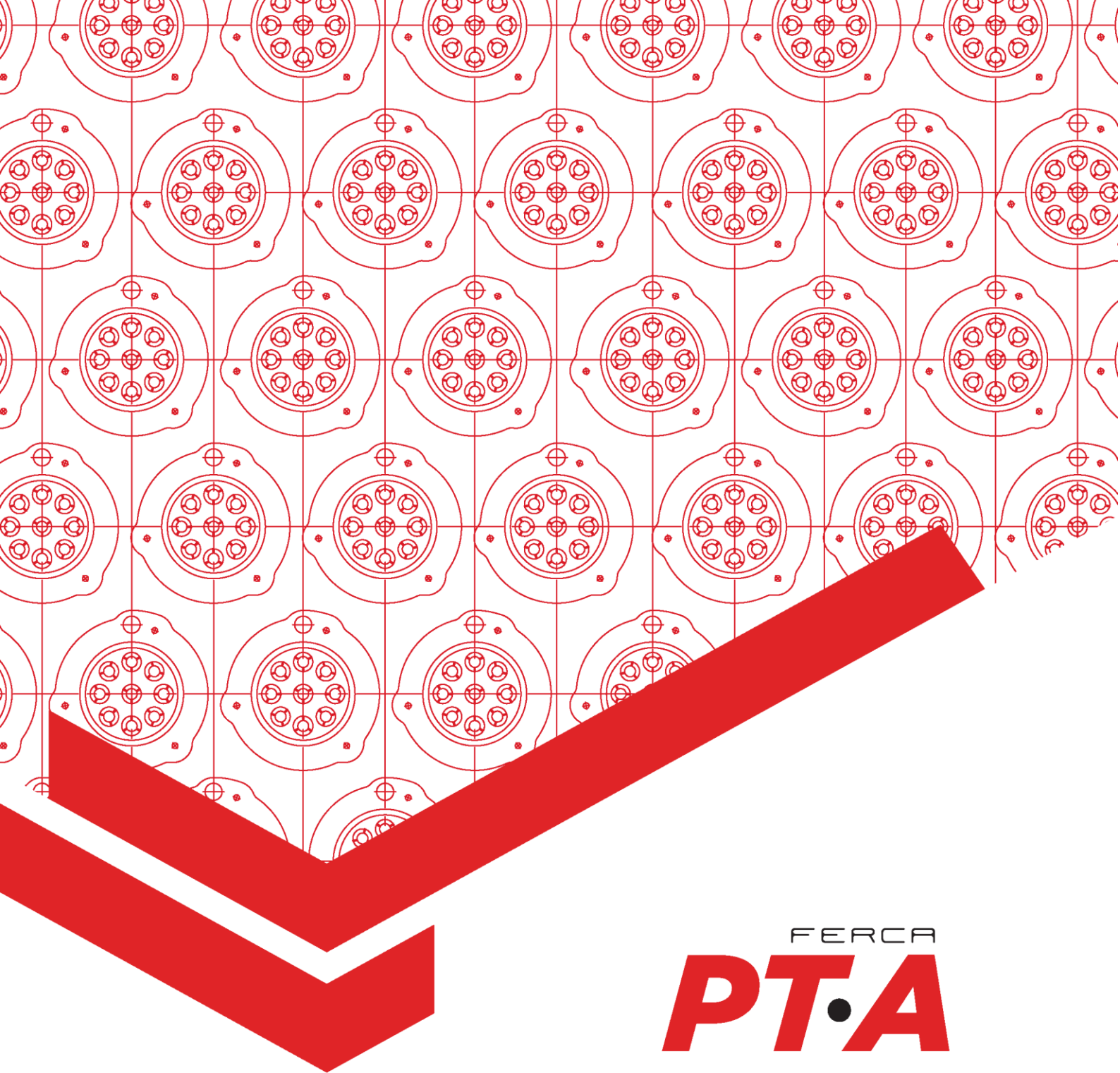


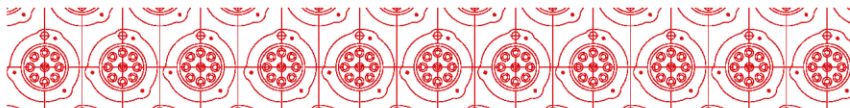


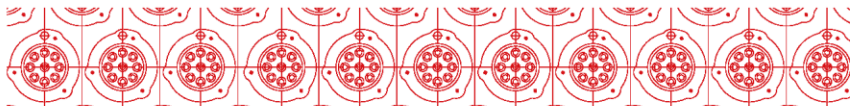
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PTA TECHNICAL MANUAL

RSF – Multistrand System



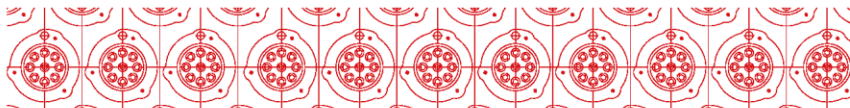




Technical Manual – PTA System – RSF Multistrand Post-Tensioning System

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INTRODUCTION TO THE **PTA SYSTEM - RSF**

The **RSF Rudloff Strongforce International** system was developed to deliver an integrated range of prestressing solutions for bridges, geotechnical works and buildings, establishing the system as a key player in a technically demanding and highly competitive international market. Built on extensive research and manufacturing experience in anchorages and dedicated construction equipment, and as part of a steel-sector group, **RSF Rudloff Strongforce International** today operates in areas such as:

- Prestressing for bridges and viaducts;
- Prestressing for buildings;
- Geotechnical consolidation systems;
- Hydraulic equipment for pulling, pushing, grouting and production lines;
- Bridge bearings and expansion joints;
- Industrial flooring.

The tendons of the **RSF Multistrand Post-Tensioning System** consist of bundles of high-strength steel strands with anchorages at each end.

The strands are usually enclosed in a duct, sleeve or tube. The void between the strands and the enclosure can be filled with a material to inhibit corrosion and, in the case of bonded tendons, to bond the strands to the structure.

The **RSF Multistrand System** is compatible with both bare strands and individually sheathed and protected strands. All strands in a tendon are normally stressed simultaneously, each strand being anchored individually by a wedge inside a conical anchor hole. The wedges grip the strands and transfer the stressing force from the hydraulic jack to the anchorage.

The design force determines the type and number of strands. The anchorage type is defined by the design requirements and the use category. The **RSF Multistrand System** includes anchorages with 4, 7, 9, 12, 15, 19, 22, 27, 31 and 37 strands. Intermediate units can be formed by leaving some of the anchorage's conical holes empty; in that case the strands must be arranged so that the applied load is centred on the anchor head.

The RSF Multistrand System is certified by the European Organization for Technical Assessment (EOTA), see certificate ETA 22/0119 (European Technical Assessment – RSF Multistrand Post-tensioning System), which guarantees its quality and suitability for use across a wide range of situations and configurations.

This “Procedures Manual”, produced by FERCA, is intended to complement the information contained in the system's certifications. Its aim is to give those involved at the design or construction stage a clearer understanding of the system's make-up, the procedures associated with each application phase, the production set-up and the risks associated with each activity, while also allowing site supervision to exercise greater control over the entire production process, from the application design to the final activity reports.



WHO IS RSF?

RSF (Rudloff StrongForce International) is the result of a strategic joint venture between the Brazilian company Rudloff Industrial and the Australian company StrongForce, with the resulting entity operating under the name Rudloff StrongForce International LLC, headquartered in Dubai, United Arab Emirates. Rudloff Industrial was founded in São Paulo, Brazil, in 1960, its founder having already produced Brazil's first prestressed beam in 1954; over more than six decades it has specialised in post-tensioning and in the manufacture of structural systems and components. StrongForce, in turn, was founded in 1989 in Queensland, Australia, and has for more than thirty years been engaged in the design and construction of post-tensioning solutions and structural strengthening. This union gave rise to RSF, a company specialising in the study, design and production of anchorage systems and their installation equipment, which has continued to expand its knowledge base through ongoing investment in the sector. Serving clients since 1965, RSF operates in more than 60 countries across all six continents, with more than 600 civil engineering structures, over 850 wind turbine towers and more than 26 million square metres of building works completed, and is firmly established both in its home markets and internationally.



RSF SYSTEMS

RSF's multistrand post-tensioning systems, intended for bridges, viaducts and major structures, have obtained European Technical Assessment ETA 22/0119, under which they carry CE marking in accordance with guideline ETAG 013 and the corresponding EAD. The RSF Multistrand system is an internal bonded, internal unbonded or external post-tensioning system with 4 to 37 strands, available in 0.5" and 0.6" strand, comprising active anchorages (AN), passive anchorages (PS) and couplers (CO). It is designed for bridge box girders and beams (precast or cast in situ), columns and transition tables, building beams, as well as containment structures such as reservoirs, tanks and silos.

RSF's post-tensioning systems for slabs and floors — the RSF Slab system — are intended for monostrand use in bonded or unbonded systems and hold European Technical Assessment ETA 22/0120, covering configurations from 1 to 5 strands. RSF supplies 0.5" and 0.6" unbonded monostrand and, in particular, encapsulated monostrand anchorages that bring full corrosion protection to the market.

In short, the company's objective has been to offer its clients more effective, durable and sustainable products, backed by European-certified systems (EOTA) and compliant with the main international codes and standards applicable to building, civil infrastructure and geotechnical projects.



