DEVICES WITH CE MARKING

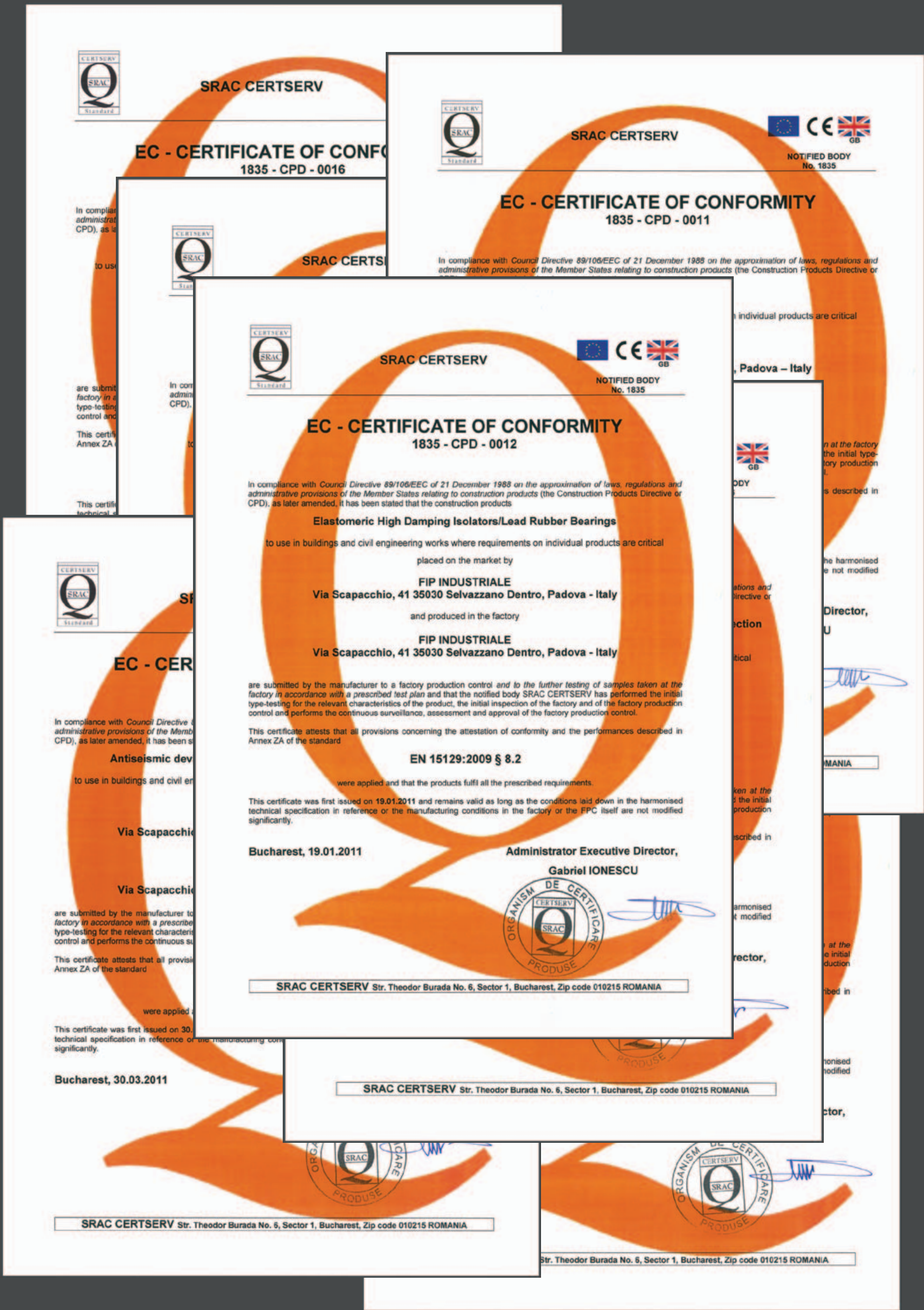
CE

ELASTOMERIC ISOLATORS

FIP INDUSTRIALE

ELASTOMERIC ISOLATORS series SI

S02



SRAC CERTSERV

NOTIFIED BODY No. 1835

EC - CERTIFICATE OF CONFORMITY

1835 - CPD - 0012

In compliance with *Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products* (the Construction Products Directive or CPD), as later amended, it has been stated that the construction products

Elastomeric High Damping Isolators/Lead Rubber Bearings

to use in buildings and civil engineering works where requirements on individual products are critical

placed on the market by

FIP INDUSTRIALE
Via Scapacchio, 41 35030 Selvazzano Dentro, Padova - Italy

and produced in the factory

FIP INDUSTRIALE
Via Scapacchio, 41 35030 Selvazzano Dentro, Padova - Italy

are submitted by the manufacturer to a factory production control *and to the further testing of samples taken at the factory in accordance with a prescribed test plan* and that the notified body SRAC CERTSERV has performed the initial type-testing for the relevant characteristics of the product, the initial inspection of the factory and of the factory production control and performs the continuous surveillance, assessment and approval of the factory production control.

This certificate attests that all provisions concerning the attestation of conformity and the performances described in Annex ZA of the standard

EN 15129:2009 § 8.2

were applied and that the products fulfil all the prescribed requirements.

This certificate was first issued on **19.01.2011** and remains valid as long as the conditions laid down in the harmonised technical specification in reference or the manufacturing conditions in the factory or the FPC itself are not modified significantly.

Bucharest, 19.01.2011

Administrator Executive Director,
Gabriel IONESCU

SRAC CERTSERV Str. Theodor Burada No. 6, Sector 1, Bucharest, Zip code 010215 ROMANIA

INTRODUCTION

CERTIFICATIONS

In 1992, **FIP Industriale** secured CISQ-ICIM certification for its Quality Assurance System in conformance with EN 29001 European Standard (ISO 9001).

FIP Industriale is proud to be the first Italian manufacturer of structural bearings, anti-seismic devices and expansion joints boasting a Quality Assurance System certified at the highest level - from design to customer service assistance.

Certification has been achieved via rigorous evaluation by an internationally recognized Third Party Organisation, thus internationally validating the quality assurance system.

ISO 9001 - Cert. N. 0057

In the framework of the enforcement of the European Construction Products Directive, **FIP Industriale** has gained the CE marking of different types of anti-seismic devices, including elastomeric isolators, in accordance with the harmonised European Standard EN 15129:2009 *Anti-seismic devices*.

DESCRIPTION

The series **SI** elastomeric isolators are reinforced rubber bearings made up of alternating layers of steel laminates and hot-vulcanized rubber. Usually, they are circular in shape but can be fabricated in square or rectangular section as well.

These devices are characterised by low horizontal stiffness, high vertical stiffness and a suitable damping capacity. These characteristics permit, respectively, to increase the fundamental period of vibration of the structure, to resist to vertical loads without appreciable settling, and to limit horizontal displacements in seismically isolated structures.

The fundamental design parameters used to determine vertical and horizontal stiffness are the isolator’s geometrical characteristics (i.e.: overall dimensions, single layer thickness, etc.) and the mechanical characteristics of its elastomer. The damping capacity of the isolators is determined by the type of elastomeric compound, which usually is a high damping one.

L'AQUILA, ITALY - ANAS new Head Office

L'AQUILA, ITALY - ANAS new Head Office: installation

CHARACTERISTICS

ELASTOMER

The rubber compounds used in the production of series **SI** elastomeric isolators are characterised by an effective dynamic shear modulus G_{din} between 0.4 MPa and 1.4 MPa and by the equivalent viscous damping coefficient equal to 10% or 15% - subject to the Design Engineer's discretion.

The table here below shows some of the physical and mechanical characteristics of the three standard rubber compounds used, measured using Italian Standard UNI a/o Italian seismic Regulations NTC-DM 14/01/2008 test methods.

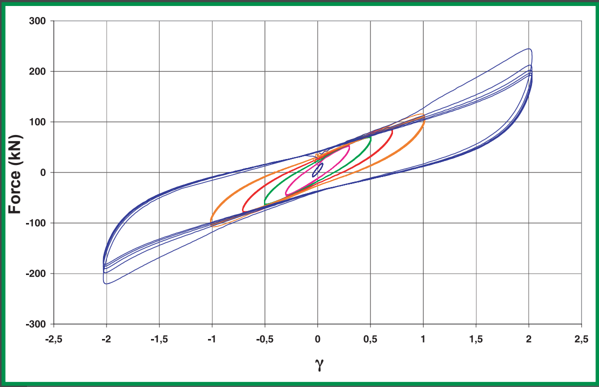
CHARACTERISTIC	COMPOUND		
	SOFT (S)	NORMAL (N)	HARD (H)
Hardness (Shore A)	40	60	75
Dynamic shear modulus G_{din} at γ = 1 (MPa)	0.4	0.8	1.4
Equivalent viscous damping coefficient ξ at γ = 1 (%)	10 / 15	10 / 15	10 / 15

High damping rubber compounds are characterised by a significant variation of the shear modulus G_{din} when the shear strain γ is lower than 0.5. This permits to avoid excessive displacements under dynamic low intensity excitations such as wind loads.

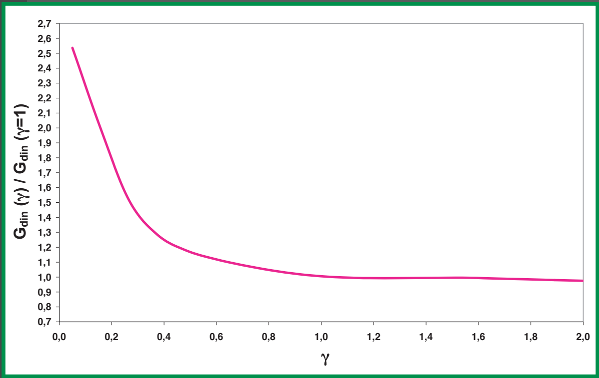
The G_{din} value remains practically constant for γ values between 1 and 2, corresponding to seismic design displacements. The equivalent viscous damping coefficient ξ also varies as a function of the shear strain γ.

The enclosed graphics show the typical course of the effective dynamic shear modulus G_{din} and the equivalent viscous damping coefficient ξ, normalized with respect to their respective values for γ = 1, as a function of the elastomer's shear strain γ.

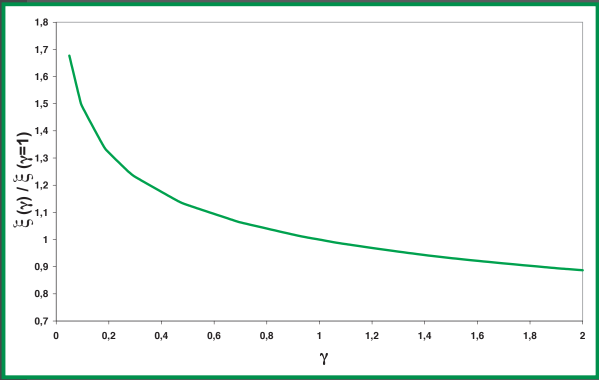
The compounds contain suitable anti-aging additives that guarantee limited variation of the physical and mechanical characteristics in time, as assessed through artificial aging tests (e.g.: 21 days at 70°C in accordance with NTC-DM 14/01/2008).



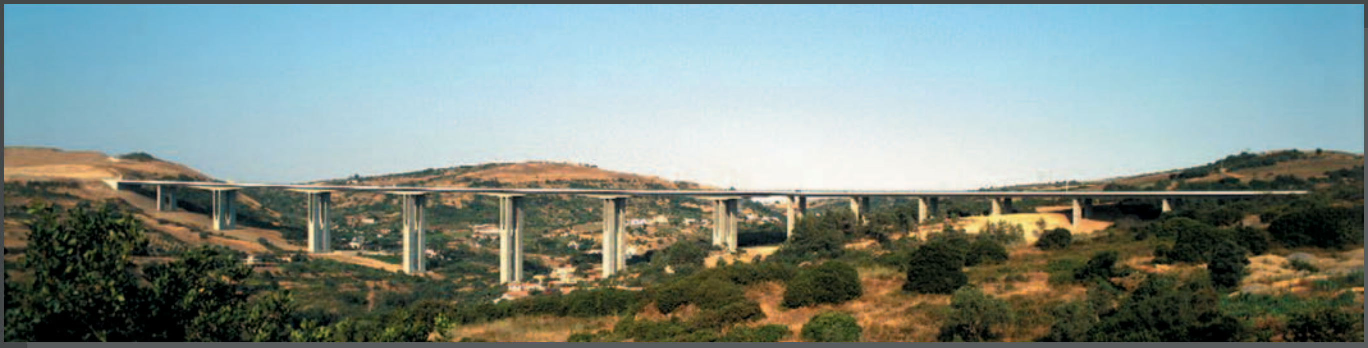
Typical hysteretic curve of an elastomeric isolator achieved during dynamic tests with increasing shear strain amplitude.



Mean variation in effective dynamic shear modulus G_{din} as a function of the shear strain γ.



Mean variation of the equivalent viscous damping coefficient ξ as a function of the shear strain γ.



PORTUGAL - Loureiro Viaduct

DESIGN AND PRODUCTION CRITERIA

STANDARDS

The series **SI** isolators can be designed *ad hoc* to satisfy all international standards (i.e.: EN 15129, AASHTO, etc.).

Notwithstanding, the standard isolators in this catalogue are designed in compliance with Italian seismic regulations (NTC-DM 14/01/2008) – which are based on Eurocode 8 – as well as with the European standard EN 1337-3:2005 (Structural Bearings. Part 3: Elastomeric Bearings) regarding the normal non-seismic service conditions.

DESIGN FEATURES

The standard elastomeric isolators whose geometric and mechanical characteristics are listed in the enclosed tables, are designed for seven different values of maximum displacement, from 100 to 400 mm. Such entity of displacement is understood to be the maximum design displacement at ULS, factored by the increased reliability factor as per Eurocode 8.

The vertical load V indicated in the tables is the maximum admissible value upon the isolator in the presence of an earthquake provoking the aforesaid displacement.

Null rotation is assumed with reference to the use of these isolators in buildings. The displacement under normal service conditions (i.e.: induced by thermal expansion) is assumed to be 10 mm.

FIP Industriale's Technical Department is at the design Engineer's disposal to check standard isolators against displacements and rotations differing from those assumed, and to design *ad hoc* isolators diverging from standard features.

ANCHORING SYSTEMS

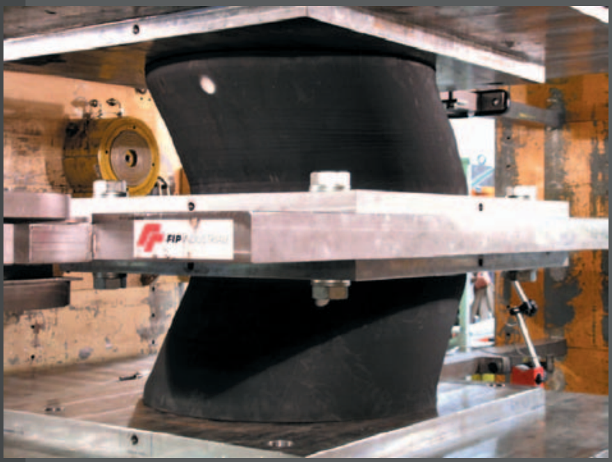
The elastomeric isolators are endowed with mechanical anchoring systems providing horizontal load transfer in accordance with Italian and international standards.

QUALITY CONTROL

FIP Industriale's internal quality control system ensures the conformity of the product to the various requirements thus guaranteeing the quality both of materials and manufacturing processes.

QUALIFICATION AND ACCEPTANCE TESTS

FIP Industriale's Test Laboratory is equipped to carry out qualification and acceptance tests on elastomeric isolators. Series **SI** isolators have also been tested at independent laboratories as well as *in situ* through snap-back tests of an entire seismically isolated building.



INSTALLATION

The typical installation procedure of an isolator anchored on its upper and lower side to reinforced *cast-in-situ* concrete structures, comprises the following phases:

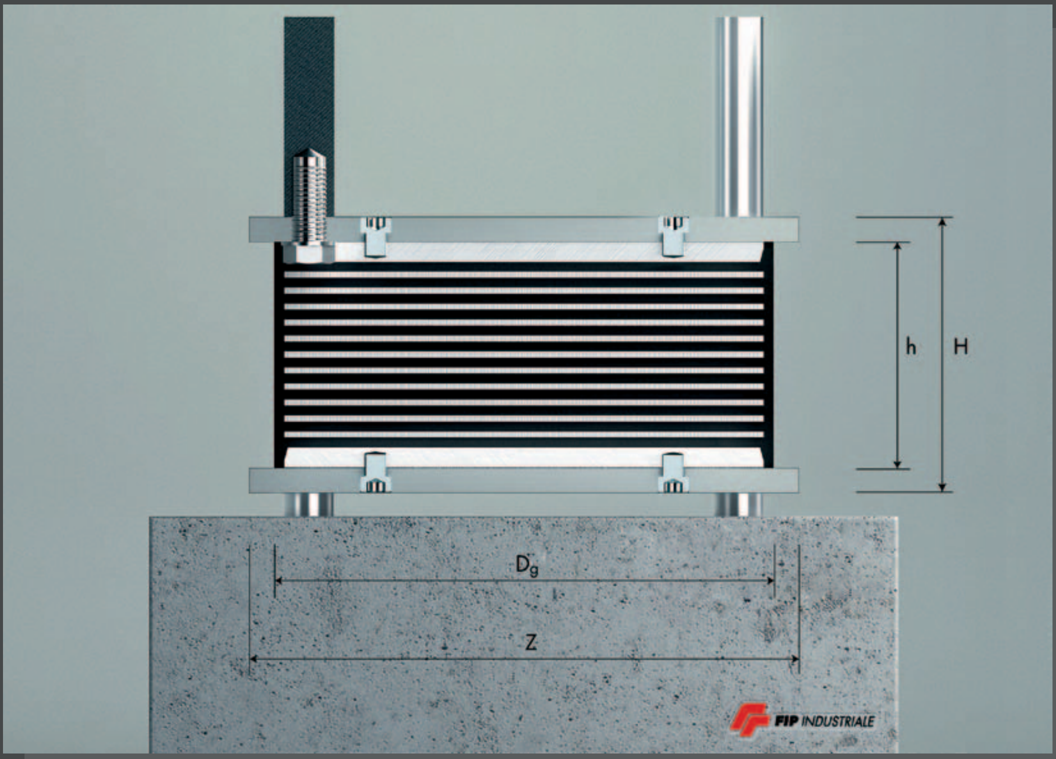
- casting of the substructure up to a level lower than the isolator itself by a few centimeters, leaving holes for the anchor dowels with a diameter at least twice that of the same;
- positioning the isolator at the design level and leveling its base horizontally;
- construction of a formwork slightly larger than the isolator and approximately 1 cm higher than its lower edge;
- grouting (epoxy mortar or shrink free cementitious mortar) to a suggested thickness between 2 and 5 cm;
- screwing of the upper dowels to the isolator (if not already affixed);
- setting the upper formwork adapting it tightly against the isolator upper plate;
- positioning the superstructure reinforcement followed by concrete casting.

MARKS

The elastomeric isolators are classified by the mark **SI** (**S**eismic **I**solator) followed by a letter (S, N, H to indicate respectively the type of soft, normal and hard compound) and two numbers. The first number represents the diameter in millimeters and the second stands for the total thickness of the rubber layers in millimeters.

Example:

SI-S 800/130 Elastomeric Isolator, diameter 800 mm, made of soft elastomeric compound with rubber layers having a total thickness of 130 mm.



