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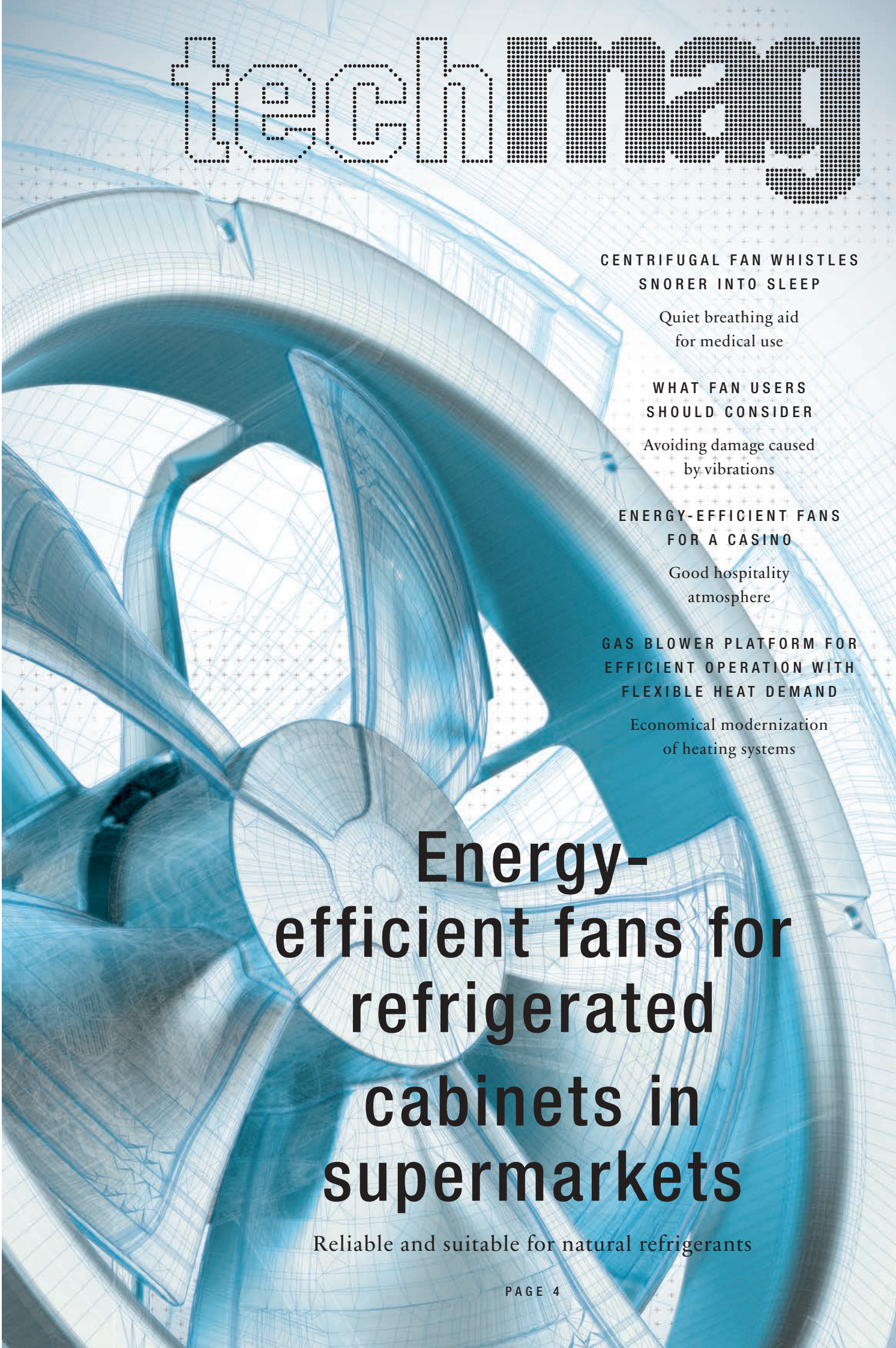

CENTRIFUGAL FAN WHISTLES SNORER INTO SLEEP

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Bernd Kistner

DIRECTOR MARKET SEGMENT
REFRIGERATION
EBM-PAPST MULFINGEN

“Staying a step ahead”

Dear Customers, Partners and Friends of ebm-papst,

There has never been a greater need for clean and efficient refrigeration technology. In the coming years, many of today’s refrigeration systems will no longer satisfy statutory requirements. Refrigeration faces additional challenges from uncertain price trends for HFC refrigerants and steadily rising electricity prices, making it all the more important to invest now in new technologies.

The path ahead is clearly indicated by the adopted Ecodesign Directive and the F-gas Regulation; the latter calls for a step-by-step reduction of nearly 80% by 2030 in the CO_2 equivalent of fluorinated refrigerants brought to market.

The right solution for every challenge

What does this mean for fans as components? On the one hand, we have to ensure that fans satisfy the safety requirements for use of natural refrigerants; on the other, we need to see to it that they work quietly and with maximum efficiency in their applications. In addition, demands on connectivity are constantly increasing, for example to provide extra customer benefits such as predictive maintenance or a further increase in overall system efficiency. Both are important aspects of the total cost of ownership and are enormously important to operators looking to significantly reduce real operating costs. Our innovative fans for refrigeration and freezing applications satisfy these requirements and ensure safe and efficient operation.

We have made these subjects our focus at this year’s Chillventa trade show in Nuremberg and want to share our smart, networked solutions for them with you there. Contact us so we can work with you to find the best fan for your application.

When you read this issue, you will find out how we have worked with our customers to do that for concrete applications. I hope you enjoy your read!

Reliable and suitable for natural refrigerants

Energy-efficient fans for refrigerated cabinets in supermarkets

The fans used in refrigerated display cases and bottle coolers in the commercial food sector have very long operating times; and so they offer great potential for saving energy. Thanks to their high efficiency levels, EC fans have set new standards in this field. Versions conforming to the European standard EN 60335-2-89 are even suitable for applications involving the use of flammable refrigerants such as R290 (propane), which can form explosive mixtures with air in the event of malfunctioning. What's more, their intelligent networking capability simplifies servicing and maintenance.

FIGURE 1: **Modern supermarkets are inconceivable without fans, as the compact refrigerated cabinets for medium and low temperature refrigeration systems could not operate without them.**

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Fans have become indispensable features of supermarkets, as the compact refrigerated cabinets for medium and low temperature refrigeration systems could not operate without them (Fig. 1). On the one hand the fans ensure that the air circulates around the device, thus keeping all the stored products equally cool. In plug-in refrigerated cabinets they are also used to dissipate heat to the surroundings, or to the central condenser in the case of so-called remote systems. Up until a few years ago, shaded-pole motors were the standard method of driving the fans. There were good reasons for this: Such motors are cheap to make, robust and long-lasting. Their low level of efficiency of just about 20% however means that they are no longer acceptable these days. They have a high current consumption and also produce waste heat that has to be dissipated from the refrigerated cabinet. And so the use of shaded-pole motors is now generally restricted to just a few niche applications.

