

# railway magazine

INTERNATIONAL SOLUTIONS FOR THE RAILWAY INDUSTRY

## INTEGRATED FIRE SAFETY

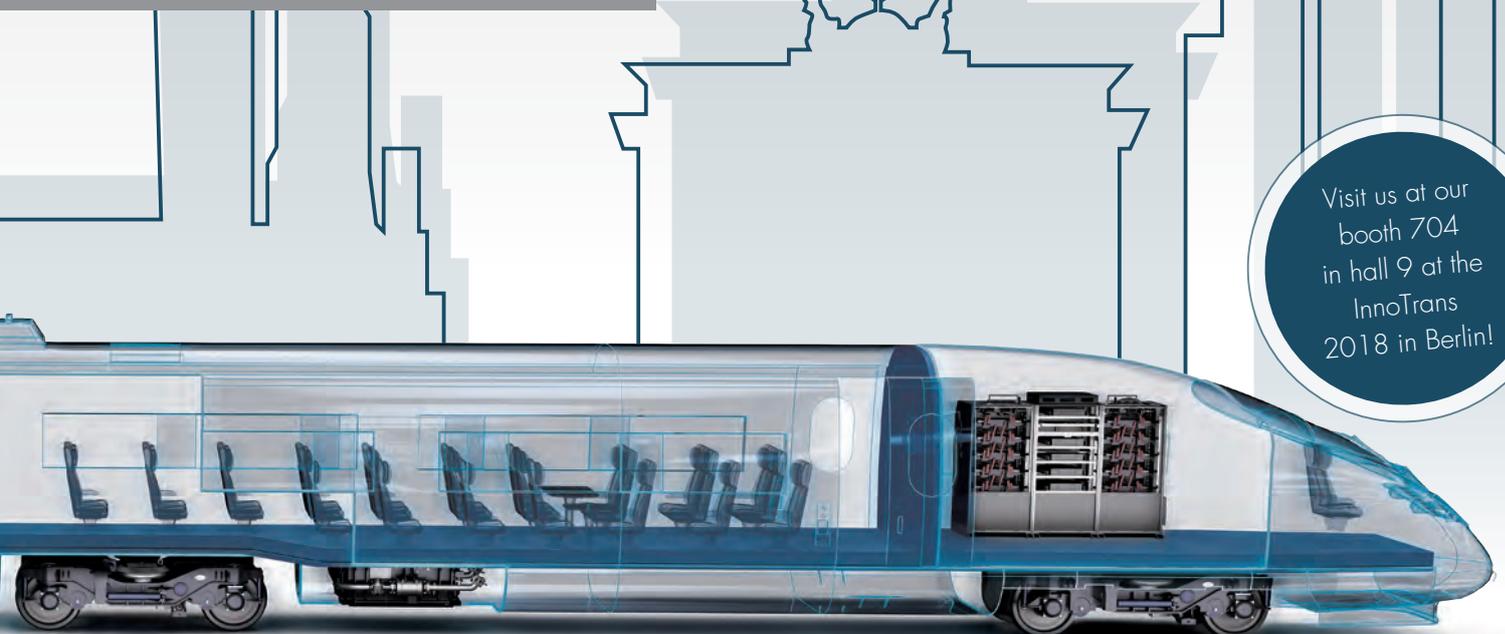
High-performance rubber compound inherently compliant with the fire safety requirements of EN 45 545. Coating is superfluous

## AGING-RESISTANT HOSES

Elastomer hoses become porous, fixed metal pipes are inflexible. ASSIWELL® is the name of the solution

## MINIMAL ELASTIC MOUNTING

The power converter of the EC250, which will travel through the Gotthard, is mounted in a new and unusual way



Visit us at our  
booth 704  
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InnoTrans  
2018 in Berlin!

# Editorial



Dear Reader,

Angst+Pfister is right on track. Many premier manufacturers of rail vehicles are now customers of our components and solutions. The growth we have made in this sector is a source of pride to us and confirms the innovative drive of our teams as well as the outstanding quality of our products. This is a highly competitive environment, which is becoming more and more complex through increasing regulation – a challenge for the suppliers of this sector too. Maximum cost efficiency is called for, despite increasingly sophisticated requirements.

However, it is precisely the challenge that provides the incentive for our engineers to deliver ever better performance in developing high-performance components. They apply their exacting skills to create new rubber compounds and solutions with optimum resistance to fire, corrosion or UV radiation – and mechanical and chemical properties that make them superior to standard commercial products. This is why Angst+Pfister is one of the leading companies in combining properties to produce compounds satisfying a whole raft of high-level requirements. Our high-tech elastomers are genuine all-

rounders. For one thing, many comply with the fire safety standards of a number of major markets such as Europe and USA.

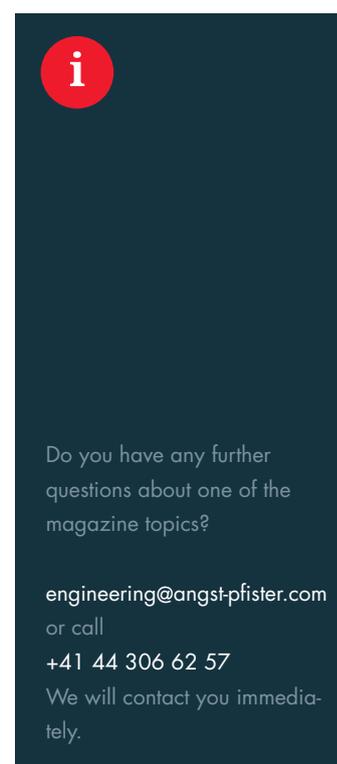
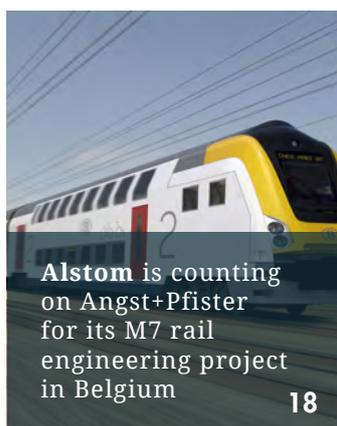
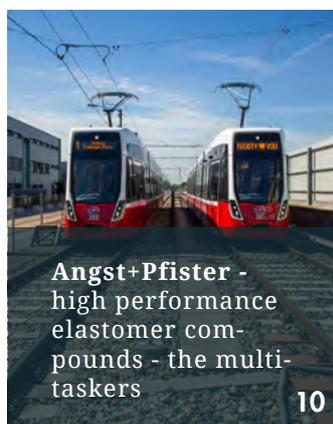
Collaboration with Angst+Pfister pays off in multiple ways: In addition to the high quality of our products, the breadth of our product portfolio is simply impressive. Our clever logistics solutions improve efficiency and are much appreciated by our customers. Ingenious design enhances both the comfort and safety of travel on the rail network. As the slogan goes: “Smart people take the train” - truer than ever, now that Angst+Pfister is on board.

The vertical buffers and layer springs we currently co-developed with Bombardier for the new Vienna trams are a good example of this. The homogenous high-performance elastomers provided by our company easily meet the R24 product requirement sets of the EN45545 railway standard for fire safety. They also have exceptional mechanical properties and exceptional resistance to ozone, pollutants and aggressive cleaning solutions while maintaining high performance in exceptionally low and high temperatures.

I wish you a pleasant read. Be inspired by our solutions expertise – and our passion for technology!

Erich Schmid  
Chief Technology Officer

# Content



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# Developments that bring technical and economic advantages

The development times are ambitiously short, the results are often even better than expected. This is what innovative companies want. And this is how it works for the Research & Development Centre of Angst+Pfister Advanced Technical Solutions in Bursa, Turkey. The engineers develop solutions for antivibration and sealing technology that optimise the total cost of ownership as well as the technology.



*Production site Angst+Pfister Advanced Technical Solutions in Bursa, Turkey.*



Numerical simulation significantly reduces development time: Angst+Pfister ATS specialists are applying their expertise daily in achieving this goal for Angst+Pfister.



“Following the co-design phase, our colleagues in Turkey usually need no more than six to nine weeks to build the prototypes.”

Erich Schmid, Chief Technology Officer, Angst+Pfister, Zurich

There is no question about it: All modern trains have floating floors to isolate vibration and absorb sound. The only imponderables for the train manufacturers are which materials and technologies to use. The development engineers from Angst+Pfister Advanced Technical Solutions in collaboration with engineers from Stadler Bussnang AG have recently designed a new floor mount for the high-speed multiple unit train EC250, which Stadler Rail AG of Switzerland is constructing for the Swiss Federal Railways. It not only meets the latest requirements of the fire protection standard DIN EN 45 545, which defines the requirements of materials and components for rail vehicles, but also in cross-comparison the new floor bearing from Angst+Pfister Advanced Technical Solutions is more efficient and more cost-effective.\*

#### Short development phases

“After the co-design phase, our colleagues in Turkey usually need just six to nine weeks to produce prototypes,” said Erich Schmid, Chief Technology Officer for Angst+Pfister

at the head office in Zurich. “We subject these to thorough tests and sometimes the customer also conducts tests at the same time,” added Eray Ulugül, the CEO of Angst+Pfister Advanced Technical Solutions (ATS) in Bursa. “Over another ten to thirteen weeks, we then use the serial production tool to produce the first samples.”

