



SYSTEMS FOR TURBOMACHINERY



Clean air solutions for turbomachinery



WE PROTECT PEOPLE & MACHINES

Clean air and a quiet environment are vital life quality factors in modern society. Also in the power, oil & gas industries, it's important to optimise these factors. A correctly designed, rational system minimises engine degradation, leading to lower operating costs, optimum efficiency and less environmental impact.

Camfil Power Systems has extensive experience of dimensioning, designing and manufacturing different system solutions in all conceivable environments. With our complete product and system offering, we can provide your installation with the right solution, including everything from the inlet system, enclosure and ventilati-

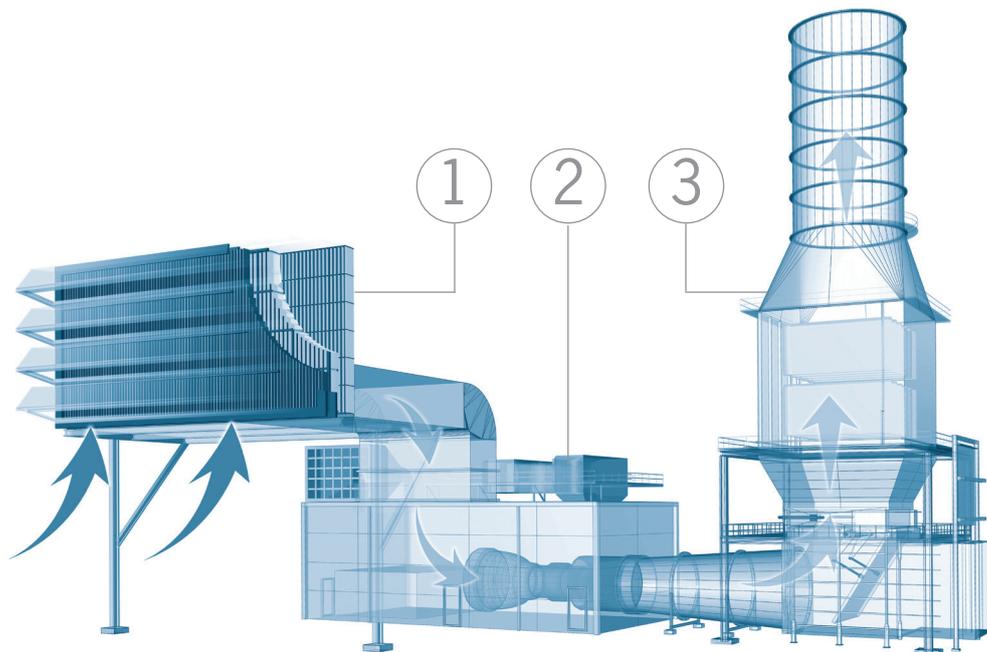
on to exhaust and damper systems. You can benefit from this expertise when you want to improve or retrofit old equipment to better match modern efficiency and performance requirements. Once in operation, our aftermarket service ensures that you get high reliability and maximum return on your investment.

The heart of our systems

We have over 40 years' experience in developing and supplying air intake systems. The heart of all our systems is their filter elements, which are specially developed according to individual requirements, the environment and the optimum operating economy. No matter which

system you choose, we help you achieve the right filter combination. With our LCC (Life Cycle Cost) programme, we study various key factors and then choose the best solution.

As part of the Camfil Group, the world's leading company for air filters and clean air solutions, we have access to a wide range of filters. Through continuous strong focus on R&D and development of test methods and standards, we also play a leading role in furthering the industry's development and ensuring customer benefit.



OPTIMUM SOLUTIONS FROM AIR INLET TO TOP OF STACK

1. Inlet systems

Air contains particles including, dust, sand and industrial pollutants, which can cause engine degradation and unnecessary machine wear. In order for gas turbines, diesel engines and compressors to work optimally, their inlet systems must supply them with clean air at the correct temperature.

We offer systems for facilities on land, offshore, in desert environments and in other environments with a high degree of natural and human-generated pollution.

Our systems are built to deliver the maximum possible efficiency combined with

the minimum possible pressure drop. This optimises the facility's operating economy. A carefully adapted inlet system minimises environmental impact and streamlines turbine operation.

