ebmpapst

the engineer's choice

WHITE PAPER

Small, but powerful.

Compact fans from ebm-papst are extremely powerful, even in the smallest of spaces.

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1. Executive summary

In many fields, the amount of electronics installed is increasing, while integration density is also growing. The interaction of people and technology – and thus spatial proximity to one another – is becoming more and more common. This poses corresponding challenges for the fans installed. In limited space, they have to be capable of moving high volumes of air, be quiet and durable, but also be as energy efficient as possible. Various voltage and frequency ranges, integration into the existing device logic, and individual control are also possible. This is why various compact fans have been developed for a wide range of applications. Axial compact, centrifugal, and diagonal compact fans are primarily used. Axial compact fans deliver a high air flow with a medium to relatively high pressure increase. Centrifugal fans provide a high pressure increase with a limited air flow. Diagonal compact fans in turn provide a high air flow with a relatively high pressure increase. However, these rules of thumb cannot always be applied blindly. In the case of applications in special sectors, such as transport technology or IT telecommunications, further requirements and standards are incorporated into development. In addition to a wide product range, individual solutions are frequently required. Holistic consideration of the entire fan unit in conjunction with detailed consultation makes even the most demanding special solutions possible. This allows us to create fans that have never existed before.

2. Major challenges for compact fans

Technology is becoming ever closer to people in many places. This also usually increases the demands on fans in these applications. For example, a low noise level for electronic cooling is important for medical technology, so that patients are not impacted. Loud refrigerated display cases in supermarkets would in turn have a negative impact on the purchasing experience. In control cabinets for IT telecommunications, servers, and power supply devices, a high cooling capacity is required. Compact fans are also used in commercial household appliances and in control and power electronics for kitchen appliances.

Expertise and technology combined

- Small installation space
- Individual installation situation
- Various designs
- Adverse ambient conditions
- Changing pressure conditions
- High air performance demand
- Extreme or changing temperatures
- Controllable speed adjustment
- AC, DC, or GreenTech EC design
- GreenIntelligence
- Adaptation to existing device logic
- Predictive maintenance

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As cooling air blowers, they also work in zero degree compartments or refrigerator compartments designed to keep food fresh. Compact fans are used in heat-pump dryers to cool the compressor. The smaller the installation space, the higher the requirements often are. Compact fans come into play here, as they play an important role in ensuring that the applications run smoothly.

Compact fan applications at a glance

- IT telecommunications (IT servers, IT routers, IT base stations, control cabinets)
- Medical technology (computer and MRI scanners, sleep therapy devices)
- Automation (robot controllers, printing machines, weaving and punching machines)
- Welding machines
- (Solar) inverters
- Variable frequency drives
- Battery cooling system, uninterruptible power supply (UPS)
- Refrigeration technology (refrigerated display cases)
- Domestic (refrigerators, heat-pump dryers)
- Transport/railway technology
- And many more

Why can compact fans in particular meet the demands set?

Compact fans provide a high output while having a compact design and are therefore highly efficient. They are made from metal or plastic. The fully metal design of the fans is particularly robust and resistant. They are primarily used in the case of environmental requirements such as direct UV radiation, in direct contact with acids and salts, or in applications subject to shock and vibration. Fans with a plastic design can be used flexibly due to their low dead weight. Outstanding strength and low weight characterize this very economical fan concept. This makes operation possible even in the most adverse ambient conditions. For example, protection of the fan electronics against humidity and condensation, protection of the motor and circuit board against splash water and moisture, as well as protection of the fan against harmful effects of salt spray are no problem. Combinations of metal housings with plastic impellers marry the advantages of both types of design. All of these types also offer the advantage of simple assembly.

