# techmag

SAVING ENERGY AT THE ICE RINK

Retrofit reduces costs and saves electricity

"WE QUALIFY THE FANS FOR TOUGH USE IN REAL LIFE."

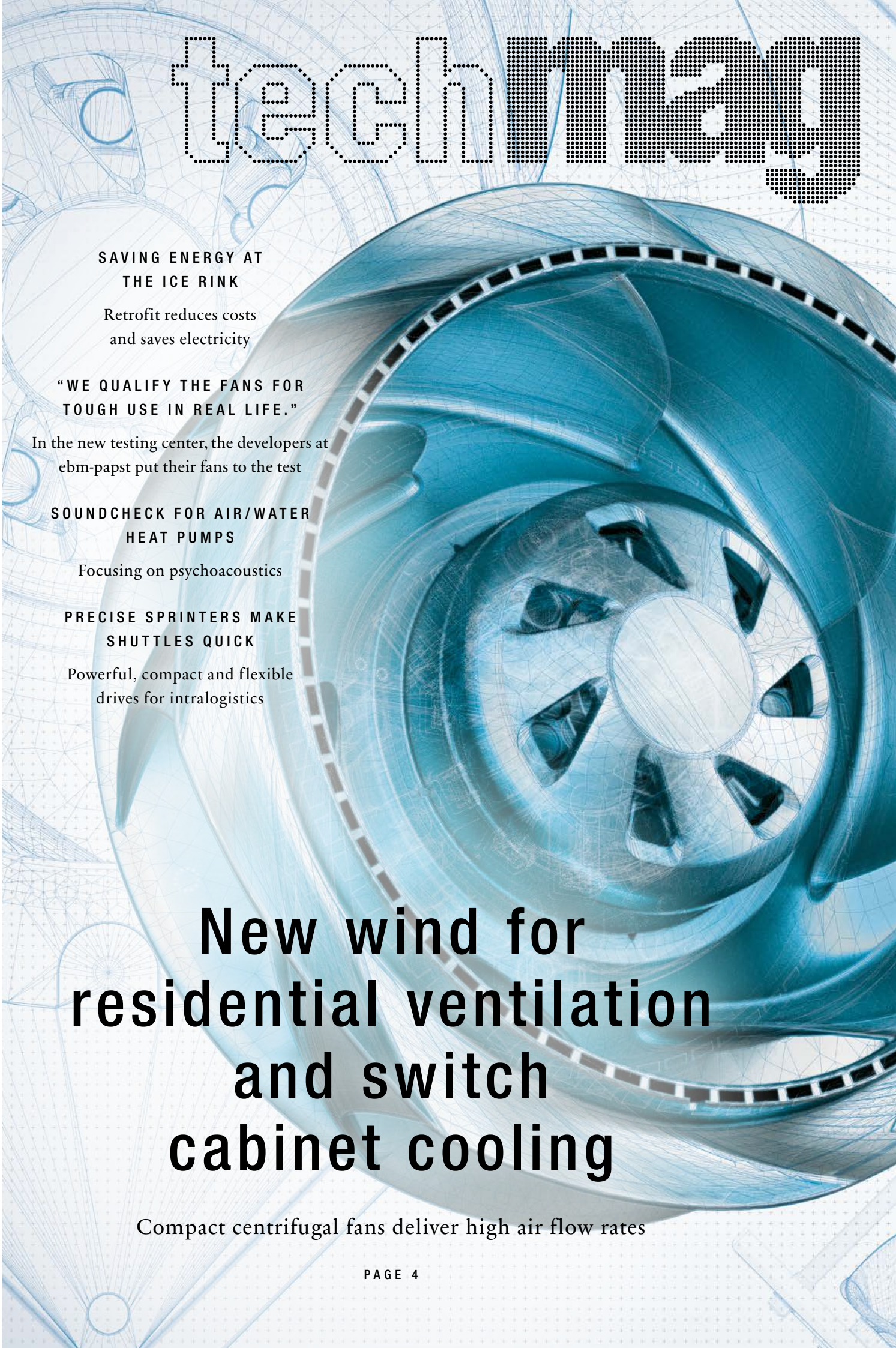
In the new testing center, the developers at ebm-papst put their fans to the test

SOUNDCHECK FOR AIR/WATER HEAT PUMPS

Focusing on psychoacoustics

PRECISE SPRINTERS MAKE SHUTTLES QUICK

Powerful, compact and flexible drives for intralogistics



# New wind for residential ventilation and switch cabinet cooling

Compact centrifugal fans deliver high air flow rates

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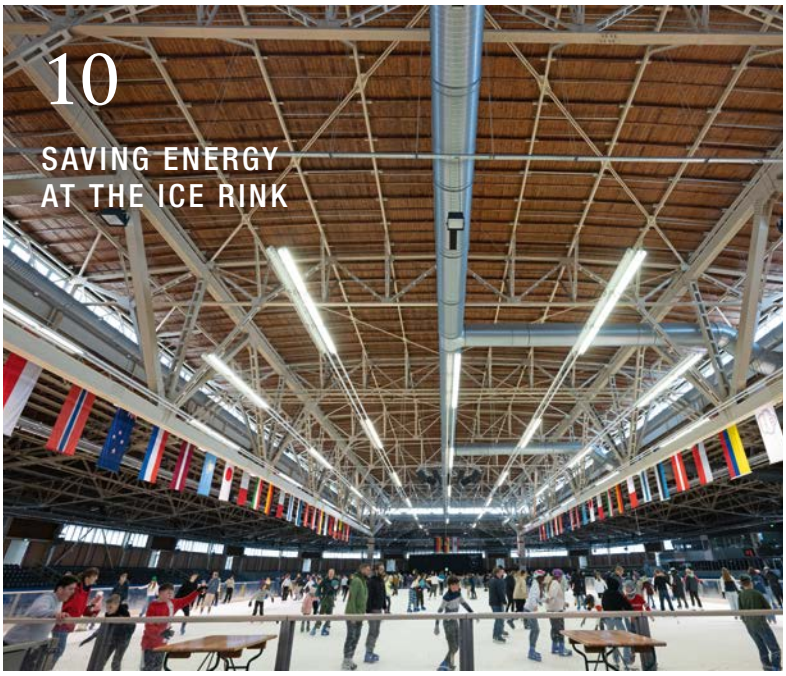





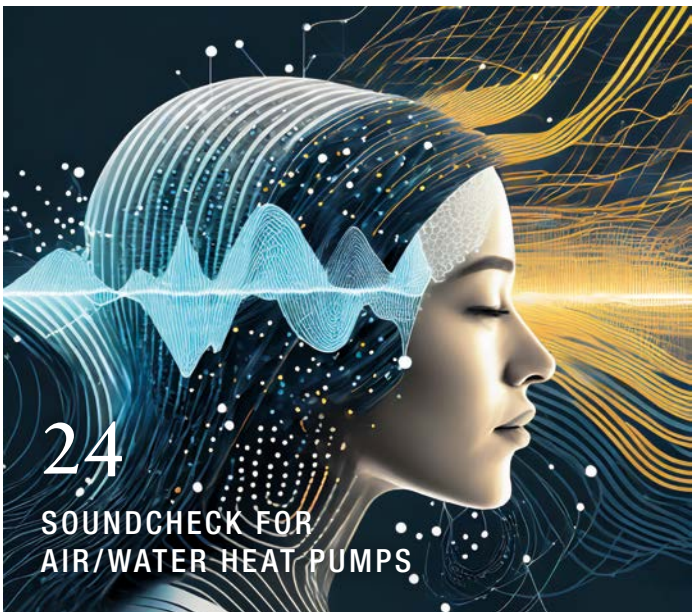



# “The new generation is making a giant leap forward”

**Bernhard Siedler**

HEAD OF PRODUCT MANAGEMENT
AT EBM-PAPST MULFINGEN

*Dear customers, partners and friends of ebm-papst,*

The requirements placed on devices for residential ventilation and air conditioning as well as on heat pumps and switch cabinet cooling are always the same: compact design, efficiency, and low noise levels. The only issue is that users and manufacturers expect constant progress in these areas, which is why we are constantly working on making improvements here. The second generation of our RadiCal centrifugal fan also demonstrates this. The world has changed significantly since it was introduced ten years ago but the new generation is now making a big leap forward to meet the demands that will be placed on it over the next ten years. One thing that stands out in particular in terms of its improved performance is that, when compared directly, the size 175 is just as powerful as the 190 of the predecessor model.

We are able to achieve this giant leap forward with design optimizations, among other things. The impeller’s full potential can be exploited thanks to the revised inlet in conjunction with the innovative blade geometry. This results in higher air flow rates. The adapted air-inlet guard plays a role in ensuring particularly low noise levels, meaning that the device is up to two decibels quieter than without the guard – without any loss of efficiency.

However, it’s not just the internal values which are impressive – it is important to us that the RadiCal is also easier to use. This is why we have significantly expanded the mounting options for the housing and made it easier to install the air-inlet guard.

