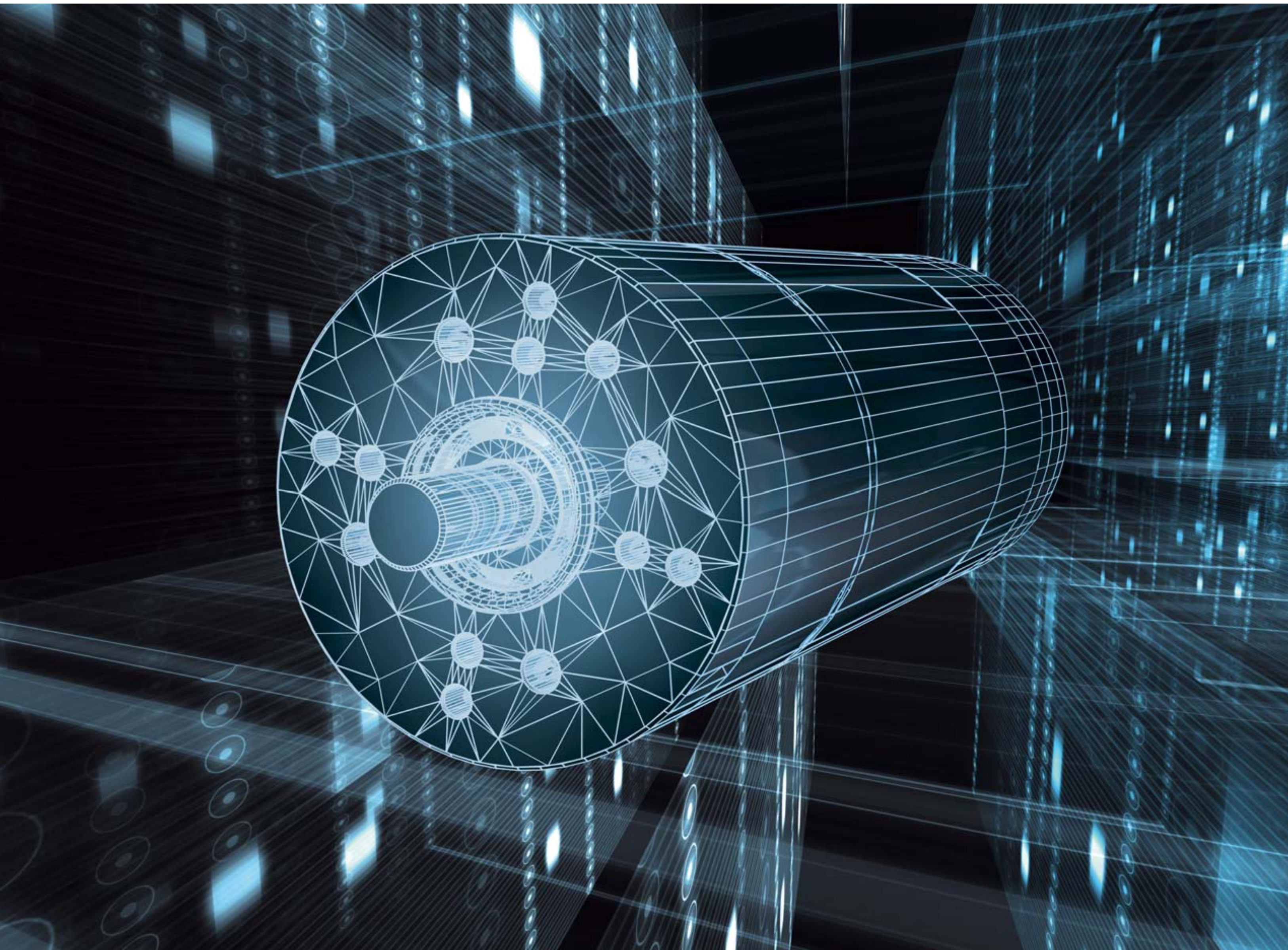
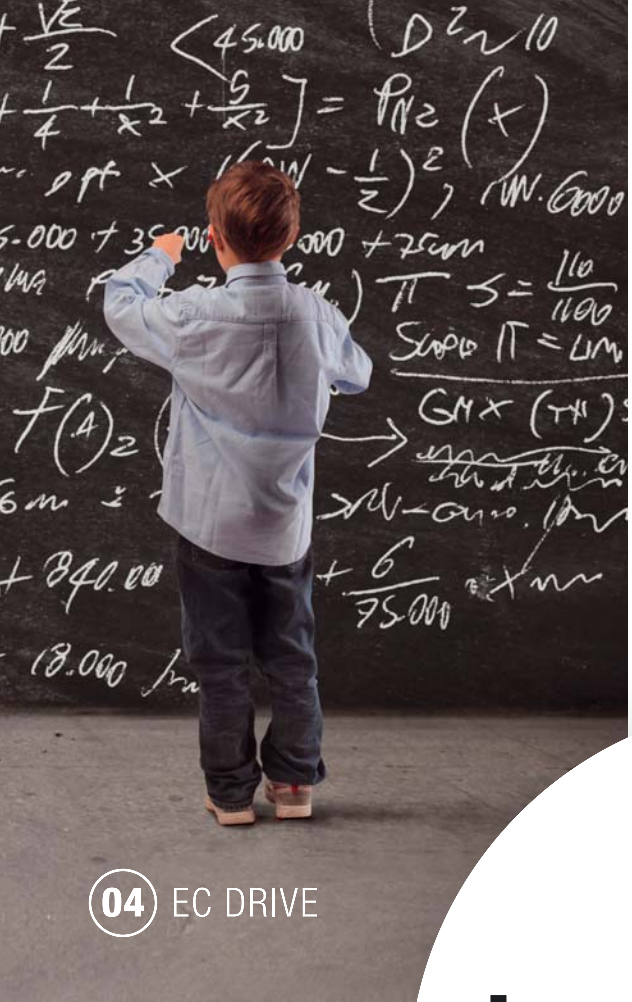
# techmag°

Technology by ebm-papst

01°2014







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# “Top quality tailor-made products immediately available at a reasonable price – how can that be possible?”

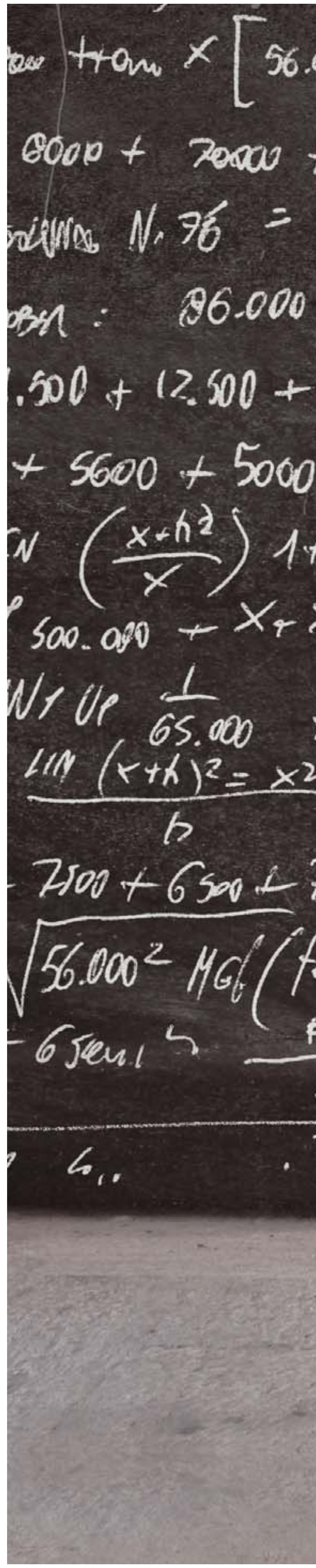
Made to measure or off the peg – a decision facing us all both privately and in our working lives. Specially developed products have the advantage of corresponding exactly to requirements. By contrast, standardised products are immediately available and far less expensive on account of the larger quantities involved. High-volume products also have the edge if top quality is required at low cost, as the greater outlay for high quality standards then also becomes economically justifiable.