UDINE, ITALY - “Gervasutta” Hospital

UDINE, ITALY - “Gervasutta” Hospital: installation

DISPLACEMENT 100 mm

SI-S	V kN	Fzd kN	Ke kN/mm	Kv kN/mm	Dg mm	te mm	h mm	H mm	Z mm	W kg
SI-S 300/52	490	1860	0.54	584	300	52	116	166	350	84
SI-S 350/50	700	3010	0.77	779	350	50	108	158	400	109
SI-S 400/50	1150	4680	1.01	1246	400	50	108	158	450	140
SI-S 450/54	1540	5770	1.18	1369	450	54	118	168	500	183
SI-S 500/54	2230	8050	1.45	1962	500	54	118	168	550	224
SI-S 550/56	2720	9310	1.70	2153	550	56	117	167	600	265
SI-S 600/56	3200	10310	2.02	2438	600	56	114	164	650	307
SI-S 650/54	3650	10830	2.46	2848	650	54	109	159	700	351
SI-S 700/60	4460	11370	2.57	2871	700	60	125	185	750	481
SI-S 800/60	6930	14990	3.35	4519	800	60	125	185	850	624
SI-S 900/60	8480	21220	4.24	5317	900	60	126	186	950	790
SI-S 1000/70	10940	22590	4.49	5316	1000	70	146	226	1050	1214
SI-S 1100/70	14840	27460	5.43	7324	1100	70	146	226	1150	1463
SI-S 1200/80	17990	28700	5.66	7224	1200	80	156	236	1250	1750

SI-N	V kN	Fzd kN	Ke kN/mm	Kv kN/mm	Dg mm	te mm	h mm	H mm	Z mm	W kg
SI-N 300/52	920	2610	1.09	879	300	52	116	166	350	84
SI-N 350/50	1400	3510	1.54	1195	350	50	108	158	400	109
SI-N 400/50	2300	4680	2.01	1824	400	50	108	158	450	140
SI-N 450/54	3080	7510	2.36	2044	450	54	118	168	500	183
SI-N 500/54	4470	9380	2.91	2822	500	54	118	168	550	224
SI-N 550/56	5440	9820	3.39	3156	550	56	117	167	600	265
SI-N 600/56	6410	10310	4.04	3627	600	56	114	164	650	307
SI-N 650/54	7310	10830	4.92	4286	650	54	109	159	700	351
SI-N 700/60	8920	11370	5.13	4362	700	60	125	185	750	481
SI-N 800/60	12690	14990	6.70	6557	800	60	125	185	850	624
SI-N 900/60	16960	21220	8.48	7879	900	60	126	186	950	790
SI-N 1000/70	19830	22590	8.98	8000	1000	70	146	226	1050	1214
SI-N 1100/70	24420	27460	10.86	10668	1100	70	146	226	1150	1463
SI-N 1200/80	25800	28700	11.31	10684	1200	80	156	236	1250	1750

SI-H	V kN	Fzd kN	Ke kN/mm	Kv kN/mm	Dg mm	te mm	h mm	H mm	Z mm	W kg
SI-H 300/52	920	2610	1.90	1122	300	52	116	166	350	84
SI-H 350/50	2240	3510	2.69	1550	350	50	108	158	400	109
SI-H 400/50	3200	4680	3.52	2276	400	50	108	158	450	140
SI-H 450/54	5400	7510	4.12	2592	450	54	118	168	500	183
SI-H 500/54	7040	9380	5.09	3475	500	54	118	168	550	224
SI-H 550/56	7610	9820	5.94	3944	550	56	117	167	600	265
SI-H 600/56	8190	10310	7.07	4585	600	56	114	164	650	307
SI-H 650/54	8770	10830	8.60	5470	650	54	109	159	700	351
SI-H 700/60	9370	11370	8.98	5612	700	60	125	185	750	481
SI-H 800/60	12690	14990	11.73	8129	800	60	125	185	850	624
SI-H 900/60	18340	21220	14.84	9930	900	60	126	186	950	790
SI-H 1000/70	19830	22590	15.71	10210	1000	70	146	226	1050	1214
SI-H 1100/70	24420	27460	19.01	13263	1100	70	146	226	1150	1463
SI-H 1200/80	25800	28700	19.79	13443	1200	80	156	236	1250	1750

Legend

V	Maximum vertical load at load combinations including the seismic action
F_{zd}	Maximum vertical load at non-seismic load combinations, at ULS, concurrent with 0 rotation and 10 mm horizontal displacement
K_e	Effective horizontal stiffness
K_v	Vertical stiffness
D_g	Elastomer diameter
t_e	Total elastomer thickness
h	Height excluding outer steel plates
H	Total height including outer steel plates
Z	Side length of outer steel plates
W	Isolator weight excluding anchoring elements

DISPLACEMENT 150 mm

SI-S	V kN	Fzd kN	Ke kN/mm	Kv kN/mm	Dg mm	te mm	h mm	H mm	Z mm	W kg
SI-S 300/76	270	1270	0.37	400	300	76	152	202	350	92
SI-S 350/75	490	2000	0.51	519	350	75	143	193	400	118
SI-S 400/75	880	3540	0.67	830	400	75	143	193	450	153
SI-S 450/78	1200	4660	0.82	948	450	78	154	204	500	202
SI-S 500/78	1800	7260	1.01	1358	500	78	154	204	550	247
SI-S 550/77	2190	9380	1.23	1566	550	77	147	197	600	287
SI-S 600/80	2690	10310	1.41	1707	600	80	147	197	650	335
SI-S 650/81	3200	10830	1.64	1898	650	81	145	195	700	384
SI-S 700/80	3710	11370	1.92	2153	700	80	151	211	750	508
SI-S 800/80	5870	14990	2.51	3389	800	80	151	211	850	659
SI-S 900/84	7490	21220	3.03	3798	900	84	158	218	950	848
SI-S 1000/84	9110	22590	3.74	4430	1000	84	164	244	1050	1252
SI-S 1100/84	12470	27460	4.53	6103	1100	84	164	244	1150	1509
SI-S 1200/96	15490	28700	4.71	6020	1200	96	176	256	1250	1807

SI-N	V kN	Fzd kN	Ke kN/mm	Kv kN/mm	Dg mm	te mm	h mm	H mm	Z mm	W kg
SI-N 300/76	550	1780	0.74	602	300	76	152	202	350	92
SI-N 350/75	990	2800	1.03	796	350	75	143	193	400	118
SI-N 400/75	1760	4680	1.34	1216	400	75	143	193	450	153
SI-N 450/78	2410	6530	1.63	1415	450	78	154	204	500	202
SI-N 500/78	3610	9380	2.01	1954	500	78	154	204	550	247
SI-N 550/77	4380	9820	2.47	2296	550	77	147	197	600	287
SI-N 600/80	5380	10310	2.83	2539	600	80	147	197	650	335
SI-N 650/81	6400	10830	3.28	2857	650	81	145	195	700	384
SI-N 700/80	7420	11370	3.85	3272	700	80	151	211	750	508
SI-N 800/80	11470	14990	5.03	4918	800	80	151	211	850	659
SI-N 900/84	14980	21220	6.06	5628	900	84	158	218	950	848
SI-N 1000/84	18230	22590	7.48	6667	1000	84	164	244	1050	1252
SI-N 1100/84	22800	27460	9.05	8890	1100	84	164	244	1150	1509
SI-N 1200/96	24240	28700	9.43	8903	1200	96	176	256	1250	1807

SI-H	V kN	Fzd kN	Ke kN/mm	Kv kN/mm	Dg mm	te mm	h mm	H mm	Z mm	W kg
SI-H 300/76	970	3060	1.30	768	300	76	152	202	350	92
SI-H 350/75	1590	3510	1.80	1033	350	75	143	193	400	118
SI-H 400/75	2450	4680	2.35	1518	400	75	143	193	450	153
SI-H 450/78	4220	7510	2.86	1794	450	78	154	204	500	202
SI-H 500/78	5820	9380	3.52	2406	500	78	154	204	550	247
SI-H 550/77	6440	9820	4.32	2868	550	77	147	197	600	287
SI-H 600/80	7060	10310	4.95	3209	600	80	147	197	650	335
SI-H 650/81	7690	10830	5.74	3646	650	81	145	195	700	384
SI-H 700/80	8310	11370	6.74	4209	700	80	151	211	750	508
SI-H 800/80	11470	14990	8.80	6096	800	80	151	211	850	659
SI-H 900/84	16810	21220	10.60	7093	900	84	158	218	950	848
SI-H 1000/84	18360	22590	13.09	8508	1000	84	164	244	1050	1252
SI-H 1100/84	22800	27460	15.84	11052	1100	84	164	244	1150	1509
SI-H 1200/96	24240	28700	16.49	11203	1200	96	176	256	1250	1807

Legend

V	Maximum vertical load at load combinations including the seismic action
F_{zd}	Maximum vertical load at non-seismic load combinations, at ULS, concurrent with 0 rotation and 10 mm horizontal displacement
K_e	Effective horizontal stiffness
K_v	Vertical stiffness
D_g	Elastomer diameter
t_e	Total elastomer thickness
h	Height excluding outer steel plates
H	Total height including outer steel plates
Z	Side length of outer steel plates
W	Isolator weight excluding anchoring elements

DISPLACEMENT 200 mm

SI-S	V kN	F_{zd} kN	K_e kN/mm	K_v kN/mm	D_g mm	t_e mm	h mm	H mm	Z mm	W kg
SI-S 300/100	105	960	0.28	304	300	100	188	238	350	100
SI-S 350/100	250	1500	0.39	389	350	100	178	228	400	128
SI-S 400/100	590	2650	0.50	623	400	100	178	228	450	166
SI-S 450/102	900	3570	0.62	725	450	102	190	240	500	220
SI-S 500/102	1420	5550	0.77	1038	500	102	190	240	550	270
SI-S 550/105	1830	6890	0.91	1148	550	105	187	237	600	316
SI-S 600/104	2230	8750	1.09	1313	600	104	180	230	650	362
SI-S 650/108	2760	10430	1.23	1424	650	108	181	231	700	418
SI-S 700/100	3110	11370	1.54	1722	700	100	177	237	750	535
SI-S 800/100	5040	14990	2.01	2711	800	100	177	237	850	694
SI-S 900/108	6670	21220	2.36	2954	900	108	190	250	950	905
SI-S 1000/112	8390	22590	2.81	3322	1000	112	200	280	1050	1327
SI-S 1100/112	11590	27460	3.39	4577	1100	112	200	280	1150	1600
SI-S 1200/112	13570	28700	4.04	5160	1200	112	196	276	1250	1865

SI-N	V kN	F_{zd} kN	K_e kN/mm	K_v kN/mm	D_g mm	t_e mm	h mm	H mm	Z mm	W kg
SI-N 300/100	210	1350	0.57	457	300	100	188	238	350	100
SI-N 350/100	510	2100	0.77	597	350	100	178	228	400	128
SI-N 400/100	1180	3720	1.01	912	400	100	178	228	450	166
SI-N 450/102	1810	4990	1.25	1082	450	102	190	240	500	220
SI-N 500/102	2840	7780	1.54	1494	500	102	190	240	550	270
SI-N 550/105	3660	9650	1.81	1683	550	105	187	237	600	316
SI-N 600/104	4470	10310	2.18	1953	600	104	180	230	650	362
SI-N 650/108	5520	10830	2.46	2143	650	108	181	231	700	418
SI-N 700/100	6230	11370	3.08	2617	700	100	177	237	750	535
SI-N 800/100	10090	14990	4.02	3934	800	100	177	237	850	694
SI-N 900/108	13350	21220	4.71	4377	900	108	190	250	950	905
SI-N 1000/112	16780	22590	5.61	5000	1000	112	200	280	1050	1327
SI-N 1100/112	21190	27460	6.79	6667	1100	112	200	280	1150	1600
SI-N 1200/112	22700	28700	8.08	7631	1200	112	196	276	1250	1865

SI-H	V kN	F_{zd} kN	K_e kN/mm	K_v kN/mm	D_g mm	t_e mm	h mm	H mm	Z mm	W kg
SI-H 300/100	370	2320	0.99	583	300	100	188	238	350	100
SI-H 350/100	900	3510	1.35	775	350	100	178	228	400	128
SI-H 400/100	1720	4680	1.76	1138	400	100	178	228	450	166
SI-H 450/102	3170	7510	2.18	1372	450	102	190	240	500	220
SI-H 500/102	4640	9380	2.70	1840	500	102	190	240	550	270
SI-H 550/105	5310	9820	3.17	2103	550	105	187	237	600	316
SI-H 600/104	5970	10310	3.81	2469	600	104	180	230	650	362
SI-H 650/108	6620	10830	4.30	2735	650	108	181	231	700	418
SI-H 700/100	7270	11370	5.39	3367	700	100	177	237	750	535
SI-H 800/100	10260	14990	7.04	4877	800	100	177	237	850	694
SI-H 900/108	15290	21220	8.25	5517	900	108	190	250	950	905
SI-H 1000/112	16910	22590	9.82	6381	1000	112	200	280	1050	1327
SI-H 1100/112	21190	27460	11.88	8289	1100	112	200	280	1150	1600
SI-H 1200/112	22700	28700	14.14	9602	1200	112	196	276	1250	1865

Legend

V	Maximum vertical load at load combinations including the seismic action
F_{zd}	Maximum vertical load at non-seismic load combinations, at ULS, concurrent with 0 rotation and 10 mm horizontal displacement
K_e	Effective horizontal stiffness
K_v	Vertical stiffness
D_g	Elastomer diameter
t_e	Total elastomer thickness
h	Height excluding outer steel plates
H	Total height including outer steel plates
Z	Side length of outer steel plates
W	Isolator weight excluding anchoring elements

DISPLACEMENT 250 mm

SI-S	V kN	F_{zd} kN	K_e kN/mm	K_v kN/mm	D_g mm	t_e mm	h mm	H mm	Z mm	W kg
SI-S 300/128	15	750	0.22	237	300	128	230	280	350	110
SI-S 350/125	100	1200	0.31	311	350	125	213	263	400	138
SI-S 400/125	290	2120	0.40	498	400	125	213	263	450	179
SI-S 450/126	530	2890	0.51	587	450	126	226	276	500	239
SI-S 500/126	1010	4500	0.62	841	500	126	226	276	550	294
SI-S 550/126	1410	5740	0.75	957	550	126	217	267	600	338
SI-S 600/128	1820	7100	0.88	1067	600	128	213	263	650	389
SI-S 650/126	2230	8940	1.05	1220	650	126	205	255	700	440
SI-S 700/130	2740	10600	1.18	1325	700	130	216	276	750	575
SI-S 800/130	4570	14990	1.55	2086	800	130	216	276	850	747
SI-S 900/132	5940	21220	1.93	2417	900	132	222	282	950	963
SI-S 1000/140	7670	22590	2.24	2658	1000	140	236	316	1050	1402
SI-S 1100/140	10720	27460	2.72	3662	1100	140	236	316	1150	1691
SI-S 1200/144	12850	28700	3.14	4013	1200	144	236	316	1250	1979

SI-N	V kN	F_{zd} kN	K_e kN/mm	K_v kN/mm	D_g mm	t_e mm	h mm	H mm	Z mm	W kg
SI-N 300/128	35	1060	0.44	357	300	128	230	280	350	110
SI-N 350/125	200	1680	0.62	478	350	125	213	263	400	138
SI-N 400/125	590	2970	0.80	729	400	125	213	263	450	179
SI-N 450/126	1070	4040	1.01	876	450	126	226	276	500	239
SI-N 500/126	2030	6300	1.25	1209	500	126	226	276	550	294
SI-N 550/126	2830	8040	1.51	1403	550	126	217	267	600	338
SI-N 600/128	3640	9950	1.77	1587	600	128	213	263	650	389
SI-N 650/126	4460	10830	2.11	1837	650	126	205	255	700	440
SI-N 700/130	5490	11370	2.37	2013	700	130	216	276	750	575
SI-N 800/130	9080	14990	3.09	3026	800	130	216	276	850	747
SI-N 900/132	11880	21220	3.86	3582	900	132	222	282	950	963
SI-N 1000/140	15350	22590	4.49	4000	1000	140	236	316	1050	1402
SI-N 1100/140	19590	27460	5.43	5334	1100	140	236	316	1150	1691
SI-N 1200/144	21170	28700	6.28	5935	1200	144	236	316	1250	1979

SI-H	V kN	F_{zd} kN	K_e kN/mm	K_v kN/mm	D_g mm	t_e mm	h mm	H mm	Z mm	W kg
SI-H 300/128	65	1810	0.77	456	300	128	230	280	350	110
SI-H 350/125	350	2890	1.08	620	350	125	213	263	400	138
SI-H 400/125	1040	4680	1.41	911	400	125	213	263	450	179
SI-H 450/126	1880	6930	1.77	1111	450	126	226	276	500	239
SI-H 500/126	3520	9380	2.18	1489	500	126	226	276	550	294
SI-H 550/126	4220	9820	2.64	1753	550	126	217	267	600	338
SI-H 600/128	4910	10310	3.09	2006	600	128	213	263	650	389
SI-H 650/126	5580	10830	3.69	2344	650	126	205	255	700	440
SI-H 700/130	6250	11370	4.14	2590	700	130	216	276	750	575
SI-H 800/130	9080	14990	5.41	3752	800	130	216	276	850	747
SI-H 900/132	13790	21220	6.75	4514	900	132	222	282	950	963
SI-H 1000/140	15470	22590	7.85	5105	1000	140	236	316	1050	1402
SI-H 1100/140	19590	27460	9.50	6631	1100	140	236	316	1150	1691
SI-H 1200/144	21170	28700	11.00	7468	1200	144	236	316	1250	1979

Legend

V	Maximum vertical load at load combinations including the seismic action
F_{zd}	Maximum vertical load at non-seismic load combinations, at ULS, concurrent with 0 rotation and 10 mm horizontal displacement
K_e	Effective horizontal stiffness
K_v	Vertical stiffness
D_g	Elastomer diameter
t_e	Total elastomer thickness
h	Height excluding outer steel plates
H	Total height including outer steel plates
Z	Side length of outer steel plates
W	Isolator weight excluding anchoring elements

DISPLACEMENT 300 mm

SI-S	V kN	F_{zd} kN	K_e kN/mm	K_v kN/mm	D_g mm	t_e mm	h mm	H mm	Z mm	W kg
SI-S 350/150	20	1000	0.26	260	350	150	248	298	400	148
SI-S 400/150	120	1470	0.34	415	400	150	248	298	450	192
SI-S 450/150	280	2420	0.42	493	450	150	262	312	500	258
SI-S 500/150	600	3770	0.52	706	500	150	262	312	550	317
SI-S 550/154	910	4690	0.62	783	550	154	257	307	600	368
SI-S 600/152	1350	5980	0.74	898	600	152	246	296	650	417
SI-S 650/153	1840	7360	0.87	1005	650	153	241	291	700	473
SI-S 700/160	2350	8610	0.96	1077	700	160	255	315	750	615
SI-S 800/160	4050	14940	1.26	1695	800	160	255	315	850	800
SI-S 900/168	5490	19240	1.52	1899	900	168	270	330	950	1049
SI-S 1000/168	6970	22590	1.87	2215	1000	168	272	352	1050	1477
SI-S 1100/168	9850	27460	2.26	3052	1100	168	272	352	1150	1782
SI-S 1200/176	12040	28700	2.57	3283	1200	176	276	356	1250	2093