Would you like to find out more about the development of the series? Then read the specialist article about the second generation of RadiCal and be inspired by the other topics in this issue!

Bernhard Siedler

ebm-papst with Adobe Firefly (AI-generated)

Compact centrifugal fans deliver high air flow rates

# New wind for residential ventilation and switch cabinet cooling

When it comes to devices for central residential ventilation and air conditioning, as well as heat pumps, air purifiers and switch cabinet cooling, ever lower energy consumption is required. One of the ways in which manufacturers are responding to this is by designing their devices to minimize installation-related pressure losses for the fan. At the same time, ventilation and air-conditioning devices need to be as compact as possible so as to minimize their footprint and have sufficient space inside for additional components. For this reason, there is a demand for compact fans that deliver large air flows with low back pressure while operating as energy-efficiently and quietly as possible. ebm-papst has developed the second generation RadiCal centrifugal fans with precisely these requirements in mind.

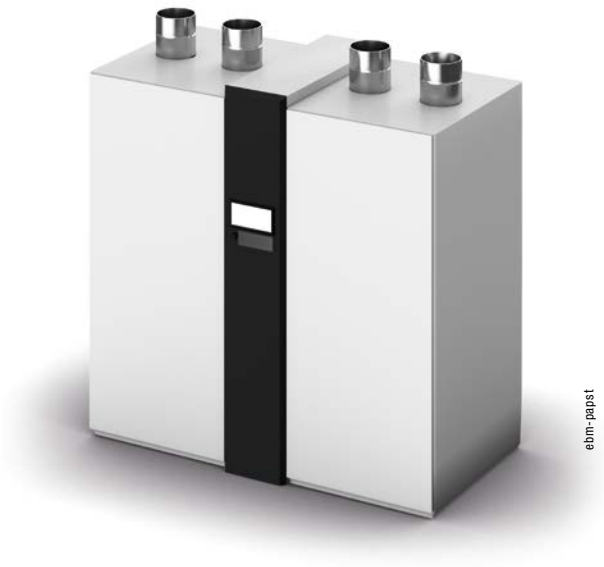

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FIGURE 1: **Ever lower energy consumption is required for devices used in central residential ventilation and air conditioning, as well as heat pumps, air purification systems and switch cabinet cooling.**

Drawing on its core competencies in aerodynamics, motor technology and electronics, fan and motor specialist ebm-papst launched the RadiCal centrifugal fan series more than 10 years ago, a series that has since proven its worth in many ventilation and air-conditioning systems. Now, the Mulfingen-based company is introducing a second generation of the fans with particularly impressive air flow rates, alongside remarkably compact dimensions and pleasant noise characteristics (Figs. 2, 3). The main contributors to this have been aerodynamic optimizations, refined GreenTech EC motors, and further improvements in control electronics. An additional size has also been included, making it even easier for users to find the right solution.

*New blade design improves aerodynamics*

With the aid of high-performance development tools and production engineering, the first step was to optimize the design of the impellers in line with aerodynamic criteria. In this, the developers benefited from plastic production, which now offers design freedom in all three dimensions – making it possible to achieve an innovative blade geometry that helps significantly increase efficiency and reduce noise. The "twisted" blades are curved into each other and the shape of the leading and trailing edges has been completely redesigned. This improves the flow behavior (Fig. 4, p. 8) while at the same time increasing the strength of the impeller, which is made of resistant plastic. The corrugated impeller cover plate also improves aerodynamic characteristics and hence air performance.

**The second generation fans are particularly impressive thanks to their excellent air flow rates, compact dimensions and pleasant noise characteristics.**

The centrifugal module, or housing box, has also been completely redesigned. The inclined struts, for example, provide an additional boost to air performance. The shape of the struts can be varied over the axial height to avoid backflow areas as effectively as possible. There is also an enlarged intake diameter, which ensures a greater air flow rate through the impeller. With the size 190, for example, the intake diameter has been increased from 132 to 150 mm, which helps air throughput.

*Significant noise reduction*

There is further potential for improvement in clearance gap losses. Finding ways to improve the air gap, in other words the distance between the inlet nozzle and the impeller, is challenging because the gap will always have a certain tolerance for manufacturing reasons. In the case of the second-generation RadiCal fans, however, new manufacturing methods have made it possible to reduce the air gap significantly, depending on the size. As a result, there is less turbulence, efficiency increases and noise is reduced (Fig. 5, p. 8).

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FIGURE 2: **The new RadiCal fans are particularly impressive thanks to their excellent air flow rates, compact dimensions and pleasant noise characteristics.**

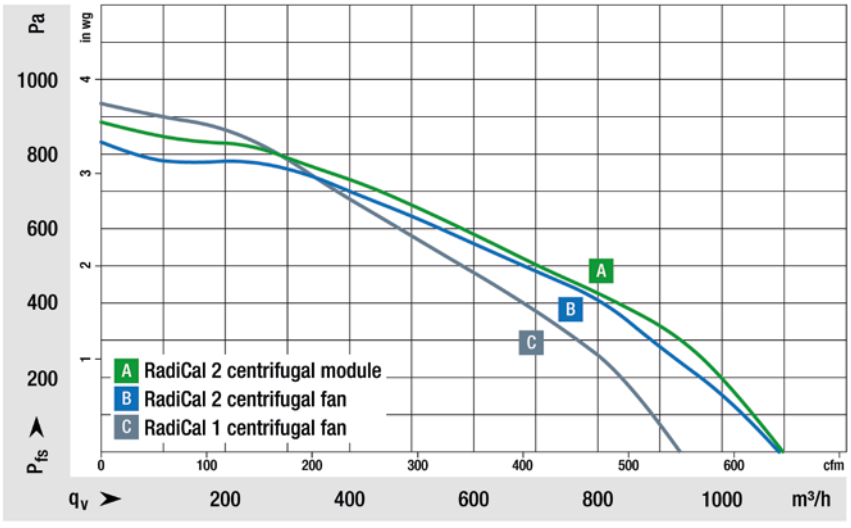


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FIGURE 3: **The compact centrifugal fans deliver high air flow rates (example size 190).**

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FIGURE 4: **The new blade design improves the aerodynamic characteristics.**

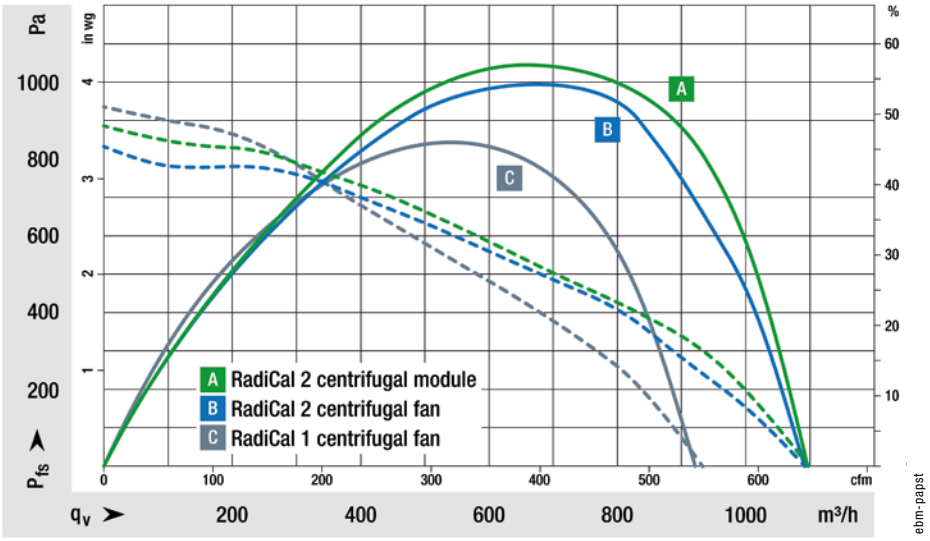


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FIGURE 5: **A comparison of efficiency clearly shows the advantages of the new RadiCal (RadiCal 2) over the predecessor model (RadiCal 1) (example size 190).**

The new air inlet grille also helps to prevent noise (Fig. 6). In this further development, the struts were initially dimensioned to minimize losses. As noise analysis showed that the rotor area had a major influence on noise development, a cap was added to the center of the air inlet grille, which significantly reduced noise in the lower frequency range. Compared with the current series version, it is up to 2 dB(A) quieter when installed in a test rig (Fig. 7).

*New motor generation*

The new EC motors also contribute to noise reduction. Depending on the size of the fans, they cover a power range of up to 170 W for single-phase networks. Fans for three-phase networks and outputs of up to 1.5 kW will follow at a later date. There are no disruptive resonances when there is a change in speed. In addition to good noise characteristics, the new generation of motors also boasts excellent EMC characteristics and durability. The commutation and control electronics are tuned to the motors and the air flow and operating point can be precisely adjusted. Control and monitoring are possible either through 0 - 10 V/PWM or optionally through MODBUS-RTU starting from the 170 W variant. Networking via the communication bus then makes it possible to use the motor data for preventive maintenance measures, for example, or to quickly adapt the fans to changes in operating conditions.

