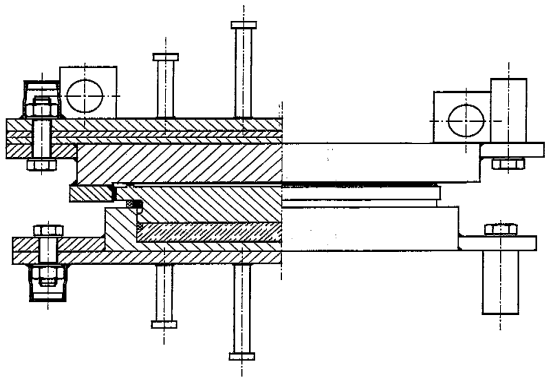
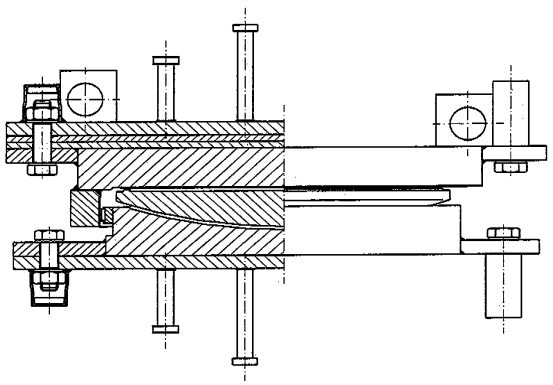
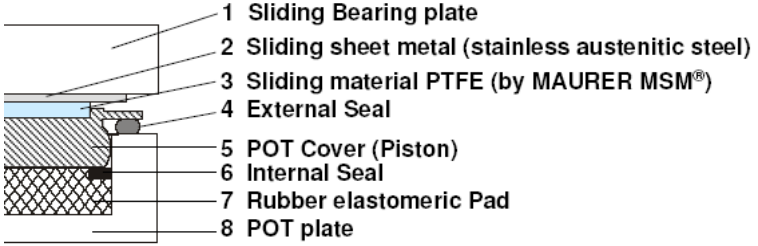
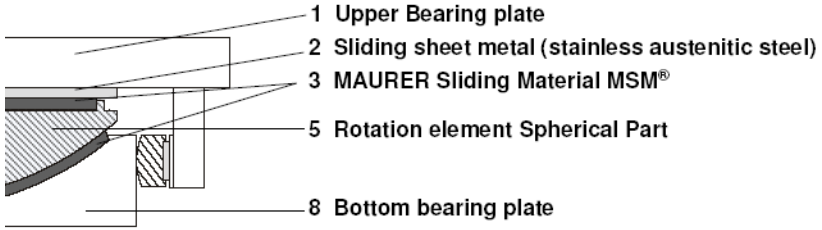
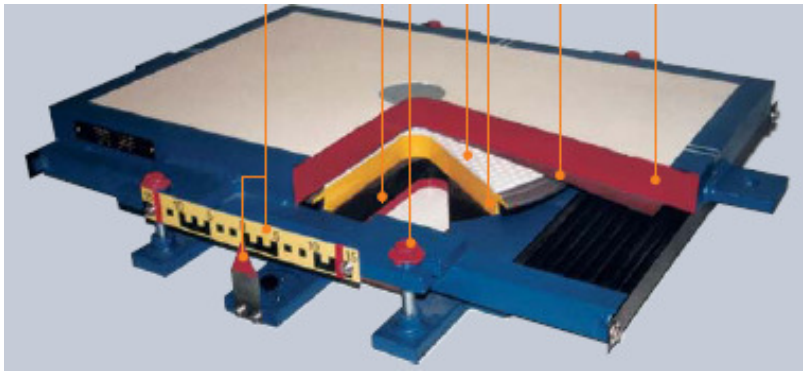
	POT Bearings	MSM® Spherical Bearings MSM® = Maurer Sliding Material
		
		
		