The energy-saving solution: EC motors as the driving force

Instead, modern fan concepts are based on the far more efficient electronically commutated EC motor, requiring roughly 70% less energy than the old motor design. As motor and fan specialist, ebm-papst has several such energy-efficient motor versions in its range that are positively predestined to be used as fan drives in refrigerated cabinets: More than ten years ago, the energy-saving motor – known as ESM – was already setting new standards in fan technology for refrigeration applications (Fig. 2). Operating with an efficiency of up to 70%, its power consumption is only a third of that of a comparable shaded-pole motor and it

Instead, modern fan concepts are based on the far more efficient electronically commutated EC motor, requiring roughly 70% less energy than the old motor design.

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FIGURE 2: **Operating with an efficiency of up to 70%, the power consumption of the ESM motor is only a third of that of a comparable shaded-pole motor and it offers the option of demand-based speed control.**

also offers the option of demand-based speed control. The lower power loss of the EC motor saves yet more energy in refrigerated cabinets. It has a design service life of more than 40,000 hours, corresponding to approx. 5 years in continuous operation.

The compact EC motors are available both as OEM components for combination with a separate impeller and as complete plug & play systems with perfectly matching individual components. The axial product range with sizes of 130, 154, 172, 200, 230, 250 and 300 is intended for installation beneath the shelves of refrigerated and freezer cabinets. By contrast, the fans with diagonal impeller of sizes 200 and 250 were designed specifically for installation in the back wall of refrigerated display cases, where installation space is often at a premium (Fig. 3). Thanks to their extremely shallow design, these fans fit in confined spaces and the diagonal fan design makes them well equipped to deal with the higher back pressure encountered in such situations.

Tangential blowers, which likewise operate with EC motors and circulate the cold air in the form of an air curtain, have also been successfully used as efficient solutions for refrigerated cabinet applications for many years now. These are particularly space-saving and quiet-running (Fig. 4).

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FIGURE 4: **Tangential blowers, that likewise operate with EC motors and have a large air distribution area, are a further interesting option for refrigerated cabinet applications.**

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FIGURE 3: **The axial product range is intended for installation beneath the shelves of refrigerated and freezer cabinets. By contrast, the fans with diagonal fan impeller were designed specifically for the back wall of refrigerated display cases.**

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FIGURE 5: **The power-saving NiQ motor is mechanically compatible with shaded-pole motors and permits simple 1:1 replacement.**

Depending on the ambient conditions, the service life of the NiQ motor may exceed 40,000 hours.

Given the energy savings that can be achieved, it is even well worth converting older refrigerated cabinets. ebm-papst can offer the energy-saving NiQ motor for this purpose (Fig. 5). Depending on the ambient conditions, the service life of the NiQ motor may exceed 40,000 hours. It is mechanically compatible with existing shaded-pole motors, has a high efficiency level of up to 70%, and its identical installation dimensions permit simple 1:1 replacement. Axial impellers with a diameter of 154 to 254 mm can also be fitted on the NiQ motor to provide a power-saving solution.

Reliability: Keeping a constant watch on the fans

Alongside the lowest possible energy consumption, reliability is another important aspect with regard to refrigerated cabinets in supermarkets. The 1.25 m long standard elements are normally fitted with one to two fans. If a fan fails, it is important to localize and rectify the fault quickly without any adverse effect on the cooling chain and before any food perishes. Preventive maintenance and fan monitoring are also useful.

Networking via the serial interface for communication via MODBUS-RTU is helpful in this case. It permits the implementation of numerous surveillance, control and regulation functions in real time by way of remote monitoring. For instance, it is possible to monitor motor operating times with regard to preventive maintenance and to simply localize the fan concerned when service work is needed. Networking via the MODBUS-RTU communication protocol also permits rapid adaptation to changes in operating conditions, for example the cooling temperature can be attained more quickly after defrosting cycles by increasing the fan speed.

Does it really always have to be ATEX?

A further major issue with regard to refrigerated cabinets is the refrigerant used. Modern refrigerants must be safe for the environment

and have a low global warming potential, whilst at the same time providing good refrigeration performance. Since January 1, 2015 this has been regulated by the directive (EU) 517/2014, also known as the fluorinated gas directive (Fig. 6). Alongside ammonia and CO_2, natural refrigerants such as isobutane, propane and propene are thus becoming increasingly popular as an ecological alternative to (partially) halogenated refrigerants. In the event of malfunctioning, the non-toxic hydrocarbons can however form readily explosive mixtures with air.

Motors and complete systems from ebm-papst are made to satisfy the requirements of the European standard EN 60335-2-89 (household appliance standard titled "Particular requirements for commercial refrigerating appliances") and so can safely be used for cooling applications in this sector. This is fully adequate for the majority of refrigerated display cases, as their cooling circuits work with the 150 g maximum refrigerant quantity set down by the standard. Using ATEX components makes no commercial sense in such cases. It is also not sufficient to just use a motor with an ATEX label. The entire fan must have the appropriate approval and the operator has to define an explosion hazard area. The latter is often particularly difficult to implement in supermarkets. In the case of high-capacity refrigeration circuits it may therefore be appropriate to split up the circuits. If that is not feasible, another practical energy-saving alternative does exist with which users can be on the safe side even with refrigerant quantities exceeding 150 g: ebm-papst can also offer fans with an energy-saving motor with ATEX approval II 3G Ex nA IIA T4 Gc. The fans are conform to the ATEX standard EN 60079 and are therefore also authorized for use in large refrigerated display cases as well as composite and cascade systems using more than 150 g of flammable refrigerant. O

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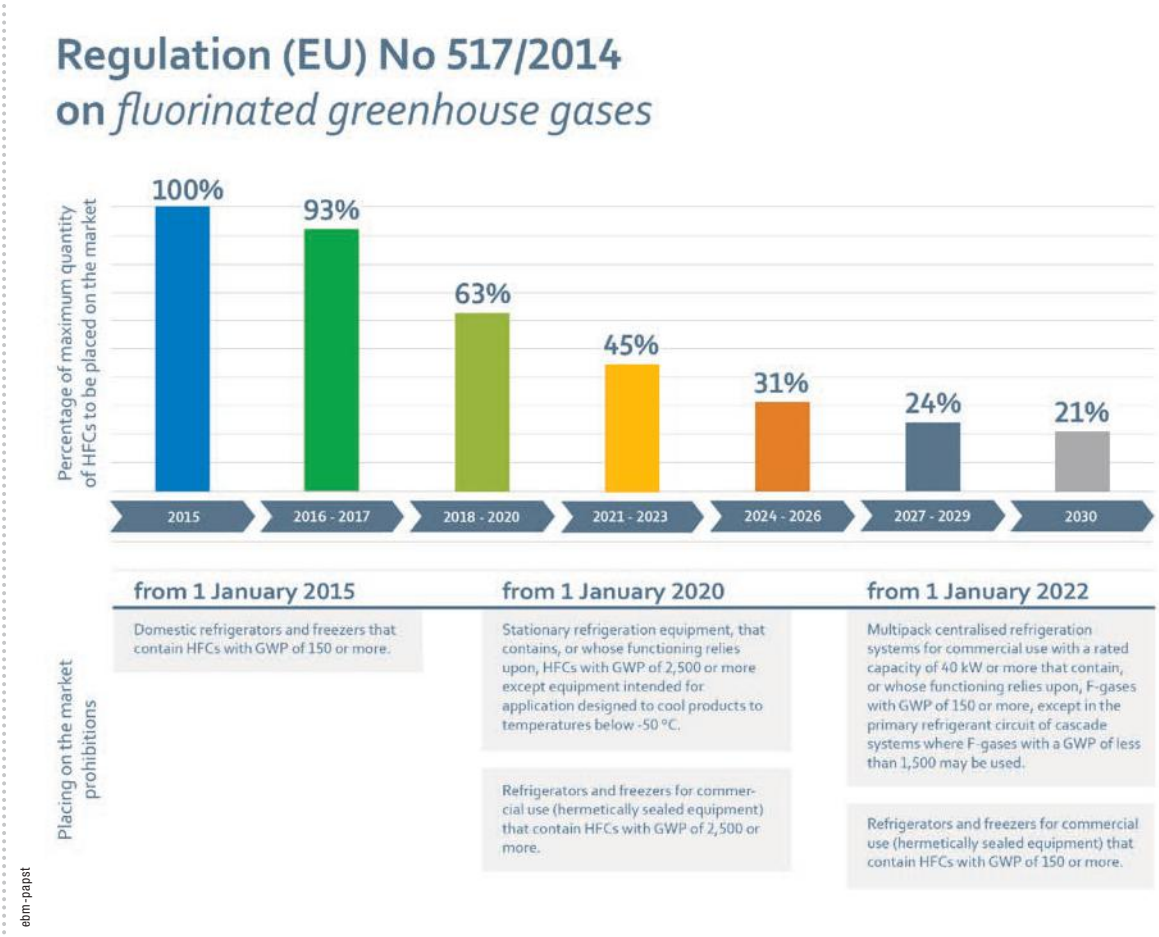