*Compact and easy to integrate*

Since no other installation situation is the same, the new centrifugal fans are very adaptable. They are available as a motorized impeller, as a centrifugal module with ready-to-install housing or with a support bracket (Fig. 8). Three different mounting levels are provided for the compact centrifugal module. If installation space is tight, users will appreciate another design detail: the backplate is smaller than the cover plate. As a result, the direction of discharge is more in the axial direction. This is an advantage if there is little space in the centrifugal direction. The fans are also a few millimeters shorter axially than their predecessor. Thanks to the high air flow rates, a smaller size can now be used compared to the predecessor model, depending on the operating points.

The second-generation RadiCal fans will be available in the familiar sizes 175, 190, 225, 250 and 280. Size 206 is new and improves the power rating. This means that the right centrifugal fans are


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FIGURE 6: **The new FlowGrid has enabled noise in the lower frequency range to be significantly reduced.**

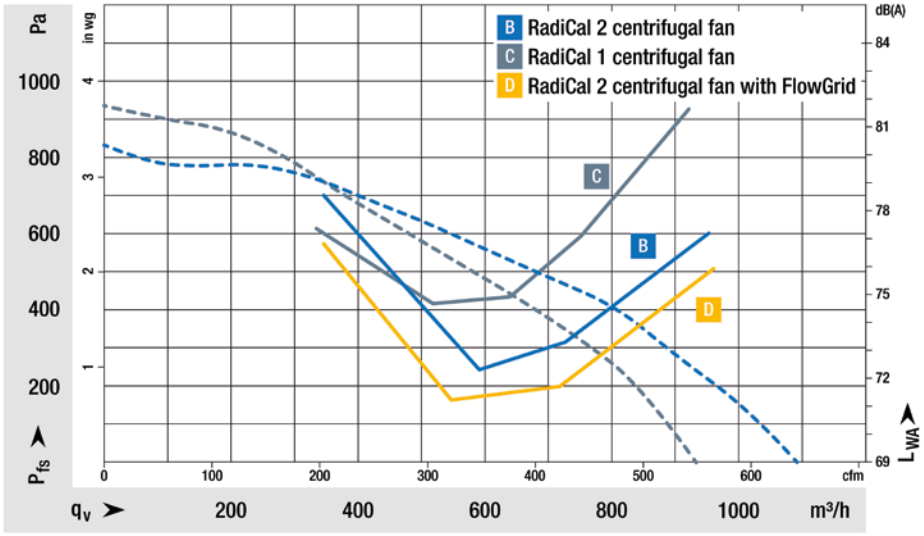


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FIGURE 7: **The new FlowGrid is also up to 2 dB(A) quieter than the current series version, not only in the case of installation-related intake-side interference, but also when installed in a test rig (size 190 example).**

available for efficient residential ventilation or switch cabinet cooling, not only delivering high air flow rates, but also operating extremely quietly.

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FIGURE 8: **The new RadiCal fans in the version with support bracket.**

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Retrofit reduces costs and saves electricity

# Saving energy at the ice rink

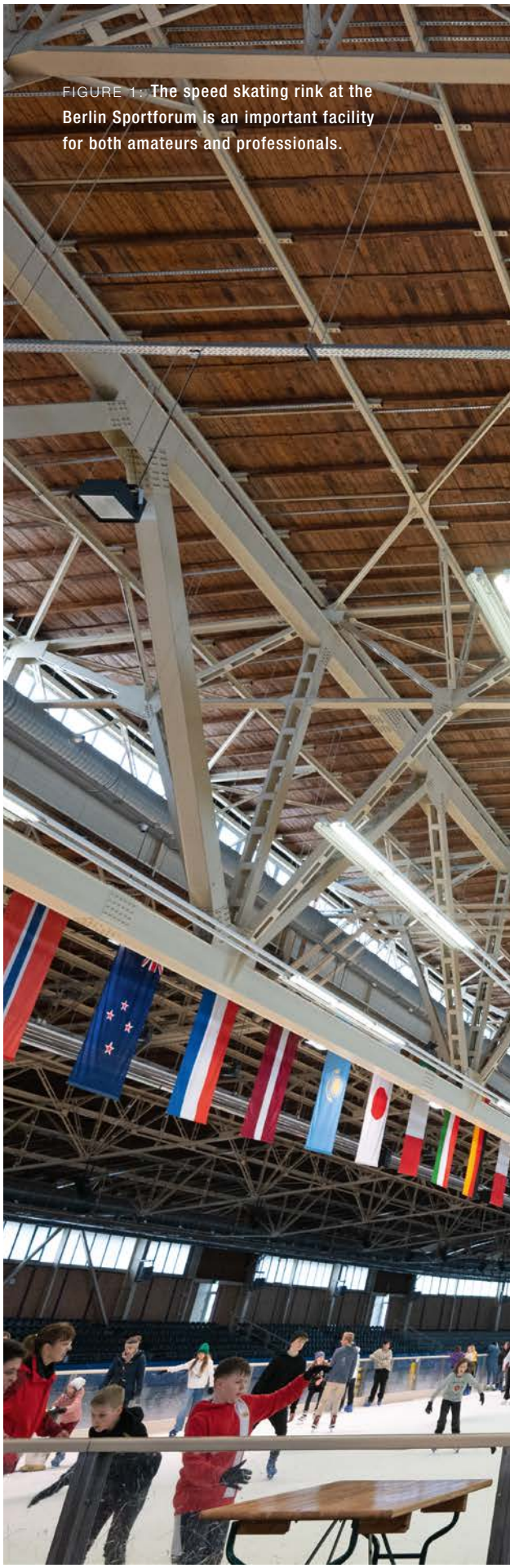

FIGURE 1: The speed skating rink at the Berlin Sportforum is an important facility for both amateurs and professionals.

The public sector faces major challenges. For example, cities and municipalities are required to achieve climate targets and save money. At the same time, the public wants to continue using public services such as sports facilities without restrictions. When it comes to air conditioning at these facilities, there is great potential for achieving a successful interplay of optimum use, energy savings, and reduced costs – all with a retrofit. The replacement of old belt-driven centrifugal fans at a speed skating rink in Berlin with a FanGrid with the latest generation of highly efficient EC fans is an impressive example of this.

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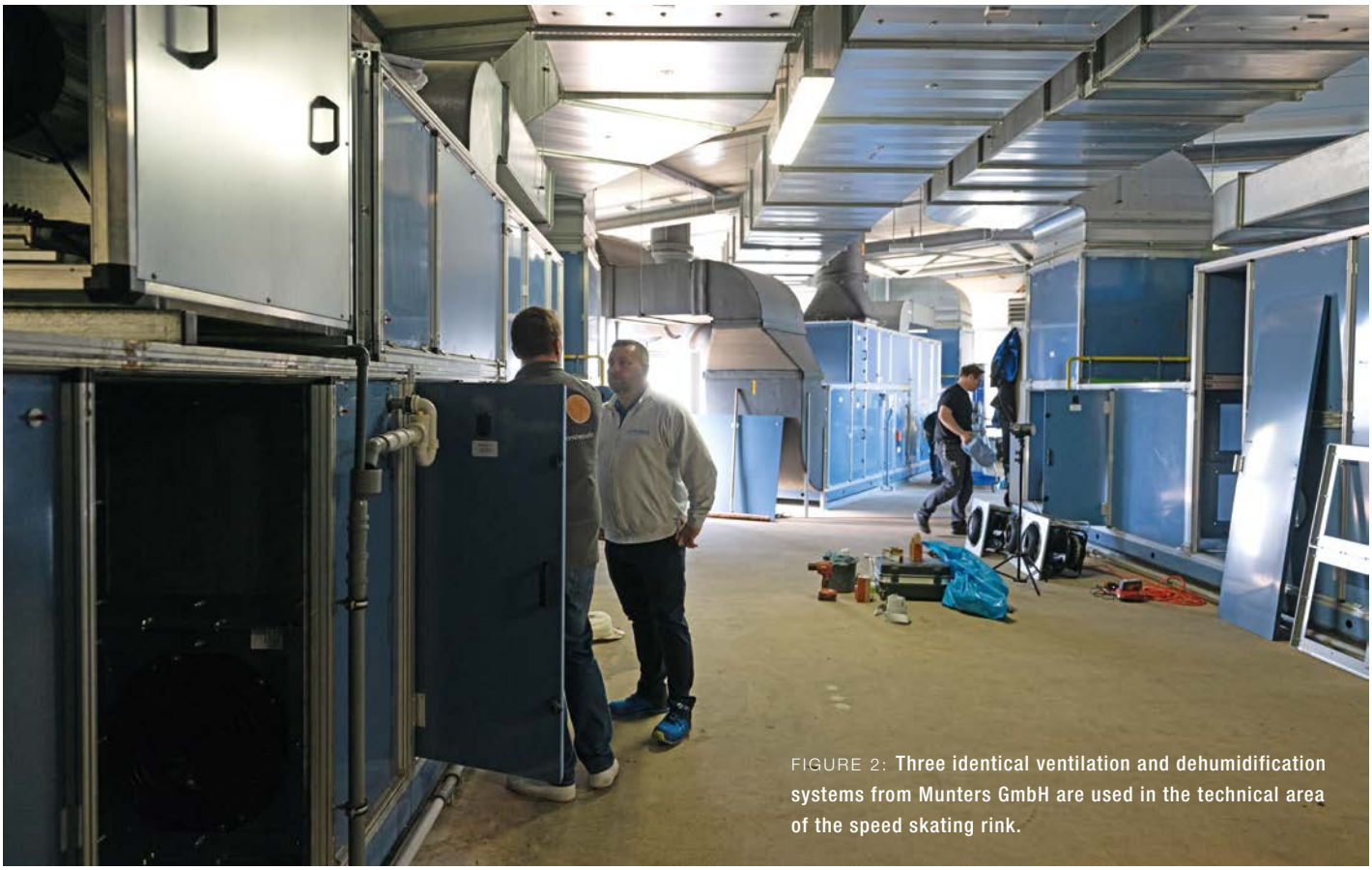