The automotive industry manages to achieve the level of production required to justify the expenditure associated with attaining its technological, quality and - above all - cost targets by standardising products across entire vehicle model ranges. Technologically sophisticated customised concepts are also in demand in the industrial drive engineering sector, however for a comparatively low product volume. Standardisation is not feasible in view of the diversity of technical requirements involved. So how is it possible to manufacture these products to a high quality standard whilst keeping costs to a minimum?

One answer to this is the modular concept. At ebm-papst, complex industrial drive systems are split up into modules in the early design phase. These modules then form the basis for the creation of any number of different products to attain the necessary volume. The active components for the ECI motor series, for example, were developed from the outset in modular form. They now form the basis for numerous successful projects in both the automotive and the industrial drive engineering sectors. What’s more, the gear units, electronics, software and sensors are also of modular design and can be combined to create drive systems to suit specific requirements. You will find more information on the ECI 63 modular system in this issue.

We hope you will enjoy reading the article as well as all the other interesting features in this tech.mag.

***MBA Dipl.-Ing. Johannes Moosmann***
***Director Business Unit Industrial Drives***
***ebm-papst St. Georgen GmbH & Co. KG***



# 63 mm drive with integrated control electronics

## Range of modules for easy configuration of modern EC drives expanded

High efficiency is only possible when all components are perfectly matched. This is especially true for the right selection and design of drives. However, development is subject to constraints in both costs and scheduling. Successful drives will be those that are based on a comprehensive modular system. Now a motor with integrated control electronics adds to the range of options among drives with a diameter of 63 mm. In addition to the mechanics, now the regulation via interfaces can be easily customised to suit local conditions.

For complex systems with many drives or special measuring instruments with high standards for control, modern technology depends on drives that can be very finely calibrated. To offer users a truly universal drive solution, ebm-papst St. Georgen is now equipping its proven ECI-63 motors with integrated control electronics (Fig. 1, page 6). The so-called K4 design with expanded basic configuration is being added to the set of modules to enable especially flexible drive applications.

**Benefits of modularity** Customisation is a fine thing, but costly in comparison with standard products. Mass production is considerably more economical but loses out on efficiency due to lack of flexibility. With a modular solution, users benefit from the economical mass production of the individual modules while being able to use drives customised according to their specifications. Now the ECI family adds another level of customisation for the 63 mm motors. In addition to the established modules for gearboxes, brakes, encoders, etc., now motor modules with fully integrated control electronics are available (Fig. 2, page 6). Depending on the desired power, these compact motors are available in versions with stator lengths of 20, 40 and 60 mm. De-

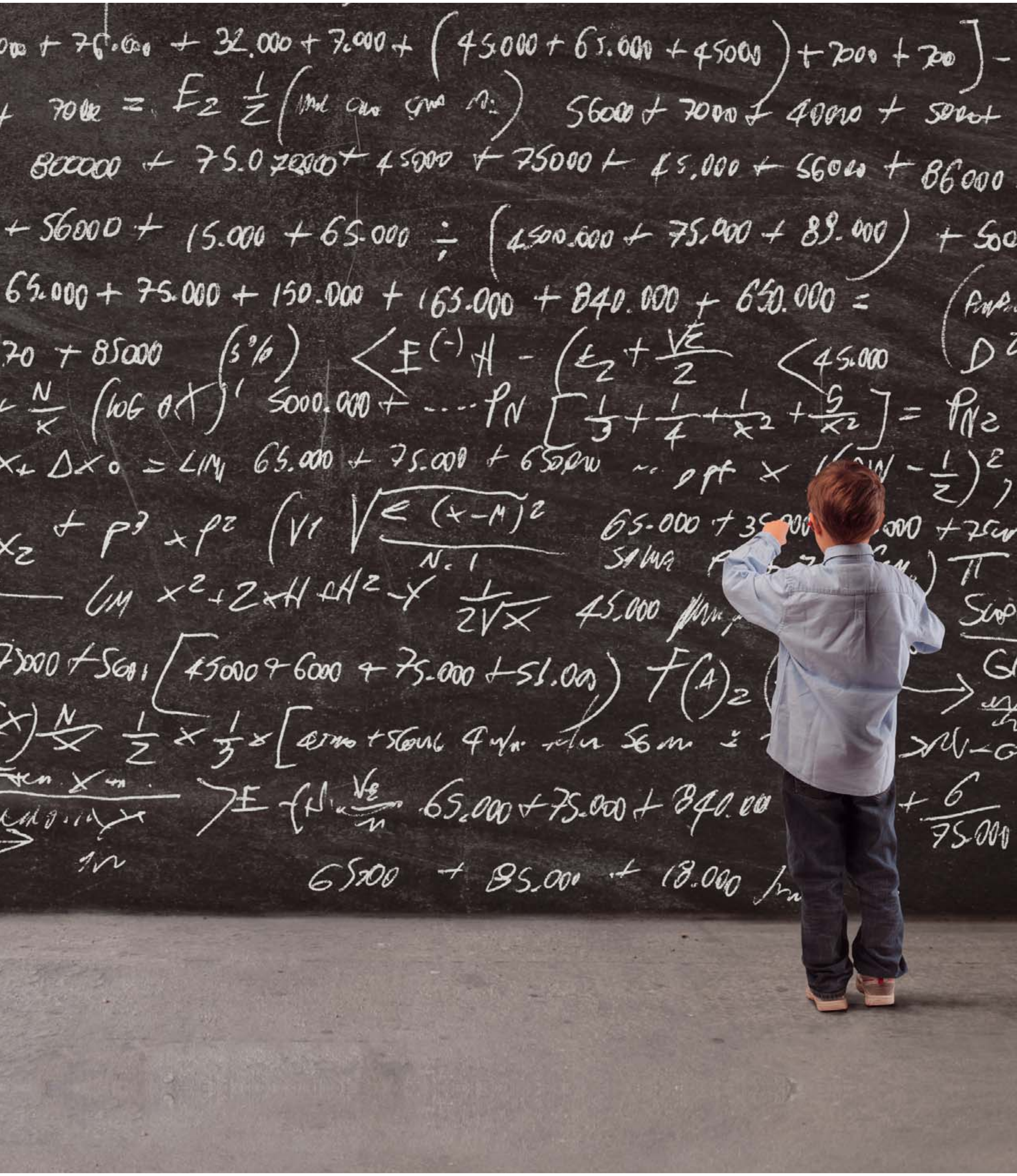


*Figure 2a,b,c,d: Find the ideal drive for practically any application by combining modules as needed*