#### Practical and theoretical know-how

The reasons for the relatively short development times are as follows: The engineers in Bursa know precisely what the customers require. The 40-strong, highly qualified development works closely with Angst+Pfister's 100 application engineers, senior engineers and CAD engineers around the world.

#### Time-saving numerical simulation

A further strength of Angst+Pfister's development team is numerical simulation: “Using the finite element method, we have been able to significantly shorten the development process,” said Eray Ulugül. The specialists from Angst+Pfister ATS are also experienced and suitably practiced in the

calculation of loads to which a component is subjected throughout its lifetime.

#### Production under the same roof

One of the great advantages is the close proximity of the development team to production: Angst+Pfister ATS was founded as a production company in 1982 and since then it has continued to develop further and expand. As part of the Angst+Pfister Group since 2013, Angst+Pfister ATS now produces around 100 million antivibration and sealing components each year. The customers are leading suppliers from the automotive sector, rail sector and ship construction. Angst+Pfister ATS is also consulted for building construction and civil engineering and, specifically, bridge construction, and also for the production of agricultural machines and the manufacture and development of electronic and household appliances.



\* Read more about the high-speed multiple unit train EC250 on page 12 and the Fire Safety Standard DIN EN 45 545 on page 30.



Lean operations: Development, prototyping, testing, compounding and production are located under one roof at Angst+Pfister ATS.

### Test stations right next door

Angst+Pfister ATS has the development expertise for customised solutions and the know-how for prototyping, initial samples and series production under one roof. “This really does allow us to keep the individual development loops and development times short in total,” said Erich Schmid. The test stations for testing are also within walking distance of the offices of the development engineers who can thus accelerate their virtual engineering. “We unite all our skills on site, this gives our customers time and saves costs,” commented Eray Ulugül. The development time is reduced and products enter the market quicker.

### Multiple certifications

Since January 2016, the Research & Development Centre for Angst+Pfister ATS in Bursa has been recognised by the Turkish Ministry for Science, Industry and Technology. In addition, Angst+Pfister ATS is certified along the entire value creation chain from development to production and delivery in accordance with ISO 9001, ISO TS 16949 and ISO 14001: All processes are based on a comprehensive quality management system and the company also meets the highest standards with regard to health, safety and the environment.

### Integrating functionality

The development engineers from Angst+Pfister ATS know how to include other aspects in addition to technology in

their work: For example, if an antivibration or sealing component is able to unify additional functionalities in a single unit, customers can reduce their storage and assembly costs: Instead of two or more parts, only one is needed. This reduces the total cost of ownership, which is reduced even further due to the generally long service life of the components. This integrated way of looking at things becomes apparent in

all areas of Angst+Pfister: The customer benefits from distinct development competences and also from higher purchasing and production efficiency and the thoughtful logistics that offer Just-in-Time, Kanban and Supply Chain Management solutions around the world. This is the integrated, and, from a cost perspective, interesting efficiency that the market needs.





The fire safety standard EN 45 545 is also adhered to. And everything undergoes intensive testing.



“Demand for numerical simulations is constantly increasing.”

Eray Ulugül, Chief Executive Officer, Angst+Pfister ATS, Turkey

When it comes to the design, development and production of antivibration components, no one comes close to achieving the same results: Eray Ulugül heads Research and Development at Angst+Pfister ATS in Bursa.

**Mr. Ulugül, you are a professional in the field of numerical simulation. What fascinates you so much about this subject and how do the customers benefit?**

**Eray Ulugül:** It is mainly my practical experience with the finite element method that is of benefit for our customers. Technical equipment alone is not enough, specific expertise is also needed. We have both. Using numerical simulation with internally developed guidelines and know-how, we can find the right elastomeric characteristic for optimal performance, and this enables us to achieve the required hardness and develop the best design and geometry for a component. Simulating the real-world conditions, to which a sealing or antivibration component is exposed, definitely saves time and development costs. That is why the demand for numerical simulations is increasing con-

tinuously and we are doing all we can to meet this demand.

**But that is not the only way to keep development times short.**

**Eray Ulugül:** Our other major advantage at Angst+Pfister ATS is having everything under one roof – from development, prototyping and testing to metal preparation, compounding and production. The tool for the production of prototypes is manufactured in six to nine weeks, the tool for series production in ten to thirteen weeks. These short periods are due to the fact that our engineering unit makes full use of its proximity to the other areas of competence like mold flow simulation to design vulcanisation tools right the first time. We work hand

in hand, and the effect is immediately evident to the customer.

**And your test systems?**

**Eray Ulugül:** We are well equipped to examine the rigidity of the components, to test their static and dynamic properties, their vibration absorption and their durability performance and to provide proof of their service life. The results input directly – and quickly – into additional engineering work. Our in-house rubber batch testing provides leading-edge technology to develop customised rubber recipes with an optimal vulcanisation process. This enables us to find the right rubber compound for unique applications i.e. high temperature, dynamic to static ratio and rebound value.

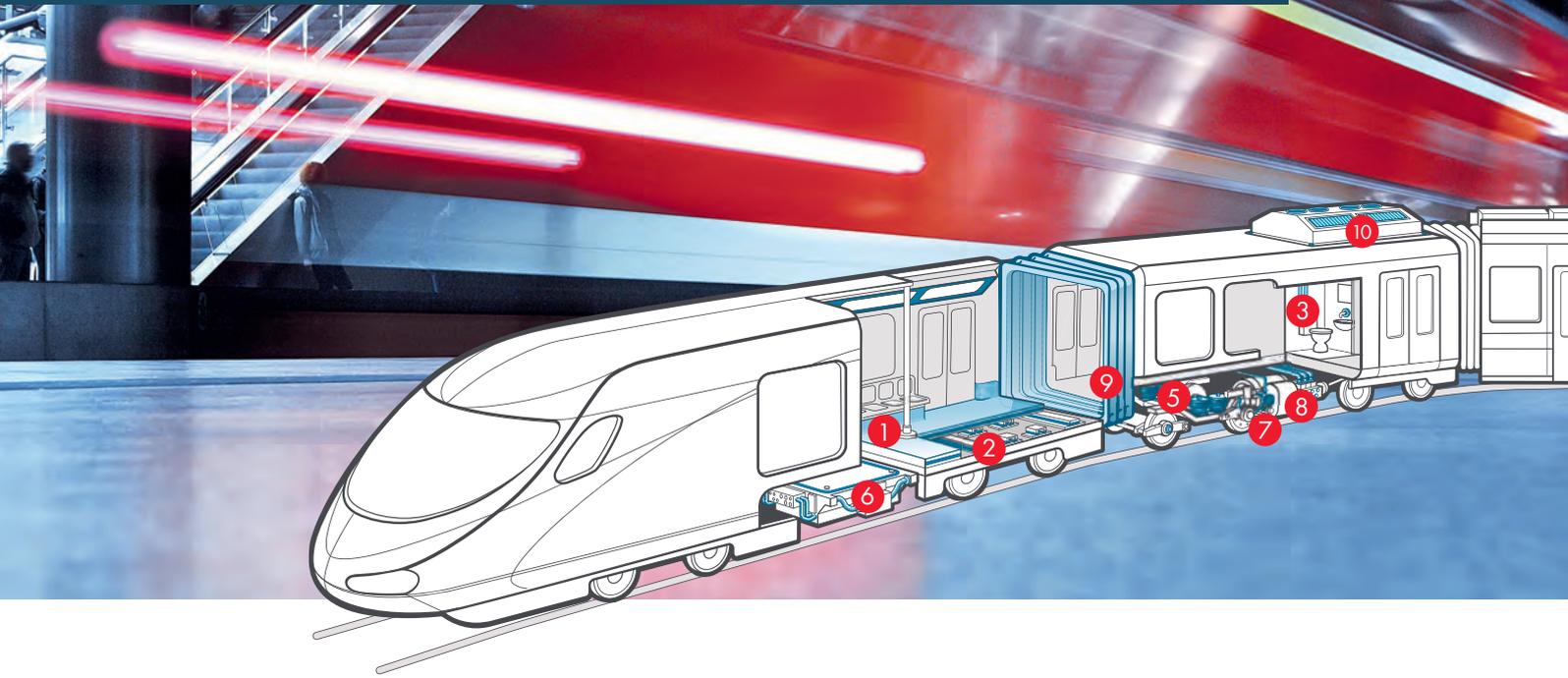


**The right rubber compound and the right partners make the difference**

The right rubber compound determines the quality of performance provided by a seal or a vibration isolation. Angst + Pfister has formed a strategic alliance with TSF, the global market leader when it comes to the development and production of high tech compounds.

# Ensuring smooth operation on the tracks and in the carriages

Since 1953, Angst + Pfister has supplied the railway industry's leading manufacturers and operators with uncompromisingly high quality products and comprehensive engineering solutions.



