



# TENSA

VOLUME	PRODUCTS CATALOGUE
<b>05</b>	<b>BEARINGS</b>

YOUR CHALLENGES,  
OUR SOLUTIONS



---

<b>01. COMPANY PROFILE .....</b>	<b>03</b>
<b>02. BEARINGS SELECTION CRITERIA .....</b>	<b>07</b>
<b>03. TENS RUBBER BEARINGS (TR).....</b>	<b>11</b>
<b>04. TENS POT BEARINGS (TP).....</b>	<b>23</b>
<b>05. TENS SPHERICAL BEARINGS (TS).....</b>	<b>39</b>
<b>06. GENERAL PROVISIONS AND PRACTICES .....</b>	<b>55</b>
<b>07. QUALITY AND TESTING.....</b>	<b>61</b>
<b>08. INSTALLATION AND REPLACEMENT .....</b>	<b>65</b>



---

# 01

---

## COMPANY PROFILE

Our mission is to constantly improve the methods  
and the quality of construction processes  
through research, innovation and cooperation  
with designers, engineers and contractors worldwide.



# TENSA

---

Tensacciai, now renamed TENSA, was founded in 1951 with headquarters in Milan, Italy. It is now active in over 50 countries with a direct presence in 14 countries. TENSA is a leader in stay cables, post-tensioning, anti-seismic devices, structural bearings and expansion joints. TENSA has extensive references and numerous certifications for its products worldwide.

## HISTORY

**1951:** Beginning of activity

**1964:** In the sixties Tensacciai undergoes a phase of remarkable growth in Italy. Post-tensioning is just at the beginning of its history and its application is still experimental.

**1970:** A programme of technological renewal begins with the adoption of the steel strand.

**1980:** Tensacciai develops new tensioning systems and equipment in the field of ground anchors, combining innovation with versatility and ease of use.

**1990:** New subsidiaries established in Brazil, India and Australia and in Europe sister companies in Portugal, Greece and the Netherlands.

**2000:** The internationalization process of Tensacciai continues unabated.

**2010:** The company becomes directly involved in projects in all five continents.

**2011:** Tensacciai is acquired by Deal - world leading solutions provider in the field of bridge construction - and becomes part of De Eccher Group. Tensacciai is now member of an organisation capable of designing, manufacturing and installing systems everywhere in the world, thanks to specialised technicians, engineers in the technical department and quality control. All production and delivery processes are attested by the ISO9001 certification.

**2012:** Tensacciai merges with Tesit, another successful concrete specialist contractor with international experience in post-tensioning, steel bars, structural bearings and expansion joints becoming a prominent player in the field of specialised subcontracting.

Tensacciai enters into a Worldwide Exclusive License Agreement with Rome-based TIS (Tecniche Idraulico-Stradali S.r.l.) - a leading company with experience in designing and producing structural bearings, expansion joints and anti-seismic devices since 1973.

**2014:** TIS is acquired by Tensacciai.

**2015:** TENSA is formed from the merging and development of the three important companies mentioned above: Tensacciai, Tesit, TIS.

## MISSION

Our mission is to constantly improve the methods and the quality of construction processes through research, innovation and cooperation with designers, engineers and contractors worldwide. A strong commitment to quality is the only way to ensure safe and long-lasting structures. We support the design from the initial stage, challenging standards to develop custom solutions. We value timely execution and service as keys to building long-term relationships.

Our core knowledge lies within stay-cables and post-tensioning systems, anti-seismic devices, structural bearings and expansion joints as well as all the related accessories, equipment and services.

TENSA strives to push its vast experience towards new methods and variations of applications, developing ingenious solutions for building new structures, whether they are buildings or infrastructures, as well as the rehabilitation of existing ones.

## PRODUCT CATALOGUES

- 01 - STAY CABLES
- 02 - POST TENSIONING
- 03 - GROUND ANCHORS
- 04 - EXPANSION JOINTS
- 05 - BEARINGS**
- 06 - DAMPERS & STUs
- 07 - SEISMIC ISOLATORS
- 08 - ELASTO PLASTIC DEVICES
- 09 - VIBRATION CONTROL





Jamal Abdul Nasser Street, Kuwait City (Kuwait)

17-09-13  
PN38E 01

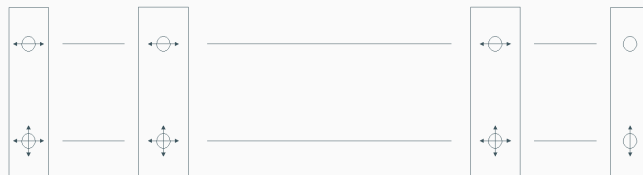
---

# 02

---

## BEARINGS SELECTION CRITERIA

The choice of bearing system represents a significant part in the structural design of constructions





# INTRODUCTION

---

In civil engineering, the design of big structures such as bridges, viaducts and buildings, presents several variables that need to be taken into account in order to realize major works that meet the expected performance requirements.

Starting from the early stages of the study of a structure, the designer has to define the static scheme to employ by speculating a certain number of constraints that link the different structural elements to each other and to the foundations.

Among the several issues that need considering for an adequate definition of the structure's constraints, there is the correct interpretation of the cinematic-deformative behavior of the individual structural elements and the global system. Structures, indeed, undergo displacements, rotations and deformations caused by acting loads (of static, dynamic, thermic nature etc.) or by phenomena such as shrinkage and creep, linked to the maturation of materials.

Movements, rotations and deformations need to be allowed for and contemplated where strictly necessary and in accordance with the designer's constraining system.

This technical catalogue takes into account the following types of bearings:

1. fixed bearings, which allow rotation between two structural elements and transfer the required loads.
2. guided sliding bearings, which transfer vertical loads, allow rotation between two structural elements, displacement in one single direction and transfer lateral load in the fixed one.
3. free sliding bearings, which transfer vertical loads, allow rotation between two structural elements and displacements in all plan directions.

Jamal Abdul Nasser Street, Kuwait City (Kuwait)



# SELECTION CRITERIA

The selection of bearings represents a relevant part in structural design, both for the safety and the durability of the different structural components. When defining which bearing devices to use, there are several aspects, linked to functionality requirements and costs, that need to be considered.

Depending on displacements, relative rotations and expected loads, TENSA suggests three types of structural bearings able to satisfy different needs:

- TR – TENS RUBBER bearing;
- TP – TENS POT bearing;
- TS – TENS SPHERICAL bearing.

## ROTATION CRITERIA:

All bearings considered above allow relative rotation between the connected structural elements.

In order to facilitate the selection of the most adequate bearing, Table 1 shows rotation range that are usually used for the design of TR Rubber bearings, TP Pot bearings and TS Spherical bearings.

BEARING TYPE	TR	TP	TS
Rotation ( $\varphi$ ) [rad]	$\leq 0.01$	$0.01 \leq \varphi \leq 0.02$	$\geq 0.02$

Table 1 - Rotation range recommended for TR, TP and TS bearings

## DISPLACEMENTS CRITERIA:

Except for fixed bearings, TR, TP and TS bearings can absorb large scale longitudinal and/or transversal displacements through relative sliding between a plate with a stainless steel surface and a PTFE liner provided with adequately lubricated cavities. Such cavities or dimples can harbor a lubricant that considerably reduces the friction coefficient. As a consequence, the PTFE wear phenomenon is reduced. In the presence of constraints allowing large displacements (e.g. a long-span continuous viaduct) it is convenient to use TP or TS bearings in order to minimize costs and reduce overall dimensions.

## LOAD MAGNITUDE CRITERIA:

In order to facilitate the selection of the most adequate type of bearing, Table 2 provides commonly used assumptions of load entity for the design of TR, TP and TS bearings.

BEARING TYPE	TR	TP	TS
Load entity	Low - Medium	Low - Medium High	Low - Medium High

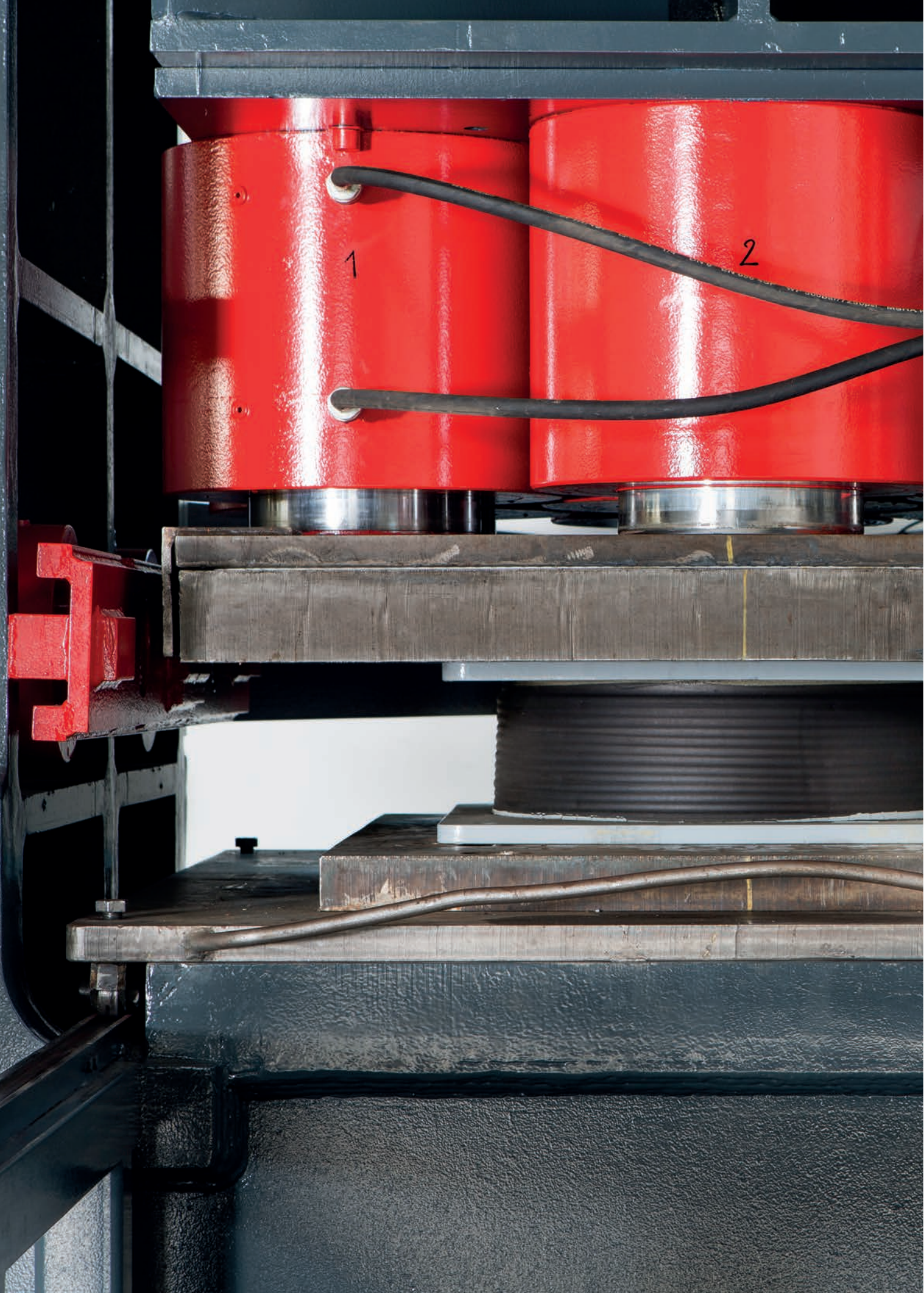
Table 2 - Tolerable load entity for TR,TP and TS bearings

These assumptions are only indicative. A correct evaluation can be found with reference to the design data (vertical load, maximum pressure transferable to the superstructure and to the plinth/pier, available dimensions on the superstructure and substructure and available vertical space to host the bearing).

Supported load being equal, one can easily claim that TR devices have larger dimensions compared to TP and TS devices.

Tables and assumptions suggested so far provide a general indication rather than rigid selection rules.

For more detailed information refer to TR, TP and TS bearings' technical tables.



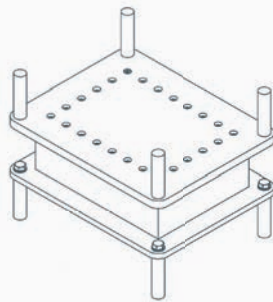
---

# 03

---

## TENS RUBBER BEARINGS (TR)

TENS RUBBER bearings represent a competitive and efficient solution, thanks to their durability and convenience



# DESCRIPTION

This chapter refers to TENS RUBBER bearings (TR). TENS RUBBER bearings are able to transfer vertical and lateral loads between the superstructure and the substructure; they allow displacements in all directions and rotations about any axis thanks to the rubber's elastic deformation.

TR bearings are usually made of alternating rubber layers and steel sheets or, alternatively, of rubber only. The bearing is realized through vulcanization.

The steel sheets are completely incorporated in the elastomer and are thus protected from external agents and corrosion. This choice of materials depends on the need for deforming elastically on the horizontal plane and of resisting vertical loads.

The rubber's total height, as sum of the individual layers' thicknesses, profoundly affects the capacity of relative displacement between the connected elements. Indeed, the allowable displacements at ULS correspond to a tangential deformation of the rubber equal to  $\tan \gamma = 1$  (this means that the maximum lateral displacement at ULS is equal to the rubber's total height, without considering upper and lower rubber covers if thinner than 2.5 mm). The bearing is able to deform in all directions of the horizontal plane.

Usually, rubber bearings have a rectangular shape (or circular upon request).

In order to extend their usage it is possible to combine them with complementary bearings such as sliders, both temporary or permanent, or mechanical restraints that bind their deformation or sliding direction.

Depending on the type of work and the design specifications, the bearing's anchorage can be normally made in the following ways:

- dowels and screws (typical for cast in situ concrete structures);
- pin (typical for steel and/or prefabricated superstructures in which masonry plates must be provided in order to host the pin);
- screws (typical for steel or prefabricated concrete structures, in case there is a linking plate provided with threaded holes and preventively grouted in the structure);
- bonding/friction (any type of structure).

Any additional steel plates can be used between the bearing and the structure, in order to facilitate installation and possible future substitutions.

TR bearings present the following advantages:

- moderate costs;
- good ability to absorb vibrations conveyed by the connected structural components;
- stability;
- easy installation/substitution;
- limited errors during the installation process;
- durability.

# CLASSIFICATION AND COMPONENTS

TENS RUBBER bearings, according to EN 1337-3, can be divided into three types:

- Type B bearings
- Type C bearings
- Type E bearings.

Below are some descriptions and explanatory diagrams.

## TYPE B BEARINGS

This type of bearing represents the basic solution and is the most convenient, because of its competitive price and its easy installation.

The device consists of vulcanized rubber layers alternating with steel sheets. The transfer of lateral loads takes place by means of the friction between the rubber and the super/substructure. Each device is individually made within a specific mould of cylindrical or cubical shape.

## TYPE C BEARINGS

Type C bearings are similar to type B with the addition of two or three outer steel plates that sometimes present a setup for anchorages.

If the bearing does not have to be mechanically anchored, outer plates present a surface with improved adherence. Also in this case the transfer of lateral loads to the super/substructure occurs by friction.

Any mechanical anchorage requires that the bearing is provided with steel plates presenting appropriate spaces for mechanical constraints. Listed below are some of the standard solutions for rubber bearings with mechanical anchorage suggested by TENSA.

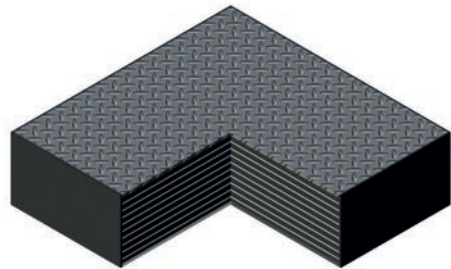
The baseplate is directly vulcanized to the bearing and is linked to the plinth by means of anchor bolts. On the upper plate, vulcanized to the rubber, there is a connection pin that finds its place in the upper masonry-plate, also provided with anchor bolts.

The bearing can be replaced simply by minimum lifting the structure, since there are no embedded anchoring elements.

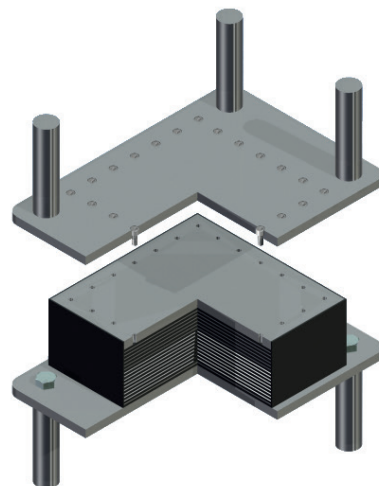
Regarding the choice of the anchorages to be used please refer to the relative section of chapter 6.



Type B rectangular bearing



Type C rectangular bearing with improved adherence



Type C rectangular bearing mechanically anchored

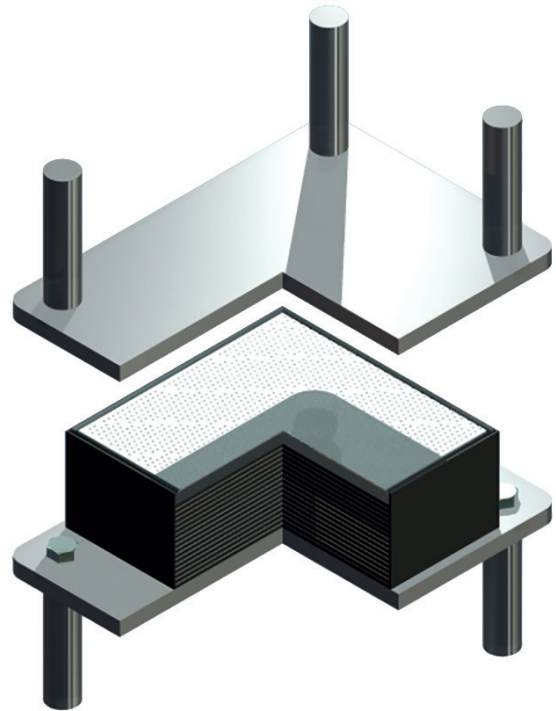
## TYPE E BEARINGS

Type E bearings are rubber bearings provided with PTFE sheets that present dimples adequately lubricated with silicone grease and in contact with an austenitic steel mirror polished surface. The displacement takes place thanks to the sliding between the two contact surfaces. This system drastically reduces the value of the friction coefficient and thus obtains larger displacements without excessive deformations of the rubber's pad. In order to avoid dirt contamination that could increase the friction and rapidly wear the PTFE, TENS's compound bearings are provided with a dust seal. Bearings are also equipped with a grading scale that allows a quick check on the structure's actual displacement during inspection.

The use of TENS RUBBER bearings type E is recommended in certain situations where displacements are important. This solution is more cost-effective and technically more adequate than the solution with movements by elastic rubber deformation.

This system allows the absorption of irreversible displacements (withdrawal, creep etc.) without deforming the rubber and moreover it allows to perform any post-tensioning operation minimizing the friction load losses.

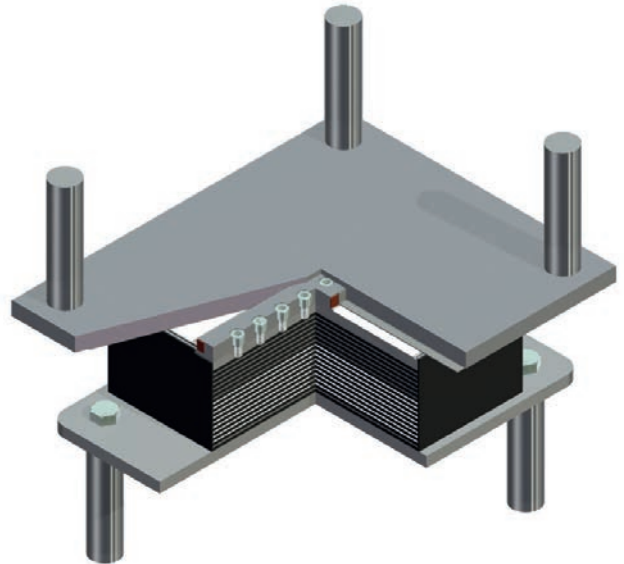
If the bearing must allow displacement in one direction only, in addition to the sliding plate covered with stainless steel in contact with PTFE, there is a central guide of steel. Alternatively, the same can take place by means of two welded guides, externally placed.



Type E bearing: solution that allows displacements in all directions

This system allows the rigid transfer of lateral actions between the upper structure and the rubber bearing (allowing it to continue deforming in said direction) or between the upper and lower structure in the only bound direction, and guarantees, at the same time, the necessary sliding capability in the free direction.

In order to also avoid the friction between the guide and the slide plate, the two vertical sides of the guide present a composite antifriction material (CM1). CM1 is made up of three layers: a bronze backing strip and a sintered interlocking porous matrix impregnated and overlaid with a PTFE/lead mixture. This material, according to the EN 1337-2 Standard, has a good mechanical resistance and a sufficiently low coefficient of friction in contact with stainless steel.

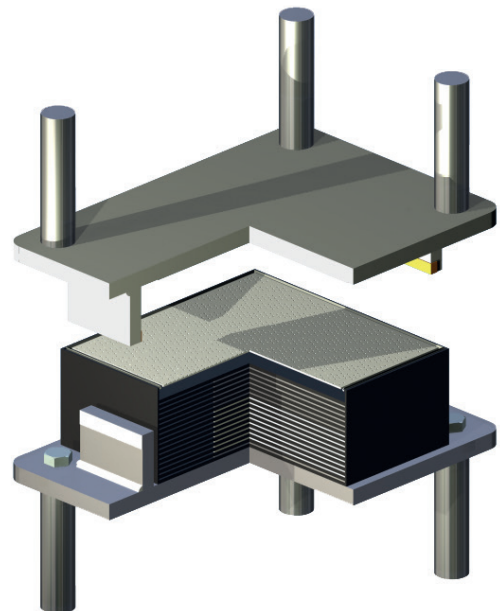


Type E bearing: solution that allows displacements in one direction only (central guide)

## TENS RUBBER FOR SPECIAL APPLICATIONS

TR bearings can be designed in order to meet multiple design and construction requirements and thus can be integrated with other elements, such as:

- a system of load cells and displacement transducers in order to estimate scale and variations of forces and displacements;
- a dielectric compound that protects the bearing from electro-erosion phenomena due to stray currents (i.e. electrified lines);
- a hydraulic or mechanical system in order to make vertical adjustments in case of differential settlements within the structure;
- additional elements to support both rare and frequent tensile loads, functioning at SLS or at ULS, that at the same time allow absorption of rotations imposed by the structure;
- additional elements that provide targeted performances during the construction/launch phase of the structure in order to have other performances in the operating phase. In this case, there can be guided or free bearings that become fixed in the operating phase or vice versa or many other combinations.



Type E bearing: solution that allows displacements in one direction only (lateral guides)



# MATERIALS

---

THE MATERIALS EMPLOYED FOR THE PRODUCTION OF CE MARKED TR BEARINGS REFER TO WHAT IS INDICATED BELOW AND TO EN 1337 STANDARD.

ELEMENT	MATERIAL	STANDARDS
Vulcanized steel plates	S235J2, S275J2 or S355J2 (as long as there is an elongation at break equal to S235)	EN 10025
Outer plates	S235J2, S275J2 or S355J2 (as long as there is an elongation at break equal to S235)	EN 10025
Elastomer	Natural Rubber NR Neoprene Compound CR	EN 1337-3
Stainless steel	Inox X2 or X5CrNiMo17/12	EN 10088
Sliding surfaces	PTFE	EN 1337-2
Lubricated grease	Silicone	EN 1337-2
Counter-plate, sliding plate, containment tile	S355J2 or S275J2	EN 10025

# MARKING

Each rubber bearing is identified with the acronym TR (TENS RUBBER). The numbers listed below represent plan dimensions and height of the device. Below is an example.

