*The pages that follow are from a magazine article prepared by Peter Holzheu, General Manager, FEY Lamellenringe, Königsbrunn Germany*

*This article offers an excellent overview of FEY sealing and retaining products.*

*Please contact us if we can be of additional assistance.*

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# *Fey laminar rings as sealing elements for rotating and static sealing applications.*

Fey laminar rings combine a low-contact, multiple labyrinth with extremely small gaps and are therefore particularly effective as a grease sealant, excluding fluid media, the ingress of dirt and dust as well as other forms of contamination. In addition to their excellent sealing characteristics on rotating parts, these low-contact laminar rings with reduced friction contribute to a significant reduction in sensible heat and wear, so making these sealing elements ideally suited for high-speed applications and use in temperature and/or friction-sensitive locations.

For static sealing applications, e.g. in axial compensators on securely screwed exhaust manifolds of internal combustion engines, exhaust gas recirculating systems and power units with operating temperatures of up to +700°C, Fey laminar rings are manufactured from high temperature-resistant chrome nickel materials and are therefore spring and heat resistant even when subjected to high temperatures.

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Those who have followed the development since 1946 of laminar rings made from spring band steel or flat wire of different qualities, including rust-free and heat-resistant grades, will remember that Germany first produced single wound laminar rings (FK2 AS) to be used initially only for fitting on used pistons in internal combustion engines in order to re-establish sealing and compression in non-circular and "worn" cylinders. This first application of the Fey rings proved to be successful over time, but was insufficient to provide economic security for the future development of Fey as a company.


picture 1

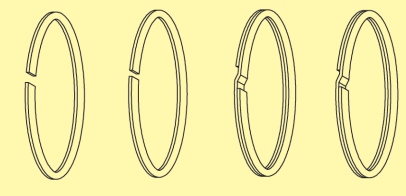
Of critical importance for the continued development of the Fey laminar ring seals was the development of a cost-effective production process using a thermal process so that the rings are manufactured in a loose, non-circular state, but then in the operating position are located in the housing bore as externally tensioned rings and on shafts as internally tensioned circular rings, all with the greatest possible light gap clearance.
Armed with these arguments and positive sealing effects as diaphragm glands and labyrinth seals, Fey was now in a position to tackle the sealing problems occurring in industry. The ever greater demand and requirements from industry led to a sealing product range offering seal diameters ranging from 15 mm to 1300 mm. Fey's production range now comprises approx. 16,800 types of seals of different circular diameters and cross-sections and a variety of ring materials.

## Design features of the laminar rings:

Simple design, small installation heights in axial and radial directions, low sliding friction, labyrinth effect, elastic and fracture-proof as well as resistance to cold and heat and a long service life.

## Design types as single wound (FK3) and double wound (FK6 / FK5 / FK5-HFL) laminar rings:

Fey laminar rings are manufactured as single wound laminar rings (AS and IS) with a butt gap and double wound laminar rings (ASD and ISD) without a butt gap. The use of the two different laminar ring geometries and the configuration of the installation technology depend on the operating conditions, the sequences of movement of the components to be sealed and the leakage requirements of the customer.
Fey laminar rings are not only arranged as single sided externally tensioned or single sided internally tensioned ring sets, but can also be combined in a groove within a ring set, externally tensioning rings with internally tensioning rings and the other way round. The protective cover of the play at the base of the groove in the bore of the housing or at the base of the shaft groove that is additionally achieved optimises the labyrinth effect and thereby the sealing effect.



**AS** = Externally tensioning rings

**IS** = Internally tensioning rings

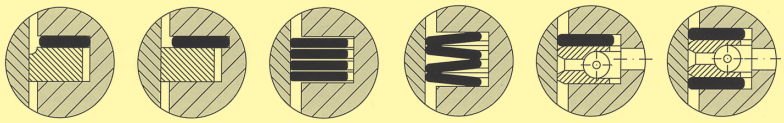
**ASD** = Externally tensioning double rings

**ISD** = Internally tensioning double rings

## Description of the type of ring and the range of applications:

***FK2***
***(lamellar piston rings)***
Laminar ring seals for new and used pistons in internal combustion engines, compressors, pneumatic and hydraulic units, shock absorbers etc.