*Figure 1: The new ECI 63.xx K4 with integrated motor electronics for optimum efficiency*

pending on the design, they deliver between 150 and 400 W to the drive shaft at an efficiency of around 90 % with outstanding overload capacity. The integrated K4 control electronics provide sinusoidal commutation allowing the motor's full potential to be utilised with field-oriented regulation down to standstill, as well as a speed and torque controller. The smooth sinusoidal current rise prevents commutation noise; the motor runs very quietly and vibration-free, thanks also to its maintenance-free ball bearings. Several digital and analogue interfaces provide for external communication. The electronics parameters can be easily adjusted after installation via the RS485 interface for adaptation to changing situations at the customer. The clear "Kickstart" user interface helps the user set parameters and select the operating mode (speed, positioning or torque mode) for quick adaptation to the required application.

Protective functions built into the electronics allow full utilisation of the drive's performance without adversely affecting its service life or reliability.

The dynamic EC motor can be easily combined with the proven planetary and angular gears and crown gearheads from ebm-papst ZEITLAUF, as befits the modular approach. These efficient gearboxes cover a wide reduction range from 6.7 to 33.3:1 for angular designs and 3.2 to 30:1 for the planetary designs.

Compact, customised drives are suitable for all applications in industrial drive engineering, particularly for automation, medical technology, in-house logistics, packaging, access control and battery-powered applications. With adjustable torque limitation, drives for winders and bobbins in the textile industry, or precision performance requirements for laboratory applications, are also no problem. ○

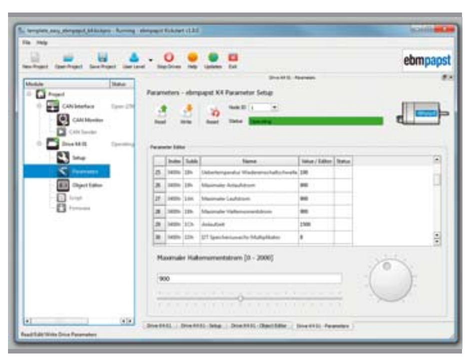


*Figure 3: Easy-to-use interface of "Kickstart" software*

**Sinusoidal commutation, extremely precise and quiet**

The pulse-width modulation often used for regulation in large motors can cause irregularities and speed variations in small drives, especially at low speeds. This is due to the rotor's lower inertia. If a sinusoidal signal with three analogue sine waves is used for regulation instead, then smooth operation is ensured even at low speeds and with small moments of inertia. The rotor can follow the smooth, sinusoidal current flow without acceleration or cogging torques. Conventional pulse or block commutation leads to additional radial and tangential forces. Especially with square-wave currents, localised perpendicular forces arise which can lead to abrupt vibrations in the stator. The resulting "commutation noise" is not to be neglected. The only solution is control electronics like the K4 with sinusoidal current flow. The sinusoidal regulation largely or completely removes the commutation component of the operating noise for smooth, vibration-free operation from standstill through the entire speed range.

*Author is engineer Johannes Moosmann, Director Business Unit Industrial Drive at ebm-papst St. Georgen*

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# “Air-guiding system” guarantees low noise output

## Air inlet grille for axial and centrifugal fans

In applications relating to refrigeration, air conditioning and ventilation technology, users frequently observe that the selected fan installed in the device does not run as quietly as expected. Such fans often generate a level of operating noise considerably higher than that stated in the product documentation. The reason for this is simple: the values stated in the documentation are based on reproducible measurements under standard conditions (without any disruptions). However, the applications themselves are subject to inflow disruptions of varying intensity that are caused by the installation conditions in the respective device. These lead to additional noise generation. Help is now at hand thanks to an air inlet grille that essentially has a straightening effect, considerably reducing undesired disruptions and effectively reducing the level of noise generation.

Heat pumps and air conditioners are installed in different ways, with varying dimensions and designs. For example, differences occur in the positioning of the openings required for ventilation, in the heat exchanger surface and in the packing density. The air flow that enters the fan is therefore influenced by the other components such as the heat exchanger, in addition to being influenced by the installation situation. Depending on the application, the inflow to the fan is subsequently highly uneven and contains non-stationary components. For example, the housing walls of rectangular heat exchangers exhibit backflow regions with corresponding circulation – that is, air turbulence (Fig. 1, page 10). These in turn are then directed towards the locations with the least amount of clearance between the fan and the housing wall. It is here that the turbulence from both sides is combined, causing ‘vortexes’ that generate high levels of turbulence. This causes major fluctuations in the pressure and speed at the front edge of the blade, which can sometimes lead to drastically increased levels of additional noise, particularly in the low-frequency range. This generates broadband noise and narrowband, tonal frequency components, also referred to as tonal noise.

The tonal noise consists of the blade-passing noise and its harmonics. The formula for this is $f=n*z*k$. The frequency of the blade-passing noise $f$ is calculated from the product of the speed of the fan $n$ and the number of blades $z$. The harmonics of the blade-passing noise are the multiple of this, designated as $k$. Accordingly, an axial fan with five blades and 1,200 rpm (20 rps), for ex-

ample, would result in a blade-passing noise at a frequency of 100 Hz. We are all familiar with the unpleasant 'humming' noises that are typically generated as a result.

**Putting an end to 'humming' noises** The additional noises generated by heat exchangers and air conditioners are not only undesired, they are intolerable. This is particularly the case in residential environments, although eliminating these noises is far from easy. It is not possible to compensate for disruptions to the inflow by optimising the fan. Providing additional insulation for the housing also brings little success in practice, as corresponding insulation panels are typically only effective as of higher frequency levels. The fan specialist ebm-papst Mulfingen therefore took a different approach: if you improve the inflow of air to the fan, this reduces the turbulence and therefore also reduces the unpleasant low-frequency noises that are caused by this.

With this in mind, the Mulfingen engineers developed the special FlowGrid air inlet grille which has a straightening effect on the inflow-

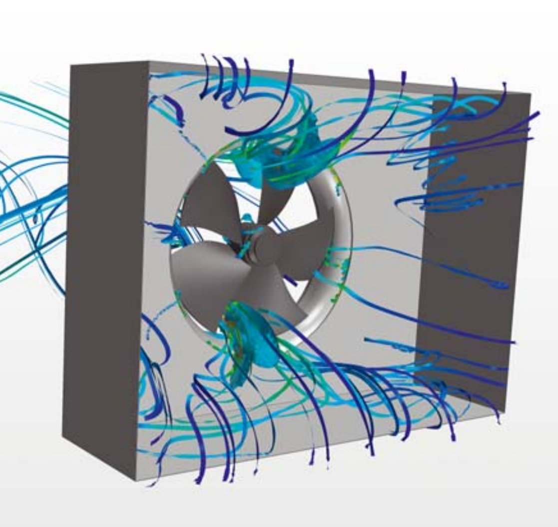

*Figure 1 (left): Typical inflow in customer device with turbulence*

*Figure 3 (right): The air inlet grille achieves a significant reduction in the sound pressure level and considerably weakens tonal noise. The figure shows the actual results of a noise measurement performed on a condenser.*