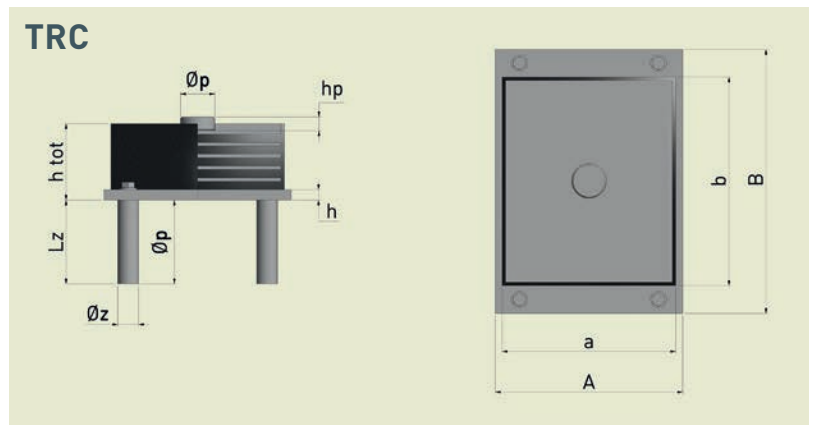
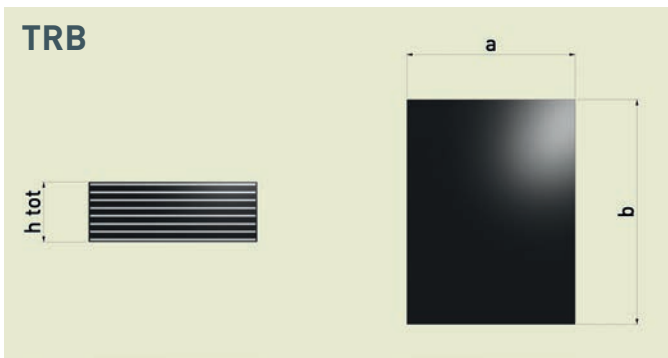
	Dimension
<b>TR</b>	<b>100X150X31</b>
TENS RUBBER	

# CATALOGUE PERFORMANCE HYPOTHESIS

Listed below are dimensional tables that refer to rubber bearings without anchorages (TR type B) and to rubber bearings with outer plates provided with lower dowels and upper pin (TR type C).

Bearing dimensions suggested here are the same as EN 1337-3.

For each plan dimension two different rubber heights have been considered in order to cover both low and high displacements. The design has been done by imposing the maximum shear deformation equal to the rubber's total height. Maximum values of vertical loads have been assumed by considering two different rotations about the transversal axis of the bearing (0.01 rad and 0.005 rad). Minimum values of vertical loads have been evaluated for rotations equal to 0.01 rad only.



# TR

## TENS RUBBER TYPE B

BEARING		GEOMETRY					
Name	Displacements Low/High	Dimensions a x b (mm)	Elastomer			Reinforcing plates t <sub>s</sub> (mm)	Height h <sub>tot</sub> (mm)
			t <sub>i</sub> (mm)	n°	T <sub>q</sub> (mm)		
TR 100 x 150 x 31	L	100 x 150	8	2	22	3	31
TR 100 x 150 x 42	H	100 x 150	8	3	30	3	42
TR 100 x 200 x 31	L	100 x 200	8	2	22	3	31
TR 100 x 200 x 42	H	100 x 200	8	3	30	3	42
TR 150 x 200 x 31	L	150 x 200	8	2	22	3	31
TR 150 x 200 x 53	H	150 x 200	8	4	38	3	53
TR 150 x 250 x 31	L	150 x 250	8	2	22	3	31
TR 150 x 250 x 53	H	150 x 250	8	4	38	3	53
TR 150 x 300 x 31	L	150 x 300	8	2	22	3	31
TR 150 x 300 x 53	H	150 x 300	8	4	38	3	53
TR 200 x 250 x 42	L	200 x 250	8	3	30	3	42
TR 200 x 250 x 75	H	200 x 250	8	6	54	3	75
TR 200 x 300 x 42	L	200 x 300	8	3	30	3	42
TR 200 x 300 x 75	H	200 x 300	8	6	54	3	75
TR 200 x 350 x 42	L	200 x 350	8	3	30	3	42
TR 200 x 350 x 75	H	200 x 350	8	6	54	3	75
TR 200 x 400 x 42	L	200 x 400	8	3	30	3	42
TR 200 x 400 x 75	H	200 x 400	8	6	54	3	75
TR 250 x 300 x 42	L	250 x 300	8	3	30	3	42
TR 250 x 300 x 86	H	250 x 300	8	7	62	3	86
TR 250 x 400 x 42	L	250 x 400	8	3	30	3	42
TR 250 x 400 x 86	H	250 x 400	8	7	62	3	86
TR 300 x 400 x 58	L	300 x 400	12	3	42	4	58
TR 300 x 400 x 106	H	300 x 400	12	6	78	4	106
TR 300 x 500 x 58	L	300 x 500	12	3	42	4	58
TR 300 x 500 x 106	H	300 x 500	12	6	78	4	106
TR 300 x 600 x 58	L	300 x 600	12	3	42	4	58
TR 300 x 600 x 106	H	300 x 600	12	6	78	4	106
TR 350 x 450 x 58	L	350 x 450	12	3	42	4	58
TR 350 x 450 x 122	H	350 x 450	12	7	90	4	122
TR 400 x 500 x 74	L	400 x 500	12	4	54	4	74
TR 400 x 500 x 138	H	400 x 500	12	8	102	4	138
TR 400 x 600 x 74	L	400 x 600	12	4	54	4	74
TR 400 x 600 x 138	H	400 x 600	12	8	102	4	138
TR 450 x 600 x 74	L	450 x 600	12	4	54	4	74
TR 450 x 600 x 154	H	450 x 600	12	9	114	4	154
TR 500 x 600 x 74	L	500 x 600	12	4	54	4	74
TR 500 x 600 x 170	H	500 x 600	12	10	126	4	170
TR 600 x 600 x 95	L	600 x 600	16	4	70	5	95
TR 600 x 600 x 200	H	600 x 600	16	9	150	5	200
TR 600 x 700 x 95	L	600 x 700	16	4	70	5	95
TR 600 x 700 x 200	H	600 x 700	16	9	150	5	200
TR 700 x 700 x 95	L	700 x 700	16	4	70	5	95
TR 700 x 700 x 221	H	700 x 700	16	10	166	5	221
TR 700 x 800 x 95	L	700 x 800	16	4	70	5	95
TR 700 x 800 x 221	H	700 x 800	16	10	166	5	221
TR 800 x 800 x 111	L	800 x 800	20	4	86	5	111
TR 800 x 800 x 261	H	800 x 800	20	10	206	5	261
TR 900 x 900 x 111	L	900 x 900	20	4	86	5	111
TR 900 x 900 x 286	H	900 x 900	20	11	226	5	286

BEARING		CHARACTERISTICS					
Name	Displacements Low/High	Horizontal stiffness $K_0$ [kN/mm]	Horizontal displacement $v_{y,d max}$ (mm)	Vertical load			Horizontal load $F_{y,d max}$ [kN]
				$F_{z,d max}$ ( $\alpha = 0.01$ ) [kN]	$F_{z,d max}$ ( $\alpha = 0.005$ ) [kN]	$F_{z,d min}$ [kN]	
TR 100 x 150 x 31	L	0,61	22	110	110	50	14
TR 100 x 150 x 42	H	0,45	30	60	60	60	14
TR 100 x 200 x 31	L	0,82	22	165	165	65	18
TR 100 x 200 x 42	H	0,60	30	95	95	80	18
TR 150 x 200 x 31	L	1,23	22	350	380	70	27
TR 150 x 200 x 53	H	0,71	38	255	255	100	27
TR 150 x 250 x 31	L	1,53	22	490	525	85	34
TR 150 x 250 x 53	H	0,89	38	355	355	120	34
TR 150 x 300 x 31	L	1,84	22	630	680	105	41
TR 150 x 300 x 53	H	1,07	38	455	455	140	41
TR 200 x 250 x 42	L	1,50	30	770	840	120	45
TR 200 x 250 x 75	H	0,83	54	510	510	160	45
TR 200 x 300 x 42	L	1,80	30	1010	1100	140	54
TR 200 x 300 x 75	H	1,00	54	670	670	190	54
TR 200 x 350 x 42	L	2,10	30	1255	1360	165	63
TR 200 x 350 x 75	H	1,17	54	835	835	215	63
TR 200 x 400 x 42	L	2,40	30	1510	1560	190	72
TR 200 x 400 x 75	H	1,33	54	1005	1005	245	72
TR 250 x 300 x 42	L	2,25	30	1345	1520	185	68
TR 250 x 300 x 86	H	1,09	62	1085	1085	215	68
TR 250 x 400 x 42	L	3,00	30	2045	2045	305	90
TR 250 x 400 x 86	H	1,45	62	1655	1655	280	90
TR 300 x 400 x 58	L	2,57	42	2020	2215	295	108
TR 300 x 400 x 106	H	1,38	78	1380	1380	340	108
TR 300 x 500 x 58	L	3,21	42	2780	3035	365	135
TR 300 x 500 x 106	H	1,73	78	1905	1905	420	135
TR 300 x 600 x 58	L	3,86	42	3575	3655	440	162
TR 300 x 600 x 106	H	2,08	78	2445	2445	495	162
TR 350 x 450 x 58	L	3,38	42	2930	3275	395	142
TR 350 x 450 x 122	H	1,58	90	2130	2130	430	142
TR 400 x 500 x 74	L	3,33	54	4115	4115	495	180
TR 400 x 500 x 138	H	1,76	102	3110	3110	530	180
TR 400 x 600 x 74	L	4,00	54	4955	4955	665	216
TR 400 x 600 x 138	H	2,12	102	4050	4050	635	216
TR 450 x 600 x 74	L	4,50	54	5690	5690	950	243
TR 450 x 600 x 154	H	2,13	114	4805	4805	700	243
TR 500 x 600 x 74	L	5,00	54	6430	6430	1295	270
TR 500 x 600 x 170	H	2,14	126	5365	5365	770	270
TR 600 x 600 x 95	L	4,63	70	7295	7670	1035	324
TR 600 x 600 x 200	H	2,16	150	5880	5880	905	324
TR 600 x 700 x 95	L	5,40	70	8970	8970	1365	378
TR 600 x 700 x 200	H	2,52	150	7415	7415	1050	378
TR 700 x 700 x 95	L	6,30	70	10170	10695	2130	441
TR 700 x 700 x 221	H	2,66	166	9035	9035	1160	441
TR 700 x 800 x 95	L	7,20	70	12245	12245	2700	504
TR 700 x 800 x 221	H	3,04	166	10345	10345	1315	504
TR 800 x 800 x 111	L	6,70	86	13340	13900	2220	576
TR 800 x 800 x 261	H	2,80	206	10795	10795	1610	576
TR 900 x 900 x 111	L	8,48	86	16835	17885	3840	729
TR 900 x 900 x 286	H	3,23	226	14770	14770	1975	729

# TR

## TENS RUBBER TYPE C

BEARING		GEOMETRY									
Name	Displacements Low/High	Dimensions a x b (mm)	Elastomer			Reinforcing plates t <sub>s</sub> (mm)	Bottom steel plate A x B x h (mm)	Height h <sub>tot</sub> (mm)	Bottom anchor dowels		
			t <sub>i</sub> (mm)	n°	T <sub>q</sub> (mm)				n°	Ø <sub>z</sub> (mm)	L <sub>z</sub> (mm)
TR 100 x 150 x 49	L	100 x 150	8	2	21	3	120 x 230 x 15	49	2	30	120
TR 100 x 150 x 60	H	100 x 150	8	3	29	3	120 x 230 x 15	60	2	30	120
TR 100 x 200 x 49	L	100 x 200	8	2	21	3	120 x 280 x 15	49	2	30	120
TR 100 x 200 x 60	H	100 x 200	8	3	29	3	120 x 280 x 15	60	2	30	120
TR 150 x 200 x 49	L	150 x 200	8	2	21	3	170 x 280 x 15	49	2	30	120
TR 150 x 200 x 71	H	150 x 200	8	4	37	3	170 x 280 x 15	71	2	30	120
TR 150 x 250 x 49	L	150 x 250	8	2	21	3	170 x 330 x 15	49	2	30	120
TR 150 x 250 x 71	H	150 x 250	8	4	37	3	170 x 330 x 15	71	2	30	120
TR 150 x 300 x 49	L	150 x 300	8	2	21	3	170 x 380 x 15	49	2	30	120
TR 150 x 300 x 71	H	150 x 300	8	4	37	3	170 x 380 x 15	71	2	30	120
TR 200 x 250 x 60	L	200 x 250	8	3	29	3	220 x 330 x 15	60	2	30	120
TR 200 x 250 x 93	H	200 x 250	8	6	53	3	220 x 330 x 15	93	2	30	120
TR 200 x 300 x 60	L	200 x 300	8	3	29	3	220 x 380 x 15	60	2	30	120
TR 200 x 300 x 93	H	200 x 300	8	6	53	3	220 x 380 x 15	93	2	30	120
TR 200 x 350 x 60	L	200 x 350	8	3	29	3	220 x 430 x 15	60	2	30	120
TR 200 x 350 x 93	H	200 x 350	8	6	53	3	220 x 430 x 15	93	2	30	120
TR 200 x 400 x 60	L	200 x 400	8	3	29	3	220 x 500 x 15	60	2	30	120
TR 200 x 400 x 93	H	200 x 400	8	6	53	3	220 x 500 x 15	93	2	30	120
TR 250 x 300 x 60	L	250 x 300	8	3	29	3	270 x 380 x 15	60	2	30	120
TR 250 x 300 x 104	H	250 x 300	8	7	61	3	270 x 380 x 15	104	2	30	120
TR 250 x 400 x 60	L	250 x 400	8	3	29	3	270 x 500 x 15	60	2	30	120
TR 250 x 400 x 104	H	250 x 400	8	7	61	3	270 x 500 x 15	104	2	30	120
TR 300 x 400 x 74	L	300 x 400	12	3	41	4	320 x 500 x 15	74	2	30	120
TR 300 x 400 x 122	H	300 x 400	12	6	77	4	320 x 500 x 15	122	2	30	120
TR 300 x 500 x 74	L	300 x 500	12	3	41	4	320 x 620 x 15	74	2	40	160
TR 300 x 500 x 122	H	300 x 500	12	6	77	4	320 x 620 x 15	122	2	40	160
TR 300 x 600 x 74	L	300 x 600	12	3	41	4	320 x 720 x 15	74	2	40	160
TR 300 x 600 x 122	H	300 x 600	12	6	77	4	320 x 720 x 15	122	2	40	160
TR 350 x 450 x 74	L	350 x 450	12	3	41	4	370 x 570 x 15	74	2	40	160
TR 350 x 450 x 138	H	350 x 450	12	7	89	4	370 x 570 x 15	138	2	40	160
TR 400 x 500 x 90	L	400 x 500	12	4	53	4	420 x 620 x 15	90	2	40	160
TR 400 x 500 x 154	H	400 x 500	12	8	101	4	420 x 620 x 15	154	2	40	160
TR 400 x 600 x 90	L	400 x 600	12	4	53	4	420 x 700 x 15	90	4	30	120
TR 400 x 600 x 154	H	400 x 600	12	8	101	4	420 x 700 x 15	154	4	30	120
TR 450 x 600 x 100	L	450 x 600	12	4	53	4	470 x 700 x 20	100	4	30	120
TR 450 x 600 x 180	H	450 x 600	12	9	113	4	470 x 700 x 20	180	4	30	120
TR 500 x 600 x 100	L	500 x 600	12	4	53	4	520 x 720 x 20	100	4	40	160
TR 500 x 600 x 196	H	500 x 600	12	10	125	4	520 x 720 x 20	196	4	40	160
TR 600 x 600 x 119	L	600 x 600	16	4	69	5	620 x 720 x 20	119	4	40	160
TR 600 x 600 x 224	H	600 x 600	16	9	149	5	620 x 720 x 20	224	4	40	160
TR 600 x 700 x 119	L	600 x 700	16	4	69	5	620 x 820 x 20	119	4	40	160
TR 600 x 700 x 224	H	600 x 700	16	9	149	5	620 x 820 x 20	224	4	40	160
TR 700 x 700 x 129	L	700 x 700	16	4	69	5	720 x 850 x 25	129	4	50	200
TR 700 x 700 x 255	H	700 x 700	16	10	165	5	720 x 850 x 25	255	4	50	200
TR 700 x 800 x 129	L	700 x 800	16	4	69	5	720 x 950 x 25	129	4	50	200
TR 700 x 800 x 255	H	700 x 800	16	10	165	5	720 x 950 x 25	255	4	50	200
TR 800 x 800 x 148	L	800 x 800	20	4	85	5	820 x 970 x 25	148	4	50	200
TR 800 x 800 x 304	H	800 x 800	20	10	205	5	820 x 970 x 25	304	4	50	200
TR 900 x 900 x 148	L	900 x 900	20	4	85	5	920 x 1070 x 25	148	4	50	200
TR 900 x 900 x 330	H	900 x 900	20	11	225	5	920 x 1070 x 25	330	4	50	200

BEARING		CHARACTERISTICS							
Name	Displacements	Top anchor pin		Horizontal stiffness $K_o$ [kN/mm]	Horizontal displacement $v_{y,d \max}$ (mm)	Vertical load			Horizontal load $F_{y,d \max}$ [kN]
	Low/High	$\emptyset_p$ (mm)	$h_p$ (mm)			$F_{z,d \max}$ ( $\alpha = 0.01$ ) [kN]	$F_{z,d \max}$ ( $\alpha = 0.005$ ) [kN]	$F_{z,d \min}$ [kN]	
TR 100 x 150 x 49	L	20	30	0,64	21	110	110	50	14
TR 100 x 150 x 60	H	20	30	0,47	29	65	65	60	14
TR 100 x 200 x 49	L	20	30	0,86	21	165	165	65	18
TR 100 x 200 x 60	H	20	30	0,62	29	95	95	80	18
TR 150 x 200 x 49	L	30	30	1,29	21	355	380	70	27
TR 150 x 200 x 71	H	30	30	0,73	37	255	255	95	27
TR 150 x 250 x 49	L	30	30	1,61	21	495	530	90	34
TR 150 x 250 x 71	H	30	30	0,91	37	355	355	120	34
TR 150 x 300 x 49	L	30	30	1,93	21	635	685	105	41
TR 150 x 300 x 71	H	30	30	1,09	37	460	460	140	41
TR 200 x 250 x 60	L	40	30	1,55	29	775	845	120	45
TR 200 x 250 x 93	H	40	30	0,85	53	515	515	155	45
TR 200 x 300 x 60	L	40	30	1,86	29	1015	1110	145	54
TR 200 x 300 x 93	H	40	30	1,02	53	675	675	185	54
TR 200 x 350 x 60	L	40	30	2,17	29	1265	1365	165	63
TR 200 x 350 x 93	H	40	30	1,19	53	840	840	215	63
TR 200 x 400 x 60	L	40	30	2,48	29	1520	1565	190	72
TR 200 x 400 x 93	H	40	30	1,36	53	1010	1010	240	72
TR 250 x 300 x 60	L	50	30	2,33	29	1355	1525	185	68
TR 250 x 300 x 104	H	50	30	1,11	61	1095	1095	210	68
TR 250 x 400 x 60	L	50	30	3,10	29	2055	2055	305	90
TR 250 x 400 x 104	H	50	30	1,48	61	1665	1665	275	90
TR 300 x 400 x 74	L	60	30	2,63	41	2025	2225	295	108
TR 300 x 400 x 122	H	60	30	1,40	77	1390	1390	335	108
TR 300 x 500 x 74	L	60	30	3,29	41	2790	3050	370	135
TR 300 x 500 x 122	H	60	30	1,75	77	1910	1910	415	135
TR 300 x 600 x 74	L	60	30	3,95	41	3585	3670	445	162
TR 300 x 600 x 122	H	60	30	2,10	77	2460	2460	490	162
TR 350 x 450 x 74	L	70	30	3,46	41	2940	3285	395	142
TR 350 x 450 x 138	H	70	30	1,59	89	2140	2140	425	142
TR 400 x 500 x 90	L	80	30	3,40	53	4125	4125	500	180
TR 400 x 500 x 154	H	80	30	1,78	101	3120	3120	530	180
TR 400 x 600 x 90	L	80	30	4,08	53	4970	4970	665	216
TR 400 x 600 x 154	H	80	30	2,14	101	4065	4065	630	216
TR 450 x 600 x 100	L	90	40	4,58	53	5705	5705	950	243
TR 450 x 600 x 180	H	90	40	2,15	113	4820	4820	695	243
TR 500 x 600 x 100	L	100	40	5,09	53	6445	6445	1295	270
TR 500 x 600 x 196	H	100	40	2,16	125	5380	5380	765	270
TR 600 x 600 x 119	L	120	40	4,70	69	7310	7680	1035	324
TR 600 x 600 x 224	H	120	40	2,17	149	5895	5895	900	324
TR 600 x 700 x 119	L	120	40	5,48	69	8985	8985	1365	378
TR 600 x 700 x 224	H	120	40	2,54	149	7430	7430	1045	378
TR 700 x 700 x 129	L	140	50	6,39	69	10185	10710	2130	441
TR 700 x 700 x 255	H	140	50	2,67	165	9055	9055	1150	441
TR 700 x 800 x 129	L	140	50	7,30	69	12260	12260	2700	504
TR 700 x 800 x 255	H	140	50	3,05	165	10365	10365	1310	504
TR 800 x 800 x 148	L	160	50	6,78	85	13360	13920	2220	576
TR 800 x 800 x 304	H	160	50	2,81	205	10815	10815	1605	576
TR 900 x 900 x 148	L	180	50	8,58	85	16855	17910	3840	729
TR 900 x 900 x 330	H	180	50	3,24	225	14795	14795	1965	729

Footbridge for Expo 2015, Milan (Italy)



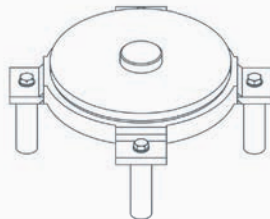
---

# 04

---

## TENS POT BEARINGS (TP)

TENS POT bearings can adapt to most structures,  
by supporting high loads while  
allowing rotations and displacements





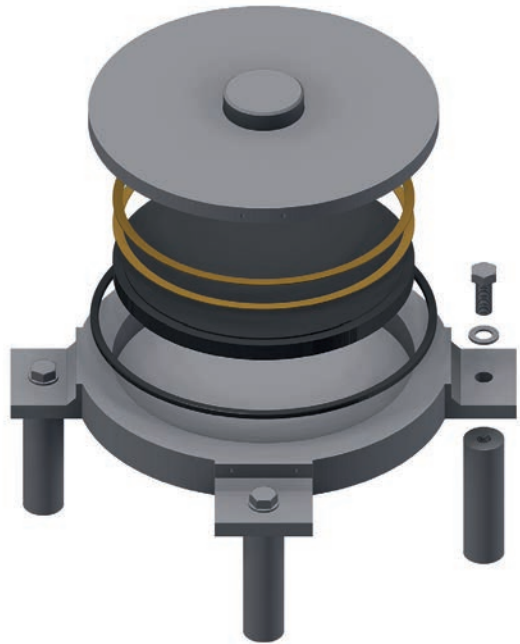
# DESCRIPTION

This chapter refers to TENS POT bearings (TP). TENS POT bearings are able to transfer vertical and lateral loads between the structure and the substructure.

