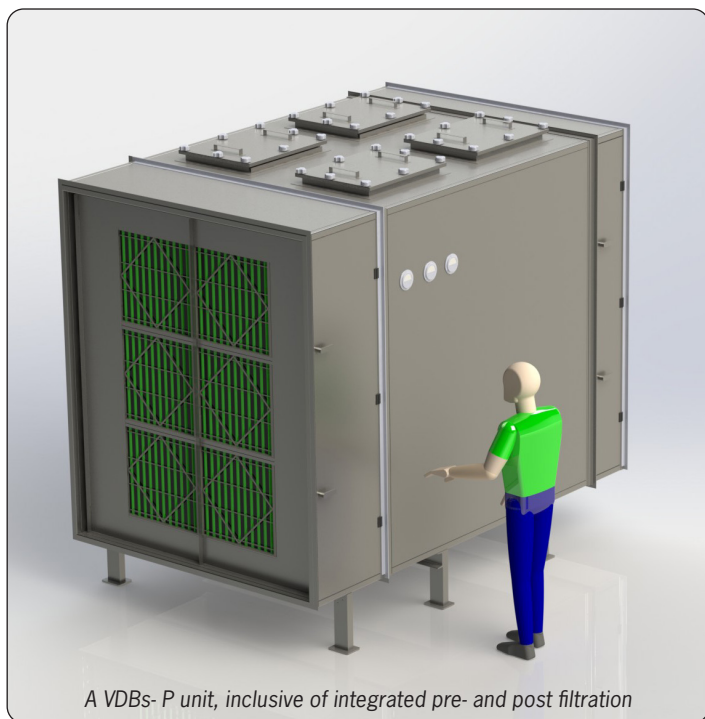
The VDBs filter is a robust solution for removing corrosive gases from supply (make-up) air systems with very high efficiency on a single pass basis. The filters contain vertical walls of molecular filtration media that are retained between perforated screens. The air passes horizontally through the filters.

A range of standard sizes accommodate flows from 1000 m<sup>3</sup>/h to 25,000 m<sup>3</sup>/h. Depending on the airflow, the filters may be configured with up to 3 separate media beds in series. This allows different medias to be combined in a layered configuration (not blended) to handle complex contaminant mixtures in the most cost-effective manner. Pre-and after-filters are easily incorporated in the filter housing to provide a total filtration solution in a single unit. VDBs filters are safe and simple to install. They are completely passive in operation and require little or no routine maintenance beyond changing the filters and media.

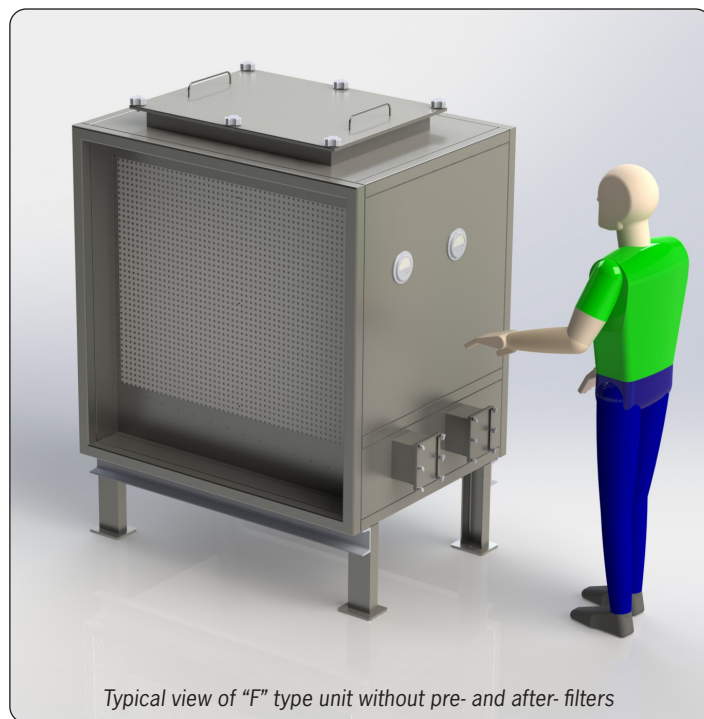
Fans and variable speed drives can be incorporated as options.