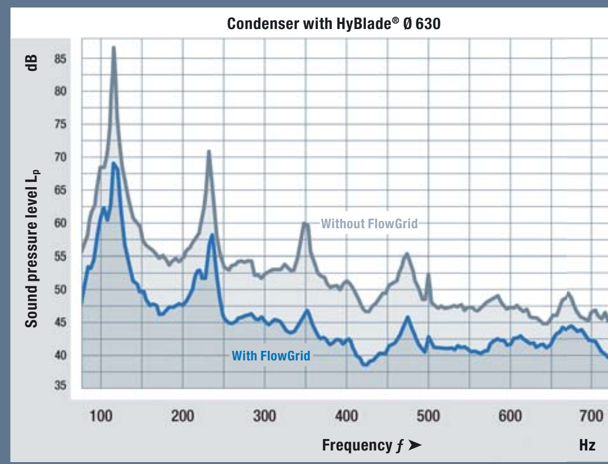


*Figure 2: The air inlet grille drastically reduces the noise-generating disruptions to the inflow and is equally effective with both axial and centrifugal fans. It has virtually no effect on power input and air performance.*

ing air (Fig. 2). This drastically reduces the noise-generating disruptions to the inflow and is equally effective with both axial and centrifugal fans. In the case of a condenser fitted with an axial fan, for example, the deployment of the air inlet grille reduces the noise level by 3.9 dB(A) and the tonal noise by 16 dB. With regard to a low profile air conditioning device (diameter 250 mm), the FlowGrid reduces the noise level by 2.5 dB(A) and reduces the tonal noise by 9 dB. Figure 3 shows the results of a noise measurement performed on an example condenser. The use of the air inlet grille reduces the sound pressure level and considerably weakens the tonal noise. Therefore, there is significantly less need for insulation and noise protection. The air inlet grille is made of injection-moulded plastic and satisfies various fire protection classes up to UL94-5VA. You can use screws to quickly and easily secure the FlowGrid to axial and centrifugal fans, and it is possible to implement any necessary application-specific adjustments while securing the FlowGrid. Depending on the design of the end device, it is even possible to retrofit the FlowGrid, for example in the course of any upcoming service work. In the case of a size 800 axial fan, the air inlet grille requires only around an additional 15 cm of installation space in the axial direction, which is typically available in the applications.

**A further option for acoustic improvement**
Purchasers in the field of ventilation, refrigeration and air conditioning technology can take additional action regarding noise reduction: further optimisations can be achieved with the help of another passive component. If users take a fan and combine the air inlet grille described above with an AxiTop diffuser on the discharge side, this both increases energy efficiency and reduces noise emissions still further – above all in the medium-frequency range. This means that the FlowGrid reduces the deep-frequency range, while the AxiTop is responsible for a further reduction in the medium-frequency range. In fans with free outflow, the exit losses that result from the operating principle are frequently underestimated as an energy consumer. The diffuser can help minimise these losses. It operates rather like a reverse nozzle and significantly reduces the exit losses thanks to its pressure-increasing effect (Fig. 4). Efficiency is increased and the operating noise is simultaneously reduced.

**Ideal operating conditions for fans** The acoustic improvement is primarily of interest when fans are in operation in environments where noise is a critical factor and the user additionally combines the diffuser with the air inlet grille (Fig. 5), for example when using a tested condenser. In this case, the outside air is drawn


*Figure 4: The diffuser reduces the noise generation in the medium-frequency range, and can be combined with the air inlet grille.*

through a heat exchanger. The condenser is fitted with an axial fan that has a diameter of 800 mm and runs a diffuser fitted on the pressure side. The noise level can be reduced by an additional 3 dB(A) with the help of the air inlet grille. Thanks to the combined use of the AxiTop and FlowGrid, the noise level is reduced by 5.8 dB(A) and the tonal noise is reduced by 20 dB – any persons present will find this to be very pleasant. Like the air inlet grille, the diffuser is also made from light, resistant plastic and is easy to mount and retrofit. As it is only 250 mm high it is generally not necessary to change the design of the application, even for the purpose of retrofitting. Purchasers will soon be able to benefit from the advantages of noise reduction in the low-frequency range: FlowGrid models sizes 450, 500, 560 and 630 axial fans will be available at the end of the first quarter of 2014. Versions for size 710 and size 800 centrifugal fans, as used in larger air conditioners, will also be entering series production soon; additional versions will follow. The AxiTop has already entered series production.

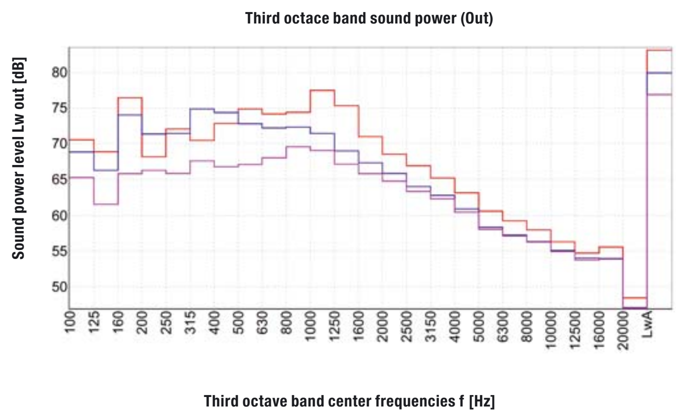


***Figure 5: The combined use of the AxiTop and FlowGrid resulted in a 5.8 dB(A) reduction in noise emissions from the tested condenser, primarily in the low-frequency range.***

Using passive components – the diffuser and the air inlet grille – the Mulfingen specialists have once again succeeded in continuing the development of fan technology and setting new standards. The optimisation of inflow and outflow provides ideal operating conditions for fans, enabling energy-efficient operation that is as quiet as possible. ○

***Authors are engineer Jens Müller and Michael Strehle, Aerodynamics Development at ebm-papst Mulfingen***

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# EC centrifugal fans for fan filter units

## Neat energy-saving solutions for clean-room applications

Tougher product quality requirements call for production in clean or ultra-clean rooms. Even the smallest of impurities in the air can adversely affect production processes and lead to high scrap rates. The air supply in such production environments needs to be almost 100 % free of dust and germs, and fans play an important role in this. However, they should be capable of more than simply "moving air". Besides the required air performance, compact dimensions, low noise emission, materials suitable for clean room use, appropriate controls, networking capabilities and energy-efficient 24/7 operation are among the crucial criteria.

Clean-room conditions are mandatory for many of today's production processes, not only in the semiconductor industry. Examples include optics and lasers, aerospace, biosciences, medical research and treatment, the production of foodstuffs and pharmaceuticals, and nanotechnology. Clean-room technology prevents contamination from compromising production processes and damaging the sensitive products (product protection). In addition, some production processes involve substances that may not be released into the outside air. Here, too, clean-room technology is necessary to prevent toxic or other reactive substances from leaving the protected area and endangering the environment or human health (personal safety).