## Floors and interiors

1



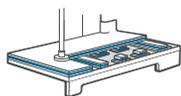
Plastic Finished Products



Sound Absorption Mats

## Floating floors

2



Antivibration Supports



Couplings

## Bathrooms and fixtures

3



APSOfluid® Water Hose Lines

## Windows and doors

4



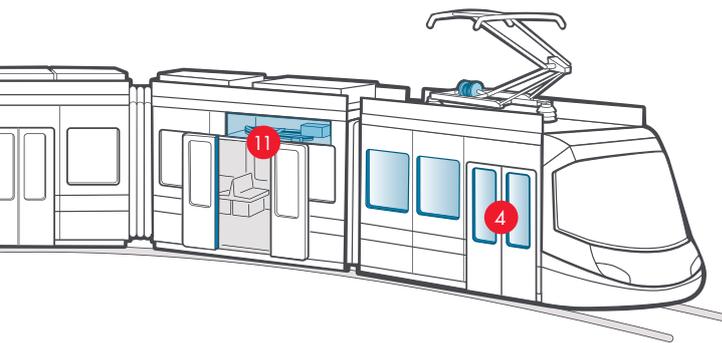
Plastic Finished Products

Railway manufacturers, maintenance organizations and track installers all benefit from our long-standing industry experience and our engineering expertise. Industry leaders rely on Angst + Pfister for standard as well as custom-designed components that meet the highest technical specifications and railway norms. Let Angst + Pfister bundle all the components you need and ship them just-in-time to your international manufacturing facilities.

Angst + Pfister's engineering team patents every year new products specifically designed for railway industry in the Antivibration, Sealing and Hosing product areas. Our solutions for railway are all compliant to the most advanced and updated standards, such as DIN EN 45 545 or other nation-specific Smoke and Fire Standards. Our representatives take part in various Standards Committees to ensure our readiness for any upcoming technical requirement.

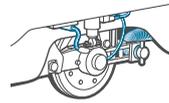
Our customers benefit from these competitive advantages through a solid partnership with Angst + Pfister which proves time and again that co-design projects are the best solutions to reduce Time-To-Market.

**SNCF laboratories, TU Munich, LAPI and LNE:** We test and certify our innovations at laboratories which are recognized globally for their expertise. Furthermore, we are proud of our Quality Management process, making Angst + Pfister a market leader in product conformity within the railway industry.



**Brake system**

7



Translational & Rotational Seals



O-Rings/ Round Cords



Punched Flat Gaskets

**Brake compressor**

8



Cone Mounts



Round Buffers

**Train junctions**

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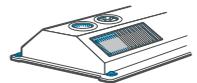
Elastomeric Profiles



Plastic Finished Products

**HVAC**

10



O-Rings/ Round Cords



Cone Mounts and Shear Mounts



Elastomeric Profiles

**Bogies**

5



Primary Buffers



HYDROFLEX® Hose Lines



Punched Flat Gaskets



Layer Springs

**Power converters/ Transformers**

6



ASSIWELL® Hose Lines



Couplings



Elastomeric Profiles

**Doors opening systems**

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Belt Drives



Elastomeric Profiles

# Angst+Pfister – high performance elastomer compounds – the multi-taskers

«When it comes to the fire prevention properties of elastomer compounds, we are at the cutting edge,» says Michael Forrer. Angst+Pfister's engineers have developed two new components for Bombardier: A vertical buffer and a layer spring – to raise the comfort level for passengers on a new tram, while ensuring maximum safety.



If, in the not too distant future, you travel by tram across the city of Vienna, your relaxed journey will, in part, be due to components made by Angst+Pfister. The components were created as a joint development project with the manufacturer Bombardier for «Flexity Vienna». «Bombardier gave us rigorous specifications for the design of the components. However, they were open to proposals for improvements,» recounts Michael Forrer. For the senior engineer for Antivibration Technology at Angst+Pfister's headquarters in Zurich, this was sufficient motivation to go that proverbial extra mile: «We have a high level of expertise for developments like this. So we leapt at the chance and contributed a few suggestions.» Consequently, the new components are the result of a co-design with the customer. «Our input enabled Bombardier to perform new finite element analysis on each of the components – until the product satisfied the very stringent requirements,» adds Michael Forrer. The specific objectives were a layer spring and a vertical buffer.

#### For a pleasant journey

Bombardier attaches the vertical buffers to the bogie frame with two bolts – with each bogie requiring two vertical buffers. The bogie acts as an interface between the vehicle body and the track, and is responsible both for a comfortable journey and for protection from the risk of derailment. When a tram travels along a bend, the vehicle body tilts against the vertical buffer. «First off, it is an end stop for extreme loading conditions or tight curves and not primarily designed to resist vibration,» explains Michael Forrer. Not only will the buffers be stressed at the sides, but the sliding plate at the top made from high-performance plastic will also be subjected to horizontal movements. «There must not be any stick-slip,» says Michael Forrer. «Otherwise, bumps to the vehicle body would be transferred – and easily heard inside.» Angst+Pfister's layer springs are used to reduce the vibration caused by uneven tracks or rolling noise. There are two layer springs positioned both left and right of the vertical buffers, mounted between the two bogie axles to absorb vibration. Without them the vibration would also be transferred to the passenger areas.

#### Performance improvement

«The vertical buffers in particular were a particularly challenging design project.» The engineers of Angst+Pfister suggested a few changes regarding the contours of the elastomer, its properties and the overall choice of material. In addition to the elastomer in the middle, the buffers have a plastic skid plate at the top and a metal component at the base (see picture). «For example, we changed the material for the skid plate from its original polyamide to polyethylene. Polyethylene has lower sliding friction coefficients.» The result was a gliding capacity three times greater. «The more pressure the component is subjected to, the better it glides,» says Michael Forrer. «Both parts had to pass a multitude of tests.» For example, the vertical buffers were compressed about 800,000 times during the endurance tests. The component performance values at the end of a test may not differ more than 25% from the start values. After all, the buffers are going to be in service a full nine years.

#### One fire protection standard, one elastomer

«Angst+Pfister, is one of the only producers able to offer a homogenous rubber component guaranteed to meet the fire protection regulations for components with up to two kilogrammes of pure elastomer mass to the market. The fire protection standard at stake is EN45545. The products that Angst+Pfister now supplies to Bombardier easily fall into the R24 product requirement classification – and that is unparalleled. «Other providers coat the bearing elastomer with a material that complies with the fire protection standard. This also conceals any imperfections in the rubber – such as cracks.» That is why clients clearly prefer a homogenous compound. In addition, suppliers who have insufficient knowledge to produce a fire protective homogenous compound have to carry out complex market analysis: According to EN45545 (section 4.7), they have to prove that the component cannot be made using a homogenous compound. «This is a loophole in the fire protection regulations. Thanks to Angst+Pfister's homogenous compounds, there is no need to go to the extra expense of conducting market research,» says Michael Forrer proudly. For elastomers: The more

flame retardant additives are added to a compound, the worse it performs in the mechanical tests. «Creating a good balance between fire protection and mechanical properties is an art in itself,» explains Michael Forrer. Moreover, the rubber has to withstand a variety of environmental factors. «Ozone, cold, heat, pollutants, aggressive cleaning solutions and so on.» Angst+Pfister also provides the customers with maintenance guidelines so that the components only have to be replaced as infrequently as possible.

#### Leading the way in fire protection

The team at Bombardier is very happy with the cooperation with Angst+Pfister. The solution-orientated, proactive approach to engineering is excellent. «Regarding the development of fire retardant rubber components, Angst+Pfister is on the right track and in a very good position. Their engineers have vast expertise. It means that we don't need to make any concessions when it comes to quality,» confirms Andreas Wolf, lead suspension engineer at Bombardier.



Vertical buffer



Layer spring



## Installing power converters in high-speed trains

Coming soon, the Stadler high-speed EC250 rushes through the Gotthard base tunnel and Angst+Pfister is on board: The power converter of ABB is installed on the underside of the railcar with completely new vibration-insulating components. The mounts are designed to reduce weight and minimise size while isolating the power converter from the train and reducing downtime. Development time was also minimal.

The success of a whole system often depends on seemingly minor details: In a modern rail transport vehicle, there mustn't be any noises from fans or other components transmitted into the passenger area. Consequently, these auxiliary power units have to be mechanically decoupled by using high-performance isolation elements. Which is why the engineers of ABB Switzerland turned to Angst+Pfister. The hanger elements, needed for the power converter, had to provide optimal vibration and acoustic isolation, while weighing as little as possible, and taking up as little space as possible. The specifications

were crystal clear, as was the window for development of just a few weeks.

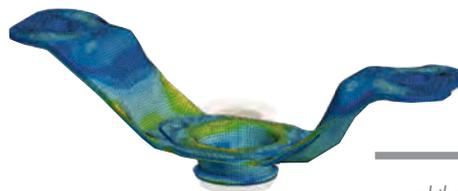
### **Please meet all requirements asap**

As a senior engineer specialised in anti-vibration technology at Angst+Pfister, Raphael Friedli knew very well that time would be short. But he also knew that it could be done. As always: At the beginning, requirements accumulate at an alarming rate: security against tearing off, isolation frequency ratios, dynamic forces with tension loads and thrust, all make the initial specifications appear impossible to reconcile. From empi-

rical knowledge and state-of-the-art data simulation, a solution emerges which previously would hardly have been conceivable. Angst+Pfister's engineers in Zurich and their R&D engineering colleagues at Angst+Pfister ATS in Bursa, Turkey, working with numerical simulations including finite element analysis jointly produce the perfect design. This in turn dramatically reduces production costs. It was the same for ABB as for the automotive industry: Applying the finite element method reduced the co-design process to only a few designs.



The design of vibration isolators, on which the power converter is mounted, ...