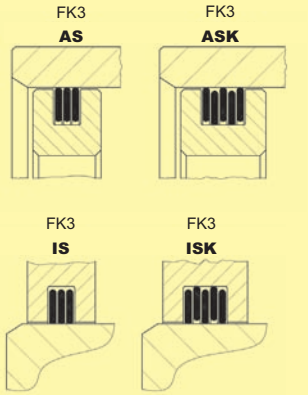
*Material:* Spring band steel C75 (DIN 1.0605) or similar quality, with spring stability and heat resistance up to +300°C



FK2 (Laminar rings)

***FK3***
***(single lamellar sealing rings)***
Single wound laminar rings (AS and IS) are used as a grease sealant in rolling and friction bearings and, when greased, offer protection against the ingress of dust and ambient moisture. As a result of their increased deflection effect, the combined ring sets "ASK" or "ISK" optimise the sealing effect.

*Material:* Spring band steel C75 (DIN 1.0605) or similar quality, with spring stability and heat resistance up to +300°C or, in chrome nickel steel, DIN 1.4310, with spring stability and heat resistance up to +450C.




**Application example:**
**curve rollers with FK3 AS**

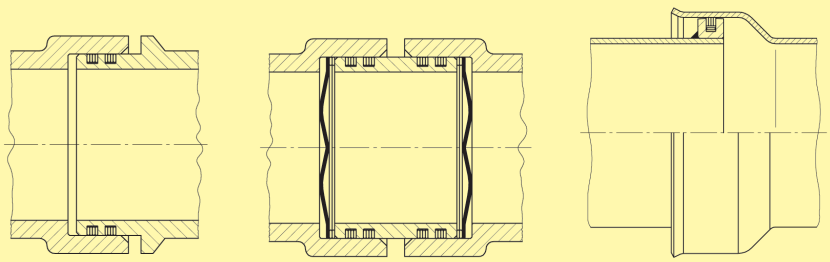
***FK4***
***(lamellar piston rings)***
This special type of laminar rings is used with pistons for open-die and drop-forge hammers, spool valves and presses. To optimise the sealing effect, the faces of the laminar rings are surface ground, enabling them to be fitted more precisely into the receiving groove.

*Material:* Spring band steel 50CrV4 (DIN 1.8159) or Ck60 (DIN 1.1221) and, with spool valves and presses, C75 (DIN 1.0605).

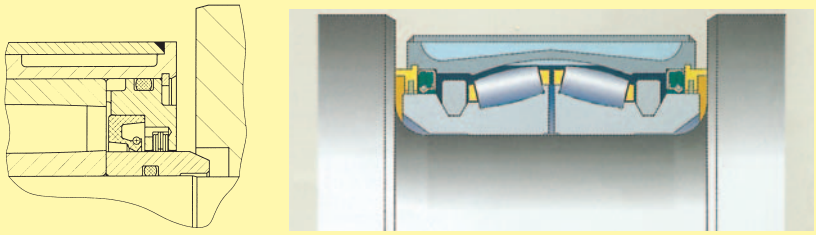
***FK5/FK5-HFL***
***(single wound lamellar sealing rings and double lamellar sealing rings)***
Fey sealing rings with the designation FK5 or FK5-HFL made from high temperature-resistant chrome nickel steels have been designed for sealing slide valves or axial compensators on exhaust gas pipes of internal combustion engines, exhaust gas recirculating systems, exhaust gas recirculating flaps, turbochargers, stationary as well as mobile turbines and aircraft propulsion units. FK5 rings are also used to seal rollers in the storage units of continuous casting systems. Fey's high temperature-resistant laminar rings are used for rotating and static applications.

*Material:* Chrome nickel steel DIN 1.4980 (FK5-HFL), rating up to max. +700°C and chrome nickel steel DIN 1.4571 (FK%), rating up to max. +500°C.