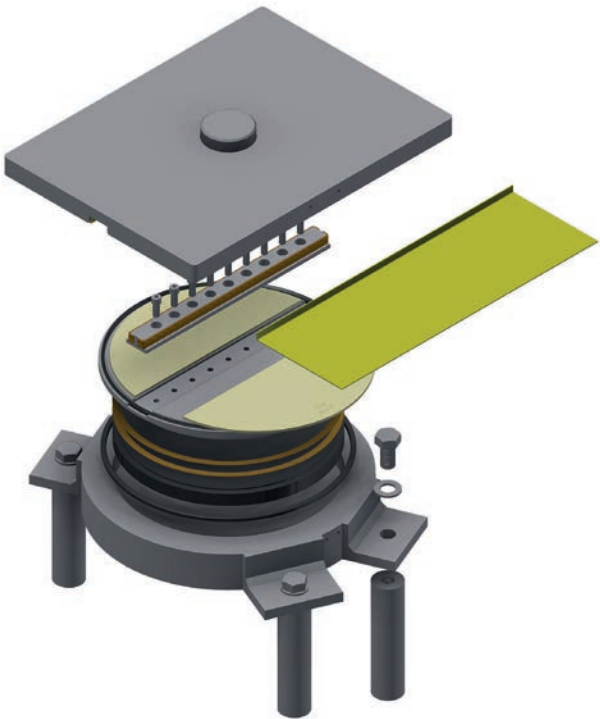
The TENS POT bearing (TP) is mainly made of a steel base-ment known as “pot”, within which an unreinforced elastomeric pad is inserted. A cylindrical steel piston is positioned in contact with the rubber’s upper surface and laterally with the basement. The vertical load thus moves from the piston to the basement through the rubber, whereas the lateral actions move stiffly because of the contact between the piston and the pot. In order to avoid the possible extrusion of the rubber, caused by the pressure induced by the piston, it is necessary to insert an adequate seal and position it in the contact perimeter between piston and basement.

In this configuration the elastomer pad is completely confined and subject to a state of triaxial stress. The elastomer thus offers a reduced resistance to deformation by rotation (limited restraint moment) and at the same time a high vertical stiffness. Such behavior allows the rotation of the piston and consequently the rotation of the superstructure linked to it about any horizontal axis, maintaining a high vertical lift.

In the case of free and guided bearings, the sliding (in one or both directions) occurs through contact between an austenitic steel mirror polished surface and a dimpled PTFE liner that can host silicon grease. PTFE’s fundamental characteristic is wear resistance measured through the total accumulated slide path (total displacement during the life of the bearing due to withdrawal, creep, thermal effects, earthquakes, load displacements etc.). For example, considering the European Standard EN 1337-2, the accumulated path of the PTFE must not be less than 10000 m or 1000 m respectively, for bridges and other structures (such as buildings, tanks etc.).



TPF bearing exploded view



TPL/TPT bearings exploded view

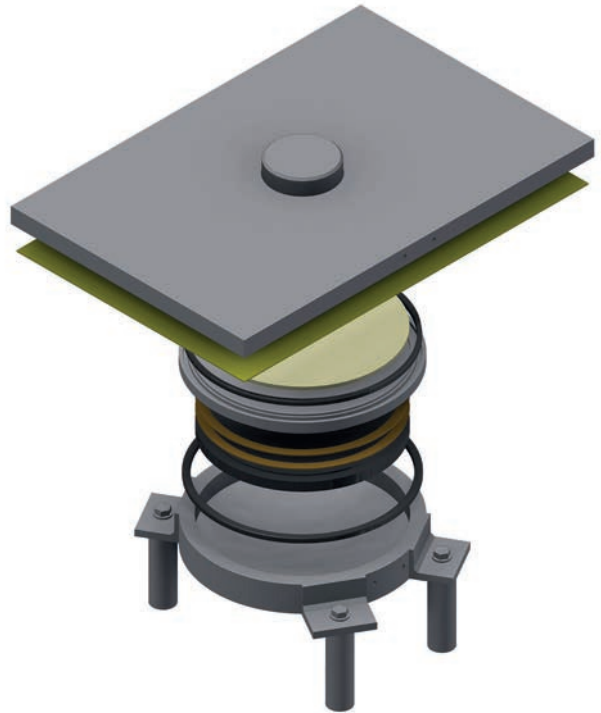
Depending on the type of work and the design specifications, the bearing's anchorage can be normally made in the following ways:

- dowels and screws (typical for cast in situ concrete structures);
- pin (typical for steel and/or prefabricated superstructures in which masonry plates must be provided in order to host the pin);
- screws (typical for steel or prefabricated concrete structures, in case there is a linking plate provided with threaded holes and preventively grouted in the structure);
- bonding/friction (any type of structure).

Any additional steel plates can be used between the bearing and the structure, in order to facilitate installation and possible future substitutions.

TP bearing presents the following advantages:

- competitive prices compared to other types of bearings;
- good ability to absorb vibrations conveyed by the connected structural components;
- stability;
- easy installation/substitution;
- durability;
- high durability of the rubber, completely protected from contact with atmospheric agents;
- high resistance to fatigue and to the application of dynamic loads, which makes it suitable for railway structures as well;
- support of very high vertical loads with negligible vertical deformations;
- allowance of rotations about any horizontal axis with minimal restraint reactions.



TPM bearing exploded view

# CLASSIFICATION AND COMPONENTS

---

TENS POT (TP) bearings can be divided into three types, with reference to imposed constraints:

## FIXED POT BEARING (TPF)

TPF bearings represent the basic solution, being fundamentally constituted by:

- **pot:** obtained through turning from a thick metal sheet where the rubber finds its place;
- **rubber:** obtained through hot pressing, it constitutes the bearing's spherical hinge that allows rotations about any horizontal axis;
- **internal seal:** the rubber's containment is guaranteed by a brass seal (2-3 rings);
- **piston:** it pressurizes the rubber and is obtained through turning from a metal sheet of adequate thickness;
- **dust seal:** it is comprised of a rubber ring inserted between the piston and the pot.

Displacements on the horizontal plane are not permitted, whereas any rotation is allowed. Lateral forces are transmitted by means of contact between the piston and the pot.

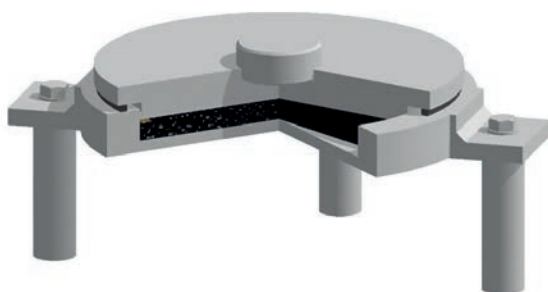
## FREE SLIDING POT BEARING (TPM)

TPM bearings, like TPF bearings, are able to transfer vertical loads while allowing rotations. Moreover, TPM allow displacements in all directions, providing a limited resistance proportional to the normal acting load and to the friction due to the sliding.

On the piston's upper part there is a cavity containing a PTFE liner protruding a few mm from it. A sliding plate is positioned in contact with it. On the lower side of the sliding plate, there is an austenitic stainless steel surface connected by means of a TIG welding. The sliding interface between dimpled PTFE and stainless steel is adequately lubricated by means of silicone grease. Friction is thus considerably reduced.

In order to avoid dirt contamination that could cause a friction increase and accelerated PTFE deterioration, TENS A's bearings are provided with a rubber dust seal positioned alongside the PTFE surfaces. Bearings are also provided with displacement indicators that allow a rapid control of the service movements during periodical inspections.

Fixed TENS POT bearing TPF



Free sliding TENS POT bearing TPM



## GUIDED SLIDING BEARING (TPL/TPT)

The TPL and TPT (guided longitudinal and transversal), just like multidirectional bearings, are able to transfer vertical loads while allowing rotations. They allow movements in one direction, but they are able to transmit lateral loads in the perpendicular direction.

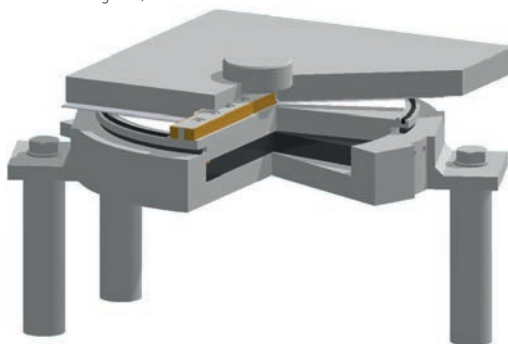
They are similar to free sliding pot bearings, with an additional central cavity in the piston that has the purpose of hosting a directional guide. This guide is composed of a steel element, partially built into the piston and linked to it through high strength screws. The guide has a sheet of anti-friction material (CM1) on its two vertical sides. The directional guide is placed in the central part of the sliding plate. The part of the plate in contact with the CM1 is coated with stainless steel in order to guarantee a contact with a low coefficient of friction in the direction of the displacement. In the case of sizeable lateral loads, the central guide can be replaced by two external guides.

In order to avoid dirt contamination that could cause a friction increase and accelerated PTFE deterioration, TENSA's bearings are provided with a rubber dust seal positioned alongside the PTFE surfaces. Bearings are also provided with displacement indicators that allow a rapid control of the service movements during the periodical inspections.

## TENS POT FOR SPECIAL APPLICATIONS

TP bearings can be designed to meet multiple design and/or construction needs and thus can be integrated with other elements, such as:

Guided sliding TENS POT bearing TPL/TPT

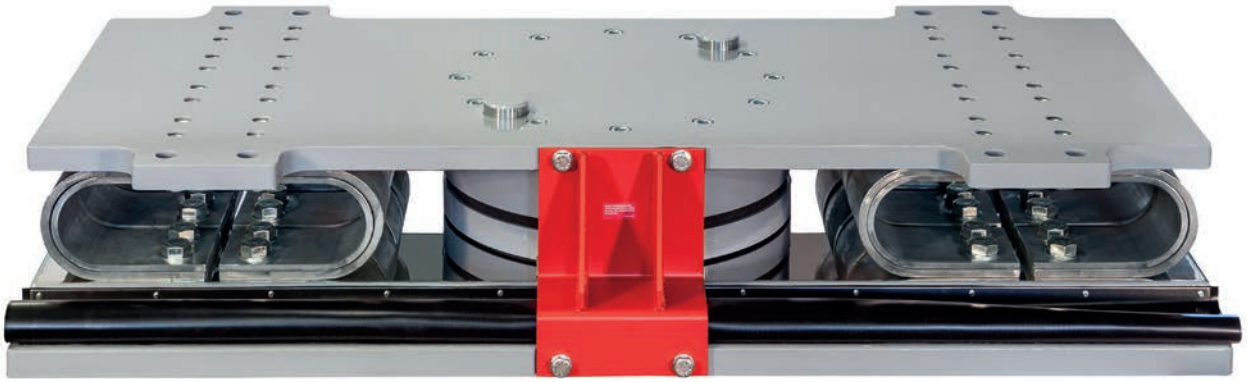


- a system of load cells and displacement transducers in order to estimate the size and variations of loads and movements;
- additional elements that make the bearing electrically insulated and thus not subject to electro-erosion phenomena caused by stray currents (e.g. electrified lines);
- a hydraulic or mechanical system in order to make vertical adjustments in case of differential settlements within the structure;
- additional elements to support both rare and frequent tensile loads, functioning at SLS or at ULS, that simultaneously allow absorption of the rotations imposed by the structure;
- additional elements that provide targeted performances during the construction/launch phase of the structure in order to guarantee other performances in the operating phase. In this case there can be guided or free sliding bearings that become fixed in the operating phase or vice versa or many other combinations;
- antiseismic devices that act only during the seismic phase. In particular:

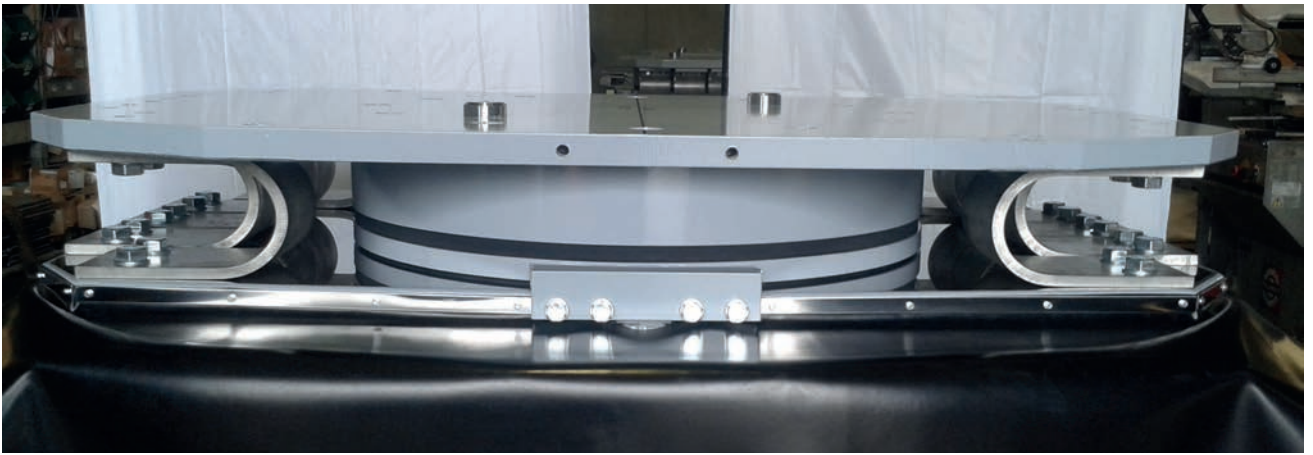
- 1) Displacements interruption and transfer of the seismic force developed in a pseudo rigid manner: this can be obtained by providing the bearings with seismic shock absorbers (Tens Shock Transmitter Device) that temporarily transform the sliding bearing into a pseudo rigid link. In the case of slow movements they provide a minimal reaction that lets the structure expand and contract freely.



TP integrated with shock absorber (TSTD) and hysteretic steel device (TEPD)



TP integrated with hysteretic device in transversal direction (TEPD)



TP integrated with hysteretic device in transversal direction (TEPD)

2) Energy dissipation: this can be obtained by linking thermal fluid viscous dampers TFVD (Tens Fluid Viscous Damper) to the bearing or hysteretic steel device TEPD (Tens Elasto-Plastic Device) with or without the shock absorber (see previous point). The union in a single device that can resist gravity loads, absorb structural rotations, guarantee adequate behavior under earthquakes and dissipate energy, means that we can refer to it as a combination of devices and not only as a simple bearing.



TP integrated with hysteretic device in transversal direction (TEPD)

3) Free sliding bearings can also be used in parallel with TDRI and TLRI isolators in order to minimize the isolation system costs, but especially to exploit their “null horizontal stiffness” characteristic. With an adequate positioning of the free sliding bearings and isolators, it’s possible to reach a good approximation to the coincidence of the center of mass with the center of stiffness. Consequently, during the seismic phase, the torsional effects on the structure are reduced.



TP integrated with hysteretic device in both direction (TEPD)

# MATERIALS

---

THE MATERIALS EMPLOYED FOR THE PRODUCTION OF CE MARKED TP BEARINGS REFER TO WHAT IS INDICATED BELOW AND TO THE EN 1337 STANDARD.

ELEMENT	MATERIAL	STANDARDS
Piston, pot, sliding plates, directional guide	S355J2 or S275J2	EN 10025
Rubber pad	Natural rubber (50 shore)	ISO 6446
Inner seal with rings (brass)	CuZn37 or CuZn39Pb3	EN 12163 and EN 12164
Sliding surfaces	Inox X2 or X5CrNiMo17/12	EN 10088
Sliding surfaces	PTFE / TENSA Slide	EN 1337-2 / ETA
CM1	Composite material consisting of three layers: a bronze backing strip and a sintered interlocking porous matrix, impregnated and overlaid with a PTFE/lead mixture	EN 1337-2
Lubricating grease	Silicone	EN 1337-2 EN 1337-5
Anchor dowels	39NiCrMo3 or S355JR	EN 10083 or EN 10025
Screws	Cl 8.8 /10.9/12.9	EN 20898

# MARKING



Each POT bearing is identified with the acronym TP (TENS POT). The numbers shown here represent the kN loads and/or displacements in mm at ULS. Below are examples of the three types.

	Fixed bearing		Horizontal load (kN)
<b>TP</b>	<b>F</b>	<b>1000</b> /	<b>100</b>
TENS POT		Vertical load (kN)	

	Guided sliding bearing		Horizontal load (kN)	
<b>TP</b>	<b>U</b>	<b>1000</b> /	<b>100</b> /	<b>± 50</b>
TENS POT		Vertical load (kN)		Displacement (mm)

	Free sliding bearing		Longitudinal displacement (mm)	
<b>TP</b>	<b>M</b>	<b>1000</b> /	<b>± 50</b> /	<b>± 25</b>
TENS POT		Vertical load (kN)		Trasversal displacement (mm)

# CATALOGUE PERFORMANCE HYPOTHESIS

The TP bearings catalogue is according to EN 1337, parts 1, 2 and 5.

The expected maximum vertical load, at ULS, is equal to 90000 kN.

Bearing devices with greater vertical load can be designed on specific request.

## TEMPERATURE, UPPER AND LOWER SUPPORTS

For the bearings design we have considered the following criteria:

- Upper steel support
- Lower concrete support Resistance Class C37/45
- Temperature between -5 °C and +30 °C

In order to calculate the contact pressures of both the lower and upper supports, in the case of concrete, one has to refer to the value of EN 1992-1 for localized pressures, quoted in chapter 6.7.

$$\sigma_{Rdu} = f_{cd} \sqrt{\frac{A_{c1}}{A_{c0}}} \leq 3.0 \cdot f_{cd}$$

Assuming a maximum value of the ratio between the areas equal to 2:

$$M_{distr} = \sqrt{\frac{A_{c1}}{A_{c0}}} = 2$$

## DESIGN DISPLACEMENTS

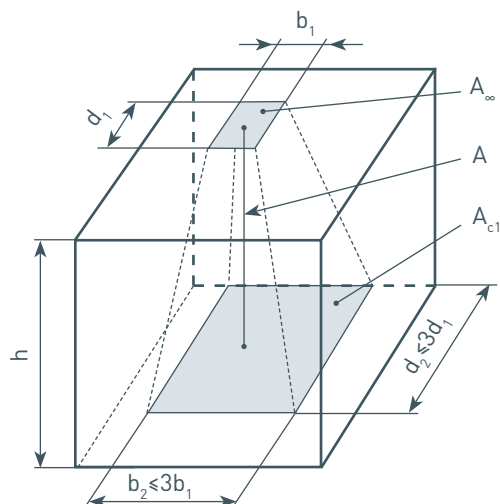
The EN 1337-1 Standard prescribes to adopt minimum displacements in longitudinal and transverse directions, respectively  $\pm 50$  mm and  $\pm 20$  mm and to increase design displacements of  $\pm 20$  mm for non-anchored bearings.

In this chapter the following minimum displacements are assumed:

- Longitudinal displacement =  $\pm 50$  mm
- Transversal displacement =  $\pm 20$  mm

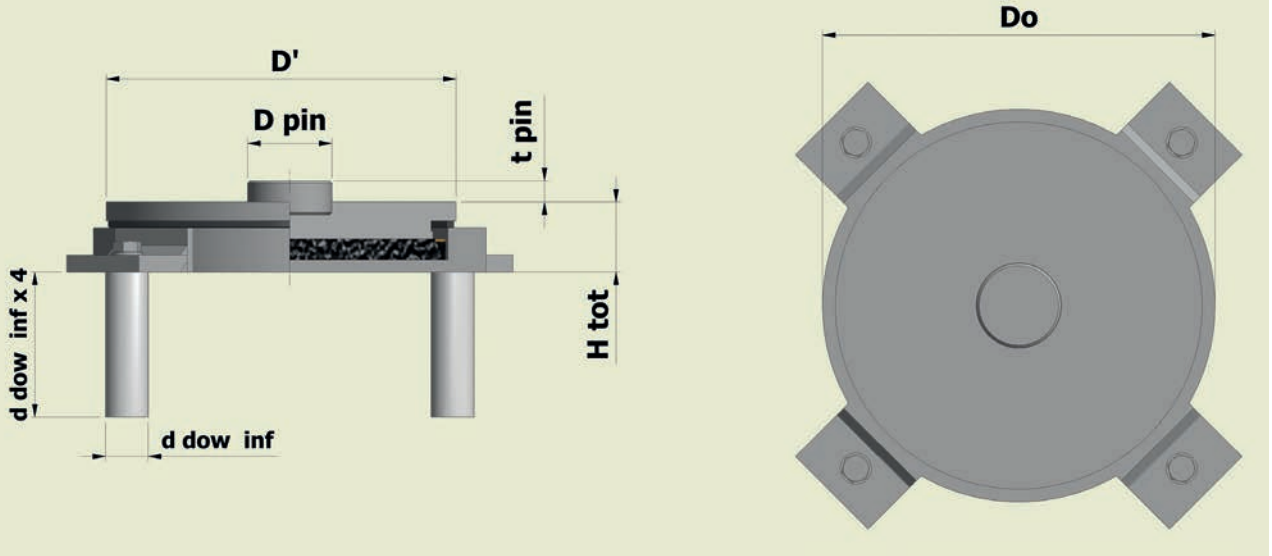
For rotations the following values are assumed:

- Rotation due to dead load  $\alpha_1 = 0.007$  rad
- Rotation due to live loads  $\alpha_2 = 0.003$  rad
- Maximum design rotation  $\alpha_{tot} = 0.010$  rad





## TPF



## DESIGN LOADS

Bearings shall be designed with reference to the following load combinations:

- ULS (for static loads)
- ULS (for seismic design situation)
- SLS

In particular:

$N_{Ed-ULS}$  = Maximum vertical load at ULS

$V_{Ed-ULS}$  = Maximum lateral load in presence of  $N_{Ed-ULS}$

$N_{Ed-Sism}$  = Vertical load in presence of  $V_{Ed-Sism}$

$V_{Ed-Sism}$  = Maximum lateral load at ULS in seismic design situation

$N_{Ed-SLS}$  = Vertical load at SLS

$V_{Ed-SLS}$  = Maximum Lateral Load at SLS in presence of  $N_{Ed-SLS}$

Further assumptions for the design of bearings proposed in the next paragraph's sheets:

$$N_{Ed-SLS} = N_{Ed-ULS} / 1.40$$

$$N_{Ed-Sism} = N_{Ed-ULS} / 1.50$$

$$V_{Ed-ULS} = V_{Ed-Sism} \times 0.50$$

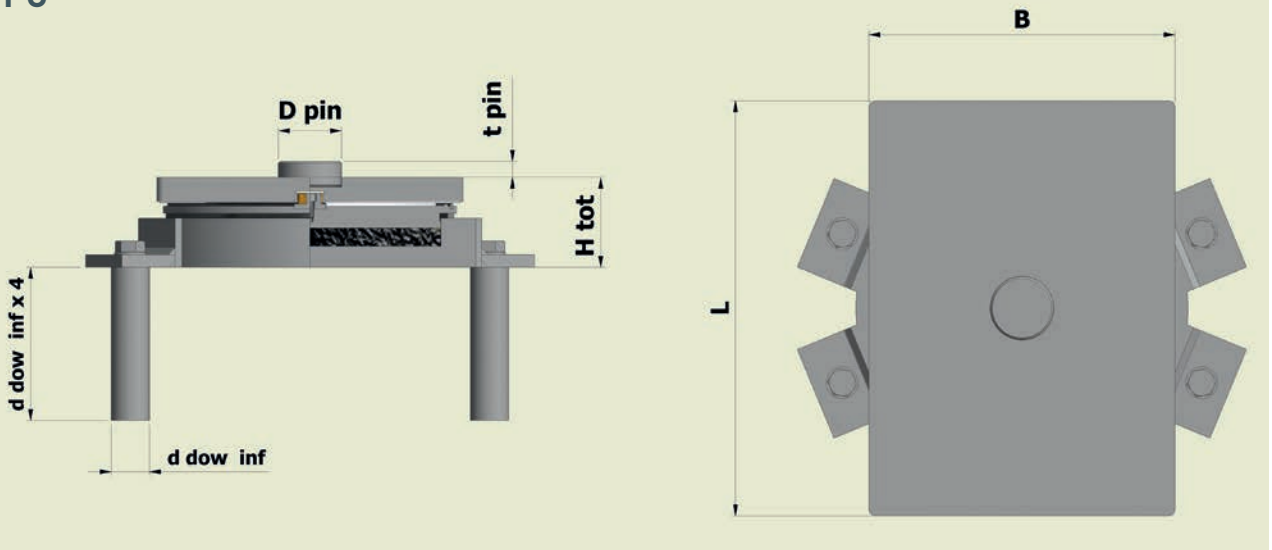
$$V_{Ed-SLS} = V_{Ed-ULS} / 1.50$$

## ANCHORAGE SYSTEMS

This section shows bearings with the following characteristics:

- Upper anchorage with pin on steel plate
  - Lower anchorage with anchor dowels for fixed and guided bearings and embedded with resin for free sliding bearings.
- Other types of anchorage can be considered.