FIGURE 6: **Directive (EU) no. 517/2014 on fluorinated greenhouse gases, also known as the fluorinated gas directive, has been in force since January 1, 2015.**

Centrifugal fan whistles snorer into sleep

Quiet breathing aid for medical use

Loss of breath during sleep, also known as sleep apnea, affects many people over 40 years of age. The number of people affected is in the double-digit percentage range, the ratio of men to women is about 5 to 1, daytime fatigue and attention deficit are the obvious effects of the disease. If untreated, it can also lead to hidden complications such as high blood pressure, cardiac insufficiency (diminished cardiac output), heart rhythm disturbances or myocardial infarction. A proven form of therapy supports the body's own respiratory reflexes through the controlled injection of air into the lungs. A new, highly dynamic centrifugal fan now supports breathing through the controlled supply of fresh air. The lightweight, efficient small fan is also well suited for long battery operation, for example for a mobile sleep therapy device. Other applications in medical technology include mechanical intensive care ventilation, mucus secretion mobilization and mobile air filter technology, e.g. respiratory protection devices.

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The reliability of medical devices and their components is particularly important. Particularly when using apnea machines at home or as a ventilator in the intensive care unit, simple operation is also important. If, for example, a ventilator is used during sleep, such a device must be located close to the user and must not interfere with healthy sleep due to operating noises. In order to meet these requirements, the fan and drive specialist ebm-papst from St. Georgen in the Black Forest developed the RV45 centrifugal fan for respiratory protection devices and similar dynamic applications that meets these requirements – safe, reliable, efficient and quiet (Fig. 1).

How does mechanical ventilation work?

The technology behind it is easy to understand: Air pressure generated by the fan inflates the lungs and thus supports breathing. But the trick is in the details: The application requires highly dynamic fan operation, meaning very rapid changes in speed. However, smooth running in dynamic operation is not easy to implement. The biological properties of breathing demand swift and smooth control of the air flow and pressure. For example, it is often necessary to generate a high "blowing pressure" for a short time at the beginning of the inhalation sequence. This pressure raises the flaccid soft palate and allows air to enter the windpipe. However, this "initial high air pressure" may only be applied very briefly and it must rise quickly, but not abruptly, in order to give the palate the necessary time to clear the windpipe. After opening the soft palate, the pressure must be quickly reduced to the inhalation level prescribed by the doctor and sustained at this level. To match the patient's respiration, the supporting flow rate and pressure must be constantly adjusted. In order to exhale, the pressure must then drop quickly again, but not abruptly, in order to allow unhindered exhalation. For the breathing dynamics, approx-

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FIGURE 1: **The RV 45 offers highly available, efficient and quiet air delivery.**

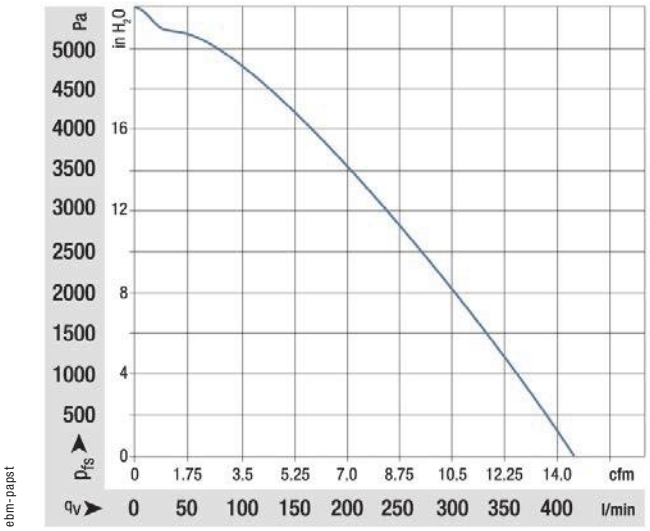

FIGURE 2: **The maximum flow rate is freely blowing up to 410 l/min and the maximum pressure increase is over 5,000 Pa.**

The compact fan RV45, which has been optimized in terms of aerodynamics and motor dynamics, provides the necessary air flow and drive technology.

imately 200 ms control time is typical with volume flows around 150 l/min and pressure fluctuations from 400 Pa to 2,000 Pa. The pressure should be kept as low as possible and never exceed 3,500 Pa to avoid lung damage. On the other hand, the adjustable high volume flow rate is important in order to be able to reliably compensate for leaks, e.g. in the respiratory mask due to poor fit or in the case of bearded wearers. In order to regulate the necessary variation in volume flow and pressure in practice, the speed of the centrifugal fan must therefore be quickly increased or decreased. The compact fan RV45, which has been optimized in terms of aerodynamics and motor dynamics, provides the necessary air flow and drive technology. Despite the strongly fluctuating operating conditions, the RV45 meets the absolute quietness required so as not to disturb the sleep of the patient or anyone else sleeping nearby.

Technology in medical service

How can the different requirements be translated into a product that can be used as universally as possible? The basic prerequisite is the use of FDA-compliant materials for air-contacting parts that meet all relevant regulations worldwide. At the same time, the entire aerodynamics of the fan was adapted to the application. Both at high and low revs, the air flow noise was significantly reduced. The RV45 is designed for use in CPAP (Continuous Positive Airway Pressure) and for operation with automatic pressure

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FIGURE 3: **If the fan is installed in a suitable, noise-damping device housing, no disturbance is to be expected even at night.**

Depending on the medical device, the user can provide their own specifically optimized control system.

adaption (APAP/auto APA and BiLevel/BIPAP). The motor, control electronics and the aerodynamics are designed in a way that each part supports the other in order to reach those diverse requirements by synergy.