**Application example:**
***FK5/FK5-HFL***
***(Einfach-Lamellen-Dichtungsringe und Doppel-Lamellen-Dichtungsringe)***



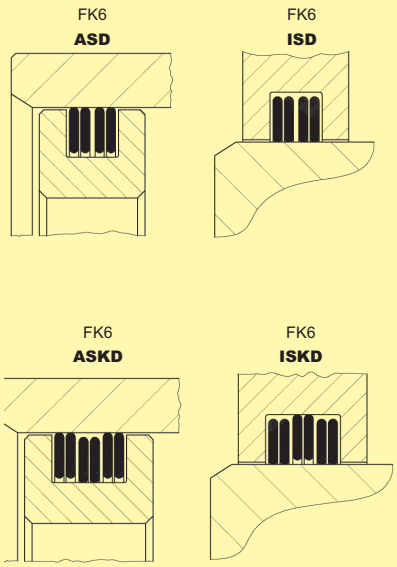
**Stranggießanlage**



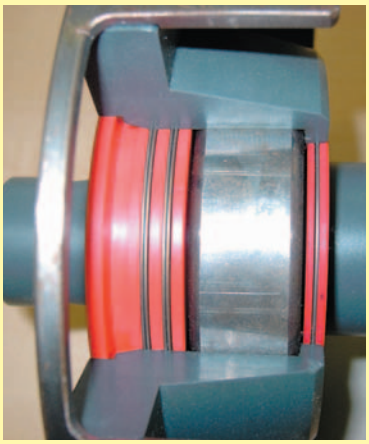
### *FK6*
### *(double lamellar sealing rings)*

Double wound laminar rings (ASD and ISD) are used where special demands are made on the seals. They are used to seal against grease on rolling and friction bearings, but are also positioned in front of hermetically acting wave sealing rings to protect against dirt. Double wound rings are also characterised by their continuous winding and uniform radial tensioning and, in contrast to single wound laminar rings (FK3), do not have axial butt openings. As a result of their increased deflection effect, the combined ring sets "ASKD" or "ISKD" optimise the sealing effect.

*Material:* Spring band steel C75 (DIN 1.0605) or similar quality, with spring stability and heat resistance up to +300°C or chrome nickel steel DIN 1.4310, with spring stability and heat resistance up to +450°C.




**Application example:**
**Bearing seals with FK6 ASD**



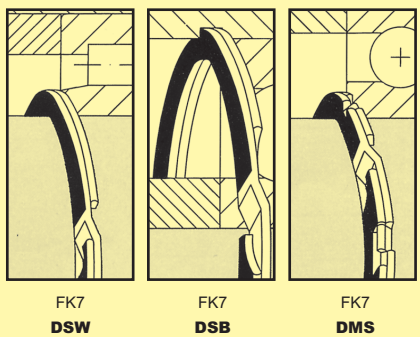
### *FK7*
### *(single lamellar retainer rings and double lamellar retainer rings)*

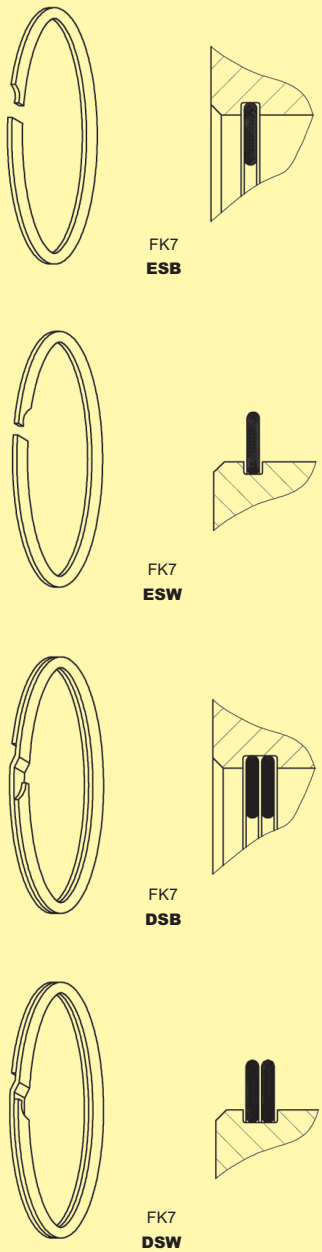
Fey retainer rings for bores and shafts can be manufactured as single wound (ESB and SW) or double wound (DSB and DSW) rings. They can be used in almost all situations where components must be safely secured axially, fixed and clamped, e.g. in gearbox construction, construction and agricultural machinery, fixing elements in vehicles and machines, the rolling and friction bearing industry as well as aircraft construction.