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FIGURE 2: **Three identical ventilation and dehumidification systems from Munters GmbH are used in the technical area of the speed skating rink.**

The Sportforum Hohenschönhausen in Berlin is a complex covering over 45 hectares with 35 facilities for different sports, including the speed skating rink. It was built in 1962 and expanded in 1986. It was the world's first 400-meter speed skating rink at the time. It is still an important training facility for both elite athletes and amateurs, as the speed skating rink is the local Olympic training center, venue for international competitions and home to numerous Berlin clubs (Fig. 1, p. 11). Athletes count on perfect conditions – including immaculately smooth ice. But this can only be achieved if the climate at the rink is also constantly cool and dry.

*Avoiding temperature fluctuations*

This is no easy task, as capacity utilization of the rink varies greatly: from a few Olympians training on the 262 and 440-meter lanes and public hustle and bustle on the 1,800 $m^2$ ice surface to competitions with 3,500 spectators in the stands. Temperature fluctuations at the rink also go hand in hand with changing capacity utilization. Condensation that col-

**The old individual fans for each process air unit were each replaced with one FanGrid with three centrifugal fans from the latest RadiPac generation.**

lects on the ceiling and the struts can form, drip onto the ice surface, and then ice up. However, these irregularities must be avoided. "To ensure that the difference between the ice and ambient temperature does not lead to condensation or mist formation, there must be a constant temperature of eight degrees Celsius in the rink," explains Sven Kuwatsch, technical manager of the Sportforum.

*Circulating and dehumidifying air*

The technical area of the speed skating rink contains three identical ventilation systems from Munters GmbH: one of them runs in continuous operation, while a second is connected if there is higher capacity utilization at the rink. A third system serves as redundancy if one of the other two fails (Fig. 2). It is not enough to simply circulate the air from the rink in order to achieve the desired temperature and thus prevent condensation, and this is why the systems also have a dehumidification unit. For this purpose, the air from the rink is drawn over a constantly rotating rotor, which the moisture settles onto. To enable the rotor to release the absorbed moisture, a small part of the rotor runs through a regeneration unit in which fresh air heated to around 130 degrees Celsius absorbs the moisture and carries it away to the outside. Because this also heats the process air, it is cooled down again before being blown back into the rink.

*Belt-driven centrifugal fans: loud, inefficient, rusty*

The systems were installed by Munters in 1998 and have been serviced regularly ever since. However, after 25 years of use under the tough conditions of an ice rink, the large belt-driven centrifugal fans for the supply and exhaust air in particular were looking worse for wear (Fig. 3). The metal parts were corroded and the old fans were also loud – and, even worse, highly inefficient. Not exactly a sustainable situation in an age when making energy and cost savings is an extremely important issue for the public sector. That's why Daniel Bürgel's suggestion to bring the systems into the present day with a retrofit came at the perfect time. The customer service consultant at Munters GmbH

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FIGURE 3A + B: **The large belt-driven centrifugal fans for supply and exhaust air were inefficient, loud, and already corroded.**

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FIGURE 4: **The old fans were replaced with a FanGrid with three centrifugal fans from the latest RadiPac generation.**

## In addition, the centrifugal fans are extremely quiet, intelligent, and incredibly user-friendly as a plug-and-play solution.

### FIVE FREQUENTLY ASKED QUESTIONS ABOUT THE RETROFIT

1. When is a retrofit worthwhile?
   If a ventilation system is 10 or 15 years old, or older, a retrofit makes sense in many cases. Switching to new EC fans saves a significant amount of energy. Other advantages include durability, saving space, and operational reliability.

2. How do I approach a retrofit?
   Retrofit experts provide support in recording performance data, work out possible concepts, and can provide a rough overview of costs. They look at the purpose of the system and at which point it should be operated optimally.

3. How does a retrofit begin?
   The first step is a current measurement of the actual status. Then it is time to select the right fan. In this process, the entire system, environmental factors (altitude, temperature, humidity, etc.), options for electrical integration, and mains supply must be taken into account. During the subsequent installation, attention must be paid to the seals in the ventilation room. The new status is then measured at the end.

4. What payback period can I expect?
   With up to 60 to 70 percent energy savings, a rough payback period of two to three years can be expected.

5. How are these savings achieved?
   Thanks to GreenTech EC technology, optimized aerodynamics, and demand-based speed control.

had just had a positive experience at a smaller ice rink in Berlin. He works closely with ventilation specialist Breuell und Hilgenfeldt GmbH, which, as an ebm-papst service center, uses highly efficient EC fans. "It works really well and we can achieve substantial energy savings," says Bürgel enthusiastically. "With savings of 30 percent calculated in advance, the Sportforum was also quick to make the decision."

*The latest generation of RadiPac – more efficient, quieter, smarter*

The old individual fans for each process air unit were each replaced with one FanGrid with three centrifugal fans from the latest RadiPac generation (Fig. 4, p. 13). They provide the solution to more demanding legal requirements and fulfill customers' desires to save more and more energy as well as money. In addition, the centrifugal fans are extremely quiet, intelligent, and incredibly user-friendly as a plug-and-play solution.

The aerodynamically optimized blade is made of high-strength, glass-fiber-reinforced composite material and is therefore resistant to harsh ambient conditions. The three-dimensional blade design enables high air flow rates and high pressures, so that even high-pressure applications can be covered. A static pressure increase of well over 2,000 Pa can be achieved. Combination with the powerful and compact EC motor with newly developed high-performance electronics means that the RadiPac's performance has been further increased compared to its predecessor. Thanks to their excellent control characteristics, they can be operated as required, which saves additional energy. They are also up to 7 dB(A) quieter than their predecessors.