... and the design of the metal bracket with which they are bolted to the undercarriage, ...



... are the result of numerical simulation. The component, which is also structurally optimised, requires less material and space.

The change in this production process, enabled by the ability of the Angst + Pfister engineers to think outside the box, resulted in a significant cost-reduction in terms of the design. The component, which also has been optimised structurally, requires less material, weighs less, and takes up less space – all vitally important considerations in the competitive world of rail vehicle construction today. A special coating renders the metal bracket corrosion-resistant, ensuring a long service life.

### Engineering and manufacturing working hand in hand

ABB can also leave the production of elastomeric bearings and the metal brackets to Angst + Pfister: Engineering and production are working under one roof at Angst+Pfister ATS in Bursa. The design engineers are working directly with the production and the local supply chain to minimise costs while ensuring quality. The tooling and prototype production is next to the R&D office to increase the speed of development and production efficiency. All of this had made it possible to deliver the pilot prototypes exactly according to schedule. The Stadler Rail EC250, or “Giruno” as the purchaser, the Swiss Fe-

deral Railways, call the trains, will soon run at up to 250 km/h between Frankfurt and Milan through the longest railway tunnel in the world. Engineering ingenuity, on a scale both large and small, has made this travel experience possible.

APSOvib®-mounts, -isolations and -brackets comply with the fire safety EU Standard 45 545 for rail vehicles.

### A metal bracket saving space, weight and cost

The power converter, with its twelve cast supports, sits directly on top of twelve of these antivibration isolators. These in turn are bolted to the underside of the wagon body by means of metal brackets. The bracket geometry and how it should be manufactured were also determined by numerical simulation. Previously, such parts were manufactured with the standard casting method. The brackets are produced by the deep-drawing process. This new solution allows production at much lower costs.



There are twelve attachment points between the power converter and undercarriage.

# Leading train makers design their railcars with ASSIWELL® all-metal hose systems – for a very good reason!

The advanced technology of Angst + Pfister easily meets the most stringent requirements. No matter whether during a Norwegian winter or an Italian summer, the reliable, failure free operation of locomotives is the number one consideration.

*The highly qualified personnel of Angst + Pfister execute the welding of the all-metal hose with precision and perfection.*



ASSIWELL® all-metal hoses are chiefly deployed in the cooling of the current inverters and transformers. In both cases, heat is produced, which has to be dissipated. Angst + Pfister is fitting the trains with high-quality cooling systems that are individually designed to ensure the circulation between cooler and converter and transformer respectively. These systems are characterized by their many junctions and narrow bending radii. ASSIWELL® metal hose systems are available in very small to very large nominal diameters and offer extreme flexibility and tight bending radii no matter the size.

#### **An exceptionally wide temperature spectrum, very long life span**

The trains, or more precisely their components, have to withstand a temperature range from -40 to +80 °C over an operating period of 40 years. The temperature range for using ASSIWELL® all-metal hose systems is far greater than the demanded requirements and consequently the temperature variation during normal operation on the tracks is not a major strain. Nor the requirement for 40 years of reliable service. Ozone and other weather conditions have hardly any effect on the all-metal hose systems.

#### **Fully impermeable**

Not only temperature and weather conditions affect the materials, but there is also

the significant stress from the ever-present vibration and movement on the tracks. Angst + Pfister has long-term experience in finding the best combination of metal pipes, metal hoses and fittings. The resulting hose system is not only durable and flexible, but also absolutely impermeable.

#### **Major advantages in comparison to conventional solutions**

Cooling systems are often designed with elastomer hoses. The material is, however, vastly inferior to metal when it comes to ageing resistance. Over time it becomes porous and fine leaks result. If a leak is not discovered and cooling is no longer adequate, the consequences can be devastating. Fixed metal pipes may well be durable and impermeable, but have virtually no tolerance. In addition, individual installation is complex and expensive. Fixed metal pipes also put more weight on the track than the ASSIWELL® solution. In rail transport, greater weight is associated with higher power consumption and therefore higher operational costs.

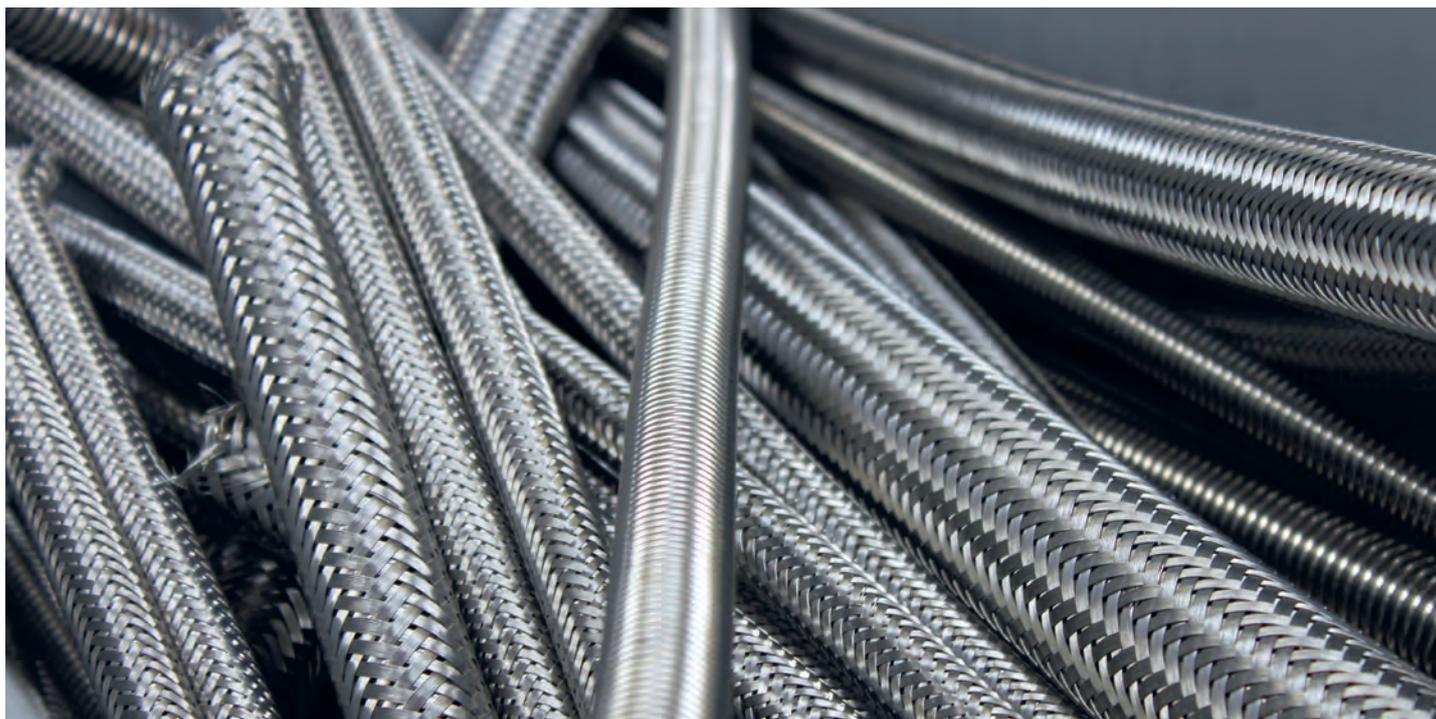
#### **Fire safety in accordance with DIN EN 45 545**

Rolling stock is subject to very strict fire safety laws. If a train is on a track with many tunnels or long tunnels, the requirements are even stricter. The ASSIWELL® all-metal hoses made of stainless steel are non-combustible and therefore ideal in meeting the

requirements for the inflammability of materials and components.