In order to equip the centrifugal blower optimally for the widest possible range of applications, the Black Forest specialists chose a highly dynamic, EC (electronically commutated) internal rotor motor as the drive. The low moment of inertia of the rotor equipped with a powerful magnet accommodates the required dynamics. The magnet and coil design, was further optimized through extensive simulation and testing. At the same time, the detent torque and structure-borne noise excitation have been minimized and efficiency improved. Since only the bearings of the EC motor are subject to wear and tear, the use of maintenance-free ball bearings with special grease lubrication enabled the service life to be increased to 50,000 hours L10IPC (25 °C) after the stricter, in-house ebm-papst test conditions were passed. This corresponds to about 6,250 nights or about 17 years with 8 hours of sleep per night.

Because the delivery rate (linear) and the delivery pressure (square) of a centrifugal fan impeller increase with the speed, the high speed of up to 50,000 rpm allows the fan to be very compact. The motor drive and control electronics are not included inside the RV45 blower and must be provided externally, which offers advantages in matching the fan to the respective task. Depending on the medical device, the user can provide their own specifically optimized control system. However, for a wide range of standard tasks or fast test operation, a control module from the manufacturer is available which is specially adapted to the motor. This "Power Module RV45" is suitable for simple speed control and includes a tachometer output, thus offering a plug & play solution for the customer. This can be useful in both medical and industrial applications, e.g. for the dynamic ventilation of fuel cells, air filter technology, packaging

machines, smoke detection systems, printed circuit board production or exhaust air systems for soldering and welding gases as well as breathing apparatus and similar devices. A version of the RV45 fan with Hall IC sensors in the motor, for a simpler in-house development of the control electronics including an NTC temperature sensor option, is available as a customer option.

Economical and compact

The RV45 is very compact with only 64 x 69.5 x 54.5 mm and is available for operation on two voltages 12 and 24 VDC. The power consumption is around 43 W in free blowing operation, but running in typical applications with speed control can often average 20 W lower, which also ensures long running times in battery operation. The possible high power consumption is indispensable for the short-term "sprint" in order to fulfill the requirements on high dynamic operation. The maximum free blowing air flow is up to 410 l/min and the maximum pressure increase is over 5,000 Pa (Fig. 2, p. 13). This is sufficient for large lung volumes, heavy soft palate cases or for use in secretion mobilization. All air-contacting parts of the 135 g lightweight fan are constructed from FDA compliant materials which are harmless to human respiratory physiology. Thanks to the selected vibration damping materials and the optimized aerodynamic design, the operating noise is minimized and is at a level similar to a whispering conversation. Built into a suitable, sound-absorbing housing, any sleep disturbance will be minimal (Fig. 3, p. 14). ○

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SLEEP APNEA: WHAT IS IT?

About 10% of all sleepers over 40 years of age are affected by sleep apnea worldwide, i.e. temporary respiratory arrests that occur during sleep. Sleep apnea syndrome is likely to occur if there are more than ten respiratory arrests per hour that last longer than 10 seconds. The periods of breathing cessation occur up to twenty times an hour in severe cases. The breathing pause is registered in the sleeper's brain and overcome by an awakening reaction. This wake-up reaction is vital and prevents suffocation but disturbs sleep. The sleeper changes from a deep sleep stage to a superficial sleep. Snorers in particular are affected by this disease. Due to sleep disturbances and lack of oxygen supply during the respiratory arrest phases, the patient feels unrested and tired in the morning, often with daytime sleepiness and a lack of attention. In addition, chronic untreated apnea syndrome can often lead to high blood pressure, heart failure (diminished cardiac output), cardiac arrhythmias and an increased tendency to heart attacks and strokes.

What fan users should consider

Avoiding damage caused by vibrations

Fans used in ventilation, refrigeration and air conditioning or other industrial applications are generally subjected to rigorous testing by their manufacturers and have to prove themselves in long endurance tests under harsh conditions. But in practice, failures still occur after far fewer hours of operation than specified in the technical documents. Ruined motor bearings are a typical kind of damage, usually caused by vibrations resulting from the way the fans are installed.

The heart beats, wings vibrate, music is played and heard – life without vibrations is difficult to imagine. Even though vibrations are everywhere and have beneficial uses, they can also be destructive. Poorly balanced car wheels can cause the steering wheel to shake, and vibrations can loosen screws or damage ball and roller bearings. Even large structures can collapse when they are subjected to rhythmic vibrations at their resonance frequency, because then a system capable of vibration can absorb large amounts of energy, which can lead to catastrophic failure. That was what happened when the Tacoma Narrows Bridge collapsed in 1940 after being forced into oscillations by unusual wind conditions, only a few months after its dedication.

Conditions of installation matter

Fans are not immune to resonance-related damage either, even though their manufacturers use state-of-the-art techniques to balance them precisely during production, as in the RadiPac series from ebm-papst (Fig. 1, p. 18). A crucial role is played by the conditions of a fan's installation, which unfortunately can neither be predicted nor allowed for. When a fan is installed in a piece of equipment, a new configuration arises that is capable of vibration at a specific structural resonance frequency. In addition, the fan's resonance characteristics change when it is fixed in position. With the speed-controlled operation that is now widespread, the likelihood that a fan will at times be operated at resonance increases considerably. Other factors are transport and handling. For example, the impeller may not be damaged by impacts, unsuitable lifting equipment and the like, and fans may only be placed on suitable surfaces. It is not unusual for vibrations to be transmitted from external system components to the fan, for example from a compressor. During operation, vibrations can result from imbalances caused by dirt on the impeller or from flow-related oscillations, for example if the gap between the impeller and the housing is too small or unfavorable intake conditions lead to turbulence.

Vibration-absorbing elements and speed range

Vibration-absorbing elements (Fig. 2, p. 18), such as appropriately designed springs or rubber elements, help to isolate fans from vibrations in their surroundings. However, certain things need to be considered when selecting them. In addition to the fan system's natural frequency,

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the addition of vibration-absorbing elements results in a new spring-mass system with its own resonance frequency. When a fan starts up, it passes through three vibration-relevant speed ranges (Fig. 3). In the range below the resonance frequency, the vibration severity is below the allowed limit of 3.5 mm/s (according to ISO 14694). Operation of the fan is possible in this range, but the vibration-absorbing elements have no effect for physical reasons. In the neighboring resonance speed range, the vibration velocity is sometimes well above the allowed limit. There is no immediate damage to the device, but lengthy operation in this range will shorten the overall service life. Besides that, high noise levels are reached. This speed range should therefore be passed through as quickly as possible, and sustained operation there should be absolutely avoided.

The speed range in which the vibration level is well below the limit starts sufficiently far from the resonance peak. Only in this range, above the minimum speed, can the vibration-absorbing elements isolate the fan from the vibrations of its system or building. To select the right vibration-absorbing elements, the operating speed of the fan in its application must be known. For every fan, one can find correctly sized vibration-absorbing elements and the associated minimum speed. If others are to be used, the aforementioned principles need to be considered.