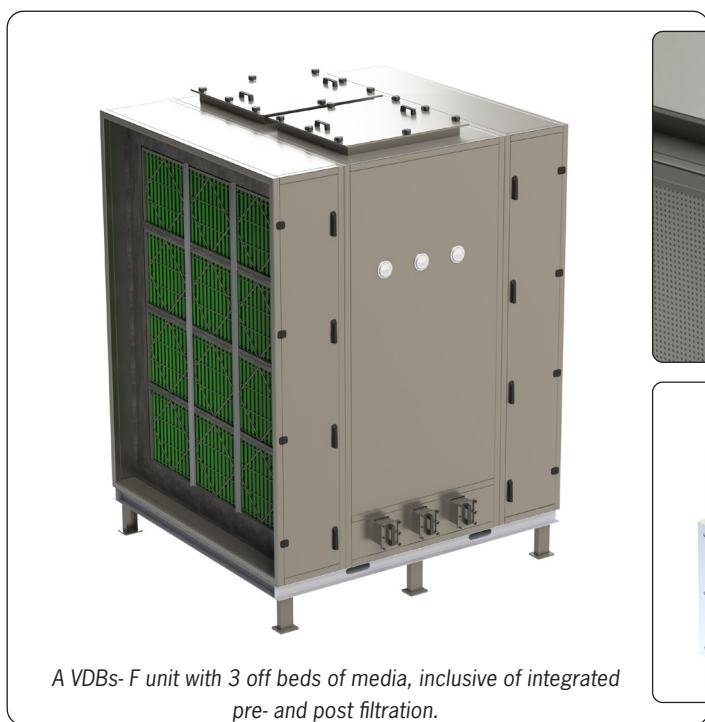
Procarb VDBs



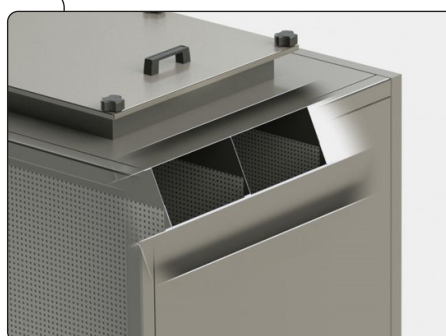
A VDBs- P unit, inclusive of integrated pre- and post filtration



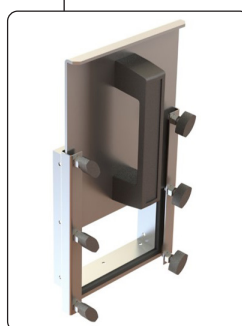
Typical view of "F" type unit without pre- and after-filters



A VDBs- F unit with 3 off beds of media, inclusive of integrated pre- and post filtration.



A VDBs- F unit showing a cut away of the unit with 2 media beds.



Slide-plate detail on VDBs-F. Plate is used to release and control flow of spent media during service procedure.

FEATURES	CUSTOMER BENEFITS
Long contact time to ensure optimum media usage and lifetime.	Lowest possible life cycle cost (LCC) and highest protection of production assets.
Inherently leak-free design.	Extremely high removal efficiency.
Integrated pre- and after-filters	Compact footprint and convenient installation of a single piece of equipment.
Double skin with insulation	Internal temperature control, and reduced risk of condensation
Multiple bed arrangement	Ability to target multiple gases utilising different media types
Media contact parts from 316 quality stainless steel.	Corrosion resistant and durable installation
Magnahelic pressure loss gauges for all filter stages	Easy to establish conditions of pre- and after- filters and filter media.

# PROCARB HORIZONTAL DEEP BED FILTER (HDB)

The HDB filter is a robust solution for removing corrosive gases from make-up air systems with very high efficiency on a single pass basis. The filters contain horizontal beds of molecular filtration media that are retained on top of a horizontal perforated screen.