## TPU



# TPF NORMAL

## FIXED TENS POT BEARINGS $V_{Sd-SEISM}/N_{Sd-SLU}=10\%$

BEARING	SEISMIC COMBINATION ULS		STATIC COMBINATION ULS		STATIC COMBINATION SLS		OVERALL SIZE	NET WEIGHT (ANCHORAGES EXCLUDED)	POT DIAMETER	PISTON DIAMETER	PIN DIAMETER	PIN PROTRUSION	BOTTOM ANCHOR DOWELS	
	$N_{Sd-Seism}$ (kN)	$V_{Sd-Seism}$ (kN)	$N_{Sd-SLU}$ (kN)	$V_{Sd-SLU}$ (kN)	$N_{Sd-SLE}$ (kN)	$V_{Sd-SLE}$ (kN)								Do x Do x Htot (mm)
TPF 500/50	340	50	500	25	360	20	175 x 175 x 50	10	175	170	20	15	2	30
TPF 1000/100	670	100	1000	50	720	40	235 x 235 x 50	16	235	230	20	15	2	30
TPF 1500/150	1000	150	1500	75	1080	50	255 x 255 x 59	23	255	250	30	15	4	30
TPF 2000/200	1340	200	2000	100	1430	70	305 x 305 x 59	30	305	300	30	15	4	30
TPF 2500/250	1670	250	2500	125	1790	90	315 x 315 x 64	35	315	310	40	15	4	30
TPF 3000/300	2000	300	3000	150	2150	100	340 x 340 x 64	40	340	330	40	15	4	30
TPF 3500/350	2340	350	3500	175	2500	120	375 x 375 x 69	51	375	360	40	15	4	30
TPF 4000/400	2670	400	4000	200	2860	140	395 x 395 x 73	61	395	375	40	16	4	40
TPF 4500/450	3000	450	4500	225	3220	150	420 x 420 x 72	67	420	400	50	15	4	40
TPF 5000/500	3340	500	5000	250	3580	170	445 x 445 x 82	84	445	420	50	16	4	40
TPF 6000/600	4000	600	6000	300	4290	200	480 x 480 x 90	111	480	450	50	18	4	50
TPF 7000/700	4670	700	7000	350	5000	240	515 x 515 x 94	128	515	480	60	18	4	50
TPF 8000/800	5340	800	8000	400	5720	270	555 x 555 x 93	147	555	510	60	20	4	50
TPF 9000/900	6000	900	9000	450	6430	300	595 x 595 x 107	202	595	545	70	19	4	60
TPF 10000/1000	6670	1000	10000	500	7150	340	630 x 630 x 107	221	630	570	70	21	4	60
TPF 11000/1100	7340	1100	11000	550	7860	370	655 x 655 x 111	245	655	595	70	22	4	60
TPF 12000/1200	8000	1200	12000	600	8580	400	685 x 685 x 130	318	685	620	70	24	4	60
TPF 13000/1300	8670	1300	13000	650	9290	440	710 x 710 x 119	300	710	640	80	23	4	60
TPF 14000/1400	9340	1400	14000	700	10000	470	755 x 755 x 133	393	755	680	80	24	4	70
TPF 15000/1500	10000	1500	15000	750	10720	500	770 x 770 x 133	406	770	690	80	25	4	70
TPF 16000/1600	10670	1600	16000	800	11430	540	790 x 790 x 132	421	790	705	90	24	4	70
TPF 17000/1700	11340	1700	17000	850	12150	570	820 x 820 x 140	476	820	730	90	26	4	70
TPF 18000/1800	12000	1800	18000	900	12860	600	850 x 850 x 140	528	850	755	90	27	4	90
TPF 19000/1900	12670	1900	19000	950	13580	640	870 x 870 x 149	591	870	770	90	28	4	90
TPF 20000/2000	13340	2000	20000	1000	14290	670	890 x 890 x 148	601	890	790	90	29	4	90
TPF 22500/2100	15000	2100	22500	1050	16080	700	985 x 985 x 158	772	985	880	100	28	4	90
TPF 25000/2200	16670	2200	25000	1100	17860	740	990 x 990 x 177	883	990	880	100	29	4	90
TPF 27500/2300	18340	2300	27500	1150	19650	770	1035 x 1035 x 167	882	1035	920	100	30	4	90
TPF 30000/2400	20000	2400	30000	1200	21430	800	1070 x 1070 x 176	991	1070	950	100	31	4	90
TPF 32500/2500	21670	2500	32500	1250	23220	840	1115 x 1115 x 176	1063	1115	990	110	30	4	90
TPF 35000/2600	23340	2600	35000	1300	25000	870	1210 x 1210 x 185	1292	1210	1090	110	31	4	90
TPF 37500/2700	25000	2700	37500	1350	26790	900	1220 x 1220 x 185	1313	1220	1090	110	32	4	90
TPF 40000/2800	26670	2800	40000	1400	28580	940	1275 x 1275 x 195	1505	1275	1140	110	33	4	90
TPF 45000/3200	30000	3200	45000	1600	32150	1070	1340 x 1340 x 203	1731	1340	1190	120	34	4	100
TPF 50000/3500	33340	3500	50000	1750	35720	1170	1385 x 1385 x 223	2067	1385	1240	130	34	4	100
TPF 55000/3900	36670	3900	55000	1950	39290	1300	1450 x 1450 x 223	2234	1450	1290	130	37	4	100
TPF 60000/4200	40000	4200	60000	2100	42860	1400	1505 x 1505 x 230	2485	1505	1340	140	37	4	100
TPF 65000/4600	43340	4600	65000	2300	46430	1540	1570 x 1570 x 249	2956	1570	1390	140	42	8	90
TPF 70000/4900	46670	4900	70000	2450	50000	1640	1625 x 1625 x 248	3110	1625	1440	150	42	8	90
TPF 75000/5300	50000	5300	75000	2650	53580	1770	1685 x 1685 x 256	3456	1685	1490	160	42	8	90
TPF 80000/5600	53340	5600	80000	2800	57150	1870	1745 x 1745 x 257	3679	1745	1540	160	44	8	90
TPF 90000/6300	60000	6300	90000	3150	64290	2100	1860 x 1860 x 279	4592	1860	1640	180	44	8	100

# TPF HIGH

## FIXED TENS POT BEARINGS $V_{Sd-SEISM}/N_{Sd-SLU}=30\%$

BEARING	SEISMIC COMBINATION ULS		STATIC COMBINATION ULS		STATIC COMBINATION SLS		OVERALL SIZE	NET WEIGHT (ANCHORAGES EXCLUDED)	POT DIAMETER	PISTON DIAMETER	PIN DIAMETER	PIN PROTRUSION	BOTTOM ANCHOR DOWELS	
	$N_{Sd-SEISM}$ (kN)	$V_{Sd-SEISM}$ (kN)	$N_{Sd-SLU}$ (kN)	$V_{Sd-SLU}$ (kN)	$N_{Sd-SLE}$ (kN)	$V_{Sd-SLE}$ (kN)								Do x Do x Htot (mm)
TPF 500/150	340	150	500	75	360	50	175 x 175 x 49	11	175	170	30	15	4	30
TPF 1000/300	670	300	1000	150	720	100	235 x 235 x 53	19	235	230	40	15	4	30
TPF 1500/450	1000	450	1500	225	1080	150	270 x 270 x 60	29	270	250	50	17	4	40
TPF 2000/600	1340	600	2000	300	1430	200	330 x 330 x 69	48	330	300	50	18	4	50
TPF 2500/750	1670	750	2500	375	1790	250	345 x 345 x 77	58	345	310	60	21	4	50
TPF 3000/900	2000	900	3000	450	2150	300	375 x 375 x 80	77	375	330	70	23	4	60
TPF 3500/1050	2340	1050	3500	525	2500	350	415 x 415 x 89	97	415	360	70	24	4	60
TPF 4000/1200	2670	1200	4000	600	2860	400	445 x 445 x 82	98	445	375	70	26	4	60
TPF 4500/1350	3000	1350	4500	675	3220	450	470 x 470 x 89	128	470	400	80	27	4	70
TPF 5000/1500	3340	1500	5000	750	3580	500	505 x 505 x 100	156	505	420	80	28	4	70
TPF 6000/1800	4000	1800	6000	900	4290	600	540 x 540 x 111	213	540	450	90	31	4	90
TPF 7000/2100	4670	2100	7000	1050	5000	700	600 x 600 x 112	249	600	490	100	33	4	90
TPF 8000/2400	5340	2400	8000	1200	5720	800	640 x 640 x 120	295	640	520	100	35	4	90
TPF 9000/2700	6000	2700	9000	1350	6430	900	675 x 675 x 137	361	675	545	110	37	4	90
TPF 10000/3000	6670	3000	10000	1500	7150	1000	720 x 720 x 139	425	720	570	120	39	4	100
TPF 11000/3300	7340	3300	11000	1650	7860	1100	755 x 755 x 137	453	755	595	120	41	4	100
TPF 12000/3600	8000	3600	12000	1800	8580	1200	785 x 785 x 146	504	785	620	130	43	4	100
TPF 13000/3900	8670	3900	13000	1950	9290	1300	800 x 800 x 152	553	800	640	130	44	4	100
TPF 14000/4200	9340	4200	14000	2100	10000	1400	860 x 860 x 153	626	860	680	140	45	4	100
TPF 15000/4500	10000	4500	15000	2250	10720	1500	880 x 880 x 153	672	880	690	140	47	8	90
TPF 16000/4800	10670	4800	16000	2400	11430	1600	910 x 910 x 169	780	910	705	150	49	8	90
TPF 17000/5100	11340	5100	17000	2550	12150	1700	940 x 940 x 177	870	940	730	150	50	8	90
TPF 18000/5400	12000	5400	18000	2700	12860	1800	985 x 985 x 180	948	985	755	160	51	8	90
TPF 19000/5700	12670	5700	19000	2850	13580	1900	1000 x 1000 x 186	1041	1000	770	160	55	8	100
TPF 20000/6000	13340	6000	20000	3000	14290	2000	1015 x 1015 x 194	1116	1015	790	160	56	8	100
TPF 22500/6300	15000	6300	22500	3150	16080	2100	1115 x 1115 x 195	1311	1115	880	180	53	8	100
TPF 25000/6600	16670	6600	25000	3300	17860	2200	1130 x 1130 x 195	1338	1130	880	180	55	8	100
TPF 27500/6900	18340	6900	27500	3450	19650	2300	1160 x 1160 x 209	1505	1160	920	190	55	8	100
TPF 30000/7200	20000	7200	30000	3600	21430	2400	1205 x 1205 x 212	1610	1205	950	190	56	8	100
TPF 32500/7500	21670	7500	32500	3750	23220	2500	1250 x 1250 x 221	1800	1250	990	190	56	8	100
TPF 35000/7800	23340	7800	35000	3900	25000	2600	1340 x 1340 x 224	2095	1340	1090	200	53	8	100
TPF 37500/8200	25000	8200	37500	4100	26790	2740	1365 x 1365 x 238	2306	1365	1090	200	56	8	100
TPF 40000/8600	26670	8600	40000	4300	28580	2870	1405 x 1405 x 242	2542	1405	1140	250	56	8	120
TPF 45000/9000	30000	9000	45000	4500	32150	3000	1480 x 1480 x 246	2794	1480	1190	250	56	8	120
TPF 50000/10000	33340	10000	50000	5000	35720	3340	1560 x 1560 x 257	3151	1560	1240	250	59	8	120
TPF 55000/11000	36670	11000	55000	5500	39290	3670	1625 x 1625 x 265	3505	1625	1290	250	62	12	100
TPF 60000/12000	40000	12000	60000	6000	42860	4000	1685 x 1685 x 270	3869	1685	1340	250	65	12	100
TPF 65000/13000	43340	13000	65000	6500	46430	4340	1765 x 1765 x 282	4481	1765	1390	250	68	8	130
TPF 70000/14000	46670	14000	70000	7000	50000	4670	1825 x 1825 x 302	5071	1825	1440	300	70	14	100
TPF 75000/15000	50000	15000	75000	7500	53580	5000	1900 x 1900 x 305	5523	1900	1490	300	73	12	120
TPF 80000/16000	53340	16000	80000	8000	57150	5340	1980 x 1980 x 317	6078	1980	1540	300	75	16	100
TPF 90000/17000	60000	17000	90000	8500	64290	5670	2090 x 2090 x 336	7163	2090	1640	300	75	16	100

# TPL NORMAL

## GUIDED SLIDING TENS POT BEARINGS $V_{Sd-SEISM}/N_{Sd-SLU}=10\%$

BEARING	SEISMIC COMBINATION ULS		STATIC COMBINATION ULS		STATIC COMBINATION SLS		OVERALL SIZE	SLIDING PLATE PLAN DIMENSIONS	NET WEIGHT (ANCHORAGES EXCLUDED)	POT DIAMETER	PISTON DIAMETER	PIN DIAMETER	PIN PROTRUSION	BOTTOM ANCHOR DOWELS	
	$N_{Sd-SEISM}$ (kN)	$V_{Sd-SEISM}$ (kN)	$N_{Sd-SLU}$ (kN)	$V_{Sd-SLU}$ (kN)	$N_{Sd-SLE}$ (kN)	$V_{Sd-SLE}$ (kN)									Do x Do x Htot (mm)
TPL 500/50/±50	340	50	500	25	360	20	150 x 150 x 90	300 x 175	23	150	175	50	15	2	30
TPL 1000/100/±50	670	100	1000	50	720	40	215 x 215 x 89	355 x 230	37	215	230	50	15	2	30
TPL 1500/150/±50	1000	150	1500	75	1080	50	245 x 245 x 98	375 x 250	48	245	250	50	15	4	30
TPL 2000/200/±50	1340	200	2000	100	1430	70	300 x 300 x 103	425 x 300	67	300	300	30	15	4	30
TPL 2500/250/±50	1670	250	2500	125	1790	90	315 x 315 x 107	435 x 310	74	315	310	40	15	4	30
TPL 3000/300/±50	2000	300	3000	150	2150	100	340 x 340 x 106	455 x 330	87	340	330	60	15	4	30
TPL 3500/350/±50	2340	350	3500	175	2500	120	375 x 375 x 111	485 x 360	105	375	360	60	15	4	30
TPL 4000/400/±50	2670	400	4000	200	2860	140	395 x 395 x 115	500 x 375	118	395	375	40	16	4	40
TPL 4500/450/±50	3000	450	4500	225	3220	150	420 x 420 x 119	525 x 400	137	420	400	60	15	4	40
TPL 5000/500/±50	3340	500	5000	250	3580	170	445 x 445 x 124	545 x 420	154	445	420	50	16	4	40
TPL 6000/600/±50	4000	600	6000	300	4290	200	485 x 485 x 137	575 x 450	198	485	450	60	16	4	50
TPL 7000/700/±50	4670	700	7000	350	5000	240	515 x 515 x 141	605 x 480	228	515	480	60	18	4	50
TPL 8000/800/±50	5340	800	8000	400	5720	270	555 x 555 x 140	635 x 510	259	555	510	70	18	4	50
TPL 9000/900/±50	6000	900	9000	450	6430	300	595 x 595 x 154	670 x 545	328	595	545	70	19	4	60
TPL 10000/1000/±50	6670	1000	10000	500	7150	340	625 x 625 x 159	695 x 570	370	625	570	70	21	4	60
TPL 11000/1100/±50	7340	1100	11000	550	7860	370	655 x 655 x 158	720 x 595	398	655	595	70	22	4	60
TPL 12000/1200/±50	8000	1200	12000	600	8580	400	685 x 685 x 172	745 x 620	473	685	620	70	24	4	60
TPL 13000/1300/±50	8670	1300	13000	650	9290	440	710 x 710 x 166	765 x 640	487	710	640	80	23	4	70
TPL 14000/1400/±50	9340	1400	14000	700	10000	470	755 x 755 x 170	805 x 680	555	755	680	80	24	4	70
TPL 15000/1500/±50	10000	1500	15000	750	10720	500	770 x 770 x 184	815 x 690	627	770	690	80	26	4	70
TPL 16000/1600/±50	10670	1600	16000	800	11430	540	790 x 790 x 184	830 x 705	654	790	705	90	25	4	70
TPL 17000/1700/±50	11340	1700	17000	850	12150	570	815 x 815 x 188	855 x 730	714	815	730	90	26	4	70
TPL 18000/1800/±50	12000	1800	18000	900	12860	600	845 x 845 x 192	880 x 755	795	845	755	90	27	4	90
TPL 19000/1900/±50	12670	1900	19000	950	13580	640	870 x 870 x 211	895 x 770	928	870	770	90	28	4	90
TPL 20000/2000/±50	13340	2000	20000	1000	14290	670	890 x 890 x 200	915 x 790	898	890	790	90	29	4	90
TPL 22500/2100/±50	15000	2100	22500	1050	16080	700	985 x 985 x 220	1005 x 880	1204	985	880	100	28	4	90
TPL 25000/2200/±50	16670	2200	25000	1100	17860	740	990 x 990 x 229	1005 x 880	1254	990	880	100	29	4	90
TPL 27500/2300/±50	18340	2300	27500	1150	19650	770	1035 x 1035 x 219	1045 x 920	1276	1035	920	100	30	4	90
TPL 30000/2400/±50	20000	2400	30000	1200	21430	800	1070 x 1070 x 238	1075 x 950	1490	1070	950	100	31	4	90
TPL 32500/2500/±50	21670	2500	32500	1250	23220	840	1115 x 1115 x 237	1115 x 990	1596	1115	990	110	30	4	90
TPL 35000/2600/±50	23340	2600	35000	1300	25000	870	1210 x 1210 x 247	1215 x 1090	1937	1210	1090	110	31	4	90
TPL 37500/2700/±50	25000	2700	37500	1350	26790	900	1220 x 1220 x 257	1215 x 1090	2062	1220	1090	110	32	4	90
TPL 40000/2800/±50	26670	2800	40000	1400	28580	940	1270 x 1270 x 267	1265 x 1140	2331	1270	1140	120	31	4	100
TPL 45000/3200/±50	30000	3200	45000	1600	32150	1070	1335 x 1335 x 275	1315 x 1190	2639	1335	1190	120	34	4	100
TPL 50000/3500/±50	33340	3500	50000	1750	35720	1170	1390 x 1390 x 297	1365 x 1240	3093	1390	1240	130	35	4	100
TPL 55000/3900/±50	36670	3900	55000	1950	39290	1300	1445 x 1445 x 320	1415 x 1290	3617	1445	1290	130	38	4	100
TPL 60000/4200/±50	40000	4200	60000	2100	42860	1400	1510 x 1510 x 313	1465 x 1340	3776	1510	1340	110	29	4	100
TPL 65000/4600/±50	43340	4600	65000	2300	46430	1540	1570 x 1570 x 322	1515 x 1390	4202	1570	1390	110	31	8	90
TPL 70000/4900/±50	46670	4900	70000	2450	50000	1640	1630 x 1630 x 322	1565 x 1440	4472	1630	1440	110	33	8	90
TPL 75000/5300/±50	50000	5300	75000	2650	53580	1770	1685 x 1685 x 347	1615 x 1490	5176	1685	1490	120	32	8	90
TPL 80000/5600/±50	53340	5600	80000	2800	57150	1870	1750 x 1750 x 349	1665 x 1540	5591	1750	1540	120	34	8	100
TPL 90000/6300/±50	60000	6300	90000	3150	64290	2100	1865 x 1865 x 365	1765 x 1640	6579	1865	1640	130	35	8	100

# TPL HIGH

## GUIDED SLIDING TENS POT BEARINGS $V_{Sd-SEISM}/N_{Sd-SLU}=30\%$

BEARING	SEISMIC COMBINATION ULS		STATIC COMBINATION ULS		STATIC COMBINATION SLS		OVERALL SIZE	SLIDING PLATE PLAN DIMENSIONS	NET WEIGHT (ANCHORAGES EXCLUDED)	POT DIAMETER	PISTON DIAMETER	PIN DIAMETER	PIN PROTRUSION	BOTTOM ANCHOR DOWELS	
	$N_{Sd-SEISM}$ (kN)	$V_{Sd-SEISM}$ (kN)	$N_{Sd-SLU}$ (kN)	$V_{Sd-SLU}$ (kN)	$N_{Sd-SLE}$ (kN)	$V_{Sd-SLE}$ (kN)									Do x Do x Htot (mm)
TPL 500/150/±50	340	150	500	75	360	50	160 x 160 x 91	310 x 185	27	160	185	50	15	4	30
TPL 1000/300/±50	670	300	1000	150	720	100	235 x 235 x 100	355 x 230	46	235	230	60	15	4	30
TPL 1500/450/±50	1000	450	1500	225	1080	150	270 x 270 x 107	395 x 270	68	270	270	70	16	4	40
TPL 2000/600/±50	1340	600	2000	300	1430	200	330 x 330 x 111	425 x 300	89	330	300	70	18	4	50
TPL 2500/750/±50	1670	750	2500	375	1790	250	345 x 345 x 129	455 x 330	119	345	330	80	20	4	50
TPL 3000/900/±50	2000	900	3000	450	2150	300	375 x 375 x 132	485 x 360	152	375	360	90	21	4	60
TPL 3500/1050/±50	2340	1050	3500	525	2500	350	415 x 415 x 141	500 x 375	175	415	375	80	23	4	60
TPL 4000/1200/±50	2670	1200	4000	600	2860	400	445 x 445 x 139	525 x 400	196	445	400	90	25	4	60
TPL 4500/1350/±50	3000	1350	4500	675	3220	450	480 x 480 x 143	545 x 420	233	480	420	90	26	4	70
TPL 5000/1500/±50	3340	1500	5000	750	3580	500	500 x 500 x 166	560 x 435	284	500	435	90	28	4	70
TPL 6000/1800/±50	4000	1800	6000	900	4290	600	545 x 545 x 175	600 x 475	375	545	475	100	30	4	90
TPL 7000/2100/±50	4670	2100	7000	1050	5000	700	600 x 600 x 179	630 x 505	428	600	505	100	32	4	90
TPL 8000/2400/±50	5340	2400	8000	1200	5720	800	625 x 625 x 190	660 x 535	493	625	535	110	34	4	90
TPL 9000/2700/±50	6000	2700	9000	1350	6430	900	675 x 675 x 191	695 x 570	556	675	570	120	36	4	90
TPL 10000/3000/±50	6670	3000	10000	1500	7150	1000	720 x 720 x 211	720 x 595	693	720	595	120	38	4	100
TPL 11000/3300/±50	7340	3300	11000	1650	7860	1100	745 x 745 x 216	755 x 630	770	745	630	140	39	4	100
TPL 12000/3600/±50	8000	3600	12000	1800	8580	1200	785 x 785 x 228	785 x 660	882	785	660	150	40	4	100
TPL 13000/3900/±50	8670	3900	13000	1950	9290	1300	800 x 800 x 234	805 x 680	952	800	680	150	42	4	100
TPL 14000/4200/±50	9340	4200	14000	2100	10000	1400	860 x 860 x 235	820 x 695	1021	860	695	100	39	4	100
TPL 15000/4500/±50	10000	4500	15000	2250	10720	1500	880 x 880 x 245	840 x 715	1134	880	715	140	31	8	90
TPL 16000/4800/±50	10670	4800	16000	2400	11430	1600	910 x 910 x 251	865 x 740	1238	910	740	110	42	8	90
TPL 17000/5100/±50	11340	5100	17000	2550	12150	1700	940 x 940 x 249	885 x 760	1349	940	760	150	74	8	90
TPL 18000/5400/±50	12000	5400	18000	2700	12860	1800	985 x 985 x 262	910 x 785	1454	985	785	120	46	8	90
TPL 19000/5700/±50	12670	5700	19000	2850	13580	1900	1005 x 1005 x 271	925 x 800	1606	1005	800	120	48	8	100
TPL 20000/6000/±50	13340	6000	20000	3000	14290	2000	1030 x 1030 x 280	950 x 825	1817	1030	825	170	96	8	100
TPL 22500/6300/±50	15000	6300	22500	3150	16080	2100	1105 x 1105 x 283	1005 x 880	1950	1105	880	160	34	8	100
TPL 25000/6600/±50	16670	6600	25000	3300	17860	2200	1120 x 1120 x 283	1015 x 890	2001	1120	890	160	35	8	100
TPL 27500/6900/±50	18340	6900	27500	3450	19650	2300	1170 x 1170 x 295	1050 x 925	2231	1170	925	160	35	8	100
TPL 30000/7200/±50	20000	7200	30000	3600	21430	2400	1205 x 1205 x 294	1080 x 955	2338	1205	955	160	35	8	100
TPL 32500/7500/±50	21670	7500	32500	3750	23220	2500	1235 x 1235 x 318	1120 x 995	2669	1235	995	140	41	8	100
TPL 35000/7800/±50	23340	7800	35000	3900	25000	2600	1340 x 1340 x 316	1215 x 1090	3093	1340	1090	160	37	8	100
TPL 37500/8200/±50	25000	8200	37500	4100	26790	2740	1365 x 1365 x 320	1215 x 1090	3190	1365	1090	160	39	8	100
TPL 40000/8600/±50	26670	8600	40000	4300	28580	2870	1425 x 1425 x 321	1265 x 1140	3505	1425	1140	160	40	8	120
TPL 45000/9000/±50	30000	9000	45000	4500	32150	3000	1485 x 1485 x 341	1315 x 1190	4026	1485	1190	170	39	8	120
TPL 50000/10000/±50	33340	10000	50000	5000	35720	3340	1560 x 1560 x 349	1365 x 1240	4306	1560	1240	170	43	8	120
TPL 55000/11000/±50	36670	11000	55000	5500	39290	3670	1625 x 1625 x 367	1415 x 1290	4889	1625	1290	180	44	12	100
TPL 60000/12000/±50	40000	12000	60000	6000	42860	4000	1690 x 1690 x 382	1465 x 1340	5486	1690	1340	190	45	12	100
TPL 65000/13000/±50	43340	13000	65000	6500	46430	4340	1765 x 1765 x 384	1515 x 1390	6087	1765	1390	190	49	8	130
TPL 70000/14000/±50	46670	14000	70000	7000	50000	4670	1835 x 1835 x 413	1565 x 1440	6915	1835	1440	250	42	14	100
TPL 75000/15000/±50	50000	15000	75000	7500	53580	5000	1905 x 1905 x 427	1615 x 1490	7716	1905	1490	250	43	12	120
TPL 80000/16000/±50	53340	16000	80000	8000	57150	5340	1980 x 1980 x 429	1665 x 1540	8231	1980	1540	250	45	16	100
TPL 90000/17000/±50	60000	17000	90000	8500	64290	5670	2090 x 2090 x 448	1765 x 1640	9602	2090	1640	250	48	16	100