SI-N	V kN	F_{zd} kN	K_e kN/mm	K_v kN/mm	D_g mm	t_e mm	h mm	H mm	Z mm	W kg
SI-N 350/150	40	1400	0.51	398	350	150	248	298	400	148
SI-N 400/150	240	2060	0.67	608	400	150	248	298	450	192
SI-N 450/150	560	3390	0.85	736	450	150	262	312	500	258
SI-N 500/150	1200	5290	1.05	1016	500	150	262	312	550	317
SI-N 550/154	1830	6580	1.23	1148	550	154	257	307	600	368
SI-N 600/152	2710	8380	1.49	1336	600	152	246	296	650	417
SI-N 650/153	3690	10310	1.74	1513	650	153	241	291	700	473
SI-N 700/160	4700	11370	1.92	1636	700	160	255	315	750	615
SI-N 800/160	7920	14940	2.51	2459	800	160	255	315	850	800
SI-N 900/168	10980	21220	3.03	2814	900	168	270	330	950	1049
SI-N 1000/168	13940	22590	3.74	3333	1000	168	272	352	1050	1477
SI-N 1100/168	18020	27460	4.53	4445	1100	168	272	352	1150	1782
SI-N 1200/176	19650	28700	5.14	4856	1200	176	276	356	1250	2093

SI-H	V kN	F_{zd} kN	K_e kN/mm	K_v kN/mm	D_g mm	t_e mm	h mm	H mm	Z mm	W kg
SI-H 350/150	70	2400	0.90	517	350	150	248	298	400	148
SI-H 400/150	420	4250	1.17	759	400	150	248	298	450	192
SI-H 450/150	990	5820	1.48	933	450	150	262	312	500	258
SI-H 500/150	2100	9070	1.83	1251	500	150	262	312	550	317
SI-H 550/154	3190	9820	2.16	1434	550	154	257	307	600	368
SI-H 600/152	3890	10310	2.60	1689	600	152	246	296	650	417
SI-H 650/153	4580	10830	3.04	1930	650	153	241	291	700	473
SI-H 700/160	5260	11370	3.37	2104	700	160	255	315	750	615
SI-H 800/160	7920	14940	4.40	3048	800	160	255	315	850	800
SI-H 900/168	12310	21220	5.30	3546	900	168	270	330	950	1049
SI-H 1000/168	14050	22590	6.55	4254	1000	168	272	352	1050	1477
SI-H 1100/168	18020	27460	7.92	5526	1100	168	272	352	1150	1782
SI-H 1200/176	19650	28700	9.00	6111	1200	176	276	356	1250	2093

Legend

V	Maximum vertical load at load combinations including the seismic action
F_{zd}	Maximum vertical load at non-seismic load combinations, at ULS, concurrent with 0 rotation and 10 mm horizontal displacement
K_e	Effective horizontal stiffness
K_v	Vertical stiffness
D_g	Elastomer diameter
t_e	Total elastomer thickness
h	Height excluding outer steel plates
H	Total height including outer steel plates
Z	Side length of outer steel plates
W	Isolator weight excluding anchoring elements

DISPLACEMENT 350 mm

SI-S	V kN	Fzd kN	Ke kN/mm	Kv kN/mm	Dg mm	te mm	h mm	H mm	Z mm	W kg
SI-S 400/175	24	1510	0.29	356	400	175	283	333	450	205
SI-S 450/180	115	2020	0.35	411	450	180	307	357	500	281
SI-S 500/180	310	3150	0.44	588	500	180	307	357	550	346
SI-S 550/175	560	4130	0.54	689	550	175	287	337	600	390
SI-S 600/176	880	5160	0.64	776	600	176	279	329	650	444
SI-S 650/180	1260	6260	0.74	854	650	180	277	327	700	507
SI-S 700/180	1740	7660	0.86	957	700	180	281	341	750	642
SI-S 800/180	3400	13280	1.12	1506	800	180	281	341	850	835
SI-S 900/180	4600	17960	1.41	1772	900	180	286	346	950	1078
SI-S 1000/182	6010	22590	1.73	2044	1000	182	290	370	1050	1515
SI-S 1100/182	8620	27460	2.09	2817	1100	182	290	370	1150	1828
SI-S 1200/192	9530	28700	2.36	3010	1200	192	296	376	1250	2150

SI-N	V kN	Fzd kN	Ke kN/mm	Kv kN/mm	Dg mm	te mm	h mm	H mm	Z mm	W kg
SI-N 400/175	45	2120	0.57	521	400	175	283	333	450	205
SI-N 450/180	230	2830	0.71	613	450	180	307	357	500	281
SI-N 500/180	620	4410	0.87	847	500	180	307	357	550	346
SI-N 550/175	1130	5790	1.09	1010	550	175	287	337	600	390
SI-N 600/176	1770	7230	1.29	1154	600	176	279	329	650	444
SI-N 650/180	2520	8760	1.48	1286	650	180	277	327	700	507
SI-N 700/180	3490	10720	1.71	1454	700	180	281	341	750	642
SI-N 800/180	6790	14990	2.23	2186	800	180	281	341	850	835
SI-N 900/180	8310	21220	2.83	2626	900	180	286	346	950	1078
SI-N 1000/182	12025	22590	3.45	3077	1000	182	290	370	1050	1515
SI-N 1100/182	16460	27460	4.18	4103	1100	182	290	370	1150	1828
SI-N 1200/192	18150	28700	4.71	4452	1200	192	296	376	1250	2150

SI-H	V kN	Fzd kN	Ke kN/mm	Kv kN/mm	Dg mm	te mm	h mm	H mm	Z mm	W kg
SI-H 400/175	85	3640	1.01	650	400	175	283	333	450	205
SI-H 450/180	400	4850	1.24	778	450	180	307	357	500	281
SI-H 500/180	1090	7560	1.53	1043	500	180	307	357	550	346
SI-H 550/175	1990	9820	1.90	1262	550	175	287	337	600	390
SI-H 600/176	2940	10310	2.25	1459	600	176	279	329	650	444
SI-H 650/180	3630	10830	2.58	1641	650	180	277	327	700	507
SI-H 700/180	4310	11370	2.99	1871	700	180	281	341	750	642
SI-H 800/180	6790	14990	3.91	2710	800	180	281	341	850	835
SI-H 900/180	10870	21220	4.95	3310	900	180	286	346	950	1078
SI-H 1000/182	12650	22590	6.04	3927	1000	182	290	370	1050	1515
SI-H 1100/182	16460	27460	7.31	5101	1100	182	290	370	1150	1828
SI-H 1200/192	18150	28700	8.25	5601	1200	192	296	376	1250	2150

Legend

V	Maximum vertical load at load combinations including the seismic action
F_{zd}	Maximum vertical load at non-seismic load combinations, at ULS, concurrent with 0 rotation and 10 mm horizontal displacement
K_e	Effective horizontal stiffness
K_v	Vertical stiffness
D_g	Elastomer diameter
t_e	Total elastomer thickness
h	Height excluding outer steel plates
H	Total height including outer steel plates
Z	Side length of outer steel plates
W	Isolator weight excluding anchoring elements

DISPLACEMENT 400 mm

SI-S	V kN	F_{zd} kN	K_e kN/mm	K_v kN/mm	D_g mm	t_e mm	h mm	H mm	Z mm	W kg
SI-S 450/204	20	1780	0.31	362	450	204	343	393	500	300
SI-S 500/204	135	2780	0.39	519	500	204	343	393	550	369
SI-S 550/203	300	3560	0.47	594	550	203	327	377	600	419
SI-S 600/200	540	4540	0.57	683	600	200	312	362	650	471
SI-S 650/207	820	5440	0.64	743	650	207	313	363	700	540
SI-S 700/200	1240	6890	0.77	861	700	200	307	367	750	669
SI-S 800/200	2730	11950	1.01	1356	800	200	307	367	850	871
SI-S 900/204	3990	15850	1.25	1564	900	204	318	378	950	1136
SI-S 1000/210	5385	20320	1.50	1772	1000	210	326	406	1050	1590
SI-S 1100/210	7860	27460	1.81	2441	1100	210	326	406	1150	1919
SI-S 1200/208	9540	28700	2.18	2778	1200	208	316	396	1250	2207

SI-N	V kN	F_{zd} kN	K_e kN/mm	K_v kN/mm	D_g mm	t_e mm	h mm	H mm	Z mm	W kg
SI-N 450/204	45	2490	0.62	541	450	204	343	393	500	300
SI-N 500/204	270	3890	0.77	747	500	204	343	393	550	369
SI-N 550/203	610	5790	0.94	871	550	203	327	377	600	419
SI-N 600/200	1090	6360	1.13	1016	600	200	312	362	650	471
SI-N 650/207	1650	7620	1.28	1118	650	207	313	363	700	540
SI-N 700/200	2490	9650	1.54	1309	700	200	307	367	750	669
SI-N 800/200	5470	14990	2.01	1967	800	200	307	367	850	871
SI-N 900/204	7980	21220	2.50	2317	900	204	318	378	950	1136
SI-N 1000/210	10780	22590	2.99	2667	1000	210	326	406	1050	1590
SI-N 1100/210	14930	27460	3.62	3556	1100	210	326	406	1150	1919
SI-N 1200/208	16670	28700	4.35	4109	1200	208	316	396	1250	2207

SI-H	V kN	F_{zd} kN	K_e kN/mm	K_v kN/mm	D_g mm	t_e mm	h mm	H mm	Z mm	W kg
SI-H 450/204	80	4280	1.09	686	450	204	343	393	500	300
SI-H 500/204	470	6670	1.35	920	500	204	343	393	550	369
SI-H 550/203	1070	8550	1.64	1088	550	203	327	377	600	419
SI-H 600/200	1920	10310	1.98	1284	600	200	312	362	650	471
SI-H 650/207	2740	10830	2.24	1427	650	207	313	363	700	540
SI-H 700/200	3420	11370	2.69	1684	700	200	307	367	750	669
SI-H 800/200	5710	14990	3.52	2439	800	200	307	367	850	871
SI-H 900/204	9470	21220	4.37	2921	900	204	318	378	950	1136
SI-H 1000/210	11280	22590	5.24	3403	1000	210	326	406	1050	1590
SI-H 1100/210	14930	27460	6.34	4421	1100	210	326	406	1150	1919
SI-H 1200/208	16670	28700	7.61	5170	1200	208	316	396	1250	2207

Legend

V	Maximum vertical load at load combinations including the seismic action
F_{zd}	Maximum vertical load at non-seismic load combinations, at ULS, concurrent with 0 rotation and 10 mm horizontal displacement
K_e	Effective horizontal stiffness
K_v	Vertical stiffness
D_g	Elastomer diameter
t_e	Total elastomer thickness
h	Height excluding outer steel plates
H	Total height including outer steel plates
Z	Side length of outer steel plates
W	Isolator weight excluding anchoring elements

MAY 2012

FIP INDUSTRIALE

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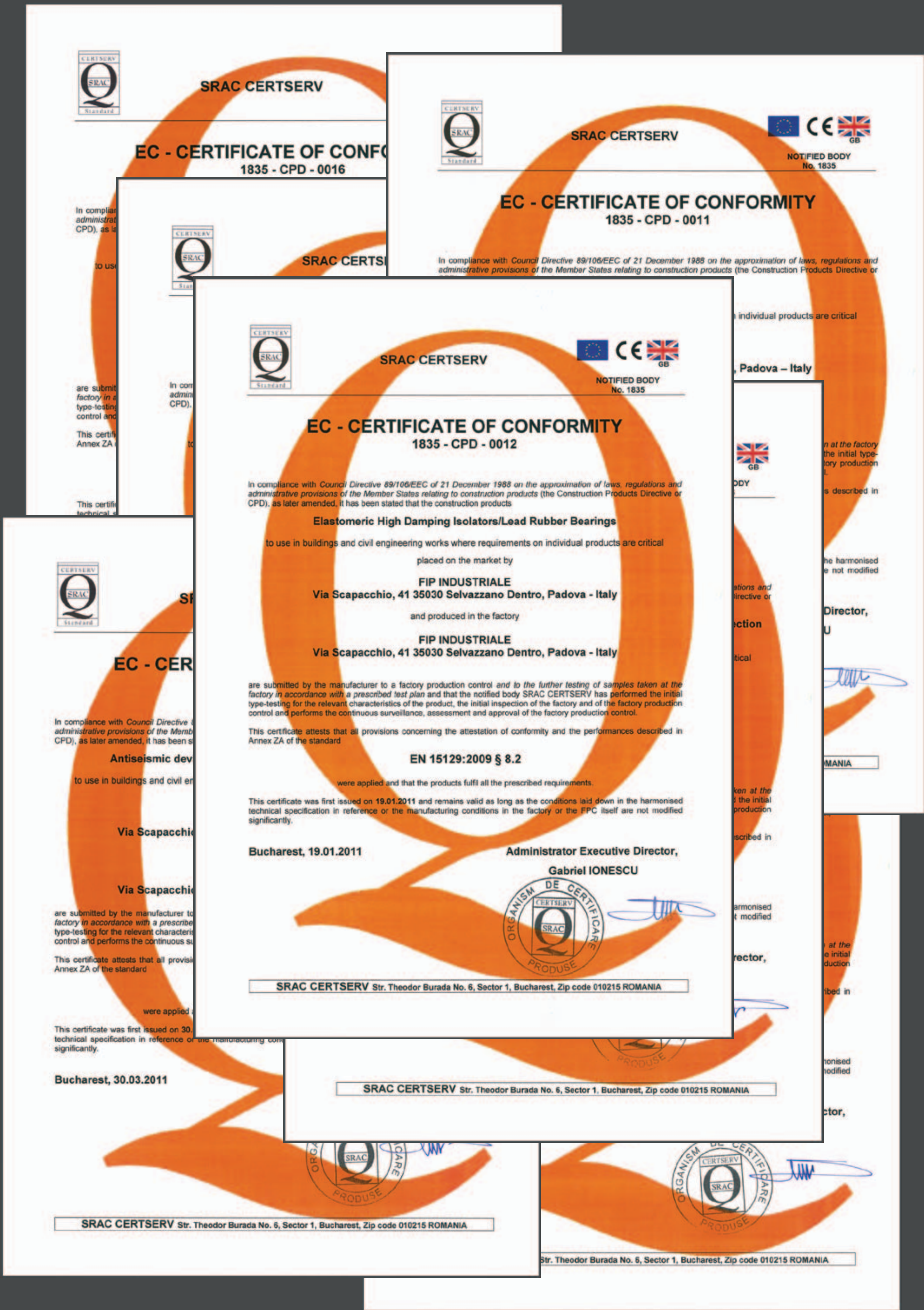
LEAD RUBBER BEARINGS

FIP INDUSTRIALE

LEAD RUBBER BEARINGS series LRB

S03



SRAC CERTSERV

NOTIFIED BODY
No. 1835

EC - CERTIFICATE OF CONFORMITY
1835 - CPD - 0012

In compliance with *Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products* (the Construction Products Directive or CPD), as later amended, it has been stated that the construction products

Elastomeric High Damping Isolators/Lead Rubber Bearings

to use in buildings and civil engineering works where requirements on individual products are critical

placed on the market by

FIP INDUSTRIALE
Via Scapacchio, 41 35030 Selvazzano Dentro, Padova - Italy

and produced in the factory

FIP INDUSTRIALE
Via Scapacchio, 41 35030 Selvazzano Dentro, Padova - Italy

are submitted by the manufacturer to a factory production control *and to the further testing of samples taken at the factory in accordance with a prescribed test plan* and that the notified body SRAC CERTSERV has performed the initial type-testing for the relevant characteristics of the product, the initial inspection of the factory and of the factory production control and performs the continuous surveillance, assessment and approval of the factory production control.

This certificate attests that all provisions concerning the attestation of conformity and the performances described in Annex ZA of the standard

EN 15129:2009 § 8.2

were applied and that the products fulfil all the prescribed requirements.

This certificate was first issued on **19.01.2011** and remains valid as long as the conditions laid down in the harmonised technical specification in reference or the manufacturing conditions in the factory or the FPC itself are not modified significantly.

Bucharest, 19.01.2011

Administrator Executive Director,
Gabriel IONESCU

SRAC CERTSERV Str. Theodor Burada No. 6, Sector 1, Bucharest, Zip code 010215 ROMANIA

INTRODUCTION

CERTIFICATIONS

In 1992, **FIP Industriale** secured CISQ-ICIM certification for its Quality Assurance System in conformance with EN 29001 European Standard (ISO 9001).

ISO 9001 - Cert. N. 0057

FIP Industriale is proud to be the first Italian manufacturer of structural bearings, anti-seismic devices and expansion joints boasting a Quality Assurance System certified at the highest level - from design to customer service assistance.

Certification has been achieved via rigorous evaluation by an internationally recognized Third Party Organisation, thus internationally validating the quality assurance system.

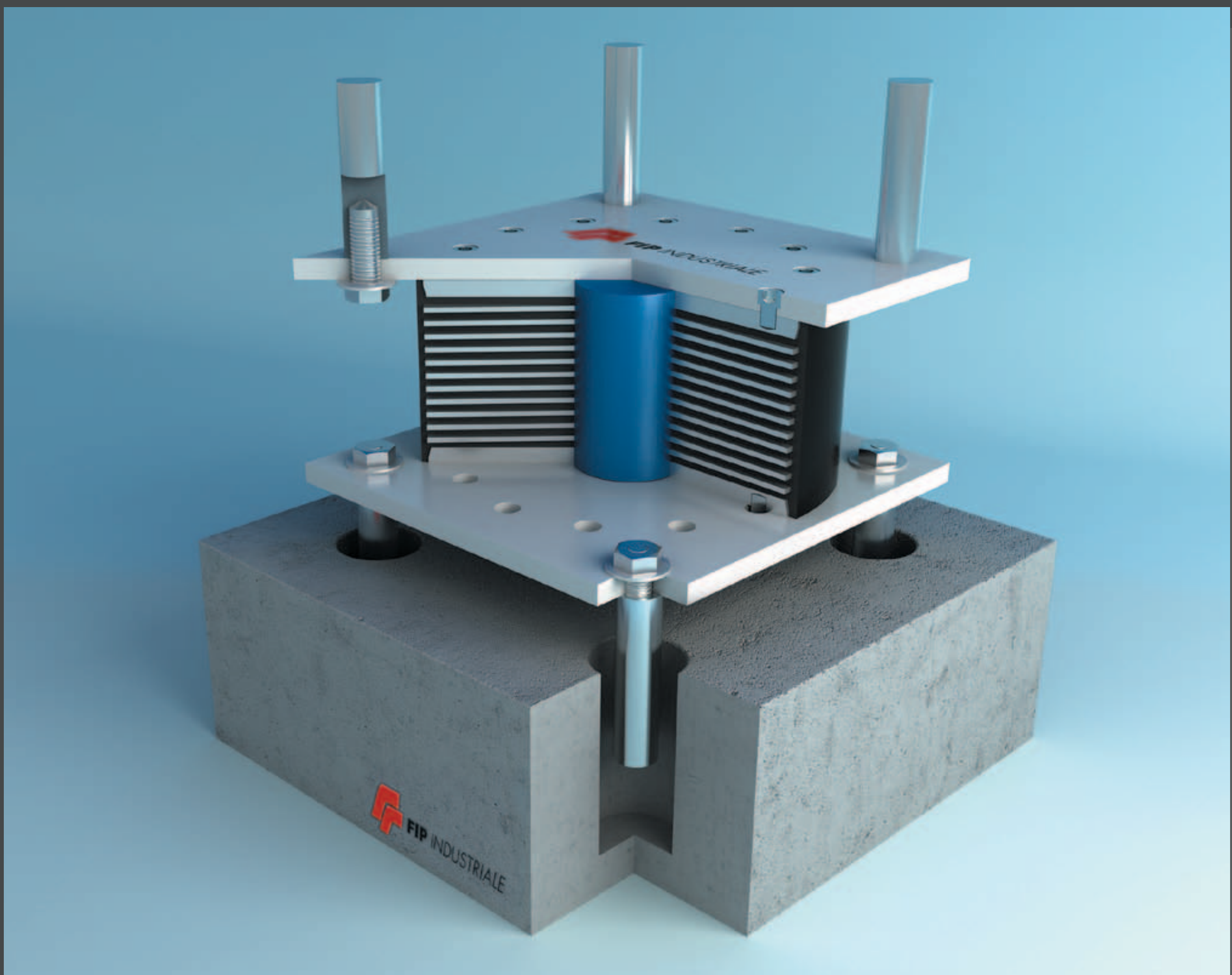
In the framework of the enforcement of the European Construction Products Directive, **FIP Industriale** has gained the CE marking of different types of anti-seismic devices, including lead rubber bearings, in accordance with the harmonised European Standard EN 15129:2009 *Anti-seismic devices*.