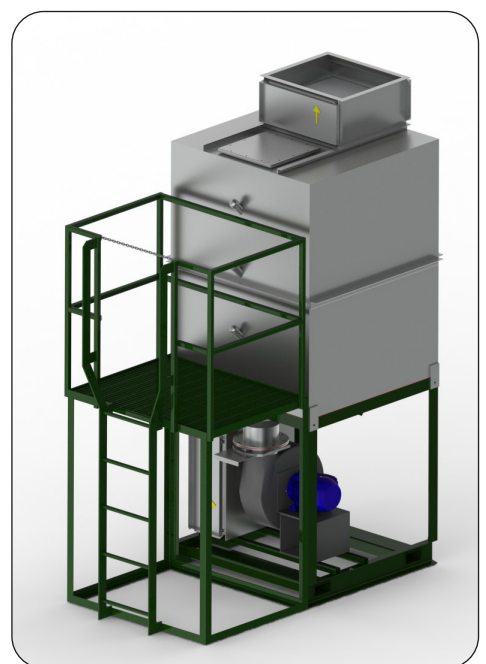
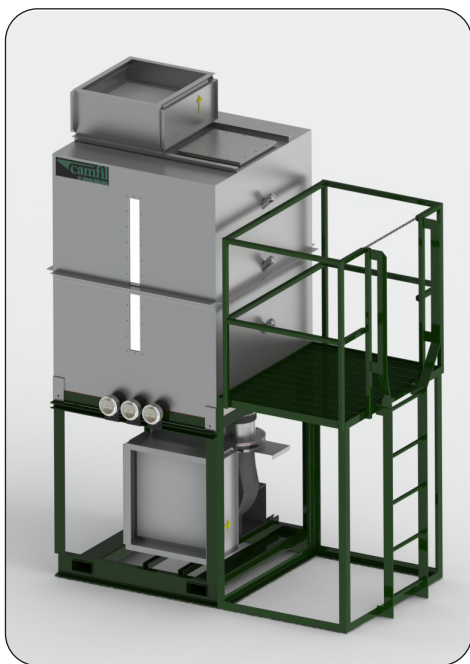
The air passes vertically through the media bed. The normal airflow direction is upward, but this arrangement can be reversed in some applications.

The filters utilise a very deep bed of media and they are particularly well suited to applications that combine low to moderate airflows and relatively high contaminant concentrations.

A range of standard sizes accommodate flows from 500 m<sup>3</sup>/h to 5,000 m<sup>3</sup>/h. Pre- and after-filters can be incorporated by the addition of bolt-on housing to provide a total filtration solution. HDB filters are safe and simple to install.

They are completely passive in operation and require little or no routine maintenance beyond changing the filters and media.

Fans and variable speed drives can be incorporated as options.



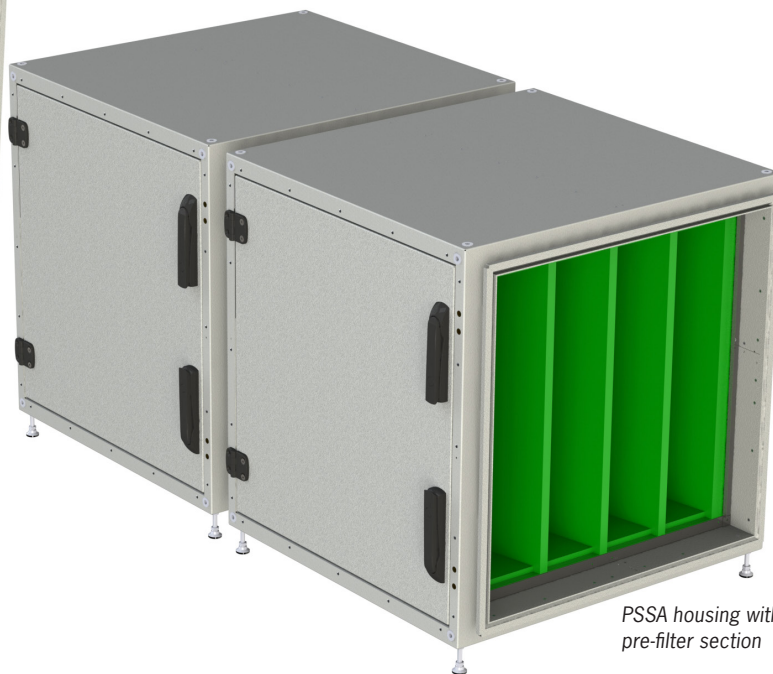
Various images of HDB filters showing: fan, access ladder and platform, Magnahelic gauges, pre- and after-filters, 3 media sampling ports and sight glass (for use with CamPure 4, 8, 9, 10 media).