The compact fans are also used where installation space is limited. Despite this, they have to be powerful and provide sufficient cooling. Depending on the place of use, it is important that the resulting

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noise emissions are not too high. Aerodynamically optimized design and high mechanical precision enable consistently low noise. In addition, there is a wide variety of sizes and designs, which means that there is a suitable fan for any application. Due to standardized series, they can be tailored to suit even the most unusual deployment and environmental conditions. Customized special versions are possible for special requirements. In addition, the compact fans can be intelligently connected to adapt to the device logic or existing control systems. Which is the better choice depends on the application involved. The installation and operating conditions are important factors for the fan to work at optimum efficiency and with minimal noise emissions.

Similar but different: compact fans meet various requirements in a wide range of areas.

Small installation space, huge effect

In the case of large amounts of heat in a small space, a high air flow is required. High-performance fans that can cope with this air performance are sometimes loud, not necessarily economical in operation, and often can only be controlled to a limited extent. Installing an advanced generation of high-performance fans improves cooling efficiency and therefore saves energy. This environmental protection concept was taken into account during design – including when it comes to subsequent disposal – to make it easier for users to meet current and future standards. Increasingly compact and powerful electronic components mean that the size of the devices can be reduced while maintaining or even increasing performance.

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3. Designs at a glance

Axial compact fans: High air flow with a medium to relatively high pressure increase

The air flow of the impeller that is similar to a propeller in axial compact fans is conducted largely parallel to the axis of rotation, in other words in the axial direction. Axial compact fans with free air delivery at zero static pressure have the lowest power consumption that rises with increasing back pressure. Axial compact fans for cooling of electronic equipment are mostly fully equipped with external housing. The electric motor is integrated in the fan hub. This compact design means it can be placed in the device in a space-saving manner. The flange is equipped with mounting holes.

Voltage 5-75 VDC, 11-440 VAC
Power consumption 0.1-275 W
Air flow rate up to 1,220 m^3/h
Applications up to 1,500 Pa

Centrifugal compact fans: High pressure increase with limited air flow

In general, many cooling tasks can be performed optimally using axial compact and diagonal compact fans. However, if the cooling airflow has to be deflected by 90° or an even higher pressure increase is required, centrifugal fans are more effective. This makes them the ideal choice for highly compact 1U and 2U rack-mount servers, as well as in many sizes and expansion levels.

Voltage 6-72 VDC, 103-264 VAC
Power consumption 1-190 W
Air flow rate up to 1,600 m^3/h
Applications up to 5,200 Pa

Diagonal compact fans: High air flow rate with relatively high pressure increase

At first glance, there is not much difference between diagonal compact and axial compact fans. The air is drawn in axially, but the outflow is diagonal. With diagonal compact fan, the conical shape of the impeller and housing results in greater compression of the intake air. The outstanding feature of this type of fan as compared to axial compact fans of the same size and offering similar performance is a far lower operating noise level at high pressures.

Voltage 9-72 VDC
Power consumption 19-360 W
Air flow rate up to 1,100 m^3/h
Applications up to 1,500 Pa

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4. Selecting the right compact fan

To understand whether an axial compact, centrifugal, or diagonal compact fan is optimal for a particular application, the basic functions are briefly described. In axial compact fans, the pressure increase is generated by deflecting the incoming air through the blades and spiraling round as it exits the fan. Here, the pressure increase depends on the angle that the air flow forms relative to the blade profile. If more pressure is required, this angle must be increased. This principle has its limits: if the inflow angle becomes too large, the profile flow stalls and the fan operates inefficiently and with more noise. If even more pressure is required, fans are deployed that use the centrifugal forces in addition to the effects described. As in any rotating system, the air in the fan impeller is also subjected to centrifugal forces that push it outwards. If axial compact fans are operated at low air flow rates, part of the air blocks the blade channel and forces the air flowing through onto a radial path through the fan. The centrifugal forces are then increasingly involved in the pressure increase. In this operating range, the axial compact fan behaves in a similar way to a centrifugal fan. Accordingly, diagonal compact or centrifugal fans are used when a greater pressure increase is required relative to the air flow. For purely centrifugal fans, the centrifugal effect is even the dominant mechanism that needs to be implemented as effectively as possible. With the same outer impeller diameter and speed, centrifugal fans can achieve significantly higher pressures than axial compact fans that are always used in cases where relatively large volumes of air need to be moved with minimum effort. These basic considerations enable the fan to be aerodynamically designed and optimized.