**Energy-saving clean-room operation** Clean rooms impose special requirements on their ventilation systems (Fig. 1, page 14), including sufficient air throughput and pressure, exact regulation of temperature and humidity, and consistent air quality. This applies regardless of the air circulation method (Fig. 2, page 15) or the room size. These requirements can be met by so-called fan filter units (FFU), which combine filter

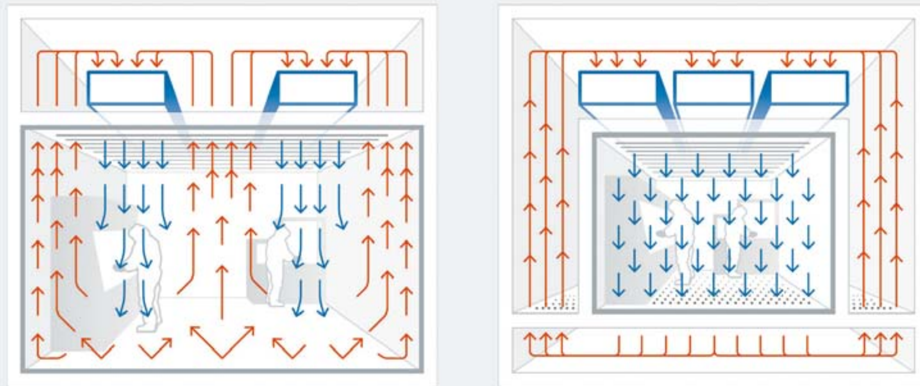

*Figure 1: Clean-room ventilation: There are two flow systems, turbulent (left) and laminar (right).*

## RadiCal® fans are 6-7 dB(A) quieter than the previous market standard

systems and fans and are designed for ceiling installation, particularly in large clean rooms (Fig. 3). The operation of clean rooms with FFUs is the most economical means of supplying extremely clean air. At the core of these FFUs are extremely compact, modular built-in fans with a very flat design that need little space for installation. Energy efficiency is becoming an increasingly important issue as air conditioning and ventilation consume by far the most energy in clean-room operation due to their high air exchange rates. Energy costs and efficiency were once matters of secondary importance, but this point of view is now being reconsidered.

Rising energy prices and the public interest in lowering greenhouse gas emissions have prompted all leading companies to focus on energy efficiency. Currently, FFU manufacturers have to guarantee overall efficiency of at least 50 % in clean-room applications. Not only are fans with a highly compact design called for, they also have to work efficiently. This makes GreenTech EC technology especially interesting for use in clean rooms, since FFUs equipped with it achieve efficiencies of more than 50 %, impossible with conventional fan technology. GreenTech EC fans can also meet strict requirements in terms of noise emission. In particular, RadiCal® fans are 6-7 dB(A) quieter than the previous market standard, a considerable improvement in both clean-room noise levels and worker comfort.

Motor and fan specialist ebm-papst Mulfingen offers a range of EC centrifugal fans specially designed for use in fan filter units and meeting all mandatory requirements for this application (Fig. 4, page 16). They are available in diameters of 310, 355 and 400 mm with air performance of 1170, 1750, and 2330 $m^3/h$ at a back pressure of up to 250-300 Pa. These fans are very compact thanks to their external rotor design, and with heights from 190 to 275 mm, they are also relatively flat, so they can be easily integrated in the equally compact FFUs.

**Easy control and networking** Thanks to their high efficiency, EC motors also generate little waste heat released into the circulated air, so the production environment is subject to less thermal stress, which reduces the demand on the cooling systems considerably. The speed of fans with EC technology can also be controlled smoothly and easily, so their air performance can always be adjusted to current needs. In terms of economy, this also makes sense as EC motors have a significantly higher efficiency in partial-load operation than motors based on other control concepts. After all, oversized air volumes will not necessarily lead to better product quality, but will inevitably result in unnecessarily high operating

***Figure 2: Plug fan module, ready for connection, for fan filter units (FFU, left), clean room ceiling FFU with filter for airborne particles on the bottom (right). (Photo: ebm-papst; M+W Group GmbH)***

expenses. The right setting for the application is crucial.

For demand-based operation, the EC fans can be controlled via an analogue 0-10 V signal or a digital RS-485 interface. The latter lends itself best to clean-room use, where several thousand fans are often in service in the FFUs. In such cases, the networking capabilities with Modbus or ebmBUS have proven very effective in practice. From configuration during commissioning to service, fault diagnosis and maintenance, making technical adjustments is considerably easier if the fans can be accessed from a central PC. The drives can be tied into the higher-level building management control system via the bus interface. The motor speeds can be smoothly adjusted via this interface, which provides a very convenient means of adjusting performance to meet demand. The air performance of the FFUs can be perfectly matched to the clean room's ambient and operating conditions. If a fan in the filter ceiling fails, it can be compensated for by increasing the speeds of the neighbouring FFUs. Such a strategy for dealing with failures provides a high degree of operational reliability by maintaining the correct air flow. From configuration and programming to alarm management, ebm-papst's FFU control software (Fig. 5, page 17), which is suitable for use with Modbus and ebmBUS, simplifies systems engineering tasks.

During operation, the user also benefits from other features of EC technology. The fans are very quiet; their drives have faultless noise properties throughout their speed range so they can meet the stringent noise suppression requirements applying to production in clean rooms. This low noise emission is mainly due to the aerodynamically optimised centrifugal impellers.

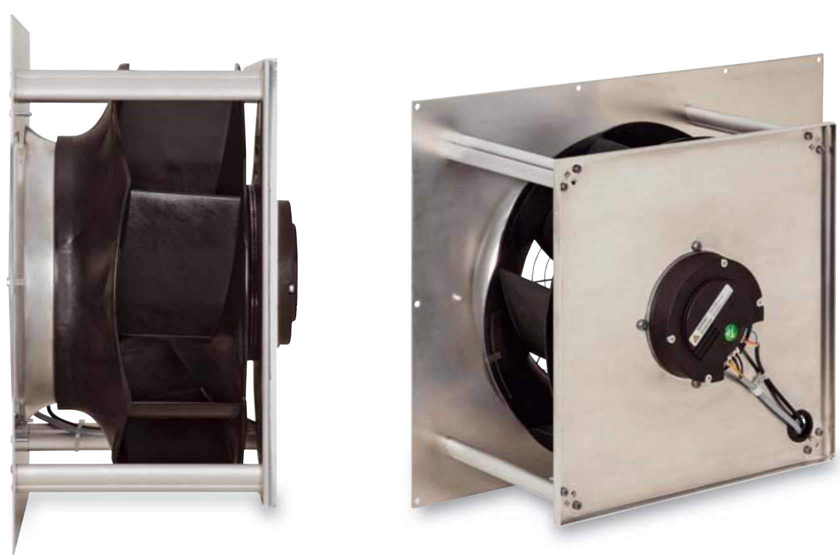

***Figure 3: Compact fans with energy-efficient GreenTech EC technology for use in fan filter units (Photo: ebm-papst)***