DESCRIPTION

Lead **R**ubber **B**earings (**LRB**) are rubber bearings – made up of alternate layers of steel laminates and hot-vulcanized rubber – with a cilindrical central lead ore. The energy dissipation provided by the lead core, through its yielding, allows to achieve an equivalent viscous damping coefficient up to about 30%, i.e. two times that of high damping elastomeric isolators (SI series).

Thanks to the high energy dissipation capacity, it is possible to reduce the horizontal displacement, in comparison with that of an isolation system with the same equivalent stiffness but lower energy dissipation capacity.

Usually, they are circular in shape but can also be fabricated in square sections; they can also be fabricated with more than one lead core.



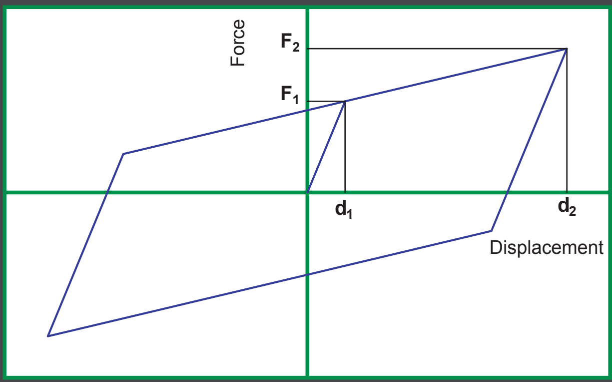
ANCONA, ITALY - “La Torre” office building

ANCONA, ITALY - “La Torre” office building: installation

CHARACTERISTICS

MODELING

The typical hysteresis loop of a Lead Rubber Bearing can be modelled as bilinear. The parameters d_1, F_1, d_2, and F_2 that define the bilinear curve are given in the following tables per each standard **LRB**.



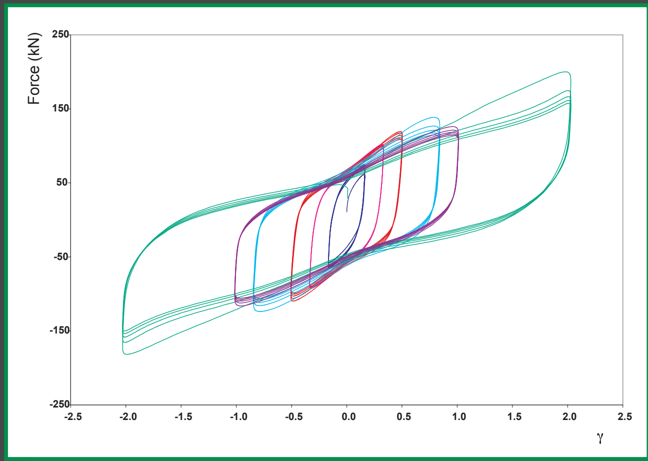
The hysteretic behaviour of an **LRB** can also be modelled as linear, by means of the effective stiffness K_e and the equivalent viscous damping coefficient ξ_e, that depend on the maximum displacement d_2 and on the corresponding force F_2 to which they refer:

$$K_e = \frac{F_2}{d_2}$$

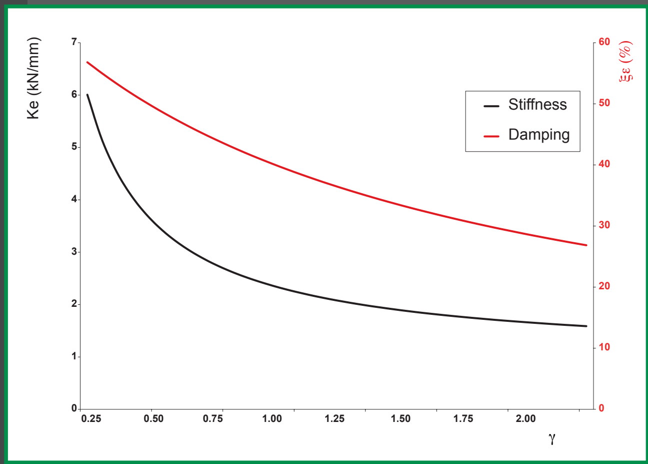
$$\xi_e = \frac{2}{\pi} \cdot \left[\frac{F_1}{F_2} - \frac{d_1}{d_2} \right]$$

The K_e and ξ_e values given in the tables refer to the displacement d_2 (maximum design displacement at ULS) but can easily be calculated for different values of the displacement. The graph on the right shows the typical variation of K_e and ξ_e as a function of the shear strain γ of the elastomer (in this case for the isolator LRB-S 800/200-175).

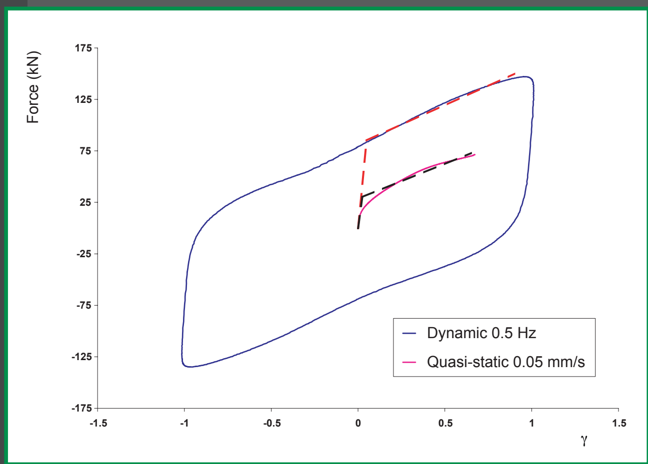
In case of slow movements, due for example to thermal changes, the constitutive behaviour of the isolator is still bilinear, but with different parameters from those corresponding to quick movements, as those induced by the earthquake. In effects, as it is shown in the graph, the forces developed during slow (quasi-static) movements are much lower than those due to earthquake. In particular, the yield force in quasi-static movements can be assumed equal to about 1/3 of the dynamic force, and the post-elastic stiffness can be assumed equal to about 90% of the dynamic value.



Typical hysteresis loops of a lead rubber bearing obtained with dynamic tests at increasing shear strain amplitude.



Typical variation of the effective stiffness and of the equivalent viscous damping coefficient as a function of the shear strain .



Comparison between the dynamic and quasi-static behavior obtained in tests at different velocity (dynamic test with sinusoidal input at frequency of 0.5 Hz and quasi-static test at velocity of 0.05 mm/s).

MATERIALS

The rubber compounds normally used in the production of LRB are characterised by an effective dynamic shear modulus G_{din} equal to 0.4 MPa (S compound) or 0.6 MPa (SN com pound). Rubber compound with higher values of G_{din} up to 1.4 MPa, may be used on request.

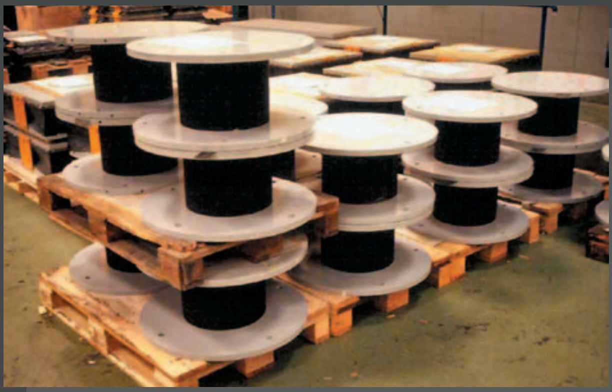
The lead used has high purity, higher than 99.85 %.

DESIGN AND PRODUCTION CRITERIA

STANDARDS

The series **LRB** isolators can be designed *ad hoc* to satisfy all international standards (i.e.: EN 15129, AASHTO, etc.).

Notwithstanding, the standard isolators in this catalogue are designed in compliance with Italian seismic regulations (D.M. dated 14/01/2008) – which are based on Eurocode 8 – as well as with the European standard EN 1337-3: 2005 (Structural bearings. Part 3: Elastomeric Bearings) regarding the normal non-seismic service conditions.

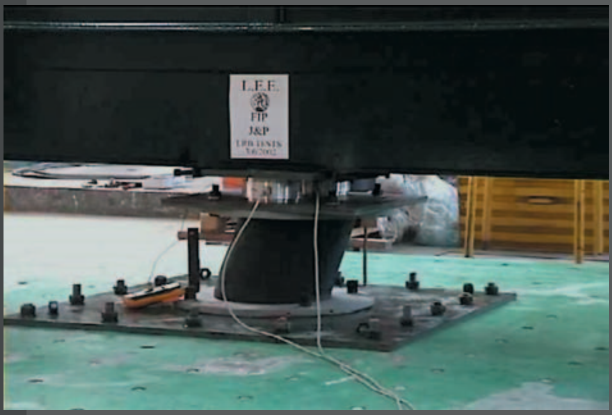


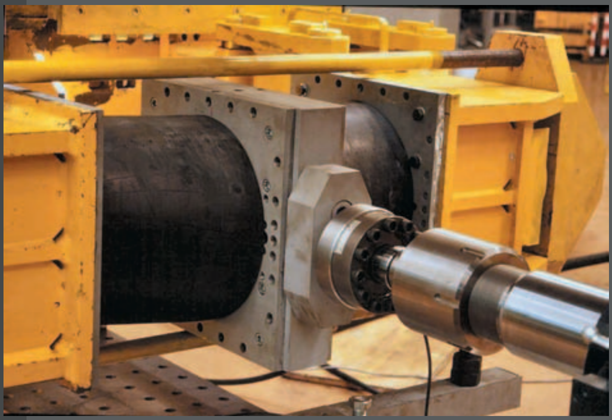
DESIGN FEATURES

The standard **LRB** whose geometric and mechanical characteristics are listed in the enclosed tables, are designed for seven different values of maximum displacement, from 100 to 400 mm. Such entity of displacement is understood to be the maximum design displacement at ULS, factored by the increased reliability factor as per Eurocode 8.

The vertical load V indicated in the tables is the maximum admissible value upon the isolator in the presence of an earthquake provoking the aforesaid displacement.

Null rotation is assumed with reference to the use of these isolators in buildings. The displacement under normal service conditions (i.e. induced by thermal expansion) is assumed to be 10 mm. **FIP Industriale**'s Technical Department is at the design Engineer's disposal to check standard isolators against displacements and rotations differing from those assumed, and to design *ad hoc* isolators diverging from standard features.





ANCHORING SYSTEMS

The **LRB** are endowed with mechanical anchoring systems providing horizontal load transfer in accordance with Italian and international standards.

QUALITY CONTROL

FIP Industriale's internal quality control system ensures the conformity of the product to the various requirements thus guaranteeing the quality both of materials and manufacturing processes.

QUALIFICATION AND ACCEPTANCE TESTS

FIP Industriale's Test Laboratory is equipped to carry out qualification and acceptance tests on **LRB**. Series **LRB** isolators have also been tested at independent laboratories.

INSTALLATION

The typical installation procedure of an isolator anchored on its upper and lower side to reinforced *cast-in-situ* concrete structures, comprises the following phases:

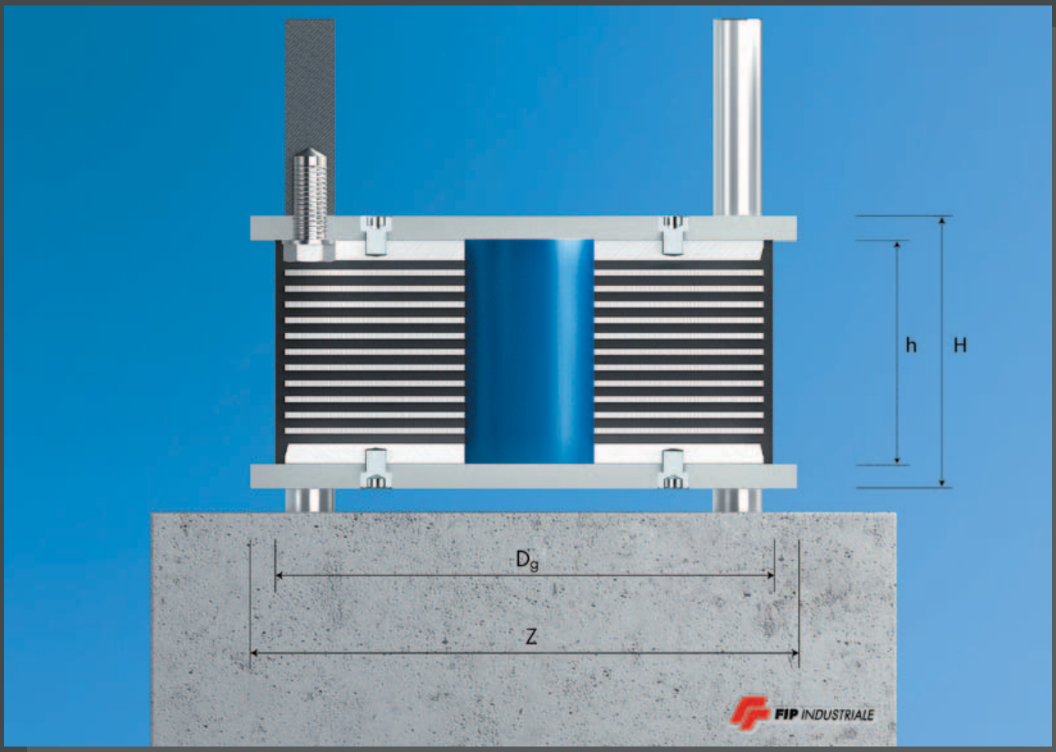
- casting of the substructure up to a level lower than the isolator itself by a few centimeters, leaving holes for the anchor dowels with a diameter at least twice that size;
- positioning of the isolator at the design level and levelling its base horizontally;
- construction of a formwork slightly larger than the isolator and approximately 1 cm higher than its lower edge;
- grouting (with epoxy mortar or non-shrink cementitious mortar) to a suggested thickness between 2 and 5 cm;
- screwing of the upper dowels of the isolator (if not already affixed);
- setting the upper formwork adapting it tightly against the isolator upper plate;
- positioning the superstructure reinforcement followed by concrete casting.

MARKS

The elastomeric isolators with lead core are classified by the mark **LRB** (**L**ead **R**ubber **B**earing) followed by one or more letters (S or SN to indicate the type of compound) and three numbers. The first number represents the external diameter in millimeters, the second stands for the total thickness of the rubber layers in millimeters, and the third represents the diameter of the lead core in millimeters.

Example:

LRB-S 700/203-150 Lead Rubber Bearing, diameter 700 mm, made of rubber compound with G=0.4 MPa, with rubber layers having a total thickness of 203 mm, and a lead core of diameter 150 mm.



BOJANO, ITALY - “G.Lombardo Radice” high school

BOJANO, ITALY - “G.Lombardo Radice” high school: installation

DISPLACEMENT 100 mm

LRB-S	V	F_{zd}	K_e	ξ_e	F_2	F_1	d_1	K_v	D_g	t_e	h	H	Z
	kN	kN	kN/mm	%	KN	KN	mm	kN/mm	mm	mm	mm	mm	mm
			At d_2 = 83 mm										
LRB-S 500/100-110	2700	3630	1.94	35	162	106	8	1164	500	100	197	247	550
LRB-S 550/100-120	4170	5430	2.33	35	194	126	8	1579	550	100	197	247	600
LRB-S 600/102-120	4830	6500	2.49	33	207	128	8	1715	600	102	190	240	650
LRB-S 650/102-120	6440	9190	2.68	30	223	129	8	2235	650	102	200	260	700
LRB-S 700/105-115	7250	10570	2.74	27	228	121	8	2374	700	105	197	257	750
LRB-S 750/112-125	9240	12530	3.08	28	257	143	9	2754	750	112	207	267	800
LRB-S 800/128-130	10310	13190	3.20	29	267	155	10	2577	800	128	223	283	850
LRB-S 850/128-130	12660	17040	3.40	27	284	157	10	3130	850	128	223	283	900
LRB-S 900/126-140	13490	19250	3.91	28	326	182	10	3359	900	126	228	288	950
LRB-S 1000/135-150	19280	26760	4.50	27	375	210	11	4344	1000	135	251	331	1050
LRB-S 1100/150-160	24050	32410	5.01	27	418	241	12	4725	1100	150	266	346	1150
LRB-S 1200/154-160	29180	38760	5.42	25	452	247	12	5498	1200	154	266	346	1250

LRB-SN	V	F_{zd}	K_e	ξ_e	F_2	F_1	d_1	K_v	D_g	t_e	h	H	Z
	kN	kN	kN/mm	%	KN	KN	mm	kN/mm	mm	mm	mm	mm	mm
			at d_2 = 83 mm										
LRB-SN 500/100-110	4050	6060	2.32	30	193	109	8	1424	500	100	197	247	550
LRB-SN 550/100-120	6260	9060	2.78	29	232	130	8	1892	550	100	197	247	600
LRB-SN 600/102-120	7250	10830	3.02	27	252	132	8	2091	600	102	190	240	650
LRB-SN 650/114-130	9760	13520	3.35	28	279	155	9	2366	650	114	218	278	700
LRB-SN 700/126-140	10540	14260	3.70	29	308	180	10	2339	700	126	227	287	750
LRB-SN 750/126-140	13950	17170	3.97	27	331	182	10	2890	750	126	227	287	800
LRB-SN 800/136-145	15210	18010	4.23	27	352	197	11	2904	800	136	234	294	850
LRB-SN 850/144-155	17420	20410	4.66	28	389	225	12	3267	850	144	245	305	900
LRB-SN 900/144-160	20360	27260	5.10	27	425	241	12	3509	900	144	254	314	950
LRB-SN 1000/153-170	29090	33970	5.85	27	488	275	12	4489	1000	153	277	357	1050
LRB-SN 1100/170-185	33050	37200	6.65	27	554	327	14	4883	1100	170	294	374	1150
LRB-SN 1200/176-185	36490	40620	7.15	25	596	336	14	5651	1200	176	296	376	1250

Legenda

V	Maximum vertical load at load combination including the seismic action (at displacement 1.2 d_2)
F_{zd}	Maximun vertical load at non-seismic load combinations, at ULS, concurrent with 0 rotation and 10 mm horizontal displacement
K_e	Effective horizontal stiffness (at displacement d_2)
ξ_e	Equivalent viscous damping coefficient (at displacement d_2)
F_2	Maximum horizontal force (at displacement d_2)
F_1	Yield force
d_1	Yield displacement
K_v	Vertical stiffness
D_g	External elastomer diameter
t_e	Total elastomer thickness
h	Height excluding outer steel plates
H	Total height including outer steel plates
Z	Side length of outer steel plate