To find the right compact fan for a particular application, the entire system needs to be fully considered. In an application-specific consultation, all system data is recorded and integrated into an individual simulation using a number of different variables. It is often useful to incorporate the selection of the right compact fan into the design early on. Tailored framework conditions for expectations such as ideal cooling capacity, perfect air flow, and low operating noise can therefore be created early in the process. Even when installing or replacing existing fans, it is useful to carry out an individual evaluation of the system. It is recommended that you know the data and variables in your own system as precisely as possible.

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Simply the right choice: the ideal fan with FanScout

With the tried-and-tested ebm-papst FanScout selection software, users can find the ideal solution at the click of a mouse. Despite the number of versions in the product range, the optimum compact fan can be selected quickly and with absolute certainty for individual requirements. The software provides completely reliable and, above all, extremely precise data, as it is based on real measured values. In no time at all, it is not only possible to determine the best solutions for an application, but also simulate various operating scenarios. that take the fans' operating points, operating times, and space requirements into account. The result is the expected annual energy consumption. To make the decision even easier, ebm-papst FanScout also takes life cycle costs into account – from the purchase price to operating and service costs.

5. Optimum properties

5.1. Quiet

Fan noises are generally generated by two different processes. On the one hand, noises generated directly by air movement and the associated pressure fluctuations (aeroacoustics) and, on the other hand, noises caused when solid bodies hit or rub (structure-borne sound). These two main processes include noises that can occur in the integrated power and control electronics. The aerodynamically generated noises represent a particular challenge in the design of fans. Even the smallest changes to the blade design, retaining struts, and housing can have a significant impact on the noise level and quality. For example, the air flow can stall at the outer and end edges of the blades and the resulting turbulence can increase the generation of noise. The air flow that blows over the struts which hold the rotor in the housing also generates turbulence. In addition, pressure fluctuations occur when a blade moves past a strut. Structure-borne sound is the second element that contributes significantly to operating noise. These vibrations in the fan structure are generated, for example, due to an imbalance of the rotor or electrical or magnetic excitation in the motor similar to the familiar transformer humming. The structure then acts like a speaker. The vibrations are particularly strong when resonant frequencies are stimulated in the fan structure. However, above a certain speed, the fan's noise emissions are dominated by the aeroacoustic effects.

Our aerodynamically optimized design and high mechanical precision therefore produces constantly low noise levels in series production. For DC and EC fans, "gentle" commutation electronics contribute

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to outstandingly smooth operation. By avoiding steep switching edges when the individual motor windings are switched, this reduces the structure-borne sound from the motor. Computer-aided and analyzed measurement series in a highly demanding acoustic measurement room are therefore accompany every fan series right from the start.

Noise in applications close to people

To counteract the problem of irritating operating noise, there are state-of-the-art fan designs which are able to significantly reduce the noise emissions depending on the operating point. Low-noise fans, which are also perceived as less disturbing due to their tone type, are particularly suitable for applications in areas in which people live and work. Many applications demand these types of quiet fans with high flow rates. If decentralized ventilation or a solar inverter is installed in a house, for example, the living environment should not be affected by irritating sounds. Fans that convey air without excess noise can make a significant contribution to making day-to-day technology quieter.

Medical devices and their components place particularly high demands on reliability. Particularly when using apnea devices at home or using respirators in intensive care, it is also important that it is as easy as possible to handle them. For example, if a respirator is used at night, this type of device must, of course, be close to the bed in the bedroom and must not disturb healthy sleep due to operating noises. To meet these requirements reliably, the RV45 centrifugal fan was developed for respirators and similarly dynamic applications. The RV45 compact fan is optimized to provide the best possible results when it comes to aerodynamics and motor performance. It also delivers the required aerodynamics and drive technology. Despite the major fluctuations in flow quantity, use at night next to the bed requires absolutely smooth operation. Noise would disturb the patient's overnight rest and possibly that of their partner in the room as well.