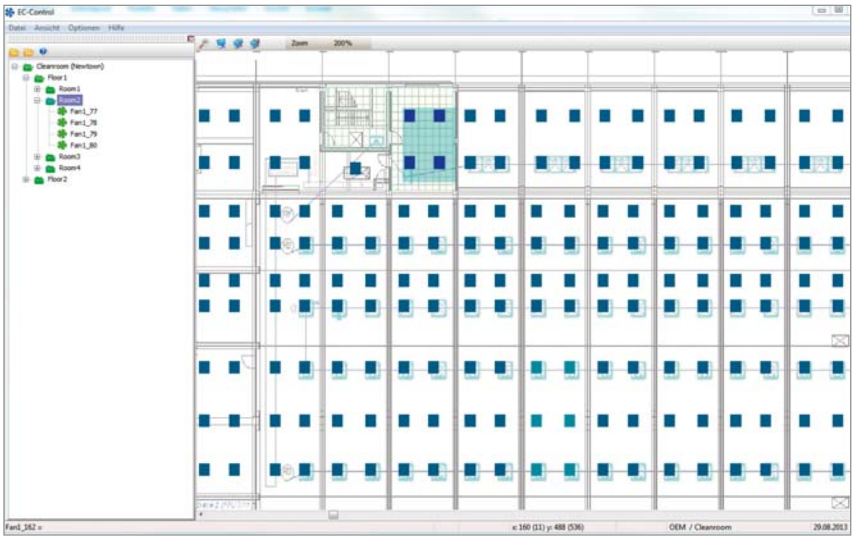

*Figure 4: The intuitive EC-Control software for EC fans networked via Modbus and ebmBUS.*

**In clean-room applications, too, users can now enjoy the full benefit of the innovative design of these plastic impellers.**

**Metal or plastic centrifugal fans** Whenever fans are used in clean rooms, their impellers are usually made of metal. There are always reservations when it comes to using plastics in the ventilation systems of clean rooms. The additives needed in plastics production are suspected of outgassing and endangering clean-room processes. The situation is completely different for applications where contamination by metals must be ruled out, such as wafer production. Here, fans made of plastic are clearly a blessing. To rule out risks to clean-room production that are associated with plastic particles in the circulated air, ebm-papst carefully analysed the issue of outgassing. The RadiCal® range of fans has been rigorously tested for substances prohibited in clean-room operation; these substances have been evaluated as per the semiconductor industry's ITRS standard. RadiCal® impellers from ebm-papst passed the relevant tests with flying colours. According to the test results, the plastics used are non-hazardous. The emission level of potential contaminants is well below the permitted limits. In clean-room applications, too, users can now enjoy the full benefit of the innovative design of these plastic impellers. After

*Figure 5: The RadiCal® fan line is especially suitable for use in fan filter units.*

all, plastic offers a considerably greater range of design options than sheet metals. The overall design of the fan results in an improved air flow through the impeller, significantly increasing the fan's aerodynamic efficiency. The rounded inlet contours on both the cover plates and the base plates of the impellers play a part in this, too. Moreover, the interaction between the inlet nozzle and the impeller inlet has been improved significantly.

These EC fans, in combination with the aerodynamically optimised plastic impellers or the proven aluminium blades, are energy-efficient, compact and adjustable components for fan filter units, well suited to the requirements of clean-room applications in every respect. Their performance has been proven around the world, including clean rooms in which flat screens are produced. For good reason, the market leaders from Korea and Taiwan chose GreenTech EC technology from ebm-papst for the production of their big flat-screen products.

*Author is Andreas Fessel, Sales Engineer at ebm-papst Mulfingen*

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# What to look out for in vehicle LED headlights

## Energy-saving lighting demands new solutions

The power density of modern LEDs makes it possible to use this type of lighting in vehicle headlights. The actual light source is insensitive to vibration and shocks. But like any other electronic component, it also needs to be operated within certain temperature limits. Small fans specially adapted to the needs of headlight operation offer a solution. To adapt the headlight to the car's needs, all components need to fulfil a few basic requirements. This also applies to the fans that are used.

Constantly higher light output from comparably small chip surface enables light developers to produce headlight units that are small and compact. This opens new possibilities for vehicle design and saving energy, as LED headlights potentially require less energy than other illuminants, with better light values. In ten cycles of the New European Driving Cycle (NEDC), one vehicle model displayed a $CO_2$ reduction of more than one gram per kilometre. The European Commission therefore officially classifies the LED headlight as innovative technology for lowering $CO_2$ emissions. The semi-conductor elements and their control, which are largely resistant to mechanical influences, present however fundamental requirements for intelligent thermal management in the headlight housing. The developers at ebm-papst have taken on this challenge and have developed compact and robust fans, which are specially adapted to the demands of the new headlight technology (Fig 1, page 20). The most important fan characteristics for functioning thermal management in LED headlights are described in detail below.

**LED technology requires new ways of thinking** When you compare the old lamps with modern LED lights, there are many differences. Often the focus is solely on efficiency, i.e. the much greater energy efficiency of LEDs and the potentially better colour temperature of the light. Modern semiconductors now achieve degrees of efficiency that are four times greater than those of halogen headlamps. In numbers, that is currently around 90 lumens per watt, equivalent to a 75 W bulb or a car headlight with a 55 W halogen light. The high luminance generated on a very small chip surface means that the chip is subjected to a high local heat stress.

Substantial waste heat is generated even in an LED with a current physical efficiency of around 30 %, plus the losses in the optical sealing compound and in the ballast module. Even in an energy-saving LED headlight housing, with several LED chips the amount of heat to be dissipated adds up to a few watts quickly. As semiconductors generally become less efficient at higher temperatures, also known as “derating”, the LED substrates also suffer efficiency loss


*Figure 1: Ruggedly designed fan that resists vibrations, shocks, heat and cold in the headlight housing.*

## The design principles of modern LED headlights call for reliable thermal management

as chip temperature rises. This leads to shorter service life. Different limits apply, depending on the chip type. A possible service life of 100,000 hours (11.4 years) for a chip in a well cooled environment quickly becomes "only" 15,000 to 30,000 hours. The same is true of components in the ballast unit. A fall in temperature of just 10 °C, for example, can double the service life of electrolyte capacitors, i.e. from 5,000 hours at 105 °C to around 40,000 hours at a moderate 75 °C. Another reason for the need for reliable cooling processes is that modern headlamps are legally required to be delivered only as compact units, which do not allow for component replacement. According to the internationally valid ECE requirements, LEDs for automotive technology may only be installed in cars as modules. This means that the diodes must be encapsulated in a component in a way that protects them from manipulation.

**LED cooling is more than just moving air**

Ambient air is the coolant of choice in operation around the world. A fan built into a headlamp can apply this air precisely to the areas where heat must be dissipated or where air is otherwise required (Fig. 2). The latter is also important for LED lights. Depending on the ambient conditions, air moisture can gather in non-hermetically sealed headlight housings. This steams up the reflector and the lens. Due to the low levels of waste heat compared to traditional halogen lamps, this water only evaporates if the (waste) air is conveyed precisely in the housing. The fan used therefore assumes a further task vital for the reliable operation of the headlight, alongside the purely cooling function. This requires the operating noise to be kept to a minimum. An aerodynamic impeller with winglets or sickle-wing profile aids this further.