Construction principle and Design	▪ The construction principle of a pot bearing corresponds to a fixed bearing and thus allows rotations around any horizontal axis (point tilting) by shear deformation of an elastomer pad included in a steel pot. ▪ The used elastomer keeps its volume constant under allround compressions and thus is incompressible. ▪ By providing a sliding plate a fixed bearing becomes a generally mobile one and/or by additional attachment of a guide stop a unidirectional mobile pot sliding bearing. ▪ Therefore a PTFE disc as a sliding material is inserted into the top of the pot cover.	▪ The construction principle of a spherical bearing corresponds to a generally mobile bearing and thus allows rotations around any axis (point tilting) by sliding motions between base plates and spherical cap. ▪ A unilaterally mobile spherical bearing becomes a generally mobile spherical bearing by the arrangement of restraints, and a fixed spherical bearing by attachment of a stop ring. ▪ A MSM® disc is inserted into the spherically machined out surface of the base plate. ▪ The hard-chrome plated lower surface of the spherical cap serves as sliding surface. ▪ A further MSM® disc is inserted into the flat top of the spherical cap, which slides on an austenitic, chromenickel-alloyed steel sheet, which is connected shear-resistantly to the sliding plate.
Function	▪ Due to the all round embedding of the elastomer pad the characteristics of the rubber, which is ideal for bearing constructions, are suitable for high loads. ▪ A vital point is the functionability of the seal. **The patented PTFE/carbon seal used by Maurer Söhne is suitable even for larger imposed load rotations which occur with steel and railway bridges**. ▪ The twisting of the bearing is rendered possible by an elastic shear deformation within the pad. ▪ Due to the resulting strain, which depends on the size of rotation, the permissible angle of rotation must be limited. ▪ With increasing rotation the restoring moment rises. Larger angles of rotation require additional constructive measures when sealing the annular gap. ▪ The pot's dimensions in the layout result from the permissible compressions in the elastomer and the adjacent components.	▪ The spherical bearing allows rotational movements of the superstructure by a sliding displacement of the spherical cap in the concavely shaped base plate. ▪ Thus the construction principle of a ball and socket joint is realized in the spherical bearing, which allows rotations with low resistance. ▪ Rotational movements of the superstructure in x- and y-direction are taken up in the even sliding surface between sliding plate and spherical cap.

<table>
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<td>Flat sliding part</td>
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- With an elastomeric pressure of 30N/mm² the friction of the sliding part is negatively affected. It is calculated for **PTFE** with

μ=1,2/(10+σm), μ=1,2/(10+30) = 0,03.

From friction coming forces have to be absorbed on the fixed bridge axis.

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- With MSM® as the sliding material the following formula of the friction is used:

μ=1,6/(15+σm)>0,2, μ = 0,02.

With this, the horizontal friction forces are **30%** less than for POT bearings.

More economic design of the fixed axis!

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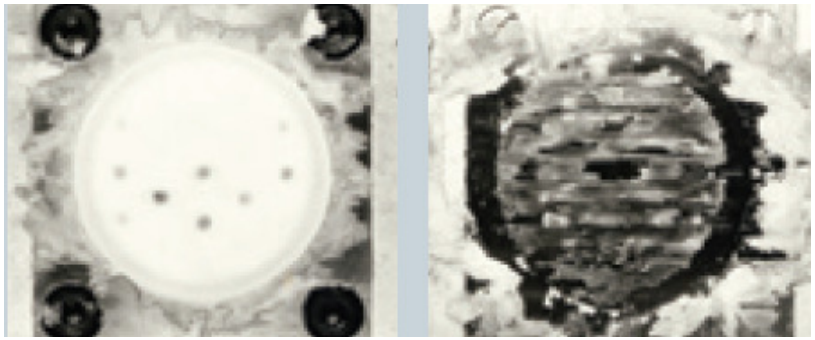
PTFE **P**olyte**T**ra**F**luor**E**thylen after opening the test bearing



PTFE -sheet stainless steel sheet

In contrast to this, the photos of the PTFE clearly show **abrasion of the material.** These photos were taken also at the MPA Stuttgart, after completion of the **10-km-long term test** according to EN 1337-2.