The advantage associated with double wound lamellar retainer rings (DSB and DSW), when compared to single wound lamellar retainer rings (ESB and ESW) is the continuous winding. The roundness of the closed winding guarantees secure, 360° contact with the base of the groove, while the complete circumferential closure ensures uniform dynamic weight during rotation. In addition, the axial loading capability is greater due to the continuous winding of the double wound ring. When greater circumferential speeds on rotating shafts are experienced and double wound "DSW" shaft retainer rings cannot be used due to excessive great centrifugal forces, double DMS lamellar retainer rings with centrifugal force protection (knob limiters) can be used.

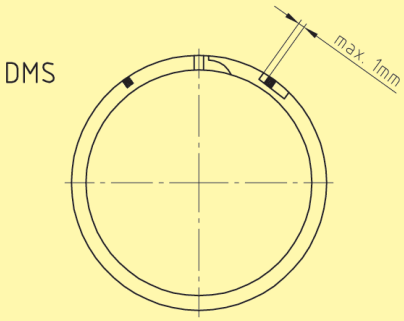
Installation and/or removal aids (half-round punch-out points at the end of the rings) are standard with double wound retainer rings, but they are a special feature on single wound retainer rings.

*Material:* Spring band steel C75 (DIN 1.0605) or similar quality, with spring stability and heat resistance up to +300°C or chrome nickel steel DIN 1.4310, with spring stability and heat resistance up to +450°C.




**Knob limiters**



### *FK8*
### *(plastic ring carrier combined with Fey laminar rings)*

Internally tensioning plastic ring carrier (material: Polyamide 6), fitted with externally tensioning laminar rings, also available in mineral fibre reinforced form, are used to seal rolling bearings against escaping grease or the ingress of dirt and splash water on vehicle axles as well as rollers and wheels on all types of equipment, drives in the transportation sector and conveyor systems.

Ring carrier versions according to Figs. (2-4) are fitted with spring-loaded sealing lips which are in constant contact with the external bearing ring and thereby effect a hermetic seal, making them ideal for applications where a great deal of splash water can be expected in the vicinity of the sealed area.

*Material:* Plastic polyamide 6, heat resistant over short periods up to +150°C and indefinitely from -40°C to +120°C.

Fig. 1

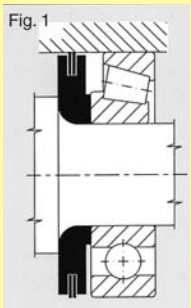


Fig. 2

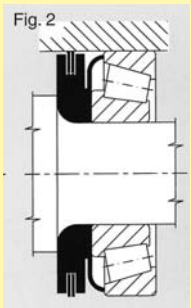


Fig. 3

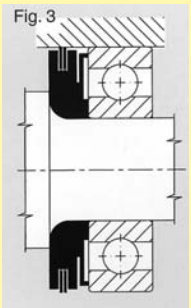
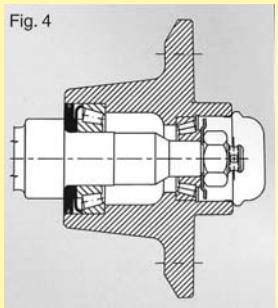


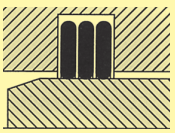
Fig. 4



### *Max. permitted speeds for rotating sealing applications*

Obviously, Fey laminar rings will also be subject to the centrifugal forces of rotating shafts or housing bores to or on which they are fitted. It is particularly when rotating components start up or slow down that laminar rings can work themselves into the opposite faces and cause some form of damage due to excessive speeds. Externally tensioning AS or ASD rings are not affected by speed, as the rings tension against the housing bore and so are not subject to centrifugal forces, irrespective of whether or not the shaft or housing rotates. The illustration shows the max. permitted standard speeds of shafts and housings for the various laminar ring combinations.