You can find more about the medical use of compact fans as quiet breathing aids at http://ebmpapst.com/rv45

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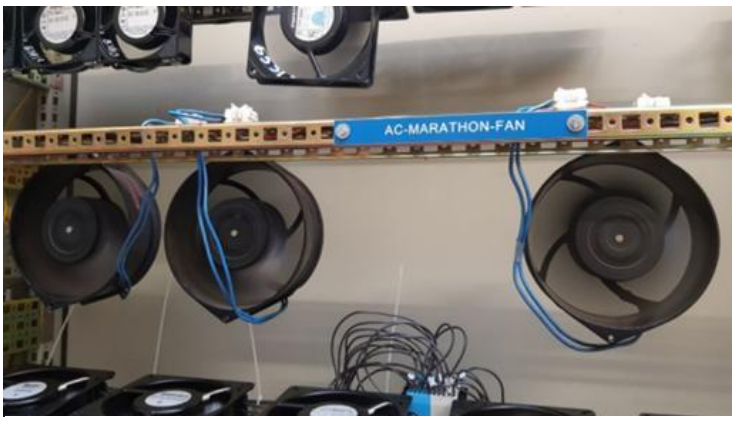
5.2. Durable

The bearing system plays a vital role both in the durability and the smooth operation of device fans. Consistently low noise levels across the entire operating time and high impact resistance characterize Sintec bearing technology. In terms of temperature resistance, these compact bearings can be used without problems in most applications. Despite the slightly higher operating noise, this bearing technology should be given preference in the event of extreme thermal stress and adverse application conditions (extreme environmental conditions, critical installation positions, etc.).



Marathon test for endurance runners, some of which have been in operation since the 1980s.

The service life specifications at ebm-papst are based on extensive service life tests and mathematically/scientifically recognized service life calculations, in which relevant new knowledge is continually being gained. When it comes to the service life of a product, many manufacturers make use of calculations and simulations. However, these specifications often do not stand up in reality, which is why theory should also be supplemented with practical findings from accelerated tests and endurance testing from the laboratory. As products cannot only be launched after long test phases, the endurance tests are performed at temperatures of 40 and 70 degrees Celsius. This is because heat accelerates the wear process. The failures are assessed in accordance with the Weibull distribution. From the distribution, it is possible to calculate the point in time at which ten percent of the tested specimens have failed and when the wear of the bearing system starts. Testing at different temperatures makes it possible to determine an "aging factor" which can be used to determine the life expectancy for other temperatures. Test specimens that are still running will not be switched off in order to obtain further findings. There is therefore the strange situation in which some fans have been in continuous operation in the test laboratory since the 1980s.

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5.3. Efficient

Greater power density, increasing miniaturization, and extreme electronic component density are placing increased demands on the cooling capacity and efficiency of fans. Therefore, intelligent and space-saving integration of the fan in the device configuration is very important. On demand, cooling must be tailored and adapted to the situation and it must also be possible to program it by specifying speed profiles. Functional transparency due to complete, interactive monitoring in all operating situations is an additional requirement.

Standard fans in electronics cooling have proven themselves a million times over. With a constant speed which is often associated with a correspondingly high noise level, they continuously provide the air flow required for extreme cases. But these extreme situations occur seldom – if at all – during operation. What is needed is an intelligent fan that adapts automatically to the level of cooling required at the time.

Increasing demands on fan energy efficiency and the trend toward ever smaller sizes with ever greater output are being met by developers with customized EC motors, for example. Small installation space, speeds independent of the respective mains frequency, and designs that can be replaced using plug & play make these electronically commutated (EC) drives the ideal inexpensive alternative and they also ensure an outstanding motor efficiency level. When it comes to ACi fans from ebm-papst, it was possible to develop products that impress compared to existing AC fans due to significantly improved efficiency, compact design, lower noise levels, and longer service life using GreenTech EC technology. The electronics make the motor – and therefore the fan – flexible: with their broad input voltage range from 90 to 265 V (at 50 or 60 Hz), they are suitable for all supply networks worldwide. The energy savings alone means that the products pay for themselves after only a few months. The savings over the entire service life, especially in systems with multiple fans, are considerable.