FEATURES	BENEFITS
Very long contact time to optimise media usage and lifetime	Confidence in high level protection for downstream equipment / environment
Convenient gravity removal of spent media, easy to regulate media flow	No requirement for expensive vacuum equipment to change media
Can be used in conjunction with any filtration media (single or multiple layers)	Ability to target specific gas types
Air contact parts from 6061 T-6 aluminium or 316 grade stainless steel, depending on application	Corrosion resistant
Painted steel support frame	Robust support
Inherently leak-free design	Highly reliable performance
Media supported on 316 quality stainless steel screen	Corrosion resistant
Lifting points for fork lift truck	Simple and safe to install, operate and maintain
Compact rectangular footprint for minimal use of plant room space	Minimum requirement for concrete or steel foundation





PSSA housing containing CamCarb 440 VG units



PSSA housing with a pre-filter section

## POSITIVE SEAL SIDE ACCESS HOUSING (PSSA)

PSSA housings provide a high-integrity minimum leakage installation for CamCarb VG filter modules in applications where the protection of sensitive control equipment from corrosion caused by acidic gases is essential for the reliable operation of critical industrial processes.

To ensure the highest levels of efficiency and the longest possible lifetime, it is necessary that CamCarb VG modules are mounted in robust housings where an engineered approach is taken to eliminate

internal leaks that would otherwise degrade performance.

As a first in the corrosion control industry, PSSA housings include a unique positive clamping mechanism to ensure leakage between the modules and the internal sealing frame is eliminated. The housings are designed to ensure ease of installation and simple servicing procedures.

Depending on the contaminant(s) to be controlled, virtually any molecular

filtration media may be used in VG modules. 1, 2 or 3 PSSA housing can be used in series to handle mixed gases or to provide extended lifetime. The VG filters and housings are passive in operation and require minimal routine maintenance.

PSSA housings may be installed in supply and recirculation air systems. A range of standard size housings are available to provide airflow capacities ranging from 800 m<sup>3</sup>/h to 10,500 m<sup>3</sup>/h.

FEATURES	CUSTOMER BENEFITS
Positive filter clamping mechanism. No special tools required.	Minimal leakage. Quick and easy filter changes.
Aluminium coated steel construction	Offers a robust protection against environmental conditions with a good finish
Double skin with insulation	Internal temperature control, and reduced risk of condensation
May be used in multiple stages	Ability to target multiple gases utilising different media
Minimal maintenance and service time	Reduced maintenance cost and equipment downtime
No requirement to handle filter media	Reduced PPE requirement for installation and maintenance
Leakage tested housing	Ensure high efficiency of contaminant removal

# CAMCARB VG MODULE

These plastic filter modules are industry standard items. There are 2 standard configurations; VG 300 and VG440.

The VG300 format is best suited for moderate duty (normally make-up air) applications and the VG440 format is best suited to light duty (recirculation air) applications.

In many other manufacturers' housings, this type of filter is known to have high mechanical leakage rates that will compromise the manufacturers claimed efficiency.

CamCarb VG filters should be used in Camfil PSSA housings where the unique clamping mechanism will eliminate the internal leaks. The modules may be filled with many different molecular filtration medias to suit different gas challenges.

Camfil strongly recommend that when multiple medias are required, they are used in a layered arrangement rather than as a blended mixture.

The layered arrangement ensures the lowest possible total cost of ownership (life cycle costs) since each individual media can be changed when it reaches the end of useful life. With a blended media, all the media needs to be replaced when just a single component has failed.



CamCarb VG 300 modules and a bank of modules outside PSSA housing.



CamCarb VG 300

CamCarb VG 440

# CAMCARB CG CYLINDER

The CamCarb CG cylindrical filter is Camfil's flagship molecular filter for moderate duty applications in process and industrial environments. When mounted on its dedicated holding frame, all internal leaks are eliminated and very high efficiency values are achieved. CamCarb CG is ideally suited to use in recirculation/return air systems in corrosion control applications. It can also be used in make-up air systems in applications where low or moderate gas concentrations are expected.

CamCarb CG is manufactured from plastic and is extremely corrosion resistance. The air-inlet endcap features a radiused profile to reduce pressure drop and a pair of co-moulded TEP thermo-elastic gaskets to eliminate air by-pass. Each cylinder is filled using a vibratory technique to ensure perfect packing density of the filtration media. The cylinders are mounted and dismantled from the base plate using a standard 24 mm wrench.

CamCarb CG filters showing inlet air end with 3 bayonet mounting pins and dual co-moulded rubber gaskets



Base of CamCarb CG filter showing integrated hex-nut used to lock cylinder onto baseplate.