#### **A strategic partner rather than a single supplier**

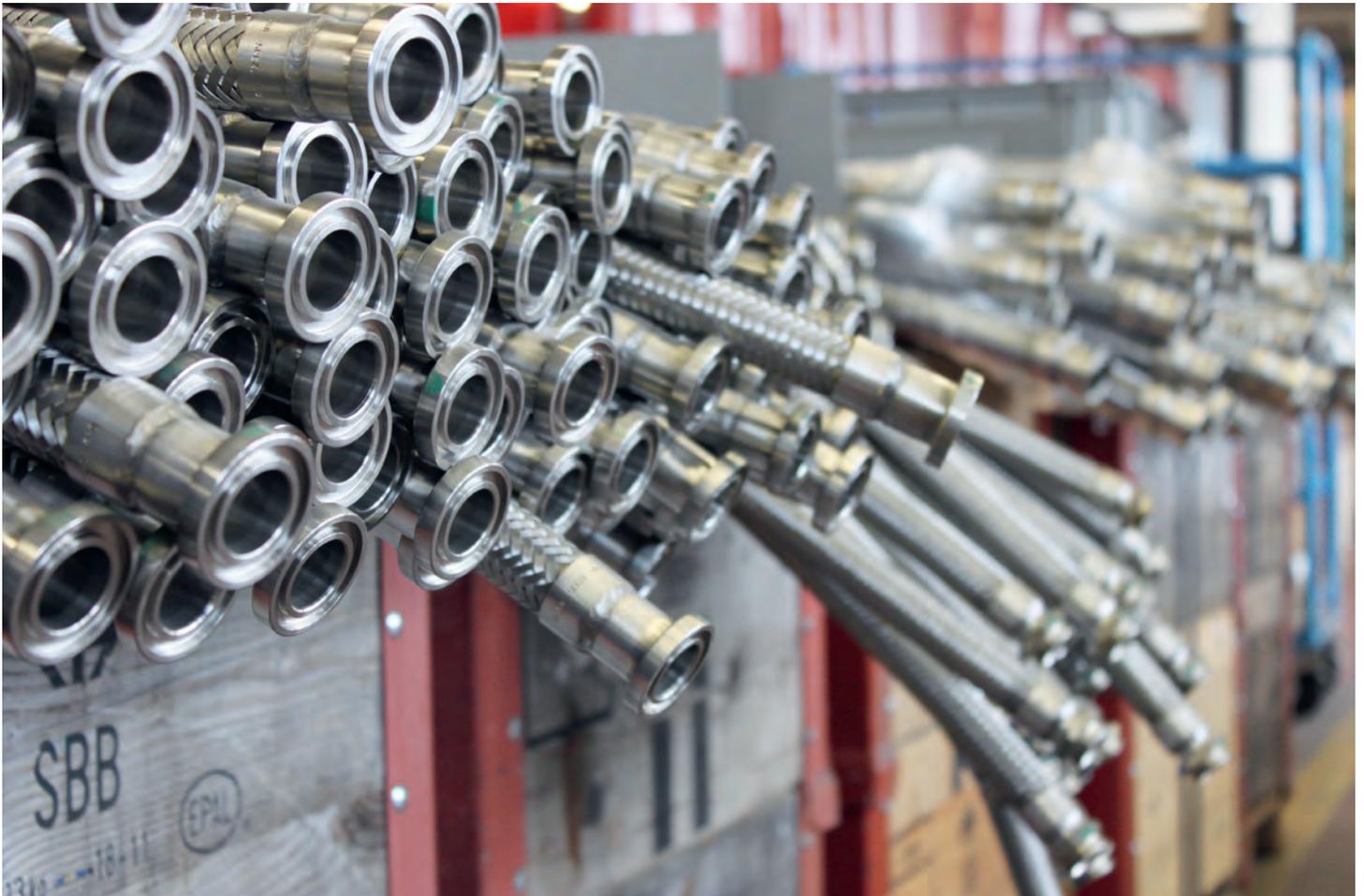
Long-term projects with high specificity and high investment require long-term partners. These project characteristics apply to the construction of rolling stock: It takes years to move from ordering to delivery of the completed trains and the construction of each model is characterised by specific requirements and conditions. Angst + Pfister offers its customers single source engineering, production and logistics. The service begins with the custom design of the metal hose appropriate to the problem to be solved. Angst + Pfister fluid technology experts, application-oriented engineers with many years of comprehensive experience, advise and support customers throughout the entire development phase, often directly on-site. As a result of 3D prototyping, the ASSIWELL® experts can build the hose directly into the virtual model of the customer. Changes and adjustments can be responded to quickly. The metal hose systems are manufactured in Angst + Pfister's Embrach workshop. Attention to the individual logistics requirements of the customer is part of the service. When all this is provided reliably and competently by one source, that is what makes a true strategic partner!



ASSIWELL® hoses: braided with metal.

## New applications for double-walled hoses

Double-walled hoses can transport two different media. In other applications, the double wall increases safety. But double-walled hoses may also be costly. However, it doesn't have to be like this. Angst + Pfister has optimized the manufacturing process of the double-walled all-metal corrugated hose ASSIWELL®. This has reduced costs and opened up new fields of application.



Double-walled hoses: now even more compact, but qualitatively the same.

### Angst+Pfister is a leading manufacturer of metal hose systems

Perfectly manufactured and perfectly welded, both hose and connection fittings require maximum production precision, because only perfect fitting work pieces can be perfectly welded, which avoids inherent stress in the material. Twenty highly qualified personnel at the Angst + Pfister workshop in Embrach perfectly weld the all-metal hoses to their

connecting parts. ASSIWELL® all-metal hose systems are always of an impressively high quality no matter whether they are intended for quick, project-oriented production of prototypes or high-volume automated production. And the quality is guaranteed: Angst + Pfister is certified at the highest level in accordance with DIN EN 15085-2 CL1 for the mechanized welding of railway vehicle parts.

**Products and services with added value**  
ASSIWELL® all-metal hose systems exemplify reliable sealing and as such, operating reliability and durability. As there are fewer connection components compared with other solutions, installation time and costs are reduced. But it is not simply the purchase and installation costs of Angst + Pfister's solutions that win you over, it is also the fact that the life cycle costs are also reduced due

to firstly the decreased weight and the consequent reduction in power consumption and then secondly the very high ageing resistance of the product. Angst + Pfister has equally high quality targets. Customers appreciate the many years of experience and reliability, on-site advice and the support during the construction process (including 3D modelling and prototyping). During the production phase, speed and adaptability are what counts, both of which Angst + Pfister offers its customers. Angst + Pfister and the leading manufacturer of rail vehicles – now that is expertise that complements itself, that reaps rewards and serves us well! It makes sense to use only one hose to transport two different media. Space and weight are saved. The double-walled hose has proven successful in other areas too: For example, where a combustion engine is operating, it will be hot. Therefore combustible media, such as fuel or oil, are better transported in a double-walled hose. It minimizes the risk of fire, because the inner hose filled with fuel is protected. All these advantages are already well-known to rail vehicle designers: Angst + Pfister's double-walled ASSIWELL® hoses have been in use for more than 20 years – and known to be reliable and extremely durable. Used in locomotives and other rail vehicles, they have covered distances equivalent to millions of times the earth's circumference.

#### **With and without abrasion protection, separation gap variable**

The engineers at Angst + Pfister install entire hose systems tailored to the precise requirements and needs of customers, and also perform all compulsory system tests. If required by the application, the engineers provide abrasion protection in the form of a fiberglass braid or a layer of heat-resistant PPS between the two ASSIWELL® hoses, thus preventing them from rubbing against or knocking each other. This is recommended particularly for high vibrations. Another option is the fiberglass braided inner and outer hose. The end-use application of the double-walled hose also determines the distance between the outer and inner hose. If the neutral space is intended purely for monitoring in order to immediately discover a potential leak in the inner hose, then this space only needs to be small.

#### **More compact structure, same high quality**

The double-walled hose can perform any number of functions, and specifically for rail vehicles, these are still increasing: Angst + Pfister has made its double-walled ASSIWELL® stainless steel hoses more compact and at the same time optimized production. In terms of quality, the hose has lost nothing: It complies with the EN 15085-2, which regulates the welding of rail vehicle parts, and it meets the ASME standards of

the American Society of Mechanical Engineers. At the Global Logistics Center near Angst + Pfister's Zurich headquarters, certified welders work partly manually and partly at mechanized welding stations. Their standard procedure involves checking each finished welded hose, including the valves, for impermeability in water at 5 bar. A helium leak test and pressure tests are also part of the service. This ensures that a high-quality product that fulfils all requirements in terms of quality, safety standards and cost streamlining is delivered to the customer.



Angst + Pfister's metal hoses are not only temperature- and ageing-resistant, but also flexible and impermeable.

# Alstom is counting on Angst+Pfister for its M7 rail engineering project in Belgium

A fast paced development timeline, solutions for complex technical requirements with combinations of strict fire protection regulations, needs for outstanding mechanical performances and suitability for complete systems integration – that was the key with which the engineers from Angst+Pfister won several contracts with the transport company Alstom. Alstom's customer, Belgian Railways, will be running with our antivibration and fluid technology as of 2018.



The M7 rail engineering project – a flagship for modern mobility solution for the people of Belgium: Nearly 1'400 new double-decker rail cars are due to be rolled out on the Belgian railway network beginning in 2018. Angst+Pfister's customer Alstom Transport is building a first batch of 90 motorized traction units for this major contract. Alstom requires antivibration and fluid technology components for the installed HVAC units as well as for the main traction transformer.

#### **It began with a special ventilator and auxiliary transformer bearings**

"In March 2016, our management was given the opportunity to present our technologies and our competences to Alstom Transport in Belgium," explains Emanuele Varini, Project Engineer at Angst+Pfister. Shortly after this, the Alstom engineers contacted Angst+Pfister. "Initially our task was to design a special vibration isolation support for an auxiliary transformer and for a ventilator necessary for the cooling system of the coaches. We provided Alstom with the preliminary sketches and information on the design, which convinced them," says Emanuele Varini. "But the real challenge was in harmonizing the mechanical qualities of the bearing ensuring long lifetime whilst meeting the requirements of the European railway fire protection regulation EN 45545-2. In addition, Alstom needed us to meet a fast paced development timeline".

#### **Angst+Pfister invests in a new product**

All this culminated in Alstom issuing a highly detailed catalog of requirements and specifications for this special HVAC bearing. This included vibration isolation properties, mechanical resistance to shock loads, temperature resistance, chemical compatibilities, corrosion protection and electrical resistance properties. On top of this, the fire

resistance level of EN 45545-2 R22 HL2 was necessary. "Rubber burns and the chemicals added to enhance the fire resistance may influence its mechanical quality," says Emanuele Varini. "Finding the optimum mix requires intensive research and tests. For this level, the rubber must pass three tests: it has to be very flame-retardant (oxygen index acc. EN ISO 4589-2), it should produce as little smoke as possible (smoke density acc. EN ISO 5659-2) and the smoke should pass a toxicity analysis (smoke toxicity acc. NF X 70-100-1/-2)," explains Emanuele Varini. In order to properly tackle the problem, an intensive tests plan was organized. "Even before the contract was awarded, Angst+Pfister decided that we would invest our resources in this project," says Emanuele Varini. This gesture of anticipatory confidence in the customer eventually paid off. The Angst+Pfister engineers set out to explore the limits of the fire retardancy and mechanical performance of the product managing to meet the customer specifications and deadlines, eventually being awarded the contract.