2. Enclosures and ventilation

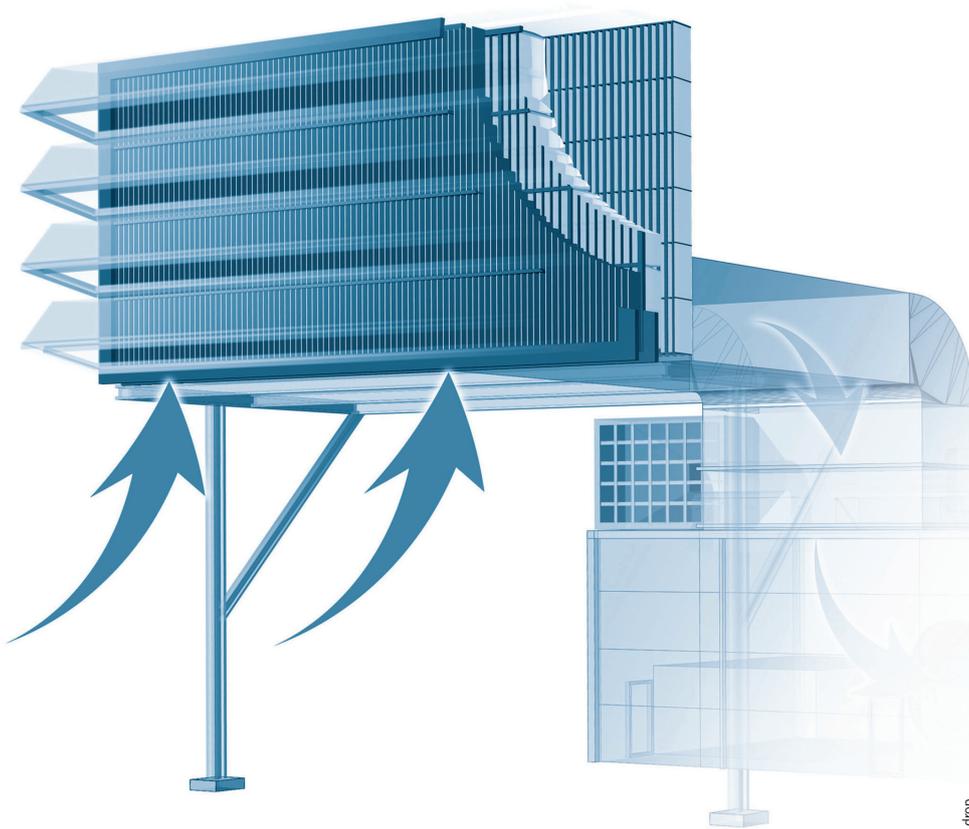
Our protected enclosures reduce noise to a level that is acceptable for the surrounding environment, and protects machinery from the stresses and strains caused by Mother Nature.

A well-dimensioned ventilation system allows the machinery to operate at the optimum ambient temperature, while safely venting out any gas and fuel emissions.

3. Exhaust systems and diverter dampers

Exhaust systems are often customised to meet noise level requirements, space requirements and profitability goals.

Numerous factors are taken into account when designing the systems, such as thermal stress at high temperatures, expansion etc. A design that ensures constant flow and low pressure drop is fundamental to ensure optimum, reliable operation.



INLET SYSTEMS

The purpose of an air inlet system is to purify the air and protect the gas turbine from harmful external impact.

The installation of a correctly adapted inlet system prolongs the life of the installation, cuts operating costs and raises the machine's efficiency, while reducing the risk of costly unplanned downtime. An inlet system can be adapted to meet countless different requirements. Besides an optimal filter combination, the system also needs to be supplemented with suitable weather protection devices and, if necessary, anti-icing systems or insect guards.

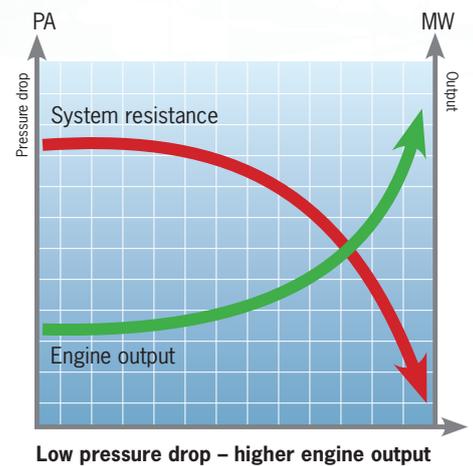
If the machine is installed in an area with high temperatures, inlet cooling is

an option that increases the machine's performance. Details such as water separation and drainage are vital to a well-functioning inlet system. When our designers develop your specific solution, they take these details into account, while also ensuring that the systems are simple to assemble and maintain.

Our inlet systems are constructed in alternative materials such as coated carbon steel, marine grade aluminium and stainless steel.