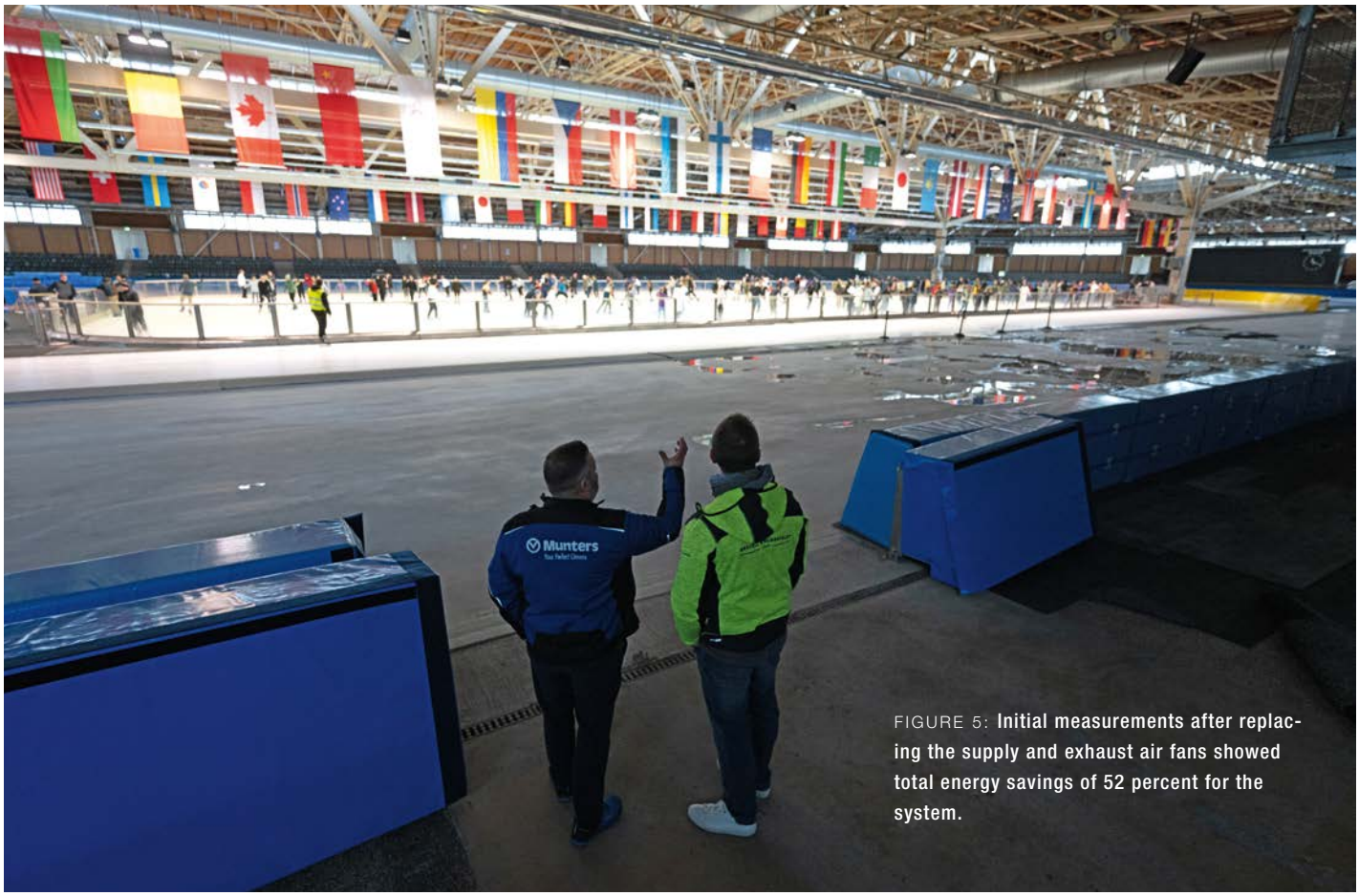


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FIGURE 5: **Initial measurements after replacing the supply and exhaust air fans showed total energy savings of 52 percent for the system.**

*Energy savings of over 50 percent*

Initial measurements after replacing the supply and exhaust air fans showed total energy savings of 52 percent for the system. With an assumed operating time of 5,000 hours per year, the savings amount to around 120,000 kWh per year – at an electricity price of 35 cents, this equates to around 42,000 euros. At the time of measurement in the spring, the large outer track had already defrosted, and only the smaller and inner surfaces were still in operation. But major deviations are not expected when the rink returns to full operation in October (Fig. 5). Either way, this retrofit is an important step for the Sportforum on its path to a smaller environmental footprint: "We're looking everywhere right now to see where we can save energy. The retrofit in the speed skating rink is one of these measures – and an effective one at that," sums up Sven Kuwatsch. ○

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FIGURE 1: **As Group Leader Validation, Erich Kemmer is responsible for the new testing center in Mulfingen-Hollenbach.**

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In the new testing center, the developers at ebm-papst put their fans to the test

# “We qualify the fans for tough use in real life.”

During the entire operating time, fans are subjected to a variety of environmental influences that impact service life, performance and long-term behavior. ebm-papst carries out extensive tests in the new, in-house testing center at the Mulfingen-Hollenbach site to avoid any weaknesses throughout the entire product development process. The aim is to offer customers a product that meets all requirements for quality and efficiency and also meets the toughest operating conditions in the field.

Motor and fan specialist ebm-papst has always been testing fans and their components, such as the motor or impeller, with standard endurance and end-of-life tests. Over time, the qualification requirements have changed: The development of DC and EC technology led to electronics qualification, followed by temperature change and climate tests for outdoor applications. "Our aim is to identify the effects of environmental influences on the fans and determine whether and how they affect service life. By doing so, we can identify critical points much faster than in the field. That is why we are not working with sterile laboratory tests, but rather 'real' environmental influences," explains Erich Kemmer, Group Leader for Environmental Simulation & Testing at ebm-papst.

Environmental influences are all forms of physical, chemical or other influences. These include temperature, humidity, salt spray, vibration – both from natural causes and human causes. For example, in a natural cause, water acts on a fan as a result of precipitation. An example of a human cause is a fan being used in a washing system. ebm-papst uses environmental simulation methods to investigate the interactions between fans and their components and their environment. The aim is to record how they affect performance and functionality, as well as long-term behavior and service life.

"There are a number of standardized test procedures and test facilities for this. In addition, we have also developed our own processes such as combined load tests," says Erich Kemmer. Since 2022, the test chambers have been centrally located in the new testing center at the site in Mulfingen-Hollenbach. All new developments and new sizes of existing fans or motors pass through these chambers during product development. To start with, general incoming inspections are carried out. Then, component tests, tests for storage and transport conditions, additional and service life


FIGURE 2: **The FanDrive DV280 also has to pass tests. It is the largest EC external rotor motor ever built by ebm-papst and reaches a torque of 180 Nm at a power output of 24 kW.**

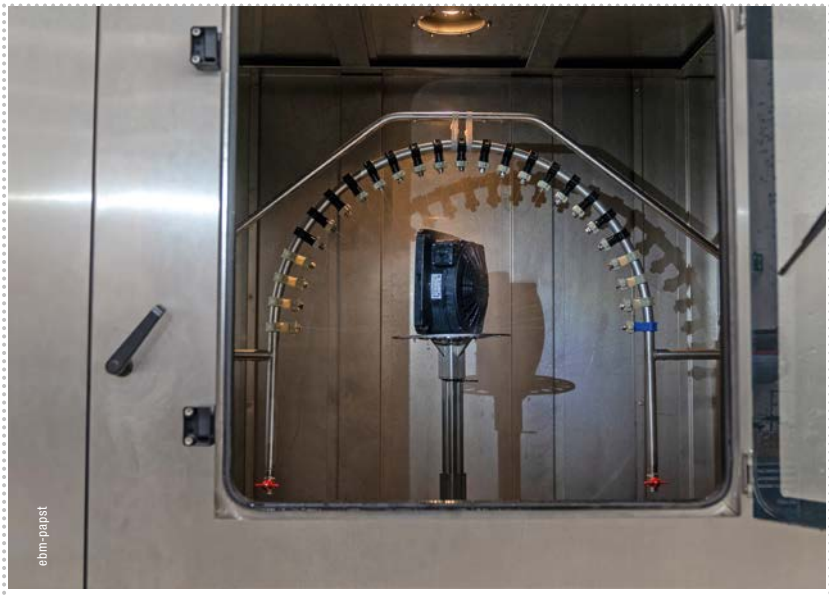



FIGURE 3: **In the IP test chamber, electronics and fans are subjected to standardized degree of protection tests in accordance with the IP code against moisture ingress. The tests at ebm-papst are supplemented by long-term climate tests to represent a load over a longer period of time.**


FIGURE 4: **In several climatic chambers, a temperature increase or drop can be generated within a very short time.**


FIGURE 5: **In addition to standardized test procedures, ebm-papst has developed its own 'combined load tests', which the test objects are subjected to throughout the entire product development process.**

tests and final output tests are performed. These are divided into test bays for shock and vibration, climate, wheel strength, centrifugal and cycle test, IP degree of protection (water), salt spray and three accelerated service life tests. It takes at least half a year for the fans to complete all of these stations – while being controlled and brought across the load limits.

*Test bay for shock, vibration and climate*

The storage and transportation of fans can affect the service life at the customer's site even before commissioning. In the shock and vibration test bay, ebm-papst simulates the loads caused by trains, trucks, ships or aircraft. For this purpose, the fans are mounted on a test bench that emits sustained vibrations of varying strengths and also individual shock pulses that could arise in real-life usage when loading or dropping them from a forklift. The system regulates the amplitude and frequency of the vibration, as well as the strength, length and number of impacts in a standardized manner in accordance with a precisely defined schedule.

In addition to shock and vibration, temperature fluctuations also play an important role in transport. For this purpose, the testing center has several different climatic chambers in which the temperature varies between -70 and + 180 degrees Celsius and the humidity between 10 and 98 percent.

A temperature shock cabinet can be used to simulate extremely fast temperature changes. This test is particularly important for components made of material compounds, such as metal and plastic, because it tests the different expansion of the different materials and shows whether weak points or breakages can occur during temperature changes.

*Test bay for wheel strength, spin and cycle test*

These three component testing stations test the maximum operating and destruction speed of plastic and metal impellers. For plastic impellers, the


FIGURE 6: **The quality of the coatings and materials is investigated in the salt spray test chamber.**


FIGURE 7: **The wheel strength of smaller or larger fans is checked at various stations.**

## ebm-papst uses environmental simulation methods to investigate the interactions between fans and their components and their environment.

wheel strength and spin test fields involve investigating the material's "growth". Plastic is a flowing material. The rotating fan creates a centrifugal load on the blades of the impeller and the plastic begins to expand. This growth must not exceed a certain value so that the air gap between the impeller and housing remains in as ideal a range as possible and that the customer has an efficient and quiet fan even after a long period of operation.