# TPM

## FREE SLIDING TENS POT BEARINGS

BEARING	SEISMIC COMBINATION ULS	STATIC COMBINATION ULS	STATIC COMBINATION SLS	OVERALL SIZE	SLIDING PLATE PLAN DIMENSIONS	NET WEIGHT (ANCHORAGES EXCLUDED)	POT DIAMETER	PISTON DIAMETER	PIN DIAMETER	PIN PROTRUSION
	N <sub>Sd-Seism</sub> (kN)	N <sub>Sd-SLU</sub> (kN)	N <sub>Sd-SLE</sub> (kN)	Do x Do x Htot (mm)	B x L (mm)	W <sub>net</sub> (kg)	Do (mm)	D' (mm)	D <sub>pin</sub> (mm)	t <sub>pin</sub> (mm)
TPM 500/±50/±20	340	500	360	175 x 175 x 76	210 x 270	20	175	170	30	15
TPM 1000/±50/±20	670	1000	720	235 x 235 x 81	270 x 330	34	235	230	30	15
TPM 1500 /±50 /±20	1000	1500	1080	255 x 255 x 80	290 x 350	39	255	250	30	15
TPM 2000 /±50 /±20	1340	2000	1430	305 x 305 x 85	340 x 400	55	305	300	30	15
TPM 2500 /±50 /±20	1670	2500	1790	315 x 315 x 90	350 x 410	60	315	310	30	15
TPM 3000 /±50 /±20	2000	3000	2150	335 x 335 x 90	370 x 430	70	335	330	30	15
TPM 3500 /±50 /±20	2340	3500	2500	365 x 365 x 95	400 x 460	85	365	360	30	15
TPM 4000 /±50 /±20	2670	4000	2860	380 x 380 x 99	415 x 475	94	380	375	30	15
TPM 4500 /±50 /±20	3000	4500	3220	405 x 405 x 99	440 x 500	105	405	400	30	15
TPM 5000 /±50 /±20	3340	5000	3580	425 x 425 x 109	460 x 520	127	425	420	30	15
TPM 6000 /±50 /±20	4000	6000	4290	460 x 460 x 113	490 x 550	149	460	450	30	15
TPM 7000 /±50 /±20	4670	7000	5000	495 x 495 x 113	520 x 580	166	495	480	30	15
TPM 8000 /±50 /±20	5340	8000	5720	530 x 530 x 117	550 x 610	200	530	510	30	15
TPM 9000 /±50 /±20	6000	9000	6430	570 x 570 x 127	585 x 645	245	570	545	30	15
TPM 10000 /±50 /±20	6670	10000	7150	600 x 600 x 132	610 x 670	276	600	570	30	15
TPM 11000 /±50 /±20	7340	11000	7860	630 x 630 x 136	635 x 695	315	630	595	30	15
TPM 12000 /±50 /±20	8000	12000	8580	655 x 655 x 136	660 x 720	336	655	620	30	15
TPM 13000 /±50 /±20	8670	13000	9290	680 x 680 x 146	680 x 740	380	680	640	30	16
TPM 14000 /±50 /±20	9340	14000	10000	720 x 720 x 150	720 x 780	444	720	680	30	16
TPM 15000 /±50 /±20	10000	15000	10720	735 x 735 x 150	730 x 790	459	735	690	40	15
TPM 16000 /±50 /±20	10670	16000	11430	755 x 755 x 150	745 x 805	479	755	705	40	15
TPM 17000 /±50 /±20	11340	17000	12150	780 x 780 x 154	770 x 830	521	780	730	40	16
TPM 18000 /±50 /±20	12000	18000	12860	810 x 810 x 154	795 x 855	552	810	755	40	16
TPM 19000 /±50 /±20	12670	19000	13580	830 x 830 x 179	810 x 870	687	830	770	40	17
TPM 20000 /±50 /±20	13340	20000	14290	855 x 855 x 178	830 x 890	710	855	790	40	17
TPM 22500 /±50 /±20	15000	22500	16080	950 x 950 x 192	920 x 980	950	950	880	40	19
TPM 25000 /±50 /±20	16670	25000	17860	965 x 965 x 192	920 x 980	969	965	880	40	20
TPM 27500 /±50 /±20	18340	27500	19650	1010 x 1010 x 206	960 x 1020	1129	1010	920	50	19
TPM 30000 /±50 /±20	20000	30000	21430	1045 x 1045 x 216	990 x 1050	1274	1045	950	50	20
TPM 32500 /±50 /±20	21670	32500	23220	1090 x 1090 x 215	1030 x 1090	1365	1090	990	50	21
TPM 35000 /±50 /±20	23340	35000	25000	1175 x 1175 x 243	1130 x 1190	1798	1175	1090	50	23
TPM 37500 /±50 /±20	25000	37500	26790	1185 x 1185 x 243	1130 x 1190	1819	1185	1090	50	24
TPM 40000 /±50 /±20	26670	40000	28580	1235 x 1235 x 262	1180 x 1240	2154	1235	1140	60	22
TPM 45000 /±50 /±20	30000	45000	32150	1305 x 1305 x 271	1230 x 1290	2460	1305	1190	60	24
TPM 50000 /±50 /±20	33340	50000	35720	1365 x 1365 x 271	1280 x 1340	2658	1365	1240	60	26
TPM 55000 /±50 /±20	36670	55000	39290	1425 x 1425 x 279	1330 x 1390	2960	1425	1290	60	28
TPM 60000 /±50 /±20	40000	60000	42860	1480 x 1480 x 298	1380 x 1440	3443	1480	1340	70	27
TPM 65000 /±50 /±20	43340	65000	46430	1540 x 1540 x 297	1430 x 1490	3676	1540	1390	70	28
TPM 70000 /±50 /±20	46670	70000	50000	1600 x 1600 x 308	1480 x 1540	4081	1600	1440	70	30
TPM 75000 /±50 /±20	50000	75000	53580	1655 x 1655 x 326	1530 x 1590	4632	1655	1490	70	32
TPM 80000 /±50 /±20	53340	80000	57150	1710 x 1710 x 335	1580 x 1640	5073	1710	1540	80	30
TPM 90000 /±50 /±20	60000	90000	64290	1835 x 1835 x 344	1680 x 1740	5918	1835	1640	80	33



Fondaco dei Tedeschi building, Venice (Italy)

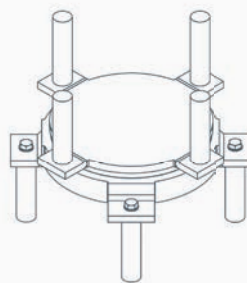
---

# 05

---

## TENS SPHERICAL BEARINGS (TS)

TENS SPHERICAL bearings can satisfy high performance requirements, by transferring considerable forces while allowing important rotations and displacements





# DESCRIPTION

This chapter refers to TENS SPHERICAL bearings (TS). TENS SPHERICAL bearings are able to transfer vertical and horizontal loads between the superstructure and the substructure, designed in order to allow the correct transfer of loads between the different structural elements, and to guarantee, at the same time, the realization of displacements and rotations according to the design. They can be used in civil works such as bridges, viaducts, buildings, roofs, industrial and hydraulic structures, tanks, military structures etc.

A TENS SPHERICAL bearing is mainly made of three steel elements: a pot, a spherical steel hinge and a piston. The first, in contact with the substructure, is obtained from a steel plate of appropriate thickness, cut to the size and in the shape (circular or square) required by the design and later handled through turning.

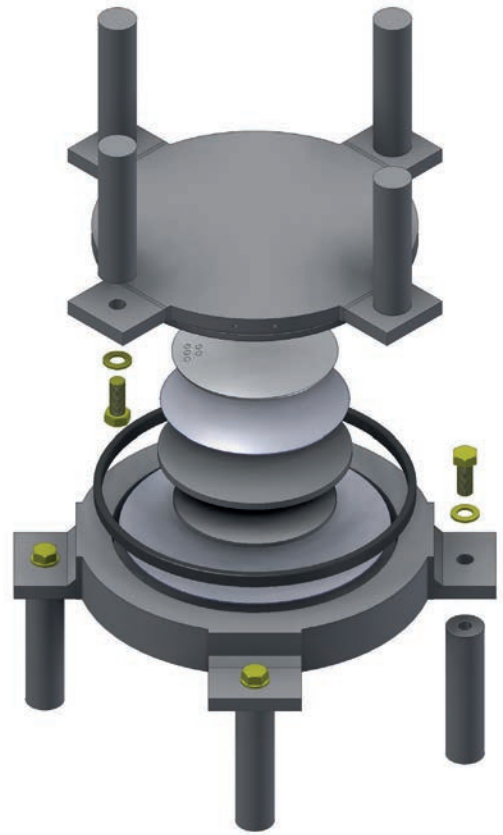
The spherical steel hinge, coupled to the piston, allows the absorption of the structure's rotations. In its lower part, a PTFE liner allows displacements through contact with a stainless steel sheet linked to the basement. The upper part of the hinge is either coated with a layer of stainless steel or subjected to a process of chromium plating surfacing that bestows high levels of hardness, wear resistance and corrosion protection.

The values of friction (generated by the contact between the stainless steel backing plate and the PTFE, lubricated and provided with recesses) are minimal and within the standard limits.

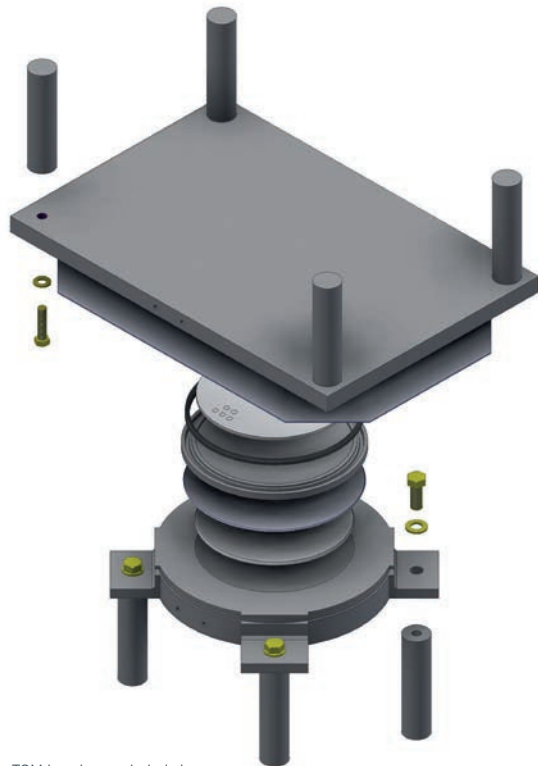
The piston has a circular plan shape with a suitable cavity for the positioning of a PTFE liner, that is adequately shaped and recessed. It is also partially included in the basement with minimum backlash (the nominal internal diameter of the basement is equal to the outer diameter of the piston). Vertical loads are transferred from the piston to the spherical hinge, and then to the basement.

The presence of the coupling spherical steel hinge – piston allows rotations at any horizontal and perpendicular axis to the curved surface of the spherical steel hinge.

This configuration is at the base of any spherical bearing and in particular it defines TSF fixed bearings, where translations are not allowed and horizontal actions are stiffly transferred through contact between the piston and the basement.



TSF bearing exploded view



TSM bearing exploded view

In the case of free and guided sliding bearings, the sliding (in one or both directions) takes place by means of contact between a mirror polished austenitic surface and a dimpled PTFE liner that can host silicone grease.

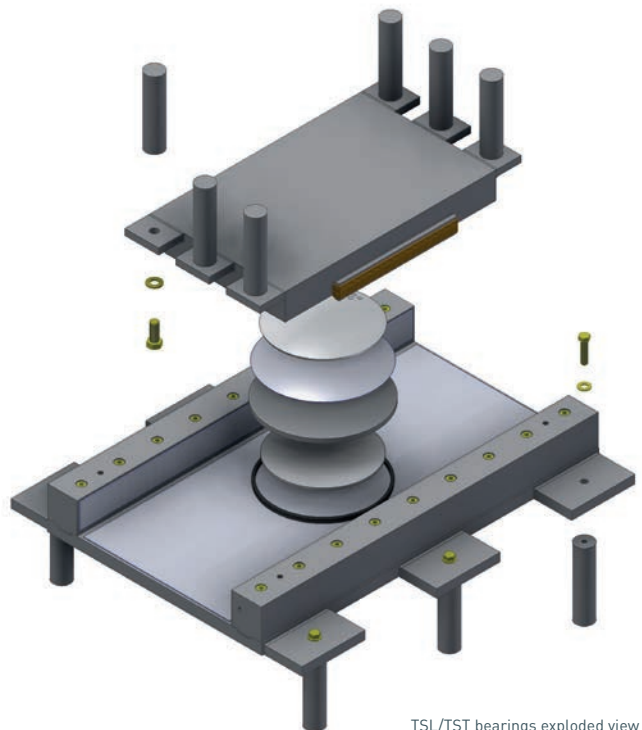
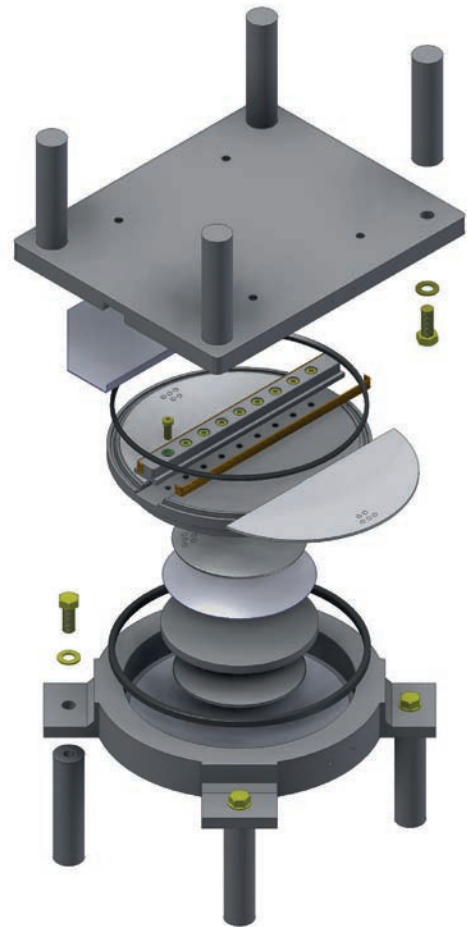
In order to obtain a unidirectional bearing one must employ an inward guide (or two external guides) for the transfer of horizontal loads in the fixed direction (perpendicular to bearing movement) and for the necessary sliding in the free direction. Depending on the type of work and on the design specifications, the bearing's anchorage can be normally made in the following ways:

- dowels and screws (typical for cast in situ concrete structures);
- pin (typical for steel or prefabricated superstructure, in which masonry plates must be provided in order to host the pin);
- screws (typical for steel or prefabricated concrete structures, in case there is a linking plate provided with threaded holes and preventively grouted in the structure);
- bonding/friction (any type of structure).

Any additional steel plates can be used between the bearing and the structure, in order to facilitate installation and possible future substitutions.

TS bearing presents the following advantages:

- easy installation/substitution;
- durability;
- support of very high vertical loads with negligible vertical deformations;
- transmission of very high horizontal loads in the presence of limited vertical loads (recommended in seismic areas);
- ability to absorb rotations about the vertical axis;
- larger rotations about any horizontal axis as compared to any other type of bearing with negligible restraint reactions;
- the large rotation capability also allows the absorption of permanent rotations of the structure (as an alternative to wedge plates);
- ability to transfer high loads with bearing sizes smaller than other bearing solutions.



TSL/TST bearings exploded view

# CLASSIFICATION AND COMPONENTS

---

TENS SPHERICAL bearings (TS) can be divided into three types depending on the granted constraint degrees:

## FIXED SPHERICAL BEARING (TSF)

Fixed bearings represent the basic solution, fundamentally composed of the following parts:

- **concave plate:** usually circular, provided with special welded side plates that allow fixing to the structure; it is obtained by turning from a thick metal sheet. In the concave upper surface, there is a cavity for PTFE, which realizes the sliding surface together with the spherical steel hinge.
- **spherical steel hinge:** contained in the basement, it constitutes the central convex element on which the rotation of the upper piston is set; it is obtained from full-machined lathe. Its convex shape allows rotation. The recess for PTFE is obtained through turning in the flat bottom surface.
- **base plate:** it is obtained through turning from a thick plate; it presses on the spherical steel hinge and includes a stainless steel lower surface that, in contact with the PTFE, allows the necessary sliding for the realization of relative rotations as required by the design.
- **anti-dust systems:** elements that prevent dirt and other external elements from penetrating the inner bearing parts and the sliding surfaces.

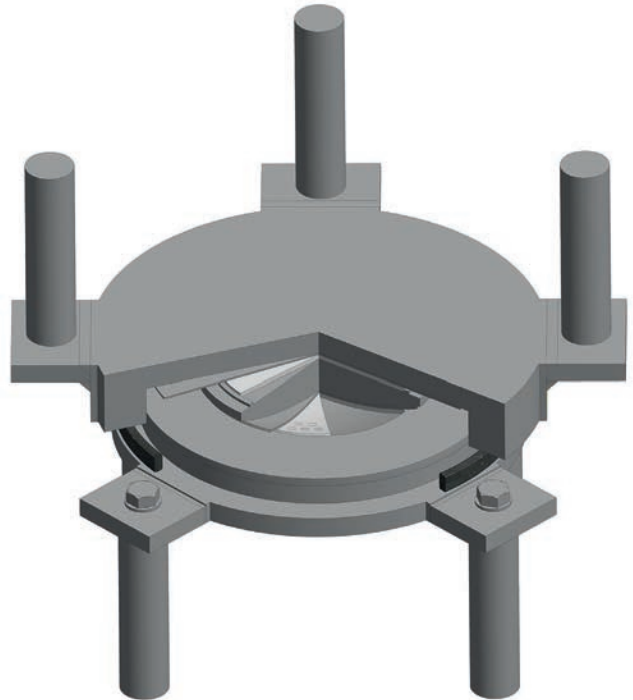
The contact piston-basement allows the rigid transfer of lateral loads between superstructure and substructure.

Fixed bearings are devices that allow the transfer of forces acting on the horizontal plane.

Translations on the horizontal plane are blocked, while rotations about the vertical and the horizontal axis are allowed.

## GUIDED SLIDING SPHERICAL BEARING (TSL/TST)

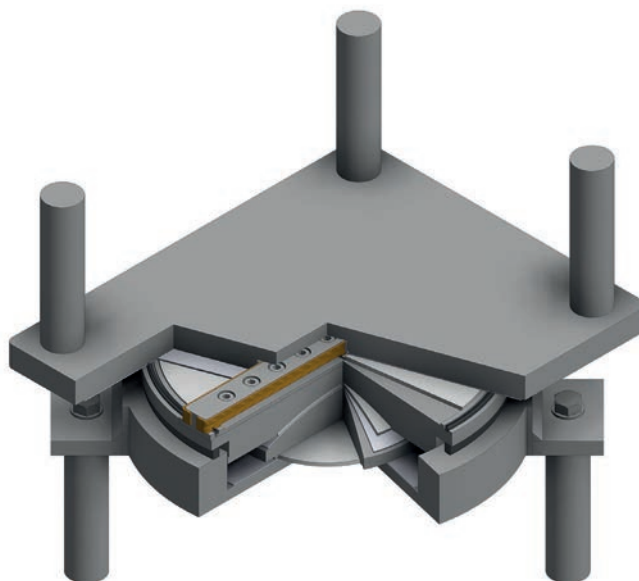
The configuration of this type of bearing is similar to the previous one, with the addition of some components that allow the device to develop translations in a single direction, longitudinal (L) or transverse (T). The transfer of the lateral load in the fixed direction takes place in a rigid manner. Guided sliding bearings are able to guarantee the same relative rotations as fixed bearings.



Fixed TENS SPHERICAL bearing TSF

In the upper part of the steel piston there is a cavity for the directional guide and the PTFE sliding plate, provided with adequate dimples (lubricated with silicone grease). This guide is made up of a rectangular steel profile, fixed to the piston by means of high strength screws. The guide presents a layer of composite material (CM1) on its two vertical sides. The sliding plate is suitably shaped in order to extract a cavity for containing the guide. The part of the sliding plate in contact with the CM1 is coated with a stainless steel surface in order to guarantee contact with a low coefficient of friction in the displacement direction. In the event of considerable horizontal loads, the central guide can be replaced with two external guides. In order to avoid dirt contamination that could increase friction and quickly deteriorate the PTFE, bearings designed and manufactured by TENSA are provided with a dust rubber seal positioned around the PTFE surfaces.

The bearings are also equipped with indicators of displacement that enable a rapid verification during periodic inspections.