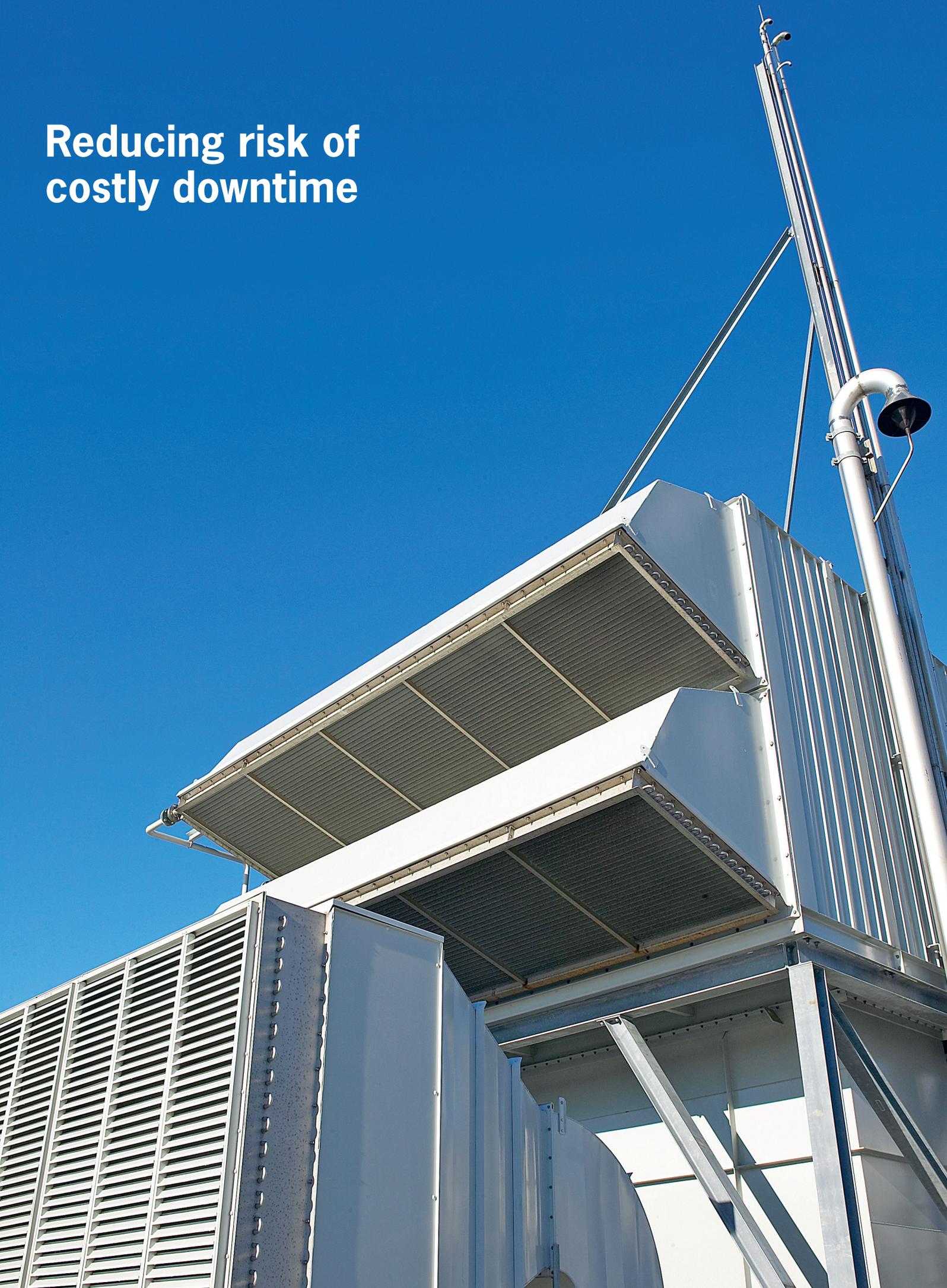
Features

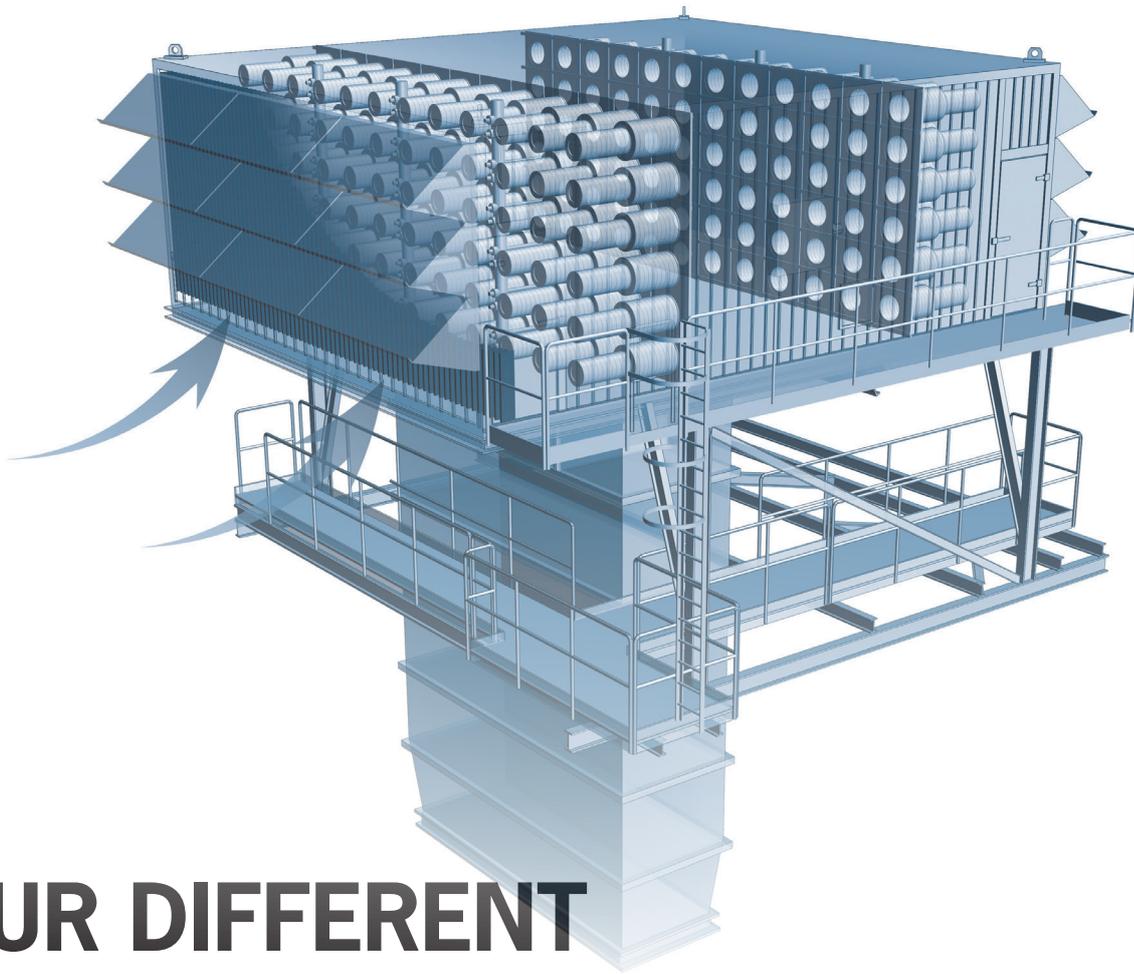
- protects against dirt
- increases engine efficiency
- cuts maintenance costs
- reduces nuisance noise