DISPLACEMENT 150 mm

LRB-S	V	F_{zd}	K_e	ξ_e	F_2	F_1	d_1	K_v	D_g	t_e	h	H	Z
	kN	kN	kN/mm	%	KN	KN	mm	kN/mm	mm	mm	mm	mm	mm
			at d_2 = 125mm										
LRB-S 500/100-110	2130	3630	1.55	31	193	106	8	1164	500	100	197	247	550
LRB-S 550/100-120	3070	5430	1.86	30	232	126	8	1579	550	100	197	247	600
LRB-S 600/102-120	3630	6500	2.01	28	252	128	8	1715	600	102	190	240	650
LRB-S 650/102-120	4920	9190	2.21	26	276	129	8	2235	650	102	200	260	700
LRB-S 700/105-115	5650	10560	2.30	23	287	121	8	2374	700	105	197	257	750
LRB-S 750/112-125	7350	12530	2.56	24	321	143	9	2754	750	112	207	267	800
LRB-S 800/128-130	8420	13190	2.64	25	331	155	10	2577	800	128	223	283	850
LRB-S 850/128-130	10430	17040	2.85	23	356	157	10	3130	850	128	223	283	900
LRB-S 900/126-140	11160	19250	3.26	23	408	182	10	3359	900	126	228	288	950
LRB-S 1000/135-150	16270	26760	3.76	23	470	210	11	4344	1000	135	251	331	1050
LRB-S 1100/150-160	20680	32410	4.17	23	521	241	12	4725	1100	150	266	346	1150
LRB-S 1200/154-160	25350	38760	4.57	21	572	247	12	5498	1200	154	266	346	1250

LRB-SN	V	F_{zd}	K_e	ξ_e	F_2	F_1	d_1	K_v	D_g	t_e	h	H	Z
	kN	kN	kN/mm	%	KN	KN	mm	kN/mm	mm	mm	mm	mm	mm
			at d_2 = 125mm										
LRB-SN 500/100-110	3200	6060	1.92	25	240	109	8	1424	500	100	197	247	550
LRB-SN 550/100-120	4600	9060	2.31	25	288	130	8	1892	550	100	197	247	600
LRB-SN 600/102-120	5440	10830	2.55	22	318	132	8	2091	600	102	190	240	650
LRB-SN 650/114-130	7580	13520	2.79	24	349	155	9	2366	650	114	218	278	700
LRB-SN 700/126-140	8730	14260	3.05	25	382	180	10	2339	700	126	227	287	750
LRB-SN 750/126-140	11260	17170	3.32	23	415	182	10	2890	750	126	227	287	800
LRB-SN 800/136-145	12650	18010	3.53	23	441	197	11	2904	800	136	234	294	850
LRB-SN 850/144-155	15780	20410	3.87	24	484	225	12	3267	850	144	245	305	900
LRB-SN 900/144-160	17090	27260	4.26	23	532	241	12	3509	900	144	254	314	950
LRB-SN 1000/153-170	24840	33970	4.90	22	612	275	12	4489	1000	153	277	357	1050
LRB-SN 1100/170-185	30780	37200	5.52	23	690	327	14	4883	1100	170	294	374	1150
LRB-SN 1200/176-185	34230	40620	6.02	21	753	336	14	5651	1200	176	296	376	1250

Legenda

V	Maximum vertical load at load combination including the seismic action (at displacement 1.2 d_2)
F_{zd}	Maximun vertical load at non-seismic load combinations, at ULS, concurrent with 0 rotation and 10 mm horizontal displacement
K_e	Effective horizontal stiffness (at displacement d_2)
ξ_e	Equivalent viscous damping coefficient (at displacement d_2)
F_2	Maximum horizontal force (at displacement d_2)
F_1	Yield force
d_1	Yield displacement
K_v	Vertical stiffness
D_g	External elastomer diameter
t_e	Total elastomer thickness
h	Height excluding outer steel plates
H	Total height including outer steel plates
Z	Side length of outer steel plate

DISPLACEMENT 200 mm

LRB-S	V	F_{zd}	K_e	ξ_e	F_2	F_1	d_1	K_v	D_g	t_e	h	H	Z
	kN	kN	kN/mm	%	KN	KN	mm	kN/mm	mm	mm	mm	mm	mm
			at d_2 = 167 mm										
LRB-S 500/100-110	1420	3630	1.35	27	224	106	8	1164	500	100	197	247	550
LRB-S 550/100-120	2120	5430	1.62	27	270	126	8	1579	550	100	197	247	600
LRB-S 600/102-120	2610	6500	1.78	24	296	128	8	1715	600	102	190	240	650
LRB-S 650/102-120	3620	9190	1.97	22	328	129	8	2235	650	102	200	260	700
LRB-S 700/105-115	4250	10570	2.08	19	347	121	8	2374	700	105	197	257	750
LRB-S 750/112-125	5680	12530	2.31	20	385	143	9	2754	750	112	207	267	800
LRB-S 800/128-130	6740	13190	2.37	21	394	155	10	2577	800	128	223	283	850
LRB-S 850/128-130	8420	17040	2.57	19	428	157	10	3130	850	128	223	283	900
LRB-S 900/126-140	9070	19250	2.94	20	490	182	10	3359	900	126	228	288	950
LRB-S 1000/135-150	13510	26760	3.39	20	565	210	11	4344	1000	135	251	331	1050
LRB-S 1100/150-160	17580	32410	3.75	20	625	241	12	4725	1100	150	266	346	1150
LRB-S 1200/154-160	21780	38760	4.15	18	692	247	12	5498	1200	154	266	346	1250

LRB-SN	V	F_{zd}	K_e	ξ_e	F_2	F_1	d_1	K_v	D_g	t_e	h	H	Z
	kN	kN	kN/mm	%	KN	KN	mm	kN/mm	mm	mm	mm	mm	mm
			at d_2 = 167 mm										
LRB-SN 500/100-110	2130	6060	1.72	21	287	109	8	1424	500	100	197	247	550
LRB-SN 550/100-120	3190	9060	2.07	21	345	130	8	1892	550	100	197	247	600
LRB-SN 600/102-120	3910	10830	2.31	19	385	132	8	2091	600	102	190	240	650
LRB-SN 650/114-130	5690	13520	2.51	20	419	155	9	2366	650	114	218	278	700
LRB-SN 700/126-140	6780	14260	2.73	21	455	180	10	2339	700	126	227	287	750
LRB-SN 750/126-140	8870	17170	3.00	19	500	182	10	2890	750	126	227	287	800
LRB-SN 800/136-145	10200	18010	3.19	19	531	197	11	2904	800	136	234	294	850
LRB-SN 850/144-155	12930	20410	3.47	20	579	225	12	3267	850	144	245	305	900
LRB-SN 900/144-160	14120	27260	3.83	20	639	241	12	3509	900	144	254	314	950
LRB-SN 1000/153-170	20940	33970	4.42	19	737	275	12	4489	1000	153	277	357	1050
LRB-SN 1100/170-185	27030	37200	4.95	20	825	327	14	4883	1100	170	294	374	1150
LRB-SN 1200/176-185	31990	40620	5.46	18	910	336	14	5651	1200	176	296	376	1250

Legenda

V	Maximum vertical load at load combination including the seismic action (at displacement 1.2 d_2)
F_{zd}	Maximun vertical load at non-seismic load combinations, at ULS, concurrent with 0 rotation and 10 mm horizontal displacement
K_e	Effective horizontal stiffness (at displacement d_2)
ξ_e	Equivalent viscous damping coefficient (at displacement d_2)
F_2	Maximum horizontal force (at displacement d_2)
F_1	Yield force
d_1	Yield displacement
K_v	Vertical stiffness
D_g	External elastomer diameter
t_e	Total elastomer thickness
h	Height excluding outer steel plates
H	Total height including outer steel plates
Z	Side length of outer steel plate

FIP INDUSTRIALE

DISPLACEMENT 250 mm

LRB-S	V	F_{zd}	K_e	ξ_e	F_2	F_1	d_1	K_v	D_g	t_e	h	H	Z
	kN	kN	kN/mm	%	KN	KN	mm	kN/mm	mm	mm	mm	mm	mm
			at d_2 = 208mm										
LRB-S 500/125-110	990	2900	1.08	27	224	106	10	932	500	125	237	287	550
LRB-S 550/125-120	1640	4340	1.29	27	270	126	10	1263	550	125	237	287	600
LRB-S 600/126-130	2040	5170	1.52	27	318	148	10	1366	600	126	226	276	650
LRB-S 650/126-140	2870	7230	1.78	26	371	172	10	1761	650	126	236	296	700
LRB-S 700/126-115	3540	8800	1.71	19	357	121	10	1978	700	126	227	287	750
LRB-S 750/126-125	4620	9530	1.98	19	413	143	10	2448	750	126	227	287	800
LRB-S 800/160-155	5730	10300	2.16	26	450	214	13	2010	800	160	267	327	850
LRB-S 850/144-150	6960	14890	2.42	22	504	203	12	2736	850	144	245	305	900
LRB-S 900/135-150	7440	17990	2.72	20	567	206	11	3110	900	135	241	301	950
LRB-S 1000/144-160	11340	26120	3.14	19	654	236	12	4046	1000	144	264	344	1050
LRB-S 1100/170-185	15330	29250	3.53	23	735	312	14	4108	1100	170	294	374	1150
LRB-S 1200/176-185	19320	37000	3.86	21	805	318	14	4751	1200	176	296	376	1250

LRB-SN	V	F_{zd}	K_e	ξ_e	F_2	F_1	d_1	K_v	D_g	t_e	h	H	Z
	kN	kN	kN/mm	%	KN	KN	mm	kN/mm	mm	mm	mm	mm	mm
			at d_2 = 208mm										
LRB-SN 500/125-130	1360	4630	1.55	26	322	148	10	1092	500	125	237	287	550
LRB-SN 550/125-120	2470	7240	1.66	21	345	130	10	1514	550	125	237	287	600
LRB-SN 600/126-120	3130	8760	1.86	19	388	132	10	1693	600	126	226	276	650
LRB-SN 650/138-130	4650	11170	2.05	20	428	155	11	1955	650	138	254	314	700
LRB-SN 700/140-140	5430	12830	2.36	20	492	180	11	2105	700	140	247	307	750
LRB-SN 750/140-140	7240	15900	2.60	18	542	182	11	2601	750	140	247	307	800
LRB-SN 800/144-155	8170	17920	2.97	19	618	222	12	2716	800	144	245	305	850
LRB-SN 850/160-170	10730	20250	3.19	21	664	265	13	2902	850	160	267	327	900
LRB-SN 900/171-185	12040	22940	3.49	23	728	312	14	2892	900	171	293	353	950
LRB-SN 1000/180-200	18100	33560	4.10	23	853	366	15	3737	1000	180	316	396	1050
LRB-SN 1100/190-200	23710	37010	4.49	21	934	374	15	4330	1100	190	322	402	1150
LRB-SN 1200/209-215	29400	40260	4.97	22	1036	434	17	4685	1200	209	341	421	1250

Legenda

V	Maximum vertical load at load combination including the seismic action (at displacement 1.2 d_2)
F_{zd}	Maximun vertical load at non-seismic load combinations, at ULS, concurrent with 0 rotation and 10 mm horizontal displacement
K_e	Effective horizontal stiffness (at displacement d_2)
ξ_e	Equivalent viscous damping coefficient (at displacement d_2)
F_2	Maximum horizontal force (at displacement d_2)
F_1	Yield force
d_1	Yield displacement
K_v	Vertical stiffness
D_g	External elastomer diameter
t_e	Total elastomer thickness
h	Height excluding outer steel plates
H	Total height including outer steel plates
Z	Side length of outer steel plate

DISPLACEMENT 300 mm

LRB-S	V	F_{zd}	K_e	ξ_e	F_2	F_1	d_1	K_v	D_g	t_e	h	H	Z
	kN	kN	kN/mm	%	KN	KN	mm	kN/mm	mm	mm	mm	mm	mm
			at d_2 = 250 mm										
LRB-S 500/150-110	540	2420	0.90	27	224	106	12	776	500	150	277	327	550
LRB-S 550/150-120	1050	3620	1.08	27	270	126	12	1052	550	150	277	327	600
LRB-S 600/150-130	1500	4350	1.28	26	319	148	12	1148	600	150	262	312	650
LRB-S 650/150-140	2290	6070	1.49	26	373	172	12	1479	650	150	272	332	700
LRB-S 700/154-150	2780	6900	1.70	26	424	197	12	1550	700	154	267	327	750
LRB-S 750/154-160	3750	9200	1.94	26	485	225	12	1926	750	154	267	327	800
LRB-S 800/168-155	4630	9800	1.94	25	486	214	14	1915	800	168	278	338	850
LRB-S 850/168-150	5990	12760	2.05	22	513	203	14	2345	850	168	278	338	900
LRB-S 900/162-150	6610	15000	2.27	20	567	206	13	2592	900	162	280	340	950
LRB-S 1000/171-160	10200	21990	2.63	19	659	236	14	3407	1000	171	303	383	1050
LRB-S 1100/170-185	12870	29250	3.30	21	825	312	14	4108	1100	170	294	374	1150
LRB-S 1200/176-185	16470	37000	3.64	19	910	318	14	4751	1200	176	296	376	1250

LRB-SN	V	F_{zd}	K_e	ξ_e	F_2	F_1	d_1	K_v	D_g	t_e	h	H	Z
	kN	kN	kN/mm	%	KN	KN	mm	kN/mm	mm	mm	mm	mm	mm
			at d_2 = 250 mm										
LRB-SN 500/150-130	710	3860	1.29	26	322	148	12	910	500	150	277	327	550
LRB-SN 550/150-145	1400	5740	1.58	27	394	184	12	1205	550	150	277	327	600
LRB-SN 600/150-150	2100	6990	1.80	25	451	198	12	1355	600	150	262	312	650
LRB-SN 650/150-170	3130	9630	2.19	26	547	253	12	1697	650	150	272	332	700
LRB-SN 700/154-160	4080	11350	2.27	23	566	229	12	1865	700	154	267	327	750
LRB-SN 750/154-170	5510	15130	2.59	22	647	259	12	2288	750	154	267	327	800
LRB-SN 800/168-155	6940	16340	2.52	19	630	222	14	2328	800	168	278	338	850
LRB-SN 850/168-170	8780	19600	2.90	20	725	265	14	2764	850	168	278	338	900
LRB-SN 900/171-185	9780	22940	3.27	21	817	312	14	2892	900	171	293	353	950
LRB-SN 1000/180-200	15080	33560	3.83	21	958	366	15	3737	1000	180	316	396	1050
LRB-SN 1100/190-200	20150	37010	4.22	19	1055	374	15	4330	1100	190	322	402	1150
LRB-SN 1200/209-215	26140	40260	4.67	19	1167	434	17	4685	1200	209	341	421	1250

Legenda

V	Maximum vertical load at load combination including the seismic action (at displacement 1.2 d_2)
F_{zd}	Maximun vertical load at non-seismic load combinations, at ULS, concurrent with 0 rotation and 10 mm horizontal displacement
K_e	Effective horizontal stiffness (at displacement d_2)
ξ_e	Equivalent viscous damping coefficient (at displacement d_2)
F_2	Maximum horizontal force (at displacement d_2)
F_1	Yield force
d_1	Yield displacement
K_v	Vertical stiffness
D_g	External elastomer diameter
t_e	Total elastomer thickness
h	Height excluding outer steel plates
H	Total height including outer steel plates
Z	Side length of outer steel plate

DISPLACEMENT 350 mm

LRB-S	V	F_{zd}	K_e	ξ_e	F_2	F_1	d_1	K_v	D_g	t_e	h	H	Z
	kN	kN	kN/mm	%	KN	KN	mm	kN/mm	mm	mm	mm	mm	mm
			at d_2 = 292mm										
LRB-S 500/175-110	240	2070	0.77	27	224	106	14	665	500	175	317	367	550
LRB-S 550/175-120	580	3100	0.92	27	270	126	14	902	550	175	317	367	600
LRB-S 600/180-130	900	3620	1.08	27	314	148	15	956	600	180	307	357	650
LRB-S 650/180-140	1530	5060	1.26	27	367	172	15	1232	650	180	317	377	700
LRB-S 700/175-150	2120	6080	1.48	26	430	197	14	1364	700	175	297	357	750
LRB-S 750/175-160	3030	8100	1.69	26	492	225	14	1695	750	175	297	357	800
LRB-S 800/176-175	3530	9150	1.95	27	570	268	14	1785	800	176	289	349	850
LRB-S 850/176-185	4870	11810	2.20	27	641	300	14	2160	850	176	289	349	900
LRB-S 900/180-195	5270	12940	2.42	27	707	333	15	2235	900	180	306	366	950
LRB-S 1000/180-200	8230	20250	2.81	24	819	354	15	3140	1000	180	316	396	1050
LRB-S 1100/190-200	11270	25900	3.07	22	894	360	15	3639	1100	190	322	402	1150
LRB-S 1200/187-200	14230	34520	3.48	20	1016	365	15	4435	1200	187	311	391	1250

LRB-SN	V	F_{zd}	K_e	ξ_e	F_2	F_1	d_1	K_v	D_g	t_e	h	H	Z
	kN	kN	kN/mm	%	KN	KN	mm	kN/mm	mm	mm	mm	mm	mm
			at d_2 = 292mm										
LRB-SN 500/175-130	290	3310	1.11	26	322	148	14	780	500	175	317	367	550
LRB-SN 550/175-145	730	4920	1.35	27	394	184	14	1033	550	175	317	367	600
LRB-SN 600/180-150	1230	5830	1.52	25	443	198	15	1129	600	180	307	357	650
LRB-SN 650/180-170	2050	8020	1.85	27	539	253	15	1414	650	180	317	377	700
LRB-SN 700/175-170	3010	9830	2.06	24	600	256	14	1618	700	175	297	357	750
LRB-SN 750/175-170	4450	13320	2.25	22	657	259	14	2013	750	175	297	357	800
LRB-SN 800/176-190	5130	14950	2.64	23	769	321	14	2137	800	176	289	349	850
LRB-SN 850/176-185	6900	19600	2.81	21	820	308	14	2600	850	176	289	349	900
LRB-SN 900/198-185	8500	19810	2.81	21	821	312	16	2498	900	198	332	392	950
LRB-SN 1000/180-200	12340	33560	3.64	19	1063	366	15	3737	1000	180	316	396	1050
LRB-SN 1100/220-200	18250	37010	3.64	19	1061	374	18	3740	1100	220	364	444	1150
LRB-SN 1200/242-215	23970	40260	4.02	19	1173	434	20	4046	1200	242	386	466	1250

Legenda

V	Maximum vertical load at load combination including the seismic action (at displacement 1.2 d_2)
F_{zd}	Maximun vertical load at non-seismic load combinations, at ULS, concurrent with 0 rotation and 10 mm horizontal displacement
K_e	Effective horizontal stiffness (at displacement d_2)
ξ_e	Equivalent viscous damping coefficient (at displacement d_2)
F_2	Maximum horizontal force (at displacement d_2)
F_1	Yield force
d_1	Yield displacement
K_v	Vertical stiffness
D_g	External elastomer diameter
t_e	Total elastomer thickness
h	Height excluding outer steel plates
H	Total height including outer steel plates
Z	Side length of outer steel plate