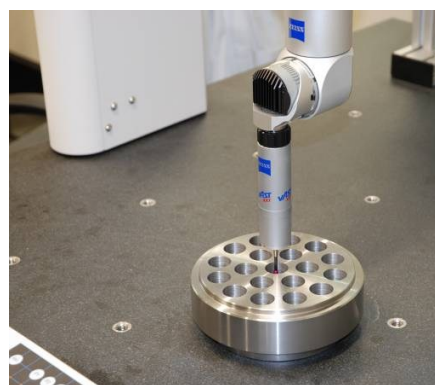
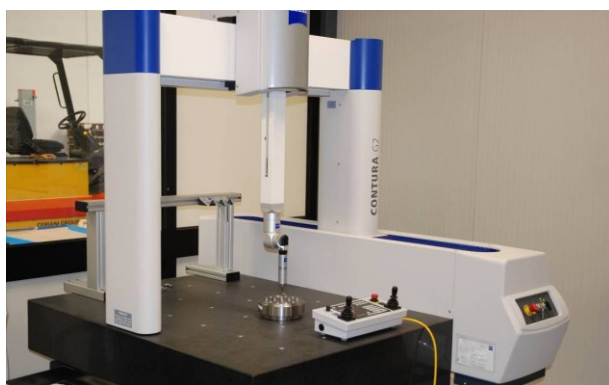
In the field of systems for geotechnical works, RSF supplies strand and bar ground-anchor systems for temporary and permanent applications, intended for the stabilisation of infrastructure and for ground improvement. RSF's ground-anchor systems comply with European standard EN 1537 ("Execution of special geotechnical work – Ground anchors"). The company distinguishes between soil anchors and rock anchors, covering applications ranging from excavation retention (sheet-pile walls, sheet piles with diaphragm walls, concrete retaining walls) to resisting uplift forces, as well as the stabilisation of eccentric foundations, natural or excavated slopes, dams and bridge foundations, and the anchoring of wind turbine towers. In rock anchors, the free length can remain unbonded, allowing the anchor to be checked and re-tensioned at any time, provided that adequate corrosion protection is ensured for the anchor head and the free length.



RSF QUALITY

Since a product is understood as the sum of the processes, resources and knowledge that give rise to it, its level of quality is intrinsically linked to the organisation's excellence in its various aspects and to the direction of the necessary investment in the dedicated pursuit of such goals.

With the achievement of a high level of quality in its products and services now absolutely central to the company's strategy, RSF operates under ISO 9001 (quality), ISO 14001 (environment) and ISO 45001 (occupational health and safety) certification, Rudloff having implemented an Integrated Management System certified to ISO 9001. The company applies rigorous quality control procedures (QA/QC) and maintains an ongoing commitment to high-standard manufacturing practices.



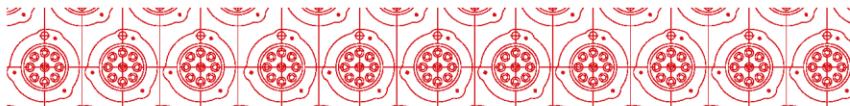
In addition, whenever required, RSF provides OEM services, manufacturing products to clients' exact specifications, and offers a qualified technical team of engineers and specialists who ensure support throughout the entire supply chain, including equipment maintenance and after-sales technical support, so as to guarantee the level of quality required of each and every part produced.

WHY USE POST-TENSIONING

Over the past decade, architecture has taken on a central role in the real-estate investment process, driving many of a project's distinctive features and thus representing an essential contributor to their success. This trend is rooted in society itself, which today values not only the comfort and functionality of spaces but also the image and social standing they convey. With this shift in paradigm came a profound change in structural design concepts: today, a structural solution's ability to enable the architect's creativity is valued more highly than strictly technical-economic criteria. By allowing slender and daring structures to be built, prestressing meets these current demands, so its use in buildings is becoming increasingly common and is expected to keep growing.

The use of prestressing systems also contributes to a significant improvement in a structure's various quality parameters — not only in terms of processes, but also in terms of its durability and performance.

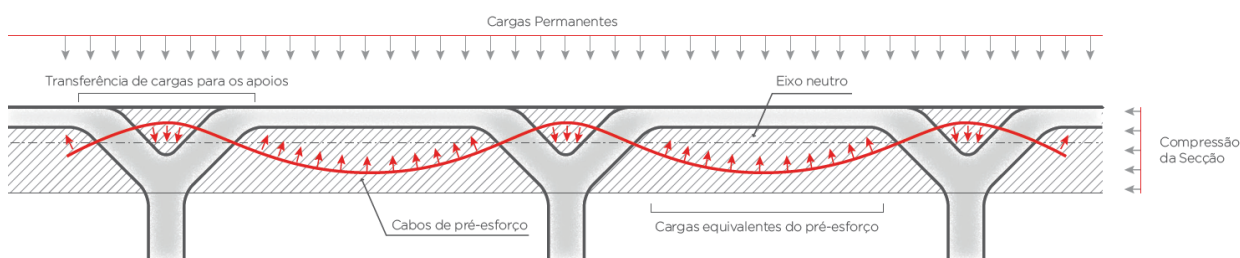




PRINCIPLES

Originating from the need to achieve large spans in bridge structures, prestressing systems — later applied to buildings — represent an innovation in structural design by introducing an active element into structural members.

Made up of high-strength steel strands, the prestressing tendons are installed inside the slab and anchored at their ends, then stressed with hydraulic equipment developed for the purpose. Thanks to their curvature in elevation and in plan, applying forces to the tendons transmits actions to the slab section that oppose the effects of gravity loads. The equivalent loads thus created partially balance the design actions and produce a general compression of the slab section, allowing a reduction in passive reinforcement, the elimination of joints and a greater contribution of the concrete section to the overall strength of the slab.



SYSTEMS

Prestressing systems are divided essentially according to their bond with the concrete — hence the terms bonded and unbonded systems — and within these a further distinction can be made between monostrand and multistrand use.

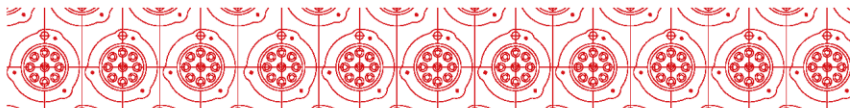
In unbonded systems, the steel is supplied inside a plastic sheath with no subsequent grouting, whereas in bonded systems the steel is supplied as strand and placed in a duct that is later grouted with cement grout, giving it full bond to the surrounding concrete section.

In terms of application, unbonded monostrand systems are the most frequently used in slender members such as slabs in building construction, while bonded multistrand is used in bridge structures and, generally, in larger structural members.

The self-sheathed monostrand is an **unbonded system** commonly used in buildings, where the prestressing tendons consist of a single strand coated with a polyethylene sheath filled with a lubricating product. This system allows greater eccentricities, lower friction losses and greater flexibility of tendon profiles.

Multistrand in flat or circular ducts is a **bonded system** in which the prestressing tendons consist of several uncoated strands placed in a metal duct that is subsequently grouted with a suitable cement grout. This system makes it possible to mobilise the maximum strength of the prestressing steel at the Ultimate Limit State.

The PTA-RSF *Multistrand PT* system is a bonded system.



ADVANTAGES

The advantages of using prestressing systems extend across structural considerations — spans, slenderness and performance — as well as economic and environmental ones.

Structural behaviour

- Longer clear spans;
- Fewer columns;
- Reduced self-weight of the structure;
- Reduced slab thicknesses;
- Greater control of deflections;
- Improved punching shear resistance;
- Reduction or elimination of joints;
- Improved seismic behaviour;
- Improved shrinkage behaviour;

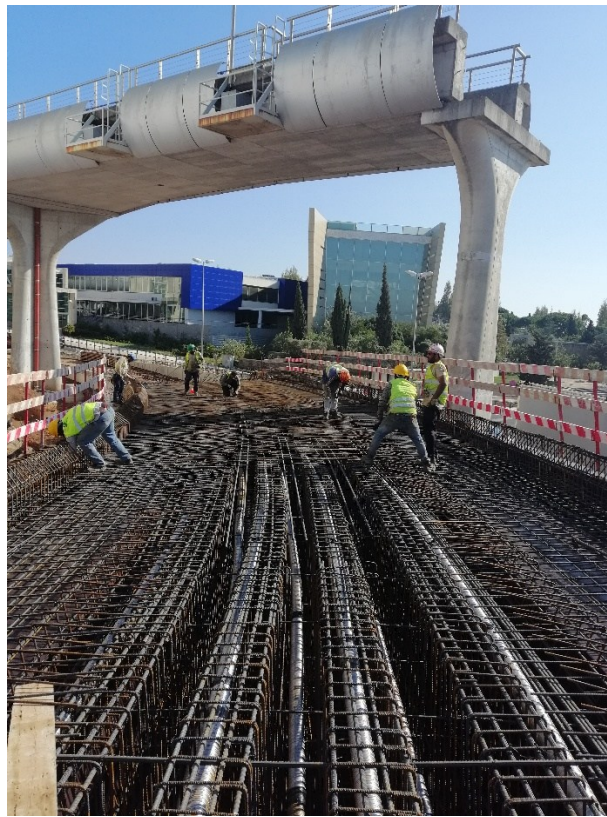
Economy

- Lower concrete and steel consumption;
- Savings in vertical elements and foundations;
- Commercial value of the large open spaces created;
- More parking spaces per m²;

Sustainability

- Reduced CO₂ emissions;
- Greater efficiency in the use of natural resources.