We offer air inlet systems for engines 3MW up to 300 MW - for static and self-cleaning pulse systems or combinations of both.

**Reducing risk of
costly downtime**





OUR DIFFERENT AIR INLET SOLUTIONS

Using pre-engineered options, the complete system can be tailored to your individual demands in line with application, ambient conditions, load and other specific parameters. Our application engineers will match the settings to your needs and the filter elements will be selected to suit your real-life conditions on site.

Static systems

Static filter systems are designed to clean combustion and ventilation air in rural, urban or industrial environments, and should be adapted according to the operating conditions at each facility.

A typical static filter system consists of

- a weather hood
- a droplet separator
- a pre-filter stage (panel or bag filters)
- a final filter stage (compact or EPA filters)

The designs are modular for easy transportation and installation. Modules are interchangeable with external bolt interface reducing engineering and installation cost. The system can be designed from 20 filters to large inlets with several hundred filters.

Pulse cleaning systems

Camfil pulse filter systems are designed to protect rotating machinery operating in high dust load environments where conventional static systems suffer from frequent service intervals resulting in reduced availability, frequent shutdowns and high maintenance costs.

Our pulse system is selfcleaning during operation, allowing full continuous operation at low stable pressure drop even in extremely dusty environments as they may occur in some parts of the world.

The system is equipped with pulse filters - a single stage automatic selfcleaning barrier filter using multiple cylindrical and/or conical filter elements. The cleaning takes place during normal operation by injecting compressed air into a number of filter elements in reverse-flow direction without interrupting the normal air flow through the system.

The dust pulsed off the filter elements can drop freely and re-entrainment of fine dust particles is greatly reduced by the positive downdraft.

Combined systems

Combined systems; pulse systems with final static (H)EPA filtration stage, are designed for operating in corrosive and high dust load environments. In these conditions, conventional systems could suffer from frequent service intervals resulting in reduced availability, frequent shutdowns, high maintenance cost and

We offer reliable air inlet systems to meet different challenges in every possible environment; from offshore to desert or environments with a high degree of pollution.



decreased engine performance due to fouling and corrosion. By combining both systems together, the major advantages of each can be attained.

Air inlet enhancement systems

An inlet system can be designed to meet countless different requirements. Besides an optimal filter combination, the system may need to be enhanced with better weather protection or screens to stop bird or insect. If the gas turbine is installed in an area with extreme temperatures, inlet cooling or anti-icing can be options that increases the turbomachinery's performance.

Weather protection

Rain hoods are used to avoid over drainage on the louver, when rainfall intensity is over 2.7 liters per second per sq meter. Snow hoods can be used if there is a snow build up on the filter house. Larger

than regular hoods, the lower air velocity prevents the flakes being entrain the inlet.

Screens

Used to prevent foreign objects from entering the inlet, screens can be grouped into three categories depending on how fine a mesh is used:

- Insect screens
- Bird screens
- Trash screens

Inlet Cooling

Cooling the turbine inlet air even by a few degrees can increase power output substantially. This is because cooled air is denser, giving the turbine a higher mass-flow rate and resulting in increased turbine output. We provide solutions for evaporative cooling, chiller coil and fogging systems.