#### **Four projects at the same time**

An open attitude is very much appreciated by the customer: As a result Alstom showed interest in a further fluid technology solution for the HVAC cooling unit – ASSIWELL® metal hoses – after the Angst+Pfister engineers demonstrated their core capabilities in the field during a proactive engagement. "This is a complex system with hoses, pipes, and covers welded together," explained the lead engineer Steve Spirlet, and continues: "Our strength does not lie only in delivering isolated components, but rather in developing an entire system. In this way we can reduce interfaces, for instance, and simultaneously the cost." Alstom appeared to be more than happy with Angst+Pfister's recommendations: "When we delivered both the antivibration and fluid system prototy-

pes, we received a further project for a special traction transformer bearing from an Alstom plant in France," reports Emanuele Varini. This time the issue was vibration damping for the main transformer of the vehicle which converts the power from the transmission lines to run the vehicle's motors. Again, speed was of essence. "The delivery deadline for the prototypes was very tight," Emanuele Varini remembers. Having met this challenge, Alstom France was then also interested in Angst+Pfister's fluid technology to cool hot oil with an air feed for this transformer. Here, too, ASSIWELL® hoses have been designed to good use.

#### **Good customer relationships motivate**

All the projects finally went into serial production but the Alstom story and the M7 rail engineering project have not finished yet. Angst+Pfister is currently engaged in designing and producing a further special antivibration tube clamp for the hoses of the cooling unit. "It paid off to make that extra effort from the beginning and to invest accordingly in order to finally exceed expectations" verifies Emanuele Varini. In addition, he lays great value in a good and personal relationship with the engineers of the customer. "We speak the same language and we can understand each other very well. Joint projects are also a lot of fun."



«It paid off to make that extra effort from the beginning and to invest accordingly in order to finally exceed expectations», verifies Emanuele Varini.

Emanuele Varini, Project Engineer, Angst+Pfister Group

# For comfortable travel and material wear prevention

Travel trends have changed – the requirements facing the rail industry as well. Angst + Pfister addresses this issue with integrated solutions isolating vibration and noise.



*The experience of nostalgia: The Furka steam train rolls through Swiss mountain landscape. – The experience of technology: Progress never stops.*

The idea of a journey on an old steam train through picturesque landscape awakens in us wonderfully nostalgic emotions. Whereas in times long since past, this new method of transport was revolutionary and pioneering – its importance to both passengers and freight made it easy to suppress the reality of how uncomfortable, noisy and bumpy these journeys must have been.

Technology has been evolving continuously, mainly to meet the need for greater safety and safeguard the health of people, but also in view of a more efficient cost-benefit ratio. Apart from minimising wear and tear as far as possible, the aim is simply to make travel more pleasant and comfortable. Essentially, it is the role of Research and Development to reduce noise emissions, isolate vibration and, of course, ensure fire safety. A major part of their work is outfitting train cars with special floor systems.

## **The authoritative specialist**

Having a background firmly rooted in modern technology, Angst + Pfister is the absolute specialist in this area and a long-standing partner in the development of solutions, the manufacture and selection of specialist materials, as well as finding and analysing products for both regional and national rail companies. High-technology floor systems are a steadily growing market, something that



Reduce material wear and vibration, increase travel comfort: Angst + Pfister has solutions.

becomes apparent when considering the big production companies in the rail industry and the business partners of Angst + Pfister, such as Alstom, Hitachi, Siemens and Bombardier – and all will be working at full capacity over the next 3–5 years.

#### Single source solutions

Angst + Pfister is well established as a trusted partner, not only through many years of experience and specialist know-how in this area, but also due to its comprehensive process optimization work, because effective collaboration is not just about being at the forefront of the latest technology, it is also a question of exactly identifying and anticipating the requirements of your partners and customers. There is a clear trend in the railway industry towards one-stop solutions. In addition to new advances in the field of R&D, cost optimization and the reduction of installation time and costs, there is also the prime consideration of achieving a more efficient supply chain management in terms of financial risk and optimization of lead times and on time de-

livery. In line with this trend, Angst + Pfister has joined forces with Bellotti and AGT Engineering in offering integrated floor system solutions.

The company Bellotti S.p.A. was founded in 1927 and is anchored in the timber sector, specializing in the production of chipboard panelling. Because panels are only part of the system, AGT Engineering was brought in as the partner with responsibility for designing the entire floor construction.

#### Various composite materials

Whereas in Europe and Asia, wood and wood composites are the combination of choice, in the USA laminated wood panels sandwiched between aluminum or composite panels are preferred, due to far stricter fire and smoke safety regulations. Wood is 30%–50% cheaper and its superior thermal and acoustic insulation properties will continue to make it the favoured based material.

Having outstanding expertise in the field of antivibration technology, Angst + Pfister



Antivibration technology for floor systems: individually designed according to region and standards such as DIN EN 45 545.

can provide for both methods a variety of suitable composite materials. All the solutions offered are fire- and smoke-resistant, and compliant with the relevant EU standard EN DIN 45 545, which has replaced national safety regulations in the EU.



The trend in the rail industry is for the customer to prefer a package solution. Angst + Pfister and Bellotti provide just that with their comprehensive floor system that absorbs noise and vibration.

# This rubber compound is naturally fireproof

In April 2016, national regulations for fire safety on railway vehicles were entirely superseded by the European standard EN 45 545. Angst+Pfister forged a path for customers to follow suit by meeting the requirements of the standard: Instead of coating components, a new rubber compound was developed for vibration isolation. Siemens uses these elements to suspend bogies.



Angst + Pfister provided the specialist knowledge for the metal-jacketed bone bush for the Avenio low-floor tram, which the city of Munich reordered from Siemens.



Advanced technology on the trams: Angst+Pfister's significant input is in the form of vibration technology.

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This is a very familiar scenario for Angst+Pfister and even more so for its customers. It's a win-win situation for everyone. The process takes place within the Angst+Pfister Group: In Zurich, Angst+Pfister's group engineering focus their entire efforts on the technological project; the development engineers of Angst+Pfister ATS in Bursa, Turkey then input their expertise, which shortens the development time, by applying their numerical simulation capability and because prototype production as well as series production are carried out under the same roof. At the same time, Angst+Pfister's consulting and sales teams, such as Andreas Gogl and his team in Austria, coordinate matters and are in constant contact with Zurich, Bursa and the customer. This is the group that produces antivibration solutions and pride themselves on exceeding expectations.

#### Fire safety standard EN 45 545 and further requirements

For Siemens Mobility, who design and manufacture high-speed trains, underground trains and trams, it was necessary to combine what at first glance appeared to be two contradictory requirements: Firstly, the new vibration insulation had to meet the requirements of fire safety standard EN 45 545 for the suspension of bogies. Secondly, despite integral fire retardants, the new components had to display approximately the same mechanical properties and the same static and dynamic stiffness as the old components.

#### Compounding specialists, too

Angst+Pfister ATS in Bursa also specialise in compounding; the development engineers there have several different iterations of

their simulation and testing methods and have developed a new rubber compound: The compound meets the parameters of the standard and is both a high-performance product and age resistant. Ultimately, a rail vehicle is designed for a long life, over ten years is the norm. The fact that the new rubber compound satisfies all requirements has been confirmed by tests in independent external laboratories.

#### Why not coat?

Andreas Gogl of Angst+Pfister Austria comments that a flame retardant coating of the old components would possibly have produced a similar result. However, Andreas Gogl and his team, that work together with the engineers of Siemens Austria and other customers in several Central European countries, noted that in their experience



"The fire safety standard EN 45 545 was indeed very challenging for the rail vehicle construction as a whole. But we managed to solve the problem – with the new rubber compound."

Andreas Gogl, General Manager, Angst+Pfister Austria



Fire safety in accordance with EN 45 545 is part of the package: Angst+Pfister designed a primary layer spring for the double-decker trains of the Rhine-Ruhr Express.

coatings can be damaged and in terms of ageing resistance cannot keep pace with rubber compounds, which have the required fire resistance already built in. “The fire safety standard EN 45 545 was indeed very challenging for the rail vehicle construction as a whole. But we managed to solve the problem – with the new rubber compound.” Angst+Pfister has used the new compound to design various metal-rubber components for Siemens: for example, a primary layer spring for the Rhine-Ruhr Express running between Cologne and Dortmund, and a metal-coated bone bush for the Avenio type low-floor tram, which the city of Munich has ordered from Siemens again.