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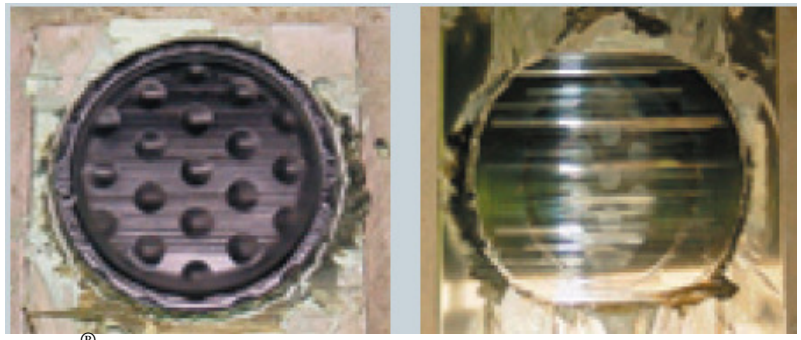
MSM® **M**aurer **S**liding **M**aterial after opening the test bearing



MSM® -sheet stainless steel sheet

Photos of an MSM® -sheet (left) and a stainless steel sheet (right), taken after opening the test bearing and after completion of the **50-km-long term test.** Little scars can be found (also at the bottom of the dimples), but **no wear**.

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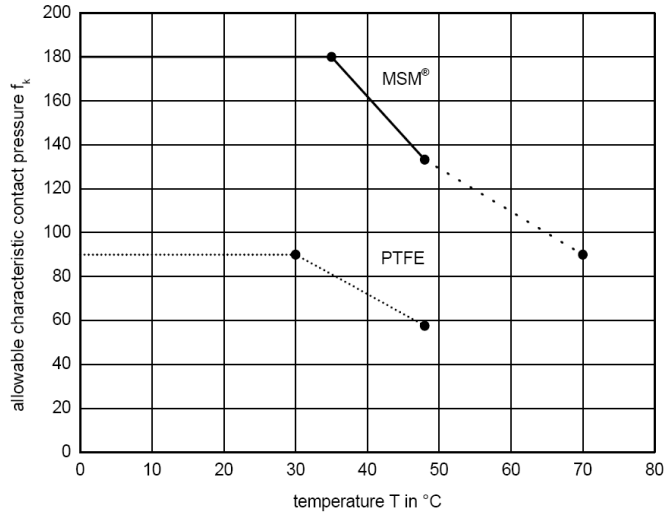