Protecting against damage with vibration measurements

As explained, there is a host of reasons and effects that can lead to excessive vibration levels, but they are not all predictable and are often unavoidable. Following the installation of a fan, vibration measurements and/or a search for resonance points should therefore be performed throughout the entire speed control range. This provides an overall impression of the system's vibration characteristics and reveals all unpredictable effects and also possible mistakes made during the run-up to commissioning. With a view to achieving longer service life, this is necessary as the consequences of excessive vibration severity due to a structural resonance or unsuitable vibration-absorbing elements can be disastrous. Moreover, incorrectly dimensioned vibration-absorbing elements do not adequately prevent the transmission of structure-borne noise. This may cause the entire ventilation system to vibrate, resulting in a high noise level and leading through feedback effects to bearing damage in the fan. Since measurement results are also strongly dependent on the positioning of the vibration sensors, the sensors have to be attached as shown in Figs. 4 and 5.

Because of possible effects during operation, such as the formation of dust deposits, this vibration check needs to be performed repeatedly, at least within the intervals specified in the operating instructions.

On the safe side

For vibration analysis of its RadiPac centrifugal fans, ebm-papst recommends measuring vibration in all three axes (Fig. 4), or at least in two axes (Fig. 5) radial and axial to the axis of rotation, using a typical vibration measuring unit. If measurements reveal ranges with excessive vibration, it may be possible to rebalance the fan in the field. Ideally, the vibration measurement unit can assist in such measures. If such measures are insufficient, the system can be subjected to design modifications such as the addition of reinforcement braces. One can also verify that the vibration-absorbing elements are working correctly and the fan is not operating below its minimum speed. If multiple fans are in use, they should be adequately spaced and kept from influencing one another (Fig. 6). Alternatively, ranges identified by the measurements as having excessive vibration levels can be avoi-

FIGURE 1: **RadiPac centrifugal fans with support brackets (left) and in cube design (right)**

FIGURE 2: **Vibration-absorbing elements, such as appropriately designed springs or rubber elements, help to isolate fans from vibrations in their surroundings.**

ded using the system's speed control. When needed, the experts at ebm-papst are available to advise customers, because considering the vibrational aspects when installing a fan is always worthwhile. Properly installed fans work reliably throughout their service lives, unexpected failures are prevented, and users also benefit from lower noise emissions.

You can order the ebm-papst installation guide free of charge from Mr. Ralf Mühleck (Ralf.Muehleck@de.ebmpapst.com).

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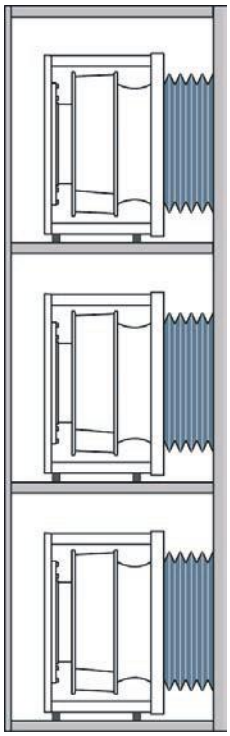

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FIGURE 6: **Proper setup for multiple fans: Each fan rests on specially designed vibration-absorbing elements (such as springs or rubber elements) on a sturdy framework that is firmly fastened to the floor.**

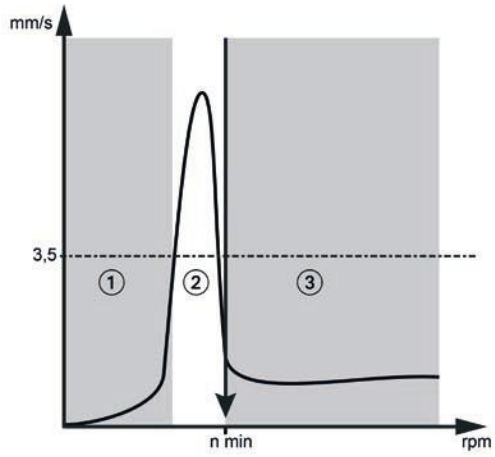

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FIGURE 3: **Basic trace of vibration speed over the speed range of a fan with vibration-absorbing elements: range below the resonance frequency (1), range near the resonance frequency (2) and range above the resonance frequency (3).**

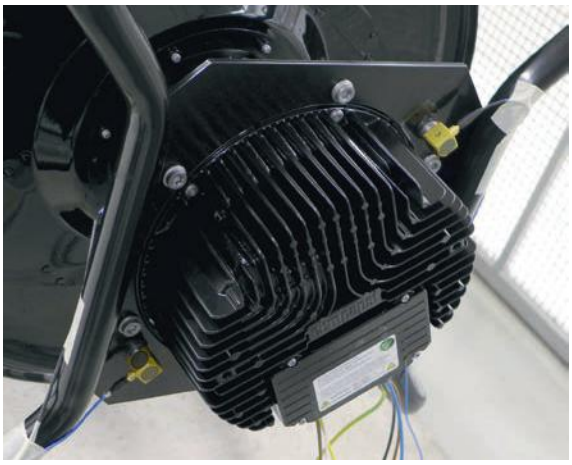

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FIGURE 4: **Triaxial sensor. Vibrations can be measured in all three directions from a single point.**

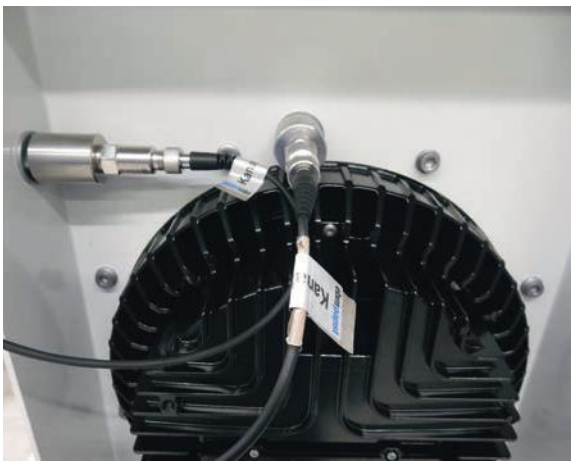

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FIGURE 5: **Vibration measurement on a RadiPac cube.**

Good hospitality atmosphere

In a gigantic new casino complex in the Chinese city of Macao, 1,100 RadiPac fans from ebm-papst ensure good air – efficiently, quietly and reliably. The Chinese gambling city that some like to refer to as the "Las Vegas of the Orient" has been one attraction richer since the 2016 opening of "The Parisian," an enormous casino complex accommodating 3,000 hotel rooms, a theater seating up to 1,200 people, and 300,000 square meters of retail floor space.

FIGURE 1: "The Parisian" opened in 2016 in Macao. The replica of the Eiffel tower is the highlight and trademark of the casino complex.

Saiver, Welcome Air-Tech

Many millions of visitors come to Macao not only for the many historic buildings dating back to the Portuguese colonial period. More than 30 casinos also make the city in the Pearl River delta a popular destination. So that the guests are not only well entertained but also feel thoroughly comfortable, the operator of the casino contracted the company Saiver to plan the air-conditioning system of the complex, which is open for business around the clock. The heart of the complex is a half-scale replica of the Eiffel Tower complete with three visitor platforms (Fig. 1). The specifications called for the system to be energy-efficient, space-saving and quiet.