#### **A single source saves time and money**

Andreas Gogl stressed the close partnership with Siemens and the matrix of skills available at Angst+Pfister: “Not only can we design the geometry of a vibration isolation system, we can also determine which rub-

ber compound is the right one. And for our Angst+Pfister ATS colleagues in Bursa, their development, compounding, prototyping and mass production units are just a few metres apart. This proximity and our internal cooperation allow problems to be solved in a relatively narrow time frame and in a cost-to-benefit ratio beneficial to our customer. “When customers can rely on a single source for everything, they can significantly shorten the time-to-market process, while at the same time being guaranteed an individual solution that is right, and complies with the fire safety standard EN 45 545.



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160 km/h

A comfortable commute over longer distances: The Rhine-Ruhr Express between Cologne and Dortmund at 160km/h will travel faster than the regional trains.



"When customers can rely on a single source for everything, they can significantly shorten the time-to-market process, while at the same time being guaranteed an individual solution that is right."

Andreas Gogl, General Manager, Angst + Pfister Austria

# The sealing frame for the locomotives of Switzerland

In Switzerland, everyone knows the Re 460 locomotives of the Swiss Federal Railways (SBB) that have been in service for 20 years. Now they are being modernized so that they can keep going for another 20 years. Even the roof filter is being replaced. Angst + Pfister has developed a sealing frame, which speeds up assembly and complies with the European fire safety standard EN 45 545 for rail vehicles.

The country may be small, but the rail network is widely branched. Every day, the 119 Re 460 class locomotives run a distance calculated by SBB to be 2.5 times the earth's circumference. The bright red locomotive, popularly known in Switzerland as Lok 2000, has become an established part of the Swiss image – and it will continue to be so. All the locomotives will be rolled into the SBB industrial plant at Yverdon-les-Bains to be completely overhauled and modernized. As of spring 2017, the first modernized locomotive will be back on the tracks: running more energy efficiently, sparkling clean and almost like new.

## Complex assembly?

### A thing of the past!

The modernization program will also replace the side filter grilles on the roof structure. Until recently, the grille frames had been installed by pressing them into a clamping profile, which consisted partly of foam rubber and partly of PVC with steel reinforcement. Attaching the clamping profile was a complex process: A technician in SBB's plant in Yverdon-les-Bains had to cut lengths which were then accurately glued and fitted into the corners of the rectangular opening in the roof construction, so that the bonding between the roof and the filter formed a se-cure

seal. The technician also had to wait for the adhesive to bond correctly before screwing the frame with the filter grille to the roof.

But that is all in the past. Sébastien Gaillard, an Angst + Pfister application engineer specialising in sealing technology, has developed a sealing frame, which can be delivered to Yverdon-les-Bains ready to assemble. The technician carrying out the assembly no longer has to measure, cut or glue and there's no more waiting. They only need to insert the sealing frame, and the metal frame including the filter grille can be screwed on straight away. Finished!

## Clever design leads to well-thought-out design

The sealing frame has to be flexible so it can be inserted. As a result Sébastien Gaillard had to do without steel reinforcement. He compensated for the loss of rigidity with a thicker profile. And instead of a single sealing lip, he drew two which allows the new profile to perfectly fit the metal frame. Foam rubber was now also out of the question. The new seal is made from one EPDM, and this is certified according to DIN EN 45 545. The now European-wide standard governs fire safety in rail vehicles. Because foam rubber was no longer being used, another design change was required as the up-

per section of the profile, unlike the lower section, has to be highly deformable allowing it to be inserted into the space provided. In this way, the sealing frame, although made throughout of only one elastomer, fulfils an entirely different function in the lower section than the upper section. Sébastien Gaillard optimized the overall geometry through several iterations and then submitted several variations to the client, the Swiss Federal Railways. In order to validate the solution, he provided cost-efficient, waterjet-cut samples which finally confirmed the decision.

## Production advantages and economic benefits

No more steel reinforcement, no more foam rubber – which in effect also opens up new possibilities in production: The sealing frame can be produced by means of hot vulcanization and is ready to fit. The corners of the sealing frame are tailored using a special tool. It guarantees the necessary cavity in the upper, flexible part of the profile, allowing it to fill the free space in the corners. Angst + Pfister has designed a solution for the Re 460 locomotive that is technically impressive, complies with the new fire safety standard DIN EN 45 545 and is also economically attractive to the SBB.



“The installation of a sealing frame used to take us around 20 minutes”, says Re 460 project leader Florian Lantz of the SBB production site in Yverdon-les-Bains. “Now we are able to achieve this within 5 minutes. With 16 frames per roof this means substantial time saving.”



SBB and Angst+Pfister also developed an appropriate solution for rearview mirrors: the material for the silicone sealing is compliant with the European fire safety standard EN 45 545.



For maintenance the roof of the locomotive is removed. The original sealing frame for the filter grilles is clearly visible. It was cut to the correct length and glued to the corners.

# Reducing rail networks' total costs of ownership

Track engineers are fitting elastic pads to the underside of concrete sleepers in a far-sighted drive to protect the track superstructure. The sleeper pads dramatically reduce wear and maintenance costs. The tracks last longer, have far less down-time, and operating expenditure over their lifetime is significantly reduced up to a factor of three. The new European standard EN 16730, introduced mid-February 2016, redefines the test procedure for sleeper pads. Angst + Pfister's ECOVIB® USP sleeper pads are tested to this new standard, are approved, and widely in use.



When a train runs over a track or a switch, the ballast underneath is dynamically stressed and shifted. The individual ballast stones scrape against one another and quickly wear away. Additional ballast is packed in, in an effort to ensure that over the course of time the track does not become displaced. Angst + Pfister's sleeper pads prevent this: They increase the contact surface between sleeper and ballast and stabilize it. The ballast is exposed to less friction and better maintains its integrity thus protecting the entire track bed and the track itself. This dramatically increases the track lifespan as well as maintenance and repair intervals, reducing maintenance costs. The sleeper pads have also been proven to reduce noise and improve comfort.

#### Amortized in two to three years

Angst + Pfister's ECOVIB® Under Sleeper Pads (USP) – consist of a layer of high-quality EVA combined with a connection layer of patented geotextile fabric. They have a lifespan of at least 35 years and are 100 percent recyclable. They increase the supporting surface of the ballast from 5% to 35% and reduce the surface pressure by 25%. Track-laying costs are reduced by a factor of 4. Maintenance and repair costs are reduced by a factor of 2 to 3, and the USP padding cost can be fully amortized in only two years.

#### All tests passed – go ahead approved

The ECOVIB® USP sleeper pads currently are in use mainly on railway lines in Germany, France, Austria, Hungary, Sweden, the Netherlands, Spain and in Switzerland. They have been fully certified by Deutsche Bahn and the French state railway company SNCF. Other countries have adopted the DB BN 918145-1 certification of the Deutsche Bahn and the CT IGEV 016 certification of the French state railway company. The European standard EN 16730, which came into force on 16 February 2016, regulates the test procedures, test system and their acceptance criteria according to track classification. Individual European countries define their own specific requirements based on this. In other words, each country will test the sleeper pads and issue approval for their respective application. There can be no question



The sleeper pads pre-cut to suit the horizontal section of the sleeper.



ECOVIB® USP sleeper pads: the special friction-fit method.

about Angst + Pfister being heavily involved. Since Angst + Pfister initiated speedy homologation in several countries, the first altogether positive results are now available: France, Italy, Belgium, Austria and Germany and soon several other European countries will all using sleepers equipped with the ECOVIB® USP.

#### ECOVIB® USP covers the entire spectrum

The new European standard distinguishes between four classes of rail track: two classes for local trains, each with different maximum axle loads and maximum speeds, one class for general train systems and large curve radiuses, and a class for heavy freight trains with a maximum axle load of 300 kN and speed of 200 km/h. There are three types of Angst + Pfister ECOVIB® USP sleeper pads available to fully cover each of these rail classes. Their specific mechanical and elastic properties mean they can be used for all four rail track classes: ECOVIB® USP APYP 5575-7 is hard, 2128-10 medium and 1322-10 soft, that is, highly elastic. The three types with a dynamic bedding module (Cdyn) between 0.13 and 0.95 N/mm3 cover the complete range of applications.

- ECOVIB® USP APYP 5575-7 Type “hard” für Cdyn 0,55–0,95 N/mm<sup>3</sup>
- ECOVIB® USP APYP 2128-10 Type “medium” für Cdyn 0,21–0,29 N/mm<sup>3</sup>
- ECOVIB® USP APYP 1322-10 Type “soft” für Cdyn 0,13–0,22 N/mm<sup>3</sup>

Angst + Pfister's expert USP engineers can provide support in testing, defining country specific requirements and new innovative formulations to reach practically any USP specification. The sleeper pads are then manufactured to suit the specific design of each sleeper type.