The centrifugal and cycle test is used for metal impellers. Here, the focus is on the simulation of start and stop cycles, as metal wheels cause an increasing strain on the connections due to the frequent ramp up and ramp down. Equally important is the maximum operating speed that is run over a longer period of time on both types of impellers. This means that a long operating time is mapped and qualified in a short time. ebm-papst has strict guidelines on what the impellers have to withstand.

*Test bay for degree of protection IP code (water)*

The IP code degree of protection test is standardized and qualified to protect housings, e.g. electronics, against water and moisture ingress. ebm-papst performs tests in accordance with IP standard IP X3 (sprayed water), X4 (injection


FIGURE 8: **In plastic impellers, the 'growth of the flowing material' is analyzed via the centrifugal load. The maximum permissible speed is exceeded many times over.**

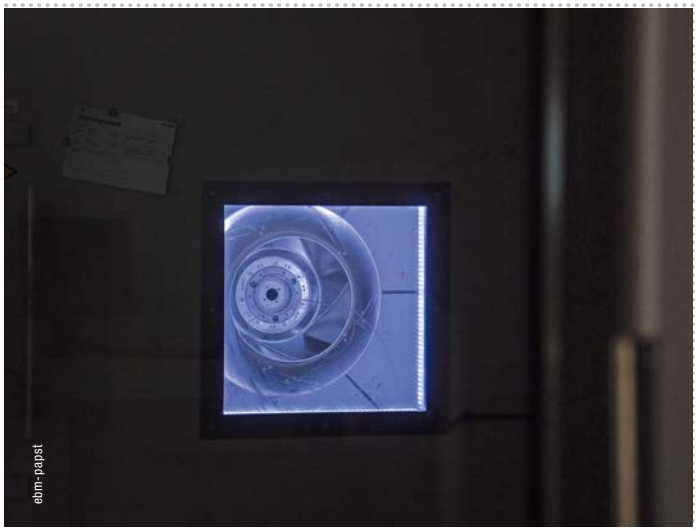



FIGURE 9: **In metal impellers, the spin and cycle test is used with a focus on start and stop cycles, because frequent ramp up and ramp down results in an increasingly heavy load on the metallic connections.**

water), X5 (water jet), X6 (water jet) and X9K (flat jet nozzle). “Many of our customers attach great importance to the IP standard,” says Erich Kemmer. “But from our point of view, they 'only' relate to the load with water over a certain period of time. So we also test our products with long-term climate tests: We add additional loads, such as freezing moisture. This is how we really put our products through their paces.”

*Test field for salt spray*

In the test chamber, the fans are exposed to artificial salt spray over a longer period of time. However, this is not about replicating a real load with salty air. This investigates the quality of the coatings and rules out that the chemical influences lead to corrosion and lead to the fan behaving incorrectly, for example as a result of infiltration of the seals, leading to moisture going into the fan.

*Test field for accelerated service life tests*

Fans need to work reliably for many years. To be able to simulate an entire product life in 'time lapses', the accelerated service life tests combine several load types. For example, a fan in the field runs at an ambient temperature of 20 to 40 degrees and at between 20 and 70 percent of its power. In the first of the accelerated service life tests, it is operated at maximum power and at the maximum permissible ambient temperature. This enables ebm-papst to cre-

ate a standard load profile of several years in a short period of time and qualifies the minimum product service life.

The two temperature change rain tests (TWR) H1 and H2 follow. These have been developed by ebm-papst itself over decades. "We knew from our decades of experience where possible weaknesses could be and these are exactly what we wanted to test out with the test bays," says Erich Kemmer. H1 and H2 are long-term tests that qualify resistance to climatic loads during operation. This involves complete devices in series production running through five temperature cycles per day over a period of 6 months. During TWR H1, condensation is added without direct rain. During H2, the fans are also directly subjected to rain.

*Digital solutions help with analysis*

With the gateways from ebm-papst neo, development engineers log parameters (e.g. speed, power, temperatures, etc.) of the test specimens and the test systems in real time. This data is backed up in a cloud and can be retrieved at any time. It is also possible to automatically check these values for deviations from the specifications in order to generate relevant alarm messages. In a next integration step, this data is automatically documented and stored at the end of the test.

*Put through their paces*

Several hundred fans and components pass through the testing center every year. And not all of them pass the extreme tests: "Our expertise helps us to identify the sensitive positions and to check them to load, so the results may not always be positive," says Erich Kemmer. "What does not meet our strict requirements does not come onto the market. After all, customers rely heavily on our quality assurance." ○



FIGURE 10 + 11: **The shock and vibration test bay simulates the loads caused by transport by train, truck, ship or aircraft. The test bench carries out sustained vibrations of varying strengths and individual shock pulses.**


FIGURE 12: **The validation experts can often detect changes in the material, such as minimal crack formation, by eye. For full safety and documentation, they use various optical analysis devices and micro-scopes.**

## FACTS AND FIGURES FOR THE TESTING CENTER AT EBM-PAPST IN MULFINGEN

- Focus: Centralization of all testing capacities
- Validation throughout the entire development and product life cycle
- Intelligent test specimen monitoring and system control
- Several hundred test specimens per year
- Area: approx. 2,500 m²
- Investment: approx. €8 million
- Construction time: 15 months

Get to know the testing center
as a multimedia story:
http://www.mag.ebmpapst.com/validation

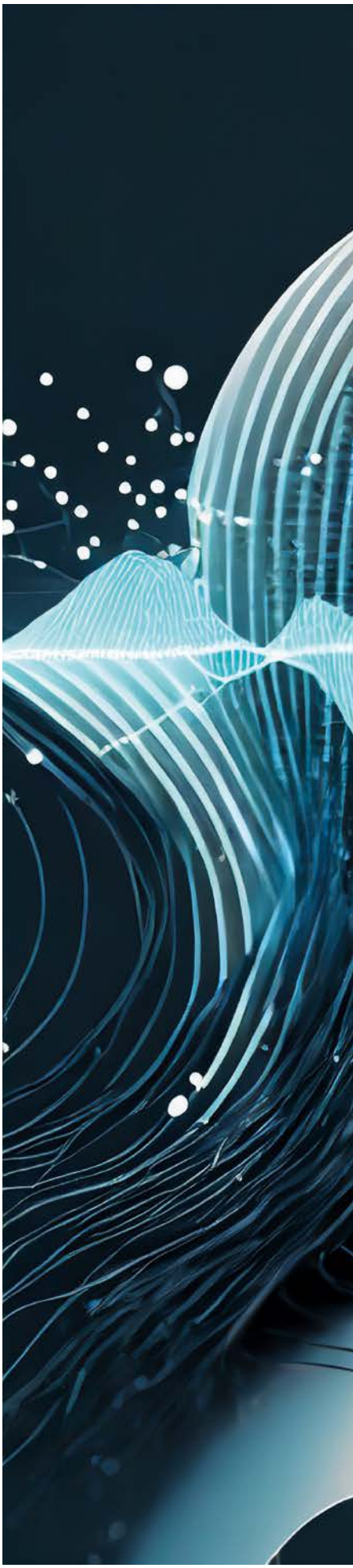

IN CONVERSATION WITH ERICH KEMMER, GROUP LEADER VALIDATION AT EBM-PAPST MULFINGEN.

YOU WOULD LIKE MORE INFORMATION ON THIS TOPIC? PLEASE ADDRESS YOUR QUESTION TO:

Erich.Kemmer@de.ebmpapst.com

Focusing on psychoacoustics

# Soundcheck for air/water heat pumps



Today, using renewable energies is absolutely essential for climate protection. That is why air/water heat pumps enjoy a high level of acceptance in heating technology. Demand for them is rising and, with heat outputs from 3 to 30 kW, they are a useful solution for detached homes and apartment blocks. In many countries, the installation of heat pumps is subsidized by public funds. However, air/water heat pumps do not work completely silently and the more dense the buildings are, the more the neighbors can get disturbed by noise pollution. It is by no means just the measurable sound pressure level that is crucial, but human noise perception, which is where psychoacoustics and its examination methods come into play.

ebm-papst with Adobe Firefly (AI-generated)