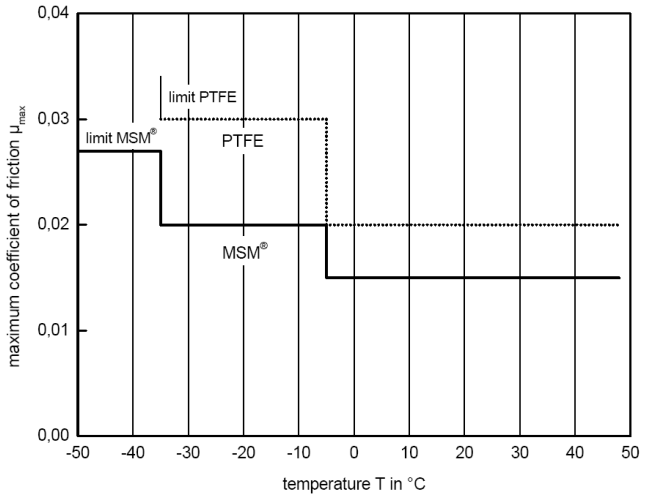

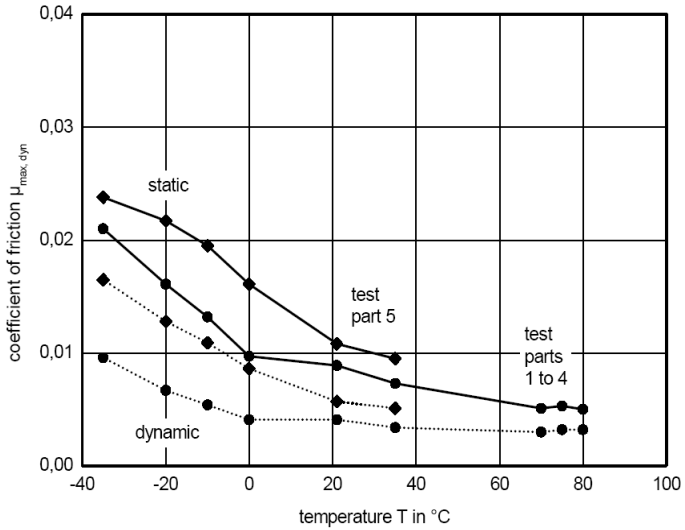

- Allowable characteristic contact pressures for Maurer sliding material MSM® and for PTFE (bridge bearing qualities) in dependence of the temperature.
- Supposable maximum coefficients of friction for Maurer sliding material MSM® and PTFE (bridge bearing qualities) at a contact pressure equal or more than it's design value (60 MPa for MSM® and 30 MPa for PTFE) in dependence of the temperature.
- Maximum static and dynamic coefficients of friction in the different temperature phases of test parts 1 to 5 of a sliding test with MSM® (Ø 75 mm x 8.1 mm, with impressed dimples, depth of the recess t1 = 5 mm) and austenitic steel as mating surface, lubri-cated with silicon grease 300 medium (bridge bearing qualities) at the contact pressure of 30 MPa.

Sliding material	**MSM®** **Maurer Sliding Material** in comparison to **PTFE** **P**olyte**T**ra**F**luor**E**thylen **(Teflon)** In the ETA (European Technical Approval: ETA-06/0131) and the German Type Approval it is mentioned that the MSM® is especially suitable for structures of high speed railways, as the MSM® is extremely wear resistant with respect to sudden rapid displacements and big accumulated displacement paths. The MSM® was tested by the independent third party (MPA Stuttgart = Material Testing Institute of University Stuttgart). MSM® can display the total band width of its superior material characteristics in the spherical bearing, facilitating **a more economic production as compared to (necessarily larger) pot sliding bearings or elastomeric sliding bearings**. ▪ MSM® is a **thermoplast without environmentally hazardous components, like** for example **fluorine or chlorine** (Expertise of the Stuttgart University in respect to the chemical stability and environmental suitability). ▪ MSM® is particularly suited for high speed motions. [In **comparison to PTFE**, it displays less wear at a **7.5-fold displacement speed**.]. ▪ MSM® can take **high loads**. [In **comparison to PTFE double contact pressure.]** ▪ MSM® causes **little friction**. At –10 °C the **coefficient of friction** is **2 %** [**PTFE 3%].** At –35 °C the coefficient of friction remains below 3 %. [**PTFE is not suited for continuously low or high temperature**.] ▪ MSM® **tested by temperature up 80°** (MPA Stuttgart = Material Testing Institute of University Stuttgart.) ▪ MSM® reaches a very **long service life**. [**5-fold accumulated sliding displacement as compared to PTFE**, **without visible signs of wear**.] ▪ MSM® is an innovative sliding material for bridge sliding bearings. ▪ MSM® is also suitable for other applications, such as incremental launch bearings, earth quake devices, or sliding bearings in buildings. ▪ MSM® is a modified polyethylene, featuring enhanced sliding characteristics and an increased load bearing capacity by means of blending with various additives. ▪ MSM® contains no filling material or regenerated material. ▪ MSM® stands for MAURER Sliding Material. The name is a registered brand name. And is exclusively produced for Maurer Söhne.

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Unmatched at high performance requirements At extreme strains (e.g. high speed motions, high contact pressures, high accumulated sliding displacements, low temperatures), MSM® is the only sliding material that matches all performance requirements. Thus, MSM® fills a gap in particular in high speed railway bridges, soft structures and bridges with high traffic loads or long span widths.
Smaller dimensions Due to the double as high design contact pressure that MSM® employs in comparison to PTFE, MSM® Spherical Bearings need only be dimensioned half their size.
Spherical Bearings instead of Pot Bearings Because the MSM® Spherical Bearing is smaller, in many cases it is also more economical to manufacture as a (necessarily larger) sliding pot bearing or sliding elastomeric bearing.
More economical construction method The smaller dimensions facilitate more slender and thus more economical constructions due to enormous savings in material.
More architectonical degrees of freedom Smaller bearings enable architectonical degrees of freedom.
40-fold increased service life In considering all material characteristics and advantages, compared to PTFE MSM® employs a minimum 40 -fold increased life time. This leads to considerably reduced maintenance costs, and thus in long term to enormous cost savings.

Conclusion: Compared to PTFE, the new sliding material MSM® displays many advantages, and even if not taking advantage of its additional performance characteristics, MSM® is neutral in respect to costs.
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<tr><td>internal Sealing</td><td>
Lifetime of Pot Bearings is defined with the wear of the sealing around the elastomeric pad.

