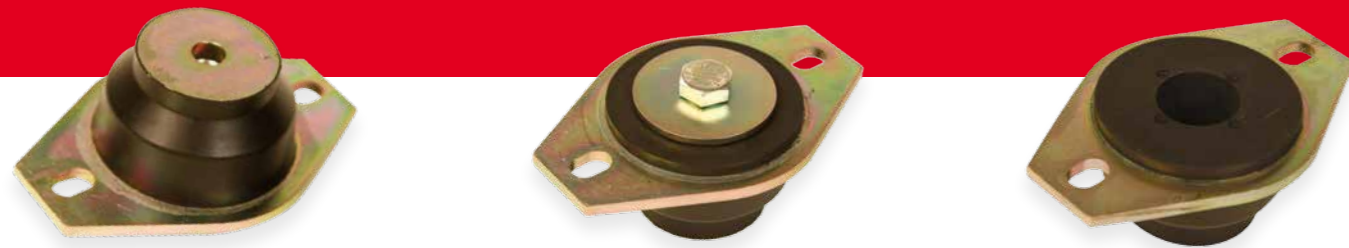


# New bearing systems for three-cylinder internal combustion engines

Manufacturers face considerable challenges when converting industrial vehicles to three-cylinder engines. Angst+Pfister has everything needed to provide intelligent solutions for engine bearings, starting right from scratch. The engineers have access to decades of company experience and advanced technologies.



Downsizing" is the future for combustion engines – even for industrial vehicles. In order to keep CO2 output within the legal requirements, there has to be a reduction in both displacement as well as the number of cylinders. It is now commonplace to find three-cylinder engines in the small vehicle market segment. The manufacturers of the industrial vehicles are having to come up with new ideas. In comparison to four-cylinder engines, three-cylinder engines have a massively increased vibration. Customer requirements for driver comfort means there is little room for trade off – comfort is an equally important requirement for the vehicles with three-cylinder engines.

## The special case of industrial vehicles

When considering vibration for four-cylinder engines, only the position of the second cylinder is significant. The one and a half configuration is the dominant arrangement for three-cylinder engines with an ignition angle of 240 degrees. In addition, there is strong vibration due to the momentum of the crank drive off the first cylinder. This creates a stagger effect. "Theoretically, this can be compensated with a balancer shaft parallel to the crankshaft," suggests Raphael Friedli, Senior Engineer in Anti-vibration Technology at Angst+Pfister. However, cost considerations mean this is often disregarded for industrial vehicles.

## Technical expertise is needed

What does this mean in terms of the bearing systems for the three-cylinder engines? The overall stiffness of the bearing system has to be significantly reduced in order to isolate strong, particularly low frequency vibration. This is firstly a challenge because of the fatigue limit of the static bearings - and secondly due to the dynamic high-stress processes of ignition, load change and acceleration. "Additionally, manufacturers of internal combustion engines set limits on the permissible acceleration and vibration. The softer the bearing system, the longer the vibration distance," says Raphael Friedli. This is the point at which the technical skills of the Angst+Pfister engineers come into play.

## An approach led by experience and advanced methodology

"A group of experts discuss the requirements for any new components," explains Raphael Friedli. Modern analysis and the development processes - such as multiple body simulation, the finite element method and CAD construction software - are applied to produce a basic design. Even more important than these procedures are the decades of experience Angst+Pfister has collated in designing both rubber and metal parts and in tool construction. "It is this that allows us to carry out several design iterations within a matter of weeks," says Raphael Friedli. This gives the engineers of Angst+Pfister an edge in their ability to produce component designs in very little time. And: The designs not only fulfil the technical specifications; they are also produced highly efficiently.

## Engine bearings cannot be analysed in isolation

Current vehicle designs with four-cylinder engines have been optimised over years for comfort and material savings. "When other engines are installed in the same vehicle, the fine tuning begins again from square one," says Raphael Friedli. The same applies to the stiffness of the mounting structure and even details such as the mirror and steering rod vibration. "Even when the



«We are an effective engineering partner for our customers as we supply new and efficient bearing systems backed up by technical production expertise.»

Raphael Friedli, Senior Engineer Anti-vibration Technology, Angst+Pfister Group

problem is limited to the engine bearing system, you cannot avoid multiple body simulation." The low excitation frequencies of the three-cylinder engines interact strongly with the various vibrations produced by the vehicle itself. This is one of the reasons why Angst+Pfister works closely with all its customers: After all, the large number of system parameters mean a comprehensive analysis can only be performed by the developers of the vehicle. Experience has shown that cooperative projects produce a faster market launch.

## Support from A to Z

The design process can follow a variety of routes: Either the customer specifies the mechanical characteristics of a component or Angst+Pfister works with the customer to define those characteristics. "As soon as a component has a design with a production drawing, a formulation for the rubber mix and the process flows are in place, then we can make a start on the prototype or

series tools," explains Raphael Friedli. These are then quality tested in-house and delivered to the customers with the necessary documentation and certification. Angst+Pfister engineers are often on site for commissioning or field tests. This allows any quick adjustments to be made – should they be necessary.



Economical three-cylinder engines are on the rise. Most different high-tech solutions ensure smooth running and temperament.