Burckhardt Compression

PERSISTO® 850 – A NEW BENCHMARK IN THE COMPRESSION OF HYDROGEN AND HYDROCARBONS

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Compressors for a Lifetime™

Dr. Inga Olliges-Stadler received her degree in Chemistry (Dipl.-Chem.) from the University of Tübingen, Germany, in 2007. From 2007 to 2011 she pursued her doctorate on the formation mechanisms of metal oxide nanoparticles, at the ETH Zurich, Switzerland, in the Department of Materials Science. Inga Olliges-Stadler worked at the Zurich University of Applied Sciences (ZHAW) in Winterthur, Switzerland, in the field of polymer coatings until 2015. After, she joined Burckhardt Compression AG and works now in plastic materials R&D.

Dr. Norbert Feistel received his degree in Mechanical Engineering (Dipl.-Ing.) from the University of Karlsruhe, Germany, in 1987. In 1988 N. Feistel joined the R&D Group of Burckhardt Compression in Winterthur. After approximately two years, in which N. Feistel's activities concentrated mainly on the labyrinth piston compressors, his responsibilities are now for the development of oil-free sealing systems. In 2002 he gained a PhD at the University Erlangen-Nuremberg, Germany, with a thesis on the operational behavior of dry-running sealing systems in crosshead compressors.

A variety of high-quality plastic compounds is now available for use as sealing and rider rings in reciprocating compressors. But in many cases, these materials have not been developed specifically for use in a reciprocating compressor. For reasons of cost effectiveness, they are optimized for as wide a range of applications as possible, e.g. in the automobile and the chemicals industries. One well-known example is the so-called Bearing Grade PEEK which, despite its disadvantages, is also used for challenging loads in a reciprocating compressor.

With Persisto® 850 and Persisto® 851, Burckhardt Compression is launching two materials on the market that have been specially developed for sealing applications in dry-running reciprocating compressors. Persisto® 850 and Persisto® 851's wear behavior is superior to that of all common materials for hydrogen compression, and the products can be applied at higher pressures thanks to improved pressure and creep resistance.

INTRODUCTION

The requirements that an optimal dry-running material for reciprocating compressor sealing elements should meet can be described as follows:

- Favorable tribological properties ensuring minimal friction and low wear
- High degree of chemical resistance for use with as many different gases as possible
- Good mechanical properties to withstand maximum load parameters
- Good shape adaptability for optimal sealing performance
- Minimum abrasiveness to avoid counter body wear

To date, this general requirement profile is not fully satisfied by any dry-running material. In particular, there is no dry-running material available that exhibits the same good wear properties in every gas and gas mixture environment. In an effort to improve service life, the dry-running materials often contain a significant proportion of abrasive fillers such as glass fibers or ceramic with the correspondingly negative consequences for soft counter body materials such as grey cast iron. Many high-temperature polymers with good mechanical properties display a high elastic modulus. This leads to rigid sealing rings or sealing ring segments which, in turn, display very poor adaptability. The latter has a particularly negative impact on oil-free compression of light gases at high pressures.

The Persisto® family stands for materials which have been specially developed for use as sealing elements in reciprocating compressors. To this aim, Burckhardt Compression uses five reciprocating compressors to test the materials for each particular application and to optimize it under real conditions.

The Persisto® materials currently available already cover a wide variety of gases in oil-lubricated as well as in dry-running environments. Persisto® 850 and Persisto® 851, the youngest members of the Persisto® family, were specifically developed for use in dry-running reciprocating compressors for the compression of hydrogen and tested on a hydrogen test compressor, whereby the highly-optimized alloy comprising polytetrafluorethylene and polyphenylene sulfide is of particular significance. **Fig. 1**