DISPLACEMENT 400 mm

LRB-S	V	F_{zd}	K_e	ξ_e	F_2	F_1	d_1	K_v	D_g	t_e	h	H	Z
	kN	kN	kN/mm	%	KN	KN	mm	kN/mm	mm	mm	mm	mm	mm
			at d_2 = 333 mm										
LRB-S 500/200-110	50	1810	0.67	27	224	106	16	582	500	200	357	407	550
LRB-S 550/200-120	260	2710	0.81	27	270	126	16	789	550	200	357	407	600
LRB-S 600/204-130	500	3190	0.95	27	315	148	16	844	600	204	343	393	650
LRB-S 650/204-140	960	4460	1.11	27	368	172	16	1087	650	204	353	413	700
LRB-S 700/203-150	1390	5240	1.28	26	427	197	16	1176	700	203	337	397	750
LRB-S 750/203-160	2170	6980	1.46	26	488	225	16	1461	750	203	337	397	800
LRB-S 800/200-175	2810	8050	1.71	27	572	268	16	1571	800	200	322	382	850
LRB-S 850/200-185	3850	10350	1.93	27	643	300	16	1901	850	200	322	382	900
LRB-S 900/207-195	4540	11250	2.11	27	704	333	17	1943	900	207	345	405	950
LRB-S 1000/207-200	7290	17610	2.45	24	816	354	17	2731	1000	207	355	435	1050
LRB-S 1100/220-200	10230	22370	2.66	22	887	360	18	3143	1100	220	364	444	1150
LRB-S 1200/220-200	13240	29340	2.99	20	996	365	18	3770	1200	220	356	436	1250

LRB-SN	V	F_{zd}	K_e	ξ_e	F_2	F_1	d_1	K_v	D_g	t_e	h	H	Z
	kN	kN	kN/mm	%	KN	KN	mm	kN/mm	mm	mm	mm	mm	mm
			at d_2 = 333 mm										
LRB-SN 500/200-130	10	2890	0.97	26	322	148	16	683	500	200	357	407	550
LRB-SN 550/200-145	280	4300	1.18	27	394	184	16	904	550	200	357	407	600
LRB-SN 600/204-150	660	5140	1.34	25	445	198	16	996	600	204	343	393	650
LRB-SN 650/204-170	1240	7080	1.62	27	541	253	16	1248	650	204	353	413	700
LRB-SN 700/203-170	1940	8480	1.79	24	595	256	16	1395	700	203	337	397	750
LRB-SN 750/203-170	3170	11480	1.95	22	651	259	16	1736	750	203	337	397	800
LRB-SN 800/200-190	4070	13160	2.32	23	772	321	16	1881	800	200	322	382	850
LRB-SN 850/200-185	5780	16910	2.47	21	823	308	16	2288	850	200	322	382	900
LRB-SN 900/225-185	6630	17430	2.47	21	824	312	18	2198	900	225	371	431	950
LRB-SN 1000/207-200	10940	29350	3.18	19	1058	366	17	3249	1000	207	355	435	1050
LRB-SN 1100/250-200	15630	32810	3.19	19	1065	374	20	3291	1100	250	406	486	1150
LRB-SN 1200/275-215	19840	38760	3.53	19	1177	434	22	3560	1200	275	431	511	1250

Legenda

V	Maximum vertical load at load combination including the seismic action (at displacement 1.2 d_2)
F_{zd}	Maximun vertical load at non-seismic load combinations, at ULS, concurrent with 0 rotation and 10 mm horizontal displacement
K_e	Effective horizontal stiffness (at displacement d_2)
ξ_e	Equivalent viscous damping coefficient (at displacement d_2)
F_2	Maximum horizontal force (at displacement d_2)
F_1	Yield force
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K_v	Vertical stiffness
D_g	External elastomer diameter
t_e	Total elastomer thickness
h	Height excluding outer steel plates
H	Total height including outer steel plates
Z	Side length of outer steel plate

MAY 2012

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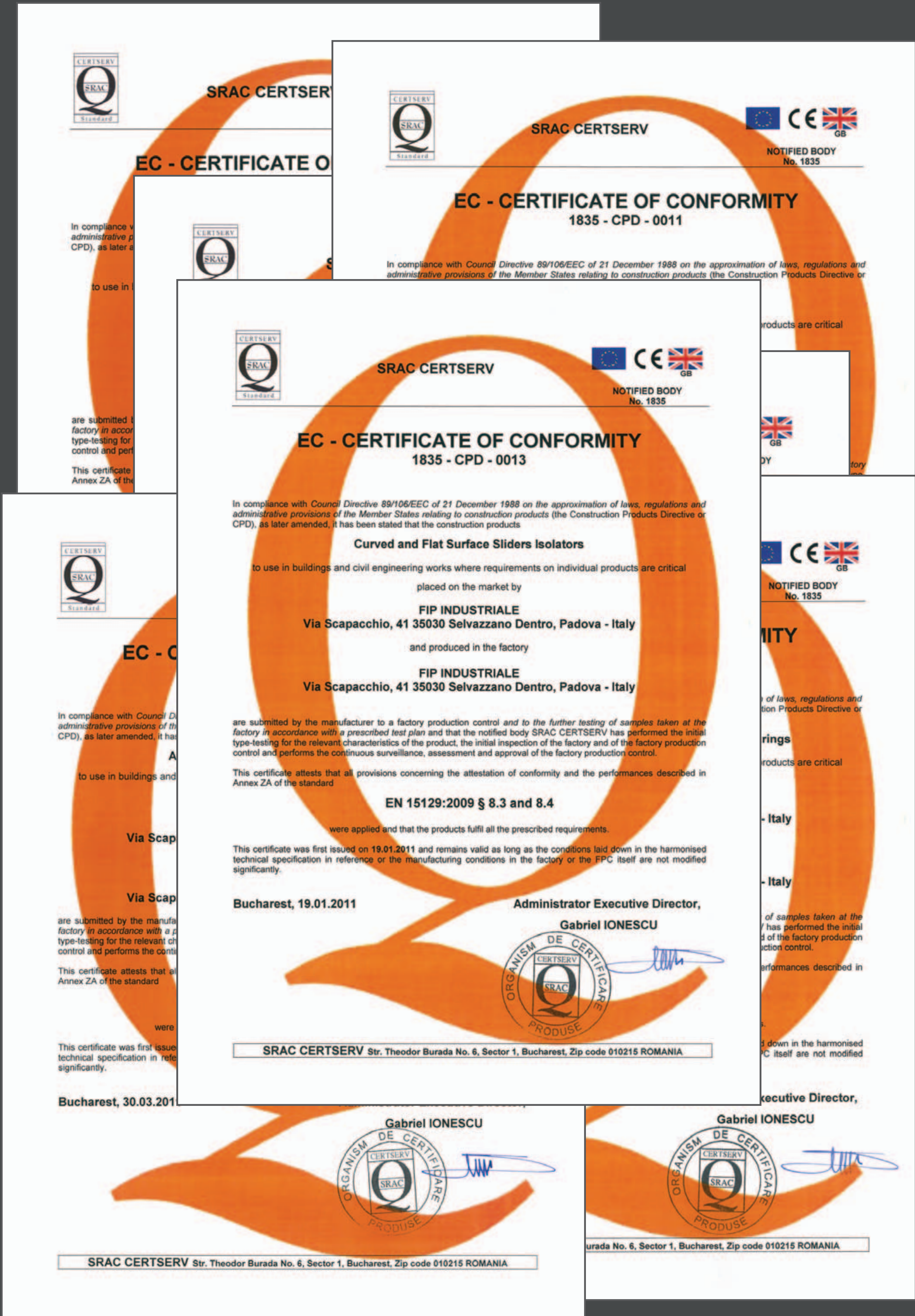
FIP INDUSTRIALE

CURVED SURFACE SLIDERS

CURVED SURFACE SLIDERS

S04



SRAC CERTSERV

NOTIFIED BODY
No. 1835

EC - CERTIFICATE OF CONFORMITY

1835 - CPD - 0013

In compliance with *Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products* (the Construction Products Directive or CPD), as later amended, it has been stated that the construction products

Curved and Flat Surface Sliders Isolators

to use in buildings and civil engineering works where requirements on individual products are critical

placed on the market by

FIP INDUSTRIALE
Via Scapacchio, 41 35030 Selvazzano Dentro, Padova - Italy

and produced in the factory

FIP INDUSTRIALE
Via Scapacchio, 41 35030 Selvazzano Dentro, Padova - Italy

are submitted by the manufacturer to a factory production control *and to the further testing of samples taken at the factory in accordance with a prescribed test plan* and that the notified body SRAC CERTSERV has performed the initial type-testing for the relevant characteristics of the product, the initial inspection of the factory and of the factory production control and performs the continuous surveillance, assessment and approval of the factory production control.

This certificate attests that all provisions concerning the attestation of conformity and the performances described in Annex ZA of the standard

EN 15129:2009 § 8.3 and 8.4

were applied and that the products fulfil all the prescribed requirements.

This certificate was first issued on **19.01.2011** and remains valid as long as the conditions laid down in the harmonised technical specification in reference or the manufacturing conditions in the factory or the FPC itself are not modified significantly.

Bucharest, 19.01.2011

Administrator Executive Director,
Gabriel IONESCU

SRAC CERTSERV Str. Theodor Burada No. 6, Sector 1, Bucharest, Zip code 010215 ROMANIA

INTRODUCTION

CERTIFICATIONS

In 1992, **FIP Industriale** secured CISQ-ICIM certification for its Quality Assurance System in conformance with EN 29001 European Standard (ISO 9001).

FIP Industriale is proud to be the first Italian manufacturer of structural bearings, anti-seismic devices and expansion joints boasting a Quality Assurance System certified at the highest level - from design to customer service assistance.

Certification has been achieved via rigorous evaluation by an internationally recognized Third Party Organisation, thus internationally validating the quality assurance system.

In the framework of the enforcement of the European Construction Products Directive, **FIP Industriale** has gained the CE marking of different types of anti-seismic devices, including curved surface sliders, in accordance with the harmonised European Standard EN 15129:2009 *Anti-seismic devices*.

ISO 9001 - Cert. N. 0057

DESCRIPTION

The curved surface sliders or **F**riction **I**solation **P**endula (**FIP**) are sliding isolators based on the working principle of the simple pendulum. In a structure that is isolated by means of curved surface sliders, the period of oscillation mainly depends on the radius of curvature of the curved sliding surface, i.e. it is almost independent from the mass of the structure. The energy dissipation is provided by the friction encountered during the movement of the sliding surfaces, and the re-centring capability is provided by the curvature of the sliding surface.

The **F**riction **I**solation **P**endulum can be designed and manufactured in two main types, with one or two primary spherical sliding surfaces that accomodates the horizontal displacement, respectively classified as **FIP** or **FIP-D** series as follows.

FIP series

The **FIP** series devices are characterised by: i) a concave slider (top element in the picture) whose radius of curvature imposes the period of oscillation and that accomodates for the horizontal displacement; ii) a base element with a secondary concave sliding surface that permits the rotation; iii) a steel intermediate element with two convex surfaces suitably shaped to be coupled with the other two elements. The device can also be installed upside-down, i.e. with the main concave slider at the bottom.

The **FIP-D** series or double concave curved surface sliders are characterised by two primary concave sliding surfaces with the same radius of curvature; both surfaces accomodate for horizontal displacement and rotation. In this case each single sliding surface is designed to accomodate only half of the total horizontal displacement, so that the dimensions in plan of the devices may be significantly smaller in comparison with **FIP** series. Another advantage of **FIP-D** series versus **FIP** series is that the eccentricity of the vertical load (P-Δ effect) is halved, i.e. is equal to half the displacement, while in **FIP** series devices it is equal to the displacement (on one side).

FIP-D series

A special thermoplastic material (red in the pictures), coupled with stainless steel, is used on both primary and secondary sliding surfaces to govern the friction.

MATERIALS

The selection of the sliding material is essential to give the curved surface sliders an optimal behaviour in terms of: i) load bearing capacity; ii) friction coefficient and consequently energy dissipation; iii) stability of the hysteretic force vs. displacement curve both with cycling and with temperature; iv) durability; v) wear resistance.

The sliding material utilized in the primary sliding surfaces is the **FFM** (**F**IP **F**riction **M**aterial), an Ultra-High Molecular Weight Poly-Ethylene (UHMW-PE) characterised by exceptional properties in terms of load bearing capacity, wear resistance, as well as stability and durability. Other important characteristics of **FFM** are the absence of stick-slip and the low value of the ratio between the break-away and the dynamic friction coefficients.

The above properties have been verified through extensive testing campaigns, including among others all the tests required by the European Standard EN 15129, carried out both in **FIP Industriale**'s laboratory and in independent laboratories.

FFM is used without lubrication. The material used in the secondary sliding surface of **FIP** series devices is **SMF** (**S**liding **M**aterial **F**IP), that is a dimpled and lubricated UHMW-PE.

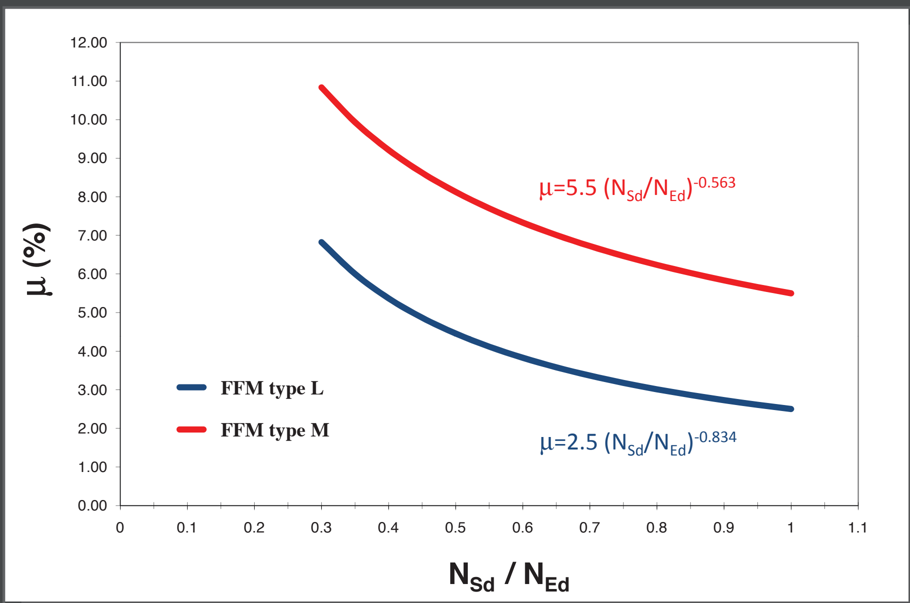
The dynamic friction coefficient is the most important parameter that the Structural Engineer needs to know when modelling a structure with curved surface sliders. For any sliding material the friction coefficient is dependent on both velocity and pressure. However, the dependence on velocity is not significant in the range of velocity associated with earthquake excitation of an isolated structure. Conversely, it is well known from literature, and confirmed by test results, that the dependence on pressure (vertical load) is not negligible; in particular, the friction coefficient decreases at the increasing of the vertical load.

Typical values of dynamic friction coefficient of **FFM** are reported in the table, respectively for **FFM** type L (Low friction) and **FFM** type M (Medium friction).

FFM type	L (low friction)	M (medium friction)
Minimum friction coefficient (%)	2.5	5.5

The above values of the friction coefficient are minimum values and correspond to the maximum design vertical load N_{Ed} of the curved surface slider, i.e. the maximum vertical load at ULS load combinations including the seismic action, or at any load combination including horizontal displacement. For the standard **FIP-D** isolators, the values of the maximum design vertical load N_{Ed} are reported in the tables at the end of this catalogue.

The graphics show how the dynamic friction coefficient varies with the vertical load; in particular, with the ratio of the vertical load N_{Sd} acting on the isolator (usually assumed constant and equal to the quasi-permanent load, see below) to the maximum vertical load N_{Ed} as defined above.



On request, different values of friction coefficient can be provided.

Austenitic steel in accordance with the European Standard EN 10088-2 is commonly used as mating surface.

MODELLING

The mathematical model that best resembles the functioning of the curved surface sliders (both **FIP** and **FIP-D** series) consists of a bilinear force-displacement curve as shown in the figure, where:

$F_0 = \mu \cdot N_{Sd}$ ➡ friction force developed by the isolator

$F_{max} = F_0 + K_r \cdot d = \mu \cdot N_{Sd} + \frac{N_{Sd}}{R} \cdot d$ ➡ maximum horizontal force

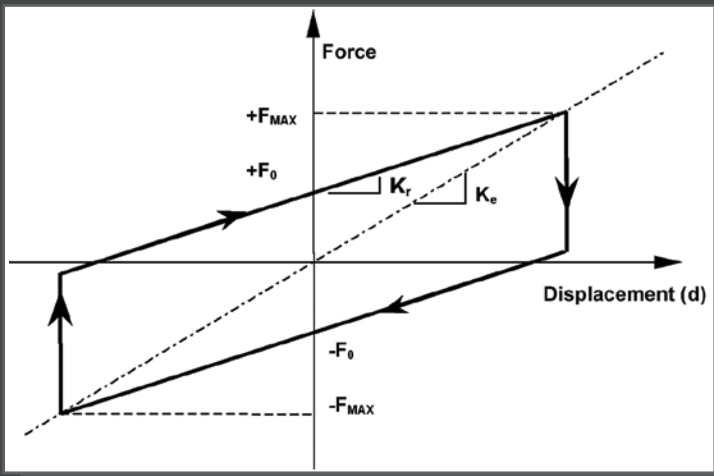
$K_r = \frac{N_{Sd}}{R}$ ➡ restoring stiffness

μ ➡ friction coefficient

N_{Sd} ➡ vertical load acting on the isolator

R ➡ equivalent radius of curvature

d ➡ displacement



The vertical load N_{Sd} used to model the behaviour of the curved surface sliders under earthquake excitation is usually the quasi-permanent vertical load, i.e. the mass multiplied by the gravity acceleration, that is the average load acting on the isolator during the earthquake. Non-linear dynamic models that take into account the variation of vertical load during the earthquake are sometimes used.

The friction coefficient μ is a function of vertical load, as shown before. Usually it is calculated at the value of quasi-permanent load, according to the law $\mu(N_{Sd}/N_{Ed})$ given above.

In **FIP** series, the equivalent radius of curvature R coincides with the geometric radius of curvature of the primary sliding surface, while in **FIP-D** series R is approximately two times the geometric radius of curvature of each sliding surface.

When the Standard used for design of structures allows to model said non linear behaviour as a linear equivalent behaviour, the effective stiffness and the effective viscous damping can be calculated with the following formulae:

$$K_e = N_{Sd} \cdot \left(\frac{1}{R} + \frac{\mu}{d} \right) \qquad \xi_e = \frac{2}{\pi} \cdot \frac{1}{\frac{d}{\mu \cdot R} + 1}$$

It is worth noting that both the effective stiffness and the effective viscous damping depend on displacement; consequently, even when it is allowed to model the isolation system as linear equivalent, an iterative procedure should be applied, until the difference between the assumed and the calculated values of displacement becomes negligible.

Thanks to the dependence of the effective stiffness on vertical load, the center of mass and the center of stiffness of the isolation system coincide in plan.

The effective fundamental period, i.e. the period associated to the effective stiffness, of a structure isolated with curved surface sliders can be estimated as:

$$T_e = 2\pi \sqrt{\frac{1}{g \cdot \left(\frac{1}{R} + \frac{\mu}{d} \right)}}$$

The period associated to the restoring stiffness K_r is instead equivalent to that of a simple pendulum of length R:

$$T = 2\pi \sqrt{\frac{R}{g}}$$

DESIGN AND PRODUCTION CRITERIA

STANDARDS

The curved surface sliders (both series **FIP** and **FIP-D**) are usually designed according to the European Standard EN 15129:2009 *Anti-seismic devices*. On request, they can be designed to satisfy other standards or technical specifications.