Guided sliding TENS SPHERICAL bearing TSL/TST

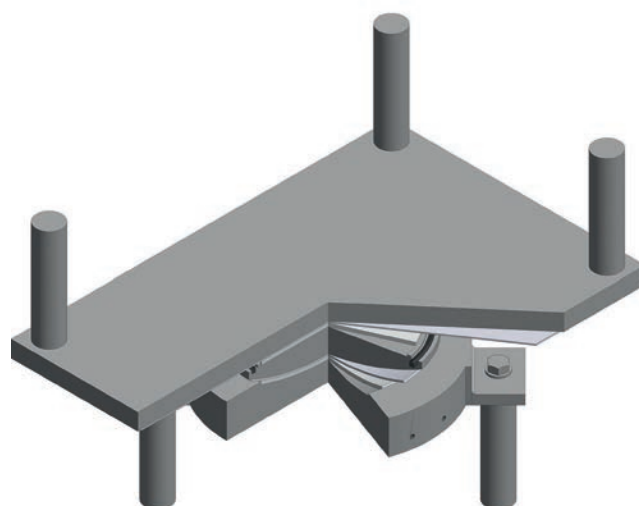
## FREE SLIDING SPHERICAL BEARING (TSM)

TSM bearings are able to transfer vertical loads allowing displacements in every directions of the horizontal plan. Unlike unidirectional bearings, they are not equipped with a directional guide. The spherical steel hinge presents a cavity containing a PTFE liner with minimum backlash and protruding a few mm.

In contact with this element, there is the upper sliding plate whose underside is provided with an austenitic stainless steel surface connected by means of TIG welding.

The sliding interface between dimpled PTFE and stainless steel is suitably lubricated by means of silicone grease. Friction and restraint resistance are thus notably reduced.

Bearings designed and manufactured by TENSA are provided with a dust rubber seal positioned around the PTFE surfaces to prevent dirt contamination. They are also equipped with indicators of displacement that enable a rapid verification during periodic inspections.



Free sliding TENS SPHERICAL bearing TSM

## TENS SPHERICAL BEARINGS FOR SPECIAL APPLICATIONS

TS bearings can be designed to meet multiple design and/or construction needs and thus can be integrated with other elements, such as:

- a system of load cells and displacement transducers in order to estimate size and variations;
- additional elements that make the bearing electrically insulated and thus not subject to electro-erosion phenomena caused by stray currents (e.g. electrified lines);
- a hydraulic or mechanical system in order to make vertical adjustments in case of differential settlements within the structure;
- additional elements to support both rare and frequent tensile loads, functioning at SLS or at ULS, that simultaneously allow absorption of the rotations imposed by the structure;
- additional elements that provide targeted performances during the construction/launch phase of the structure in order to guarantee other performances in the operating phase. In this case there can be guided or free sliding bearings that become fixed in the operating phase or vice versa or many other combinations;
- anti-seismic devices that act only during the seismic

phase. In particular, two different configurations can be obtained:

1. Displacement interruption and transfer of the seismic force developed in a pseudo rigid manner: this can be obtained by providing the bearings with a seismic shock absorber (Tens Shock Transmitter Device) that temporarily transforms the sliding bearing into a pseudo rigid link. In the case of slow movements they provide a minimal reaction that lets the structure expand and contract freely.
2. Energy dissipation: this can be obtained by linking a hydraulic viscous damper TFVD (Tens Fluid Viscous Damper) to the bearing or an hysteretic steel device TEPD (Tens Elasto-Plastic Device) arranged in series or less to the shock absorber (see previous point). The union in a single device that can resist gravity loads, absorb structural rotations, guarantee adequate behavior under earthquakes and dissipate energy means that we can refer to it as a hybrid constraining device and not only as a simple bearing.

Fondaco dei Tedeschi building, Venice (Italy)



# MATERIALS

---

THE MATERIALS EMPLOYED FOR THE PRODUCTION OF CE MARKED TS BEARINGS REFER TO WHAT IS INDICATED BELOW AND TO EN 1337 STANDARD.

ELEMENT	MATERIAL	STANDARDS
Concave plate, spherical steel hinge, pot, sliding plates	S355J2, S275J2	EN 10025
Sliding surfaces	PTFE/TENSA Slide	EN 1337-2 / ETA
Sliding surfaces	INOX X2 or X5CrNiMo17/12	EN 10088
CM1	Composite material made of three layers: a bronze backing strip and a sintered interlocking porous matrix, impregnated and overlaid with a PTFE/lead mixture	EN 1337-2
Lubricating grease	Silicone	EN 1337-2
Anchor dowels	39NiCrMo3, S355JR	EN 10083 or EN 10025
Screws	C1 8.8/10.9/12.9	EN 20898

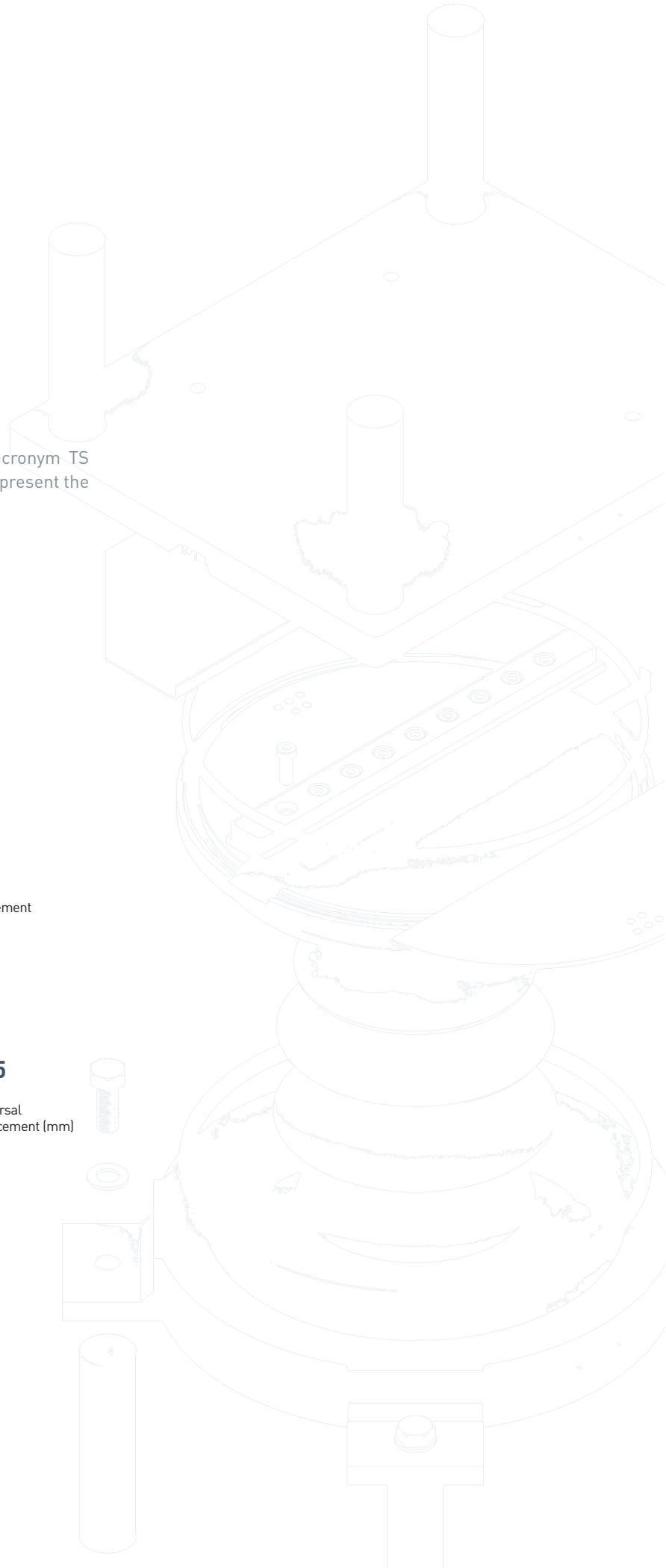
# MARKING

Each spherical bearing is identified with the acronym TS (TENS SPHERICAL). The numbers here shown represent the loads in kN and/or displacements in mm at ULS. Listed below are examples of the three types.

TS	Fixed bearing	1000	/	100
	F			
TENS SPHERICAL				

TS	Unidirectional bearing	1000	/	100	/	± 50
	U					
TENS SPHERICAL						

TS	Multidirectional bearing	1000	/	± 50	/	± 25
	M					
TENS SPHERICAL						



# CATALOGUE PERFORMANCE HYPOTHESIS

TS bearings catalogue is in accordance with EN 1337, parts 1, 2 and 7.

The expected maximum vertical load, at ULS, is equal to 100000 kN.

Bearing with greater vertical load can be designed on specific request.

## TEMPERATURE, UPPER AND LOWER SUPPORTS

For the bearing design we have considered the following criteria:

- Upper steel support
- Lower concrete support Resistance Class C37/45
- Temperature between -5 °C and +30 °C.

In order to calculate the contact pressure of both lower and upper supports, in the case of concrete, one has to refer to the value of EN 1992-1 for localized pressures, quoted in chapter 6.7.

$$\sigma_{Rdu} = f_{cd} \sqrt{\frac{A_{c1}}{A_{c0}}} \leq 3.0 \cdot f_{cd}$$

Assuming a maximum value of the ratio between the areas equal to 2:

$$M_{distr} = \sqrt{\frac{A_{c1}}{A_{c0}}} = 2$$

## DESIGN DISPLACEMENTS

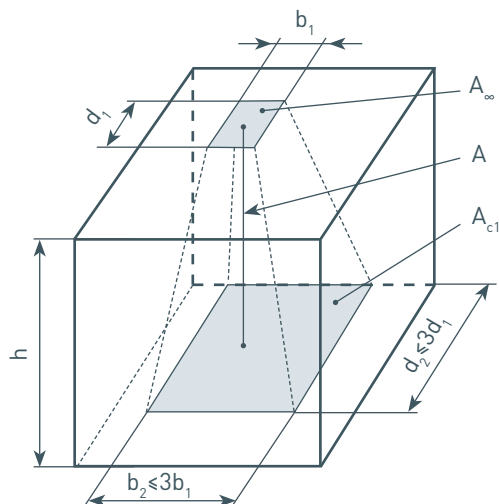
The EN 1337-1 Standard requires the adoption of minimum displacements in longitudinal and transverse directions, respectively  $\pm 50$  mm and  $\pm 20$  mm and to increase design displacements of  $\pm 20$  mm for non-anchored bearings.

In this chapter the following minimum displacements are assumed:

- Longitudinal displacement =  $\pm 50$  mm
- Transversal displacement =  $\pm 20$  mm

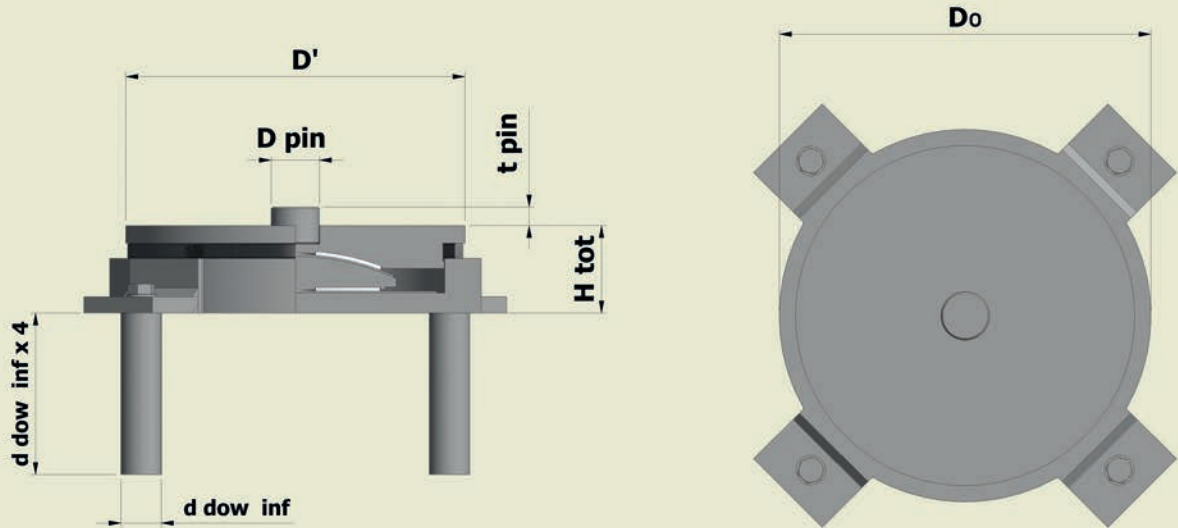
For rotation the following value is assumed:

- Maximum design rotation  $\alpha_{tot} = 0.020$  rad





## TSF



## DESIGN LOADS

Bearings shall be designed with reference to the following load combinations:

- ULS (for static loads)
- ULS (for seismic design situation)
- SLS

In particular:

$N_{Ed-ULS}$  = Maximum vertical load at ULS

$V_{Ed-ULS}$  = Maximum lateral load in presence of  $N_{Ed-ULS}$

$N_{Ed-Sism}$  = Vertical load in presence of  $V_{Ed-Sism}$

$V_{Ed-Sism}$  = Maximum lateral load at ULS in seismic design situation

$N_{Ed-SLS}$  = Vertical load at SLS

$V_{Ed-SLS}$  = Maximum Lateral Load at SLS in presence of  $N_{Ed-SLS}$

Further assumptions for the design of bearings proposed in the next paragraph's sheets:

$$N_{Ed-SLS} = N_{Ed-ULS} / 1.40$$

$$N_{Ed-Sism} = N_{Ed-ULS} / 1.50$$

$$V_{Ed-ULS} = V_{Ed-Sism} \times 0.50$$

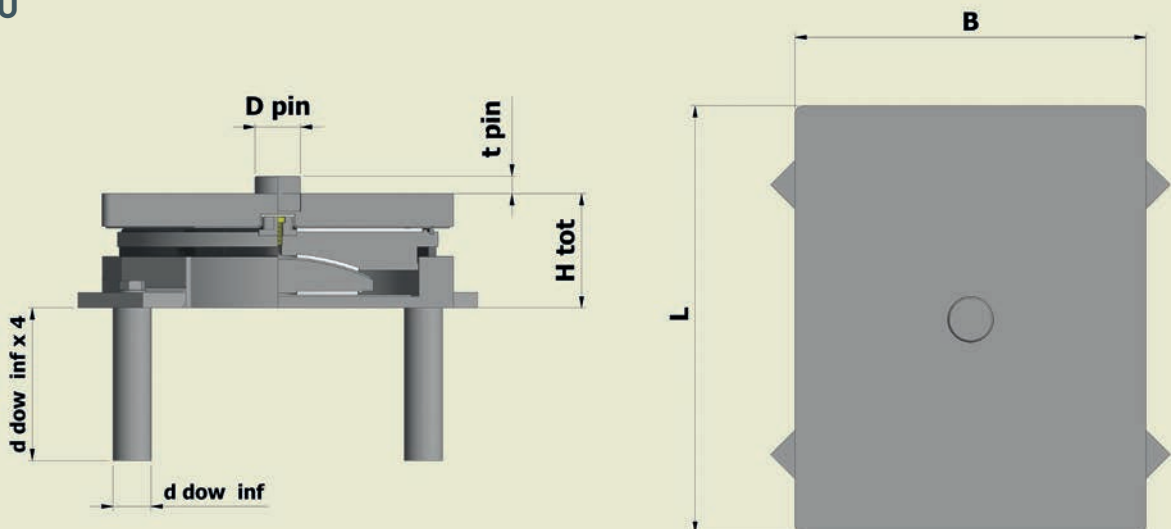
$$V_{Ed-SLS} = V_{Ed-ULS} / 1.50$$

## ANCHORAGE SYSTEMS

This section shows bearings with the following characteristics:

- Upper anchorage with pin on steel plate
  - Lower anchorage with anchor dowels for fixed and guided bearings and embedded with resin for free sliding bearings.
- Other types of anchorage can be considered.

## TSU



# TSF LOW

## FIXED TENS SPHERICAL BEARINGS $V_{Sd-SEISM}/N_{Sd-SLU}=10\%$

BEARING	SEISMIC COMBINATION ULS		STATIC COMBINATION ULS		STATIC COMBINATION SLS		OVERALL SIZE Do x Do x Htot (mm)	NET WEIGHT (ANCHORAGES EXCLUDED) W (kg)	CONCAVE PLATE DIAMETER Do (mm)	PIN DIAMETER D <sub>pin</sub> (mm)	PIN PROTRUSION t <sub>p</sub> (mm)	N°	BOTTOM ANCHOR DOWELS d <sub>Anchor</sub> (mm)
	N <sub>Sd-Seism</sub> (kN)	V <sub>Sd-Seism</sub> (kN)	N <sub>Sd-ULS</sub> (kN)	V <sub>Sd-ULS</sub> (kN)	N <sub>Sd-SLS</sub> (kN)	V <sub>Sd-SLS</sub> (kN)							
TSF 500/50	340	50	500	25	360	20	220 x 220 x 78	20	205	20	8	2	30
TSF 1000/100	670	100	1000	50	720	40	265 x 265 x 97	37	255	30	9	2	30
TSF 1500/150	1000	150	1500	75	1080	50	295 x 295 x 96	46	285	30	11	4	30
TSF 2000/200	1340	200	2000	100	1430	70	350 x 350 x 97	65	340	30	12	4	30
TSF 2500/250	1670	250	2500	125	1790	90	375 x 375 x 97	75	365	40	12	4	30
TSF 3000/300	2000	300	3000	150	2150	100	415 x 415 x 97	93	415	40	13	4	30
TSF 3500/350	2340	350	3500	175	2500	120	410 x 410 x 96	91	410	40	15	4	30
TSF 4000/400	2670	400	4000	200	2860	140	445 x 445 x 110	121	440	50	14	4	40
TSF 4500/450	3000	450	4500	225	3220	150	465 x 465 x 109	130	460	50	15	4	40
TSF 5000/500	3340	500	5000	250	3580	170	470 x 470 x 114	140	465	50	16	4	40
TSF 6000/600	4000	600	6000	300	4290	200	530 x 530 x 114	174	510	60	16	4	50
TSF 7000/700	4670	700	7000	350	5000	240	570 x 570 x 123	220	550	60	18	4	50
TSF 8000/800	5340	800	8000	400	5720	270	620 x 620 x 127	272	605	60	19	4	50
TSF 9000/900	6000	900	9000	450	6430	300	635 x 635 x 146	327	610	70	19	4	60
TSF 10000/1000	6670	1000	10000	500	7150	340	650 x 650 x 145	339	625	70	20	4	60
TSF 11000/1100	7340	1100	11000	550	7860	370	695 x 695 x 145	390	670	70	22	4	60
TSF 12000/1200	8000	1200	12000	600	8580	400	745 x 745 x 145	451	720	80	21	4	60
TSF 13000/1300	8670	1300	13000	650	9290	440	740 x 740 x 153	469	715	80	23	4	60
TSF 14000/1400	9340	1400	14000	700	10000	470	765 x 765 x 162	529	730	80	25	4	70
TSF 15000/1500	10000	1500	15000	750	10720	500	790 x 790 x 171	599	755	90	24	4	70
TSF 16000/1600	10670	1600	16000	800	11430	540	850 x 850 x 162	654	815	90	25	4	70
TSF 17000/1700	11340	1700	17000	850	12150	570	875 x 875 x 161	691	840	90	26	4	70
TSF 18000/1800	12000	1800	18000	900	12860	600	845 x 845 x 179	701	800	90	27	4	90
TSF 19000/1900	12670	1900	19000	950	13580	640	910 x 910 x 179	816	865	100	26	4	90
TSF 20000/2000	13340	2000	20000	1000	14290	670	930 x 930 x 179	855	885	100	28	4	90
TSF 22500/2250	15000	2250	22500	1125	16080	750	945 x 945 x 188	931	900	100	30	4	90
TSF 25000/2500	16670	2500	25000	1250	17860	840	1035 x 1035 x 187	1120	990	110	31	4	90
TSF 27500/2750	18340	2750	27500	1375	19650	920	1030 x 1030 x 208	1264	985	120	31	4	90
TSF 30000/3000	20000	3000	30000	1500	21430	1000	1090 x 1090 x 217	1464	1035	120	33	4	100
TSF 32500/3250	21670	3250	32500	1625	23220	1090	1130 x 1130 x 226	1651	1075	130	33	4	100
TSF 35000/3500	23340	3500	35000	1750	25000	1170	1175 x 1175 x 226	1793	1120	130	35	4	100
TSF 37500/3750	25000	3750	37500	1875	26790	1250	1170 x 1170 x 253	1998	1115	140	35	4	100
TSF 40000/4000	26670	4000	40000	2000	28580	1340	1235 x 1235 x 254	2261	1190	140	37	4	100
TSF 45000/4500	30000	4500	45000	2250	32150	1500	1385 x 1385 x 234	2606	1340	150	39	8	90
TSF 50000/5000	33340	5000	50000	2500	35720	1670	1455 x 1455 x 242	2993	1410	160	40	8	90
TSF 55000/5500	36670	5500	55000	2750	39290	1840	1510 x 1510 x 261	3489	1465	160	43	8	90
TSF 60000/6000	40000	6000	60000	3000	42860	2000	1565 x 1565 x 270	3870	1510	190	40	8	100
TSF 65000/6500	43340	6500	65000	3250	46430	2170	1615 x 1615 x 269	4116	1560	190	43	8	100
TSF 70000/7000	46670	7000	70000	3500	50000	2340	1680 x 1680 x 288	4791	1625	200	44	8	100
TSF 75000/7500	50000	7500	75000	3750	53580	2500	1730 x 1730 x 306	5426	1675	210	45	8	100
TSF 80000/8000	53340	8000	80000	4000	57150	2670	1875 x 1875 x 294	6181	1830	210	48	8	100
TSF 90000/9000	60000	9000	90000	4500	64290	3000	1965 x 1965 x 302	6862	1900	230	49	8	120
TSF 100000/10000	66670	10000	100000	5000	71430	3340	2045 x 2045 x 331	8151	1980	240	52	8	120