# CAMCLEANER MOLECULAR

The Camfil Vertical CamCleaner is a free-standing, mobile air cleaner designed for the removal of corrosive gases within control rooms at industrial sites.

The device is completely self-contained and includes pre-filtration, molecular filtration using CamCarb CG cylinders, after-filtration, a fan and controls. Dirty air enters at low level and passes upwards through the unit, clean air is discharged at the top. Dampers at the bottom allow the unit to be used in 100% fresh air mode (with duct connection to external source) 100% recirculation mode, or in a combination of the two modes.

The CamCleaner is particularly useful if there is no external recirculation system and additional filtration is required to overcome the effect of ingress of fugitive gases.

The CamCleaner is quiet and has a high aesthetic finish. It is therefore also ideally suited to use in process control rooms with a high level of human occupancy. Nominal flow capacity is 1700 m<sup>3</sup>/h.



CamCleaner Molecular in a control room

# CAMPURE

## MOLECULAR FILTRATION MEDIA

Achieving a cost effective molecular filtration solution is very dependent on selecting the most appropriate media for the application. It is necessary to take into account the target gas(es), temperature and relative humidity. It is equally important to ensure that sufficient media is deployed in the filter to ensure that a high efficiency value is maintained over an extended period and a low life cycle cost (LCC) or total cost of ownership (TCO) value is obtained.

There are many commercial adsorbents available to filter manufacturers, contractors, service companies and end users. Even to the trained eye many are visually indistinguishable. The reality is however; depending on manufacturing method, quality assurance procedures and

perhaps most importantly performance testing, the value provided in a real-world installation can be extremely variable.

Camfil manufacture all their CamPure media for corrosion control applications in-house according to stringent QA procedures in an ultra-modern, purpose designed facility that uses the latest process control technologies. Performance testing is also undertaken in-house in Camfil's unique molecular filtration test laboratory.

In this facility, media samples and full size filters can be mounted in a test duct and the airflow conditioned to mimic the customers' application (temperature and relative humidity).

When the desired conditions are stable and the media has reached equilibrium with the airflow, gases or vapours can be injected upstream of the test piece at real-world concentrations that also mimic the customers application (typically low parts per million level).

Using extremely sensitive upstream and downstream real-time gas monitors, the efficiency of the filter is immediately revealed. This facility is capable of producing results from procedures in accordance with ISO 10121-1 / 10121-2 and ASHRAE 145.1 / 145.2.



# ON-SITE PERFORMANCE MONITORING

The use of molecular filtration for the prevention of corrosion in electrical or electronic equipment is a critical application. The safe and reliable operation of end-user assets and processes are dependent on the performance of the molecular filters. Camfil provide customers with support services to monitor the on-going effectiveness of their filters.

Conceptually these involve; either monitoring the impact of the air quality in the enclosed space or monitoring the condition of the media in the filter.

The impact of the air quality is assessed by reactivity monitoring or measuring the rate of corrosion of copper and silver sensors. This can be done by either (i) a passive or (ii) a continuous real-time technique. The passive method involves exposing copper and silver foil coupons for 30 days inside the enclosed space (CamPure coupons).

The coupons are then returned to the Camfil laboratory for the analysis of any corrosion layer that has formed on the foil surface. The results are reported according to the 4 categories within ISA 71.04. The technique is simple to execute, however the results only show the average achieved classification (no short term high or low values).

Real-time monitoring involves a similar technique. Very sensitive thin-film copper and silver sensors are exposed in the enclosed space, however they are integrated into a self-contained analyser and data logger (ISA-Check II) that is continuously assessing the rate of corrosion development on the foils and displaying the actual current classification according to ISA71.04-2013. Variations in air quality are identified and all data is readily down-loaded to a windows based software for further review and visualisation.

Condition monitoring of molecular filtration media can be a powerful tool for indicating the current performance of a filter and estimating the residual life. The technique involves removing samples of media from a filter and returning them to the Camfil laboratory for analysis. A series of tests are made that compare the “as received” media to the “when new” condition and the condition of the media when it is known to be at the end of its useful life.