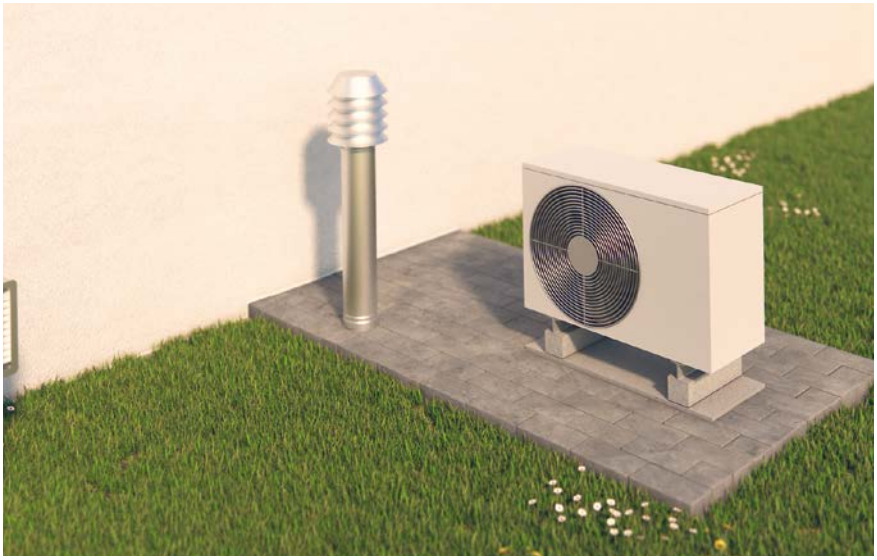


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FIGURE 1: **Air/water heat pumps do not work completely silently and the more dense the buildings are, the more the neighbors can get disturbed by noise pollution.**

In principle, a heat pump (Fig. 1) works like a refrigerator, which withdraws heat from the food stored in it and transfers it outside. Air/water heat pumps extract heat from the surrounding air and transfer the heat to the heating system, which warms the living areas or is used to heat water. Fans ensure the necessary external air flow through the device's evaporator and inevitably generate more or less noise during operation. This also applies to the fans with GreenTech EC motors that are particularly quiet. Where they are installed can also have a negative impact on noise generation. Noise generation always needs to be considered by those who use air/water heat pumps. As a rule, it is not usually sufficient to merely observe the limit values of the local standards and noise protection ordinances.

*When is a noise pleasant?*

The values defined in the guidelines and standards, which can be measured on the test stand, have little to do with individual human noise perception. Until now, standards and directives have not adequately dealt with tonality, i.e.

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FIGURE 2: **The psychoacoustics laboratory for test subjects at ebm-papst in Mulfingen/Germany.**

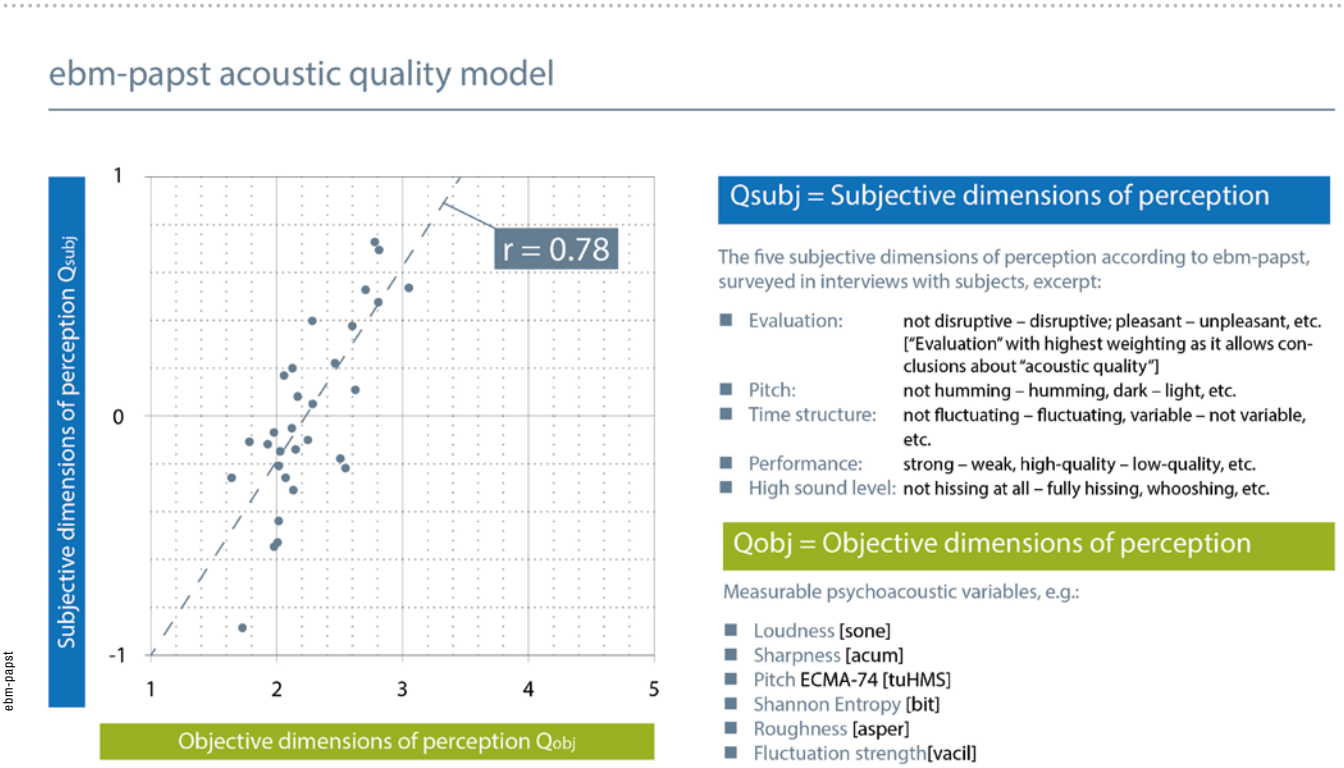


FIGURE 3: **ebm-papst also examines fans in installation scenarios from a psychoacoustic point of view and has developed its own metric for acoustic quality. For this purpose, subjective dimensions of perception with measurable psychoacoustic variables are brought into play. The closer the correlation coefficient r is to 1, the more suited the model to depicting the subjective aspects of perception through objective (measurable) ones. The acoustic quality Q, which then represents the fan's perceived noise, should be as high as possible.**

the relations between tones. Different psychoacoustic tests are currently looking into this. Psychoacoustics aims to define why we perceive noise as pleasant or unpleasant. For example, trumpet music and an excavator at a construction site have approximately the same measurable sound power, but our psychoacoustic assessment of them is completely different.

Motor and fan specialist ebm-papst studied this issue early on and set up a special psychoacoustics laboratory for test subjects to demonstrate the operating noise of heat pumps and the fans installed in it in various configurations (Fig. 2). Developers question the subjects afterwards to build up a scientifically founded database, for example based on the following key psychoacoustic parameters: loudness [sone], sharpness [acum], pitch [mel], roughness [asper] and fluctuation strength [vacil]. In addition, tonality and stimulus are also significant variables. Tonality is present when single tones are noticeable within a noise, which increases the interference effect. Noises that contain rapid changes in level, e.g. knocking or ramming noise, are identified with impulsiveness. Both impulsiveness and tonality can be measured with microphones and compared with the test subjects' statements. Assessments by the test subjects are analyzed using statistical and psychological methods. The results are incorporated into in-house fan development, but also provide information about the tested air/water heat pumps and which fans are best suited to the individual installation scenario. Ultimately, the aim is to ensure that the operating noise of a high-quality heat pump that is already very low is perceived as pleasant by the widest possible group of test subjects.

*Metric for psychoacoustic evaluation*

Research on psychoacoustics is in full swing and we can look forward to more results. As part of a doctoral thesis carried out at ebm-papst, for example, it has already been possible to develop a metric (Fig. 3, p. 27), which is now used for psychoacoustic evaluation in the end device. The aim of this metric is to create a correlation between the subjective perceived noise quality, which presents itself in different "dimensions", and objectively measurable variables. During the extensive hearing tests carried out, different dimensions of perception were compared to one another and to physical measured values. A total of 123 test subjects between the ages of 19 and 60 were played 89 sounds in three series of experiments in realistic conditions. For each series of experiments, 30 to 40 of these test subjects assessed the noise recorded (Fig. 4) in terms of performance (slow/strong, high-quality/low-quality), sound level (hissing or whooshing), time structure (fluctuating), quality (pleasant/disruptive) and pitch (humming, dark/light). In addition, different noises were directly compared and noises were checked against one property for a rating scale.

Additional interviews from the test subjects revealed that the noise characteristics dark, deep, slow, monotone, consistent, soft and light were considered pleasant. On the contrary, rattling, fluttering, clashing, dripping, humming, changing, high, bright and hissing properties were considered unpleasant. Overall, it was quite acceptable for the test subjects that operating noise was generated, but they must be perceived as pleasant. Finally, however, the evaluation of the hearing tests showed above all that the "disturbance level" can be largely combined with objective psychoacoustic parameters.