# TSF HIGH

## FIXED TENS SPHERICAL BEARINGS $V_{Sd-SEISM}/N_{Sd-SLU}=30\%$

BEARING	SEISMIC COMBINATION ULS		STATIC COMBINATION ULS		STATIC COMBINATION SLS		OVERALL SIZE	NET WEIGHT (ANCHORAGES EXCLUDED)	CONCAVE PLATE DIAMETER	PIN DIAMETER	PIN PROTRUSION	BOTTOM ANCHOR DOWELS	
	$N_{Sd-Seism}$ (kN)	$V_{Sd-Seism}$ (kN)	$N_{Sd-ULS}$ (kN)	$V_{Sd-ULS}$ (kN)	$N_{Sd-SLS}$ (kN)	$V_{Sd-SLS}$ (kN)							Do x Do x Htot (mm)
TSF 500/150	340	150	500	75	360	50	230 x 230 x 93	27	220	30	11	4	30
TSF 1000/300	670	300	1000	150	720	100	280 x 280 x 105	47	280	40	13	4	30
TSF 1500/450	1000	450	1500	225	1080	150	305 x 305 x 107	55	300	50	15	4	40
TSF 2000/600	1340	600	2000	300	1430	200	395 x 395 x 109	91	375	60	16	4	50
TSF 2500/750	1670	750	2500	375	1790	250	405 x 405 x 120	109	390	60	19	4	50
TSF 3000/900	2000	900	3000	450	2150	300	450 x 450 x 125	139	425	70	19	4	60
TSF 3500/1050	2340	1050	3500	525	2500	350	450 x 450 x 142	159	425	70	21	4	60
TSF 4000/1200	2670	1200	4000	600	2860	400	505 x 505 x 142	203	480	80	21	4	60
TSF 4500/1350	3000	1350	4500	675	3220	450	515 x 515 x 144	212	480	80	23	4	70
TSF 5000/1500	3340	1500	5000	750	3580	500	515 x 515 x 162	243	480	90	25	4	70
TSF 6000/1800	4000	1800	6000	900	4290	600	545 x 545 x 170	271	500	90	28	4	90
TSF 7000/2100	4670	2100	7000	1050	5000	700	635 x 635 x 171	384	590	100	29	4	90
TSF 8000/2400	5340	2400	8000	1200	5720	800	705 x 705 x 170	475	660	110	30	4	90
TSF 9000/2700	6000	2700	9000	1350	6430	900	690 x 690 x 198	533	645	120	32	4	90
TSF 10000/3000	6670	3000	10000	1500	7150	1000	745 x 745 x 197	619	690	120	33	4	100
TSF 11000/3300	7340	3300	11000	1650	7860	1100	760 x 760 x 216	709	705	130	34	4	100
TSF 12000/3600	8000	3600	12000	1800	8580	1200	805 x 805 x 206	763	750	130	36	4	100
TSF 13000/3900	8670	3900	13000	1950	9290	1300	820 x 820 x 214	843	775	140	37	4	100
TSF 14000/4200	9340	4200	14000	2100	10000	1400	870 x 870 x 214	955	825	140	39	4	100
TSF 15000/4500	10000	4500	15000	2250	10720	1500	895 x 895 x 223	1039	850	150	39	8	90
TSF 16000/4800	10670	4800	16000	2400	11430	1600	910 x 910 x 232	1124	865	150	41	8	90
TSF 17000/5100	11340	5100	17000	2550	12150	1700	980 x 980 x 233	1314	935	160	41	8	90
TSF 18000/5400	12000	5400	18000	2700	12860	1800	1025 x 1025 232	1442	980	160	43	8	90
TSF 19000/5700	12670	5700	19000	2850	13580	1900	1075 x 1075 233	1577	1020	180	41	8	100
TSF 20000/6000	13340	6000	20000	3000	14290	2000	1065 x 1065 251	1687	1010	190	43	8	100
TSF 22500/6300	15000	6300	22500	3150	16080	2100	1105 x 1105 249	1795	1050	190	44	8	100
TSF 25000/6600	16670	6600	25000	3300	17860	2200	1115 x 1115 x 268	1963	1060	190	45	8	100
TSF 27500/6900	18340	6900	27500	3450	19650	2300	1150 x 1150 x 277	2161	1095	200	45	8	100
TSF 30000/7200	20000	7200	30000	3600	21430	2400	1240 x 1240 x 257	2346	1185	200	45	8	100
TSF 32500/7500	21670	7500	32500	3750	23220	2500	1270 x 1270 x 275	2637	1215	210	45	8	100
TSF 35000/7800	23340	7800	35000	3900	25000	2600	1335 x 1335 x 275	2940	1290	210	47	8	100
TSF 37500/8200	25000	8200	37500	4100	26790	2740	1395 x 1395 x 275	3230	1350	220	47	8	100
TSF 40000/8600	26670	8600	40000	4300	28580	2870	1365 x 1365 x 302	3290	1300	220	49	8	120
TSF 45000/9000	30000	9000	45000	4500	32150	3000	1465 x 1465 x 301	3797	1400	230	49	8	120
TSF 50000/10000	33340	10000	50000	5000	35720	3340	1555 x 1555 x 321	4583	1490	240	52	8	120
TSF 55000/11000	36670	11000	55000	5500	39290	3670	1760 x 1760 x 291	5445	1705	250	54	12	100
TSF 60000/12000	40000	12000	60000	6000	42860	4000	1815 x 1815 x 309	6270	1770	260	57	12	100
TSF 65000/13000	43340	13000	65000	6500	46430	4340	1870 x 1870 x 317	6692	1750	270	59	8	130
TSF 70000/14000	46670	14000	70000	7000	50000	4670	1935 x 1935 x 325	7547	1890	280	61	14	100
TSF 75000/15000	50000	15000	75000	7500	53580	5000	1990 x 1990 x 343	8280	1925	290	63	12	120
TSF 80000/16000	53340	16000	80000	8000	57150	5340	2045 x 2045 x 362	9391	2000	300	65	16	100
TSF 90000/17000	60000	17000	90000	8500	64290	5670	2250 x 2250 x 352	10971	2205	310	66	16	100
TSF 100000/18000	66670	18000	100000	9000	71430	6000	2290 x 2290 x 378	12099	2225	320	68	14	120

# TSL LOW

## GUIDED SLIDING TENS SPHERICAL BEARINGS $V_{Sd-SEISM}/N_{Sd-SLU}=10\%$

BEARING	SEISMIC COMBINATION ULS		STATIC COMBINATION ULS		STATIC COMBINATION SLS		OVERALL SIZE	SLIDING PLATE PLAN DIMENSIONS	NET WEIGHT (ANCHORAGES EXCLUDED)	POT DIAMETER	CONCAVE PLATE DIAMETER	PIN DIAMETER	PIN PROTRUSION	BOTTOM ANCHOR DOWELS	
	$N_{Sd-Seism}$ (kN)	$V_{Sd-Seism}$ (kN)	$N_{Sd-ULS}$ (kN)	$V_{Sd-ULS}$ (kN)	$N_{Sd-SLS}$ (kN)	$V_{Sd-SLS}$ (kN)									$D' \times D' \times H_{tot}$ (mm)
TSL 500/50±50	340	50	500	25	360	20	230 x 230 x 119	190 x 290	38	230	185	20	8	2	30
TSL 1000/100±50	670	100	1000	50	720	40	270 x 270 x 127	230 x 330	56	270	225	30	9	2	30
TSL 1500/150±50	1000	150	1500	75	1080	50	325 x 325 x 124	280 x 380	78	325	280	30	11	4	30
TSL 2000/200±50	1340	200	2000	100	1430	70	350 x 350 x 129	305 x 405	94	350	305	30	12	4	30
TSL 2500/250±50	1670	250	2500	125	1790	90	380 x 380 x 143	330 x 430	122	380	330	40	12	4	30
TSL 3000/300±50	2000	300	3000	150	2150	100	420 x 420 x 129	375 x 475	136	420	375	40	13	4	30
TSL 3500/350±50	2340	350	3500	175	2500	120	420 x 420 x 147	370 x 470	153	420	370	40	15	4	30
TSL 4000/400±50	2670	400	4000	200	2860	140	440 x 440 x 157	390 x 490	179	440	390	50	14	4	40
TSL 4500/450±50	3000	450	4500	225	3220	150	455 x 455 x 155	410 x 510	192	455	410	50	15	4	40
TSL 5000/500±50	3340	500	5000	250	3580	170	500 x 500 x 146	450 x 550	218	500	450	50	16	4	40
TSL 6000/600±50	4000	600	6000	300	4290	200	525 x 525 x 170	480 x 580	291	525	480	60	16	4	50
TSL 7000/700±50	4670	700	7000	350	5000	240	555 x 555 x 179	495 x 595	333	555	495	60	18	4	50
TSL 8000/800±50	5340	800	8000	400	5720	270	570 x 570 x 187	520 x 620	372	570	520	60	20	4	50
TSL 9000/900±50	6000	900	9000	450	6430	300	630 x 630 x 178	570 x 670	436	630	570	70	19	4	60
TSL 10000/1000±50	6670	1000	10000	500	7150	340	665 x 665 x 187	595 x 695	499	665	595	70	21	4	60
TSL 11000/1100±50	7340	1100	11000	550	7860	370	685 x 685 x 201	615 x 715	571	685	615	70	22	4	60
TSL 12000/1200±50	8000	1200	12000	600	8580	400	740 x 740 x 191	660 x 760	624	740	660	80	21	4	60
TSL 13000/1300±50	8670	1300	13000	650	9290	440	725 x 725 x 209	655 x 755	672	725	655	80	23	4	70
TSL 14000/1400±50	9340	1400	14000	700	10000	470	760 x 760 x 210	675 x 775	724	760	675	80	24	4	70
TSL 15000/1500±50	10000	1500	15000	750	10720	500	835 x 835 x 205	735 x 835	849	835	735	90	23	4	70
TSL 16000/1600±50	10670	1600	16000	800	11430	540	845 x 845 x 215	755 x 855	923	845	755	90	24	4	70
TSL 17000/1700±50	11340	1700	17000	850	12150	570	850 x 850 x 223	755 x 855	957	850	755	90	26	4	70
TSL 18000/1800±50	12000	1800	18000	900	12860	600	895 x 895 x 232	785 x 885	1120	895	785	90	27	4	90
TSL 19000/1900±50	12670	1900	19000	950	13580	640	905 x 905 x 232	805 x 905	1156	905	805	100	26	4	90
TSL 20000/2000±50	13340	2000	20000	1000	14290	670	900 x 900 x 251	795 x 895	1212	900	795	100	27	4	90
TSL 22500/2250±50	15000	2250	22500	1125	16080	750	940 x 940 x 258	830 x 930	1357	940	830	100	29	4	90
TSL 25000/2500±50	16670	2500	25000	1250	17860	840	985 x 985 x 27278	870 x 970	1594	985	870	110	30	4	90
TSL 27500/2750±50	18340	2750	27500	1375	19650	920	1045 x 1045 x 280	925 x 1025	1811	1045	925	120	30	4	90
TSL 30000/3000±50	20000	3000	30000	1500	21430	1000	1185 x 1185 x 258	1030 x 1130	2117	1185	1030	120	32	4	100
TSL 32500/3250±50	21670	3250	32500	1625	23220	1090	1120 x 1120 x 297	995 x 1095	2217	1120	995	130	32	4	100
TSL 35000/3500±50	23340	3500	35000	1750	25000	1170	1245 x 1245 x 288	1090 x 1190	2633	1245	1090	130	34	4	100
TSL 37500/3750±50	25000	3750	37500	1875	26790	1250	1270 x 1270 x 307	1120 x 1220	2924	1270	1120	140	34	4	100
TSL 40000/4000±50	26670	4000	40000	2000	28580	1340	1315 x 1315 x 306	1145 x 1245	3094	1315	1145	140	36	4	100
TSL 45000/4500±50	30000	4500	45000	2250	32150	1500	1380 x 1380 x 315	1200 x 1300	3489	1380	1200	150	37	8	90
TSL 50000/5000±50	33340	5000	50000	2500	35720	1670	1445 x 1445 x 343	1255 x 1355	4146	1445	1255	160	39	8	90
TSL 55000/5500±50	36670	5500	55000	2750	39290	1840	1500 x 1500 x 353	1300 x 1400	4550	1500	1300	180	38	8	90
TSL 60000/6000±50	40000	6000	60000	3000	42860	2000	1640 x 1640 x 340	1415 x 1515	5304	1640	1415	190	39	8	100
TSL 65000/6500±50	43340	6500	65000	3250	46430	2170	1620 x 1620 x 390	1385 x 1485	5817	1620	1385	190	44	8	100
TSL 70000/7000±50	46670	7000	70000	3500	50000	2340	1670 x 1670 x 409	1425 x 1525	6441	1670	1425	200	45	8	100
TSL 75000/7500±50	50000	7500	75000	3750	53580	2500	1720 x 1720 x 419	1465 x 1565	6946	1720	1465	210	45	8	100
TSL 80000/8000±50	53340	8000	80000	4000	57150	2670	1860 x 1860 x 396	1580 x 1680	7695	1860	1580	210	48	8	100
TSL 90000/9000±50	60000	9000	90000	4500	64290	3000	1855 x 1855 x 475	1580 x 1680	9138	1855	1580	230	49	8	120
TSL 100000/10000±50	66670	10000	100000	5000	71430	3340	2030 x 2030 x 472	1735 x 1835	10965	2030	1735	240	52	8	120

# TSL HIGH

## GUIDED SLIDING TENS SPHERICAL BEARINGS $V_{Sd-SEISM}/N_{Sd-SLU}=30\%$

BEARING	SEISMIC COMBINATION ULS		STATIC COMBINATION ULS		STATIC COMBINATION SLS		OVERALL SIZE	SLIDING PLATE PLAN DIMENSIONS	NET WEIGHT (ANCHORAGES EXCLUDED)	POT DIAMETER	CONCAVE PLATE DIAMETER	PIN DIAMETER	PIN PROTRUSION	BOTTOM ANCHOR DOWELS	
	$N_{Sd-Seism}$ (kN)	$V_{Sd-Seism}$ (kN)	$N_{Sd-ULS}$ (kN)	$V_{Sd-ULS}$ (kN)	$N_{Sd-SLS}$ (kN)	$V_{Sd-SLS}$ (kN)									$D' \times D' \times H_{tot}$ (mm)
TSL 500/150±50	340	150	500	75	360	50	235 x 235 x 119	210 x 310	43	235	190	30	11	4	30
TSL 1000/300±50	670	300	1000	150	720	100	295 x 295 x 133	265 x 365	76	295	250	40	13	4	30
TSL 1500/450±50	1000	450	1500	225	1080	150	330 x 330 x 145	305 x 405	105	330	285	50	15	4	40
TSL 2000/600±50	1340	600	2000	300	1430	200	355 x 355 x 159	335 x 435	136	355	315	60	16	4	50
TSL 2500/750±50	1670	750	2500	375	1790	250	385 x 385 x 157	360 x 460	156	385	340	60	19	4	50
TSL 3000/900±50	2000	900	3000	450	2150	300	415 x 415 x 166	385 x 485	193	415	365	70	19	4	60
TSL 3500/1050±50	2340	1050	3500	525	2500	350	495 x 495 x 156	420 x 520	236	495	420	70	21	4	60
TSL 4000/1200±50	2670	1200	4000	600	2860	400	500 x 500 x 193	440 x 540	304	500	420	80	21	4	60
TSL 4500/1350±50	3000	1350	4500	675	3220	450	545 x 545 x 193	460 x 560	357	545	455	80	23	4	70
TSL 5000/1500±50	3340	1500	5000	750	3580	500	545 x 545 x 204	480 x 580	384	545	460	90	23	4	70
TSL 6000/1800±50	4000	1800	6000	900	4290	600	590 x 590 x 232	520 x 620	524	590	500	90	27	4	90
TSL 7000/2100±50	4670	2100	7000	1050	5000	700	660 x 660 x 232	560 x 660	613	660	540	100	28	4	90
TSL 8000/2400±50	5340	2400	8000	1200	5720	800	695 x 695 x 241	590 x 690	692	695	570	110	29	4	90
TSL 9000/2700±50	6000	2700	9000	1350	6430	900	775 x 775 x 241	610 x 710	790	775	600	120	29	4	90
TSL 10000/3000±50	6670	3000	10000	1500	7150	1000	805 x 805 x 250	655 x 755	934	805	635	120	32	4	100
TSL 11000/3300±50	7340	3300	11000	1650	7860	1100	800 x 800 x 258	680 x 780	998	800	660	130	32	4	100
TSL 12000/3600±50	8000	3600	12000	1800	8580	1200	905 x 905 x 249	700 x 800	1100	905	690	130	35	4	100
TSL 13000/3900±50	8670	3900	13000	1950	9290	1300	895 x 895 x 268	725 x 825	1213	895	705	140	35	4	100
TSL 14000/4200±50	9340	4200	14000	2100	10000	1400	965 x 965 x 268	755 x 855	1361	965	735	140	37	4	100
TSL 15000/4500±50	10000	4500	15000	2250	10720	1500	970 x 970 x 277	780 x 880	1471	970	760	150	37	8	90
TSL 16000/4800±50	10670	4800	16000	2400	11430	1600	1005 x 1005 x 275	800 x 900	1549	1005	780	150	39	8	90
TSL 17000/5100±50	11340	5100	17000	2550	12150	1700	1015 x 1015 x 304	825 x 925	1762	1015	805	160	39	8	90
TSL 18000/5400±50	12000	5400	18000	2700	12860	1800	1065 x 1065 x 315	855 x 955	1982	1065	835	160	43	8	90
TSL 19000/5700±50	12670	5700	19000	2850	13580	1900	1100 x 1100 x 324	875 x 975	2172	1100	855	180	41	8	100
TSL 20000/6000±50	13340	6000	20000	3000	14290	2000	1140 x 1140 x 314	890 x 990	2208	1140	870	190	40	8	100
TSL 22500/6300±50	15000	6300	22500	3150	16080	2100	1170 x 1170 x 341	930 x 1030	2556	1170	910	190	42	8	100
TSL 25000/6600±50	16670	6600	25000	3300	17860	2200	1200 x 1200 x 341	960 x 1060	2689	1200	940	190	44	8	100
TSL 27500/6900±50	18340	6900	27500	3450	19650	2300	1260 x 1260 x 349	995 x 1095	2959	1260	975	200	44	8	100
TSL 30000/7200±50	20000	7200	30000	3600	21430	2400	1385 x 1385 x 328	1035 x 1135	3202	1385	1035	200	45	8	100
TSL 32500/7500±50	21670	7500	32500	3750	23220	2500	1400 x 1400 x 348	1065 x 1165	3507	1400	1065	210	45	8	100
TSL 35000/7800±50	23340	7800	35000	3900	25000	2600	1455 x 1455 x 357	1095 x 1195	3847	1455	1095	210	47	8	100
TSL 37500/8200±50	25000	8200	37500	4100	26790	2740	1470 x 1470 x 377	1120 x 1220	4173	1470	1120	220	47	8	100
TSL 40000/8600±50	26670	8600	40000	4300	28580	2870	1530 x 1530 x 386	1150 x 1250	4616	1530	1150	220	49	8	120
TSL 45000/9000±50	30000	9000	45000	4500	32150	3000	1580 x 1580 x 394	1205 x 1305	5051	1580	1205	230	49	8	120
TSL 50000/10000±50	33340	10000	50000	5000	35720	3340	1665 x 1665 x 413	1260 x 1360	5792	1665	1260	240	52	8	120
TSL 55000/11000±50	36670	11000	55000	5500	39290	3670	1740 x 1740 x 442	1330 x 1430	6675	1740	1310	250	54	12	100
TSL 60000/12000±50	40000	12000	60000	6000	42860	4000	1795 x 1795 x 460	1380 x 1480	7448	1795	1360	260	57	12	100
TSL 65000/13000±50	43340	13000	65000	6500	46430	4340	1875 x 1875 x 480	1445 x 1545	8596	1875	1425	270	59	8	130
TSL 70000/14000±50	46670	14000	70000	7000	50000	4670	1925 x 1925 x 497	1490 x 1590	9297	1925	1470	280	61	14	100
TSL 75000/15000±50	50000	15000	75000	7500	53580	5000	2065 x 2065 x 495	1550 x 1650	10483	2065	1550	290	63	12	120
TSL 80000/16000±50	53340	16000	80000	8000	57150	5340	2125 x 2125 x 506	1595 x 1695	11235	2125	1590	300	65	16	100
TSL 90000/17000±50	60000	17000	90000	8500	64290	5670	2225 x 2225 x 531	1670 x 1770	12924	2225	1670	310	66	16	100
TSL 100000/18000±50	66670	18000	100000	9000	71430	6000	2275 x 2275 x 559	1740 x 1840	14465	2275	1740	320	68	14	120

# TSM

## FREE SLIDING TENS SPHERICAL BEARINGS V $N_{Sd-SEISM} / N_{Sd-SLU} = 10\%$

BEARING	SEISMIC COMBINATION ULS	STATIC COMBINATION ULS	STATIC COMBINATION SLS	OVERALL SIZE	SLIDING PLATE PLAN DIMENSIONS	NET WEIGHT (ANCHORAGES EXCLUDED)	CONCAVE PLATE DIAMETER	PIN DIAMETER	PIN PROTRUSION	BOTTOM ANCHOR DOWELS	
	$N_{Sd-Seism}$ (kN)	$N_{Sd-ULS}$ (kN)	$N_{Sd-SLS}$ (kN)								Do x Do x Htot (mm)
TSM 500/±50/±20	340	500	360	155 x 155 x 77	230 x 290	21	155	30	6	2	30
TSM 1000/±50/±20	670	1000	720	195 x 195 x 84	270 x 330	31	195	30	6	2	30
TSM 1500/±50/±20	1000	1500	1080	240 x 240 x 78	325 x 385	43	240	30	7	2	30
TSM 2000/±50/±20	1340	2000	1430	265 x 265 x 80	350 x 410	50	265	30	7	2	30
TSM 2500/±50/±20	1670	2500	1790	290 x 290 x 91	375 x 435	68	290	30	7	2	30
TSM 3000/±50/±20	2000	3000	2150	325 x 325 x 85	420 x 480	80	325	30	8	2	30
TSM 3500/±50/±20	2340	3500	2500	330 x 330 x 99	415 x 475	90	330	30	8	2	30
TSM 4000/±50/±20	2670	4000	2860	350 x 350 x 105	435 x 495	103	350	30	8	2	30
TSM 4500/±50/±20	3000	4500	3220	380 x 380 x 103	475 x 535	125	380	30	9	2	30
TSM 5000/±50/±20	3340	5000	3580	395 x 395 x 101	490 x 550	132	395	30	9	2	30
TSM 6000/±50/±20	4000	6000	4290	425 x 425 x 106	520 x 580	155	425	30	10	2	30
TSM 7000/±50/±20	4670	7000	5000	465 x 465 x 109	565 x 625	195	465	30	10	2	30
TSM 8000/±50/±20	5340	8000	5720	490 x 490 x 111	590 x 650	216	490	30	11	2	30
TSM 9000/±50/±20	6000	9000	6430	515 x 515 x 117	615 x 675	247	515	30	12	2	30
TSM 10000/±50/±20	6670	10000	7150	565 x 565 x 111	685 x 745	297	565	30	12	2	40
TSM 11000/±50/±20	7340	11000	7860	575 x 575 x 123	685 x 745	327	575	40	11	2	40
TSM 12000/±50/±20	8000	12000	8580	595 x 595 x 130	705 x 765	363	595	40	12	2	40
TSM 13000/±50/±20	8670	13000	9290	630 x 630 x 123	745 x 805	399	630	40	12	2	40
TSM 14000/±50/±20	9340	14000	10000	635 x 635 x 135	745 x 805	430	635	40	13	2	40
TSM 15000/±50/±20	10000	15000	10720	665 x 665 x 134	780 x 840	469	665	40	13	2	50
TSM 16000/±50/±20	10670	16000	11430	680 x 680 x 137	795 x 855	497	680	40	14	2	50
TSM 17000/±50/±20	11340	17000	12150	695 x 695 x 140	810 x 870	539	695	40	14	2	50
TSM 18000/±50/±20	12000	18000	12860	715 x 715 x 152	830 x 890	606	715	40	15	2	50
TSM 19000/±50/±20	12670	19000	13580	735 x 735 x 149	850 x 910	628	735	40	15	2	50
TSM 20000/±50/±20	13340	20000	14290	785 x 785 x 138	925 x 985	700	785	50	14	2	50
TSM 22500/±50/±20	15000	22500	16080	825 x 825 x 149	965 x 1025	814	825	50	15	2	60
TSM 25000/±50/±20	16670	25000	17860	860 x 860 x 15155	1000 x 1060	943	860	50	16	2	60
TSM 27500/±50/±20	18340	27500	19650	880 x 880 x 17176	970 x 1030	986	880	50	17	2	60
TSM 30000/±50/±20	20000	30000	21430	930 x 930 x 172	1070 x 1130	1176	930	60	16	2	60
TSM 32500/±50/±20	21670	32500	23220	960 x 960 x 17179	1100 x 1160	1282	960	60	17	2	60
TSM 35000/±50/±20	23340	35000	25000	1000 x 1000 x 175	1130 x 1190	1341	1000	60	18	4	50
TSM 37500/±50/±20	25000	37500	26790	1065 x 1065 x 185	1235 x 1295	1689	1065	60	19	4	50
TSM 40000/±50/±20	26670	40000	28580	1090 x 1090 x 183	1260 x 1320	1742	1090	60	19	4	50
TSM 45000/±50/±20	30000	45000	32150	1150 x 1150 x 196	1320 x 1380	2039	1150	70	19	4	60
TSM 50000/±50/±20	33340	50000	35720	1200 x 1200 x 222	1295 x 1355	2282	1200	70	20	4	60
TSM 55000/±50/±20	36670	55000	39290	1260 x 1260 x 216	1415 x 1475	2628	1260	70	22	4	60
TSM 60000/±50/±20	40000	60000	42860	1320 x 1320 x 220	1460 x 1520	2867	1320	80	21	4	60
TSM 65000/±50/±20	43340	65000	46430	1375 x 1375 x 235	1500 x 1560	3224	1375	80	23	4	60
TSM 70000/±50/±20	46670	70000	50000	1430 x 1430 x 249	1535 x 1595	3685	1430	80	24	4	70
TSM 75000/±50/±20	50000	75000	53580	1480 x 1480 x 253	1585 x 1645	3973	1480	90	23	4	70
TSM 80000/±50/±20	53340	80000	57150	1530 x 1530 x 268	1620 x 1680	4395	1530	90	24	4	70
TSM 90000/±50/±20	60000	90000	64290	1625 x 1625 x 286	1700 x 1760	5279	1625	90	27	4	90
TSM 100000/±50/±20	66670	100000	71430	1715 x 1715 x 305	1770 x 1830	6104	1715	100	28	4	90



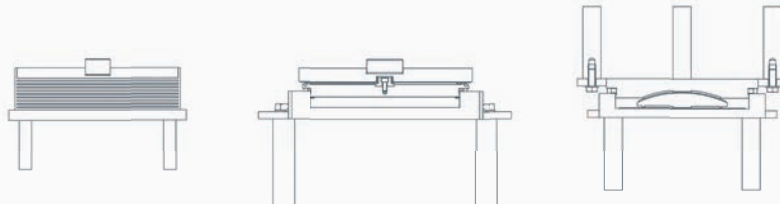
---

# 06

---

## GENERAL PROVISIONS AND PRACTICES

An overlook of the regulations and the operational  
procedures that warrant the efficiency  
of our bearing systems





## ANTICORROSIVE TREATMENT

---

In order to guarantee the requested degree of protection from atmospheric agents, the steel elements are expected to undergo a protective cycle, according to the EN 1337-9 requirements. In case certain projects or specifications require a higher corrosion resistance, a different cycle in compliance with ISO 12944 can be considered.