The fans can also be controlled intelligently. This technology brings with it a whole host of advantages: higher efficiency, low maintenance, longer service life, sound reduction, intelligent control characteristics, and incomparable energy efficiency. Pioneering EC technologies that exceed the performance classes of the ErP Directive with regard to efficiency are already setting the course for the future. With this competitive advantage, users are also well prepared for future requirements.

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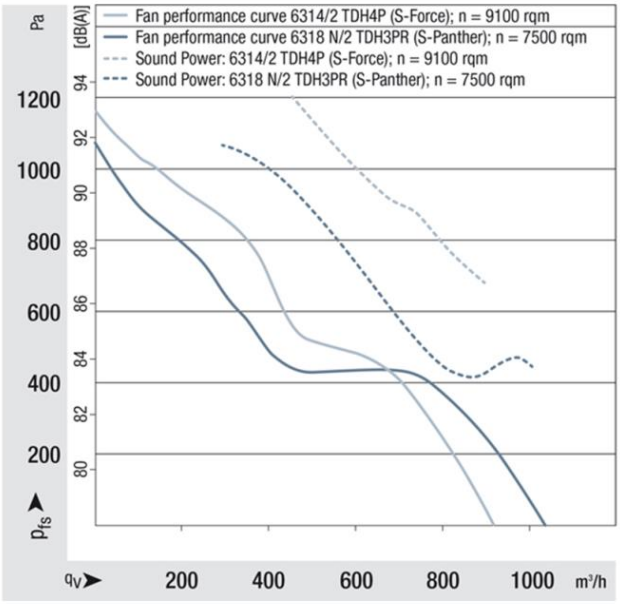
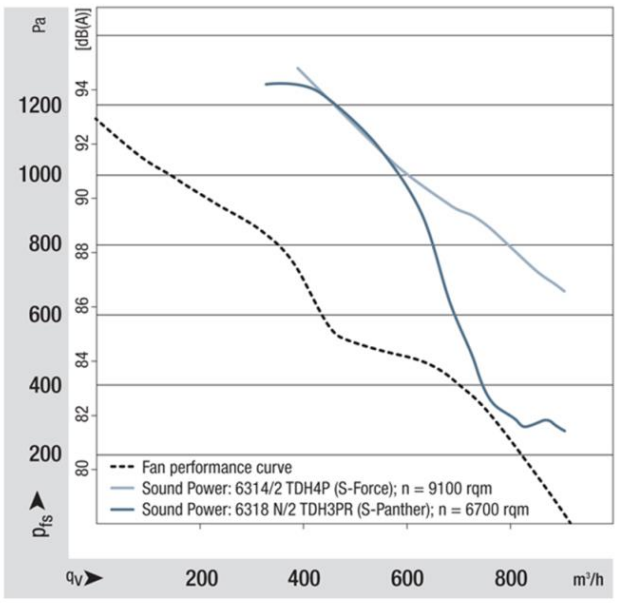
5.4. Compact

To offer users of future technologies an adapted fan solution, compact high-performance fans from ebm-papst have been developed: the S-Panther and AxiForce series. Technology is growing closer and closer to people in many areas. Quiet-running fans can improve people's sense of well-being in their surroundings. This is why these fans have been designed especially with regard to low noise emissions without having to compromise in air performance or efficiency. To achieve this, the aerodynamics had to be redesigned from scratch and the fan had to be newly developed. As such, compact fans are used to cool control units used in automation, variable frequency drives, robot controllers, LED displays, for cooling 5G power modules for the mobile network infrastructure, electronics cooling of servers for video streaming and data center equipment. At an operating point of 108 m³/h at 285 Pa back pressure, the AxiForce 80 delivers an increase in efficiency to 42% and reduces noise emission by 7 dB(A) due to aerodynamically optimized fan impellers and fan housings. A special environment-resistant variant with fully enclosed electronics was also developed, satisfying the requirements of protection class IP68 – dustproof and protected against powerful water jets. This variant can also pass a 30-day salt spray test. The new generations of compact fans therefore deliver more power with less noise. and achieve considerable performance increases in the applications.