Anti Icing

Generally used on gas turbine inlets when the air temperature is between -5 to 5°C and the relative humidity is above 70%. Icing on the filter is also influenced by the velocity of air. We provide solutions for steam or hot water heat exchangers, electric resistance heating and compressor bleed or exhaust



THE COST OF FOULING

When electricity is generated by gas turbines, the fuel cost typically represents 60% of the electricity selling price. Meanwhile, environmental requirements continue to increase. This is why many operators are now looking for better filtration systems to avoid fouling and keeping fuel consumption at a minimum.

Axial compressor fouling is primarily caused by airborne submicron particles. Fouling changes the shape of both rotating and stationary vanes and results in a reduction of both mass flow and pressure ratio generated by the compressor. The net result of fouling is a reduction of power output and an increase in heat rate for a given combustor outlet temperature.

Conversely, if an engine is not running at its temperature limit, a fouled engine has to run hotter to produce a given output.

A secondary effect of fouling is an increase in airfoil temperatures in the high pressure turbine, as fouling in the internal vane and blade cooling passages reduces heat transfer effectiveness and ultimately reduces the life of the hot section.

The costs of fouling far exceed the cost of eliminating it, but since capital costs tend to weigh heavily in equipment purchase decisions, many gas turbines are equipped with inadequate inlet air filtration and the operator ends up paying many times more in extra operating costs.

Many operators are now looking at possibilities to operate their gas turbines for longer periods of 2-3 years without shutdowns. Keeping the engine clean by preventing small particles from entering the air inlet system is one important step towards achieving this target. It means taking gas turbine filtration systems from the now typical medium efficiency technology to clean room technology or HEPA filtration. By going from the typical F8 grade to H12, penetration is dramatically reduced. For example, penetration on 0.4 micron particles is reduced from typically 25% for a F8 filter to less than 0.5% in a H12 filter – a huge improvement which cuts fouling dramatically.

WHY HIGH-QUALITY FILTERS ACTUALLY COST LESS

High-quality filters cost a little more initially. But in the long run, products such as Camfil gas turbine filters, which use the latest technology and the best filter media, actually lower your energy bill and your costs by maintaining their efficiency longer with the lowest pressure drop. Benefits such as higher power output, lower fuel consumption, reduced downtime and extended turbine life all combine to decrease your total cost of ownership.

What products meet your needs?

The air filtration marketplace includes products that present various advantages and disadvantages when compared to other air filter offerings. There are also different types of media incorporating varying principles of particle capture, each with its own advantage when applied in an inlet filter system. How can you and other filter users differentiate manufactu-

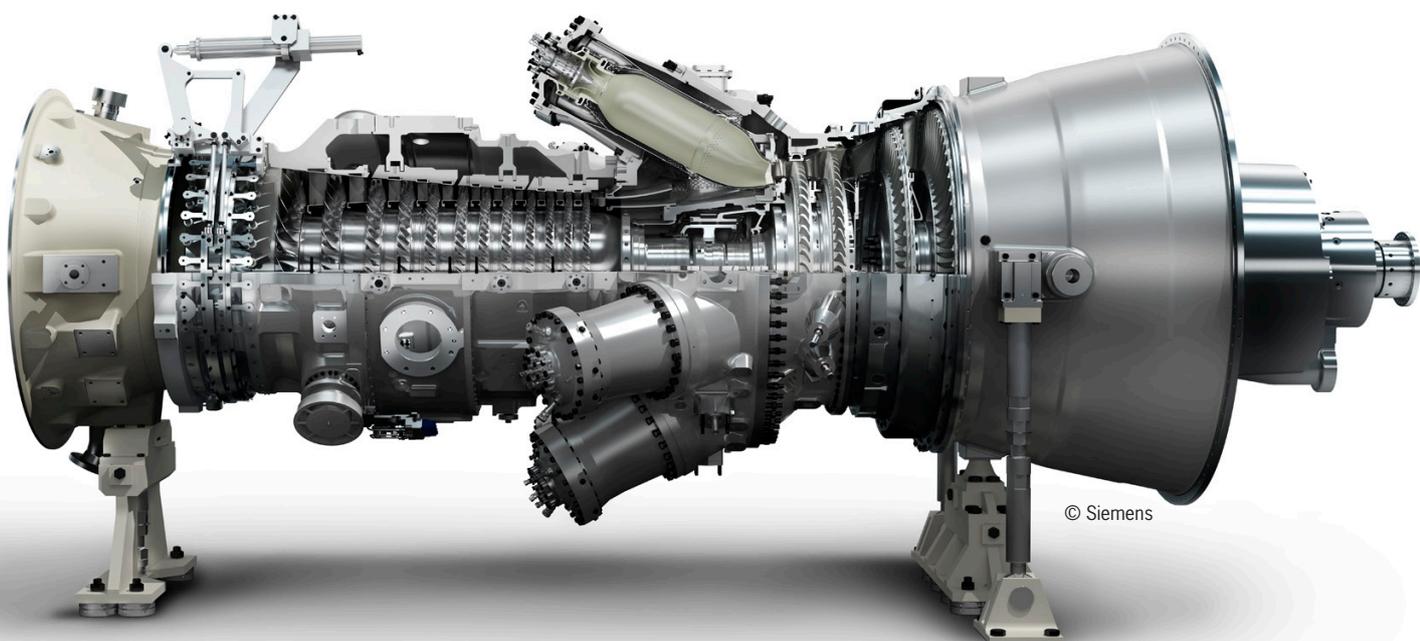
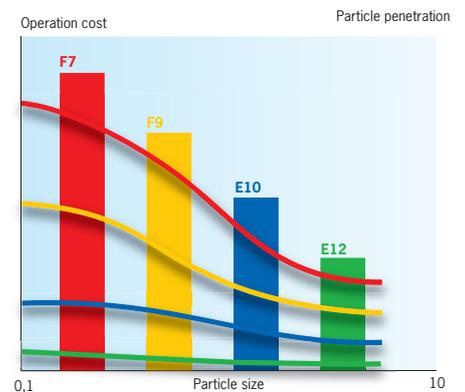
rers' claims and make sound decisions as to what products are applicable to meet your needs?