But there are other things to consider. In a vehicle, the required operating temperature range is between around -40 °C to +120 °C. There are also the various climactic factors such as air moisture and salt content, as well as any dust that may be in the air. When driving, attention also has to be paid to the additional vibration, shock and impact stresses, as well as electromagnetic influences. A fan needs to be able to resist these, whilst having the most compact construction possible. Furthermore, the materials used also need to be resistant. The plastics used, for example, may not release plasticizers (so-called fogging) as these can lead to the headlight becoming permanently blinded. Plastics that prevent fogging require other processing parameters, for example oil cooling instead of water cooling in the injection moulding tool and adjusted cycle times. Even seemingly trivial things must be taken into account, such as laser marking for bar codes and type designations instead of the usual (adhesive)

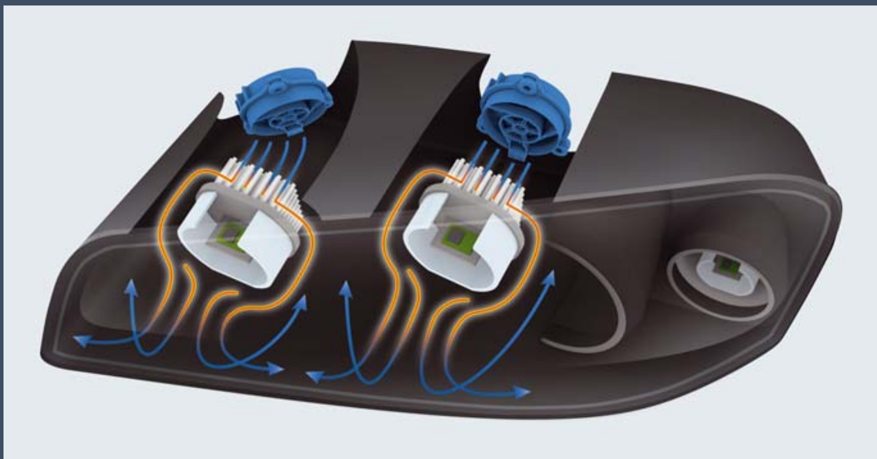

*Figure 2: LED cooling is more than just moving air.*

labels or ink marking. Our ability as a manufacturer to fall back on decades of experience and expertise in development and production is something that end users quickly recognise in the reliability and long service life of our products.

If the fan is mechanically stable, with maintenance-free bearings and made from fogging-resistant materials, the next question is that of operating parameters. Integrated motor electronics with outward data interface allow the fan to be used universally in a range of applications, as well as for fine tuning the thermal management in individual headlights via the vehicle's on-board electronics, for example by changing the speed to adjust air flow.

The design principles of modern LED headlights call for reliable thermal management. Small, rugged fans exactly tuned to the specific characteristics of the vehicle and of LED technology ensure reliable dissipation of excess heat, allowing trouble-free headlight operation for more than a decade. The very tight integration of optics, electronics and cooling in an LED headlight calls for early design consultations among all specialists to ensure optimum results in terms of economic and lighting efficiency.

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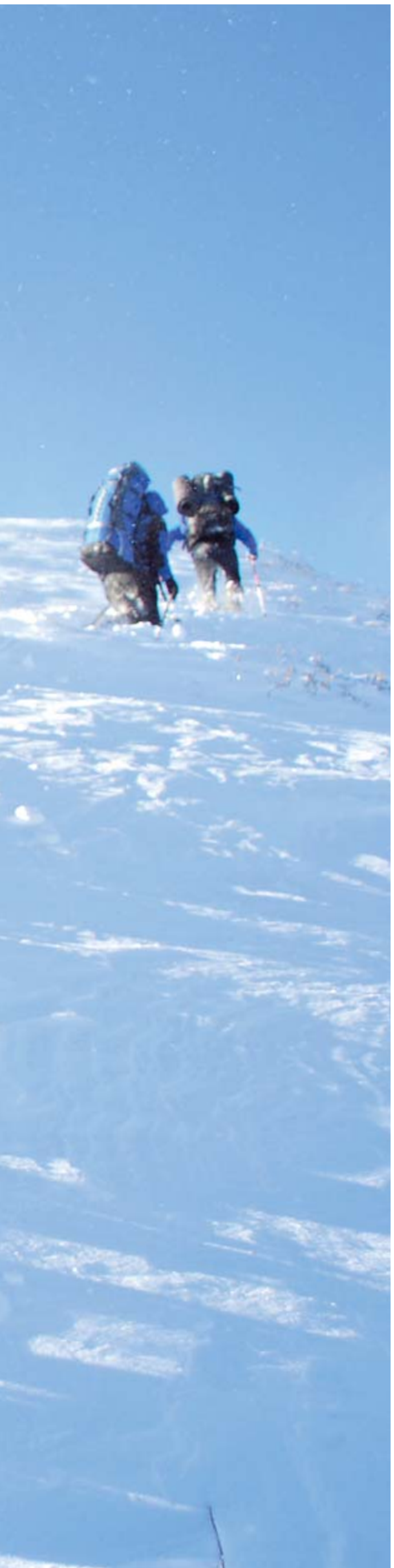

# Fit for frigid environments

## Axial fans for cooling units and evaporators

Besides efficiency, especially important requirements for fans used in evaporators today are service life and ruggedness as well as compact dimensions permitting the production of space-saving evaporation units. Moreover, convenient service access is important for activities such as cleaning and de-icing the devices. The air throw also plays an important role in distributing cold air to a cold store's remotest corners. Fans designed especially to meet such requirements provide a variety of benefits. Not only do they improve ease of use, they also help to protect valuable chilled goods as well as contributing to reduced energy costs. In this respect, designs with GreenTech EC technology deliver particularly impressive results.

Axial fans in evaporators have to withstand difficult conditions (Fig. 1, page 24). Work on the cold side of the cooling circuit is very demanding. Ice formation and removal, which often require crude tools, call for rugged solutions that also work reliably in harsh conditions. While develop-

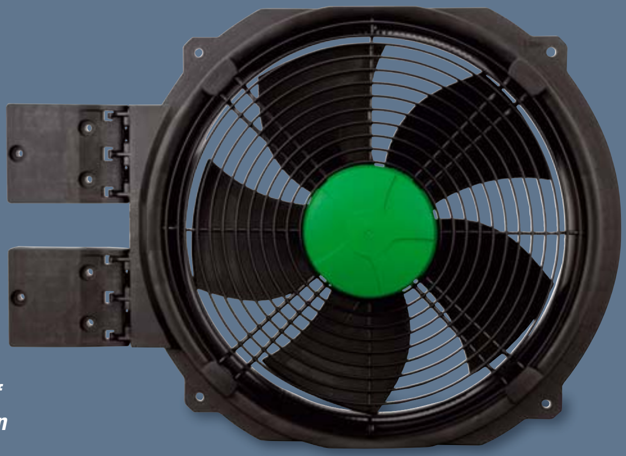

*Figure 1 (left): The rugged axial fan series is specially designed for evaporator applications.*

*Figure 2 (right): AxiCool is a series of compact fans for evaporators, shown here with optional hinge.*

**The optional air-guiding system nearly doubles the fan's air throw while increasing the flow resistance only minimally so that the air volume stays nearly constant.**

ing the AxiCool series, motor and fan specialist ebm-papst Mulfingen gave special consideration to such requirements. Thanks to their many practical design details, the new axial fans are ideally adapted to their field of application, simplifying compliance with hygiene regulations (Fig. 2).