**AS** = Externally tensioning rings
Drehzahl des Gehäuses oder Ringträgers unbegrenzt.



**IS** = Internally tensioning rings
Drehzahl des Gehäuses unbegrenzt. Drehzahl der Welle bzw. der IS-Ringe max.4 m/sec.

**ASK** = Externally tensioning combind rings (Einzelringe)
Drehzahl des Gehäuses max.10 m/sec. Drehzahl des Ringträgers bzw. der IS-Ringe max.4 m/sec.

**ISK** = Internally combind tensioning rings (Einzelringe)
Drehzahl des Gehäuses max.10 m/sec. Drehzahl der Welle bzw. der IS-Ringe max.4 m/sec.

**ASD** = Externally tensioning double rings
Drehzahl des Gehäuses oder Ringträgers unbegrenzt.

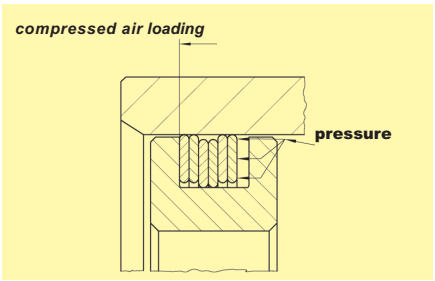
**ISD** = Internally tensioning double rings
Drehzahl des Gehäuses unbegrenzt. Drehzahl der Welle bzw. der ISD-Ringe max.10 m/sec.

**ASKD** = Externally tensioning combind double rings
Drehzahl des Gehäuses unbegrenzt. Drehzahl des Ringträgers bzw. der ISD-Ringe max.10 m/sec.

**ISKD** = Internally tensioning combind double rings
Drehzahl des Gehäuses unbegrenzt. Drehzahl der Welle bzw. der ISD-Ringe max.10 m/sec.

### *Max. permitted compressed air loading for static sealing applications*

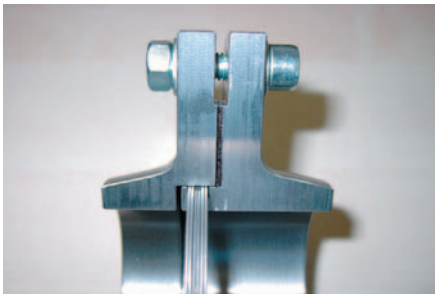
The max. permitted compressed air loading for static sealing applications depends on the medium to be sealed (gas, grease or fluid media), ring and groove geometries, ring material selection and, naturally, the operating conditions around the point of sealing. In the case of different types of seals e.g. against hot gases (up to +700°C) on exhaust gas manifold system of mobile and stationary internal combustion engines, exhaust gas pressures of approx. 12 bar are standard. Pressures of up to 400 bar can arise in aircraft propulsion units and steam turbines. In the case of very heavy pressure loading against Fey laminar rings, it is particularly important to determine the number of sealing grooves one behind the other. The general rule is, the more sealing grooves there are, the higher the throttling or deflecting effect will be, but with the smallest axial installation space.



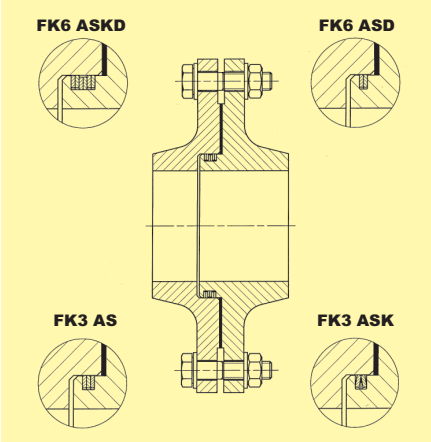

The illustration shows the sealing effect at high pressure loading, whereby the laminar ring package is pressed continuously against a flank of the groove.

### *Future-oriented developments (patents)*

Given the positive sealing effects, the range of possible application for Fey laminar rings has developed enormously over the last few years. Future-oriented new developments (Fey laminar ring patents), naturally in close co-operation with many national and international customers, have made it possible to provide a lasting solution for some extreme sealing problems. A current example is the use of Fey laminar rings in what are known as flange connections.