Saiver is a globally operating manufacturer of air handling units (AHUs). The company has entered a joint venture for the Asian market with Welcome Air Tech Ltd., a HVAC equipment supplier based in Hong Kong. Together they designed and built a total of 350 AHUs for the large-scale project in Macao, which not only ensure the supply of fresh air to the building but also regulate the temperature

The specifications called for the system to be energy-efficient, space-saving and quiet.

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FIGURE 2: **Saiver's AHUs are completely preassembled for plug & play installation on-site, which saves time and money.**

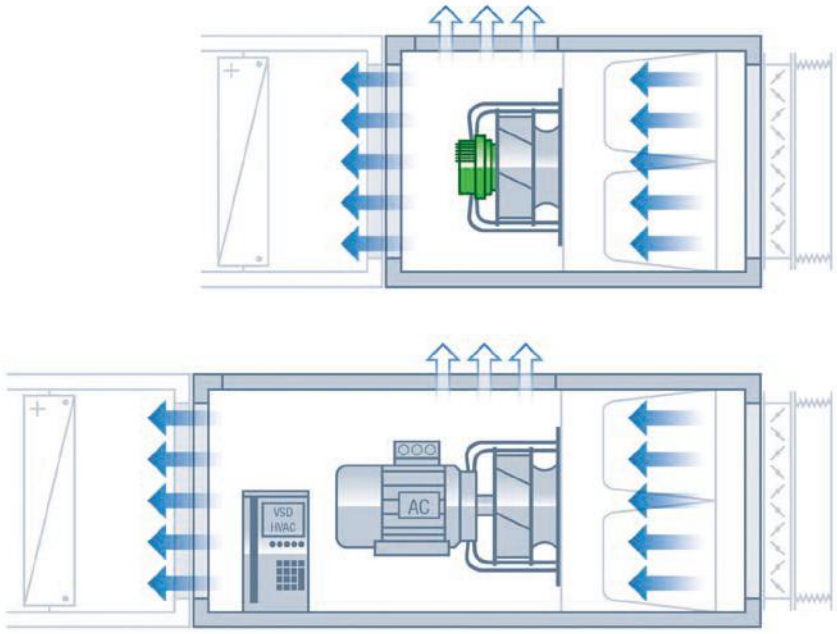

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FIGURE 3: **The AHUs can be dimensioned smaller with the RadiPac EC fans.**

and humidity inside. For the air conditioning, 1,100 RadiPac EC fans from ebm-papst were installed; they circulate more than 12,000,000 cubic meters of air per hour. ebm-papst specially designed the centrifugal fans of the RadiPac series for use in air conditioners and ventilation units.

Custom-made solutions

The requirements for air conditioning in this project are complex. From the hotel rooms and stores to the giant reception hall and the theater, the requirements for air conditioning vary from place to place. Tailor-made solutions were developed and the units were adjusted to the specific conditions. Three different RadiPac models are used for the ventilation units: size 310 with an air flow rate of 5,000 m^3/h, size 450 with an air flow rate of 10,000 m^3/h and lastly size 630 with an air flow rate of 20,000 m^3/h. The AHUs were completely prefabricated in China and therefore easy to install on site. This saved time at the construction site and meant lower costs for the builder. The RadiPac EC fans permitted lean production at the customer's end; they are designed for plug & play installation.

Compact design

It was important to the casino operator to maximize the usable space in the building, so space-consuming equipment rooms had to be avoided wherever possible. Thus, a lot of performance had to be accommodated on little space. The engineers designed the AHUs so that they can be mounted on platforms in the ceiling and docked directly onto air distribution ducts. For this type of application, the otherwise commonly used belt-driven fans were unsuitable, primarily because the design principle of this drive form requires a relatively large amount of space: variable frequency drive, motor, belt drive and fan are each installed individually and separately. This is different with the RadiPac: electronics and motor form one unit, which saves space and also enables easy installation. An integrated control electronics system replaces the external variable frequency drive and, as the

electronics and the motor are ideally matched to each other, additional electronic filters and shielded cables become superfluous. This way, the length of the ventilation units could be reduced (Fig. 2, p. 22).

Powerful, reliable and efficient

In spite of their more compact design, the AHUs had to be powerful enough to move the air under sufficiently high pressure through the air-conditioning ducts, some of which extend over three stories. Depending on where the fans are used, air flows of up to 80,000 m^3/h are required. Saiver therefore relied on FanGrids with up to six RadiPac EC fans arranged in parallel (Fig. 3). The parallel operation of multiple small fans has huge advantages over large individual fans in ventilation technology. The even flow through the heat exchangers or filters leads to better heat transfer performance and more efficient filtering of the air (Fig. 4). In addition, several small fans require much less space, which reduces the costs of the system.

Redundancy for more reliable operation

The fans use EC motors with an external rotor design, i.e. grid-fed, permanently energized, synchronous motors with electronic commutation, also called BLDC (brushless DC) motors, which boast efficiencies that are far above efficiency class IE 4. They work much more efficiently than a fan driven by an asynchronous motor via belt (Fig. 5). Belt-driven fans also have the drawback that they are relatively high-maintenance and break down as soon as just one component fails. If the only fan breaks down, this in turn means a complete failure of the ventilation system. Not only can this be unpleasant for guests because of the rising temperatures, it can also become dangerous quickly if the CO_2 concentration in the air increases in consequence. So that the

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FIGURE 4: **Air flow through a heat exchanger with a FanGrid solution (top) and an individual fan solution (bottom). The latter exhibits non-uniform flow through the heat exchanger and thus poorer heat transfer values.**