Make sure your turbine filters live up to the existing standards and to the desired performance in operation on site. Most importantly, choose quality.

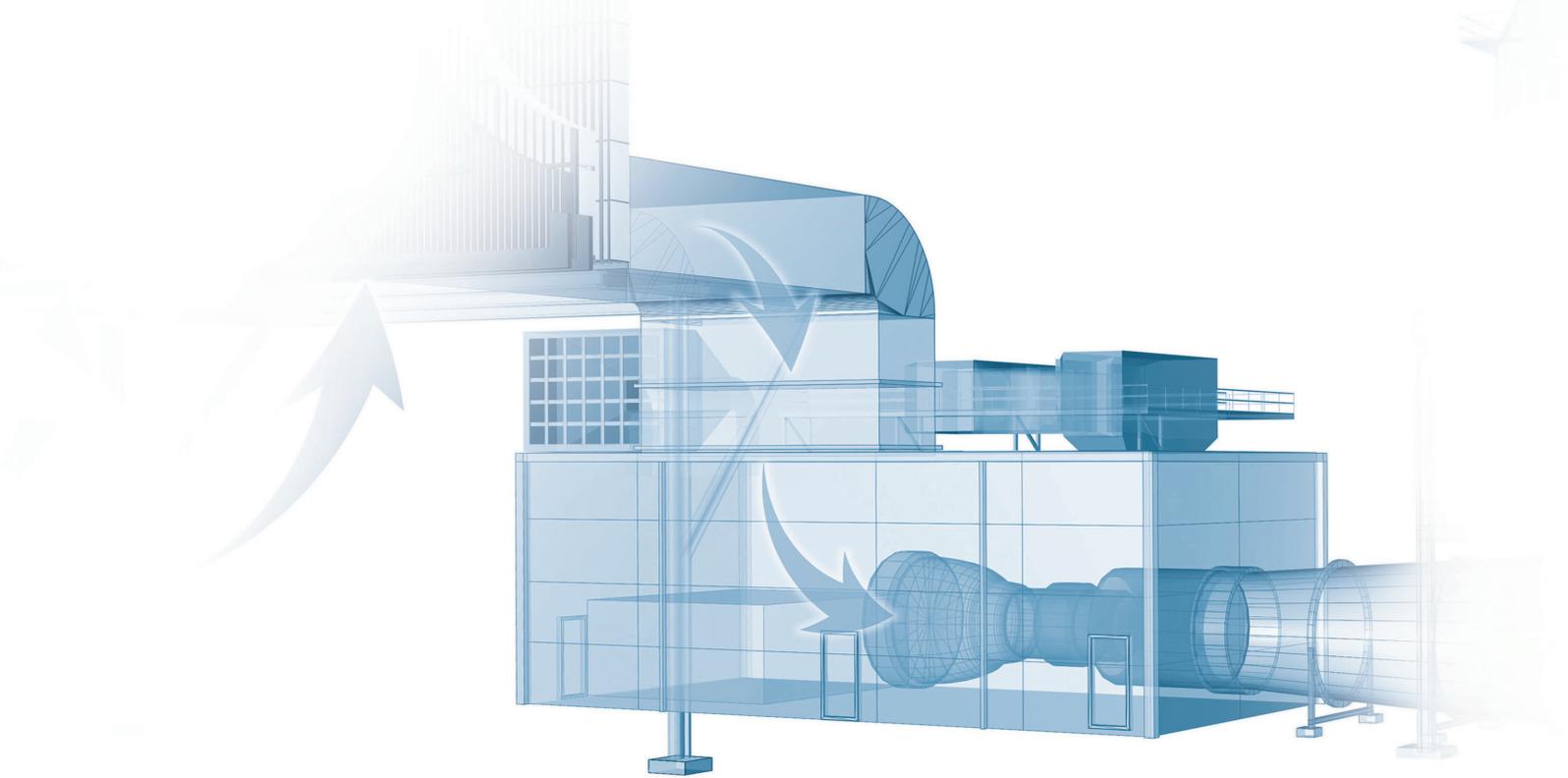
The cost of clean air is not the cost of replacement filters

Turbine operators are requesting more and more that filter systems be optimized, not only in terms of price but also with regard to the total cost for the intake system, including filter usage, compressor cleaning, CO₂-emission costs, energy costs and other factors. We run calculations to determine the optimum combination of filters needed for the lowest total cost over a given time period. Camfil's

LCC program takes into account such factors as engine sensitivity, energy cost, running time, filter price, cleaning cost, different environments and filter characteristics. Our calculations are based on real-life testing data from a large number of sites.