CHAPTER 1

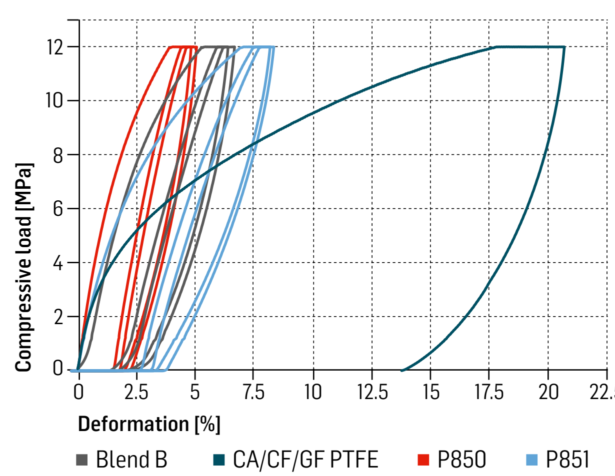
PERSISTO® 850 AND 851

Gas bottle filling is an important hydrogen compression application with tendency to rise because of its use in mobility applications. The previous standard pressure of 200 barg (2900 psig) for the cylinder racks already placed high demands on the sealing materials, which can be met by either PEEK-based materials in standard designs or carbon and glass-filled PTFE or PTFE/PPS polymer blends with special ring designs. Here it must be noted that the sealing effect displayed by modified PEEK in hydrogen is poor because of its limited adaptability, while low resistance to wear leads to a short MTBO (mean time between overhaul). Bottle pressure has since been raised to 300 barg (4350 psig), pushing the limits of carbon and glass-filled PTFEs and polymer blends even when combined with special designs. This is not a problem for Persisto® 850 though. Manufactured in a hot-pressing method, Persisto® 850 has been specifically optimized to display good pressure-creep properties and high wear resistance for hydrogen applications at high pressures and can be used up to a cylinder pressure of 330 barg (4790 psig) and a packing pressure of 200 barg (2900 psig). For lower pressures of up to 50 barg (725 psig), the Persisto® 851 is recommended, which is produced by a standard sinter process.

The highly-optimized alloy comprising PTFE and PPS is of particular importance for both materials. In the case of Persisto® 850 with its special processing, this offers favorable properties for the requisite sealing functions and permits a higher load and a reduced creep compared to conventional filled PTFE materials and polymer blends. At the same time, sealing and rider rings made of Persisto® 850 and Persisto® 851 display good flexibility and correspondingly good adaptability. **Fig. 2**

Fig. 1
Hydrogen test compressor at Burckhardt Compression AG in Winterthur, Switzerland.

Fig. 2
Pressure-creep properties displayed by Persisto® 850 at 125 °C compared to conventional H_2 materials.



CHAPTER 2

MATERIAL VALIDATION IN A HYDROGEN COMPRESSOR

Good mechanical properties are imperative for high pressure loads but are not always associated with long service lives. Despite significantly higher mechanical parameters than PTFE-based materials, modified PEEK, for example, displays unfavorable tribological properties in hydrogen which, in turn, leads to shorter service lives

Fig. 3
Patented ring design of the RS320 packing ring made from Persisto® 850 for high differences in pressure.

In an effort to establish the wear properties displayed by Persisto® 850 and Persisto® 851, the materials were tested in two dry-running piston rod sealing systems and compared with the properties of three standard polymer blends and one carbon and glass-filled PTFE. Each test lasted 250 hours at an average piston speed of 3.5 m/s, a suction pressure of 24 barg (350 psig), a discharge pressure of 80 barg (1160 psig) at the first stage and a discharge pressure of 200 barg (2900 psig) at the second stage. The counter body material was a tungsten carbide-coated piston rod with a diameter of 50 mm. When designing the sealing elements, and especially for high pressure differences, care must be taken to ensure that the wear compensation is primarily based on shifts in ring components rather than deformation thereof[1], which is why the RS320 ring design was selected for the high-load second stage as it seals entirely without bending stress. RS310 packing rings were used for the first stage. The wear coefficients thus established are depicted in Figure 4. The values of both Persisto® materials are significantly lower in the first stage at 80 barg (1160 psig) discharge pressure than those of conventional polymer blends or carbon and glass-filled PTFE grades. The full potential of Persisto® 850 combined with the RS320 design is displayed at a discharge pressure of 200 barg (2900 psig). One property profile of the materials tested is summarized in Table 1 and confirms the superiority of Persisto® 850 over the H_2 materials used to date. **Fig. 3, Fig. 4, Table 1**

Fig. 4
Wear coefficients of packing rings made from Persisto® 850 at a) 80 barg (1160 psig) and ring design RS310 and b) 200 barg (2900 psig) and ring design RS320 compared to H_2 materials available on the market.