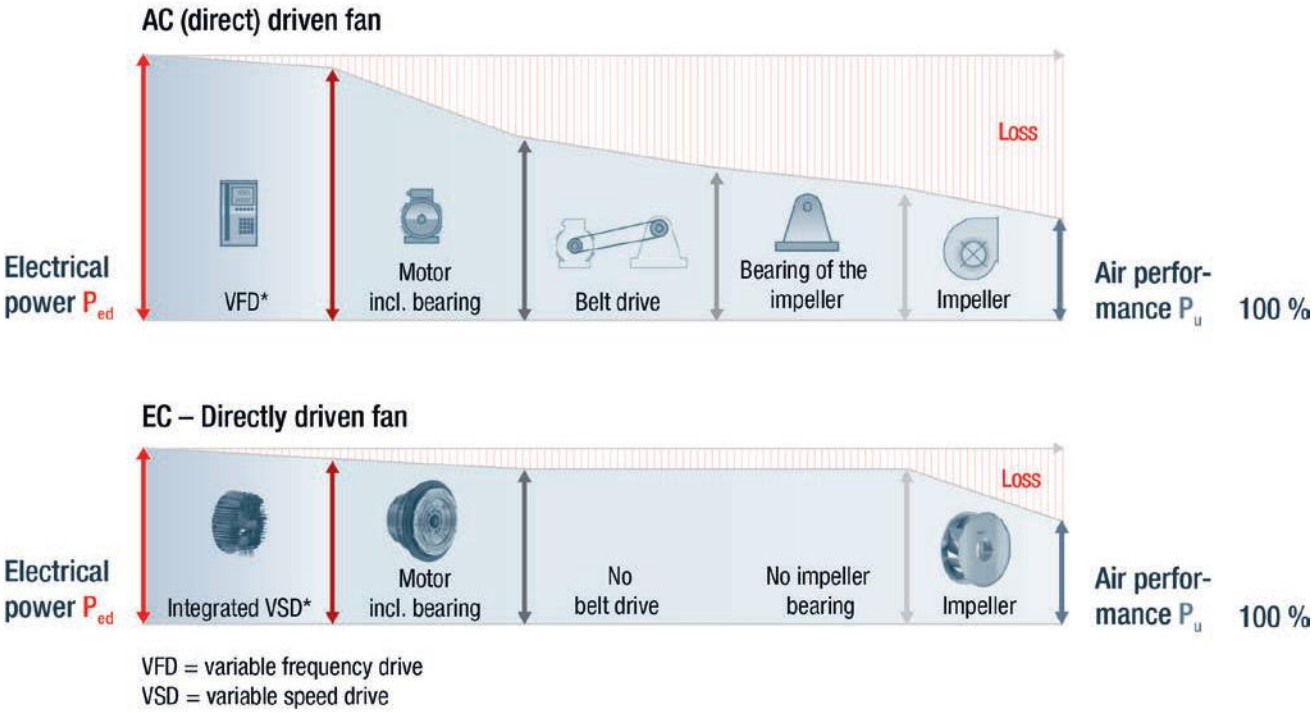

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FIGURE 5: **Power input of a belt-driven fan compared to a RadiPac EC fan.**

EC fans are designed for plug & play installation.

required air volume is provided in the building at all times, the FanGrid was laid out redundantly. This parameter specifies how many fans can be switched off without dropping below the required air flow. The most powerful unit manages to move 80,000 m^3/h against 1,500 Pa – with great energy efficiency thanks to EC technology.

Quiet and smart

Hotel guests as well as visitors to the theater and casino not only appreciate the good air quality, they also gladly do without the disturbing noises. The RadiPac EC fans score over the belt-driven fans in this aspect as well. They are much quieter, especially at low speeds. This is due to the commutation and the stator design in the EC motors, which ensure low-noise magnetization of the main field. Thanks to the MODBUS interface in the EC motors, they are ideal for integration in Building Management Systems (BMS). The operator can also monitor the energy consumption and speed of the fans remotely. ○

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Gas blower platform for efficient operation with flexible heat demand

Economical modernization of heating systems

Modern heating systems have to function efficiently, ecologically and economically without being excessively expensive to buy. A reasonable compromise is the key, particularly when replacing old heating systems. If new systems are too expensive, this will deter people from carrying out modernization and neither they nor the environment will benefit from the associated potential for savings. Condensing technology in combination with modern gas blowers can present an economical solution in such cases. Thanks to a broad power modulation range, these blowers operate highly efficiently in conjunction with renewable energies as well. And so this practical, inexpensive solution is perfectly equipped for adaptation to later modernization work, such as building insulation or radiator replacement, and is thus future-proof.

pictworks, Adobe Stock

Specifications, like those defined in the Climate Action Plan 2050, are set down in law with a view to protecting the environment. The overall aim is to reduce carbon dioxide emissions by 80 to 95% as compared to the 1990 level. Building heating systems in particular offer great potential for savings. Simply by making consistent use of condensing technology and significantly increasing the rate at which old heating systems are replaced (6% p. a.), it would be possible to lower the CO_2 emissions generated by total power consumption in Germany by around 15% by the year 2030.

A practicable approach to heating system renewal

In theory, house owners can save a lot of money and fuel by using the latest technology in their heating systems. In practice, however, that is associated with a great deal of expense and sometimes a lot of construction work. This naturally gives rise to a considerable modernization backlog, and regrettably plenty of boilers more than 30 years old are still to be found. What is to be done? Gradual modernization, starting with the boiler, then the windows and later on insulation of the outside walls or attic conversion etc., is a solution which reduces the financial burden and is less nerve-wracking in the short term. It does however presuppose that the new heat source will be able to cope with the different requirements and always operate efficiently. Regional building regulations often additionally demand the use of renewable energies in the event of extensive modernization. The problem: if base load heat pumps are fitted, these should be designed for a fixed heat output or a fixed heating temperature to obtain efficient operation. If conditions are altered by later renovation work, such as further insulation measures or fitting new radiators, the heat pump will often operate less efficiently, and what was intended as a "saving" will actually make heating more expensive. Such problems can be avoided by using a heating system with scalable output (Fig. 1). Operation of the heating system in conjunction with thermal solar

Extremely efficient method of heating: Condensing technology with gas blower.

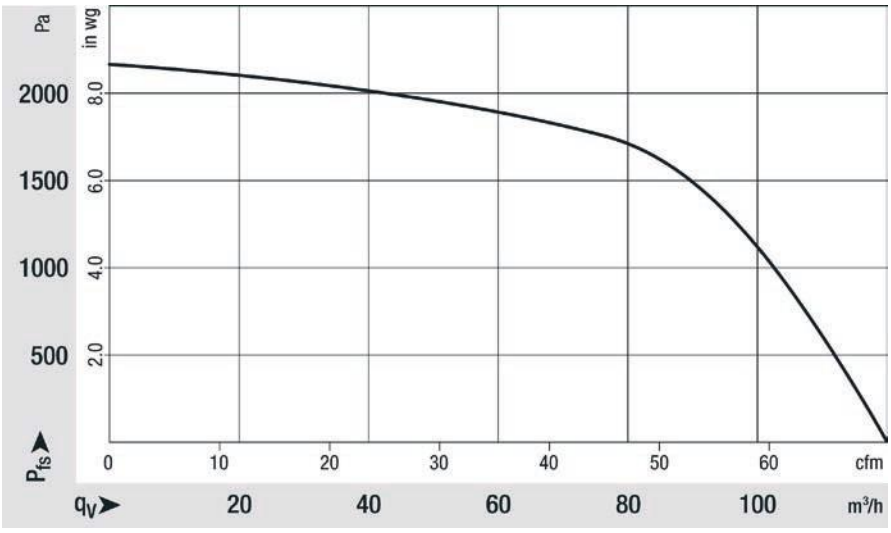

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FIGURE 1: **By way of example, the pressure/air flow graph of the VG 100 shows the broad performance range of the new gas blowers.**