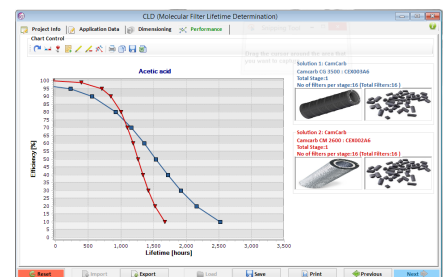
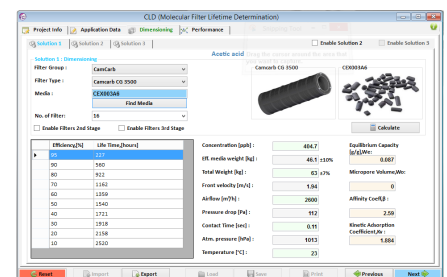
CamPure coupon

# SPECIALISED SOFTWARE

The lifetime of a ProCarb filter can be simulated using the unique Camfil Carbon Lifetime Determination (CLD) software for molecular filtration. The purpose of this software is to provide “best estimates” of the performance of molecular filtration products under selectable conditions that closely approximate real applications. Predicting the performance of molecular filters in the real world is a complex issue. This software takes account of the key factors that affect the performance

of molecular filters; the gas/vapour to be controlled, concentration, type of adsorbent, amount of adsorbent (contact time), and temperature.

The software has been developed using adsorption theory, many years application knowledge, field measurements and results of extensive product testing in Camfil's unique molecular filtration test rig.



CLD Software for molecular filtration



ISA-Check II unit with copper and silver sensors.

# CAMFIL REAL-TIME CORROSIVITY MONITOR ISA-CHECK II

Camfil offer the latest advanced technology real-time corrosion sensor: **ISA-Check II.**

This entirely new product has been developed specifically for use in heavy process industries and offers some unique customer benefits.

Real-time information on the air corrosivity is crucial for effective corrosion protection of valuable control assets. ISA-Check II measures and registers the change over time in the electrical resistance (ER) of a thin metal track applied on an insulating substrate. If the metal corrodes, the cross-sectional area of the track decreases and

the ER increases. The changes in ER can be directly translated into corrosion depth and corrosion rate.

The ISA-Check II monitoring system is comprised of four principal parts:

- Electronic logger for measuring and recording ER
- Sensitive thin-film metal corrosion sensors
- Non-contact communication interface between the logger and computer, the "data pencil"
- User-friendly software programme, WINISACHECK



ISA-Check II unit with copper and silver sensors, with data pencil.

FEATURES	CUSTOMER BENEFITS
Battery powered. Lifetime > 3 years.	No need to hardwire or have skilled technician for installation.
3 colour LED indicates copper reactivity class according to ISA 71.04-2013. (G1, G2, G3/GX)	Instant indication of air classification according to the most commonly adopted standard.
Single button operation to scroll through menu and display commands.	Simple to operate.
Utilises 2 different metal sensors, usually copper and silver	Results are compliant with ISA 71.04.-2013
Measures temperature and relative humidity.	Allows customer to monitor important parameters that influence rate of corrosion.
Measures atmospheric pressure	Indicates control room pressurization.
Non-contact data reading allows the logger to remain in place when data is downloaded to laptop.	Very convenient to upload data to a laptop.
User-friendly WINISA-Check II software provides rapid interpretation of results in terms of corrosion depth and corrosion rate and classifies the air quality and corrosivity according to three standards.	Very convenient to process, manipulate and display data.



ISA-Check II unit with data pencil and laptop based software.

## Camfil – a global leader in air filters and clean air solutions

For more than half a century, Camfil has been helping people breathe cleaner air. As a leading manufacturer of premium clean air solutions, we provide commercial and industrial systems for air filtration and air pollution control that improve worker and equipment productivity, minimize energy use, and benefit human health and the environment.

We firmly believe that the best solutions for our customers are the best solutions for our planet, too. That's why every step of the way – from design to delivery and across the product life cycle – we consider the impact of what we do on people and on the world around us. Through a fresh approach to problem-solving, innovative design, precise process control and a strong customer focus we aim to conserve more, use less and find better ways – so we can all breathe easier.

The Camfil Group is headquartered in Stockholm, Sweden, and has 30 manufacturing sites, six R&D centres, local sales offices in 30 countries, and 4,500 employees and growing. We proudly serve and support customers in a wide variety of industries and in communities across the world. To discover how Camfil can help you to protect people, processes and the environment.

[www.camfil.com](http://www.camfil.com)