STEEL

Prestressing tendons are made up of 7-wire strands and are characterised by high strength and low relaxation coefficients. Prestressing steels are generally designated as normal (T15), super (T15S) and compact (T15C), corresponding to sections of 140, 150 and 165 mm² respectively. For further information, see European standard EN 10138.

All anchorage systems produced by *RSF RUDLOFF STRONGFORCE* are certified by European Technical Assessment for the three types of steel available on the market.



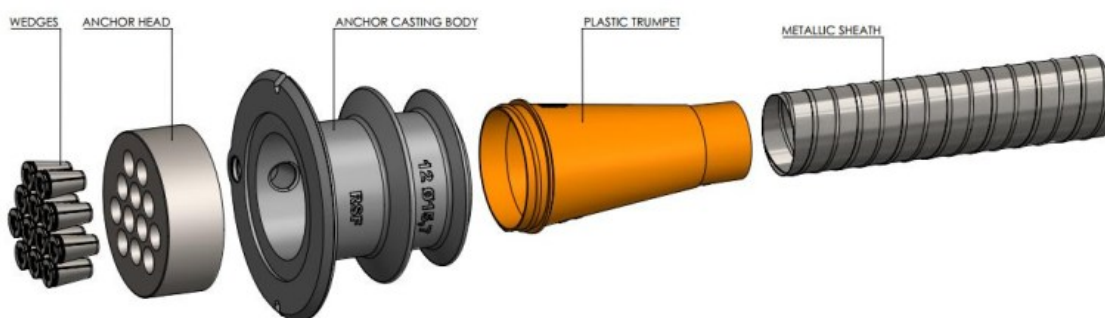
Diameter	Standard	Steel type	Nominal diameter	Nominal area	Mass	Breaking force P _{tk}	Proof force at 1% Pt0.1k	Relaxation 1000 h	
			mm	mm ²	g/m	kN	kN	%	%
0.6" / T15	EN 10138	Normal	15.2	140	1095	260	230	2.5	4.5
0.6" / T15S	EN 10138	Super	15.7	150	1170	279	248	2.5	4.5
0.6" / T15C	EN 10138	Compact	15.2	165	1290	300	264	2.5	4.5

Modulus of elasticity = 195 ± 10 kN/mm²

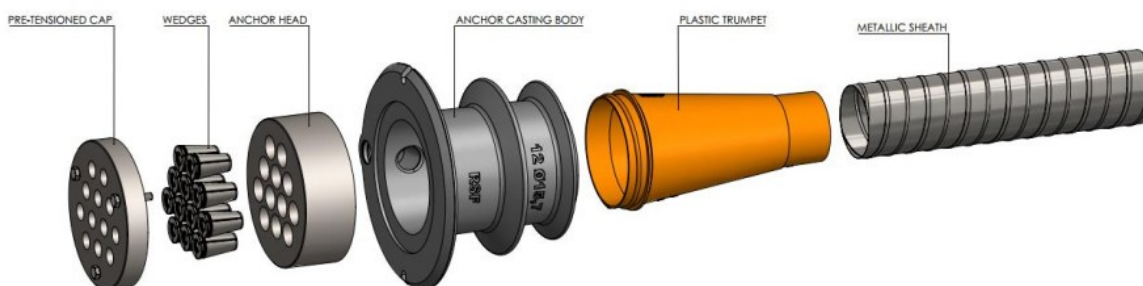
RSF-AN/CO/PS SYSTEMS – MULTISTRAND ANCHORAGES

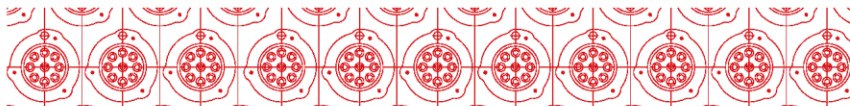
The RSF multistrand system — *RSF Multistrand Post-tensioning System* — was designed to fully comply with European Assessment Document EAD 160004-00-0301 (under guideline ETAG 013) and holds European Technical Assessment ETA 22/0119, issued by ITeC. It is an internal bonded post-tensioning system with 4 to 37 strands, covering 0.5" (12.7 mm), 0.6" (15.2 mm) and 0.62" (15.7 mm) strand, with maximum prestressing forces (0.9F_{p0.1}) ranging from 743 kN (5Ø12.7) to 8,192 kN (37Ø15.7). The active anchorage (AN) consists of an anchor head, a cast anchor body and wedges; the system also includes passive anchorages (PS) and couplers (CO). The design was validated by tests which, under this ETA, verify resistance to static loads, fatigue resistance, load-transfer capacity to the structure, friction losses, corrosion resistance and behaviour in fire.

- RSF NA Active Anchorage

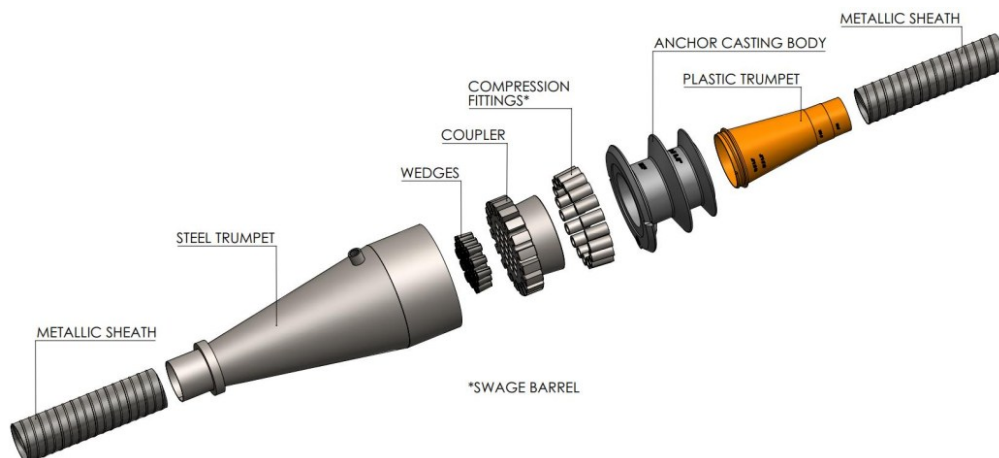


- RSF NA Passive Anchorage

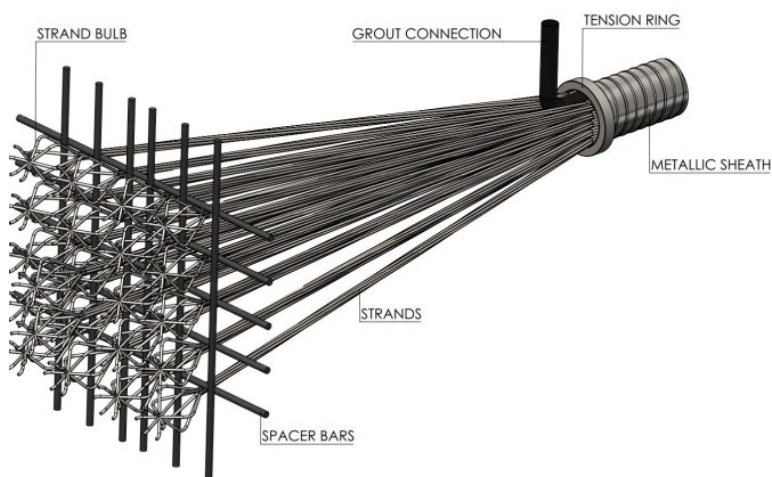




- RSF CO Anchorage



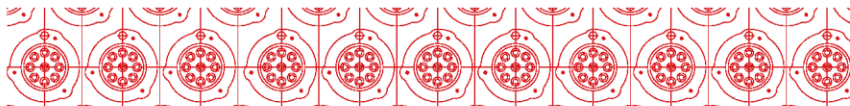
- RSF PS Anchorage



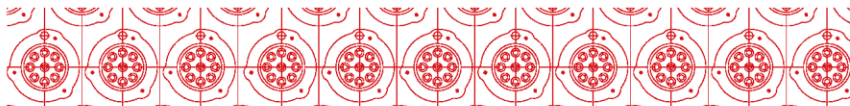
The connection between the anchorage and the ducts is made by an H.D.P.E. plastic cone that ensures correct strand deviation and minimises losses. All metal trumpets have threaded holes so they can be fixed to the formwork with threaded rod or bolts.

The cast anchor body receives the anchor head and ensures the transfer of the prestressing force to the concrete. The strands are locked into the anchor head, which is fitted with conical holes shaped to match the retaining wedges that grip each strand. The transition between the anchorage and the plastic ducts and the (metal or plastic) conduits is provided by elements that ensure correct strand deviation and sealing of the anchorage zone. For site application, the system also includes anchorage caps, vents and duct couplers, trumpet sealing (adhesive tape and heat-shrink sleeves), as well as void formers (in metal, plastic or wood) that create the jack space for stressing. To ensure proper confinement of the concrete in the load-introduction zone, spiral (bursting) reinforcement is also provided, ensuring safe transfer of the prestressing forces from the anchorages to the concrete members or structures. The exact designations of the steels and of the cast iron of the anchor head, the cast body and the wedges are specified in the annexes to ETA 22/0119.