Comparison sound power and fan performance S-Force and S-Panther, size 172 mm.



Comparison sound power S-Force and S-Panther, size 172 mm at same performance.

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For example, if we look at the performance data of the 172 mm S-Force fan at 6000 rpm compared to the state-of-the-art S-Panther series fan with the same dimensions at 4500 rpm, the maximum air performance has been raised and the pressure saddle curve has been lowered. For most applications, this design is suitable for providing as much cooling air as possible. A design which has been refined further, which is mounted on blades with winglets and separation edges, enabled the sound power level to be reduced over the entire frequency range. The new strut design, specially adapted to the blade geometry, also plays a part in this. The improved air duct design enables a lower speed with the same air performance, which in turn reduces noise emissions.

If the speed of the new fan from the S-Panther series is varied so that the same characteristic curve as the predecessor model is achieved, a significant reduction in the noise level can be determined. Even at medium power levels, the operating noise at the same operating point has been reduced by up to 9 dB (A). The operating range to the left of the indicated line exhibits a high level of breakaway in terms of the aerodynamic flow. The sound levels of both fans are the same here. Despite this, the new fans still offer significant improvements in noise perception here. The blade passing noise which is always irritating to users and results from the number of blades and the rotational frequency, has been significantly reduced.

You can find a clear summary of other applications at https://ebmpapst.com/s-panther

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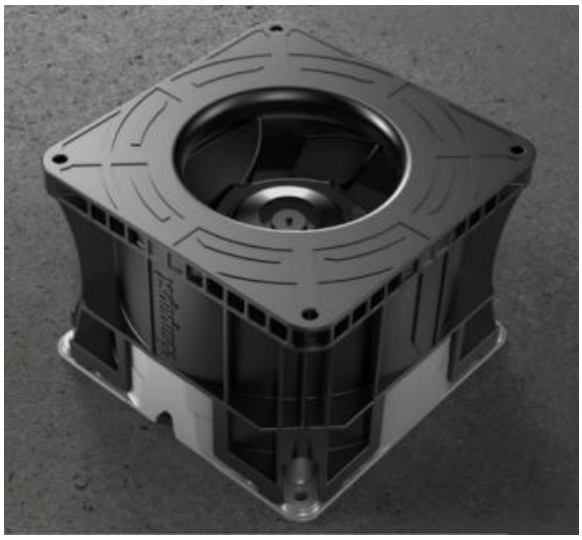
6. Side note: diagonal compact fans for IT telecommunications applications

Compact fans require powerful power packs that combine the characteristics of quiet and efficient operation in a compact size. ebm-papst recently developed a fan for a well-known electronics giant's latest generation of IT servers. 50% greater air performance and 6 decibels less noise than the best competitor product currently on the market were required.

What does that mean for ICT applications?

With the new DiaForce diagonal compact fan from ebm-papst, the performance of the system is uncompromisingly improved. Thanks to its power reserves, redundancy can be created, thus increasing the reliability of the system. For example, if the outside temperature rises due to faulty air conditioning, it is simply possible to increase the speed. This is not possible with conventional single-stage fans because they have to be operated at the power limit even during normal operation. Even in the future, the increasing performance requirements for ICT applications, such as the new 5G communication standard, autonomous driving, or artificial intelligence, are no obstacle due to the outstanding performance of the DiaForce.