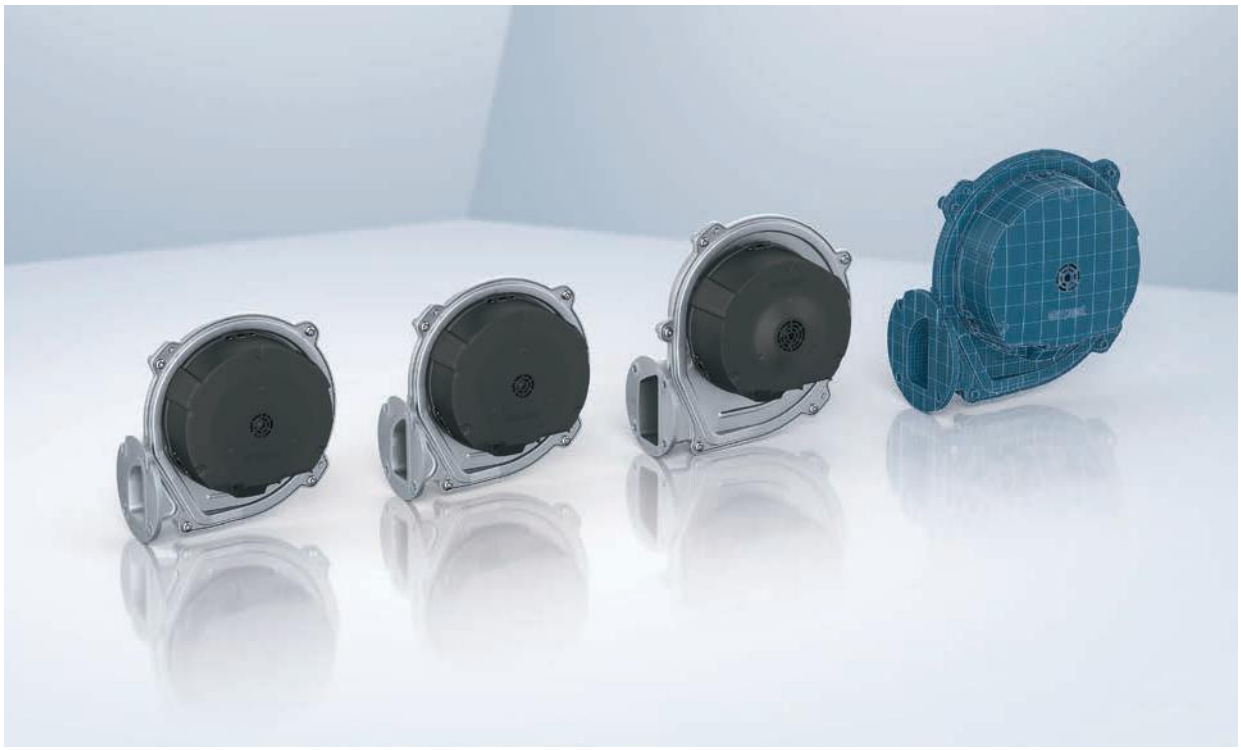

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FIGURE 2: **The new RadiMix product range reduces the existing number of gas blower types between 0.5 and 150 kW by a good 20%.**

collectors is associated with a fluctuating heat demand, to which the heating system has to flexibly react. Ideally, a heating system should be able to satisfy all these requirements without any loss of efficiency. What form could such an economical and ecological solution take?

Condensing technology with gas blower

Condensing technology is an extremely efficient method of heating. Gas condensing boilers are not just a compact and inexpensive solution, they also offer a scalable heat output. Thanks to the low heating water temperatures permitted by the design, the condensing units are also ideal for combination with other heating concepts such as solar heating and heat pumps. Condensing technology makes use not only of the "normal" heat of the energy contained in the fuel (gas), but also of much of the so-called latent heat of the water vapor contained in the exhaust gas from the combustion process.

Its high hydrogen content makes natural gas particularly suitable for this. Given an energy content of around 10 kWh/m^3 natural gas, this yields up to 3 kW extra heat output with a natural gas consumption of 2 m^3/h – corresponding to a conventional heat output of roughly 20 kW. This is obtained solely through the lowering of the exhaust gas temperature from the standard 150 °C to e.g. 40 °C and hence 80% condensation of the water vapor contained in it (around 1.5 l per m^3 gas). As compared to conventional systems with an exhaust gas temperature of 150 °C, this represents an up to 15% increase in efficiency. This offers many advantages, as less fuel is required and a gas condensing boiler is far more compact than a conventional boiler. The low temperatures also make exhaust gas ducting less expensive. What's more, modern condensing boilers are electronically controlled and flexibly adapt the burner and pump output to the heating output currently required. This reduces the switching rate of the device and the cooling losses in the intervals between the operating phases.
But here again the efficiency levels given only ever reflect a momentary status and only relate to the current ratio between input and output power. This is however not sufficient for the assessment of a condensing boiler, as it does not take the standby heat loss into account. In other words, it only calculates the losses occurring with the burner in operation – and, even then, only at one operating point. A shift in the operating points as a result of different usage or extensive modernization etc. will render the entire cost-benefit analysis invalid. An answer to this problem is a scalable burner output which can be achieved with the broad modulation ranges of the gas blowers

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FIGURE 3: **A lot of platform components can be combined for different output classes.**

In future, the gas blowers will also be available with venturi and gas valve as a perfectly coordinated complete system for particularly low-emission combustion.

used. These adapt ideally to the instantaneous heat demand without any loss of efficiency. The old rule of thumb, that 50% of the maximum heat output as per DIN 4701 is often sufficient to cover 90% of the heating energy demand and that many heating boilers are over-dimensioned with correspondingly high standby losses to cover the remaining 10%, thus no longer applies.

Modern gas blower platform for outputs from 0.5 to 150 kW

With their broad modulation range, the new RadiMix gas blowers from ebm-papst Landshut reduce precisely these standby losses. This means that the blowers can adapt the gas/air mixture quantity in a broad range up to 1:15 whilst maintaining a constant quality for optimum, low-emission combustion. At the same time, the new RadiMix product range reduces the number of different gas blower types by a good 20% (Fig. 2, p. 29). Boiler manufacturers now require just three versions to cover output levels from 0.5 to 80 kW, and a fourth blower will be coming onto the market next year to fill the gap up to 150 kW. The smallest gas blower, the VG 71, provides a heat output of up to 35 kW whereas the figure for the larger version, the VG 100, is up to 50 kW. The VG 108 with a heat output of up to 80 kW is ideal for large heating systems in apartment blocks, for example. Alongside the variable heat output, installation has also become more versatile, e.g. thanks to 360° motor positioning and hence the possibility of connector positioning to suit customer requirements. In future, the gas blowers will also be available with venturi and gas valve as a perfectly coordinated complete system for particularly low-emission combustion (Fig. 3).

Each blower features a new motor concept, specially adapted aerodynamics and isolation from vibration developed specially for the blowers to guard against structure-borne noise. The design of the motors with maintenance-free ball bearings is adapted to the higher air mixture conveying capacity required, for example through the use of a magnet material with far greater magnetic remanence and a completely new motor topology. Depending on the

version, this can enhance drive efficiency by a good 5%. Alongside a decrease in air-borne noise, it also proved possible to significantly reduce vibration (structure-borne noise) through simulation and testing with state-of-the-art development tools. As compared to the predecessor model, the operating noise dropped by more than 3 dB(A) depending on the blower type. The electronics have also been completely re-designed and now feature optional BUS interfaces for easy integration into digital systems. Operating states such as output, service status, temperatures, operating voltage and other data processed in the blower control systems can be called up via planned BUS interfaces (ebm-papst is pursuing the approach of working with the LIN-Bus protocol). This not only makes incorporation of the blower into the boiler control system easy to implement, it will also permit preventive maintenance or remote diagnosis in the near future. Thanks to the use of a cooling concept already successfully employed in other products, the electronics are also located in the cooling airflow, thus making for greater reliability and a longer service life. A robust motor protective cap permanently attached to the housing encloses all the drive components. ○

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