## STORAGE AND HANDLING

---

Bearings must always be handled with particular care in order to avoid possible damage (for the lifting it is recommended to use bandages, thus avoiding contact with wires and steel chains or other materials).

If bearings are not immediately installed upon arrival on site, the client shall store them appropriately and protect them from collisions, humidity, heat sources and any other possible conditions that do not comply with TENSA's storage procedures.

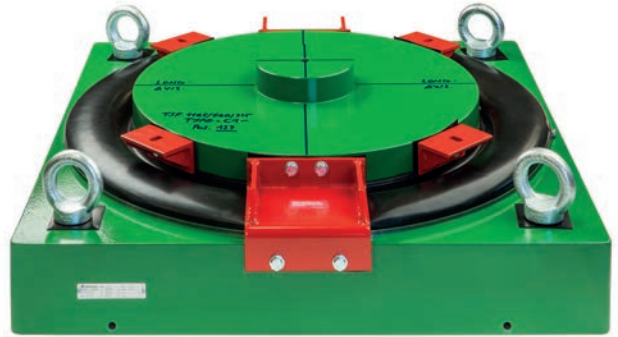
## INSPECTION AND MAINTENANCE

---

The standards protocol calls for the first inspection after one year from the installation. Subsequent periodic inspections shall be performed every 5 years unless in the meantime the structure experiences seismic events. In this case an additional inspection is required. The inspection form prepared by TENSA must be filled out with care and in the case of any deviation from the acceptable parameters the supplier shall be immediately informed for a more accurate check of the bearing. The periodic inspection allows the assessment of the correct (or incorrect) behavior of the bearing in relation to the geometry taken on due to acting loads and to control the state of anticorrosive protection with the possibility of intervention with localized touch ups. During inspections the following properties should be controlled:

- sufficient residual motion capability, bearing in mind the structure's temperature;
- visible defects: cracking, incorrect positioning, unexpected movements and deformations;
- condition of sealing and fastening;
- condition of anticorrosive protection, dust covers and seals;
- condition of sliding surfaces;
- visible defects of the adjacent structural parts.

# ANCHORAGE



As far as the choice of anchorage is concerned, one must refer to the EN 1337-1 Standard, which expects the bearings to be mechanically linked to the structure in at least one of the following situations:

CASE I: When the structure undergoes dynamic stresses with possible extreme load fluctuations, for example in case of seismic action or in railway bridges, friction must not exert resistance against lateral forces.

CASE II: When the non-sliding condition does not happen at ULS, namely when the following inequality is not being checked

$$V_{Ed} \leq V_{Rd}$$

with

$V_{Ed}$  = design shear force

$V_{Rd} = \frac{\mu_k \cdot N_{Sd} + V_{pd}}{\gamma_{\mu}}$  = design value of the shear strength

where

$N_{Ed}$  = minimum design force acting perpendicularly to the contact surface

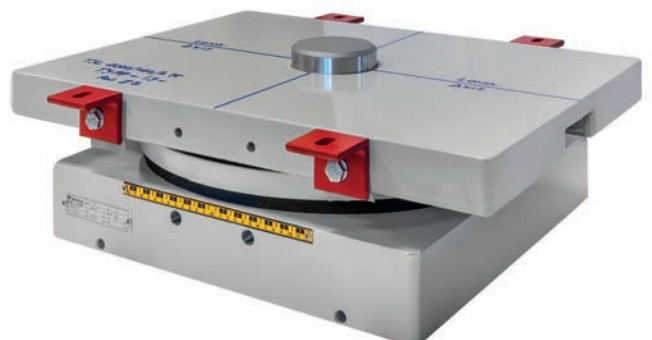
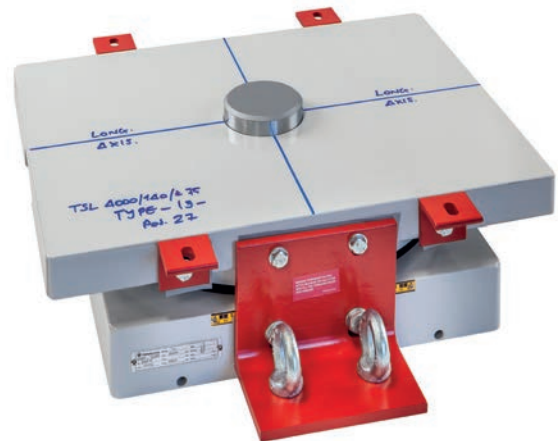
$V_{pd}$  = design strength of all mechanical fastening devices

$\mu_k$  = characteristic value of the friction coefficient (0.4 steel on steel, 0.6 steel on concrete)

$\gamma_{\mu}$  = partial safety factor for friction (2.0 steel on steel, 1.2 steel on concrete)

In bearing devices with mechanical anchorage, lateral loads are commonly transmitted to the structure through one of the following systems:

- Screws. Shear passes directly in the used screw. This solution minimizes the lifting of the structure during substitution;
- Embedded screws and dowels. The shear-resistant section is the one of the used dowels and not of the screw; it is able to transfer a greater force by limiting the dimensions of the screws and dowels;
- Steel pins. The shear-resistant section is that of the pin. Where usable, it allows a more rapid installation.



---

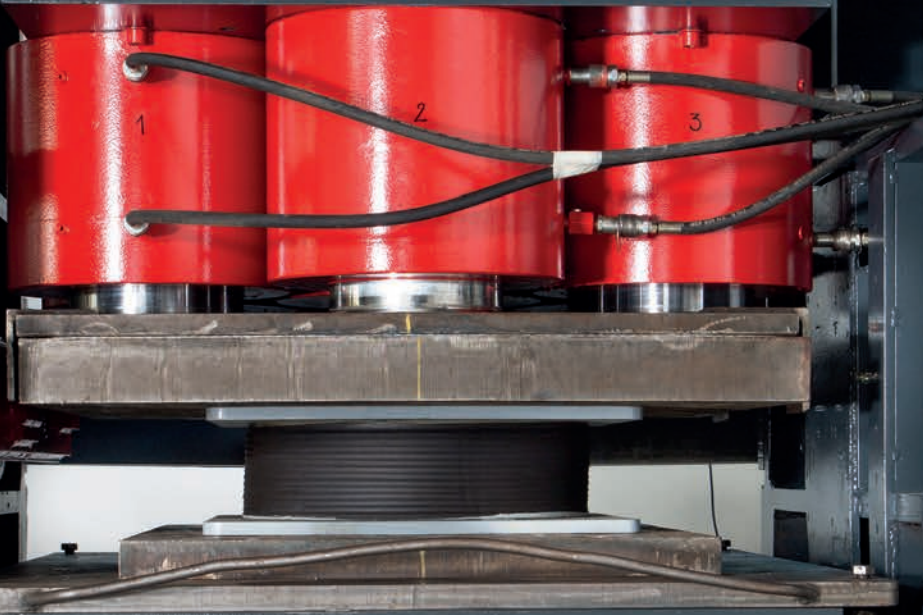
Train line viaduct, Oued Tlélat-Tlemcen (Algeria)







# TENSA



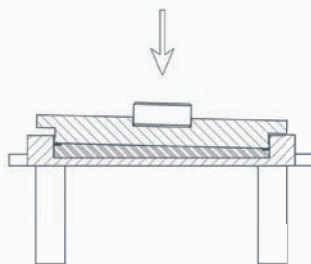
---

# 07

---

## QUALITY AND TESTING

Testing and control are fundamental processes  
that guarantee our clients the quality  
and efficiency of our bearings



# QUALITY AND CONTROL

Bearings are produced according to the EN ISO 9001:2008 quality system and to what is further agreed with the contractor.

The whole design and production process linked to CE marked bearing (EN 1337-2, EN 1337-3, EN 1337-5, EN 1337-7) is being controlled through operating instructions, quality control plans and quality registration documents (FPC - Factory Production Control). In particular, controls on raw materials, production and finishing parameters ensure that all delivered products meet the requested provision as far as expected performances, quality and durability are concerned.

Moreover TENSA is being regularly inspected by independent certification bodies.

For products manufactured under the requirements of EN 1337-3, EN 1337-5 and EN 1337-7, bearings are accompanied by the declaration of constancy of performance in accordance with the CPR 305/2011.

In the case of non CE marked products, TENSA will provide, along with the bearings, a declaration of conformity to the requirements of the standard adopted for the design and production.

# CE MARKING AND OTHER STANDARDS

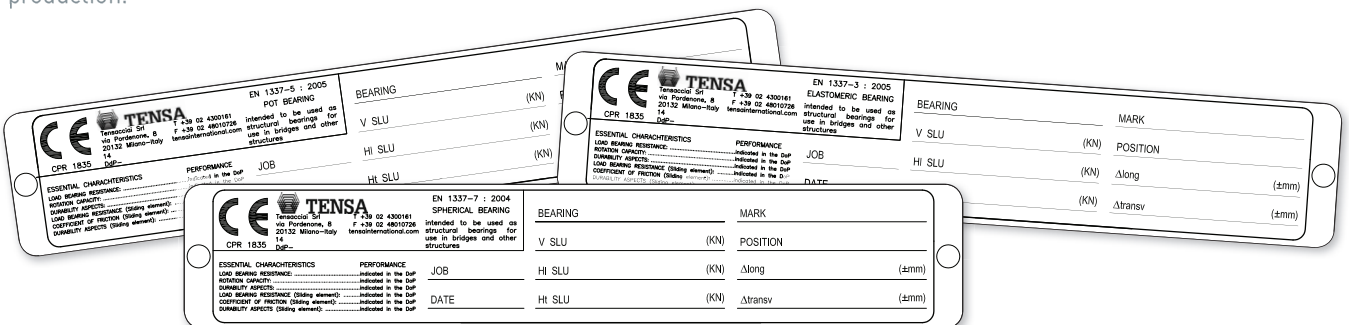
For EU market, TR, TP and TS bearings are designed and produced by TENSA in accordance with the European EN 1337 regulations and decrees.



Traceability and information on each individual bearing manufactured is always guaranteed.

Bearings are provided with an aluminum nameplate that conveys the following indications:

- certification body's identification number;
- name or identification brand of the producer;
- registered address of the producer;
- the last two digits of the year when the Certification was obtained,
- number of the Certificate of Conformity;
- number of the Declaration of Constancy of Performance;
- reference to the current European Standard;
- product description: generic name, materials, dimensions and intended use.



Alternatively, TENSA is able to design and produce bearings in accordance with any applicable international code, including AASHTO LRFD Bridge Design Specification, BS 5400, DIN 4141, SETRA, FEMA, ASCE, etc. and/or according to particular project specifications.

# TESTING AND LABORATORY

---

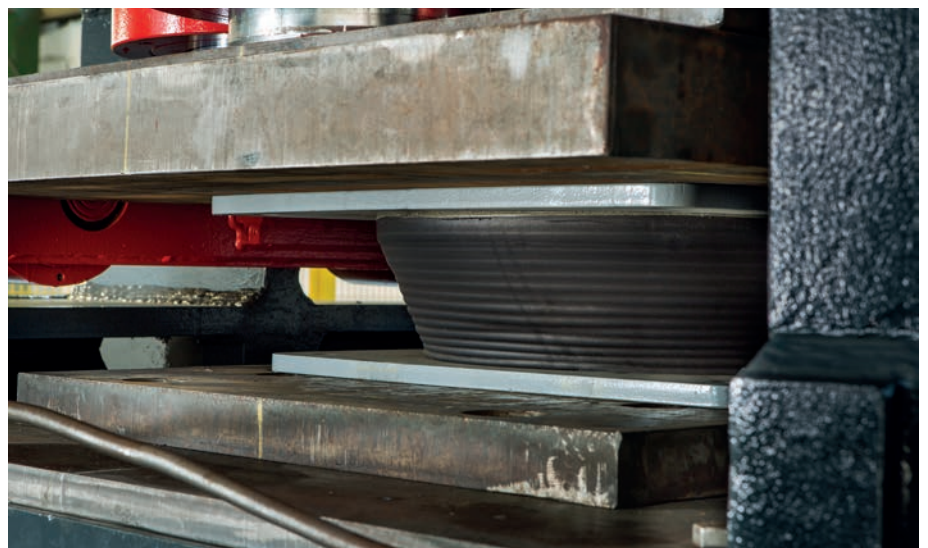
Some standards (AASHTO LRFD, ASCE, ...) require the experimental evidence of the bearing's properties and performances. The purpose of testing is to ensure the good quality of the manufactured bearings. The requested tests can be carried out in the internal laboratory: TENSA has the necessary equipments, personnel and skills.

TENSA laboratory is provided with a series of jacks with different load and stroke capacities. The testing equipment reaches a vertical load capacity of 35000 kN, an horizontal load capacity of 2000 kN and a displacement of +/- 200 mm. The output data are processed by the Technical Department thanks to an ad-hoc software.



Compression stiffness test on rubber bearing

Horizontal stiffness test on rubber bearing







---

# 08

---

## INSTALLATION AND REPLACEMENT

The installation methods are conceived starting from the first phases of the bearing design



# SETUP PROCEDURES

---

For the installation of bearings, it is recommended to stick to TENSA's provisions. In general, bearings should be installed in accordance with the indications reported on them that indicate the direction of the installation, as well as possible presets.

Bearings need to be always horizontally positioned. In the case of sloping decks, it is recommended, in any case, to contact TENSA's Technical Department in order to find the most suitable solutions in relation to design requirements (steel wedges, resin prisms, compensatory casting etc.).

It is quite common to use upper and lower anchorage systems, such as steel dowels linked to the bearing through screws that allow any replacement or pins placed in either cavities inside the structure or in preventively positioned masonry plates. The link to the structure, if allowed by the regulations and the design, can also be done through bedding and bonding with epoxy resin.

Listed below are the most common setup procedures:

## **BEARING INSTALLATION IN A BRIDGE WITH PREFABRICATED BEAMS:**

- Reinforcement of the plinth with positioning of perforated sheaths (such as those used for post tensioning) or polystyrene in order to create space for anchor bolts;
- Casting of the plinth;
- Positioning of bearings by inserting the dowels in the spaces but without grouting;
- Positioning of the prefabricated beam (or steel beam) and fixing of the bearing to the beam (to achieve this there will have to be a steel plate inside the beam in order to link the bearing). In this phase the load is still on the crane used to move the beam;
- Transfer of the load from the crane to the bearing ;
- Grouting of anchor dowels.

## **IN THE CASE OF STEEL BEAMS IT IS COMMON TO ADD AN UPPER PLATE, AS EXPLAINED BELOW:**

- Reinforcement of the plinth with positioning of perforated sheaths (such as those used in post tensioning) or polystyrene in order to create space for anchor bolts;
- Casting of the plinth;
- Positioning of bearings provided with upper plate previously positioned and insertion of dowels in the spaces obtained in the plinth;
- Positioning of the metallic beam with transfer of loads to the bearings;
- Grouting of dowels;
- Welding of the plate to the steel beam;
- Local varnishing in order to restore the anticorrosive protection.

## **BEARING INSTALLATION IN CAST IN SITU STRUCTURES:**

- Reinforcement of the plinth with positioning of perforated sheaths (like those used in post tensioning) or polystyrene in order to create space for anchor bolts;
- Casting of the plinth;
- Positioning and insertion of bearings in the dedicated spaces ;
- Positioning of formworks and scaffolding deck;
- Casting of the deck;
- Grouting of anchor dowels.

## BEARING INSTALLATION IN STRUCTURES BUILT ON TEMPORARY STEEL SHIMS:

- Reinforcement of the plinth with positioning of perforated sheaths (like those used in post tensioning) or polystyrene in order to create space for anchor bolts;
- Casting of the plinth a few cm below the design level;
- Positioning of a lower metallic plate with anchor dowels, but without grouting;
- Realization or positioning of the deck on temporary steel shims at its definite level;
- Insertion and linking of bearings to the metallic lower plate and then to the deck (the bearing reaches perfect flatness by means of wooden wedges that have to be positioned between the plinth and the beam);
- Preparation of a formwork on the plinth in order to proceed with the contextual grouting of dowels and mortar bedding of the bearing;
- Once the bedding casting has reached the minimum design strength, the load can be transferred from temporary steel shims to the bearings.

Once the installation is completed, the temporary fixing plates will have to be removed. Such plates have the sole aim of maintaining the bearing bundled for displacement, transport and installation.

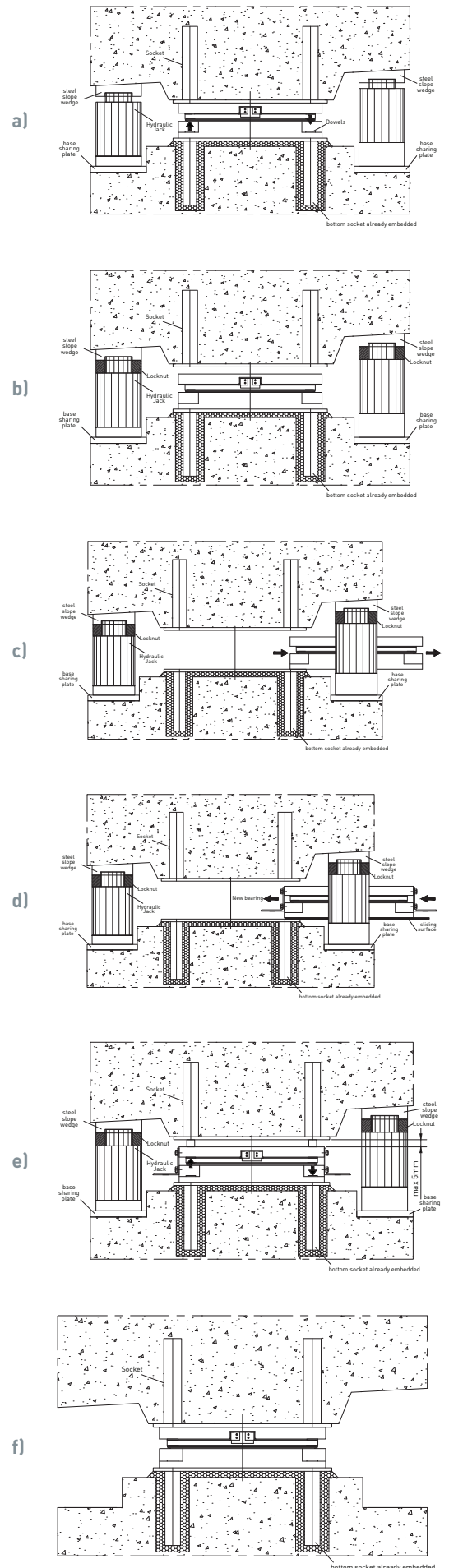
## REPLACEMENT

A deck lifting is required to replace the bearing. It can be variable from a few millimeters up to 3-4 centimeters and it depends on the type of anchorages and on the type of structures.

Lifting is obtained by hydraulic jacks located in an appropriate position defined by the structures' designer.

For a 'standard' replacement of a bearing with upper and bottom dowels/bolts the following phases are necessary:

- Positioning of the hydraulic jacks and displacement transducers and removal of dowels/bolts from upper and bottom sockets
- Deck lifting in movement control in order to release the bearing and locking of the jacks' collar for safety reasons
- Bearing removal, surface cleaning and check for perfect horizontality
- Placement of the new bearing using a sliding surface or similar for an easier installation
- Placement of the upper anchorages centering the upper embedded sockets followed by the placement of the bottom ones
- Unloading of the the jacks until the transfer of the vertical load to the new bearing, removal of the jacks and the bearing's temporary fixing and final check of the tightness of the bolts.



Jamal Abdul Nasser Street,  
Kuwait City (Kuwait)





# TENSA AROUND THE WORLD

---

## TENSA HEADQUARTERS

### TENSA – HEAD OFFICE

Via Pordenone, 8  
20132 Milano - ITALY  
T +39 02 4300161  
F +39 02 48010726  
[mail@tensainternational.com](mailto:mail@tensainternational.com)

### TENSA – ROME OFFICE

Via Cremona, 15b  
00161 Roma - ITALY  
T +39 06 8084621  
F +39 06 8085427  
[mail@tensainternational.com](mailto:mail@tensainternational.com)

### TENSA – WORKSHOP

Via Buttrio, 36  
33050 Pozzuolo del Friuli (UD) - ITALY  
T +39 0432 6071  
[mail@tensainternational.com](mailto:mail@tensainternational.com)

## BRANCHES

### TENSA AMERICA LLC

1111 Kane Concourse, S.te 200  
Bay Harbor Island – 33154 FL  
T +1 305 8669917  
[mail@tensaamerica.com](mailto:mail@tensaamerica.com)  
[www.tensaamerica.com](http://www.tensaamerica.com)

### TENSA INDIA

Private LTD, India  
K-71, Lokmanya Pan Bazar,  
Chunabhathi,  
Mumbai 400021  
M + 91 98 70793974  
[www.tensaindia.com](http://www.tensaindia.com)

### TENSA RUSSIA

5th Yamskogo Polya Street, 5  
Bldg 1, 16th Floor  
125040 Moscow  
T +7 495 2300024  
[mail@tensarussia.com](mailto:mail@tensarussia.com)  
[www.tensarussia.com](http://www.tensarussia.com)





#### TENSA PORTUGAL

Constr. Civil e Obras Publicas  
Rua Eng. Frederico Ulrich, 3210-3  
Sala 314  
4470-605 Moreira da Maia  
T +351 229416633  
F +351 229415151  
[mail@tensainternational.com](mailto:mail@tensainternational.com)  
[www.tensainternational.com](http://www.tensainternational.com)

#### TENSA AUSTRALIA

Level 1, 488 Botany Road  
Alexandria, NSW 2015  
T +61 2 8332 6151  
F +61 2 8332 6101  
[mail@tensainternational.com](mailto:mail@tensainternational.com)  
[www.tensainternational.com](http://www.tensainternational.com)

#### TENSA MIDDLE EAST

RAKIA Business Center 5  
Building A4, floor 12, office 1209  
T +971 72432888  
[mail@tensainternational.com](mailto:mail@tensainternational.com)  
[www.tensainternational.com](http://www.tensainternational.com)





**TENSA**

**Via Pordenone, 8  
20132 Milano, Italy**

**T +39 02 4300161**

**F +39 02 48010726**

**mail@tensainternational.com**

**www.tensainternational.com**