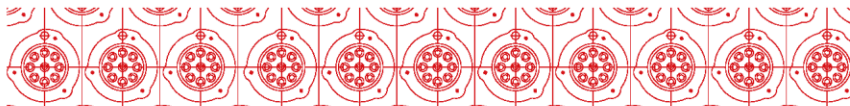
The following tables present the various tendon characteristics by number of strands:



Characteristic Tensile Strength and Prestressing Force of the RSF Multistrand Post-Tensioning System for Ø15.2 Strand							
Designation	Number of strands	Nominal cross-sectional area	Nominal mass	Characteristic value of maximum force	Force at 0.1% proof stress	Maximum prestressing force	Maximum overstressing force
	n	A_p	M	F_{pk}	$F_{p0.1}$	$0.9 \cdot F_{p0.1}$	$0.95 \cdot F_{p0.1}$
		mm ²	kg/m	kN	kN	kN	kN
4 Ø15.2	4	572	4.50	1,064	956	860	908
5 Ø15.2	5	715	5.63	1,330	1,195	1,076	1,135
6 Ø15.2	6	858	6.76	1,596	1,434	1,291	1,362
7 Ø15.2	7	1,001	7.88	1,862	1,673	1,506	1,589
8 Ø15.2	8	1,144	9.01	2,128	1,912	1,721	1,816
9 Ø15.2	9	1,287	10.13	2,394	2,151	1,936	2,043
10 Ø15.2	10	1,430	11.26	2,660	2,390	2,151	2,271
11 Ø15.2	11	1,573	12.39	2,926	2,629	2,366	2,498
12 Ø15.2	12	1,716	13.51	3,192	2,868	2,581	2,725
13 Ø15.2	13	1,859	14.64	3,458	3,107	2,796	2,952
14 Ø15.2	14	2,002	15.76	3,724	3,346	3,011	3,179
15 Ø15.2	15	2,145	16.89	3,990	3,585	3,227	3,406
16 Ø15.2	16	2,288	18.02	4,256	3,824	3,442	3,633
17 Ø15.2	17	2,431	19.14	4,522	4,063	3,657	3,860
18 Ø15.2	18	2,574	20.27	4,788	4,302	3,872	4,087
19 Ø15.2	19	2,717	21.39	5,054	4,541	4,087	4,314
20 Ø15.2	20	2,860	22.52	5,320	4,780	4,302	4,541
21 Ø15.2	21	3,003	23.65	5,586	5,019	4,517	4,768
22 Ø15.2	22	3,146	24.77	5,852	5,258	4,732	4,995
23 Ø15.2	23	3,289	25.90	6,118	5,497	4,947	5,222
24 Ø15.2	24	3,432	27.02	6,384	5,736	5,162	5,449
25 Ø15.2	25	3,575	28.15	6,650	5,975	5,378	5,676
26 Ø15.2	26	3,718	29.28	6,916	6,214	5,593	5,903
27 Ø15.2	27	3,861	30.40	7,182	6,453	5,808	6,130
28 Ø15.2	28	4,004	31.53	7,448	6,692	6,023	6,357
29 Ø15.2	29	4,147	32.65	7,714	6,931	6,238	6,584
30 Ø15.2	30	4,290	33.78	7,980	7,170	6,453	6,812
31 Ø15.2	31	4,433	34.91	8,246	7,409	6,668	7,039
32 Ø15.2	32	4,576	36.03	8,512	7,648	6,883	7,266
33 Ø15.2	33	4,719	37.16	8,778	7,887	7,098	7,493
34 Ø15.2	34	4,862	38.28	9,044	8,126	7,313	7,720
35 Ø15.2	35	5,005	39.41	9,310	8,365	7,529	7,947
36 Ø15.2	36	5,148	40.54	9,576	8,604	7,744	8,174
37 Ø15.2	37	5,291	41.66	9,842	8,843	7,959	8,401

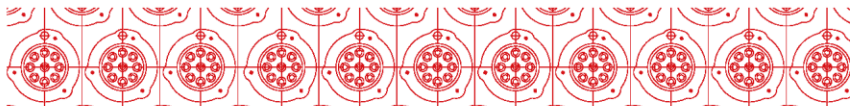


Characteristic Tensile Strength and Prestressing Force of the RSF Multistrand Post-Tensioning System for Ø15.7 Strand							
Designation	Number of strands	Nominal cross-sectional area	Nominal mass	Characteristic value of maximum force	Force at 0.1% proof stress	Maximum prestressing force	Maximum overstressing force
	n	A_p	M	F_{pk}	$F_{p0.1}$	$0.9 \cdot F_{p0.1}$	$0.95 \cdot F_{p0.1}$
		mm ²	kg/m	kN	kN	kN	kN
4 Ø15.7	4	600	4.69	1,116	984	886	935
5 Ø15.7	5	750	5.86	1,395	1,230	1,107	1,169
6 Ø15.7	6	900	7.03	1,674	1,476	1,328	1,402
7 Ø15.7	7	1,050	8.20	1,953	1,722	1,550	1,636
8 Ø15.7	8	1,200	9.38	2,232	1,968	1,771	1,870
9 Ø15.7	9	1,350	10.55	2,511	2,214	1,993	2,103
10 Ø15.7	10	1,500	11.72	2,790	2,460	2,214	2,337
11 Ø15.7	11	1,650	12.89	3,069	2,706	2,435	2,571
12 Ø15.7	12	1,800	14.06	3,348	2,952	2,657	2,804
13 Ø15.7	13	1,950	15.24	3,627	3,198	2,878	3,038
14 Ø15.7	14	2,100	16.41	3,906	3,444	3,100	3,272
15 Ø15.7	15	2,250	17.58	4,185	3,690	3,321	3,506
16 Ø15.7	16	2,400	18.75	4,464	3,936	3,542	3,739
17 Ø15.7	17	2,550	19.92	4,743	4,182	3,764	3,973
18 Ø15.7	18	2,700	21.10	5,022	4,428	3,985	4,207
19 Ø15.7	19	2,850	22.27	5,301	4,674	4,207	4,440
20 Ø15.7	20	3,000	23.44	5,580	4,920	4,428	4,674
21 Ø15.7	21	3,150	24.61	5,859	5,166	4,649	4,908
22 Ø15.7	22	3,300	25.78	6,138	5,412	4,871	5,141
23 Ø15.7	23	3,450	26.96	6,417	5,658	5,092	5,375
24 Ø15.7	24	3,600	28.13	6,696	5,904	5,314	5,609
25 Ø15.7	25	3,750	29.30	6,975	6,150	5,535	5,843
26 Ø15.7	26	3,900	30.47	7,254	6,396	5,756	6,076
27 Ø15.7	27	4,050	31.64	7,533	6,642	5,978	6,310
28 Ø15.7	28	4,200	32.82	7,812	6,888	6,199	6,544
29 Ø15.7	29	4,350	33.99	8,091	7,134	6,421	6,777
30 Ø15.7	30	4,500	35.16	8,370	7,380	6,642	7,011
31 Ø15.7	31	4,650	36.33	8,649	7,626	6,863	7,245
32 Ø15.7	32	4,800	37.50	8,928	7,872	7,085	7,478
33 Ø15.7	33	4,950	38.68	9,207	8,118	7,306	7,712
34 Ø15.7	34	5,100	39.85	9,486	8,364	7,528	7,946
35 Ø15.7	35	5,250	41.02	9,765	8,610	7,749	8,180
36 Ø15.7	36	5,400	42.19	10,044	8,856	7,970	8,413
37 Ø15.7	37	5,550	43.36	10,323	9,102	8,192	8,647

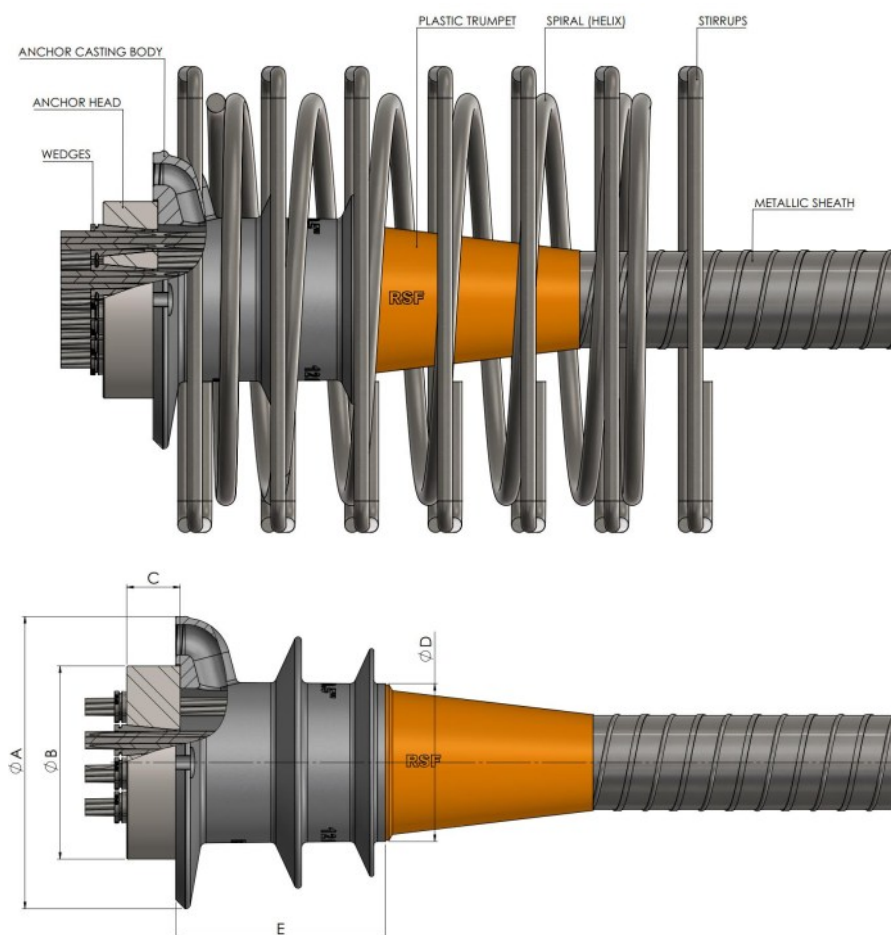


CORROSION PROTECTION

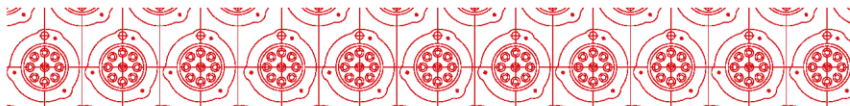
Recognising corrosion protection as a decisive factor in the long-term performance of prestressing systems, RSF offers a set of integrated measures with several levels of protection that ensure the durability and reliability of the systems under conditions of high exposure. To this end, the system uses plastic ducts and metal or plastic conduits, anchorage caps/capsules, sealing of the anchorage zone with adhesive tape and heat-shrink sleeves, and the injection of protective products — cement grout in accordance with EN 447 for bonded tendons, or grease/wax in accordance with EAD 160027-00-0301 for unbonded tendons. RSF also offers, within its monostrand range, encapsulated monostrand anchorages for full corrosion protection.