#### Patented bonding technology

Fibres make all the difference: Angst + Pfister's ECOVIB® USP sleeper pads have geotextile webbing integrated on one side. Its random fibres lock as the pad is placed into the still wet concrete. The hydration suction of the wet concrete pulls the fibres into the concrete. As the concrete dries and sets, a powerful bond between the concrete sleeper and sleeper pad is created. The pad has now formed a mechanically tight attachment to the concrete body. The high-strength bond carries loads of 1.0 N/mm<sup>2</sup> and more. This innovative technology is patented throughout Europe; as such it is unique and cannot be copied.



approved according  
EU Standard EN 16730

# EN 45 545 Fire Protection Certificates

on Angst + Pfister products



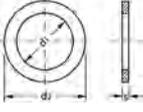
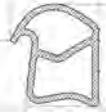
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## APSOvib® Antivibration Technology

Part type		Material	Hardness ShA +/-5	DIN EN 45 545
Antivibration elements for bogies (layer springs, primary buffers, round and stop buffers)		NR	50 ShA	R24: HL2
		NR(BR)	70 ShA	R24: HL3
Floor supports		CR	45 ShA	R10: HL2
		CR	49 ShA	R9: HL3, R10: HL3
		CR	70 ShA	R9: HL3, R10: HL3
		EPDM	46 ShA	R10: HL3
Floor supports – Metal Cushion		Metal Cushion		> HL3
Floor supports – PUR metal		APSOPUR® L55 (12.5 mm)		R10: HL3

## APSOseal® Sealing Technology

Part type		Production technology	Material	Type	Hardness ShA +/-5 (Density g/cm <sup>3</sup> )	DIN EN 45 545
Molded parts, molded flat gaskets, o-rings		Compression	EPDM	Compact	60 ShA	R1: HLR2
			EPDM	Compact	65 ShA	R22: HL2, R23: HL2
			EPDM	Compact	70 ShA	R22: HL3, R23: HL3
			VMQ	Compact	40 ShA	R22: HL3, R23: HL3
			VMQ	Compact	70 ShA	R22: HL2, R23: HL3
Flat gaskets		Punching	EPDM	Compact	70 ShA	R22: HL3, R23: HL3
			VMQ	Foam	(0,16 g/cm <sup>3</sup> )	R22: HL3, R23: HL3
			VMQ	Foam	(0,208 g/cm <sup>3</sup> )	R22: HL2, R23: HL2
			VMQ	Foam	(0,35 g/cm <sup>3</sup> )	R22: HL3, R23: HL3
			VMQ	Foam	(0,43 g/cm <sup>3</sup> )	R22: HL3, R23: HL3
			CR	Foam – closed cells	(0,195 g/cm <sup>3</sup> )	R24: HL3
Elastomeric profiles		Extrusion	EPDM	Compact	50 ShA	R22: HL2, R23: HL2, R24: HL2
			EPDM	Compact	60 ShA	R22: HL3, R23: HL3, R24: HL3
			EPDM	Compact	65 ShA	R22: HL3, R23: HL3
			EPDM	Compact	70 ShA	R22: HL3, R23: HL3
			EPDM	Compact	75 ShA	R22: HL3, R23: HL3
			EPDM	Compact	77 ShA	R22: HL3, R23: HL3
			EPDM	Foam	(0,8 g/cm <sup>3</sup> )	R22: HL2, R23: HL2
			EPDM	Foam – mixed closed and open cells	(0,8 g/cm <sup>3</sup> )	R22: HL2, R23: HL2
			VMQ	Compact	40 ShA	R22: HL3, R23: HL3
			VMQ	Compact	50 ShA	R22: HL3, R23: HL3
			VMQ	Compact	60 ShA	R22: HL3, R23: HL3
			VMQ	Compact	70 ShA	R22: HL3, R23: HL3
			VMQ	Foam – closed cells	(0,35 g/cm <sup>3</sup> )	R22: HL3, R23: HL3
			VMQ	Foam – closed cells	(0,55 g/cm <sup>3</sup> )	R22: HL3, R23: HL3

## APSOfluid® Fluid Handling Technology

Part type	Product	Material	DIN EN 45 545
Industrial hoses	Conveyance hose for water	EPDM	R22: HL3 R23: HL3
	Cable protection hose	EPDM and NBR	R22: HL3 R23: HL3
	Cable protection hose	Silicon	R22: HL3 R23: HL3
	Air brake hose	CR	R22: HL3 R23: HL3
Hydraulic hoses	Hydraulic hose Type 2TE	NBR/EPDM	R22: HL3 R23: HL3
	Hydraulic hose Type 1SC	NBR/EPDM	R22: HL3 R23: HL3
	Hydraulic hose Type 2SC	NBR/EPDM	R22: HL3 R23: HL3
	Hydraulic hose Type 1SN	NBR/EPDM	R22: HL3 R23: HL3
	Hydraulic hose Type 2SN	NBR/EPDM	R22: HL3 R23: HL3
Shrink hoses	Shrink hose flame-retardant	Polyolefin	R22: HL3 R23: HL3
Metal hoses	ASSIWELL® metal hoses	Stainless Steel	> HL3

## APSOplasti® Engineering Plastics Technology

Material	Type	DIN EN 45 545
UP-HLM FR	Hand layup GRP Laminate	R1, R2, R3: HL2
UP-GRP	Pultrusion profile	R1, R2, R3: HL3 R22, R23, R24: HL3
UP-GM 203	Red/white	R1, R2, R3: HL2 R22, R23, R24: HL3
EP-GC 202	Natural, (Yellow/brown)	R7, R17: HL2 R1, R2, R3, R11, R12, R22, R23, R24: HL3
PE-UHMW FR	Black	R7: HL2 R10, R24, R26: HL3
PE-UHMW FR ECBlack		R8, R17: HL1, R2: HL2, R3, R4, R10, R25, R26: HL3
PA 66 FR	Black	R17, R23: HL1 R24, R26: HL3
PA 6 FR	White/black	R22, R23, R24, R26: HL3
PA 6 FR	Extrusion profile, coloured	R22, R23, R24, R26: HL3
PC FR transp	Transparent, flame-retardant	R1: HL1, R3: HL2 R4, R22, R23, R24: HL3



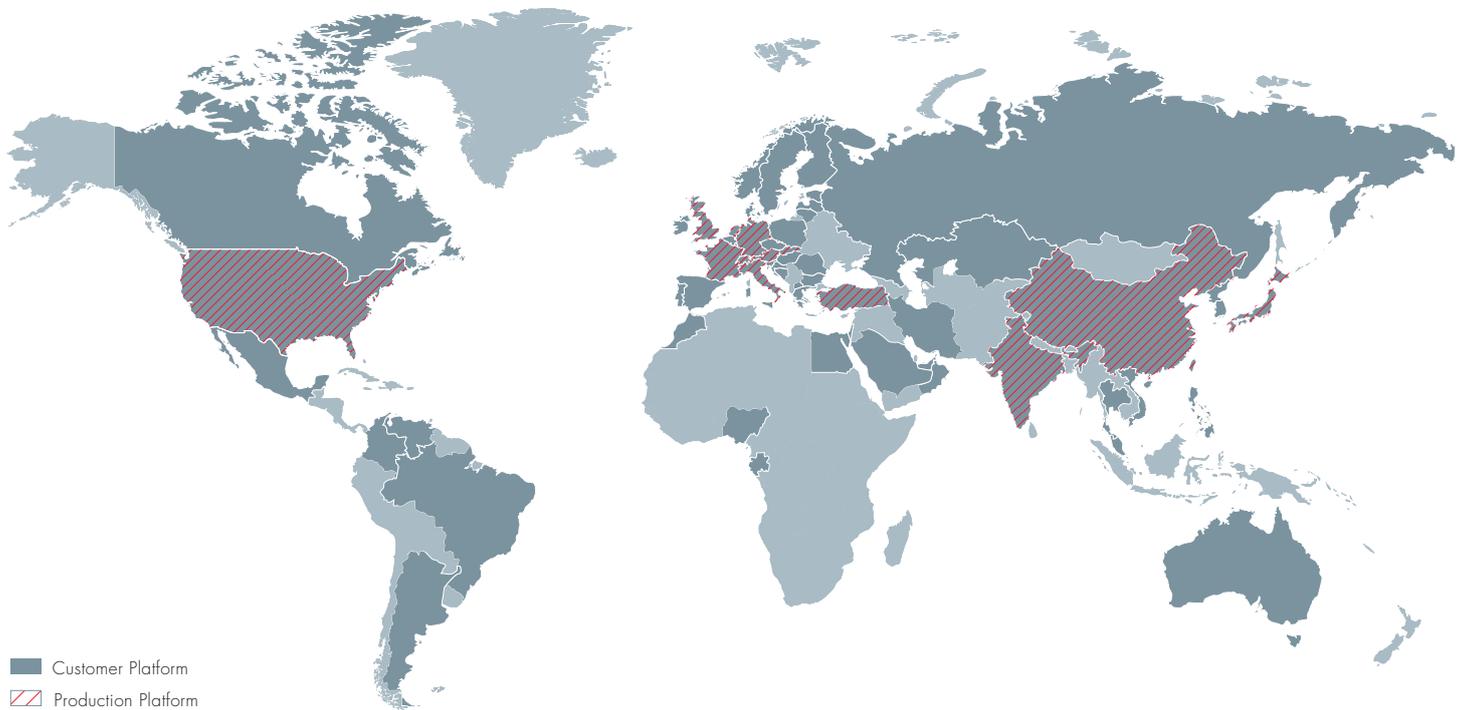
In addition to this range of products, we can supply you with special and/or customized products up on request at any time: consult us!

## Services

The Angst+Pfister Group supplies its services to every corner of the globe. We are offering solutions tailored to the customer's specific needs with our local application specialists. We are providing engineering-lead solutions to thousands of original equipment manufacturers in over 50 countries.

## Production Platform

Our global production platform spans across 15 countries. In addition to our own state-of-the-art manufacturing, we have reserved capacity with internationally renowned production partners. This allows us to always select the best production location based on our customers' quality, quantity and delivery requirements.



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