High air performance for ICT applications: the newly developed innovative DiaForce

As with an axial compact fan, the innovative diagonal compact fan DiaForce also draws in and blows out air in an axial direction. Compared to a centrifugal fan, this design is advantageous when integrating it into the application. But the real revolutionary part happens between the intake and outlet, more specifically in the unique geometry of the impeller and housing: the DiaForce's cover plate is cut in a conical shape, meaning the intake opening is smaller than the outlet opening. This creates a larger pressure increase. Therefore, in terms of its characteristics, the DiaForce is between an axial and a centrifugal fan. The blade tips pass directly into the cover plate. As a result, there is no tip gap and therefore hardly any turbulence in the gap area, where there is a significant pressure gradient. This aerodynamic optimization significantly reduces noise.

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7. Side note: axial compact and centrifugal fans in transport technology

Digitalization doesn't even stop for transport technology and provides more on-board power electronics that have to be cooled. Whether you're transporting people or goods: reliability, noise, and safety are top priorities. Compact fans from ebm-papst meet these requirements in compliance with all the necessary standards. Compact size combined with simultaneous performance, demands with regard to convenience, efficiency, and environmental performance place high demands on fans for use in vehicles – whether with combustion engines, fuel cells, or electric drive technology. Added to this are railway-specific requirements and compliance with standards such as functionality in the event of shocks and vibrations, noise reduction, EMC compatibility and IP protection.

As the number of power electronics installed is increasing, the demand for effective but compact cooling is also increasing in this diverse area of application. That's why compact fans from ebm-papst are used in a wide variety of applications: to cool converters, control cabinets, or electronics, for ventilation and exhaust in toilets and for high-performance brake cooling. Trucks, train, and construction machinery drivers also benefit from being able to perfectly control the air conditioning in their cabs, making their everyday working lives easier. The proximity to people means that the fans used need not only be powerful and compact, but also quiet in operation. The axial compact fans from ebm-papst are ideally suited to these requirements in the respective application-specific environment. They are available in sizes from 25-225 mm and deliver air performance levels of up to 1,000 m³/h – free air.

Standards for additional safety apply particularly in railway engineering. For example, EN 44545 fire protection in railway vehicles and EN 50121-3-2 place special requirements on the electromagnetic compatibility of the installed components. The compact fans from ebm-papst are also designed according to "EN 50533: 2011 Railway applications - Three-phase train line voltage characteristics, class 1."

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8. Conclusion

Of course, the best solution has to be found for each project. To find it, you need to consider the ventilation and drive engineering aspects as a whole. Ideally, this is achieved with benchmark-setting motor technology, highly developed electronics, and aerodynamically optimized designs that are perfectly coordinated with one another. These system solutions open the way to synergies that are unique globally and reduce work for the user significantly. Intelligent solutions for electronics cooling ensure that users stay ahead of the competition through innovative and durable top-quality technology. This enables them to concentrate entirely on their core expertise. In addition to a large product range, the development of individual solutions is often also required. Of course, they have to be available quickly, in line with the market, at a fair price, and often tailored down to the last detail. This allows us to create fans that have never existed before.

Just like the application areas and individual requirements, the compact fans are also correspondingly diverse. In order to satisfy all requirements and performance ranges, relevant ideal solutions have been created. Even specially tailored designs are not an obstacle for very special requirements. This means that compact fans can provide high air performance even in a small installation space. Holistic consideration of the entire fan unit in conjunction with detailed consultation makes even the most demanding special solutions possible.

About ebm-papst

The ebm-papst Group, a family-owned company in Mulfingen, Germany, is the world market leader in fans and drives. Founded in 1963, the technology leader with its core competences motor technology, electronics and aerodynamics, has set international market standards ever since. With over 20,000 products, ebm-papst offers customized, energy-efficient and intelligent solutions for virtually any ventilation and drive technology requirements.

In fiscal year 2019/20, the hidden champion achieved a turnover of 2.188 billion euros and employed almost 15,000 people in 29 production sites (e.g. in Germany, China and the US) as well as in 48 sales locations. With their fan and drive solutions, ebm-papst defines and sets the benchmark in practically all industries, such as ventilation, air-conditioning and refrigeration, heating, automotive, IT, mechanical engineering, catering and household appliances, intralogistics and medical engineering.

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