DESIGN FEATURES

The standard **FIP-D** isolators whose geometrical and mechanical characteristics are listed in the enclosed tables, are designed for seven different values of maximum displacement, from 100 to 400 mm.

Such entity of displacement is understood to be the maximum displacement d_{Ed} according to EN 15129:2009.

For buildings and other structures other than bridges, d_{Ed} is given by the design displacement under seismic action d_{bd}, factored by the magnification factor γ_x as per Eurocode 8 (EN 1998-1:2005, § 10.3 (2)P).

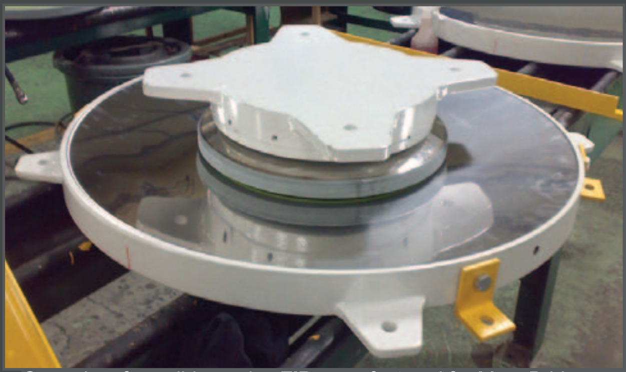
For bridges, d_{Ed} coincides with d_{max} as defined in EN 1998-2:2009, § 7.6.2, i.e. is obtained by adding to the amplified design seismic displacement $\gamma_x d_{bd}$, the potential offset displacement due to the permanent actions, the long-term deformations of the superstructure, and the 50 % of the thermal action.

The vertical load N_{Ed} indicated in the tables is the maximum vertical load at ULS load combinations including the seismic action, or at any other load combination including horizontal displacement. The vertical load at zero horizontal displacement can be higher than N_{Ed}, and usually in r.c. structures depends on concrete strength.

The equivalent radius of curvature is fixed for each value of displacement; three different values have been used, 2.5 m for displacement 100 and 150 mm, 3.1 m for displacement 200 and 250 mm, and 3.7 m for displacement 300, 350 and 400 mm. It is recommended to use in a structure isolators with the same equivalent radius of curvature, in order to avoid differential vertical displacements associated to horizontal displacement.

A rotation value of 0.01 rad is assumed in the design, combined with maximum horizontal displacement d_{Ed}. At lower values of displacement, higher values of rotation are allowed.

FIP Industriale's Technical Department may also design ad hoc curved surface sliders different from the standard ones to satisfy the Engineer's requirement, e.g. with different values of radius of curvature, displacement, vertical load, rotation, friction coefficient, or of the **FIP** series.



Curved surface slider series **FIP** manufactured for Mary Bridge, Turkmenistan

TURKMENISTAN - Mary Bridge

QUALITY CONTROL

FIP Industriale's internal quality control system ensures the conformity of the product to the various requirements thus guaranteeing the quality both of materials and manufacturing processes.

TYPE AND FACTORY PRODUCTION CONTROL TESTS

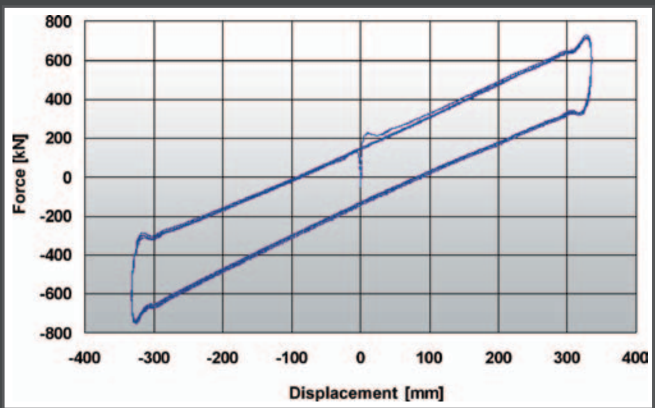
Both series **FIP** and **FIP-D** isolators have been tested at independent laboratories. In particular, full scale isolators of different sizes have been subjected to type tests according to the European Standard EN 15129, to the Italian Standard NTC 2008, and to other national Standards as well.

Furthermore, two **FIP-D** isolators were tested at the Seismic Response Modification Device Test Facility at the University of California at San Diego, USA, in order to verify their behaviour when submitted to a simultaneous bi-directional dynamic horizontal movement under vertical load. The isolators were subjected both to simultaneous sinusoidal movements along two primary axes (the so called "clover leaf" path as per EN 15129) and to a bi-directional time-history of horizontal displacement which reproduces the effect of an actual earthquake.

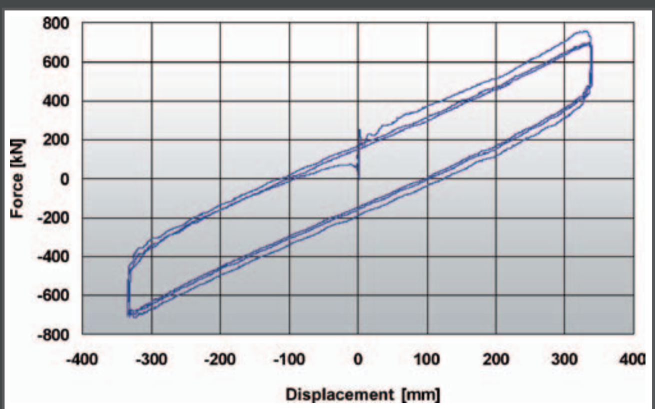
The reliability of **FIP Industriale**'s technology has been confirmed by the above mentioned type tests, as well as by many factory production control tests performed both at independent laboratories and at **FIP Industriale**'s Test Laboratory according to EN 15129 and the Italian Standard NTC 2008. Furthermore, dynamic tests on entire buildings of the C.A.S.E. project in L'Aquila, isolated with **FIP-D** isolators, were carried out by the Italian Civil Defence.

• Type tests on a double concave curved surface slider at Eucentre Trees Laboratory in Pavia.

• Bi-directional type tests on a **FIP-D** isolator at the SRMD Test Facility at the University of California at San Diego, USA.



• Experimental hysteretic cycles of a double concave curved surface slider obtained in a test at constant velocity.



• Experimental hysteretic cycles of a double concave curved surface slider obtained in a sinusoidal test.

• Dynamic tests on a building of the C.A.S.E. project in l'Aquila (Italy) isolated with **FIP-D** devices.

DESIGN AND PRODUCTION CRITERIA

ANCHORING SYSTEMS

The curved surface sliders are fixed on to the structure by means of mechanical anchoring systems providing 100 % of the horizontal load transfer (despite the European Standard EN 15219:2009 allows that only 75 % of the horizontal load is supported by mechanical anchorages when the minimum vertical load on the isolators during the seismic action has been determined by non-linear dynamic analysis).

INSTALLATION

The typical installation procedure of an isolator anchored on its upper and lower side to reinforced cast-in-situ concrete structures, comprises the following phases:

- casting of the substructure up to a level lower than the isolator itself by a few centimeters, leaving holes for the anchor dowels with a diameter at least twice that of the same;
- positioning the isolator at the design level and leveling its base horizontally;
- construction of a formwork slightly larger than the isolator and approximately 1 cm higher than its lower edge;
- grouting (epoxy mortar or shrink free cementitious mortar) to a suggested thickness between 2 and 5 cm;
- screwing of the upper dowels to the isolator (if not already affixed);
- setting the upper formwork adapting it tightly against the isolator upper plate;
- positioning the superstructure reinforcement followed by concrete casting;
- following the hardening of the concrete, and in any case before the structure starts to be utilized, remove the transportation brackets (usually yellow) unscrewing the screws; re-tight all screw in their respective threaded holes in order to ensure the maximum anti-corrosion protection of the holes.

It is recommended to pay attention to protect the sliding surfaces of the isolators during the pouring of concrete. Should the sliding surfaces get accidentally dirty during installation, they shall be cleaned as soon as possible.

FIRE RESISTANCE

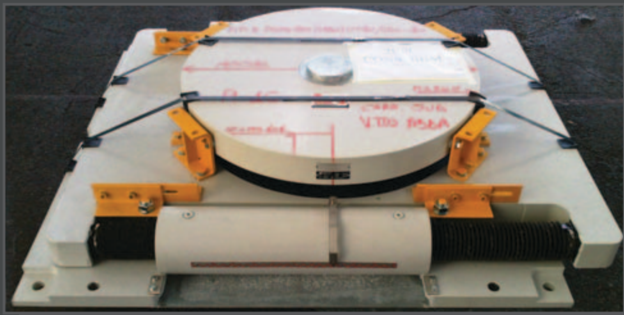
Curved surface sliders are characterised by intrinsic fire resistance, usually higher than 240 minutes, when installed in reinforced concrete structures, i.e. when the exposure to fire is only through lateral surface. However, replacement of the entire isolator that has been subjected to fire or at least of some parts of it (e.g. the sliding material and the stainless steel) could be necessary.

For curved surface sliders installed in steel structures, a passive fire protection system is recommended for the isolators as well as for the structural elements.

COMBINATION OF DEVICES

Curved surface sliders can be combined with other anti-seismic devices, to obtain special performance, useful in particular in bridge applications.

For example, they can be combined with shock transmission units for application on mobile piers of a bridge; the shock transmission units allow the slow movements due to the variations of temperature without transmitting a significant horizontal force to the pier, while under an earthquake the shock transmission units become stiff and the curved surface slider is activated, thus dissipating energy and ensuring the re-centring according to its force vs. displacement curve. This behaviour can be important in order to reduce the horizontal force transmitted to the pier under service conditions.



• **FIP-D** isolator combined with shock transmission units.

MARKS

The curved surface sliders or double concave curved surface sliders are classified by the mark **FIP** or **FIP-D**, respectively, followed by a letter and 3 numbers. The letter identify the friction coefficient (L: low friction – M: medium friction), the first number is a conventional number, the second number represents the total displacement in millimeters and the third number (in brackets) stands for the equivalent curvature radius in millimeters.

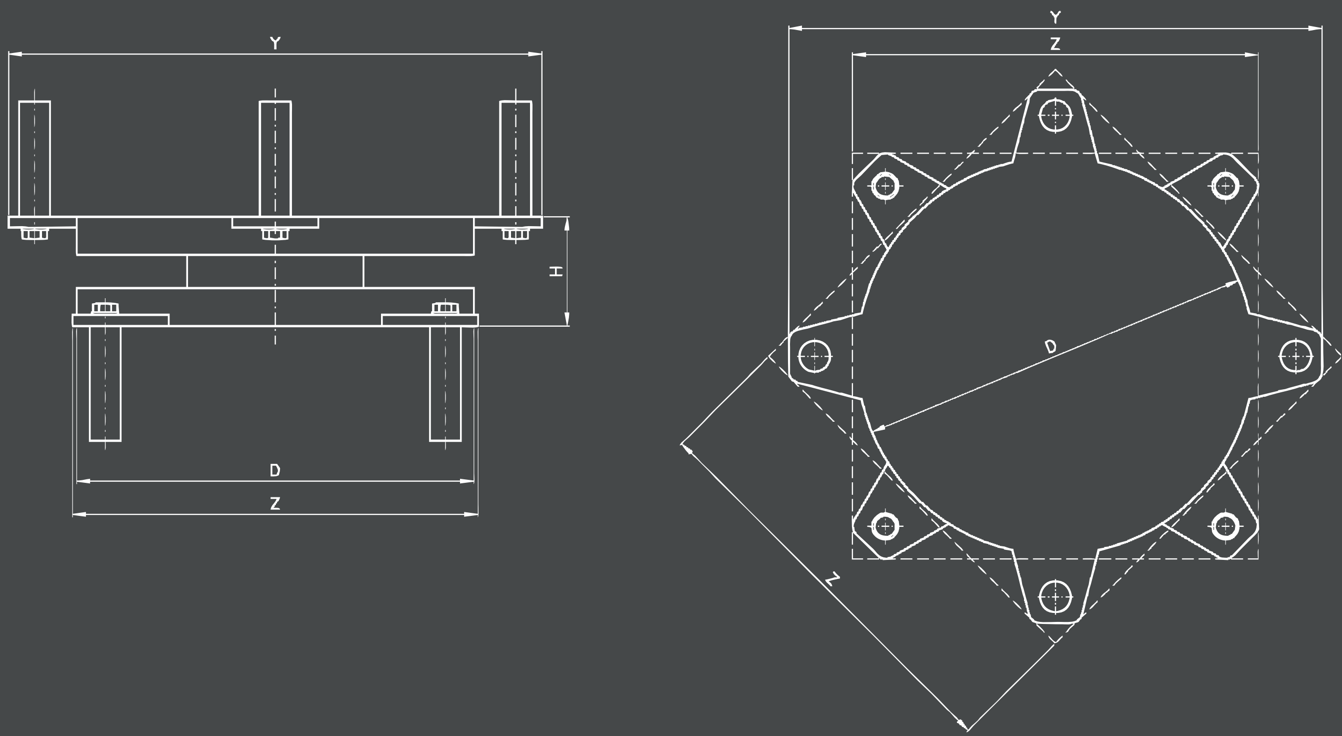
Example:

FIP-D L 1200/600 (3700)	double concave curved surface slider that permits ± 300 mm horizontal displacement in all directions, with an equivalent curvature radius of 3700 mm and using low friction sliding material.

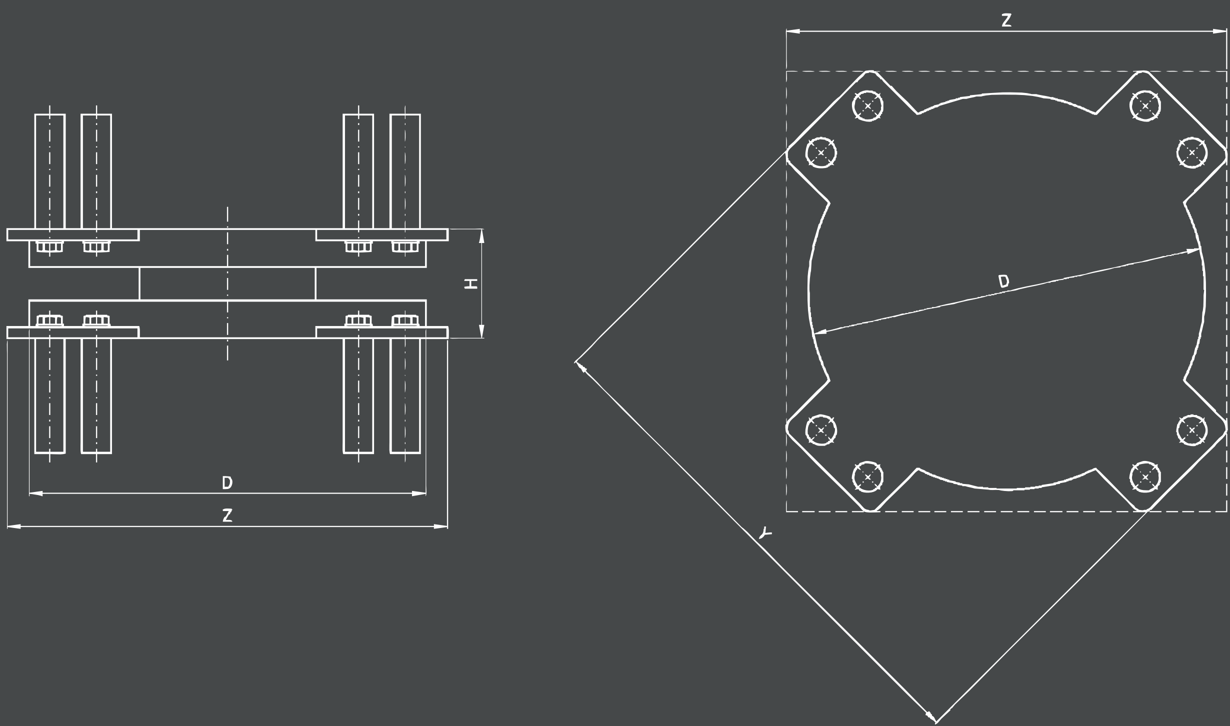
• TURKMENISTAN - Avaza Bridge

• CASTEL DI SANGRO, ITALY - private building

SCHEME FIP-D



Schematic drawing for FIP-D isolator with four upper/lower dowels



Schematic drawing for FIP-D isolator with eight or more upper/lower dowels

TABLES FIP-D STANDARD

Displacement ±100 mm

Low friction		Medium friction							
Isolator Mark	N_{Ed} kN	Isolator Mark	N_{Ed} kN	D mm	Y mm	Z mm	H mm	n	W kg
FIP-D L 250/200 (2500)	1000	FIP-D M 250/200 (2500)	220	350	460	350	98	4	50
FIP-D L 340/200 (2500)	1500	FIP-D M 340/200 (2500)	560	380	490	380	104	4	65
FIP-D L 440/200 (2500)	2000	FIP-D M 440/200 (2500)	990	410	520	410	99	4	75
FIP-D L 510/200 (2500)	2500	FIP-D M 510/200 (2500)	1330	430	600	470	96	4	85
FIP-D L 590/200 (2500)	3000	FIP-D M 590/200 (2500)	1690	450	620	480	117	4	110
FIP-D L 670/200 (2500)	3500	FIP-D M 670/200 (2500)	2100	470	640	490	113	4	120
FIP-D L 760/200 (2500)	4000	FIP-D M 760/200 (2500)	2540	490	660	510	110	4	130
FIP-D L 910/200 (2500)	5000	FIP-D M 910/200 (2500)	3270	520	690	530	136	4	180
FIP-D L 1100/200 (2500)	6000	FIP-D M 1100/200 (2500)	4380	560	810	630	138	4	230
FIP-D L 1200/200 (2500)	7000	FIP-D M 1200/200 (2500)	4980	580	830	650	144	4	260
FIP-D L 1400/200 (2500)	8000	FIP-D M 1400/200 (2500)	5960	610	860	670	156	4	300
FIP-D L 1600/200 (2500)	9000	FIP-D M 1600/200 (2500)	7030	640	890	690	158	4	340
FIP-D L 1750/200 (2500)	10000	FIP-D M 1750/200 (2500)	7780	660	910	700	164	4	380
FIP-D L 2100/200 (2500)	12500	FIP-D M 2100/200 (2500)	9830	710	1040	810	202	4	560
FIP-D L 2500/200 (2500)	15000	FIP-D M 2500/200 (2500)	12120	760	1090	850	208	4	680
FIP-D L 2950/200 (2500)	17500	FIP-D M 2950/200 (2500)	14630	810	1050	970	213	8	800
FIP-D L 3450/200 (2500)	20000	FIP-D M 3450/200 (2500)	17360	860	1100	1000	259	8	1100
FIP-D L 4150/200 (2500)	25000	FIP-D M 4150/200 (2500)	21600	930	1210	1120	253	8	1300
FIP-D L 4950/200 (2500)	30000	FIP-D M 4950/200 (2500)	26250	1000	1280	1340	332	12	2000
FIP-D L 6500/200 (2500)	40000	FIP-D M 6500/200 (2500)	35300	1120	1400	1430	344	12	2650
FIP-D L 8050/200 (2500)	50000	FIP-D M 8050/200 (2500)	44700	1230	1510	1670	433	16	4000
FIP-D L 9650/200 (2500)	60000	FIP-D M 9650/200 (2500)	54250	1330	1610	1910	424	20	4800