© Siemens



ENCLOSURES & VENTILATION

Turbomachines need to be protected against weather and excessive temperatures. The surrounding environment must also be protected from the high noise levels generated by the machinery. This is done most effectively by enclosing the machine and installing silencers beside the inlet and outlet openings. An enclosure also provides effective protection against fire and varying weather conditions.

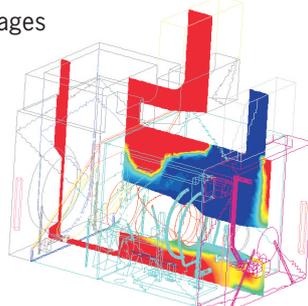
Our enclosures are built as an integrated part of the system. Lighting, easy-to-open doors, lifting beams and service areas are just some of the features inherent in our designs. Our most commonly used materials are coated carbon steel, stainless steel and aluminium. The enclosures can be delivered skid mounted or as free-standing modules. The systems are effectively insulated against vibrations.

Our enclosures are designed with efficient ventilation to cool the air, thus ensuring reliable, safe engine operation. The ventilation systems are equipped

with filters, fire dampers, silencers and fans to ensure safe, even operation. Speed-controlled fan engines make it possible to vary the air flow, maintain constant temperature and minimise power consumption.

Features

- dampens nuisance noise from the gas turbine
- protects against fire and varying weather conditions
- provides an attractive exterior
- facilitates servicing and inspection
- ensures even ventilation, optimum temperature and safe operation
- offers protection in the event of gas leakages



CFD analysis for optimal ventilation



Filter house for enclosure ventilation on a Siemens SGT 800 gas turbine.

**Reducing disturbing
noise and providing
effective protection**



EXHAUST SYSTEMS & DIVERTER DAMPERS

Exhaust systems are necessary to guide the exhaust flue gases of gas turbines into the atmosphere. In simple cycle installations, the exhaust flue gases leave the gas turbine through a diffuser, turning box or elbow, bypass stack and are released into the atmosphere.

In combined cycle installations, the exhaust flue gas leaves the gas turbine through the diffuser into a diverter damper. The position of the diverter damper is correctly adapted to the selected mode of operation, either leading the exhaust flue gas through the bypass stack or through a heat recovery steam generator into the atmosphere.

Use of exhaust systems behind the gas turbines is mandatory as the exhaust flue gases have temperatures of 400°C-650°C and contain harmful substances that may not be freely released into the atmosphere. The noise emitted by gas turbines is also at a health risk level, and

must be reduced through noise reduction measures. The most frequently used method is the installation of an absorbing silencer splitter in the bypass stack.

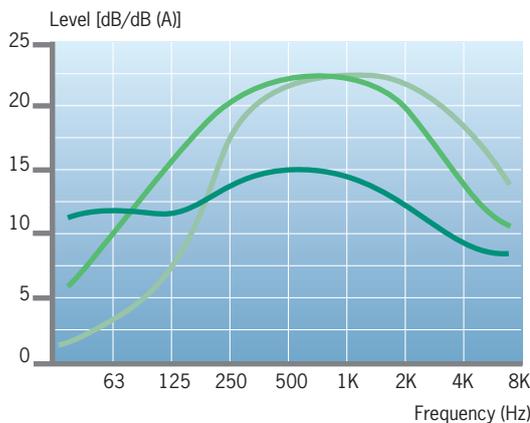
Our advantage is that we can design and deliver the whole exhaust system, from the gas turbine's exhaust flange to the connecting flange of the heat recovery steam generator, which has the following basic components:

- exhaust diffuser
- diverter damper
- bypass stack with silencer on a turn-key basis worldwide.