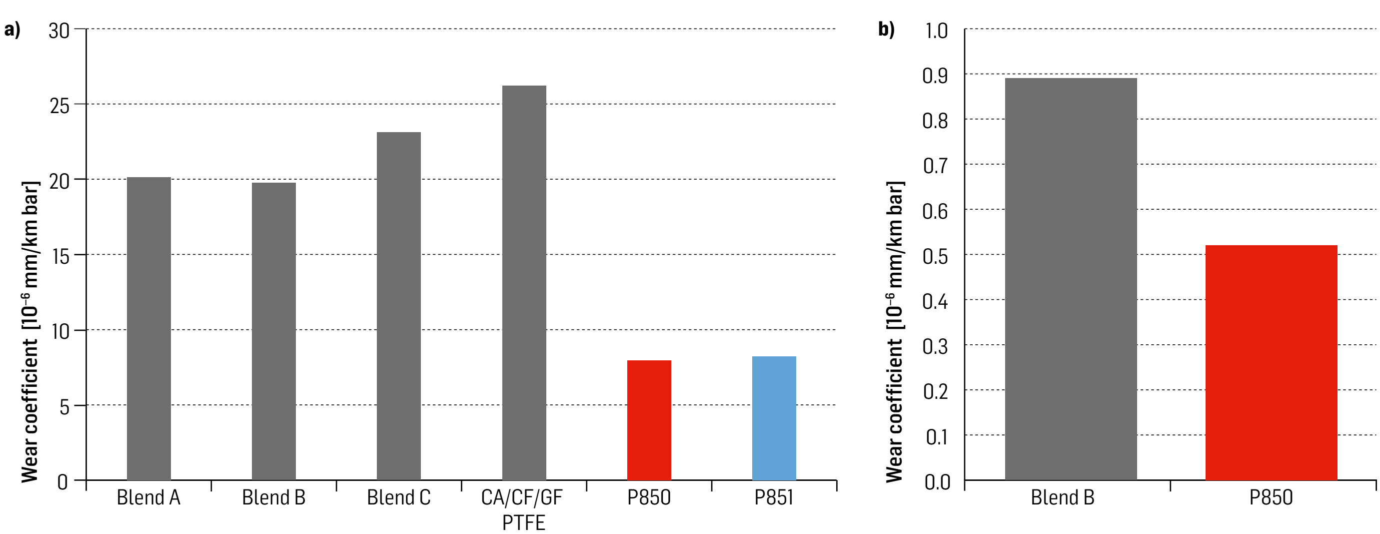


Table 1
Wear properties of Persisto® 850 and Persisto® 851 compared with CA/CF/GF filled PTFE and modified PEEK.

Material class	Filled PTFE	High-temperature Polymer	Polymer blend	
Ring material	**PFTE + CA/CF/GF**	**Bearing grade PEEK**	**Persisto® 851**	**Persisto® 850**
Sealing efficiency H_2	high	low	**high**	**high**
Load capacity	low	very high	**medium**	**high**
Wear resistance H_2	low	very low	**high**	**very high**
Abrasiveness	high	high	**low**	**low**
Costs	very low	very high	**low**	**medium**

CHAPTER 3

SCOPE OF APPLICATION

Persisto® 850 und Persisto® 851 can be used in a wide range of gases and gas mixtures, but they are not recommended for compressing oxygen-containing gases. Apart from hydrogen, these two new materials are predestined for applications with various hydrocarbons (incl. boil-off gas), carbon monoxide, carbon dioxide or ammonia. Thanks to its special composition, the atmospheric dew point of the gases can be significantly below –70 °C (bone-dry). As Persisto® 850 and Persisto® 851 do not contain any abrasive fillers, expensive counter body materials or coatings can be dispensed with.

Burckhardt Compression's line of Persisto® 850 products sets it apart as a specialist offering new solutions for complex sealing applications in reciprocating compressors. Together with innovative ring designs and heterogeneous Redura® sealing system [2], the custom-made Persisto® 850 compounds are efficiently and reliably moving the ranges of application toward higher pressures. Burckhardt Compression guarantees the longest service lives as well as increased reliability, thereby pushing the limits of the possible. **Fig. 5**

Fig. 5
Model of a heterogeneously constructed packing according to the Redura® principle with pressure breakers (RB210) and sealing elements (RS310).

Nomenclature

PTFE Polytetrafluorethylene
PEEK Polyetheretherketone
PPS Polyphenylenesulfide
CF Carbon fiber
GF Glass fiber
CA Carbon

Literature

1 N. Feistel
Performance improvement of dry-running sealing systems by optimization of wear compensation
9th EFRC Conference in Vienna, September 2014.

2 N. Feistel
Sealing systems of heterogeneous design in accordance with the Redura® principle
Compressor Tech 2, March 2015

Burckhardt Compression

PERSISTO® MATERIALS ARE CHARACTERIZED BY

STRINGENT MANUFACTURING PROCESS CONTROL

EXCELLENT TRIBOLOGICAL PROPERTIES

LOWEST LIFE CYCLE COSTS

COMPRESSOR COMPONENTS
BEST PERFORMANCE AND LONGEST LIFETIME

- Compressor valves
- Redura® rings & packings
- Capacity control systems
- Capital parts
- Labyrinth piston compressor components
- Hyper/secondary compressor components

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- Field service
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- Condition monitoring & diagnostics
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23.26.14.40 – 04/2018

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