ANCHORAGE CONFIGURATION - AN SYSTEM



Tendons		Dimensions (mm)				
Ø15.2	Ø15.7	ØA	ØB	C	ØD	E
4		160	114.3	45	82	100
7		200	127	45	100	125
9		235	146.05	46	117	160
12		250	165.1	46	135	180
15		275	190.5	53	153	195
19		300	203.2	76	164	215
22		330	228.6	67	184	250
27		360	254	71	203	270
31		380	270	82	209	280
37		420	279.4	104	233	340

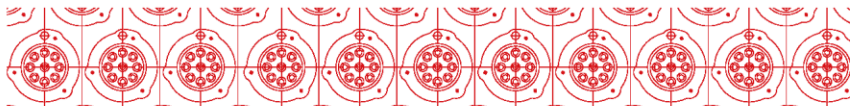


EDGE AND CENTRE-TO-CENTRE DISTANCES - AN SYSTEM

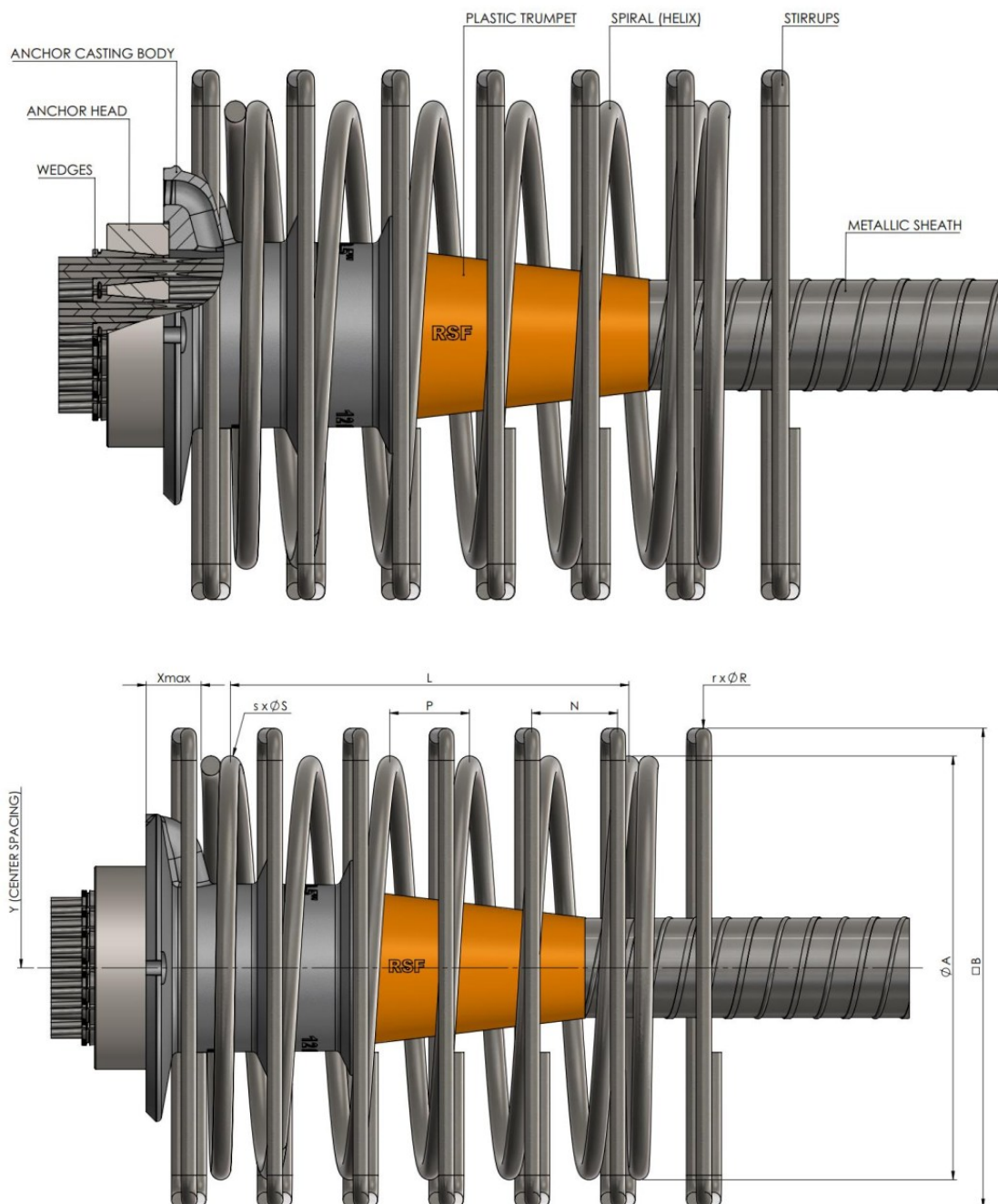
The following tables give the minimum centre-to-centre distances between anchorages ($X_{\text{centre}}/Y_{\text{centre}}$) and the edge distances to the concrete face ($X_{\text{edge}}/Y_{\text{edge}}$) for the AN System, as a function of the concrete strength class and the tendon configuration. Values are given for tendons with 4, 7, 9, 12, 15, 19, 22, 27, 31 and 37 strands of $\varnothing 15.2$ mm and $\varnothing 15.7$ mm, for concrete classes C25/30, C30/37, C35/45 and C40/50.

Centre-to-Centre and Edge Distance for Concrete Class											
Mean concrete strength at the time of prestressing [N/mm ²]		C25/30					C30/37				
Tendons		4 $\varnothing 15.2$	7 $\varnothing 15.2$	9 $\varnothing 15.2$	12 $\varnothing 15.2$	15 $\varnothing 15.2$	4 $\varnothing 15.2$	7 $\varnothing 15.2$	9 $\varnothing 15.2$	12 $\varnothing 15.2$	15 $\varnothing 15.2$
		4 $\varnothing 15.7$	7 $\varnothing 15.7$	9 $\varnothing 15.7$	12 $\varnothing 15.7$	15 $\varnothing 15.7$	4 $\varnothing 15.7$	7 $\varnothing 15.7$	9 $\varnothing 15.7$	12 $\varnothing 15.7$	15 $\varnothing 15.7$
Centre-to-centre distance [mm]	$X_{\text{centre}}/Y_{\text{centre}}$	240/240	315/315	410/410	435/435	455/455	230/230	285/285	370/370	400/400	420/420
Edge distances in concrete [mm]	$X_{\text{edge}}/Y_{\text{edge}}$	135/135	170/170	220/220	230/230	240/240	130/130	155/155	200/200	215/215	225/225
Tendons		19 $\varnothing 15.2$	22 $\varnothing 15.2$	27 $\varnothing 15.2$	31 $\varnothing 15.2$	37 $\varnothing 15.2$	19 $\varnothing 15.2$	22 $\varnothing 15.2$	27 $\varnothing 15.2$	31 $\varnothing 15.2$	37 $\varnothing 15.2$
		19 $\varnothing 15.7$	22 $\varnothing 15.7$	27 $\varnothing 15.7$	31 $\varnothing 15.7$	37 $\varnothing 15.7$	19 $\varnothing 15.7$	22 $\varnothing 15.7$	27 $\varnothing 15.7$	31 $\varnothing 15.7$	37 $\varnothing 15.7$
Centre-to-centre distance [mm]	$X_{\text{centre}}/Y_{\text{centre}}$	515/515	555/555	615/615	655/655	715/715	470/470	505/505	560/560	600/600	655/655
Edge distances in concrete [mm]	$X_{\text{edge}}/Y_{\text{edge}}$	270/270	290/290	320/320	340/340	370/370	250/250	265/265	295/295	315/315	340/340