**Ice formation less worrisome; defrosting cycles optimised** Unfortunately it will never be possible to avoid ice formation on heat exchangers and fans completely, but it can be minimised with an attendant extension of maintenance intervals. This wish, expressed by many users, was realised by the developers of the new series with a variety of measures. For example, the wall ring and fan blades are made of rugged plastic, a material for which ice formation is less of a worry than it is for metal-based designs to begin with. By contrast, the fans' safety grilles are still made of metal. The reason is clear enough when one considers that in practice, ice is also removed from the grille by mechanical means. In addition, the metal safety grille is not curved, making cleaning easier. This hybrid design makes the overall system robust and specially designed for this application.

The wall ring's two-part construction is a further practical design detail that counteracts ice formation and optimises defrosting cycles by making it possible to retrofit a heating tape when needed. Installing the heating tape directly in the wall ring has the benefit of avoiding unnecessary heat transfer into the cold store because the hollow space acts as insulation (Fig. 3). Heat originates where it is needed, reliably preventing ice formation between the fan blades and the wall ring where it could block the fan.

**Melt water, hygiene and cleaning** Drainage channels on the inside of the wall ring ensure that melt water, such as that formed during regular de-icing, can drain in the direction of the drip pan that is normally installed on the evaporator (Fig. 4). This also keeps the fan blades from freezing up when cooling is resumed and averts the danger of water being sprayed into the cold store when the fan restarts. This feature gains in significance as hygiene requirements become more stringent. For example, contamination by splash water must be prevented for foodstuffs in open storage.

Convenient cleaning also plays an important role, especially in connection with hygiene requirements, and the fans' surface design allows for this. Flat, smooth surfaces keep the rate of contamination build-up low to begin with. The motor is protected from splash water for additional protection during cleaning with a water jet. Fan designs with a swivel joint in the integrated mounting flange also simplify required servicing

*Figure 3 (left): The heating tape can be inserted into the removable ring after installation; it prevents unnecessary heat transfer into the cold store.*

*Figure 4 (right): Integrated drainage channels reduce water accumulation in the wall ring, decreasing the danger of impeller freeze-up.*

such as cleaning the heat exchanger. The technician simply loosens the attachment screws and can then swing the fan to the side (Fig. 5).

**Air-guiding system for increased air throw** Fans used in cold stores face further requirements. For instance, the distribution of cold air needs to be as uniform as possible, so their air throw becomes a key criterion. The AxiCool series thus includes an optional air-guiding system (Fig. 6) that nearly doubles the fan's air throw while increasing the flow resistance only minimally so that the air volume and with it the refrigeration capacity stay nearly constant (Fig. 7a + 7b, page 26). It can be said to "replace" the safety grille; it is easily installed and can also be retrofitted without difficulty at any time. Problem-free removal facilitates easy cleaning, e.g. with a dishwasher.

The axial fans in the AxiCool series are available in sizes of 300, 350 and 450 mm. With their air performance ranging from 800 to 6,200 m³/h, they are suited to a wide variety of typical evaporator applications (Fig. 8, page 27). Both directions of air flow are possible for the designs with safety grilles. The AxiCool series is available for operating temperatures to -40 °C; its external-rotor design allows for very compact dimensions. The complete evaporator unit thus requires little space. The fans already exceed the 2015 ErP requirements today and are available in identical dimensions with both AC and energy-efficient GreenTech EC motors.

**Designs with EC motors for especially high efficiency** EC motors produce less waste heat than AC motors because of their significantly higher efficiency – a major advantage for refrigeration applications. At the same time, their energy consumption is lower. For example, for a size 350 fan it is 25 % lower than for the same design with an AC motor. That pays off in practice: at an air volume of 2,500 m³/h the EC fan consumes 42 W less than the AC version. In addition to the direct energy savings resulting from the fan's reduced power consumption, the waste heat it transfers into the cold store also needs to be considered. The refrigeration process has to use electrical power to remove this waste heat. All told, in the overall refrigeration process savings of approximately 55 W can be achieved with the EC fan. Given an electricity price of 0.13 euro/kWh and a working time of 6,000 h/year, the savings per fan add up to 43 euros per year.

As an additional advantage, the user can choose between a two-step motor design or a demand-based control system using a 0-10 V signal that simplifies customised adaptations for special refrigeration requirements. Typical example applications include maturing processes for

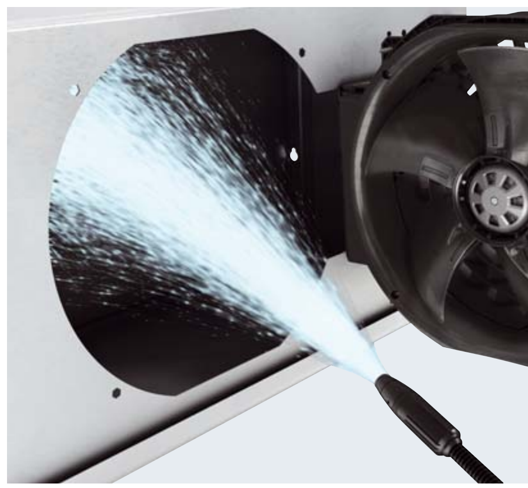

*Figure 5: The fan can be swung open for easy cleaning of the evaporator unit.*

*Figure 6 (left): The air throw can be nearly doubled with the optional air-guiding system.*

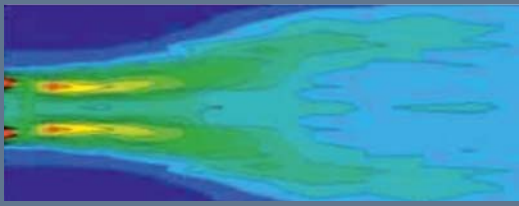

*Figure 7a (top right): Air distribution without air-guiding system.*

*Figure 7b (bottom right): Optimum air distribution with air-guiding system.*

cheese storage, or the storage of sensitive fruits and vegetables. In addition, the aeroacoustically optimised design of the fans with HyBlade® plastic impellers allows for noise reduction of up to 4 dB(A) in comparison with typically available solutions using sheet metal blades. As a compact, efficient Plug & Play solution perfectly tailored to its application, the AxiCool series has a wide variety of uses.

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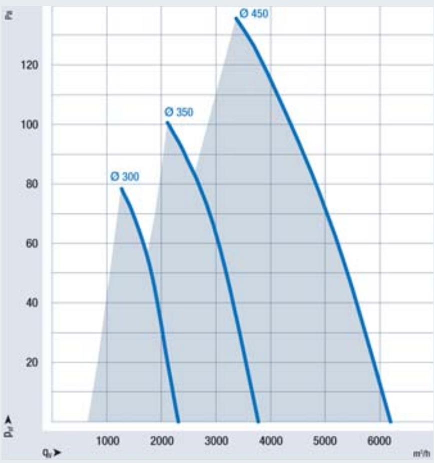


**Figure 8: AxiCool air performance range**

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