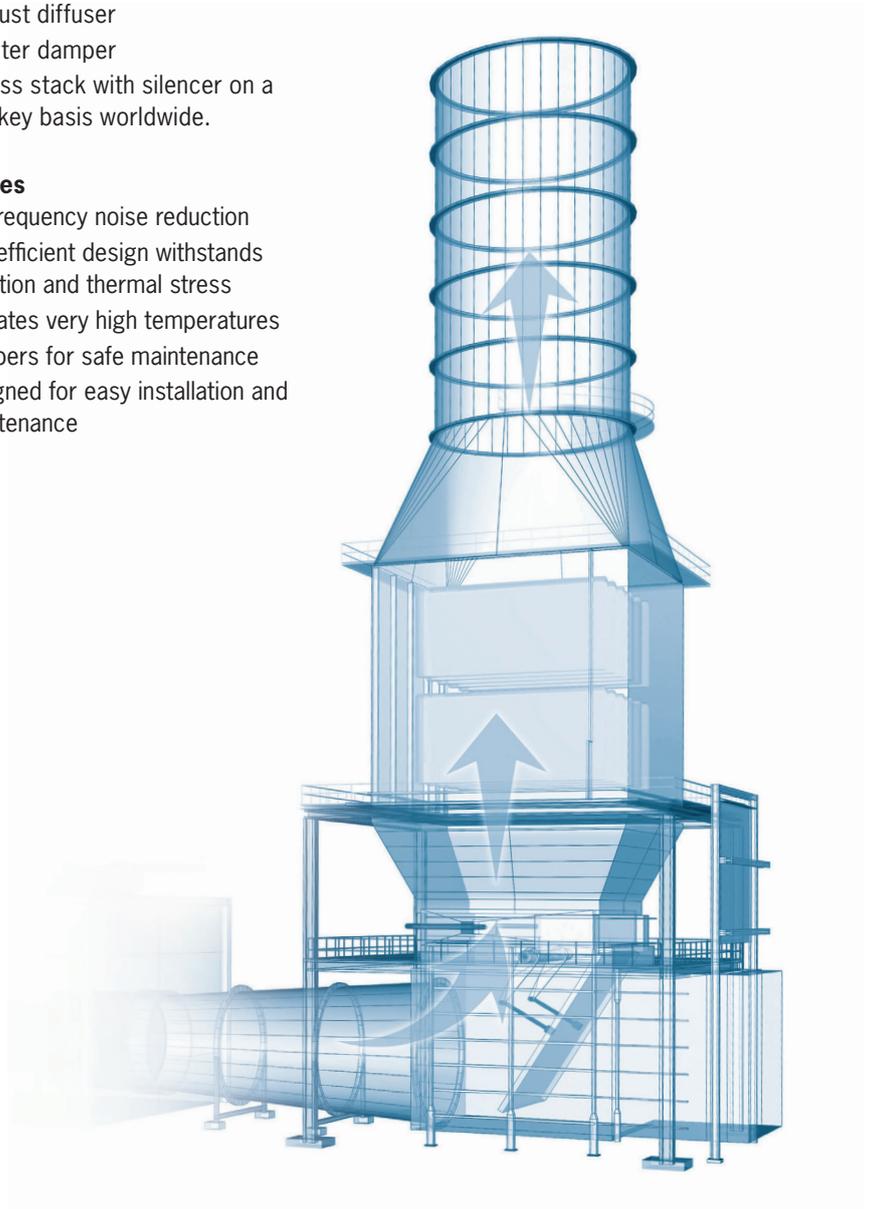
Features

- low-frequency noise reduction
- flow-efficient design withstands vibration and thermal stress
- tolerates very high temperatures
- dampers for safe maintenance
- designed for easy installation and maintenance

Functional principle of absorption silencers



- High-frequency tuned absorption splitter
- Low-frequency wide spectrum relaxation splitter
- Absorption splitter combined with panel resonator



**The right
system solution
– a wise investment**



Long experience

Camfil Power Systems has been supplying cost-effective air intake systems and acoustic solutions to the industry for over 50 years. Our success is based on a development process in close collaboration with our customers and suppliers. Each solution is unique for you, as our customer.

Global presence

Thousands of our installations are used worldwide, around the clock, year after year. We operate globally but work locally. You always have a Camfil Farr representative close at hand. We understand your needs – and speak your language.

Experience of project management

We're used to leading and managing projects. Our project team performs all contracts in close collaboration with our customers. Each project has its own project manager who ensures that the customer's requirements and preferences are met throughout the course of the project.

Production

All production takes place at our own factories, or is carried out by carefully selected subcontractors in our global network. This means that production can often be carried out close to the location where the equipment will finally be delivered.

Certification

We supply systems for gas turbines from 1 MW to over 300 MW. All our activities are controlled by our ISO-9001-certified quality control programme. We are also a certified SCC (Security Certificate Contractor), which is of crucial importance when performing installation and assembly operations.

Service and aftermarket

We have a carefully selected aftermarket service for spare parts and upgrade. Safe service guarantees reliable function and ensures you get the highest possible return on your investment.



**We believe in long term partnership.
We're with you all the way.**



CAMFIL – a global leader in air filters and clean air solutions.

Camfil is a global leader in the air filtration industry with more than half a century of experience in developing and manufacturing sustainable clean air solutions that protect people, processes and the environment against harmful airborne particles, gases and emissions. These solutions are used globally to benefit human health, increase performance and reduce energy consumption in a wide range of air filtration applications.

Our 26 manufacturing plants, six R&D sites, local sales offices and 3,800 employees provide service and support to our customers around the world. Camfil is headquartered in Stockholm, Sweden. Group sales total more than SEK 6 billion per year.