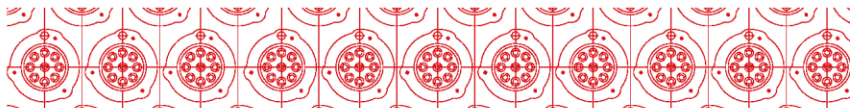
Centre-to-Centre and Edge Distance for Concrete Class											
Mean concrete strength at the time of prestressing [N/mm ²]		C35/45					C40/50				
Tendons		4 $\varnothing 15.2$	7 $\varnothing 15.2$	9 $\varnothing 15.2$	12 $\varnothing 15.2$	15 $\varnothing 15.2$	4 $\varnothing 15.2$	7 $\varnothing 15.2$	9 $\varnothing 15.2$	12 $\varnothing 15.2$	15 $\varnothing 15.2$
		4 $\varnothing 15.7$	7 $\varnothing 15.7$	9 $\varnothing 15.7$	12 $\varnothing 15.7$	15 $\varnothing 15.7$	4 $\varnothing 15.7$	7 $\varnothing 15.7$	9 $\varnothing 15.7$	12 $\varnothing 15.7$	15 $\varnothing 15.7$
Centre-to-centre distance [mm]	$X_{\text{centre}}/Y_{\text{centre}}$	210/210	250/250	325/325	350/350	375/375	200/200	240/240	315/315	340/340	360/360
Edge distances in concrete [mm]	$X_{\text{edge}}/Y_{\text{edge}}$	120/120	140/140	175/175	190/190	200/200	115/115	135/135	170/170	185/185	195/195
Tendons		19 $\varnothing 15.2$	22 $\varnothing 15.2$	27 $\varnothing 15.2$	31 $\varnothing 15.2$	37 $\varnothing 15.2$	19 $\varnothing 15.2$	22 $\varnothing 15.2$	27 $\varnothing 15.2$	31 $\varnothing 15.2$	37 $\varnothing 15.2$
		19 $\varnothing 15.7$	22 $\varnothing 15.7$	27 $\varnothing 15.7$	31 $\varnothing 15.7$	37 $\varnothing 15.7$	19 $\varnothing 15.7$	22 $\varnothing 15.7$	27 $\varnothing 15.7$	31 $\varnothing 15.7$	37 $\varnothing 15.7$
Centre-to-centre distance [mm]	$X_{\text{centre}}/Y_{\text{centre}}$	420/420	445/445	490/490	525/525	575/575	400/400	425/425	470/470	505/505	550/550
Edge distances in concrete [mm]	$X_{\text{edge}}/Y_{\text{edge}}$	225/225	235/235	260/260	275/275	300/300	215/215	225/225	250/250	265/265	290/290



ANCHORAGE REINFORCEMENT AND DISTANCES - AN SYSTEM

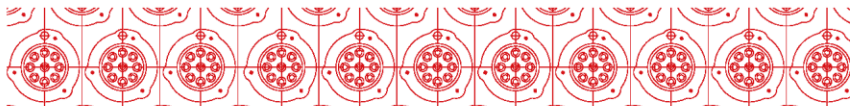


The following tables show the diameters, pitches, spacings and distances that the reinforcement in the anchorage zones must comply with for concrete classes C25/30, C30/37, C35/45 and C40/50.



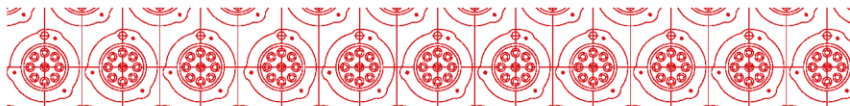
Ø15.2 / Ø15.7	Helix + Stirrup Combination									C25/30	
	Helix					Stirrup					
	ØS	s	P	ØA	L	ØR	r	N	B	Xmax	Y
4	12	6	50	220	200	-	-	-	-	35	240
7	12	6	60	260	240	12	4	75	295	35	315
9	16	7	65	345	325	12	7	70	390	40	410
12	16	7	65	370	325	12	7	70	415	45	435
15	16	7	75	390	375	16	6	75	435	50	455
19	16	9	60	450	420	16	6	90	495	50	515
22	16	10	60	490	480	16	7	75	535	50	555
27	16	11	55	545	495	16	8	70	595	50	615
31	16	12	55	585	550	16	10	60	635	55	655
37	20	11	65	645	585	16	9	75	695	55	715

Ø15.2 / Ø15.7	Helix + Stirrup Combination									C30/37	
	Helix					Stirrup					
	ØS	s	P	ØA	L	ØR	r	N	B	Xmax	Y
4	12	6	50	210	200	-	-	-	-	35	230
7	12	6	50	230	200	12	5	75	265	35	285
9	16	7	65	315	325	12	6	75	350	40	370
12	16	7	65	345	325	12	6	75	380	45	400
15	16	7	65	355	325	16	6	75	400	50	420
19	16	8	60	405	360	16	7	75	450	50	470
22	16	10	50	440	400	16	7	75	485	50	505
27	16	11	50	495	450	16	9	65	540	50	560
31	16	11	50	535	450	16	10	60	580	55	600
37	20	11	60	590	540	16	9	75	635	55	655



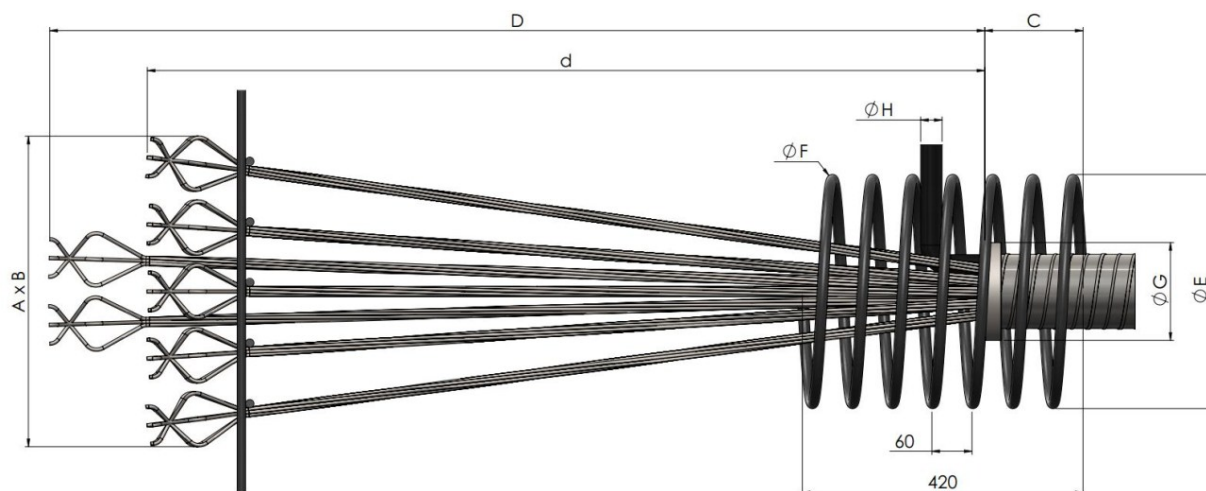
Ø15.2 / Ø15.7	Helix + Stirrup Combination									C35/45	
	Helix					Stirrup					
	ØS	s	P	ØA	L	ØR	r	N	B	Xmax	Y
4	12	6	45	190	180	-	-	-	-	35	210
7	16	6	65	195	260	12	4	80	230	35	250
9	16	7	50	270	250	12	5	70	305	40	325
12	16	7	50	295	250	12	5	70	330	45	350
15	16	8	50	310	300	16	6	70	355	50	375
19	16	8	50	355	300	16	7	60	400	50	420
22	16	10	45	380	360	16	8	55	425	50	445
27	16	11	45	425	405	16	10	50	470	50	490
31	16	11	45	460	405	16	12	45	505	55	525
37	20	11	50	510	450	16	10	60	555	55	575

Ø15.2 / Ø15.7	Helix + Stirrup Combination									C40/50	
	Helix					Stirrup					
	ØS	s	P	ØA	L	ØR	r	N	B	Xmax	Y
4	16	5	70	180	210	-	-	-	-	35	200
7	16	6	55	220	220	-	-	-	-	35	240
9	16	7	50	260	250	12	7	50	295	40	315
12	16	7	50	285	250	12	7	50	320	45	340
15	16	7	50	290	250	16	7	50	340	50	360
19	20	7	60	330	300	16	6	75	380	50	400
22	20	8	60	355	360	16	9	50	405	50	425
27	20	8	60	395	360	20	8	65	450	50	470
31	20	9	60	435	420	20	8	65	485	55	505
37	20	10	55	480	440	20	9	60	530	55	550

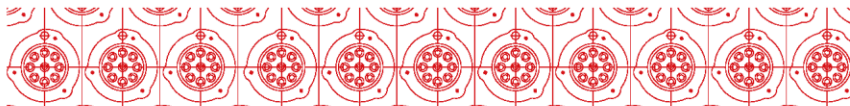


PS SYSTEM – BONDED PASSIVE ANCHORAGES

The PS-series passive anchorages are produced in full compliance with the applicable regulatory standards. In this type of anchorage, the strands are splayed at their far end to increase the bond to the concrete.