Brass sealings lifetime is confirmed with approval tests of one 1 km sliding path,
for POM (polyoxymethylene) sealings with two 2 km sliding path. After this distance, the sealing were wear out.
Carbon filled PTFE MAURER use this kind of sealing in the production of MAURER POT Bearings.

Because of the relatively high wear of brass sealings, this type is not permitted for railway bridges.
</td><td>

Spherical bearings need no sealing of the rotation part.
The same sliding material is used for translation and rotation part, namely MSM® (Maurer Sliding Material).
MSM® passed during the necessary type approval tests an accumulated sliding path of 50 km, without any significant wear.

With this, the lifetime of bearings rotation part is much longer than for pot bearings.
min. 25 times higher!!!
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</table>

Restoring moments	▪ If the elastomeric pad is deformed with the structure rotation, the pad works like a spring and produces a so called „**restoring moment**“. ▪ For sliding pot bearings this moment has to be accepted by the sliding material. The restoring moment occurs not only during rotation, it is still present as long as the pad is deformed. Thus, the restoring moment is a relevant factor of the boarder wear of the sliding material. For a pot bearing with a vertical load of 10000kN and 0.75% rotation the restoring moment is calculated as follows: $Me.d = 0{,}188 \times a^3 \times (F0+(F1 \times \phi_1)+(F2 \times \phi_2)) = 0{,}188 \times 330^3 \times (0{,}01+(1 \times 0{,}05)+(5 \times 0{,}025))$ **$Me.d = 1{,}25\ E^6$ kNmm**	▪ Spherical bearings do not have restoring moments, if they are in rest. ▪ Only during rotation they produce a rotation moment, coming from friction, which is to accept with the sliding material. ▪ With an geometric ratio of R/D = 1,3 is the moment (V=10000kN, 0.75% rotation): $M = V \times \mu \times R = 10000 \times 0{,}02 \times 500$ **$M = 1{,}0\ E^5$ Nmm** **It’s 12,5 times smaller** then by POT-Bearing!!
Lifetime	▪ Because of the above mentioned points, a replacement of the pot bearings after 15 - 20 years have to be planned financially.	▪ The high wear resistance of MSM® in the flat and curved sliding area raises **the life time of the bearing on the level of the bridge itself**. A budget for replacement costs is not necessary.
Installation and Inspection	▪ Because there is no possibility to inspect the elastomeric pad sealing, a statement about completed bearing condition is not possible during the cyclical structure inspections. ▪ Only with measurement of the tilting gap is an assumption of the sealing possible. A wear forecast is impossible.	▪ Condition of the flat and curved sliding area could be inspected and examined from outside. ▪ With this an analysis and forecast of the bearing wear is possible.

Maintenance Frequency	▪ With the higher wear an inspection with the usual intevals is recommended. After 20 years a replacement has to be estimated.	▪ Because of the high lifetime of MSM® it is possible to **enlarge** the inspection intervals. This is cost safing. A replacement of the bearings during bridge life is **not** expected.

The results with respect to the load bearing capacity, tribology and ageing show the usability of Maurer Sliding Material **MSM® at temperatures up to +70 °C, which does not apply for PTFE**.

(MPA Stuttgart = Material Testing Institute of University Stuttgart)

The assumed working life of 50 years is based on the assumptions of a **maximum accumulated sliding path of c · 50 000 m and** a maximum of **15 mm/sec of average sliding speed** in the main sliding surfaces (for **PTFE** acc. EN 1337-2:2004 c · **10 000 m and 2 mm/sec**), where c (c ≥ 1) is a factor to correct the difference between the constant amplitude slide path used in the approval tests and the variable amplitude movements which occur due to traffic.

ETA-06/0131 (European Technical Approval) approved by the EOTA (European Organization for Technical Approvals, 2.2.9 Displacement capacity, Page 12)

Approvals and Literature

- ETA-06/0131 (European Technical Approval) approved by the EOTA (European Organization for Technical Approvals)
- Technical Approvals by German Institute for Civil Engineering (Deutsches Institute für Bautechnik in Berlin.
- Tests by MPA Stuttgart the independent third party (MPA Stuttgart = Material Testing Institute of University Stuttgart) to get the approval.
- Type approval pot or spherical bearings MSM® respectively
- German Type Approval (No. Z-16.4-436)
- European Standard Norm EN1337-2 / EN1337-5
- Maurer Soehne Brochures