Displacement ±150 mm

Low friction		Medium friction							
Isolator Mark	N_{Ed} kN	Isolator Mark	N_{Ed} kN	D mm	Y mm	Z mm	H mm	n	W kg
FIP-D L 250/300 (2500)	1000	FIP-D M 250/300 (2500)	220	400	510	400	101	4	65
FIP-D L 340/300 (2500)	1500	FIP-D M 340/300 (2500)	560	430	540	430	96	4	75
FIP-D L 440/300 (2500)	2000	FIP-D M 440/300 (2500)	990	460	630	490	101	4	100
FIP-D L 510/300 (2500)	2500	FIP-D M 510/300 (2500)	1330	480	650	500	97	4	110
FIP-D L 590/300 (2500)	3000	FIP-D M 590/300 (2500)	1690	500	670	520	118	4	140
FIP-D L 670/300 (2500)	3500	FIP-D M 670/300 (2500)	2100	520	690	530	114	4	150
FIP-D L 760/300 (2500)	4000	FIP-D M 760/300 (2500)	2540	540	710	540	110	4	160
FIP-D L 910/300 (2500)	5000	FIP-D M 910/300 (2500)	3270	570	820	640	136	4	220
FIP-D L 1100/300 (2500)	6000	FIP-D M 1100/300 (2500)	4380	610	860	670	135	4	260
FIP-D L 1200/300 (2500)	7000	FIP-D M 1200/300 (2500)	4980	630	880	680	140	4	290
FIP-D L 1400/300 (2500)	8000	FIP-D M 1400/300 (2500)	5960	660	910	700	164	4	360
FIP-D L 1600/300 (2500)	9000	FIP-D M 1600/300 (2500)	7030	690	940	720	156	4	380
FIP-D L 1750/300 (2500)	10000	FIP-D M 1750/300 (2500)	7780	710	1040	810	160	4	460
FIP-D L 2100/300 (2500)	12500	FIP-D M 2100/300 (2500)	9830	760	1090	850	208	4	650
FIP-D L 2500/300 (2500)	15000	FIP-D M 2500/300 (2500)	12120	810	1050	970	213	8	770
FIP-D L 2950/300 (2500)	17500	FIP-D M 2950/300 (2500)	14630	860	1100	1000	217	8	910
FIP-D L 3450/300 (2500)	20000	FIP-D M 3450/300 (2500)	17360	910	1190	1110	260	8	1250
FIP-D L 4150/300 (2500)	25000	FIP-D M 4150/300 (2500)	21600	980	1260	1330	254	12	1550
FIP-D L 4950/300 (2500)	30000	FIP-D M 4950/300 (2500)	26250	1050	1330	1380	333	12	2150
FIP-D L 6500/300 (2500)	40000	FIP-D M 6500/300 (2500)	35300	1170	1450	1630	342	16	2950
FIP-D L 8050/300 (2500)	50000	FIP-D M 8050/300 (2500)	44700	1280	1560	1880	429	20	4400
FIP-D L 9650/300 (2500)	60000	FIP-D M 9650/300 (2500)	54250	1380	1660	2120	438	24	5500

Equivalent radius of curvature R = 2500 mm

LEGEND

N_{Ed}	Maximum vertical load at ULS load combinations including the seismic action, or at any load combination including horizontal displacement
D	Isolator diameter excluding anchoring elements
Y	Maximum overall plan dimension
Z	Side length of the square that circumscribes the isolator including anchoring elements
H	Isolator height excluding dowels
n	Number of upper/lower dowels
W	Isolator weight excluding dowels

Displacement ±200 mm

Low friction		Medium friction		D	Y	Z	H	n	W
Isolator Mark	N_{Ed} kN	Isolator Mark	N_{Ed} kN	mm	mm	mm	mm		kg
FIP-D L 280/400 (3100)	1000			460	570	460	108	4	85
FIP-D L 370/400 (3100)	1500	FIP-D M 370/400 (3100)	270	490	600	490	114	4	110
FIP-D L 470/400 (3100)	2000	FIP-D M 470/400 (3100)	670	520	690	530	109	4	130
FIP-D L 550/400 (3100)	2500	FIP-D M 550/400 (3100)	980	540	710	540	106	4	140
FIP-D L 630/400 (3100)	3000	FIP-D M 630/400 (3100)	1340	560	730	560	125	4	170
FIP-D L 720/400 (3100)	3500	FIP-D M 720/400 (3100)	1730	580	750	580	121	4	180
FIP-D L 810/400 (3100)	4000	FIP-D M 810/400 (3100)	2150	600	770	600	128	4	210
FIP-D L 1000/400 (3100)	5000	FIP-D M 1000/400 (3100)	3100	640	890	690	152	4	290
FIP-D L 1150/400 (3100)	6000	FIP-D M 1150/400 (3100)	3950	670	920	710	146	4	310
FIP-D L 1350/400 (3100)	7000	FIP-D M 1350/400 (3100)	4850	700	950	730	150	4	360
FIP-D L 1450/400 (3100)	8000	FIP-D M 1450/400 (3100)	5500	720	970	740	176	4	430
FIP-D L 1650/400 (3100)	9000	FIP-D M 1650/400 (3100)	6500	750	1000	770	169	4	460
FIP-D L 1800/400 (3100)	10000	FIP-D M 1800/400 (3100)	7250	770	1100	850	175	4	550
FIP-D L 2200/400 (3100)	12500	FIP-D M 2200/400 (3100)	9350	820	1150	890	214	4	710
FIP-D L 2600/400 (3100)	15000	FIP-D M 2600/400 (3100)	11500	870	1110	1010	220	8	860
FIP-D L 3050/400 (3100)	17500	FIP-D M 3050/400 (3100)	14000	920	1160	1040	235	8	1100
FIP-D L 3450/400 (3100)	20000	FIP-D M 3450/400 (3100)	16250	960	1240	1140	265	8	1300
FIP-D L 4300/400 (3100)	25000	FIP-D M 4300/400 (3100)	21000	1040	1320	1370	280	12	1800
FIP-D L 5100/400 (3100)	30000	FIP-D M 5100/400 (3100)	25500	1110	1390	1420	361	12	2450
FIP-D L 6650/400 (3100)	40000	FIP-D M 6650/400 (3100)	34500	1230	1510	1670	357	16	3200
FIP-D L 8200/400 (3100)	50000	FIP-D M 8200/400 (3100)	44000	1340	1620	1920	429	20	4600
FIP-D L 9800/400 (3100)	60000	FIP-D M 9800/400 (3100)	53500	1440	1720	2160	426	24	5600

Displacement ±250 mm

Low friction		Medium friction		D	Y	Z	H	n	W
Isolator Mark	N_{Ed} kN	Isolator Mark	N_{Ed} kN	mm	mm	mm	mm		kg
FIP-D L 280/500 (3100)	1000			510	620	510	111	4	110
FIP-D L 370/500 (3100)	1500	FIP-D M 370/500 (3100)	270	540	650	540	106	4	120
FIP-D L 470/500 (3100)	2000	FIP-D M 470/500 (3100)	670	570	740	570	111	4	160
FIP-D L 550/500 (3100)	2500	FIP-D M 550/500 (3100)	980	590	760	590	117	4	190
FIP-D L 630/500 (3100)	3000	FIP-D M 630/500 (3100)	1340	610	780	610	124	4	200
FIP-D L 720/500 (3100)	3500	FIP-D M 720/500 (3100)	1730	630	880	680	130	4	250
FIP-D L 810/500 (3100)	4000	FIP-D M 810/500 (3100)	2150	650	900	700	126	4	260
FIP-D L 1000/500 (3100)	5000	FIP-D M 1000/500 (3100)	3100	690	940	720	152	4	330
FIP-D L 1150/500 (3100)	6000	FIP-D M 1150/500 (3100)	3950	720	970	740	156	4	390
FIP-D L 1350/500 (3100)	7000	FIP-D M 1350/500 (3100)	4850	750	1000	770	159	4	440
FIP-D L 1450/500 (3100)	8000	FIP-D M 1450/500 (3100)	5500	770	1020	780	175	4	490
FIP-D L 1650/500 (3100)	9000	FIP-D M 1650/500 (3100)	6500	800	1130	870	177	4	590
FIP-D L 1800/500 (3100)	10000	FIP-D M 1800/500 (3100)	7250	820	1150	890	182	4	650
FIP-D L 2200/500 (3100)	12500	FIP-D M 2200/500 (3100)	9300	870	1110	1010	220	8	820
FIP-D L 2600/500 (3100)	15000	FIP-D M 2600/500 (3100)	11500	920	1160	1040	235	8	1050
FIP-D L 3050/500 (3100)	17500	FIP-D M 3050/500 (3100)	14000	970	1250	1150	220	8	1150
FIP-D L 3450/500 (3100)	20000	FIP-D M 3450/500 (3100)	16250	1010	1290	1180	269	8	1450
FIP-D L 4300/500 (3100)	25000	FIP-D M 4300/500 (3100)	21000	1090	1370	1410	263	12	1850
FIP-D L 5100/500 (3100)	30000	FIP-D M 5100/500 (3100)	25500	1160	1440	1450	343	12	2500
FIP-D L 6650/500 (3100)	40000	FIP-D M 6650/500 (3100)	34500	1320	1600	1740	342	16	3500
FIP-D L 8200/500 (3100)	50000	FIP-D M 8200/500 (3100)	44000	1390	1670	2130	428	24	5100
FIP-D L 9800/500 (3100)	60000	FIP-D M 9800/500 (3100)	53500	1490	1820	2250	423	20	5950

Equivalent radius of curvature R = 3100 mm

LEGEND

N_{Ed}	Maximum vertical load at ULS load combinations including the seismic action, or at any load combination including horizontal displacement
D	Isolator diameter excluding anchoring elements
Y	Maximum overall plan dimension
Z	Side length of the square that circumscribes the isolator including anchoring elements
H	Isolator height excluding dowels
n	Number of upper/lower dowels
W	Isolator weight excluding dowels

TABLES FIP-D STANDARD

Low friction		Medium friction		Displacement ±300 mm					
Isolator Mark	N_{Ed} kN	Isolator Mark	N_{Ed} kN	D mm	Y mm	Z mm	H mm	n	W kg
FIP-D L 310/600 (3700)	1000			570	680	570	139	4	160
FIP-D L 400/600 (3700)	1500			600	710	600	134	4	180
FIP-D L 510/600 (3700)	2000	FIP-D M 510/600 (3700)	310	630	800	630	138	4	220
FIP-D L 590/600 (3700)	2500	FIP-D M 590/600 (3700)	600	650	820	650	134	4	230
FIP-D L 670/600 (3700)	3000	FIP-D M 670/600 (3700)	930	670	840	670	143	4	250
FIP-D L 760/600 (3700)	3500	FIP-D M 760/600 (3700)	1300	690	940	720	150	4	300
FIP-D L 860/600 (3700)	4000	FIP-D M 860/600 (3700)	1700	710	960	740	146	4	320
FIP-D L 1050/600 (3700)	5000	FIP-D M 1050/600 (3700)	2650	750	1000	770	171	4	400
FIP-D L 1200/600 (3700)	6000	FIP-D M 1200/600 (3700)	3450	780	1030	790	175	4	460
FIP-D L 1400/600 (3700)	7000	FIP-D M 1400/600 (3700)	4300	810	1060	810	179	4	530
FIP-D L 1600/600 (3700)	8000	FIP-D M 1600/600 (3700)	5250	840	1090	840	195	4	590
FIP-D L 1750/600 (3700)	9000	FIP-D M 1750/600 (3700)	6000	860	1190	920	200	4	690
FIP-D L 1900/600 (3700)	10000	FIP-D M 1900/600 (3700)	6700	880	1210	930	196	4	720
FIP-D L 2250/600 (3700)	12500	FIP-D M 2250/600 (3700)	8650	930	1170	1050	243	8	950
FIP-D L 2700/600 (3700)	15000	FIP-D M 2700/600 (3700)	10900	980	1220	1090	241	8	1100
FIP-D L 3150/600 (3700)	17500	FIP-D M 3150/600 (3700)	13300	1030	1310	1190	247	8	1350
FIP-D L 3550/600 (3700)	20000	FIP-D M 3550/600 (3700)	15500	1070	1350	1220	290	8	1700
FIP-D L 4400/600 (3700)	25000	FIP-D M 4400/600 (3700)	20000	1150	1430	1450	287	12	2100
FIP-D L 5200/600 (3700)	30000	FIP-D M 5200/600 (3700)	24500	1220	1500	1500	356	12	2750
FIP-D L 6750/600 (3700)	40000	FIP-D M 6750/600 (3700)	33500	1340	1620	1750	356	16	3600
FIP-D L 8350/600 (3700)	50000	FIP-D M 8350/600 (3700)	43000	1450	1730	2170	433	24	5300
FIP-D L 9800/600 (3700)	60000	FIP-D M 9800/600 (3700)	51000	1540	1870	2280	418	20	6000

Low friction		Medium friction		Displacement ±350 mm					
Isolator Mark	N_{Ed} kN	Isolator Mark	N_{Ed} kN	D mm	Y mm	Z mm	H mm	n	W kg
FIP-D L 310/700 (3700)	1000			620	730	620	129	4	170
FIP-D L 400/700 (3700)	1500			650	820	650	134	4	210
FIP-D L 510/700 (3700)	2000	FIP-D M 510/700 (3700)	310	680	850	680	129	4	230
FIP-D L 590/700 (3700)	2500	FIP-D M 590/700 (3700)	600	700	870	700	136	4	270
FIP-D L 670/700 (3700)	3000	FIP-D M 670/700 (3700)	930	720	890	720	154	4	320
FIP-D L 760/700 (3700)	3500	FIP-D M 760/700 (3700)	1300	740	990	760	150	4	350
FIP-D L 860/700 (3700)	4000	FIP-D M 860/700 (3700)	1700	760	1010	770	146	4	370
FIP-D L 1050/700 (3700)	5000	FIP-D M 1050/700 (3700)	2650	800	1050	800	171	4	460
FIP-D L 1200/700 (3700)	6000	FIP-D M 1200/700 (3700)	3450	830	1080	830	174	4	520
FIP-D L 1400/700 (3700)	7000	FIP-D M 1400/700 (3700)	4300	860	1110	860	178	4	600
FIP-D L 1600/700 (3700)	8000	FIP-D M 1600/700 (3700)	5250	890	1220	940	193	4	700
FIP-D L 1750/700 (3700)	9000	FIP-D M 1750/700 (3700)	6000	910	1240	950	207	4	810
FIP-D L 1900/700 (3700)	10000	FIP-D M 1900/700 (3700)	6700	930	1260	970	202	4	830
FIP-D L 2250/700 (3700)	12500	FIP-D M 2250/700 (3700)	8650	980	1220	1090	241	8	1050
FIP-D L 2700/700 (3700)	15000	FIP-D M 2700/700 (3700)	10900	1030	1310	1190	247	8	1300
FIP-D L 3150/700 (3700)	17500	FIP-D M 3150/700 (3700)	13300	1080	1360	1230	254	8	1550
FIP-D L 3550/700 (3700)	20000	FIP-D M 3550/700 (3700)	15500	1120	1360	1330	275	12	1700
FIP-D L 4400/700 (3700)	25000	FIP-D M 4400/700 (3700)	20000	1200	1480	1480	291	12	2300
FIP-D L 5200/700 (3700)	30000	FIP-D M 5200/700 (3700)	24500	1270	1550	1700	360	16	3100
FIP-D L 6750/700 (3700)	40000	FIP-D M 6750/700 (3700)	33500	1390	1670	1960	358	20	4050
FIP-D L 8350/700 (3700)	50000	FIP-D M 8350/700 (3700)	43000	1500	1780	2200	414	24	5350
FIP-D L 9800/700 (3700)	60000	FIP-D M 9800/700 (3700)	51000	1590	1920	2320	417	20	6300

Equivalent radius of curvature R = 3700 mm

LEGEND

N_{Ed}	Maximum vertical load at ULS load combinations including the seismic action, or at any load combination including horizontal displacement
D	Isolator diameter excluding anchoring elements
Y	Maximum overall plan dimension
Z	Side length of the square that circumscribes the isolator including anchoring elements
H	Isolator height excluding dowels
n	Number of upper/lower dowels
W	Isolator weight excluding dowels

Displacement ±400 mm

Low friction		Medium friction							
Isolator Mark	N_{Ed} kN	Isolator Mark	N_{Ed} kN	D mm	Y mm	Z mm	H mm	n	W kg
FIP-D L 310/800 (3700)	1000			670	780	670	131	4	210
FIP-D L 400/800 (3700)	1500			700	870	700	136	4	260
FIP-D L 510/800 (3700)	2000	FIP-D M 510/800 (3700)	310	730	900	730	140	4	310
FIP-D L 590/800 (3700)	2500	FIP-D M 590/800 (3700)	600	750	920	750	136	4	320
FIP-D L 670/800 (3700)	3000	FIP-D M 670/800 (3700)	930	770	1020	780	154	4	390
FIP-D L 760/800 (3700)	3500	FIP-D M 760/800 (3700)	1300	790	1040	790	150	4	410
FIP-D L 860/800 (3700)	4000	FIP-D M 860/800 (3700)	1700	810	1060	810	156	4	460
FIP-D L 1050/800 (3700)	5000	FIP-D M 1050/800 (3700)	2650	850	1100	850	180	4	560
FIP-D L 1200/800 (3700)	6000	FIP-D M 1200/800 (3700)	3450	880	1130	880	173	4	590
FIP-D L 1400/800 (3700)	7000	FIP-D M 1400/800 (3700)	4300	910	1240	950	184	4	750
FIP-D L 1600/800 (3700)	8000	FIP-D M 1600/800 (3700)	5250	940	1270	970	199	4	810
FIP-D L 1750/800 (3700)	9000	FIP-D M 1750/800 (3700)	6000	960	1290	990	204	4	900
FIP-D L 1900/800 (3700)	10000	FIP-D M 1900/800 (3700)	6700	980	1220	1090	199	8	910
FIP-D L 2250/800 (3700)	12500	FIP-D M 2250/800 (3700)	8650	1030	1270	1120	247	8	1200
FIP-D L 2700/800 (3700)	15000	FIP-D M 2700/800 (3700)	10900	1080	1360	1230	254	8	1500
FIP-D L 3150/800 (3700)	17500	FIP-D M 3150/800 (3700)	13300	1130	1410	1260	259	8	1750
FIP-D L 3550/800 (3700)	20000	FIP-D M 3550/800 (3700)	15500	1170	1450	1460	280	12	2000
FIP-D L 4400/800 (3700)	25000	FIP-D M 4400/800 (3700)	20000	1250	1530	1520	275	12	2350
FIP-D L 5200/800 (3700)	30000	FIP-D M 5200/800 (3700)	24500	1320	1600	1740	343	16	3150
FIP-D L 6750/800 (3700)	40000	FIP-D M 6750/800 (3700)	33500	1440	1720	1990	360	20	4350
FIP-D L 8350/800 (3700)	50000	FIP-D M 8350/800 (3700)	43000	1550	1830	2240	414	24	5650
FIP-D L 9800/800 (3700)	60000	FIP-D M 9800/800 (3700)	51000	1640	1970	2560	416	24	6750

Equivalent radius of curvature R = 3700 mm

LEGEND

N_{Ed}	Maximum vertical load at ULS load combinations including the seismic action, or at any load combination including horizontal displacement
D	Isolator diameter excluding anchoring elements
Y	Maximum overall plan dimension
Z	Side length of the square that circumscribes the isolator including anchoring elements
H	Isolator height excluding dowels
n	Number of upper/lower dowels
W	Isolator weight excluding dowels

• L'AQUILA, ITALY - C.A.S.E. Project, installation of **FIP-D**

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