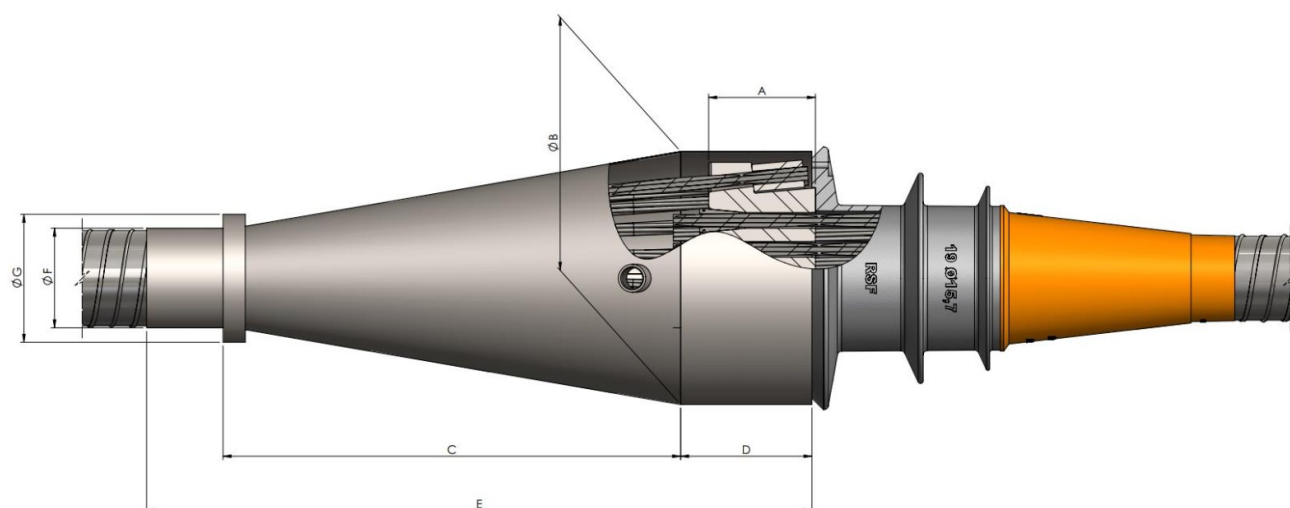


Tendons		Arrangement 1			Arrangement 2			Dimensions in [mm]						
Ø15.2	Ø15.7	A	B	*	A	B	*	C	d	D	ØE	ØF	ØG	ØH
1		90	90	1	-	-	-	-	-	1350	-	-	-	16/20
2		190	90	2	-	-	-	-	-	1350	-	-	-	16/20
3		290	90	3	-	-	-	-	-	1350	-	-	64	21/25
		210	90	2	-	-	-	-	1150	1350	-	-	64	21/25
4		390	90	4	210	190	4	-	-	1350	-	-	70	28/32
		310	90	2	-	-	-	155	1150	1350	-	-	70	28/32
5		330	90	3	-	-	-	155	-	1350	-	-	80	28/32
7		450	90	4	230	210	5	155	1150	1300	200	16	83	28/32
9		430	230	8	-	-	-	155	1150	1300	230	16	114	28/32
		-	-	-	390	330	12	155	1150	-	230	16	114	28/32
12		430	230	8	-	-	-	155	1150	1300	230	16	114	28/32
		-	-	-	390	330	12	155	1150	-	230	16	114	28/32
15		450	230	9	370	370	9	155	1150	1300	300	16	130	28/32
19		570	230	10	470	390	16	155	1150	1300	300	16	140	28/32
22		690	230	12	-	-	-	155	1450	1600	350	16	146	28/32
		-	-	-	490	470	20	155	1250	1400	350	16	146	28/32
27		690	260	17	-	-	-	155	1500	1650	350	16	171	28/32
		-	-	-	530	510	20	155	1450	1600	350	16	171	28/32
31		810	260	14	-	-	-	165	1750	1900	400	20	171	28/32
		-	-	-	570	510	20	165	1550	1700	400	20	171	28/32
37		1050	370	18	-	-	-	175	2400	2550	400	20	178	28/32
		-	-	-	690	510	24	175	1850	2000	400	20	178	28/32



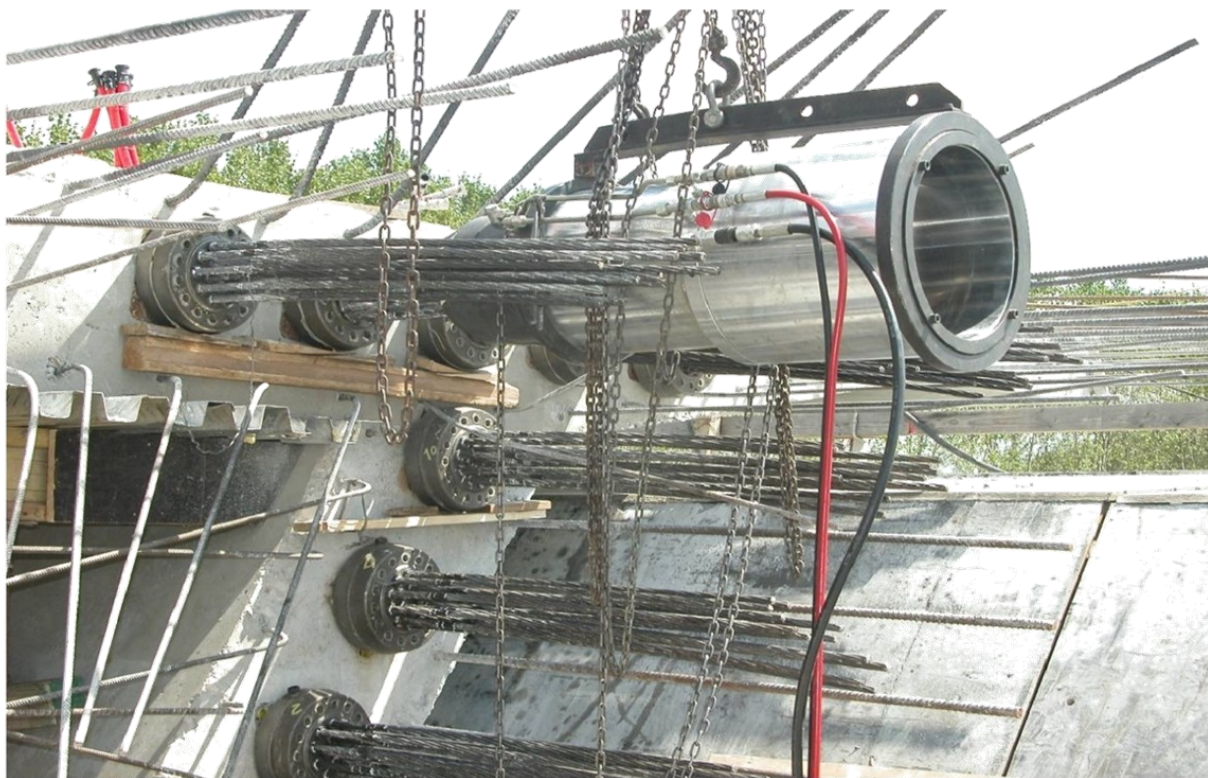
Reference	Arrangement	Reference	Arrangement	Reference	Arrangement	Reference	Arrangement
1/2 Strands	1	3 Strands	1	4 Strands	1	4 Strands	2
5 Strands	1	7 Strands	1/2	9/12 Strands	1	9/12 Strands	2
15 Strands	1	15 Strands	2	19 Strands	1	19 Strands	2
22 Strands	1	22 Strands	2	27 Strands	1	27 Strands	2
31 Strands	1	31 Strands	2	37 Strands	1	37 Strands	2
White dot – represents D Black dot – represents d							

CO SYSTEM – COUPLERS



Dimensions (mm)							
Ø15.2 / Ø15.7	ØA	ØB	C	ØD	E	ØF	ØG
4	110	160	210	150	440	65	83
7	122	190	300	150	550	70	95
9	122	220	360	150	610	80	105
12	122	240	400	150	650	90	121
15	122	260	510	150	760	95	133
19	122	280	510	150	760	105	146
22	122	310	610	150	860	120	159
27	150	340	660	170	940	130	168
31	150	360	660	170	940	140	178
37	160	400	840	190	1140	150	203

The CO coupler consists of a machined head with fixing points for the stressing and re-stressing strands (active/passive). The passive strands are held by a spring mechanism that keeps the wedge in position from the threading operation until the load is applied. The wedge-and-spring system is protected by a metal cap.



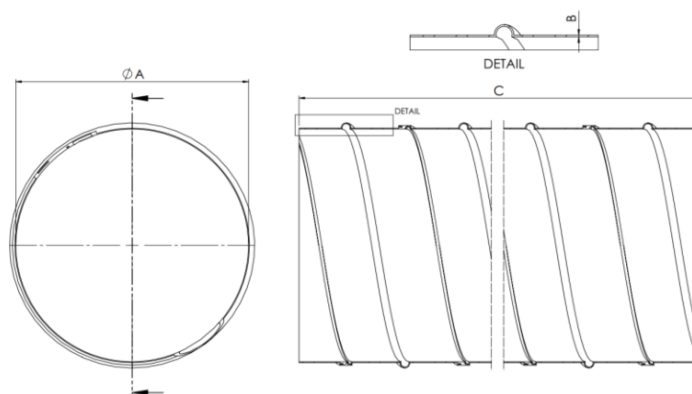
DUCTS & ACCESSORIES

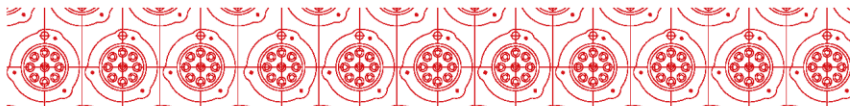
Metal or polyethylene ducts are the most economical way to form voids in post-tensioned members, providing good secondary corrosion protection and the required bond between the tendons and the concrete. Primary corrosion protection is provided by the alkalinity of the injection grout and by the concrete itself, while secondary protection is provided by the duct and the protective barrier it forms around the tendon.