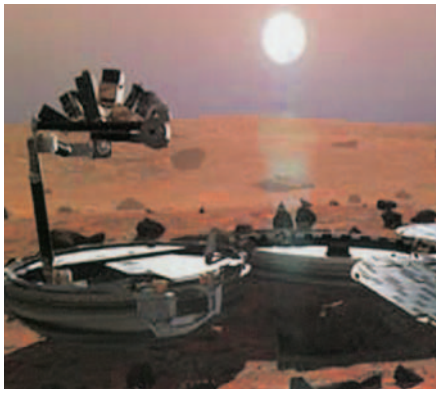
The patented "Fey idea", conceived not least in response to the new German technical air regulations, is to protect the flange seal in the flange connection durably against environmental influences such as solid, fluid and gaseous media, high pressures, heat expansion in all directions, tolerance-based tangential bending etc. by using Fey laminar rings.




The advantage is obvious: use of a Fey laminar ring seal can extend the service life of flange connections under extreme boundary and operating conditions and so reduce maintenance work and plant downtimes as well as operating costs. The effectiveness of these patented new Fey developments is currently being determined in a variety of ring configurations at the Institute of Technology (Faculty of Physical Engineering) in Münster under the leadership of Professor Dr. Wolfgang Tietze.

Sealing combinations of Fey laminar rings in the form of diaphragm glands and hermetically acting seals such as shaft sealing rings have proven themselves to great advantage in the past. Fey laminar rings are intended to keep as many as possible of the ultra-fine particles of the sealed medium away from the sensitive sealing lips of the shaft sealing rings and thereby act as a kind of protective seal.

Another forward-looking application of Fey laminar rings is its use in space. The "Mars Express" European space probe, launched in June 2003, is also equipped with Fey laminar rings. Fey laminar rings have also been developed and installed in the grab arm of the "Beagle 2" landing module to protect the articulated joints against Mars dust. The "friction-free Fey diaphragm gland" was preferred to other sealing units and released by the German Aviation and Aerospace Centre (DLR) after numerous and intensive tests.

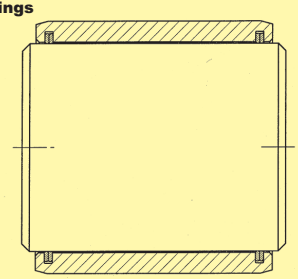


At this point in my report about Fey laminar rings I would like to close with the following words which the "inventor of Fey rings", Mr Josef Fey, senior, used to say in numerous technical discussions with Fey customers as well as Fey technicians:

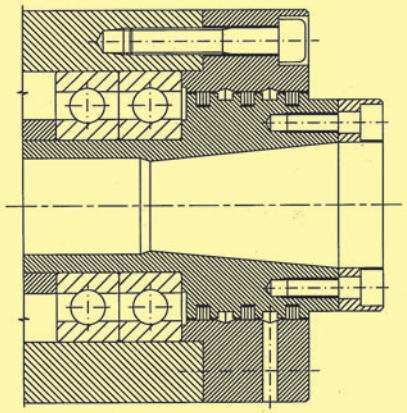
*„Every possible seal will satisfy its tasks under the conditions for which it was designed, but not under all possible conditions“.*

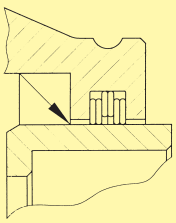
***Application example with Fey Laminar rings***

**Laminar rings as protective seals for friction bearings**

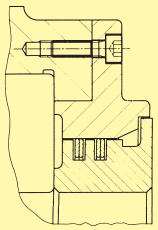


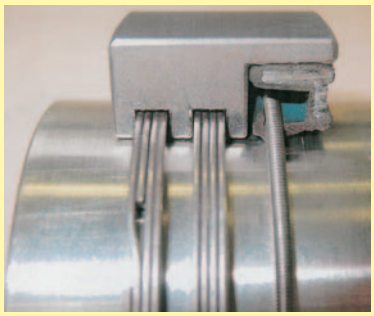
**Laminar rings for sealing in fast-running operating spindles**





**Combination Fey rings as protective seals for shaft sealing rings**





**Laminar rings as protective seals for wheel set bearing units on rail vehicles**