*Physical and psychoacoustic parameters for assessing noise*

Based on this, two follow-up objectives can now be defined: In future, the aim is to also use psychoacoustics in addition

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FIGURE 4: **In this measuring device, noises are recorded via a variety of microphones and then played to the test subjects for evaluation.**

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FIGURE 5: **ebm-papst fans are not only ideal for use in heat pumps with flammable refrigerants. They are also aerodynamically and acoustically optimized.**

to the physical parameters for assessing noise in fans (Fig. 5). The aim is also to work towards the introduction of an international standard based on standardized psychoacoustic variables. This would then be an important prerequisite for ensuring that air/water heat pumps with as pleasant an operating noise as possible help to avoid any nuisance in the neighborhood due to noise pollution. ○

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FIGURE 1: **The same applies to shuttle applications as to all intralogistics: the faster the vehicles can accelerate and brake, the higher the throughput rate and the more goods can be picked or supplied.**

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Powerful, compact and flexible drives for intralogistics

# Precise sprinters make shuttles quick

To use up as little space as possible, warehouses are usually built vertically. Shuttle vehicles then drive to all the storage positions at all levels. They are the only way to store, remove or move different products quickly and purposefully so that they can be picked and sent smoothly. Drive systems that meet high requirements in terms of dynamics, positioning accuracy and service life are required as the driving force behind the shuttles, but they must also have sufficient torque while being as compact as possible.

The same applies to shuttle applications as to all intralogistics: the faster the vehicles can accelerate and brake, the higher the throughput rate and the more goods can be picked or supplied (Fig. 1, p. 30/31). Accuracy when driving up to the storage locations and handling the products or product carriers is also an important requirement for this, as is reliability, because if the hard-working vehicles fail, the warehouse processes come to a standstill.

*Tough requirements for the drives*

Drives that ensure that shuttles move in a targeted manner within the shelf systems play a key role here. For example, the one – or sometimes two – traction drives must be dynamic, accurate and robust for the movements in the direction of the x-axis and it must be easy to integrate them into the application. The latter not only applies to the drive's dimensions, but also to its connection to the vehicle's control system. The telescopic drives for the pick-up device that removes the goods from or adds them to the shelf is just as important for smooth shuttle operation. Here, there is often even less installation space for the necessary motor-transmission combinations than there is for the traction drive. In some types of warehouse, shuttles do not only travel in one direction, they can also travel across the warehouse. This requires similar drive concepts to the traction drive, in some cases with much more compact dimensions.

Manufacturers are well-advised to find a motor manufacturer that can give them skilled support in selecting a motor and that has a broad range. Drive solutions from a single source not only provide logistical benefits, they usually simplify coordination and shorten the time to market. That is why ebm-papst offers a wide selection of motors, control electronics, transmissions, and brake and sensor modules that can be combined to create a tailor-made drive (Fig. 2). The electronically commutated ECI motors, for example, cover a continuous power range from 30 to 750 watts in sizes 42, 63 and 80 mm. Then, different transmissions matched to the drives ensure the necessary reduction ratio of the high-


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FIGURE 2: **Modular drive system: All individually selected drive components are placed in a common housing.**

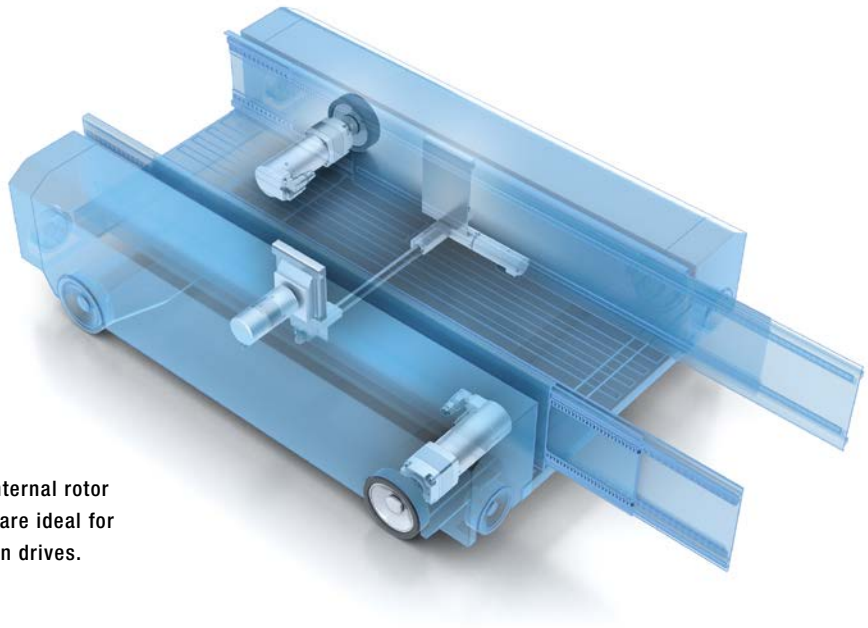

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FIGURE 3: **The ECI internal rotor motors, for example, are ideal for use as shuttle traction drives.**

## ebm-papst offers a wide selection of motors, control electronics, transmissions, and brake and sensor modules that can be combined to create a tailor-made drive.

speed internal rotor motors. The transmissions can also be combined with the external rotor motors in the VDC series. The latter cover a power range up to 125 watts in the smallest installation space and also boast a long service life and good control properties. The modular drive system offers several thousand variants in total. Defined preferred types are ready for shipment within just 48 hours, making them available for sampling exceptionally quickly. In addition, the motor and transmission specialists offer project-specific engineering, e.g. when it comes to fine tuning the motors or special transmissons and when adaptations to the overall length, cable assembly or additional encoders are required.

*Dynamic traction drives*

The modular drive system enables standard solutions to be implemented for many applications. For example, the ECI internal rotor motors are ideal for use as shuttle traction drives, depending on the required power, either in size 63 or 80 (Fig. 3). They require little installation space, achieve high torques

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FIGURE 4: **The VDC 49.15 external rotor motor is an ideal telescopic drive. With a power of 110 W, it is just 52 mm long with a diameter of 63 mm and can be easily combined with the robust Optimax planetary gear.**

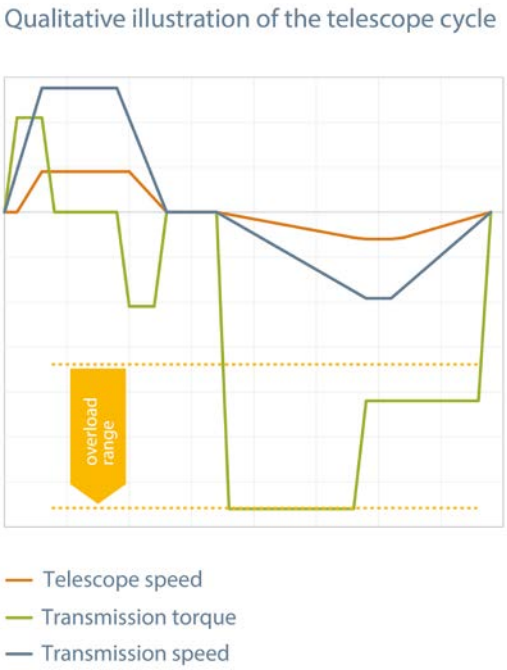


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FIGURE 5: **The compact telescopic drive exhibits impressive results.**

at 24 or 48 V, and are able to deliver three times the nominal power for a short time. Combined with the Optimax transmissions, which already have overload capacity, compact, robust drive systems are created, which can also be controlled based on the application through the motor electronics chosen. The K1 electronics module is designed for operation with external control electronics. If the drives are to communicate via CANopen, EtherCAT or other common BUS systems, the K5 electronics module is the right choice. It can have an external or integrated design. Configurable, integrated control electronics for speed, torque and position are available for analog actuation.

The planetary gears in the Optimax series also have a high power density and are also very robust and durable. Another special feature of the transmission series is the high torques. The medium variant, for example, offers peak torques of up to 150 Nm with an installation edge dimension of 63 mm and a length of just 102 mm in the two-stage version.

*Bespoke telescopic drive*

In the shuttles, space for the telescopic drive is usually at a premium. This is a typical area of application for the VDC 49.15 external rotor motor (Fig. 4), for example. With a power of 110 W, it is just 52 mm long with a diameter of 63 mm and can also be easily combined with the robust Optimax planetary gear. This compact design means that one drive can be used per telescopic arm, thus two drives per telescope, which massively increases the power density of the shuttle and the throughput rate of the warehouse. It is also possible to adapt

the transmission design, with the appropriate number of units.

The test stand proves what this type of telescopic drive can achieve. All shuttle drives can be tested before they are used and the profiles required for the application can be run off. If necessary, the values then form the basis for fine tuning, as the motors can often do far more than what it says on the data sheets. In any case, the telescopic drive described above delivers impressive results on the test stand (Fig. 5). In combination with a two-stage Optimax planetary gear, a drive unit delivers a torque of 10.5 Nm to the output shaft. Therefore, the telescopic mechanism can move 50 kg cargo load with an acceleration of 1.1 m/s$^2$. A drive solution like this is also recommended if the width of the gripper system has to be adjusted to adapt it to different product carriers. If there is no standard solution, the motor and transmission specialists can help with the selection and engineering. ○

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