CIRCULAR METAL DUCTS

Metal ducts are available in different versions. They are made of pressed steel strip to EN 10139:1999 and can be galvanized. Metal duct sections are 5.8 metres long and are all supplied with a screwed coupler on each section. Metal ducts can be of the following types:





ØA (mm)	B (mm)	C (mm)	Number of strands
			Ø15.2 / Ø15.7
Ø45	0.25	0 - 6.000	4
Ø50	0.30		5
Ø55			6 / 7
Ø60			8
Ø65			9
Ø70			10 / 11
Ø75	0.35		12 / 13
Ø80			14
Ø85			15 / 16 / 17
Ø90			18 / 19
Ø95	0.40		20 / 21
Ø100			22 / 23
Ø105			24 / 25
Ø110			26 / 27 / 28
Ø115			29 / 30
Ø120	≥0.40		31 / 32 / 33
Ø125			34 / 35
Ø130			36 / 37

- The duct diameter recommended in the table above may be reduced in special cases, provided that a filling ratio (steel cross-section / duct) ≤ 0.5 is maintained. For special cases (long tendons, many curvatures, etc.), a larger duct is recommended.
- Minimum steel strip thickness.
- The duct length depends on the design requirements. For duct lengths greater than 6 metres, a duct coupler in accordance with EN 523 is used.

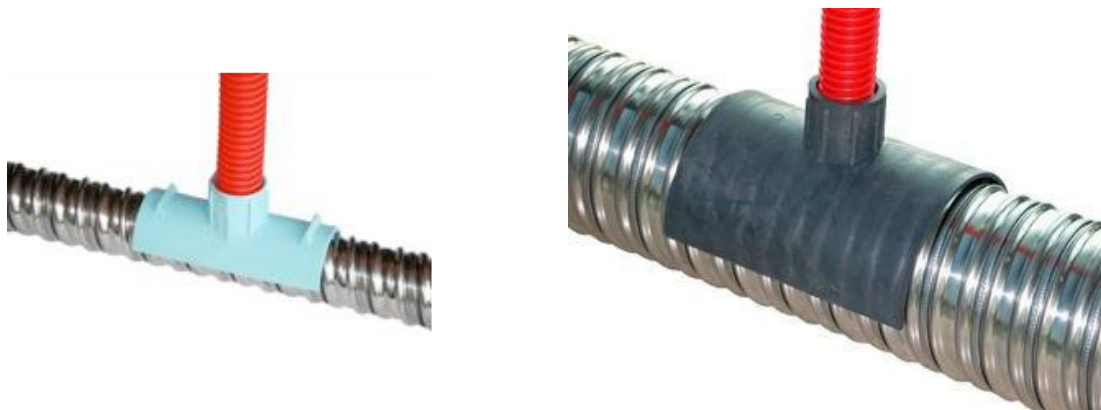
POLYETHYLENE DUCTS “SP”



SP polyethylene ducts are available in different forms. They are made of H.D.P.E. in accordance with the FIB specifications, in sections of variable length between 5.8 m and 11.8 m. They are blue and have a heat-shrink coupler at each connection. SP ducts can be supplied in the following types:

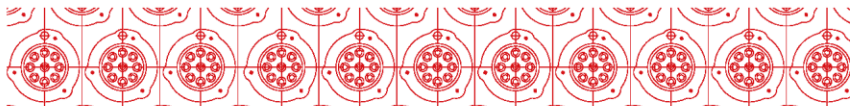
- SPA corrugated with a thickness of 2.00 mm.
- SPB corrugated with a thickness of 2.50 mm.
- SPC corrugated with a thickness of 3.00 mm.
- SPD corrugated with a thickness of 3.50 mm.

VENT BASE



Positioning vents on corrugated ducts ensures the correct removal of internal air during the grouting operation. They must be installed at all points of the tendon where air pockets could form. The DD-1001 vent is made of flexible material so that it can be used with ducts of all diameters.

Corrugated and rigid tubes for grouting, plus all the connections and valves needed to carry out the grouting.



DE-WEDGING TABLE

The de-wedging tables make it possible to release the load from the tendons for replacement of the tendons or of the wedges in all anchorages of the RSF range, and are compatible with the multistrand stressing equipment.



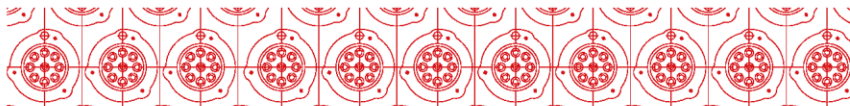
A



B



C



EQUIPMENT

HYDRAULIC JACKS

For multistrand stressing, FERCA uses hydraulic jacks from leading manufacturers — PAUL (Germany) and DSI/DYWIDAG — selected according to the stressing force and the size of the tendon to be stressed. The equipment fleet comprises several models, covering stressing forces from about 850 kN up to about 4,800 kN. These are hydraulically driven units with hydraulically assisted wedge seating that keeps seating (draw-in) losses to a minimum, and with a hollow ram that guides the strands through the jack, ensuring reliable and safe operation. They also allow overstressing and controlled release to compensate for friction losses, as well as electronic recording of force and elongation for quality-control purposes. The different configurations — including front-grip versions for confined spaces — and the ram stroke allow fast, low-effort operation during stressing.

Characteristics	Unit	PAUL M850 kN	DSI 1700 kN	PAUL M 3000 kN	PAUL M 4800 kN
Capacity	kN	850	1700	3000	4800
Strand range	No.	1-4	4-7	9-12	15-19
Seating ram	mm	250	250	250	300
Weight	kg	92	203	280	680
Ram area	cm ²	173.77	298.45	527.79	860.01
Stressing pressure	Bar (max.)	500	585	600	600
Return pressure	Bar (max.)	420	200	200	200
Seating pressure	Bar (max.)	420	365	420	420
Ram stroke	mm	210	350	400	500
Maximum diameter	mm	290	330	250	320
Length	mm	950	1050	1000	1340



Paul Tensa M850



DSI 1700



Paul Tensa M3000

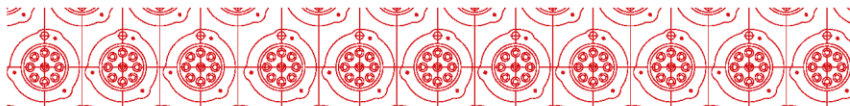


Paul Tensa M4800

All jacks are supplied complete, with the accessories needed to carry out stressing. Each jack is identified by its stressing force — for example, M4800 (PAUL TENSA M, 4,800 kN) — with the core (interchangeable internal parts) configured according to the number of strands; when it differs from the factory standard, the designation is extended accordingly (e.g. M4800-22, for 22 strands). The jacks are driven from the hydraulic pumps via hoses, providing the following independent functions:

- Stressing,
- Return,
- Wedge seating (power seating).

The strands are introduced into the jack using a strand guiding/separating device. When stressing active anchorages, the jack bears on its head through a support ring; only in certain types of anchorage does the jack bear directly on the anchorage itself.



The main features of the “M” series jacks are as follows:

- 350° rotation about an axis,
- Reduced tendon extension required,
- Automatic seating via hydraulic circuit,
- Compact dimensions,
- Front grip,
- Easy handling and maintenance,
- Easy inspection/cleaning of the drag wedges,

The jacks are identified by a serial number and are supplied with their calibration certificate.



HYDRAULIC PUMPS

Paul NG50 (PT)

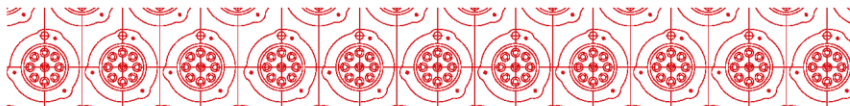
The NG50 is a hydraulic power pack (pumping unit) from PAUL, the leading German manufacturer of prestressing and post-tensioning equipment. It is designed to supply the hydraulic power that drives stressing jacks, cylinders and related equipment used in the production of prestressed concrete members. It is a compact, simple-to-operate unit that can work with manual or electric control at a working pressure of 420 bar.

In essence: drive is typically by a three-phase electric motor, with AC, pneumatic or petrol versions also available; control is by a manual hydraulic valve, with the option of additional electric controls for the setting-up functions. The pump is a radial-piston type mounted on the motor flange, with a return filter to clean the oil, and the complete station comprises the base unit, the power pack, a pressure gauge, hydraulic couplings and an interconnecting cable.



A summary of this hydraulic pump's characteristics follows:

- Power: 5.5 kW
- Weight: 110 kg
- Control: push-button panel
- Functions: stressing-seating-return
- Max. stressing pressure: 620 bar.
- Max. seating pressure: 150 bar.
- Max. return pressure: 150 bar.
- Dimensions: 1350×740×1060 mm
- Hydraulic hoses: three



GROUTING PUMP

For grouting, FERCA uses the Häny IC 310. This equipment is a compact grouting unit from the Swiss manufacturer Häny AG, combining mixer, agitator and pump in a single assembly — preparing and pumping cement grout (or bentonite suspensions) for the grouting of anchorages, soil nails, prestressing tendons and similar applications, reaching up to 100 bar of pressure and about 2 m³/h of flow.



Characteristics	Unit	Model Hany IC310E
Weight	kg	625
Dimensions	mm	1600×780×1600
Mixer	l	100
Mixing time	sec	40"
Agitator	l	150
Max. grouting pressure	Bar	100
Max. grouting capacity	m ³ /h	2.0
Mixer power	kW	10.5

